LEYBOLD®

CONTROL ENGINEERING & AUTOMATION

CONTROL TECHNOLOGY - AUTOMATION - INDUSTRY 4.0

LD DIDACTIC

BENEFITS OF THE LEYBOLD SOLUTIONS

TPS-SYSTEMS
Easy to move and set up. Small enough to transport; large enough for impressive experiments.

DIGITISED PROCESSES
Modern control and automation systems are digitised processes, based on microcontrollers and software.

MODULAR
Easily combinable processes, delivering unsurpassed adaptability for individual problems. TPS devices can be combined into extensive and complex overall configurations.

EXPANDABLE
The combination of technical and electronic sub-processes (controlled systems and system simulations) mean higher demands of trainees and students for model processes and sequencers. Systems can be expanded to Industry 4.0.

COMPUTER SUPPORT
Professional software, such as „TIA Portal", „WinFACT", „LabVIEW™", „espial" or „MATLAB™" , allow for programming and optimisation of control problems. The systems of the CASSY family (Sensor-CASSY 2, Profi-CASSY and CASSY Lab 2) are available for evaluation and optimisation of control systems.

PLUG & PLAY
Electronic manuals with prepared measurement data files or proposed solutions are all part of the equipment. No laborious calibrations and preliminary adjustments required.

WHAT IS THIS ALL ABOUT?

The catalogue describes equipment, experiments and devices for control engineering and automation. Before the advent of information processing systems, control engineering was often described in terms of instrumentation and control.

Early controllers, in the form of hard-wired relay and contactor circuits, increased productivity on the assembly lines of American slaughterhouses and in the emerging automotive industry as early as in the late 19th century.

To distinguish relay and contactor controls from modern programmable logic controllers (PLCs), they are sometimes called hard-wired programmed logic controls. Their theoretical background is simple. Due to the hard-wiring, all solutions are adapted individually to a specific application. Only the development of programmable logic controllers in the last third of the 20th century, brought along the breakthrough, leading to widespread use of controllers in virtually the entire industrial production. Unlike control technology, control engineering is heavy on theory.

Automatically sequenced and fixed command control for disturbance compensation can be found in many areas of daily living today. Apart from the usual system evaluations – such as by step responses – they require specific measures and optimisations. This catalogue's great size reflects its practical significance.

In order to make it easier to orient yourself, the catalogue is organized into the following subchapters:

- Measurement technology & sensors
- Didactic control engineering
- Applied control engineering
- Industrial control engineering
- Control technology
- Automation technology
- Process automation
- Hydraulics
- Pneumatics
- Industry 4.0

The setups contain very different learning systems from connector systems through to multimedia courses, experiment plates, and system simulations. In addition to the specially designed, didactic devices, it offers specially prepared training and teaching packages on the basis of industrial components, particularly in the area of programmable logic controllers (PLCs).

LEYBOLD®

LEYBOLD®

INDUSTRY 4.0 –
FOR VOCATIONAL TRAINING & CONTINUING EDUCATION

LD DIDACTIC

The transformation of the industrial world and its continuing digitisation place increasing demands on skilled workers and engineers.

The foundations must be laid during training. Therefore we – as a developer and producer of educational systems with years of experience – are called upon to prepare these topics for training and classes in a didactically and methodically clear manner.

With strong partners such as:

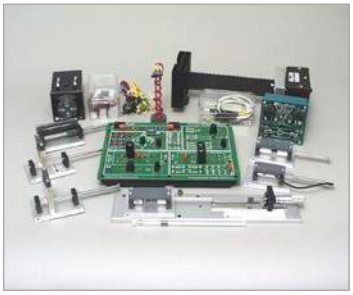
- Siemens
- Bosch Rexroth

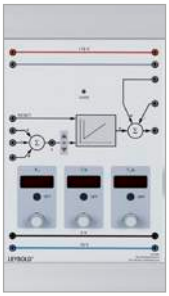
we have managed to prepare original components of industry manufacturers using our TPS system. This makes these products understandable and user friendly for the real world of training.

The LEYBOLD concept is modular, allowing the training and the didactic concept to be transferred from the complex system to the fundamentals, as well as vice versa.

Teaching Industry 4.0 with LEYBOLD systems:

- FEEDBACK sensor technology fundamentals
- LEYBOLD COM3LAB as multimedia support
- LEYBOLD control engineering – because it is not just about controlling
- Siemens PLC as industrial controller
- LEYBOLD ASIMA, compact, flexible universal system simulation
- Complete System Industry 4.0





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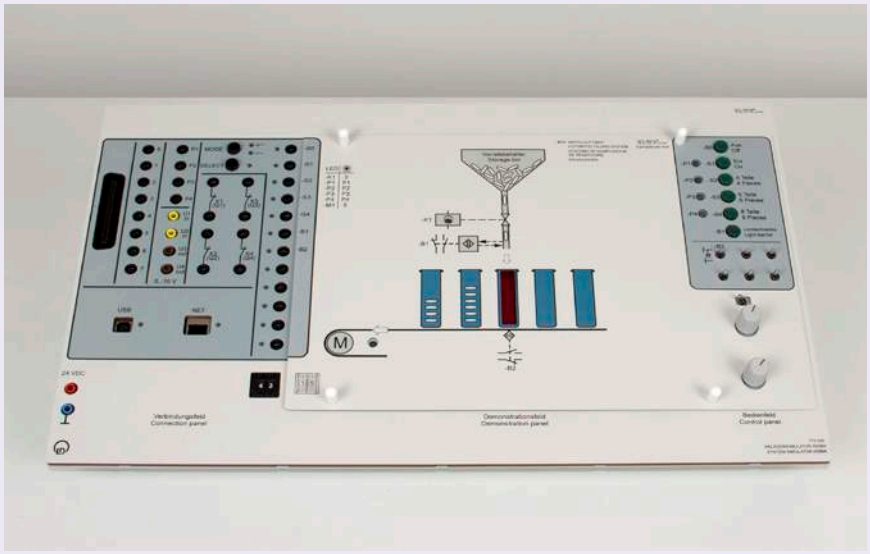
CONTENTS

HIGHLIGHT PRODUCTS

ASIMA II

773 050

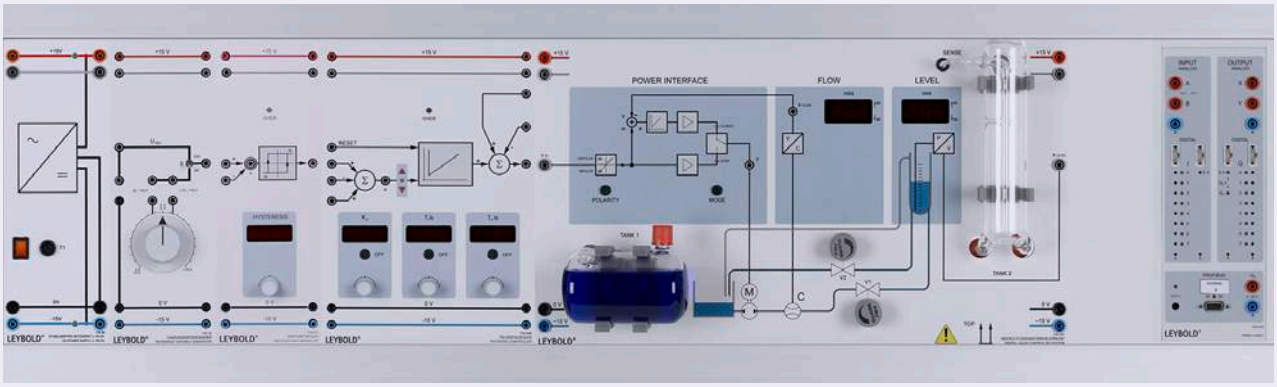
The System Simulator ASIMA II is the perfect addition for the SPC S7-1516. A total of 33 different systems are available. The experiment spectrum ranges from testing of SPC functions through to complex systems with controllers and facilitates universal use of ASIMA in education. The COM3LAB course, ASIMA, is included.



MECHATRONIC & INDUSTRY 4.0

E6.7.2 & E6.9

It allows creating a continuous learning approach, from the fundamentals up to an industrial production system. Mechatronic models help the student create a transition to real industrial systems. It forms the prerequisite for the operation, maintenance and repair of complex production systems.



FLOW & LEVEL CONTROL

E6.3.1.2

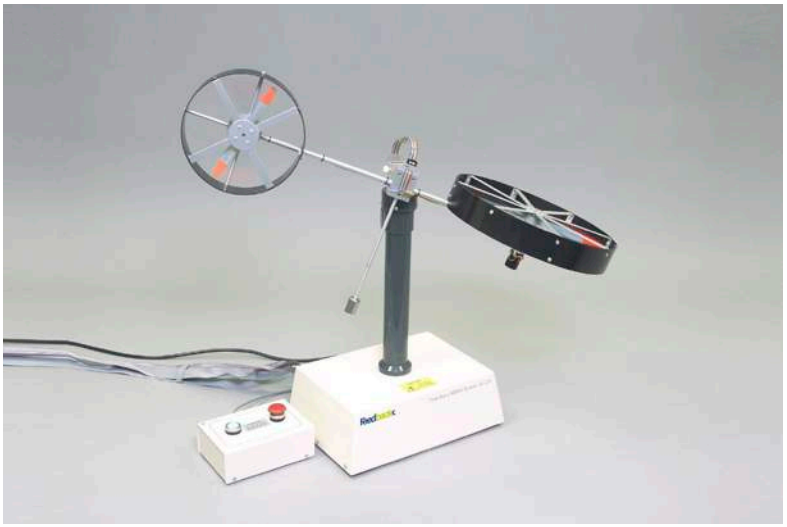
The liquid control system is comprised mainly of a pump as well as holding and measuring tanks. Two valves are used to control inflow and outflow of the fluid. The device contains an impeller wheel flowmeter with subordinate flow controller.

A dip tube with pressure sensor detects the liquid level in the measuring tank and converts it into an electric signal. The measurement values of the flow and fill level are displayed on 7-segment displays. The digital liquid control system is characterised by a very compact build. It is delivered complete with all sensors and operation equipment and needs very few accessories.

TWIN ROTOR MIMO SYSTEM

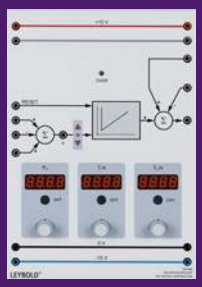
E6.3.5

The dual rotor system illustrates the principles of a non-linear MIMO (Multiple Input, Multiple Output) system with significant cross-coupling. The system acts like a helicopter with fixed angles of attack of the rotor blades, in which the aerodynamic forces are controlled by varying the rotational speeds of the two motors. Significant cross-coupling between the two axes occurs, as each rotor affects both angular positions. Using the Advantech PCI card, an impressive development environment for digital control can be created. The user is guided through the design process and learns to identify the system by means of phenomenological process models, dynamic analysis, discrete models, controller design, controller tests on the model, controller implementation in real-time applications, implementation of various control strategies and data visualisation.



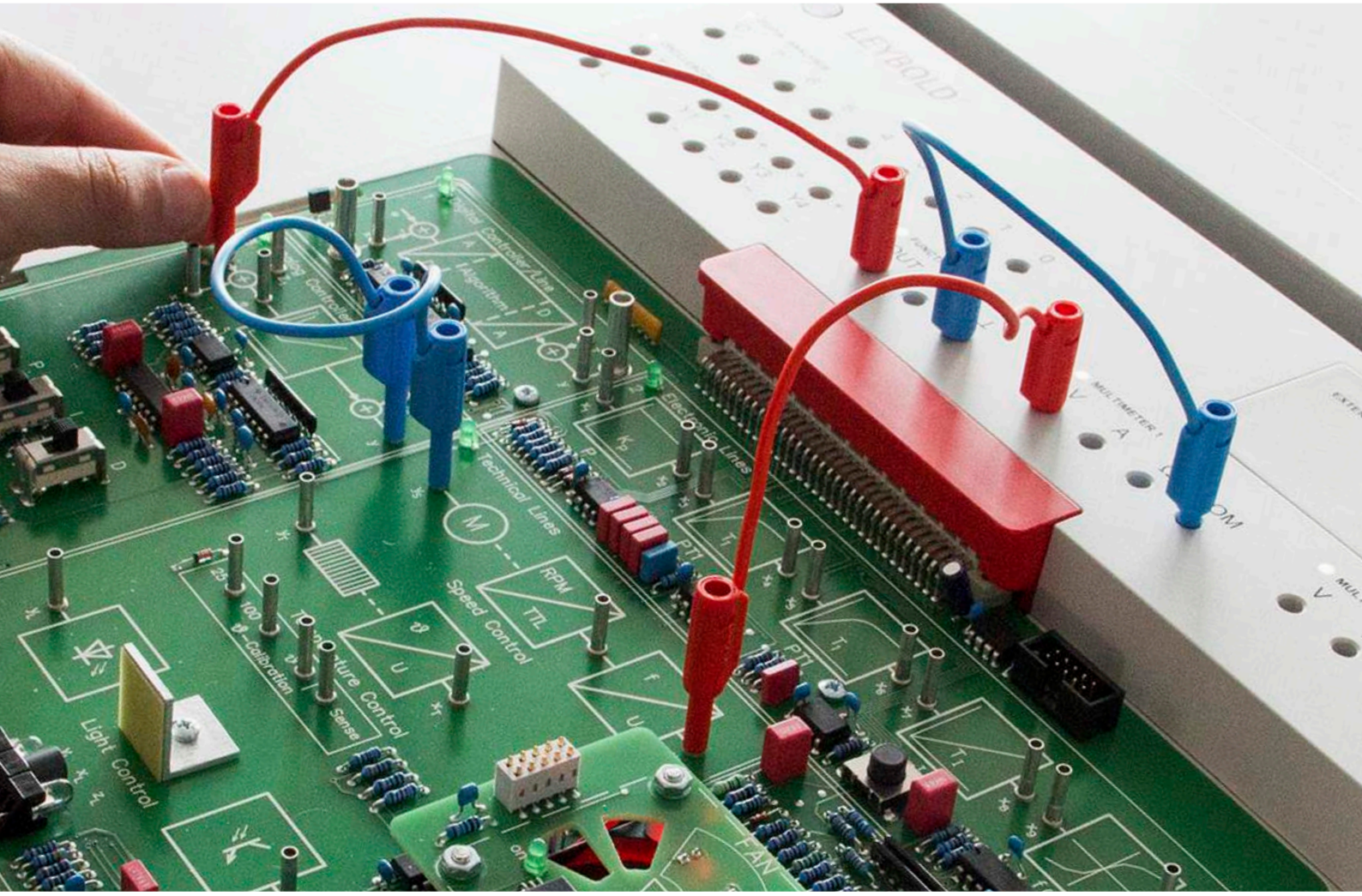
PID DIGITAL CONTROLLER NET

734 064N



Networked 32-bit digital controllers for integration into the LeyLab network. The digital controller is configured, for example, as a P, PI, PD, or PID controller as a control for continuous processes. Including input summing junction for two reference variables and one control variable, measuring point for control difference, trend display of the control difference with three LEDs. The P, I and D component can be switched off individually.
Including output summing junction for adding or subtracting two external and internal disturbances. The internal disturbance can be switched through the network. Choice of controller parameters via buttons and rotary encoders.
The integrator works with an anti-wind-up limit. The differentiator uses an adaptive smoothing algorithm to reduce the quantisation noise and is equipped with an internal slew limiter.

COM3LAB MULTIMEDIA



MASTER UNIT

The master unit is compatible with all courses and includes two digital multimeters, a function generator, a digital storage oscilloscope, and a digital analyser. A completely new subject area can be accessed by simply changing the course PCB in the master unit.

OPTIMUM COMBINATION OF THEORY AND PRACTICE

COM3LAB Multimedia combines interactive learning software with real hardware and is used in schools, universities and industrial companies for training in various fields of electrical engineering and electronics.

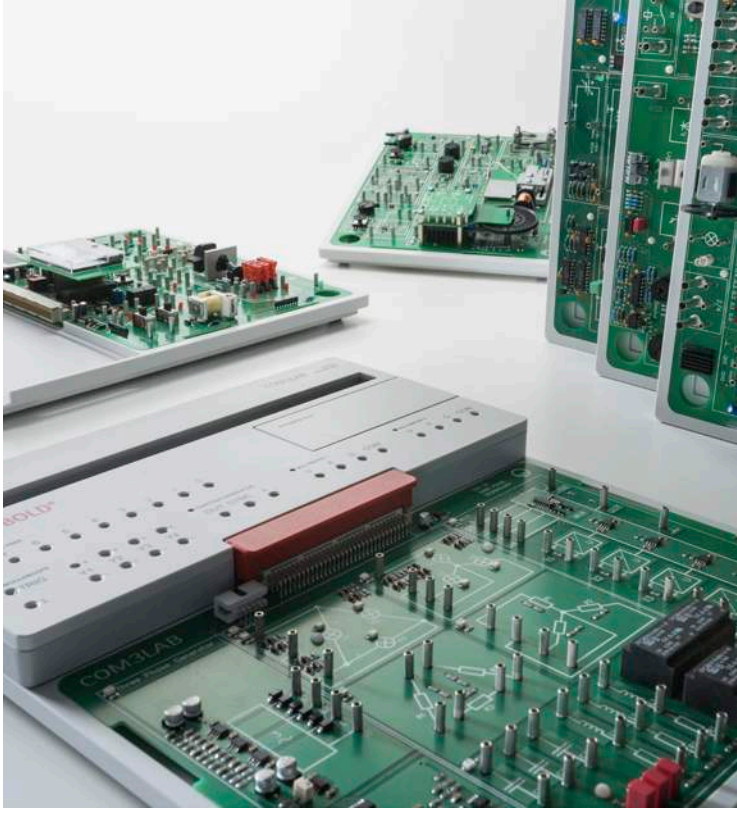
Likewise, the COM3LAB courses on instrumentation and control faithfully implement the modern methods of blended learning. They offer flexible application in the classroom since they are suitable for demonstration, hands-on self-study, or for project work in teams.

COM3LAB COURSE: AUTOMATION & BUS TECHNOLOGY

This course provides the basic knowledge of programmable logic controllers (PLCs) and demonstrates their networking, including sensors and actuators, based on the PROFIBUS.

With many examples, explanations, exercises and practical tasks, fundamentals and operation of PLCs and PROFIBUS are presented in an intuitively accessible manner.

The compact and complex hardware of this course enables practical transfer of knowledge. The ability to connect additional external PROFIBUS components provides extensive options for presenting the processes in bus and automation technology realistically and without much effort.



COM3LAB COURSE: CONTROL TECHNOLOGY I & II

These courses teach control engineering practically with many examples. Important learning objectives, such as fuzzy control, stability analysis in accordance with Nyquist, or controller optimisation, can be achieved with additional cost for controlled systems, instrumentation and control equipment.

The course, Control Technology I, focuses on getting to know the different controllers. Analysis and calculations of controlled systems are developed step by step.

The course, Control Technology II, covers complex control systems and their behaviour.

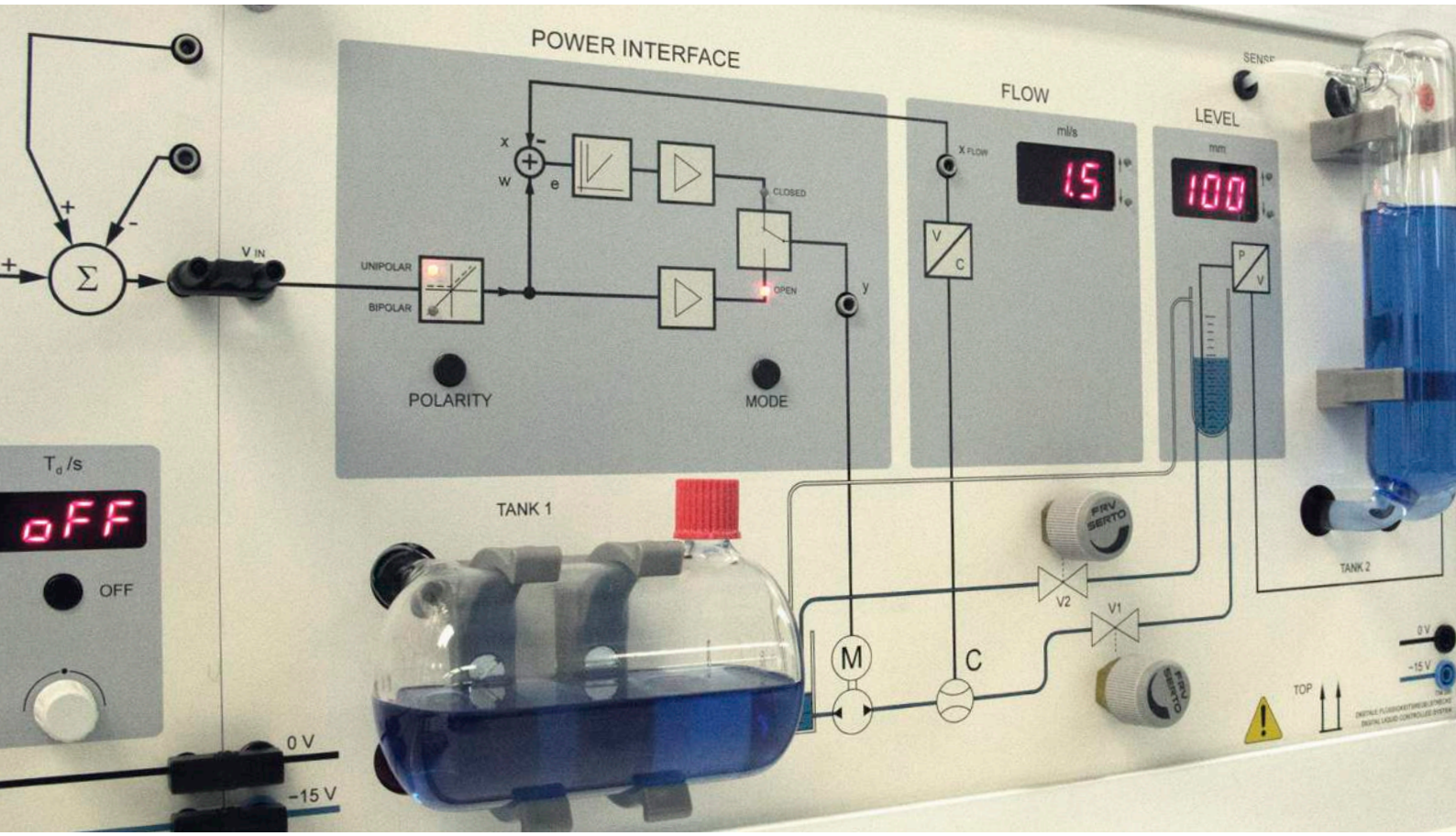
COM3LAB COURSE: OPERATIONAL AMPLIFIER

This course provides insight into the world of the operational amplifier. From a standard circuit through to realisation of a function generator, it covers all important topic areas. This course gives students the foundation for other courses in control engineering.

COM3LAB COURSE: SENSOR TECHNOLOGY

It teaches the basic knowledge of measuring non-electrical variables. Using many examples, explanations, exercises and practical tasks, it presents the principles and functions of the sensors and the associated measuring circuits in an intuitively accessible manner.

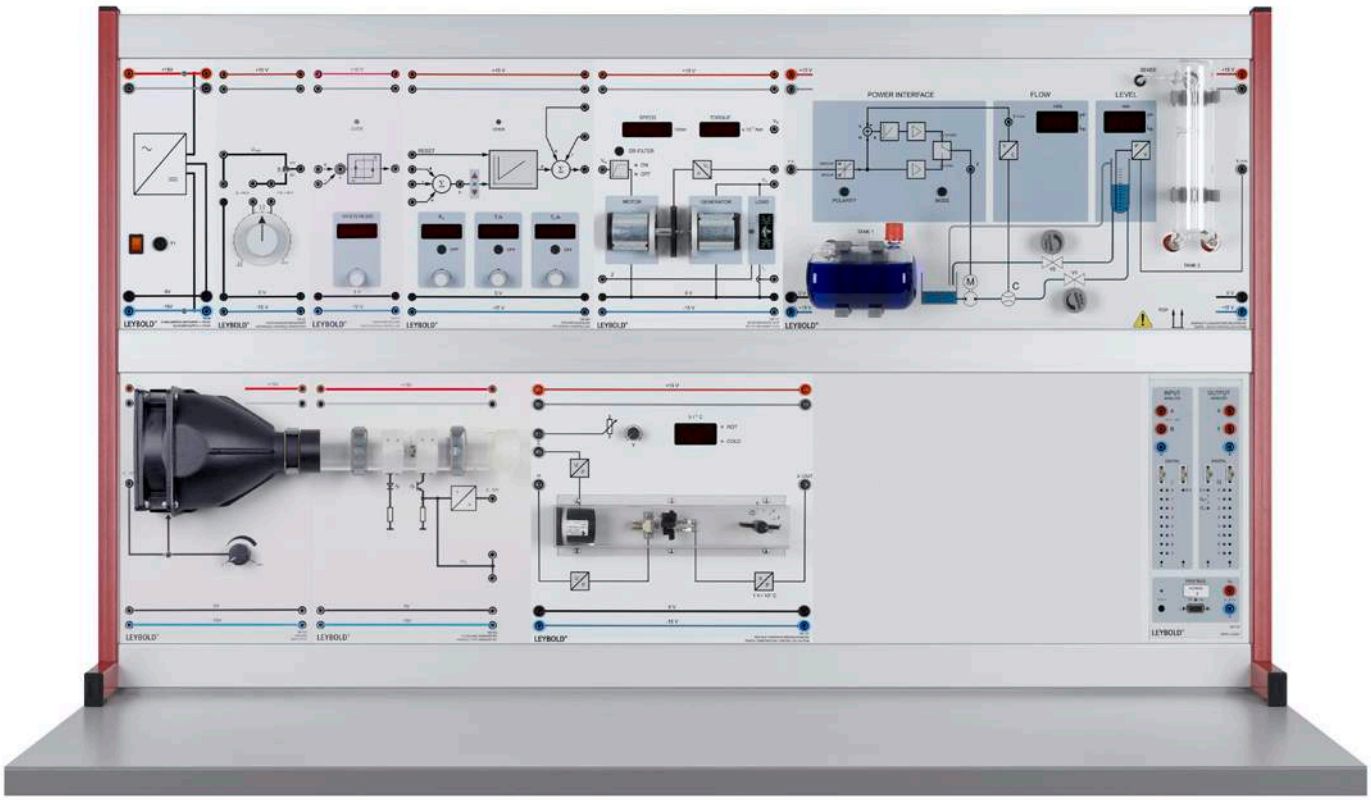
TPS - TRAINING PANEL SYSTEM



The LEYBOLD training panels are the centerpiece of the successful training systems. The equipment set configurations feature an outstanding modular design. All of the required training fields can be covered in their respective training topic areas using the TPS training panel equipment sets.

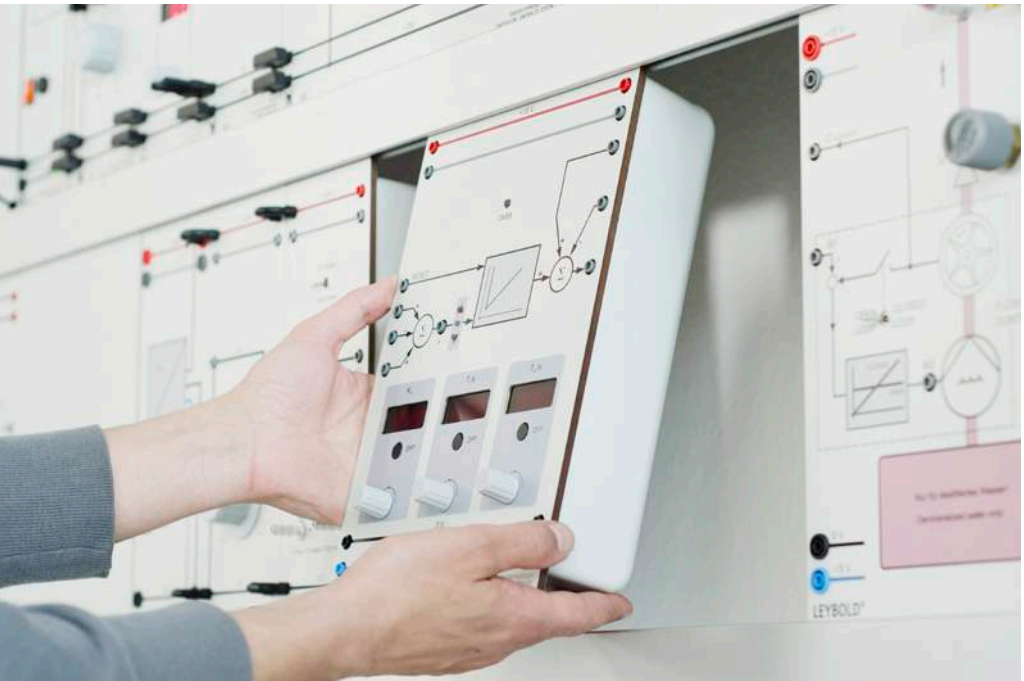
THE MODULAR TRAINING PANEL SYSTEM FOR STUDENT EXPERIMENTS & CLASSROOM DEMONSTRATIONS

- Use of original components
- Experiment literature for classroom preparation and experiment procedur
- Featuring clearly laid out frontal panels
- High scratch and wear resistance



The systematic use of 4-mm safety sockets, cables and bridging plugs (jumpers), ensure that the experiment procedures are carried out safely. With the support of extensive experiment instructions and literature the students and trainees have lots of opportunities to acquire knowledge and new skills while at the same time deepening what they have already learned previously.

The proven TPS training panel system is also perfectly suited for instructors who have to demonstrate complex experiments. The additional TPS.NET and CASSY technologies offer the option of conducting all experiments with computer assistance. This builds a bridge between traditional learning and new technologies.



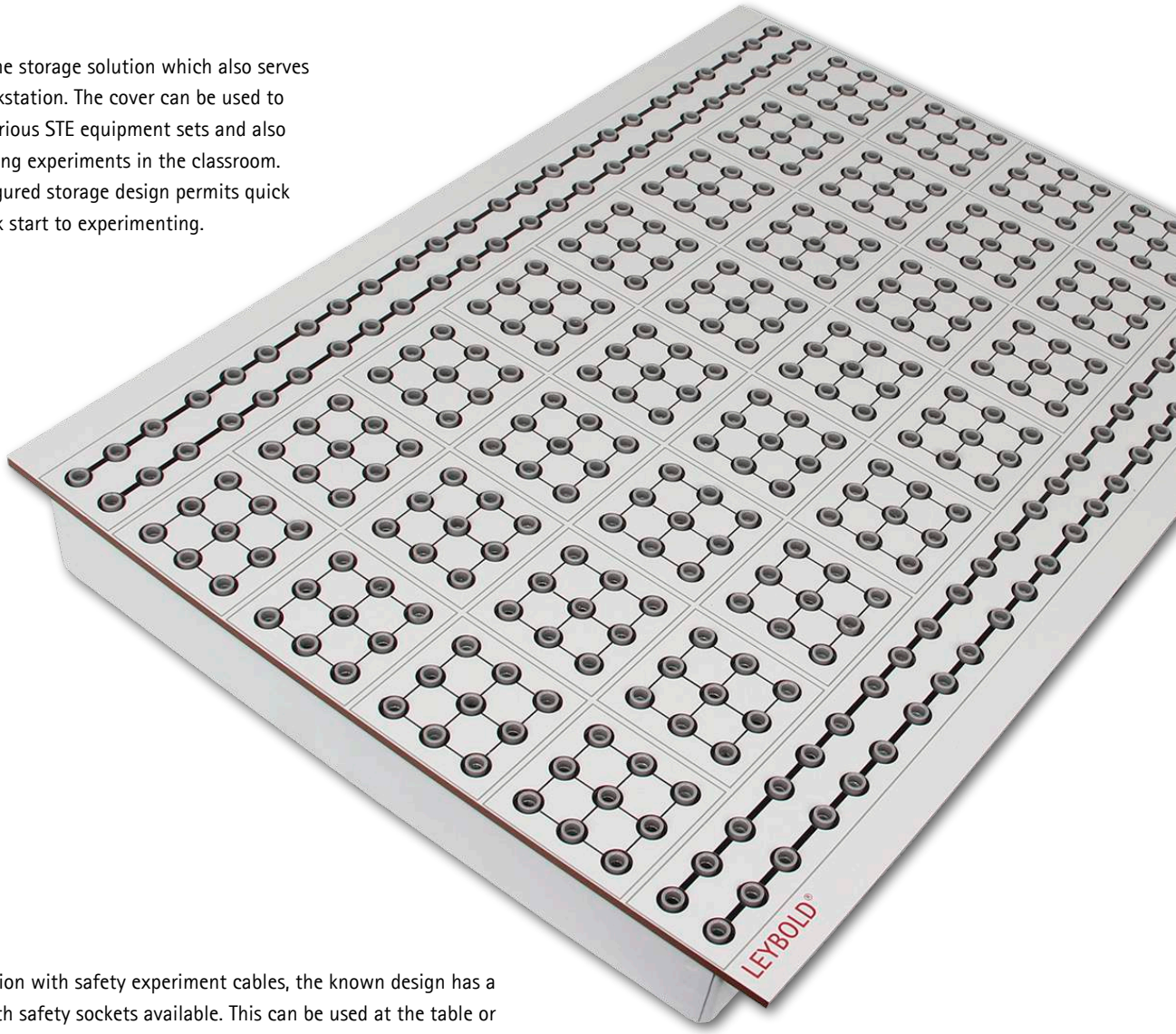
Thanks to the modular design, technology labs can quickly and easily be outfitted or extended using the TPS system.

STE PLUG-IN SYSTEM

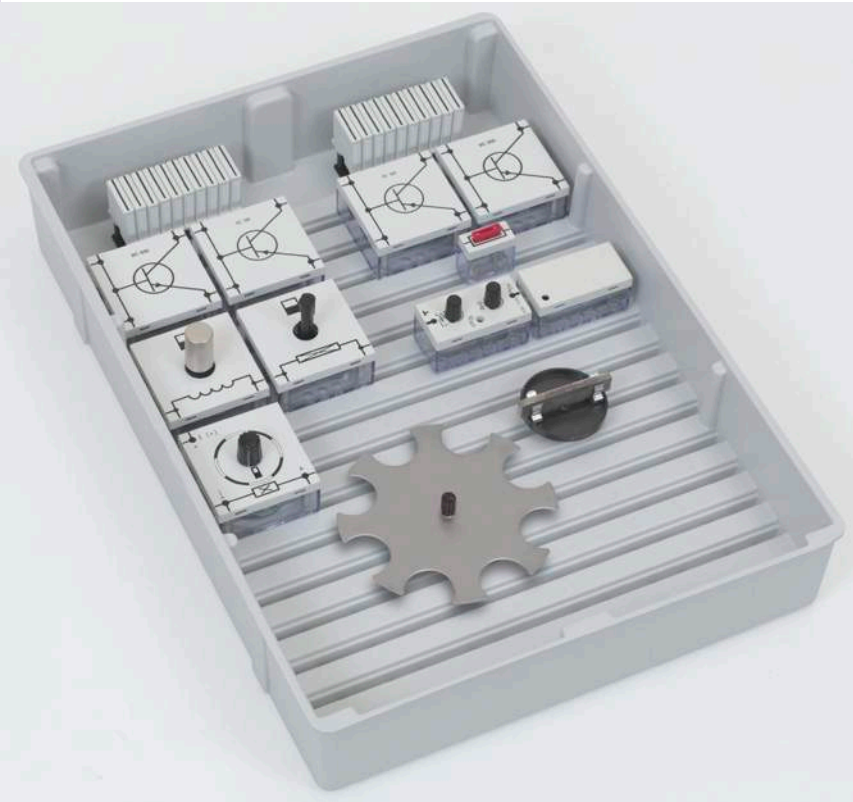
The LEYBOLD plug-in system is a tried and tested experimentation program for electrical engineering and electronics. The extensive experimentation program covers beside the basics also advanced topics, for example, communications, IT, open take out and closed-loop control technology as well as areas from automotive electronics.

Instruction sheets for students and accompanying teacher information are available to assist with the performance of experiments. The printed symbols on the plug-in housing elements, connectors and training panels provide the experiment set-ups with a circuit-like appearance. This facilitates the knowledge transfer between the circuit diagrams in the text books and the circuitry being assembled and makes the documenting of the experiment set-ups easier to do. At the end it ultimately promotes circuit-based thinking, learning and experimenting.

The STE case is the storage solution which also serves as a student workstation. The cover can be used to accommodate various STE equipment sets and also assist in performing experiments in the classroom. The clearly configured storage design permits quick setup and a quick start to experimenting.

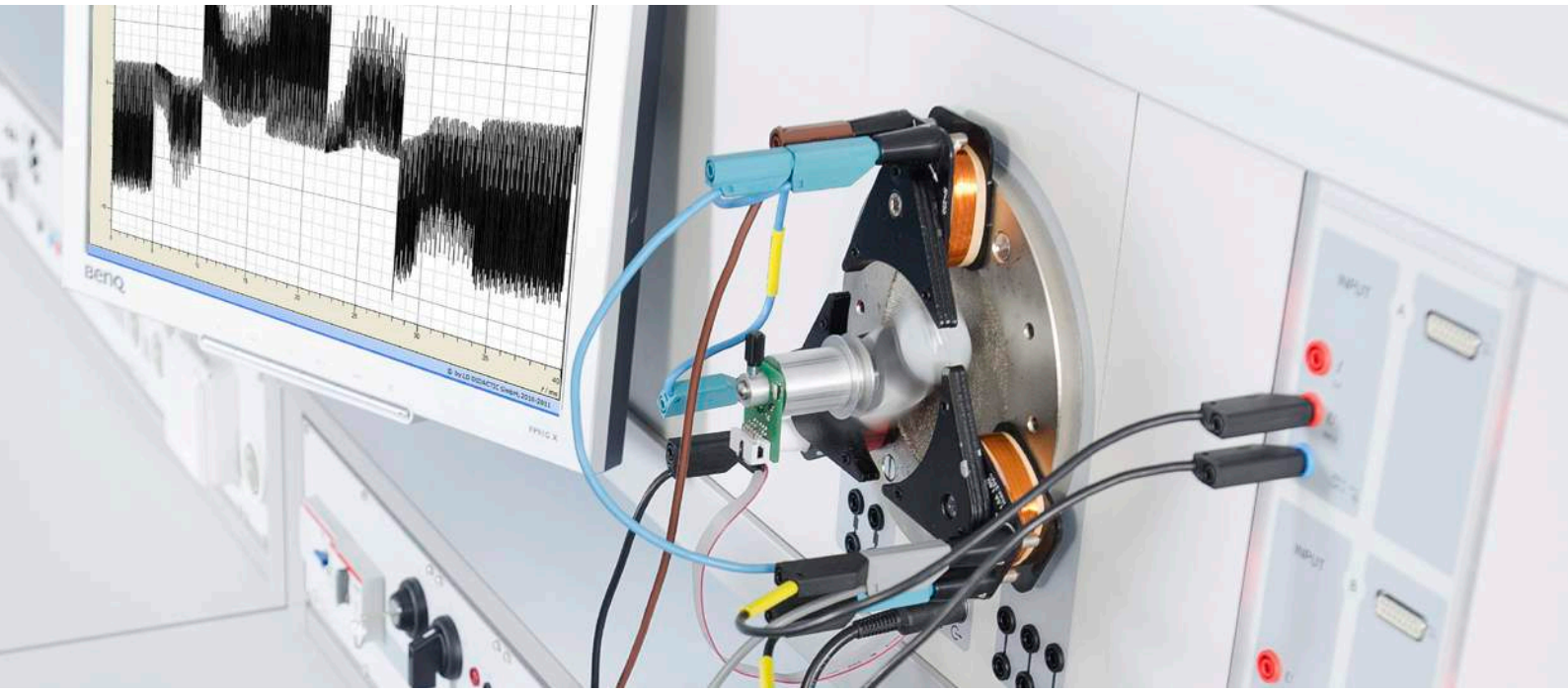


For experimentation with safety experiment cables, the known design has a Plug-in board with safety sockets available. This can be used at the table or for demonstration in the panel frame.



The STE elements come ready for operation and assembly with their electrical and electronic components encased in transparent housings to protect against external mechanical damage. Thanks to the transparent bottom part the original component is visible.

CASSY - COMPUTER-ASSISTED MEASUREMENT & EVALUATION



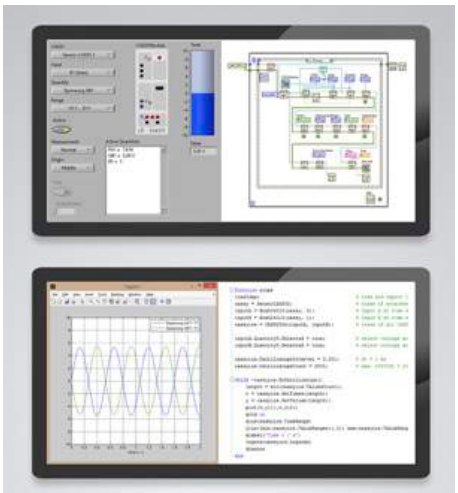
The modular CASSY system makes computer-assisted measurement and evaluation possible for all training and educational levels up to university level.

THE CASSY SYSTEM COVERS:

1. Interfaces for recording measurement data
2. Comprehensive offering of sensors for the detection of electrical and non-electrical variables
3. CASSY Lab 2: The intuitive and easy-to-use software for measurement and evaluation designed to fit all of the equipment and sensors

SOFTWARE (SELECTION)

- CASSY Lab 2
- WinFACT
- MATLAB
- LabVIEW
- LEYLAB



SENSOR-CASSY 2

INTERFACE FOR RECORDING MEASUREMENT DATA

- For connection to the USB port of a computer, to an additional CASSY module or to the CASSY display (WiFi optional)
- Simultaneous measurement of voltage, current and two additional variables possible
- Automatic sensor box recognition
- Can be setup as table-top, console or demonstration unit (also in CPS/TPS experiment frames)

PLUG & PLAY

Automatic detection and setting of Sensor-CASSY and sensor boxes

COMPATIBLE

with all CASSY sensor boxes and sensors

Sensor-CASSY 2 (524 013) provides two electrically separated voltage inputs, an alternative current input and two sensor box inputs parallel to this. All inputs have variable measurement ranges.

PROFI-CASSY

INTERFACE FOR ALL AREAS OF ELECTRICAL ENGINEERING

- For connection to the USB port of a computer,
- Microcontroller-controlled with the CASSY-operating system (upgrades and expansions can be easily updated anytime via software)
- Variable set-up as table-top, console or demonstration device (also in CPS/TPS experiment frames)

More details about our products and equipment can be found at:

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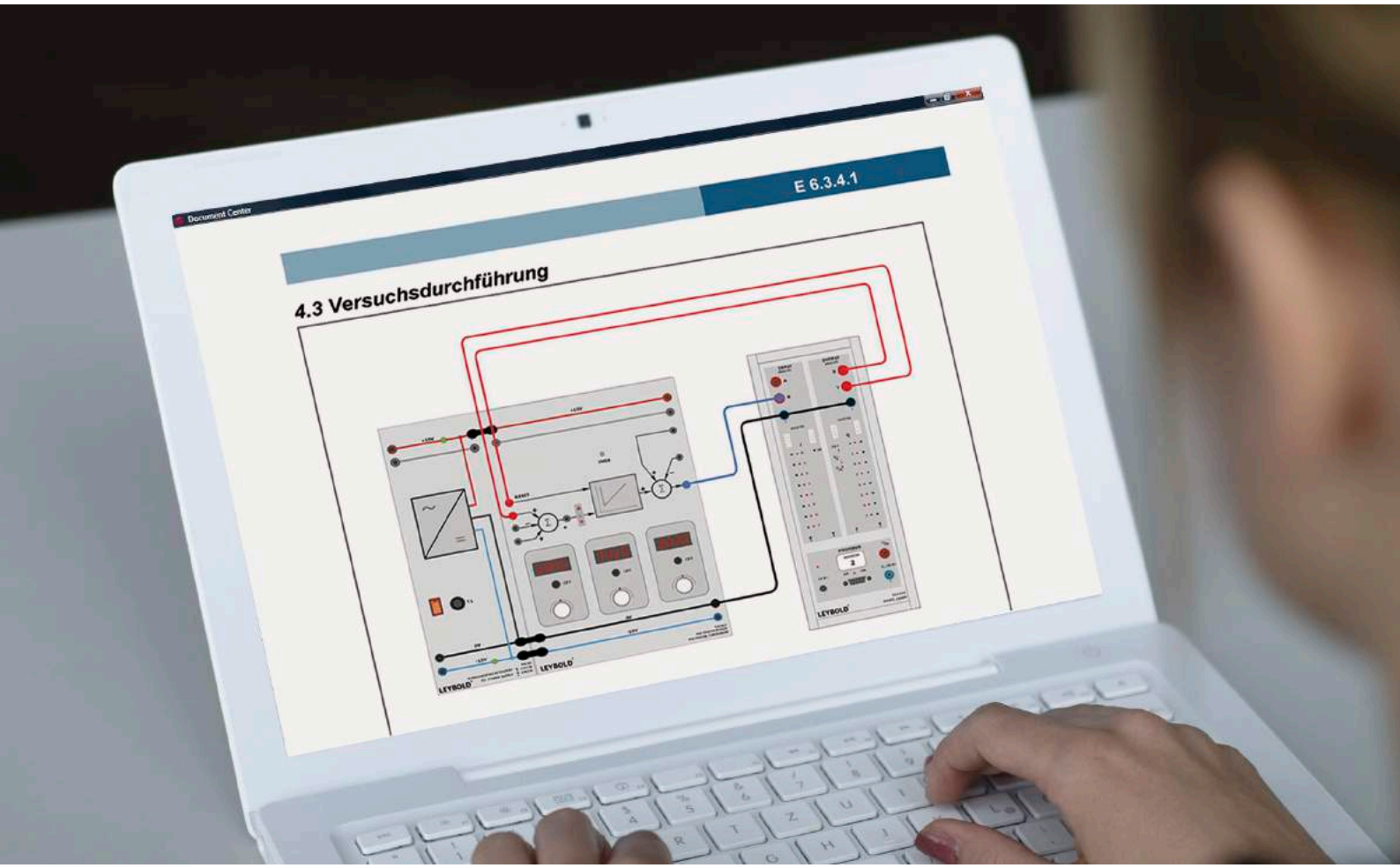
DOCUMENT CENTER



LEYBOLD'S ELECTRONIC LIBRARY

- Display and manage student experiment literature, demonstration experiment instructions or operating instructions in one program
- Automatically update all documents thanks to free online updates
- Benefit from convenient, fault-tolerant keyword and catalogue number search features

THE DAYS OF ENDLESS SEARCHING ARE OVER

The time consuming search for experiment instructions in folders is finally over. The free-of-charge Document Center saves you valuable class preparation time. With the Document Center you have digital access to all the technical documentation which we have placed at your disposal (partially with costs) in the form of extensive literature packets.

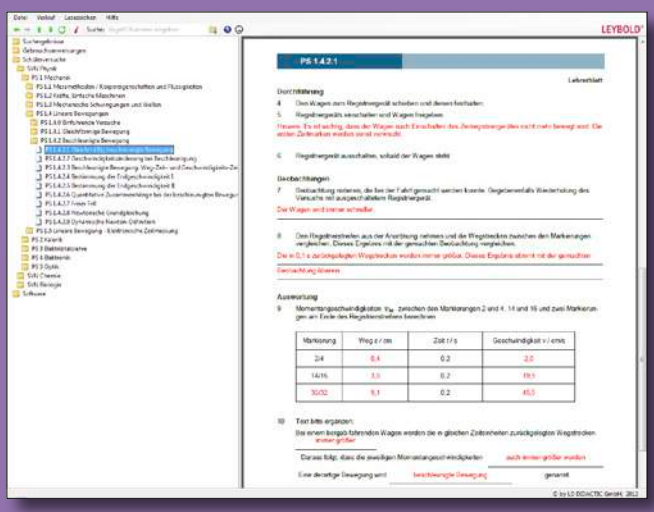
Once installed, you can set the documents to automatically update to the latest versions. The literature packets are clearly displayed in the form of a table of contents that also guides you intuitively to the desired document. The more literature packets you have installed, the more entries you will have in your table of contents.

Using the fault-tolerant search function you can quickly and easily find the correct document. Here again, the more literature packets installed, the more powerful the search function becomes.

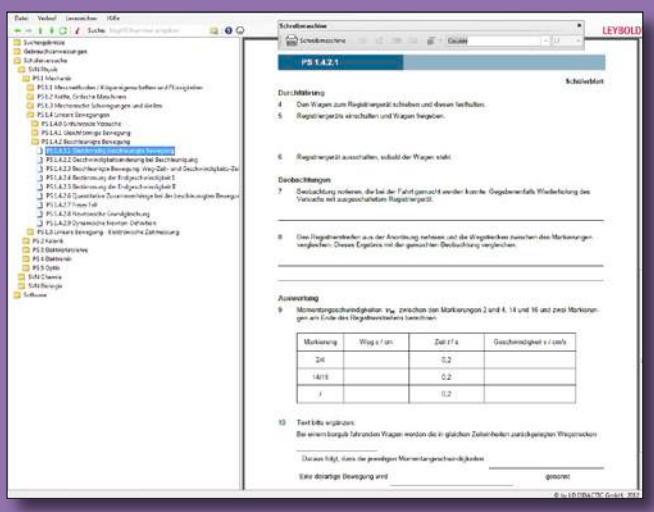
CONDUCT EXPERIMENTS INTERACTIVELY & LOG THE RESULTS DIGITALLY

Literature packets not only contain documents but also application data. Thus, for example, it is possible to take settings and examples from one of the experiment descriptions included in the literature packet and load this data into CASSY Lab 2 with a simple click of the mouse.

If student and teacher versions from a packet are installed, switching back and forth between versions is also as easy as a mouse click. Student documents can be filled out in the Document Center and logged findings saved or printed out as a hardcopy.



Teacher version



Student version

LEYBOLD BENEFITS

- established content
- practical experiments
- educational materials for presentation
- documentation with solutions
- flexible use in teaching
- time saving by complete set-up

E6.1 MEASUREMENT TECHNOLOGY & SENSORICS

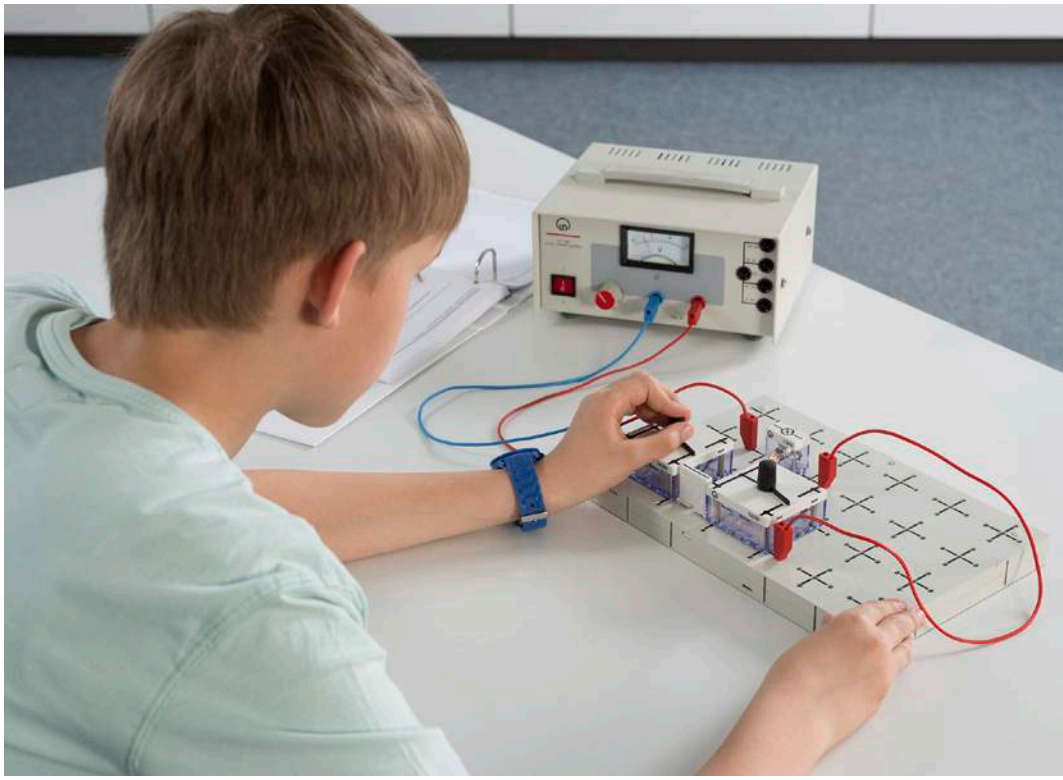
E6.1.1

MEASURING ELECTRICAL QUANTITIES

E6.1.1.1
DC Technology

E6.1.1.2
AC Technology

E6.1.1.3
Electronic Measurement Circuits



DC Technology (E6.1.1.1)

Cat. No.	Description	E6.1.1.1	E6.1.1.2	E6.1.1.3
727 512	Basic Set T 2.2, STE	1		
576 74	Plug-in board, DIN A4, STE	1	1	1
521 485	AC/DC power supply, 0...12 V/3 A	1	1	1
685 44ET4	Batteries, 1.5 V (AA), set of 4	1	1	
531 120	Multimeter LDanalog 20	2	2	
LDS 00001	Stopwatch, digital	1		
501 48	Bridging plugs, STE 2/19, set of 10	1	1	1
500 421	Connecting lead 19 A, 50 cm, red	3	3	
500 424	Connecting lead 19 A, 50 cm, black	3	3	
565 622	LIT: DC Circuits T 2.2 (English)	1*		
727 513	Basic Set T 2.3		1	
726 962	Function generator 200 kHz		1	1*
562 791	Plug-in power supply, 12 V AC		1	1*
575 214	Oscilloscope 30 MHz, two-channel, analogous		1	1
575 24	Screened cable, BNC/4 mm		1	1
726 19	Panel frame SL85, single-level		1	
727 531N	Basic set STE 6.1.1			1
727 649N	Supplementary Set T 6.1.11			1
531 2741	Digital multimeter 3315			1
501 532	Connecting leads, 19 A, set of 30			1
726 88	AC/DC stabilizer			1*
531 282	Multimeter Metrahit Pro			1*
531 57	Multimeter METRAport 3A			1*
727 510N	Complete equipment set DC/AC/EL			1*

Cat. No.	Description	E6.1.1.1	E6.1.1.2	E6.1.1.3
565 712	LIT: Discrete components and basic circuits in electronics T 6.1.1			1*
565 852	LIT: Electronic Measuring Device Circuits T 6.1.11			1*

* additionally recommended

DC Technology

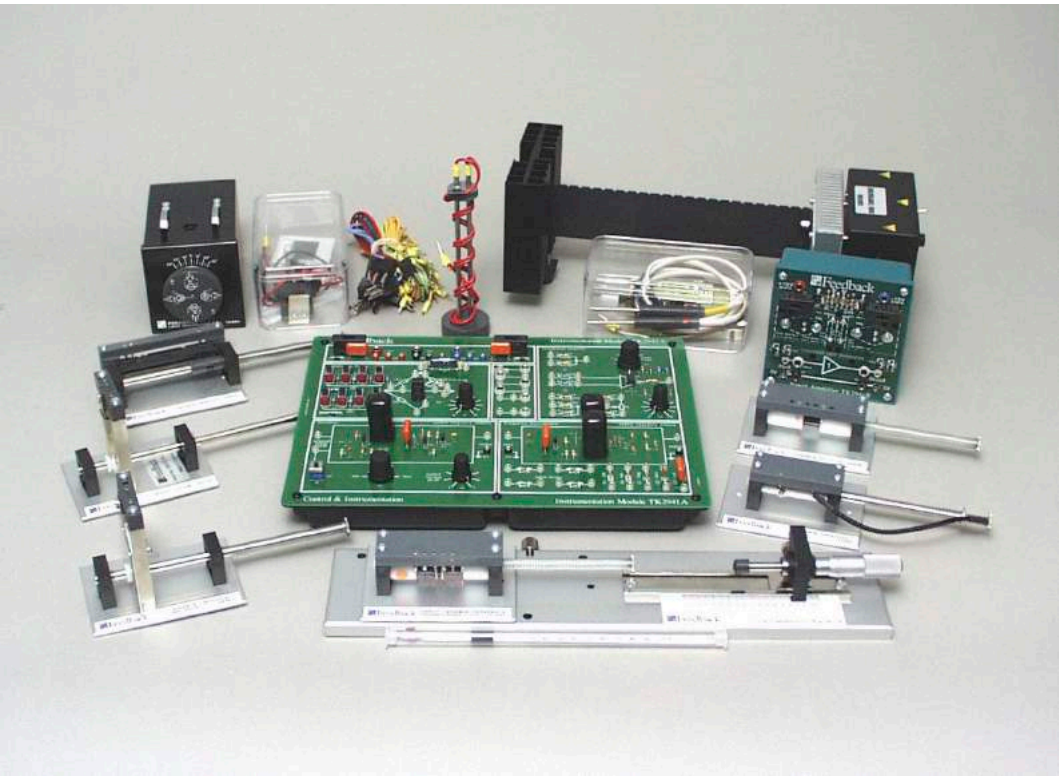
The topics covered range from the construction of simple circuits through to Kirchhoff's Circuit Laws and Ohm's Law as well as the measurement of characteristic curves of non-linear resistances. Also included are experiments for DC technology and the load characteristics of voltage sources.

AC Technology

The topics covered range from the production and graphing of AC current parameters through to measurement technology and how to use an oscilloscope. Measurements are taken from AC circuits with ohmic, capacitive, and inductive elements.

Electronic Measurement Circuits

Basic equipment for the design and measurement of electronic voltage measuring devices. Topics are the frequency-compensated input circuit with protective circuit, the high-impedance input amplifier, measuring amplifier for direct and alternating voltage as well as precision rectifiers.



E6.1.2

MEASURING NON-ELECTRICAL QUANTITIES

E6.1.2.1
Sensors & Transducers

Sensors & Transducers (E6.1.2.1)

Cat. No.	Description	E6.1.2.1
TK2 942-1	Complete Transducers Kit	1

Sensors & Transducers

Force and temperature are known examples of non-electrical quantities that need to be converted for further processing in automatic control systems. The components of this training system are based on real industrial sensors. The internal structure and the principle of operation of the sensors remain hidden from the user. The sensors are optimized for the specific application.

System

Many engineering applications and systems depend on accurate measurements and monitoring. Transducers are fundamental to the measurement process, consequently the study of different types of transducers, how they operate and how their output signals can be processed, is essential knowledge for engineers.

Features

The TK2942-001 Tranducers Kit introduces students to the concepts and understanding of common transducer devices and standard signal conditioning methods via 28 excellent practical assignments. It comprises the Measurements Package TK2941M, the Electro-mechanical Transducers Kit TK2941E, the Heat Transducers Kit TK2941H, the Light Transducers Kit TK2941L, the Power Supply 01-100 and includes all leads and accessories.

Topics

- Electro-mechanical transducers utilising variation in resistance
- Wheatstone bridge
- Amplifiers
- Liquid depth & resistivity
- Displacement
- Strain
- Electro-mechanical transducers
- Utilising variation in capacitance
- Variable area & distance
- Use of an oscillator & discriminator in FM systems
- Electro-mechanical transducers utilising variation in inductance
- Electromagnetic inductance
- Variable inductance transducer
- Mutual inductance transistor
- Linear variable differential transformer
- Transducer circuits
- Light transducers
- The nature of light
- Photoconductive cell
- Semiconductor photodiode
- Phototransistor
- Spectral response
- Heat transducers

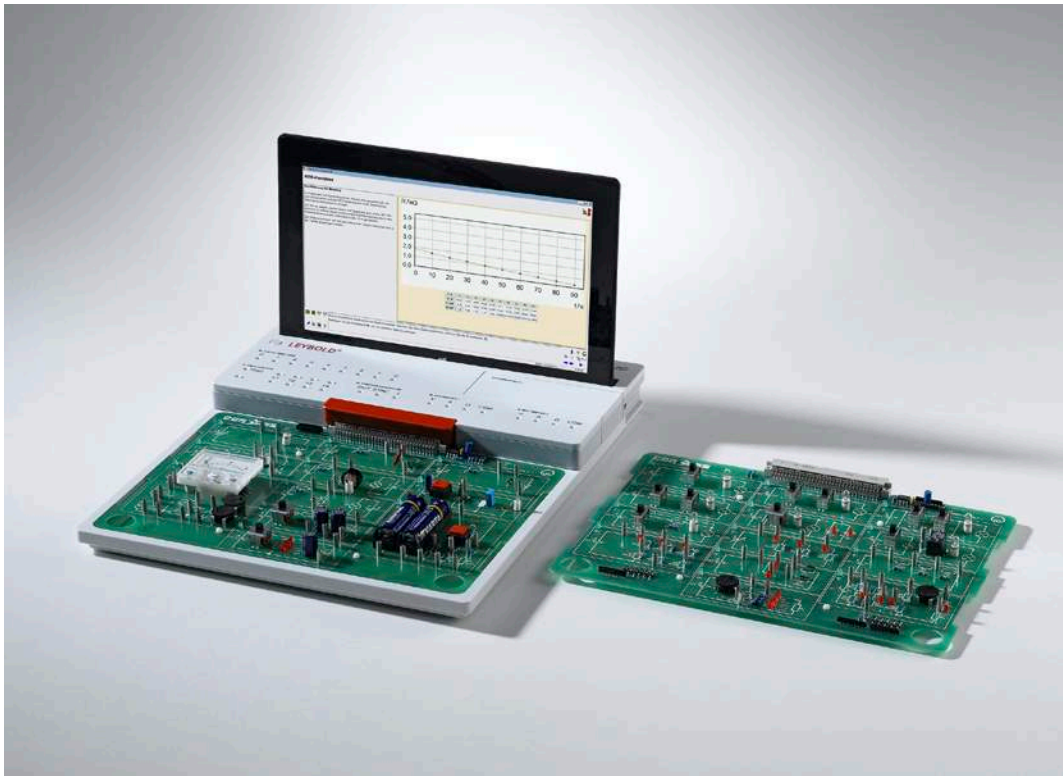
E6.1.3

COM3LAB MULTIMEDIA: MEASUREMENT TECHNOLOGY

E6.1.3.1
Basics of Electircal Engineering

E6.1.3.2
Operational amplifier

E6.1.3.3
Instrumentation &
Sensor Technology



Basics of Electircal Engineering (E6.1.3.1)

Cat. No.	Description	E6.1.3.1	E6.1.3.2	E6.1.3.3
700 1101	COM3LAB Course: DC Technology I	1		
700 1201	COM3LAB Course: DC Technology II	1		
700 1301	COM3LAB Course: AC Technology I	1		
700 1401	COM3LAB Course: AC Technology II	1		
700 1501	COM3LAB Course: Electronic Components I	1		
700 1601	COM3LAB Course: Electronic Components II	1		
700 9101	COM3LAB Course: Protoboard II	1		
700 9102	COM3LAB: Protoboard II Accessories	1		
700 020	COM3LAB: Master Unit	1	1	1
700 022	Set of Safety Cables (2 mm, 16 Qty., 6 x 30 cm & 10 x 15 cm)	1	1	1
688 129	Mains cable with hock-proof plug and cold connector	1	1	1
700 00CBT	DVD: COM3LAB Software	1	1	1
700 027	COM3LAB: Suitcase	1*	1*	1*
700 8101	COM3LAB Course: Operational Amplifier		1	
700 8401	COM3LAB Course: Sensor Technology			1
700 8402	COM3LAB: Sensor Technology Accessories			1
	additionally required: 1 PC with Windows 7/8/10			

* additionally recommended

Basics of Electrical Engineering

The COM3LAB courses introduce the fundamentals of electrical engineering. They familiarise students with the measurement of current and voltage in direct and alternating current circuits. It also trains students in how to use function generators, multimeters and oscilloscopes.

Operational amplifier

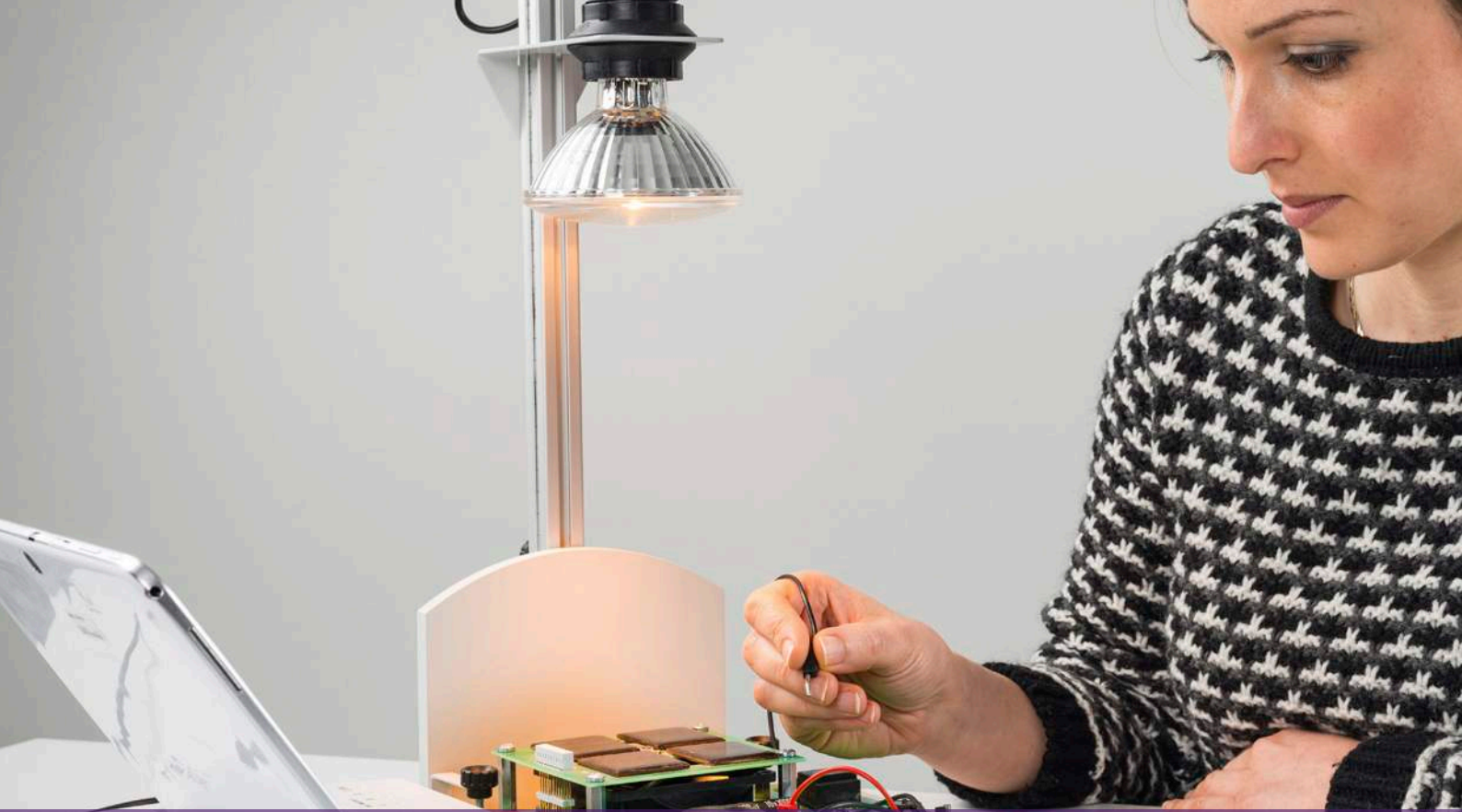
This course gives you insight into the world of the operational amplifier. From the standard circuit to the implementation of a function generator, all important topic areas are dealt with. This course forms the basis for the courses of control technology.

Instrumentation & Sensor Technology

The operational amplifier COM3LAB course gives participants an understanding of important basic electronic circuits such as amplifiers, filters, evaluation circuits, etc.

The sensor technology COM3LAB course builds upon this with emphasis on the measurement of non-electric variables. Graphics, animations and quizzes liven up the theory section. Real experiments and especially hands-on experience with real sensors and evaluation circuits are central to this multimedia set. The sensor technology course is very compact and despite the wealth of experiments is still very compact.

Experiments are operated and evaluated with COM3LAB CBT.



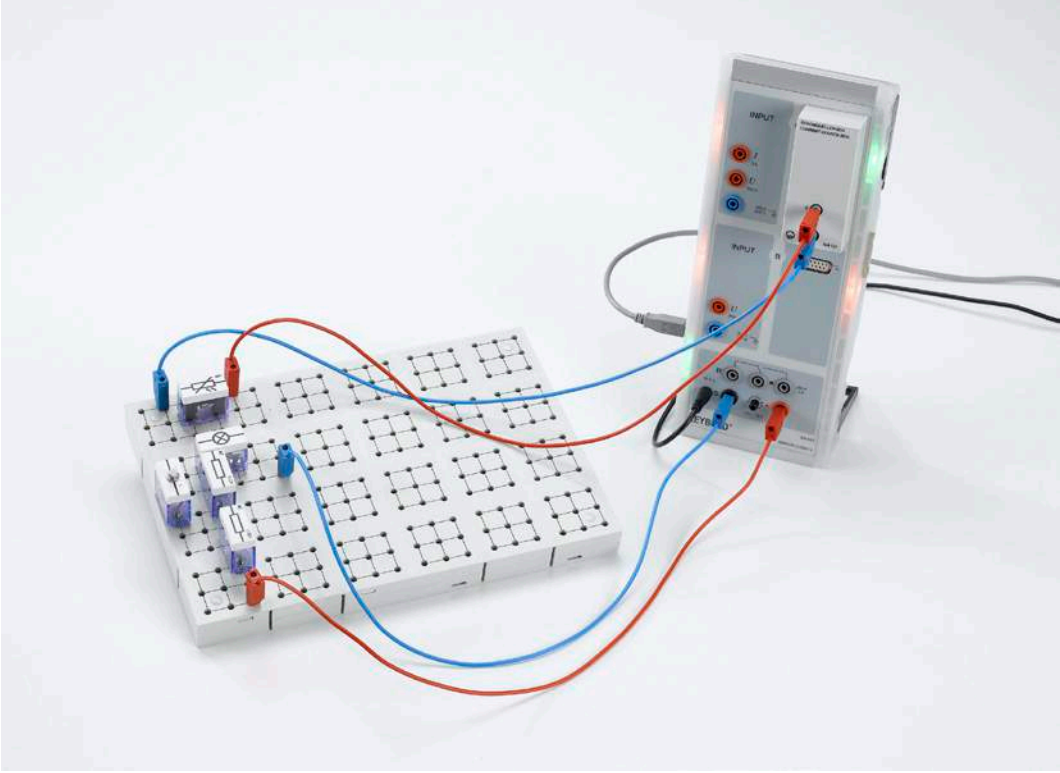
E6.2 DIDACTIC CONTROL TECHNOLOGY

E6.2.1

CONTROL TECHNOLOGY WITH CASSY

E6.2.1.1
Closed Loop Brightness Control

E6.2.1.2
Closed Loop Voltage Control



Closed Loop Brightness Control (E6.2.1.1)

Cat. No.	Description	E6.2.1.1	E6.2.1.2
576 74	Plug-in board, DIN A4, STE	1	1
579 05	Lamp holder, E10, lateral, STE 2/19	1	
505 10	Bulbs, 3.8 V/0.27 W, E10, set of 10	1	1
579 13	Toggle switch, STE 2/19	1	1
578 02	Photoresistor LDR 05, STE 2/19	1	
577 20	Resistor, 10 W, STE 2/19	1	
577 23	Resistor, 20 W, STE 2/19	1	
577 28	Resistor, 47 W, STE 2/19	1	
577 32	Resistor, 100 W, STE 2/19	1	
524 013	Sensor-CASSY 2	1	1
524 220	CASSY Lab 2	1	1
524 031	Current source box	1	
501 46	Connecting leads, 19 A, 100 cm, red/blue, pair	2	2
579 43	Motor and tachogenerator, STE 4/19/50		2
307 641ET5	PVC tubing, 6 mm diam., 5 m		1
579 06	Lamp holder, E10, top, STE 2/19		3
501 48	Bridging plugs, STE 2/19, set of 10		1
524 011USB	Power-CASSY USB		1
	additionally required: 1 PC with Windows 7/8/10		

Closed Loop Brightness Control

The aim of the experiments is the computer-aided realisation of closed control loops. With PID- and 2-Point controllers the power of an incandescent lamp is controlled, whose brightness is measured using a photo resistor.

Closed Loop Voltage Control

The aim of the experiments is the computer-aided realisation of closed control loops. PID- and 2-point controllers supervise a generator which supplies a constant voltage independently of the load.

Experiments are operated and evaluated with CASSY Lab 2.

Basics of Closed Loop Control Engineering (E6.2.2.1)

E6.2.2

COM3LAB MUTLIMEDIA: CONTROL TECHNOLOGY

E6.2.2.1
Basics of Closed Loop Control Engineering

E6.2.2.2
Advanced Closed Loop Control Engineering

Cat. No.	Description	E6.2.2.1	E6.2.2.2
700 8101	COM3LAB Course: Operational Amplifier	1	1
700 8201	COM3LAB Course: Control Technology I	1	1
700 8401	COM3LAB Course: Sensor Technology	1	1
700 8402	COM3LAB: Sensor Technology Accessories	1	1
700 020	COM3LAB: Master Unit	1	1
700 022	Set of Safety Cables (2 mm, 16 Qty., 6 x 30 cm & 10 x 15 cm)	1	1
688 129	Mains cable with hock-proof plug and cold connector	1	1
700 00CBT	DVD: COM3LAB Software	1	1
700 027	COM3LAB: Suitcase	1*	1*
700 83	COM3LAB Course: Control Technology II		1
700 3101	COM3LAB Course: Automation and Bus Technology		1
	additionally required: 1 PC with Windows 7/8/10		

* additionally recommended

Basics of Closed Loop Control Engineering

The Fundamentals of the Control Engineering multimedia training package has at its core the courses for sensor technology and Control Engineering I. This ensures that all aspects of classic Control Engineering are covered. The additional Operational Amplifier course explains the function of important basic electronic circuits. It gives learners an understanding of the control engineering of sensors, controllers, transformers, etc.

Objectives

- Behaviour of control circuit and open-path control
- Use of sequence and fixed value control
- Characteristics of analogue and digital controllers
- etc.

Advanced Closed Loop Control Engineering

The multimedia training package Advanced Control Engineering contains the package Fundamentals of Control Engineering as well as the courses Automation and Bus Technology and Control Engineering II.

Objectives

- Evaluation of the stability of control circuits
- Discussion of controller-related questions in the frequency range
- Integration of external control circuits
- etc.

Experiments are operated and evaluated with COM3LAB CBT.

E6.2.2

MUTLIMEDIA:
CONTROL TECHNOLOGY

E6.2.2.3
Control & Instrumentation
Principles

Control & Instrumentation Principles (E6.2.2.3)

Cat. No.	Description	E6.2.2.3
33- 033	Control & Instrumentation Principles	1
93- 420	ESPIAL Software Package	1
93- 400	ESPIAL Tools	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

System

This trainer allows the investigation of control system principles by using a servo mechanism comprising a d.c. motor, a variety of sensors and both analogue and digital controllers. Students are also introduced to the fundamentals of transducers and signal processing. The curriculum is divided into twenty four assignments ranging from basic control concepts to more advanced topics such as transfer function analysis.

Features

The product uses Espial software (supplied separately) in which each assignment comprises clear objectives, background, theory and experimentation. All required test instrumentation is provided within the software and includes a four-channel real-time data logger and bar-graph display, voltmeter, frequency counter and transfer function analyzer with Bode and Nyquist displays. The system comprises three items, the mechanical unit, electronic unit and a power supply. The mechanical unit is an open-board format containing a servo mechanism and support electronics. It contains a power amplifier driving a d.c. motor connected to a set of transducers and an adjustable eddy current brake. the digital encoders are of pen construction to allow visual inspection of their functionality. A dual-function LCD meter measures either voltages or rotation speed. The electronic unit comprises an open printed circuit board with front panel mimic. It contains analogue signal processing blocks, an embedded controller with USB interface, analogue to digital converters, PWM drive and the instrumentation data converters. A complete block diagram is on the front panel with access via 2 mm sockets to allow each practical to be configured rapidly and the instrumentation blocks connected. LEDs show the output signals from the digital encoders. A function generator block is provided with sine, square and triangle output signals.

E6.2.2

COM3LAB MUTLIMEDIA: CONTROL TECHNOLOGY

E6.2.2.4
Control of didactical systems

Control of didactical systems (E6.2.2.4)

Cat. No.	Description	E6.2.2.4
700 8201	COM3LAB Course: Control Technology I	1
700 83	COM3LAB Course: Control Technology II	1
700 020	COM3LAB: Master Unit	1
700 022	Set of Safety Cables (2 mm, 16 Qty., 6 x 30cm & 10 x 15 cm)	1
688 129	Mains cable with hock-proof plug and cold connector	1
700 00CBT	DVD: COM3LAB Software	1
500 851	Safety connecting leads, 32 A, set of 32	1
501 511	Set of 10 bridging plugs, black	1
568 222	LIT: Fundamentals of Automatic Control Technology II, Vol. 2	1
726 09	Panel frame T130, two-level	1
726 86	DC-Power Supply ± 15 V/3 A	1
734 111	Set of machines 10 W	1
734 121	Digital Temperature Controlled System	1
734 265	Digital Liquid Controlled System	1
	additionally required: 1 PC with Windows 7/8/10	

Liquid control system

In this project the liquid level measurement is used in order to maintain a preslecetable filling level height with a control loop. In the process, the filling level is controlled by the digital controller of the COM3LAB control technology. The system is very clear and shows the interplay of reference and actual value on closed control loops in didactic form. Filling level and flow can both be examined on one unit.

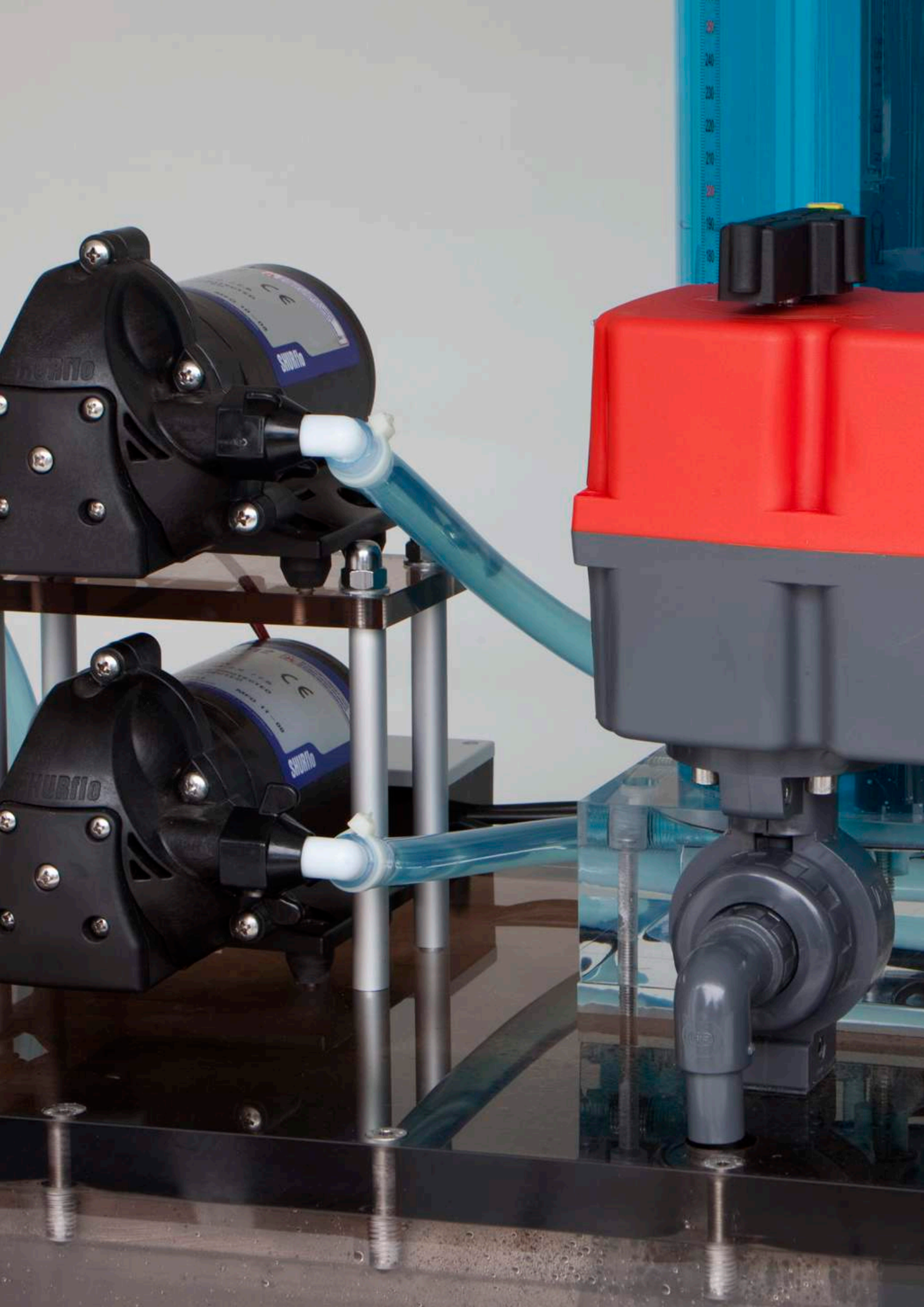
Temperature controlled system

The task is to control the precisely defined temperature profiles for the casting metal in its housing, in order to keep it constant. These temperature profiles are set by using the thermally quick temperature control system. The good control dynamics shorten the measuring time. The temperature control system can be actively cooled via the COM3LAB control technology and the control behavior can be analyzed using switchable disturbance variables.

Set of machines

With the course COM3LAB control technology, the output voltage of the generator is kept constant even when changing the load. The set of machines used here enables a multitude of experiments to be carried out. With the virtual laboratory of COM3LAB, the step response of the system can be recorded, the optimum control parameters identified or timeline diagrams of the controlled system recorded.

Experiments are operated and evaluated with COM3LAB CBT.



E6.3 APPLIED CONTROL TECHNOLOGY

E6.3.1 TECHNICAL CONTROLLED SYSTEMS
- E6.3.1.1 TEMPERATURE CONTROL
- E6.3.1.2 FLOW & LEVEL CONTROL
- E6.3.1.3 CONTROL OF AIRFLOW
- E6.3.1.4 BRIGHTNESS CONTROL
- E6.3.1.5 SPEED & VOLTAGE CONTROL
- E6.3.1.6 HEELING CONTROL

E6.3.2 SERVO CONTROL
- E6.3.2.1 DC SERVO
- E6.3.2.2 AC SERVO
- E6.3.2.3 STEPPER MOTOR

E6.3.3 PROCESS ENGINEERING
- E6.3.3.1 COMPACT TRAINER: PROCESS CLOSED LOOP CONTROL
- E6.3.3.2 CHEMICAL ENGINEERING: BLUE-BOTTLE PROCESS

E6.3.4 SYSTEMS & COMPONENTS OF CONTROL ENGINEERING
- E6.3.4.1 ELECTRONIC CONTROLLED SYSTEMS
- E6.3.4.2 DIGITAL CLOSED LOOP CONTROL
- E6.3.4.3 FUZZY CONTROL
- E6.3.4.4 FREQUENCY RESPONSE & CONTROLLER DESIGN
- E6.3.4.5 STABILITY & OPTIMISATION

E6.3.5 TECHNICAL PROCESSES WITH LARGE SCALE MODELS
- E6.3.5.9 BALL & PLATE
- E6.3.5.11 INVERTED PENDULUM
- E6.3.5.12 TWIN ROTOR MIMO SYSTEM
- E6.3.5.13 WORKSHOP: MODULAR SERVO SYSTEMS
- E6.3.5.14 MAGNETIC LEVITATION SYSTEM
- E6.3.5.15 PRECISION MODULAR CONTROL WORKSHOP

E6.3.1

TECHNICALLY CONTROLLED SYSTEMS

E6.3.1.1
Temperature Control

Temperature Control (E6.3.1.1)

Cat. No.	Description	E6.3.1.1
734 064N	PID digital controller Net	1
734 02	Reference variable generator	1
734 121	Digital Temperature Controlled System	1
734 011	Two position controller	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
726 86	DC-Power Supply ± 15 V/3 A	1
500 59	Safety bridging plugs, black, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1
500 641	Safety connecting lead, 100 cm, red	3
500 642	Safety connecting lead, 100 cm, blue	3
500 644	Safety connecting lead, 100 cm, black	3
726 10	Panel frame T150, two-level	1*
734 482	WinFACT COM3LAB / CASSY Edition	1*
775 680EN	LIT: E6.3.1.1 Temperature Control	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

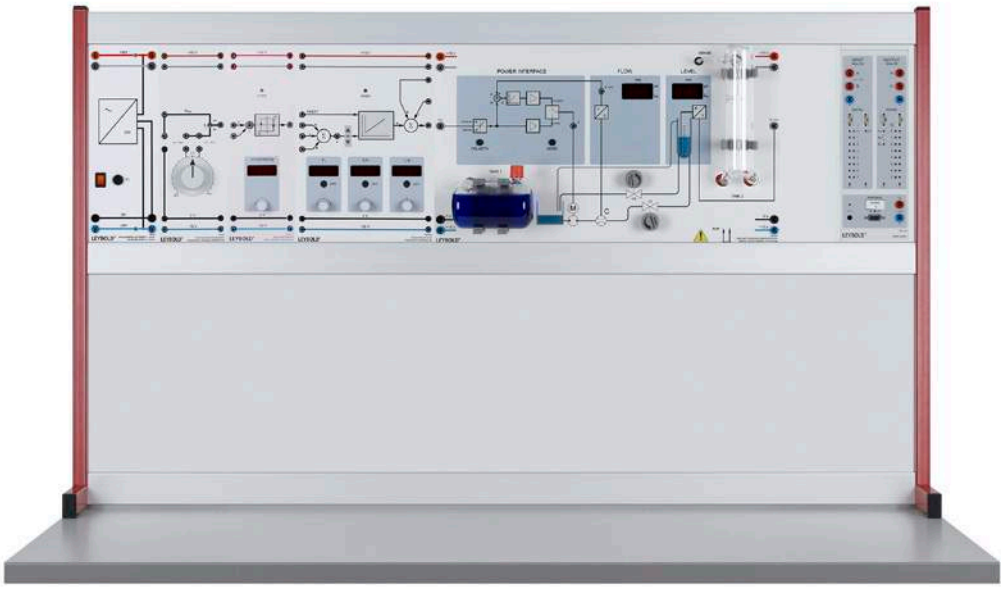
Temperature Control

Controlling the temperature of residential buildings, vehicles, or workpieces is a classic example of systems with large time constants. The temperature controlled system works with two-point controllers as well as with PID and software controllers. It has a 7-segment display for the current temperature. A halogen lamp serves as the heat source and also ensures visibility of the heating process. The temperature is measured with an NTC thermistor. A ventilator and closable cap are available in the heater duct for investigation of the disturbance behaviour. Two integrated power amplifiers (for heating and cooling) facilitate direct activation with the controller, control elements are not necessary. The temperature controlled system can also be operated with fuzzy controlling.

Topics

- Characteristic curve for the temperature controlling system
- Recording the jump response
- Optimal amount, replacement controlled system
- Technical controller
- Controller in the limit range
- Empirical tuning of controllers
- etc.

Experiments are operated and evaluated with CASSY Lab 2 and WinFACT.



Flow & Level Control (E6.3.1.2)

E6.3.1

TECHNICALLY CONTROLLED SYSTEMS

E6.3.1.2
Flow & Level Control

Cat. No.	Description	E6.3.1.2
734 011	Two position controller	1
734 02	Reference variable generator	1
734 064N	PID digital controller Net	1
734 265	Digital Liquid Controlled System	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
726 86	DC-Power Supply ± 15 V/3 A	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
500 641	Safety connecting lead, 100 cm, red	3
500 642	Safety connecting lead, 100 cm, blue	3
500 644	Safety connecting lead, 100 cm, black	3
726 10	Panel frame T150, two-level	1*
734 482	WinFACT COM3LAB / CASSY Edition	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Flow & Level Control

The liquid control system is comprised mainly of a pump as well as holding and measuring tanks. The inflow and outflow of liquids can be manipulated using two valves. The device contains an impeller wheel flowmeter with subordinate flow controller. An immersion pipe with pressure sensor records the fill level in the measuring tank and converts it into an electric signal for the fill level. The measured variables for flow rate and fill level are displayed on 7-segment displays. The digital liquid control system is characterized by a very compact build. It is delivered complete with all sensors and operation equipment and needs very few accessories.

Topics

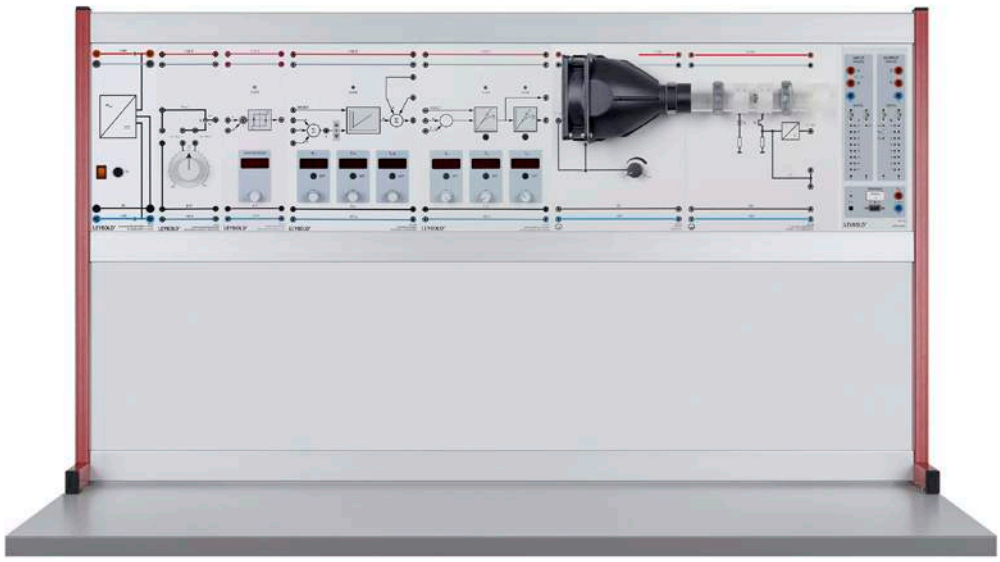
- Control design through pole-zero compensation
- Determination of the controller gain Kp from a batch run
- Control unit design through numerical optimization
- Rule of thumb method
- Digital liquid controlled system
- Flow measurement
- etc.

Experiments are operated and evaluated with CASSY Lab 2 and WinFACT.

E6.3.1

TECHNICALLY CONTROLLED SYSTEMS

E6.3.1.3
Control of Airflow



Control of Airflow (E6.3.1.3)

Cat. No.	Description	E6.3.1.3
734 02	Reference variable generator	1
734 011	Two position controller	1
734 064N	PID digital controller Net	1
734 091	Digital Controlled System	1
666 630	Blower	1
666 632	Windmill type anemometer	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
726 86	DC-Power Supply ± 15 V/3 A	1
500 59	Safety bridging plugs, black, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1
500 641	Safety connecting lead, 100 cm, red	3
500 642	Safety connecting lead, 100 cm, blue	3
500 644	Safety connecting lead, 100 cm, black	2
726 10	Panel frame T150, two-level	1*
734 482	WinFACT COM3LAB / CASSY Edition	1*
734 492	WinFACT LD Licence	1*
775 682EN	LIT: E6.3.1.3 Control of airflow	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Control of Airflow

The airflow system is comprised of a sensor for measuring the flow and a controllable wind generator. The wind generator is directly activated, with a PID controller for example. An external power amplifier is not necessary for this. The airflow in the measuring tube is measured with a vane wheel anemometer. The cap on the air tube acts upon the controlled system as an external disturbance variable.

Topics

- Measuring airflow
- Step responses of the controlled system
- Evaluation of the step response with adjusting function
- Determination of the system parameters of a PT2 component
- Computer-based system identification
- Empirical optimisation for the airflow system
- etc.

Experiments are operated and evaluated with CASSY Lab 2 and WinFACT.

Brightness Control (E6.3.1.4)

E6.3.1

TECHNICALLY CONTROLLED SYSTEMS

E6.3.1.4
Brightness Control

Cat. No.	Description	E6.3.1.4
734 02	Reference variable generator	1
734 064N	PID digital controller Net	1
734 311	Light controlled system	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
726 86	DC-Power Supply ± 15 V/3 A	1
500 59	Safety bridging plugs, black, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1
500 641	Safety connecting lead, 100 cm, red	3
500 642	Safety connecting lead, 100 cm, blue	1
500 644	Safety connecting lead, 100 cm, black	1
726 10	Panel frame T150, two-level	1*
734 482	WinFACT COM3LAB / CASSY Edition	1*
775 683EN	LIT: E6.3.1.4 Brightness Control	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Brightness Control

Light control systems contain light sources for usable and disturbance light as well as a photo sensor. The LED light sources are activated directly with the controller. An external control element (power amplifier) is not necessary. The diffusing screen spatially influences the controlled system as an external disturbance variable. Influenced by the relatively high limit frequencies of the opto semiconductors, the light control system has a time response similar to a fast PT1 system. The resulting system order is n = 1; there is only one main energy store. Light control is required for rooms where light is critical to safety, such as in sports arenas or hospitals. One biological example would be the ability of the eye to adapt to different levels of brightness (pupils).

Topics

- Characteristic curve for the temperature controlling system
- Recording the jump response
- Optimal amount, replacement controlled system
- Technical controller
- Controller in the limit range
- Empirical tuning of controllers
- etc.

Experiments are operated and evaluated with CASSY Lab 2 and WinFACT.

E6.3.1

TECHNICALLY CONTROLLED SYSTEMS

E6.3.1.5
Speed & Voltage Control

Speed & Voltage Control (E6.3.1.5)

Cat. No.	Description	E6.3.1.5
734 02	Reference variable generator	1
734 064N	PID digital controller Net	1
734 111	Set of machines 10 W	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
726 86	DC-Power Supply ± 15 V/3 A	1
500 59	Safety bridging plugs, black, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1
500 641	Safety connecting lead, 100 cm, red	3
500 642	Safety connecting lead, 100 cm, blue	3
500 644	Safety connecting lead, 100 cm, black	2
726 10	Panel frame T150, two-level	1*
734 482	WinFACT COM3LAB / CASSY Edition	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

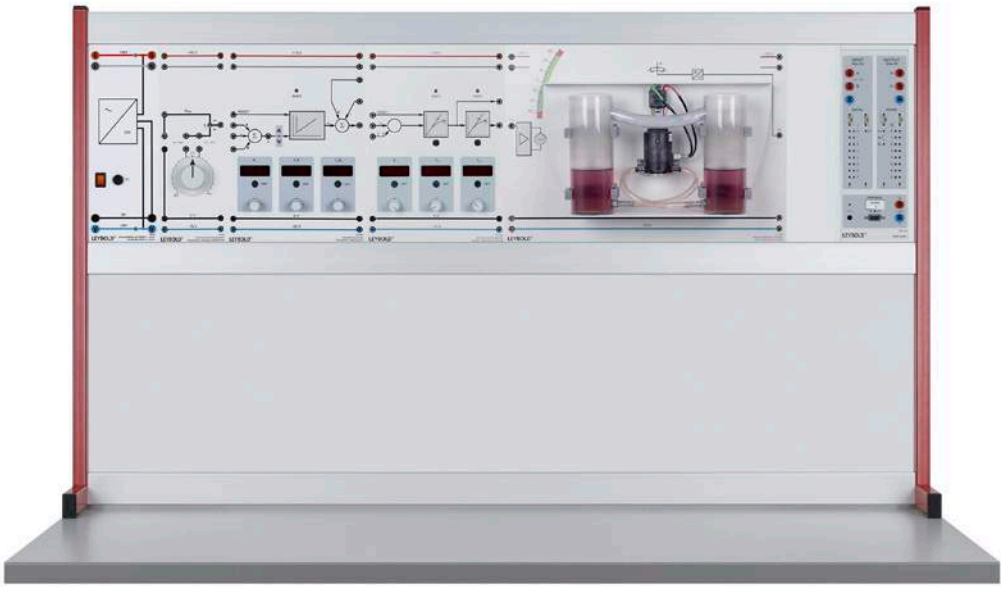
Speed & Voltage Control

The 10 W machine set has two direct current machines with permanent excitation and an electronically controllable load. The machines are mechanically connected to each other by way of their shafts and come together to form a motor-generator unit. Load characteristic lines are recorded and disturbance interferences in speed and voltage control are investigated with the electronically controllable load. The drive engine and load are driven directly by the upstream controller. An external control element is not necessary for this. A switchable prefiltergives the 10 W machine set the dynamic behaviour of a larger machine set.

Topics

- Characteristic curve for the temperature controlling system
- Recording the jump response
- Optimal amount, replacement controlled system
- Technical controller
- Controller in the limit range
- Empirical tuning of controllers
- etc.

Experiments are operated and evaluated with CASSY Lab 2 and WinFACT.



Heeling Control (E6.3.1.6)

E6.3.1

TECHNICALLY CONTROLLED SYSTEMS

E6.3.1.6
Heeling Control

Cat. No.	Description	E6.3.1.6
510 48	Magnets, 35 mm Ø, pair	1
734 02	Reference variable generator	1
734 064N	PID digital controller Net	1
734 091	Digital Controlled System	1
734 300	Heel Controlled System	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1*
726 86	DC-Power Supply ± 15 V/3 A	1*
500 59	Safety bridging plugs, black, set of 10	1*
500 592	Safety bridging plugs with tap, black, set of 10	1*
500 641	Safety connecting lead, 100 cm, red	3*
500 642	Safety connecting lead, 100 cm, blue	3*
500 644	Safety connecting lead, 100 cm, black	3*
309 42	Colouring, red, 10 g	1
726 10	Panel frame T150, two-level	1*
775 690EN	LIT: E6.3.1.6 Heeling control	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Heeling Control

Heeling is the rolling movement of a ship on a swell or during loading. Heeling is especially noticeable when freight trains are driven onto ferries. For rail vehicles, the railway leading onto the ferry should be free of breaks in the rails where the ferry and pier meet. Controlling problems of this nature - involving position stabilisation - can be investigated with the heeling control model. The system can be equally well operated with the PID digital controller (734 064) or a software controller on a WinFACt basis. Position controlling using ballast tanks is also important for aircraft.

Topics

- Characteristic curve for the temperature controlling system
- Recording the jump response
- Optimal amount, replacement controlled system
- Technical controller
- Controller in the limit range
- Empirical tuning of controllers
- etc.

Experiments are operated and evaluated with CASSY Lab 2 and WinFACT.

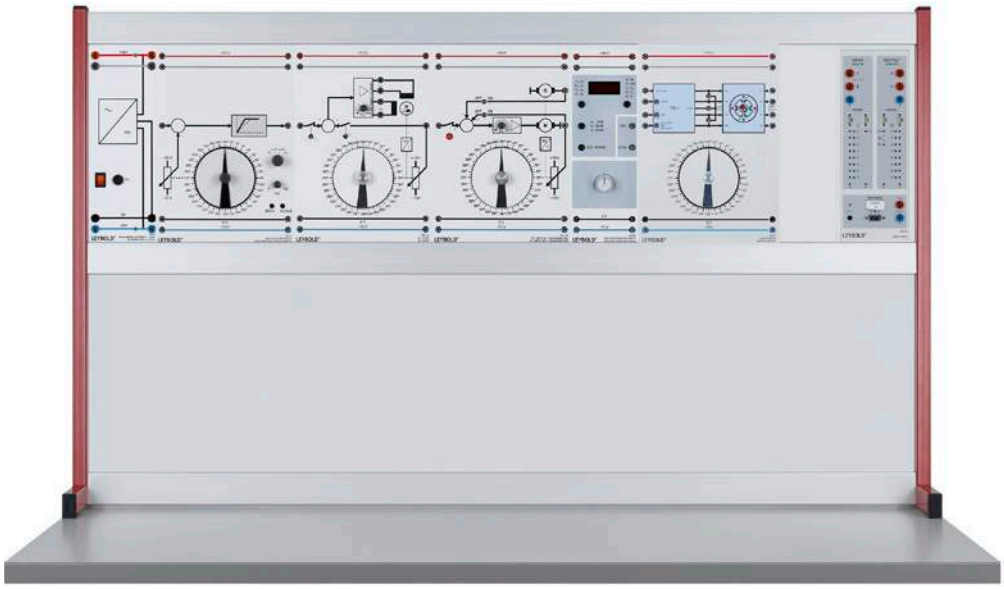
E6.3.2

SERVO CONTROL

E6.3.2.1
DC Servo

E6.3.2.2
AC Servo

E6.3.2.3
Stepper Motor



DC Servo (E6.3.2.1)

Cat. No.	Description	E6.3.2.1	E6.3.2.2	E6.3.2.3
734 10	Servo setpoint generator	1	1	
734 44	DC servo with tachogenerator	1		
734 36	Mass Disc with Hook	1		
524 016S2	Profi-CASSY Starter 2	1		1*
726 09	Panel frame T130, two-level	1	1	1
726 86	DC-Power Supply ± 15 V/3 A	1	1	1
500 59	Safety bridging plugs, black, set of 10	1	1	1
500 641	Safety connecting lead, 100 cm, red	1		1
500 642	Safety connecting lead, 100 cm, blue	1		
500 644	Safety connecting lead, 100 cm, black	2		1
775 325EN	LIT: E2.6.1.2 DC Servo	1*		
734 482	WinFACT COM3LAB / CASSY Edition	1*	1*	
726 10	Panel frame T150, two-level	1*	1*	
734 02	Reference variable generator		1	
734 45	AC servo		1	
524 013S	Sensor-CASSY 2 Starter		1	
500 851	Safety connecting leads, 32 A, set of 32		1	
775 330EN	LIT: E2.6.1.3 AC Servo		1*	
728 55	Stepper motor			1
726 962	Function generator 200 kHz			1
531 57	Multimeter METRAport 3A			1
	additionally required: 1 PC with Windows 7/8/10			

* additionally recommended

DC Servo

The equipment set incorporates student experiments which can be carried out in a laboratory safely using safety extra-low voltage. Experiment instructions are contained in a manual in either printed or digital form.

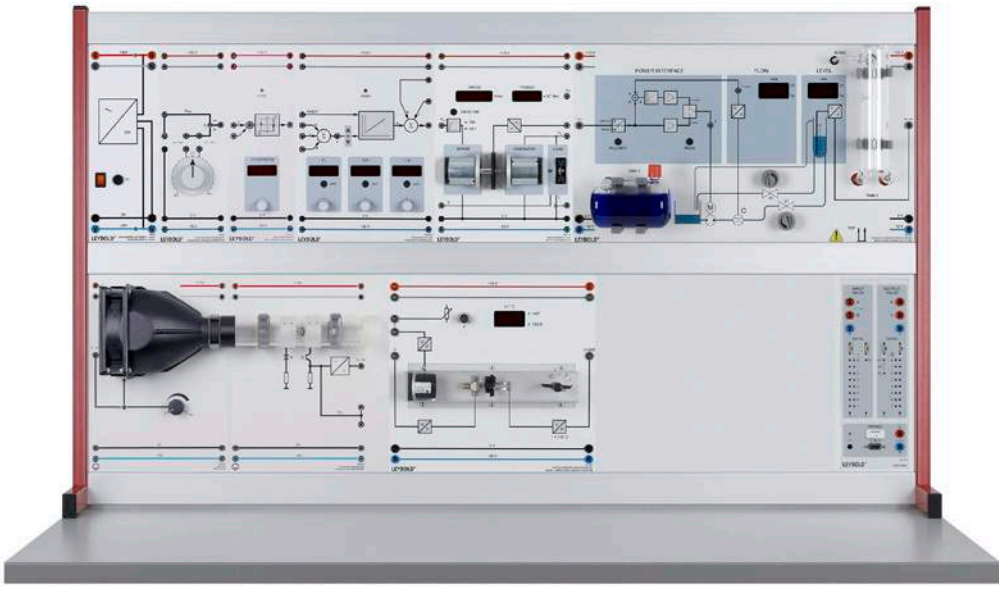
AC Servo

The equipment set incorporates student experiments which can be carried out in a laboratory safely using safety extra-low voltage. Experiment instructions are contained in a manual in either printed or digital form.

Stepper Motor

Stepper motors are a special variety of synchronous motor with a large number of pole pairs. The rotor follows the stator field in steps, the size of which is determined by the number of poles. With normal loading, the angular position of the rotor can be determined precisely. If overloaded, however, step losses arise and information about the current position of the rotor is lost. Stepper motors can be wired to operate in both half-step and full-step modes. Due to their discontinuous operation, stepper motors are the ideal drive systems for digital servo systems.

Experiments are operated and evaluated with CASSY Lab 2 and WinFACT.



Compact Trainer: Process Closed Loop Control (E6.3.3.1)

E6.3.3

PROCESS ENGINEERING

E6.3.3.1
Compact Trainer:
Process Closed Loop Control

Cat. No.	Description	E6.3.3.1
734 064N	PID digital controller Net	1
734 02	Reference variable generator	1
734 121	Digital Temperature Controlled System	1
734 265	Digital Liquid Controlled System	1
734 111	Set of machines 10 W	1
666 630	Blower	1
666 632	Windmill type anemometer	1
734 011	Two position controller	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
726 86	DC-Power Supply ± 15 V/3 A	1
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	1
500 641	Safety connecting lead, 100 cm, red	3
500 642	Safety connecting lead, 100 cm, blue	3
500 644	Safety connecting lead, 100 cm, black	3
726 10	Panel frame T150, two-level	1*
734 482	WinFACT COM3LAB / CASSY Edition	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Process Closed Loop Control

Large, intricate processes are often broken down into sub-processes in the interest of clarity. This facilitates the step-by-step commissioning of production facilities and efficient error resolution when a breakdown occurs. The setup is comprised of various different sub-processes.

Each controlled system on its own is perfect for the execution of numerous experiments. At the same time the module experiment design featuring experiment plates allows for easy combination of sub-processes. If you integrate additional electronic transfer components (from E 6.3.4), then additional dead time and time constants arise that influence the entire process.

Following equipments could be connected:

- Temperature regulations
- Fill level control
- Flow controlling
- Current control
- Speed control

Experiments are operated and evaluated with CASSY Lab 2 and WinFACT.

E6.3.3

PROCESS ENGINEERING

E6.3.3.2
Blue-Bottle Control

Blue-Bottle Control (E6.3.3.2)

Cat. No.	Description	E6.3.3.2
524 013	Sensor-CASSY 2	1
524 220	CASSY Lab 2	1
524 069	Immersion photometer S	1
666 425	Panel frame C50, two-level, for CPS	1
666 438	Woulff's bottle with manometer, CPS	1
667 3095	Screw cap, GL 45, with hole	1
667 3107	Silicone seal GL 45/26, 10 pcs	1
666 482	Aeration pump, controllable, CPS	1
501 44	Connecting leads, 19 A, 25 cm, red/blue, pair	1
667 7977	Electronic Balance 440-3N, 200 g : 0.01 g	1
664 157	Watch glass dish, 125 mm diam.	2
666 966	Spoon-ended spatula, PP, 180 mm	2
666 003	Pipetting ball (Peleus ball)	1
665 996	Graduated pipette, 5 ml	1
665 756	Measuring cylinder, 500 ml, with plastic base	1
604 501	PVC tubing, 7 mm diam., 1 m	1
604 460	Hose clamp, 8...12 mm	1
602 347	Laboratory bottle, 500 ml, GL 45 thread	1
673 2920	Methylene blue solution, 100 ml	1
673 6800	Sodium hydroxide, pellets, 100 g	1
672 1100	D(+)-Glucose, 100 g	1
675 3400	Water, pure, 1 l	1
	additionally required: 1 PC with Windows 7/8/10	

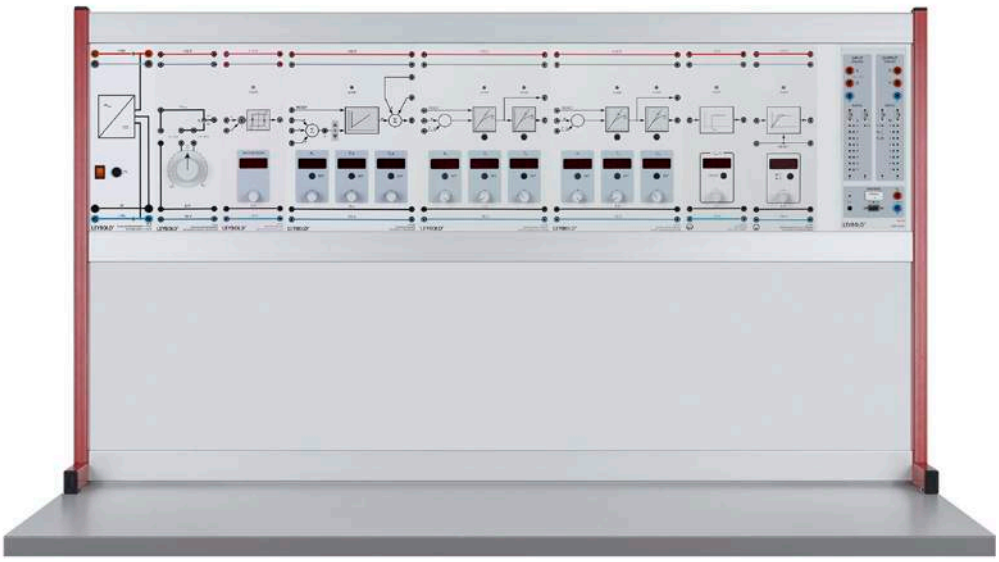
Blue-Bottle Control

The blue bottle experiment is a model experiment for a organic redox system. The redox indicator methylene blue is reduced by glucose to its colourless form which is then oxidised by air to form again the coloured version. The air is led into solution by a pump. Additional glucose in solution will then reduce it to its colourless form. The process is reversible. In this experiment a automated version with a two-point control system is used.

Topics

- To learn about organic redox reactions and redox indicator methylene blue
- To perform the blue bottle experiment in a new, automated version
- To set up and use a two-point control system
- To perform photometry using an immersion photometer
- To use carbohydrates such as glucose as a reducing age

Experiments are operated and evaluated with CASSY Lab 2.



Electronic Controlled Systems (E6.3.4.1)

E6.3.4

SYSTEMS & COMPONENTS OF CONTROL ENGINEERING

E6.3.4.1
Electronic Controlled Systems

E6.3.4.2
Digital Closed Loop Control

Cat. No.	Description	E6.3.4.1	E6.3.4.2
734 02	Reference variable generator	1	1
734 011	Two position controller	1	
734 064N	PID digital controller Net	1	1
734 091	Digital Controlled System	2	2
734 0891	Dead time element	1	
734 0951	2nd Order transfer element	1	
524 016S2	Profi-CASSY Starter 2	1	1
726 09	Panel frame T130, two-level	1	1
726 86	DC-Power Supply ± 15 V/3 A	1	1
500 59	Safety bridging plugs, black, set of 10	1	3
500 592	Safety bridging plugs with tap, black, set of 10	1	1
500 641	Safety connecting lead, 100 cm, red	3	3
500 642	Safety connecting lead, 100 cm, blue	3	3
500 644	Safety connecting lead, 100 cm, black	3	3
564 19EN	LIT: E6.3.4.1 Control of Electronic Lines	1*	
734 482	WinFACT COM3LAB / CASSY Edition	1*	1*
734 41	Sample and Hold Element		1
726 10	Panel frame T150, two-level		1*
734 492	WinFACT LD Licence		1*
775 700EN	LIT: E6.3.4.2 Digital Control		1*
	additionally required: 1 PC with Windows 7/8/10		

* additionally recommended

Electronic Controlled Systems

The setup facilitates experiments on a wide variety of levels: ranging from the basics to university-level learning. It investigates the transfer components in the time range and the behaviour of the controlled systems formed by them. Digital adjusters for controller parameters and system time constants facilitate simple, intuitive operation of devices with higher precision. This allows for fast, reproducible, and targeted experimentation. Continuous and discontinuous controller designs are available to choose from. The Profi-CASSY interface is ideally equipped to support the use of graphic analysis methods (e.g. using the tangent method) and facilitates experiments with modern interface controllers and computer-aided control technology. For more in-depth experimentation and for simulations, it is recommended that you also use the WinFACT software.

Topics

- Setpoint and disturbance behaviour
- Recording and analysing step responses
- Output parameters of an open-path control
- Time response of transfer components
- Second order transfer component
- Behaviour of the dead-time component
- etc.

Experiments are operated and evaluated with CASSY Lab 2 and WinFACT.

E6.3.4

SYSTEMS & COMPONENTS OF CONTROL ENGINEERING

E6.3.4.3
Fuzzy Control

E6.3.4.4
Frequency Response & Controller Design

E6.3.4.5
Stability & Optimisation

Fuzzy Control (E6.3.4.3)

Cat. No.	Description	E6.3.4.3	E6.3.4.4	E6.3.4.5
734 091	Digital Controlled System	1	2	2
734 121	Digital Temperature Controlled System	1		
734 111	Set of machines 10 W	1		
734 300	Heel Controlled System	1		
524 016S2	Profi-CASSY Starter 2	1	1	1
726 09	Panel frame T130, two-level	1	1	1
726 86	DC-Power Supply ± 15 V/3 A	1	1	1
500 59	Safety bridging plugs, black, set of 10	1	1	1
500 592	Safety bridging plugs with tap, black, set of 10	1	1	1
500 641	Safety connecting lead, 100 cm, red	2	2	2
500 642	Safety connecting lead, 100 cm, blue	2	2	2
500 644	Safety connecting lead, 100 cm, black	2	2	2
510 48	Magnets, 35 mm Ø, pair	1		
726 10	Panel frame T150, two-level	1*	1*	1*
775 692EN	LIT: E6.3.4.3 Fuzzy-Control	1*		
734 492	WinFACT LD Licence	1*	1*	1*
734 265	Digital Liquid Controlled System	1*		
666 630	Blower	1*		
666 632	Windmill type anemometer	1*		
734 064N	PID digital controller Net		1	1
734 0891	Dead time element		1	1
734 0951	2nd Order transfer element		1	1
500 612	Safety connecting lead, 25 cm, blue		1	
775 720EN	LIT: E6.3.4.4 Frequency Response of Linear Systems & Controller Design in the Frequency Domain		1*	
775 730EN	LIT: E6.3.4.5 Stability & Optimisation			1*

Cat. No.	Description	E6.3.4.3	E6.3.4.4	E6.3.4.5
	additionally required: 1 PC with Windows 7/8/10			

* additionally recommended

Fuzzy Control

Fuzzy logic is a technology for controlling and regulating technical systems without mathematical modelling. With fuzzy logic, control strategies are simply defined with colloquial elements. To formulate the control-related problems in the form of linguistic (= language) rules, physical input variables (e.g. Temperature) are fuzzified, meaning converted from a crisp to a fuzzy value using a membership function.

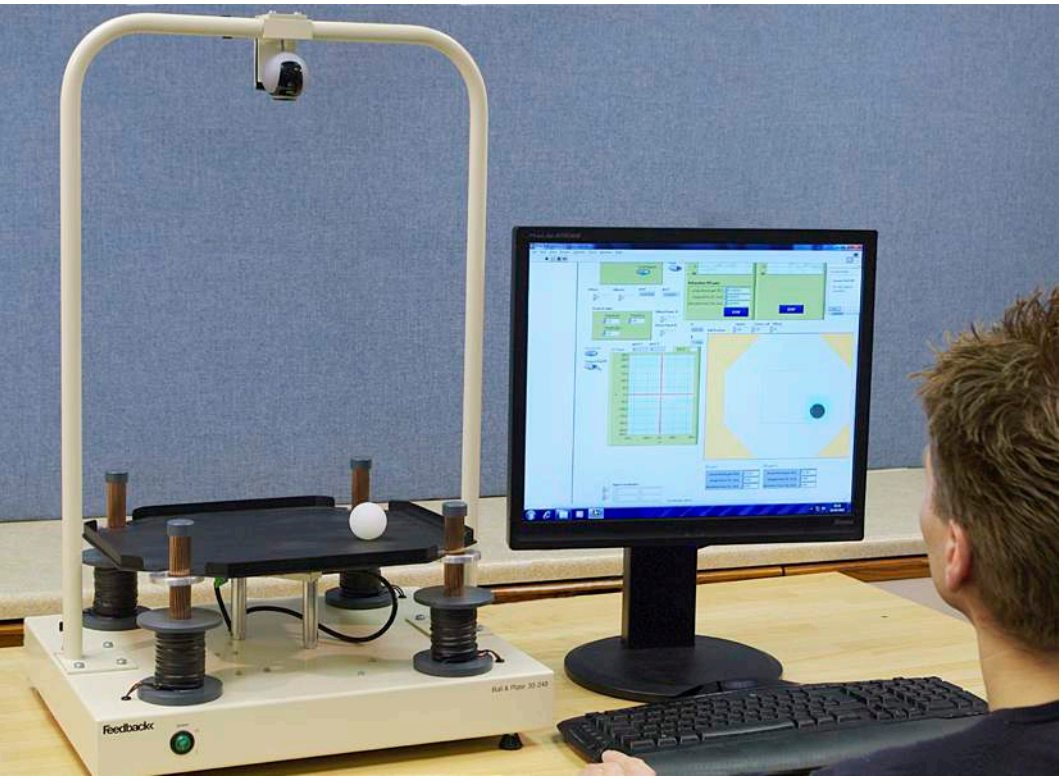
Frequency Response & Controller Design

The frequency response of a system is usually illustrated graphically, for which there are two different graphing methods called the Bode plot and the Nyquist plot. With this setup, frequency responses of real transfer components are measured and recorded. For a PT3 controlled system, a PI controller is designed in accordance with the compensation method. In the Bode diagram, the stability of the closed control circuit is determined from the phase margin of the open circuit.

Stability & Optimisation

Investigating stability and optimising controlled systems are two of the most important tasks related to control engineering. The result decides the usability of the controller for the intended purpose.

Experiments are operated and evaluated with CASSY Lab 2 and WinFACT.



Ball & Plate (E6.3.5.9)

E6.3.5

TECHNICAL PROCESSES WITH LARGE SCALE MODELS

E6.3.5.9
Ball & Plate

Cat. No.	Description	E6.3.5.9
33-052	Ball & Plate Control System	1
	additionally required: 1 PC with Windows 7/8/10	

Ball & Plate

The Ball and Plate Control System is controlled by (National Instruments NI) LabVIEW using a NI interface card and demonstrates a classic control problem of balancing a sphere on a flat surface and maintaining its position. It can then be programmed to make the ball describe a circular or any other shaped path around the plate. The unique electromagnetic table actuation enables the study of this unstable system in real-time using sophisticated controllers in NI LabVIEW. The progressive nature of the student exercises enables the study of the problem from first principles to more advanced control concepts. The product provides a useful insight into control engineering at all levels of undergraduate study and enables advanced users to model and control the Ball and Plate using their own strategy.

Topics

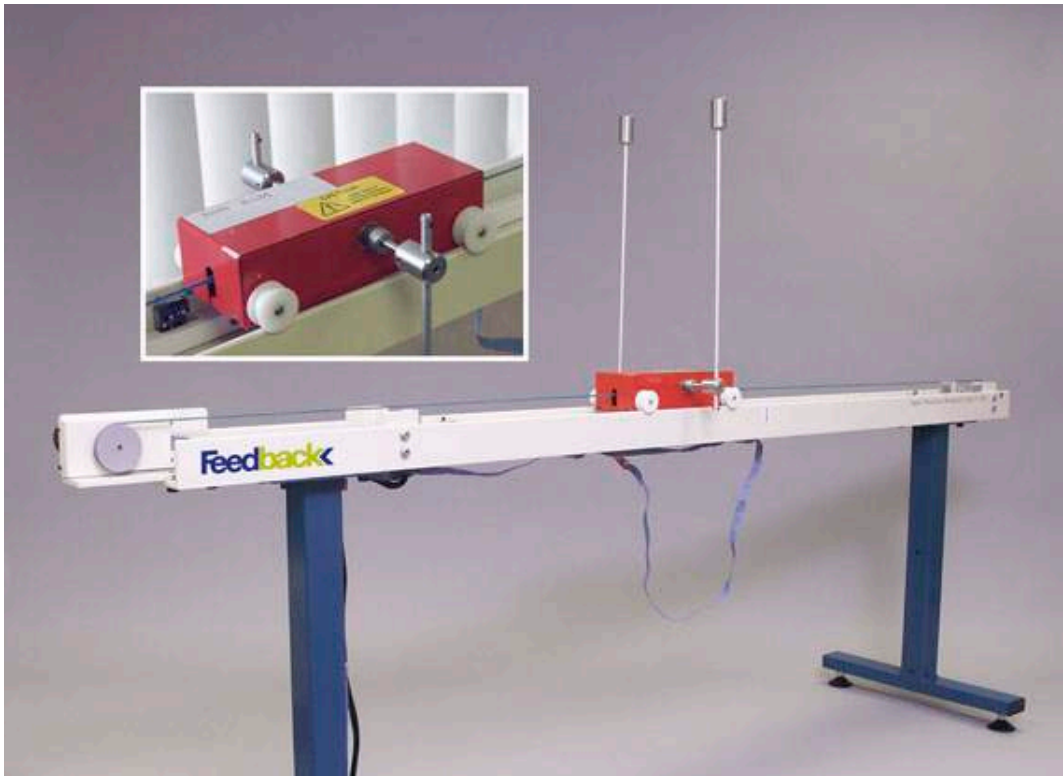
- Non-linear model simplification
- Non-linear model testing
- Model linearization
- Plant control
- PID controllers
- Plate orientationcontrol
- etc.

A LabVIEW™ license is required for this experiment and is not included in the scope of delivery.
The equipment can require additional software modules.

E6.3.5

TECHNICAL PROCESSES WITH LARGE SCALE MODELS

E6.3.5.11
Inverted Pendulum



Inverted Pendulum (E6.3.5.11)

Cat. No.	Description	E6.3.5.11
33-005-PCI	Set Digital Pendulum System	1
	additionally required: 1 PC with Windows 7/8/10	

Inverted Pendulum

The Digital Pendulum is a modern version of a classical control problem; that of erecting and balancing a free swinging pendulum in its inverted position or moving a hanging pendulum in a controlled manner. The cart on the track is digitally controlled to swing up (self erecting) and to balance the pendulum into an upright sustained position or to move the cart with pendulum in an unperturbed down position. The cart track is of limited length, imposing constraints on the control algorithm. In pendulum mode the system is used to control the twin arm pendulum from an initial position, hanging at rest with the cart in the centre of its travel along the track, to a final position with the pendulum upright and the cart restored to its central position. In crane mode the control problem is to move the position of the cart without undue movement of the pendulum. This problem is typical of that experienced when controlling a gantry crane. Using MATLAB™ together with the detailed training manuals supplied by Feedback and an Advantech PCI card (which creates an impressive digital control system development environment) the user is guided through the design process using phenomenological process models, dynamics analysis, discrete models identification, controller design, controller tests on the model, controller implementation in real-time applications, implementation of various control strategies and visualisation.

Topics

- Pendulum Model
  - Equations of motion
  - Non-linear model
  - Linear models
  - etc.
- Pendulum set-up control
  - Plant control
  - PID controller
  - PID control of cart model position
  - etc.

A MATLAB™ license is required for this trial and is not included in the scope of delivery.
The equipment can require additional software modules.

Twin Rotor MIMO System (E6.3.5.12)

E6.3.5

TECHNICAL PROCESSES WITH LARGE SCALE MODELS

E6.3.5.12
Twin Rotor MIMO System

Cat. No.	Description	E6.3.5.12
33-007-PCI	Set Twin Rotor MIMO System	1
	additionally required: 1 PC with Windows 7/8/10	

Twin Rotor MIMO System

The twin-rotor system demonstrates the principles of a non-linear MIMO (multiple input, multiple output) system, with significant cross-coupling. It's behaviour resembles a helicopter, but the angle of attack of the rotors is fixed and the aerodynamic forces are controlled by varying the speeds of the motors. Significant cross-coupling is observed between the actions of the rotors, with each rotor influencing both angle positions. Using MATLAB™ (not supplied) together with the detailed training manuals supplied by Feedback and an Advantech PCI card which creates an impressive digital control system development environment, the user is guided through the design process using phenomenological process models, dynamics analysis, discrete models identification, controller design, controller tests on the model, controller implementationin real-time applications, implementation of various control strategies and data visualisation.

Topics

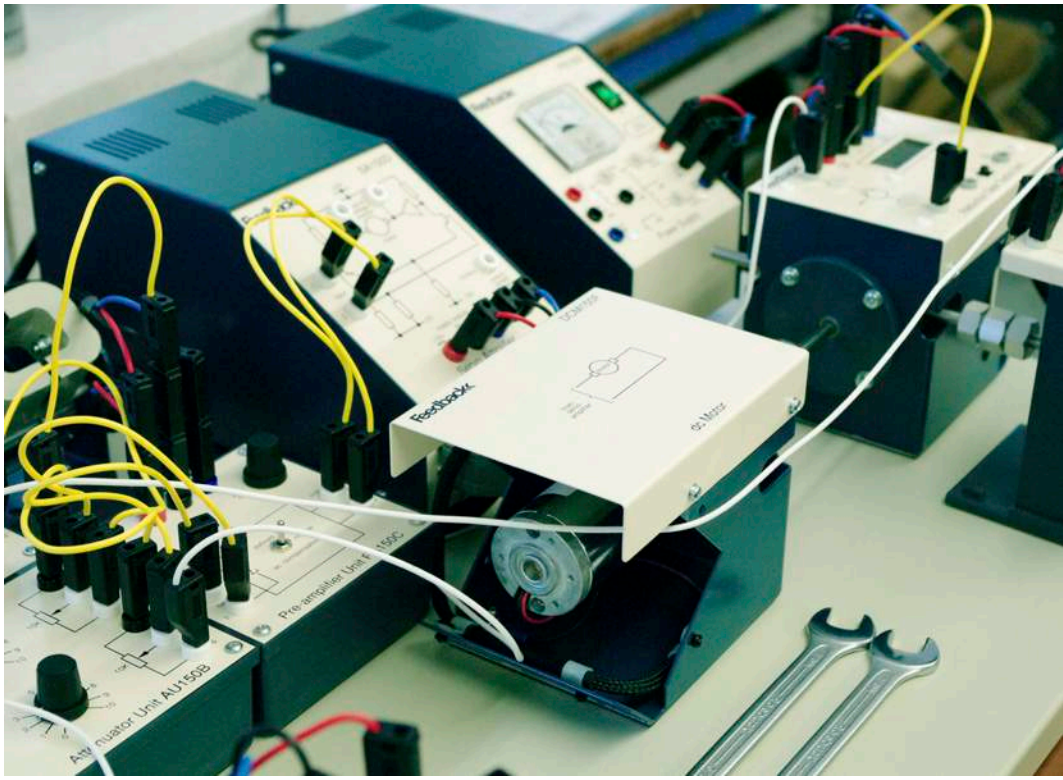
- 1-degree of freedom (DOF), PID stabilising & tracking horizontal controller
- 1-DOF, PID stabilising & tracking vertical controller with gravity compensation
- 2-DOF, PID stabilising & tracking controller
- Parameter tuning
- Coupled dynamics analysis
- etc.

A MATLAB™ license is required for this trial and is not included in the scope of delivery.

E6.3.5

TECHNICAL PROCESSES WITH LARGE SCALE MODELS

E6.3.5.13
Modular Servo Systems



Modular Servo Systems (E6.3.5.13)

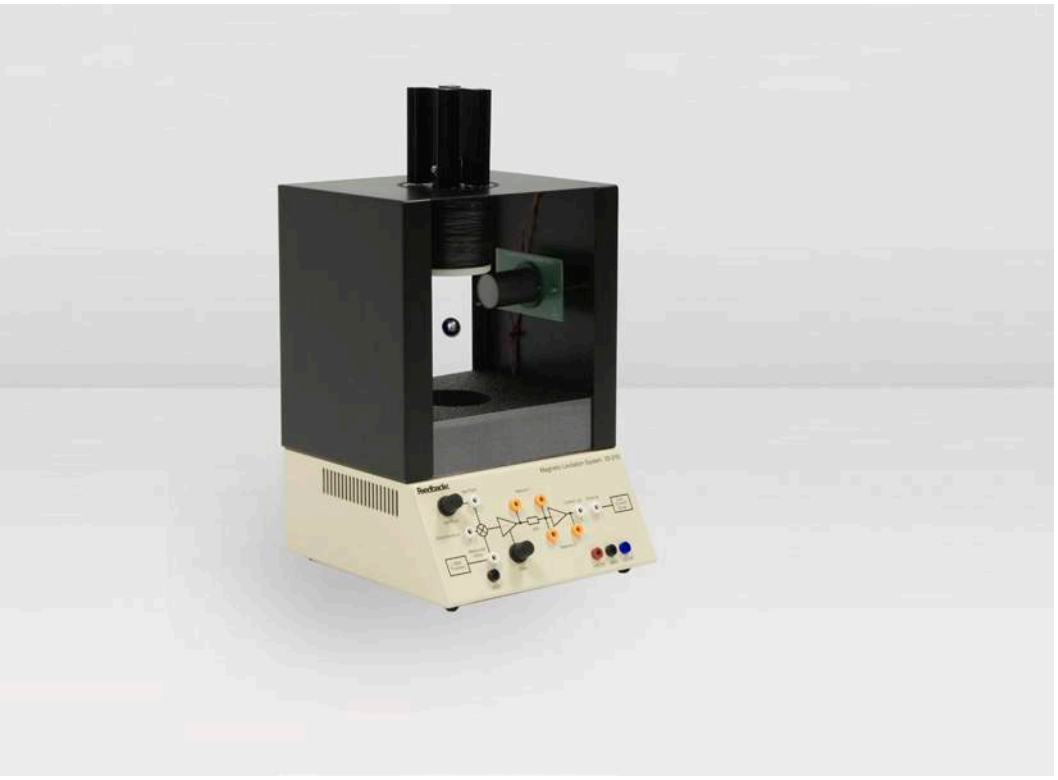
Cat. No.	Description	E6.3.5.13
MS1 50	Modular Servo System (DC, AC, DC/AC, complete system)	1
	additionally required: 1 PC with Windows 7/8/10	

Modular Servo Systems

The modular servo system enables students to study the theory and practice of automatic control systems. It illustrates modern circuitand constructional techniques. The system is modular and therefore, versatile. Each unitis fitted with a magnetic base which holds the unit to the plastic coated steel base plate, irrespective of the angle at which the base plate is positioned. Individual units may be so arranged to create operating block schematic systems and interconnections between the units are made by jumper leads terminated in 4 mm stackable plugs. The modular concept of the MS150 system permits the study of individual units and also, by combination, the investigation and performance testing of complete systems.

Topics

- Operational amplifiers
- Motor speed characteristics
- DC error channel
- Simple position control
- Closed-loop position control
- Simple speed control
- etc.



Magnetic Levitation System (E6.3.5.14)

E6.3.5

TECHNICAL PROCESSES WITH LARGE SCALE MODELS

E6.3.5.14
Magnetic Levitation System

Cat. No.	Description	E6.3.5.14
33-006-PCI	Magnetic Levitation System (MATLAB Vers.)	1
	additionally required: 1 PC with Windows 7/8/10	

Magnetic Levitation System

This classic magnetic levitation control problem is now presented in a new and innovative form. A 25 mm diameter, hollow steel sphere is suspended in space with visually appealing results and convenient time constants. Both analogue and digital control solutions are implemented.

Convenient sockets on the enclosure panel allow for quick changes of analogue controller gain and compensation components.

Topics

- Analogue Operation
  - Non-linear models
  - Unstable systems
  - Linearisation about an operating point
  - etc.

- Digital Operation
  - Non-linear models
  - Unstable systems
  - Linearisation about an operating point
  - etc.

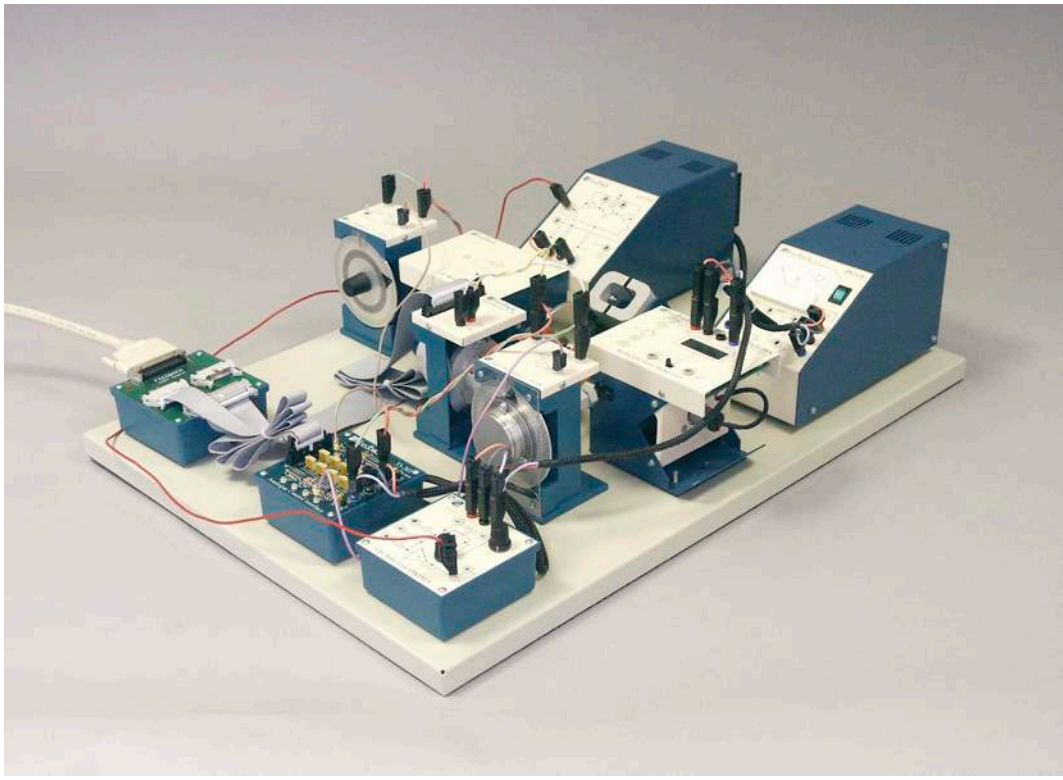
A MATLAB™ license is required for this trial and is not included in the scope of delivery.

The equipment can require additional software modules.

E6.3.5

TECHNICAL PROCESSES WITH LARGE SCALE MODELS

E6.3.5.15
Precision modular control workshop



Precision modular control workshop (E6.3.5.15)

Cat. No.	Description	E6.3.5.15
33-008-PCI	Precision Modular Control Workshop	1
	additionally required: 1 PC with Windows 7/8/10	

Precision Modular Control Workshop

The Precision Modular Servo Workshop provides a rapid and direct path from control system design to hardware implementation. The resolution and accuracy of the system and the consistency of it's performance, makes the Precision Modular Servo Workshop ideal for serious study of digital linear servo control systems. As well as allowing study of digital control the Precision Modular Servo Workshop also provides a complete introduction to servos, from fundamental studies of analogue servos through to full, real-time digital control. It is fully supported with laboratory assignments which have been designed to give students a full understanding of the control paths within the equipment.

Topics

- Precision modular servo (PMS)
- Testing the d.c. motor
- PMS model identification - static friction compensation, model 1 & 2 identification
- PMS position control - PID control of motor position, real-time PID control of motor position, position tracking
- PMS control, under variable control conditions - simple gain scheduling algorithm, gain scheduling
- etc.

A LabVIEW™ license is required for this experiment and is not included in the scope of delivery.

The equipment can require additional software modules.

E6.4 INDUSTRIAL CONTROLLERS & CONTROLLED SYSTEMS

E6.4.1

INDUSTRIAL CONTROLLERS & CONTROLLED SYSTEMS

E6.4.1.1
Automatic Control with Compact Controllers

Automatic Control with Compact Controllers (E6.4.1.1)

Cat. No.	Description	E6.4.1.1
734 431	Compact controller	1
734 300	Heel Controlled System	1
734 091	Digital Controlled System	1
734 19	Gain and offset adjust	1
726 86	DC-Power Supply ± 15 V/3 A	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
500 641	Safety connecting lead, 100 cm, red	2
500 642	Safety connecting lead, 100 cm, blue	1
500 644	Safety connecting lead, 100 cm, black	2
775 750EN	LIT: E6.4.1.1 Control with Industrial Compact Controllers	1*
726 10	Panel frame T150, two-level	1*

* additionally recommended

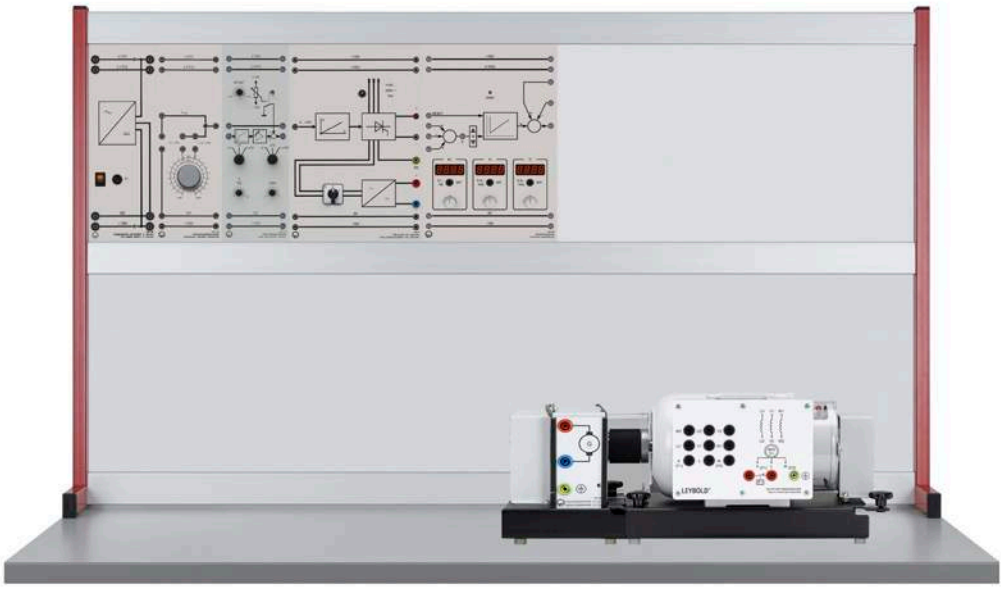
Automatic Control with Compact Controllers

This chapter describes experiments with the widely used compact controller Siemens SIPART DR 19 in the industry. The tests use only the analogue input X and analogue output Y of the SIPART DR 19. For the use of external sensors or the digital inputs and outputs, please refer to the manuals.

Topics

- Digital industrial controllers
- SIPART DR19
- Unipolar controller operation
- Bipolar controller operation
- Compact controller on the electronic control loop
- Fault control at the heel regulation range

Experiments are operated and evaluated with CASSY Lab 2.



Control of an Industrial Machine 0.3 (E6.4.1.2)

E6.4.1

INDUSTRIAL CONTROLLERS & CONTROLLED SYSTEMS

E6.4.1.2
Control of an
Industrial Machine 0.3

Cat. No.	Description	E6.4.1.2
731 86	DC compound machine 0.3	1
734 02	Reference variable generator	1
734 19	Gain and offset adjust	1
734 22	Actuator 115...230 V/1 kW	1
734 064N	PID digital controller Net	1
775 755EN	LIT: E6.4.1.2 Control of IMA 300W	1*
726 09	Panel frame T130, two-level	1*
726 86	DC-Power Supply ± 15 V/3 A	1*
731 06	Coupling 0.3	1*
731 08	Coupling guard 0.3	1*
731 07	Shaft end guard 0.3	2*
731 09	Tacho generator 0.3	1*
524 016S2	Profi-CASSY Starter 2	1*
500 59	Safety bridging plugs, black, set of 10	2*
500 592	Safety bridging plugs with tap, black, set of 10	1*
500 644	Safety connecting lead, 100 cm, black	3*
500 604	Safety connecting lead, 10 cm, black	2*
500 640	Safety connecting lead, 100 cm, yellow/green	2*
500 641	Safety connecting lead, 100 cm, red	4*
500 642	Safety connecting lead, 100 cm, blue	5*
531 583	Multimeter METRAport 40 S	1*
	additionally required: PC with operating system Windows 7/8/10	

* additionally recommended

Control of an Industrial Machine 0.3 kW

An idling direct current motor loaded only by its own ventilator and bearing and brush friction is functioning as a technical controlled system. This establishes speed control in the first quadrant (active acceleration). Braking occurs passively via the ventilator and friction losses. In addition to the measurements, the process is simulated on the PC as well. A numerical optimisation of the controller is carried out in accordance with the ITAE criteria using the WinFACT LD Edition (734 491) software.

Topics

- Technical Controlled Systems
- Characteristic line for the drive engine
- Step response for an industrial machine
- Technical controller
- Controller tuning
- Determination of the controller parameters with PID Design Centre

Experiments are operated and evaluated with CASSY Lab 2 and WinFACT.

E6.4.2

TECHNICAL PROCESSES WITH INDUSTRIAL COMPONENTS

E6.4.2.1
Process Instrumentation

Process Instrumentation (E6.4.2.1)

Cat. No.	Description	E6.4.2.1
38-023	Process Instrumentation Trainer (PIT)	1
38-023-SW	PROCESS INST.TRNR UTY SW	1

Process Instrumentation

Modern control devices and sensors are becoming increasingly complex and functionally very powerful. This trainer enables students to be exposed to the selection and utilisation of such devices, the sensors, actuators and programmable devices being industrial units. It provides hands-on experience of their setting-up, calibration and use. The equipment is based on a mobile trolley incorporating all electrical, water (including a water heater) and air controls, a self-contained unit. The punched front panel provides a construction area that allows devices to be firmly fixed to it.

Topics

- Current loop resistor
- Current / pressure converter
- Control valve
- Pressure transmitters
- Flowmeter
- Frequency transmitter
- etc.

Temperature in Airstream (E6.4.2.2)

E6.4.2

TECHNICAL PROCESSES WITH INDUSTRIAL COMPONENTS

E6.4.2.2
Temperature in Airstream

Cat. No.	Description	E6.4.2.2
37-100	Process Control Trainer	1
531 831	Joule and wattmeter	1*
522 561	Function generator P	1*
PID 150Y	PID (proportional–integral–derivative) Controller	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Temperature in Airstream

The 37-100 Process Control Trainer teaches the basic characteristics of a large plant, but is compact and portable. It enables distance/velocity lag, transfer lag, system response, proportional and two step control to be demonstrated.

Topics

- A practical process in miniature
- Closed and open-loop continuous control
- Two-step control
- Fast response times enable dynamic behaviour to be seen on an oscilloscope
- Exhibits thermal time constants & time transport lag
- etc.

E6.4.2

TECHNICAL PROCESSES WITH INDUSTRIAL COMPONENTS

E6.4.2.3
Level & Flow

Level & Flow (E6.4.2.3)

Cat. No.	Description	E6.4.2.3
38-001	Level & Flow Process Control	1
93-420	ESPIAL Software Package	1*
38-002	Temperature Process Control	1*
38-610	Forced Air Cooler	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Level & Flow

The Level & Flow Process Control Trainer is a single loop system allowing the study of the principles of process control, using liquid level and flow rates as the measured process variables. The system is a completely self-contained, low pressure flowing water circuit supported on a benchtop-mounted panel, making it suitable for individual student work or for group demonstrations. It comprises a dual compartment process tank, linked to a sump tank by manual and solenoid operated valves. Water is pumped through the system, via a variable area flow meter and motorised control valve. Level is measured in the process tank. Flow is measured through an optical pulse flowmeter.

Topics

- Flow & level familiarisation & calibration
- Interface familiarisation & calibration
- Controller familiarisation & calibration
- Float Level Transmitter
- Pulse Flow Transmitter
- On-Off Control
- etc.

Experiments are operated and evaluated with ESPIAL.
The equipment can require additional software modules.

Four-Tank System (E6.4.2.4)

E6.4.2

TECHNICAL PROCESSES WITH INDUSTRIAL COMPONENTS

E6.4.2.4
Four-Tank System

Cat. No.	Description	E6.4.2.4
33-041	Coupled Tanks System (Prepared for MATLAB™)	1
	additionally required: 1 PC with Windows 7/8/10	

Four-Tank System

The Coupled Tanks set-up is a model of a chemical plant fragment. Very often tanks are coupled through pipes and the reactant level and flow has to be controlled. The Coupled Tanks experiment is designed so that the system can be configured. The Coupled Tanks system has 4 translucent tanks each with a pressure sensor to measure the water level. The couplings between the tanks can be modified by the use of seven manual valves to change the dynamics of the system imposing the use of different controllers. Water is delivered to the tanks by two independently controlled, submersed pumps. Step disturbances generation is provided by four manual valves. Drain flow rates can be modified using easy-to-change orifice caps. The system can be operated with MATLAB™, SIMULINK® or NI LabVIEW™.

Topics

- Non-linear model
- Linearisation
- Linear model simulation
- 1 tank & 2 tank identification
- PID control of water levels in top tanks
- PID control of water levels in bottom tanks
- etc.

A LabVIEW™ or MATLAB™ license is required for this experiment and is not included in the scope of delivery.

The equipment can require additional software modules.

E6.4.2

TECHNICAL PROCESSES WITH INDUSTRIAL COMPONENTS

E6.4.2.5
Temperature in Water

Temperature in Water (E6.4.2.5)

Cat. No.	Description	E6.4.2.5
38-002	Temperature Process Control	1
38-610	Forced Air Cooler	1*
93-420	ESPIAL Software Package	1*
38-001	Level & Flow Process Control	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

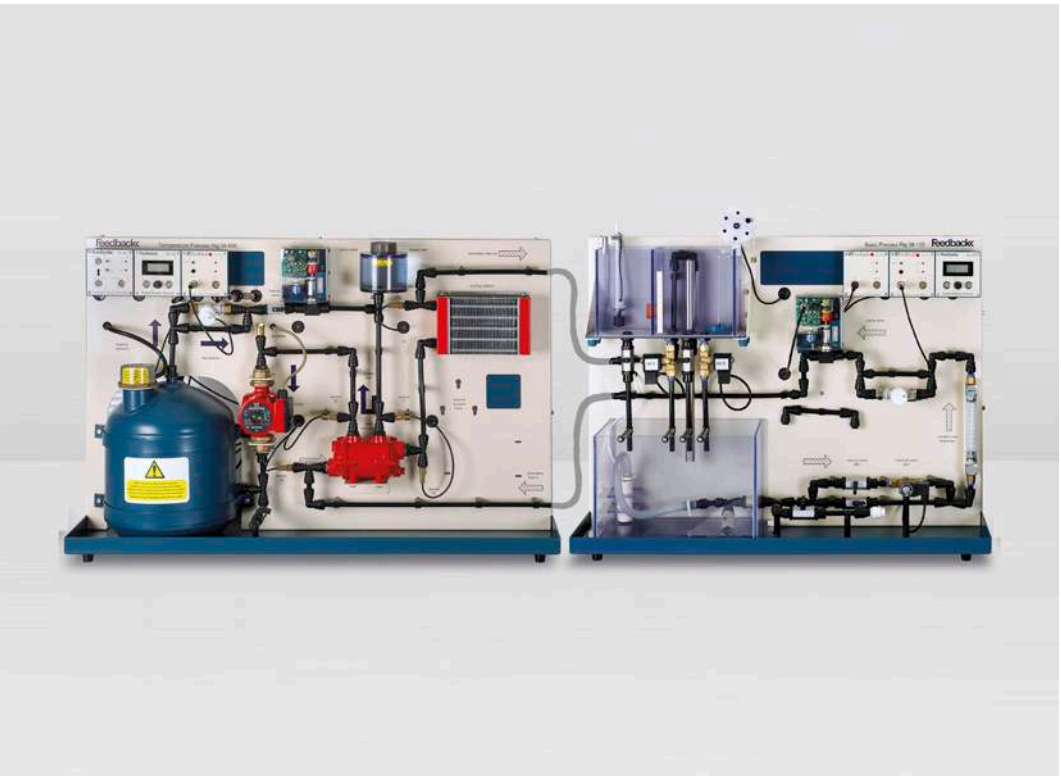
Temperature in Water

The Temperature Training System is a two loop system, using water as the process fluid which allows the study of the principles of process control using primary and secondary circuit temperatures as the process variables to be controlled. Both circuits pass through the heat exchanger and the secondary circuit contains a fan-assisted cooling radiator. Thermistor temperature sensors are located in the inlet and outlet streams of both primary and secondary sides of the heat exchanger and the outlet of the radiator. The primary flow is also monitored. The Trainer can be used with a cold mains water supply through the Auxiliary Temperature Control Pack 38-480, which is supplied as part of the system. This comprises a motorised control valve, a flow meter and a signal conditioning unit. Alternatively the Temperature Trainer can be connected to the Level & Flow Process Trainer, which then supplies the cold water circuit. This combination allows more complex control systems to be investigated.

Topics

- Temperature familiarisation & calibration
- Interface familiarisation & calibration
- Controller familiarisation & calibration
- Pulse Flow Transmitter
- On-Off Control
- Study of P, PI and PID control of temperature & flow
- etc.

Experiments are operated and evaluated with ESPIAL.
The equipment can require additional software modules.



E6.4.2

TECHNICAL PROCESSES WITH INDUSTRIAL COMPONENTS

E6.4.2.6
Cascaded Loop with Remote Control

Cascaded Loop with Remote Control (E6.4.2.6)

Cat. No.	Description	E6.4.2.6
38-003	Level, Flow & Temperature Process Control	1
93-420	ESPIAL Software Package	1
38-610	Forced Air Cooler	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Cascaded Loop with Remote Control

The combined PROCON Level, Flow & Temperature Process Control System is self-contained and has all of the features of the individual Level & Flow and Temperature systems plus remote set-point control. Remote set-point control can be affected with the PROCON Level, Flow & Temperature Process Control System by using two process controllers. The 4-20mA analogue remote set-point input allows various forms of cascade control to be implemented between linked or interactive control loops. The process set-point can be local and remote or dual, selected from the front panel, or in response to a logic input. When dual set-point is selected the function can be ratio or bias action. A Programmable Logic Controller (PLC) 38-350 is also available separately. It can be used with the Process Interface 38-200 to provide an alternative control method with on/off elements to the standard Process Controller 38-300 (included).

Topics

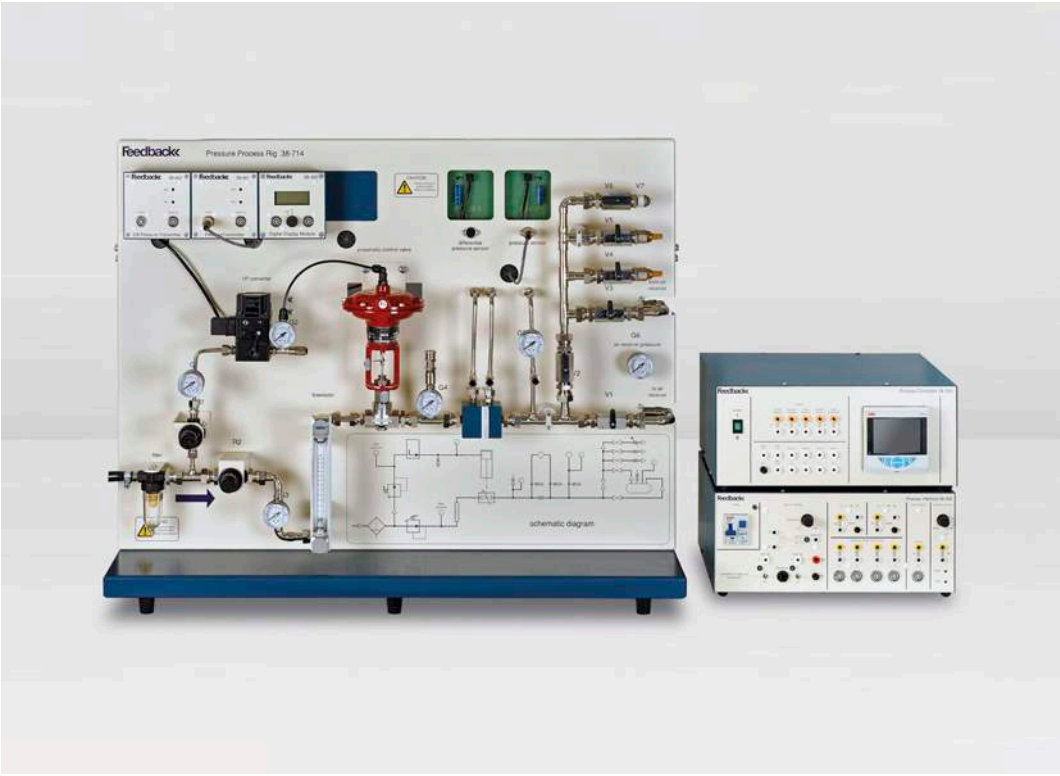
- Flow & level familiarisation & calibration
- Temperature familiarisation & calibration
- Interface familiarisation & calibration
- Controller familiarisation & calibration
- Float level transmitter
- Pulse flow transmitter
- etc.

Experiments are operated and evaluated with ESPIAL.
The equipment can require additional software modules.

E6.4.2

TECHNICAL PROCESSES WITH INDUSTRIAL COMPONENTS

E6.4.2.7
Air Pressure



Air Pressure (E6.4.2.7)

Cat. No.	Description	E6.4.2.7
38-004	Pressure Process Control Trainer	1
93-420	ESPIAL Software Package	1
38-820-230	Air Compressor	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

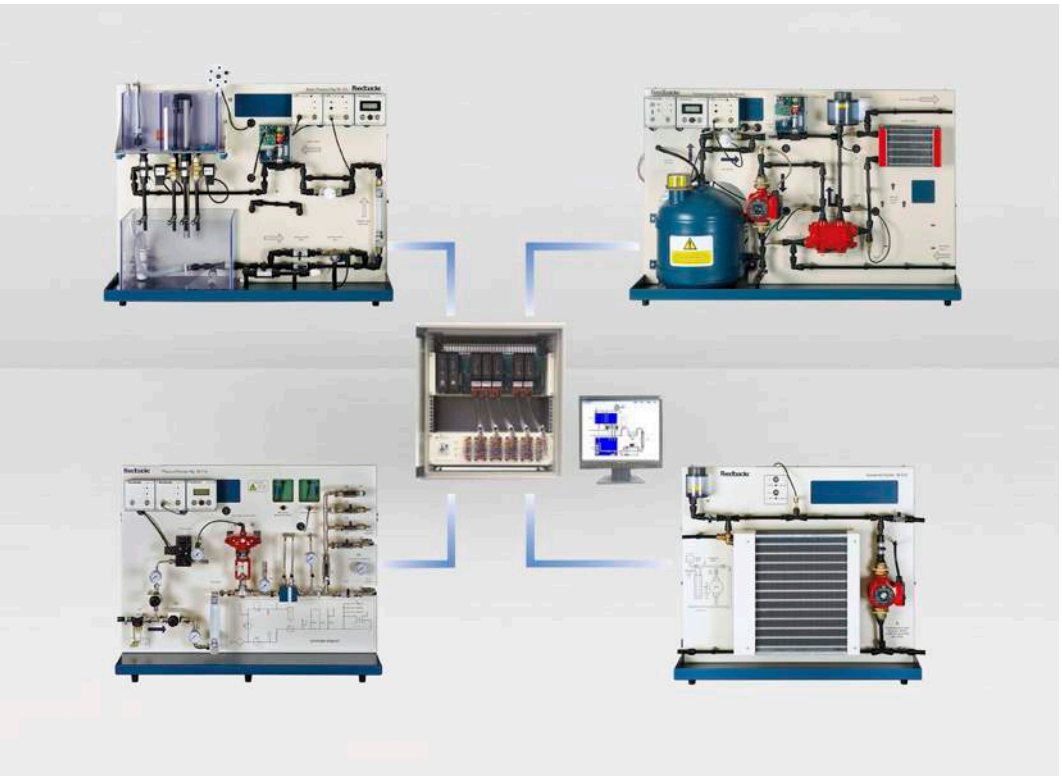
Air Pressure

The Pressure Process Control Training System is a single loop pneumatic control system. It enables the study of the principles of both pressure regulation of a process and the control of flow in a pressurised system. The system comprises a low pressure air circuit supported on a bench-mounted panel, making it suitable for individual student work or for group demonstration. The trainer requires a compressed air supply at a recommended input pressure of 40 psi (not supplied) An input filter/drier is used to clean the supplied air. Separately regulated branches provide air for the process and for valve control. The process branch comprises a regulator, a variable area flow meter, a pneumatically operated control valve, an orifice block with changeable orifice plates and both differential and point of measure pressure sensors.

Topics

- Pressure safety, familiarisation & calibration
- I/P converter & pneumatic control valve operation
- Controller familiarisation & calibration
- Automatic control systems
- Serial communication
- Pressure sensor
- etc.

Experiments are operated and evaluated with ESPIAL.
The equipment can require additional software modules.



E6.4.2

TECHNICAL PROCESSES WITH INDUSTRIAL COMPONENTS

E6.4.2.8
Distributed Control

Distributed Control (E6.4.2.8)

Cat. No.	Description	E6.4.2.8
38-009	Distributed Control System (DCS)	1
38-820-230	Air Compressor	1
93-420	ESPIAL Software Package	1
38-820-120	PROCON COMPRESSOR 115V	1*

* additionally recommended

Distributed Control

The Feedback Distributed Control System (DCS) trainer is a complete training solution that combines the operations of a leading commercial DCS process management controller package, namely the Emerson Delta V, with an assortment of our proprietary training rigs.

The training rigs offer a range of processes:

- Level & Flow
- Temperature
- Pressure
- Forced Air Cooling

These may be operated separately or combined to produce a multi-process, multi-loop system. The trainer is supplied complete with the PC, software, controller and I/O modules that are needed to monitor and control the process rigs. A control cabinet houses the components that provide the interface between the PC and the rigs.

Topics

- Distributed control system background theory
- Delta V Explorer
- Trainer configuration
- Basic on-off control
- Advanced on-off control
- etc.

Experiments are operated and evaluated with ESPIAL.
The equipment can require additional software modules.

E6.4.2

TECHNICAL PROCESSES WITH INDUSTRIAL COMPONENTS

E6.4.2.9
Fault Diagnostics

Fault Diagnostics (E6.4.2.9)

Cat. No.	Description	E6.4.2.9
34-250	Industrial (fault-finding) Process Trainer	1
34-252-1	PLC Interface for 34-250	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Fault Diagnostics

This trainer teaches fault diagnosis and rectification in industrial processes. Faults are introduced by the instructor via switches concealed behind a locked compartment, to which the student does not have access. These switches provide both short circuits and open circuits and can also switch in or out circuit elements to simulate a variety of fault conditions.

Topics

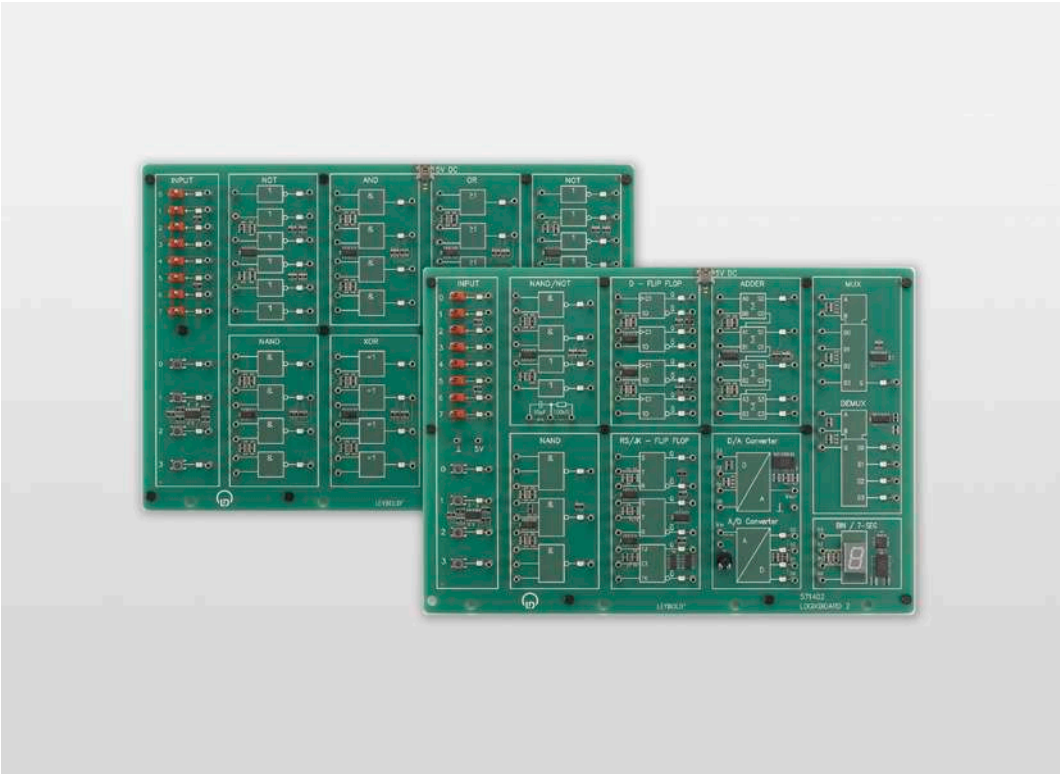
- Introduction to the system
- Fault finding methodologies
- Fault analysis flow charts
- Fault finding from circuit diagrams
- Fault identification to line replaceable unit level
- etc.

E6.5 OPEN LOOP CONTROL ENGINEERING

E6.5.1

BASICS OF
OPEN LOOP CONTROL

E6.5.1.1
Compact Course:
Digital Technology



Compact Course: Digital Technology (E6.5.1.1)

Cat. No.	Description	E6.5.1.1
571 401	Logic board 1	1
571 402	Logic board 2	1

Compact Course Digital Technology

Theory and praxis of open loop control technology are basically carried out with two equipment sets for self-study.

Basic logic gates (AND, OR, NOT, NAND, XOR) of digital electronics are introduced. These are used to investigate the laws of logical operations (de Morgan's law, associative law and distributive law) and non-feedback logic circuits (switch networks). Then, simple flip-flop circuits with feedback are assembled to study storage of information. An adder is explored as a practical example of a switching network (logic circuits without feedback). Various flip-flop circuits enhance the knowledge of switching logic circuits with feedback. Applications of digital technology will be investigated, e.g. multiplexing, demultiplexing, control of a 7-segment display, and DAC respectively ADC conversion are covered. Switching states are displayed by means of an LED at each of the outputs.

Topics

- Logic gates: AND, OR, NOT and XOR
- flip–flop
- Adder
- AD converter / DA converter
- Multiplexer
- RS-flip-flops
- etc.

E6.5.1

BASICS OF
OPEN LOOP CONTROL

E6.5.1.2
Digital Technology

Digital Technology (E6.5.1.2)

Cat. No.	Description	E6.5.1.2
700 1701	COM3LAB Course: Digital Technology I	1
700 1801	COM3LAB Course: Digital Technology II	1
700 020	COM3LAB: Master Unit	1
700 022	Set of Safety Cables (2 mm, 16 Qty., 6 x 30 cm & 10 x 15 cm)	2
688 129	Mains cable with hock-proof plug and cold connector	1
700 00CBT	DVD: COM3LAB Software	1
700 027	COM3LAB: Suitcase	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Digital Technology I

In the course Digital Technology I the bases and laws of switch algebra are dealt with using logic links.

Topics

- TTL components (AND, OR, XOR)
- Link of binary inputs
- Basic laws
- etc.

Digital Technology II

In the course Digital Technology II various flip-flop applications, e.g. shift registers, parallel-serial converters or the serial data transmission are dealt with. Both courses deal extensively with troubleshooting.

Topics

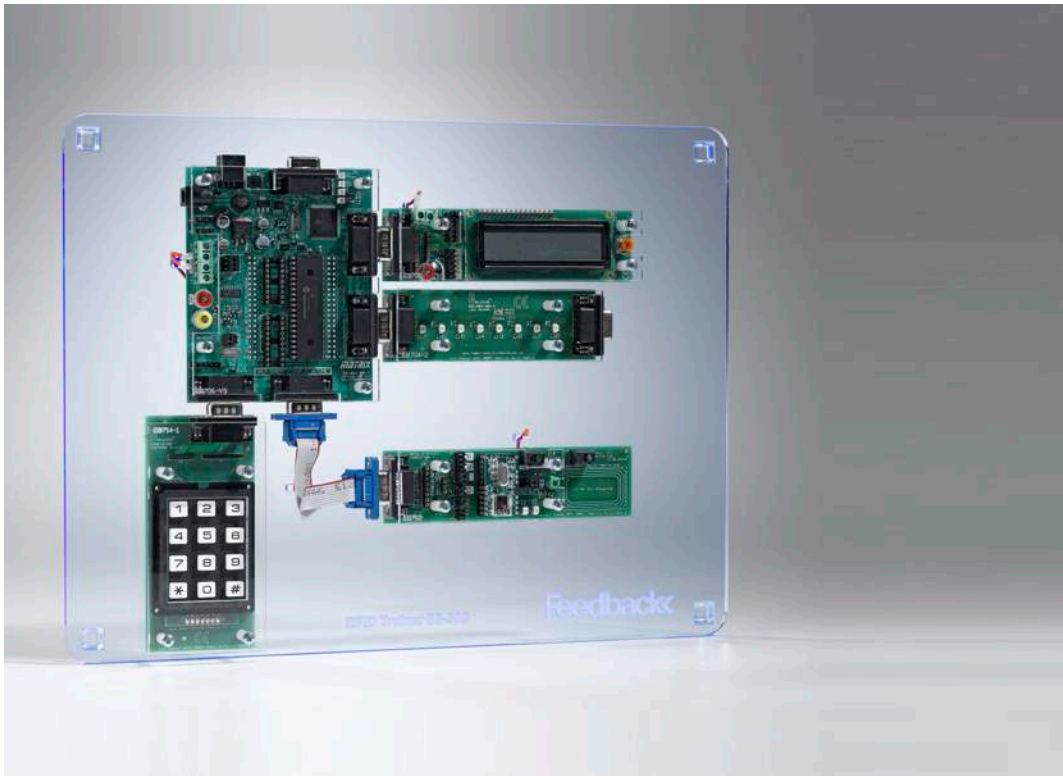
- Flip-flop (RS, JK, D)
- Binary mat
- Forward and reverse counter
- etc.

Experiments are operated and evaluated with COM3LAB CBT.

E6.5.1

BASICS OF OPEN LOOP CONTROL

E6.5.1.3
Embeded Systems



Embeded Systems (E6.5.1.3)

Cat. No.	Description	E6.5.1.3
55-500	RFID Trainer	1
55-600	Embedded Internet Trainer	1
55-800	FPGA Trainer	1
	additionally required: 1 PC with Windows 7/8/10	

Embeded Systems

The equipment consists of 3 trainers, which are widely used embedded systems in the control and in automation technology. With these systems, the student learns basic technologies for industry 4.0 systems and „Internet of Thinks (IoT). This is the basis for the development of fast-reacting sensors and communication systems, as these are necessary in microcontrollers or portable systems.

RFID Trainer

The RFID Trainer provides a complete course in developing RFID systems. It gives students who are familiar with microcontrollers an understanding of the programming involved in developing RFID systems. An RFID board and four RFID tags embedded into credit cards are included. This hardware enables students to learn about reading and writing transponder data in both I-code and Mirfare mode.

Embedded Internet Trainer

The Embedded Internet Trainer provides students with a full understanding for modern digital communications protocols and the development of embedded internet-based products.

FPGA Trainer

The Field-programmable Gate Array Trainer provides a platform for learning FPGA programming in either VHDL or Verilog. The trainer includes a FPGA development board, LED boards, switch boards, a dual 7-segment display board, a prototype board, serial D/A board and a power output board.

Topics

RFID Trainer

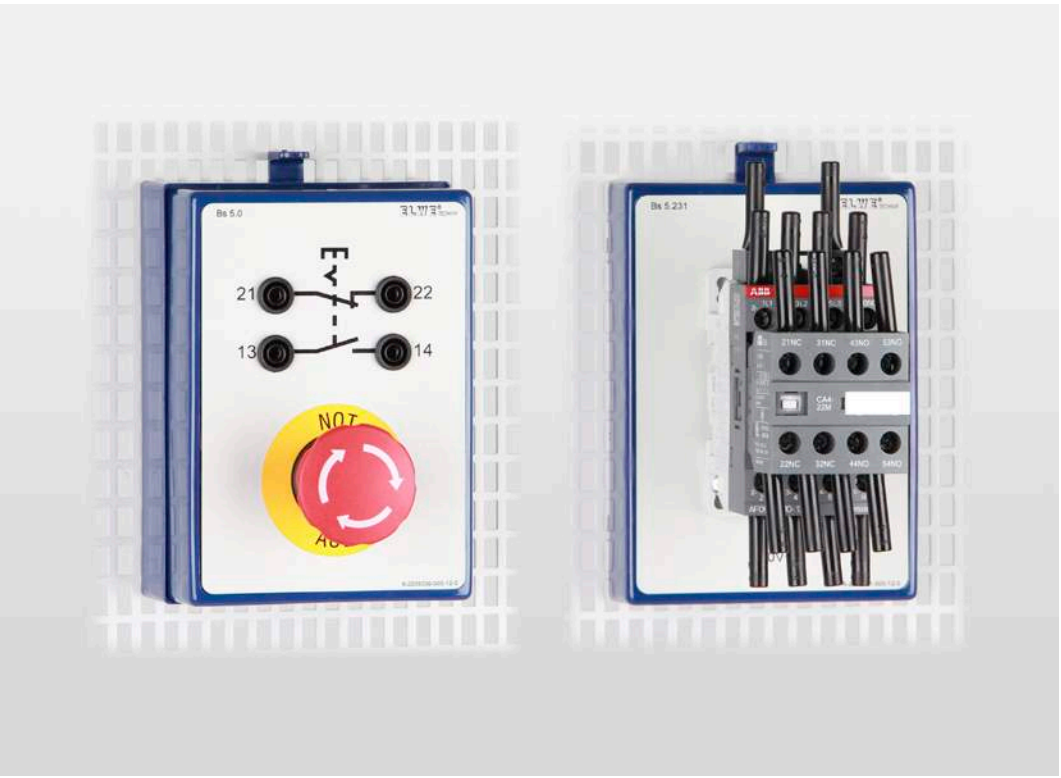
- RFID systems & applications
- Configuring RFID readers

Embedded Internet Trainer

- Ethernet, DLC, MAC, ARP, TCP, IP, UDP, ICMP, HTTP & POP3 protocols
- MAC packet structure & message creation using microcontrollers

FPGA Trainer

- PLD technology
- Getting to know QUARTUS II



E6.5.2

INDUSTRIAL CONTROLS

E6.5.2.11
Contactor Controls
with Modules 24 V

E6.5.2.12
Contactor Controls
with Modules 230 V

Contactor Controls with Modules 24 V (E6.5.2.11)

Cat. No.	Description	E6.5.2.11	E6.5.2.12
8-2 405110-000-12-0	BS 5.110 Three-phase motor simulator	1	1
8-2 205000-000-12-0	BS 5.0 Emergency Shut-Down Pushbutton	1	1
8-2 205027-000-12-1	BS 5.27 Multifunction Relay	2	2
8-2 205028-000-12-0	BS 5.28 Auxilliary Contactor 24 V, 4 NCC's, 4 NOC's	3	
8-2 205031	BS 5.31 Contactor 24 V AC / DC	5	
8-2 205034-000-12-1	BS 5.34 Limit switch	2	2
8-2 215320-000-12-0	BS 5.320 Motor protection relay 0.63...1.0 A	1	1
8-2 205350-000-12-0	BS 5.350 Pilot lamp 24 V, triple	1	
8-2 205381-000-12-0	BS 5.381 Pushbutton switch 0-1-2	3	3
8-2 215900-000-12-0	BS 5.900 Circuit breaker, quadruple	1	1
8-2 230056-000-12-0	BS 30.56 Relay 24 V DC, 2 NOC / 2 NCC	1	1
531 192	Digital multimeter MX 24B	1	1
726 75	Three-phase supply unit with ELCB	1	1
562 793NA	Power Adapter 6...24 V	1	
500 851	Safety connecting leads, 32 A, set of 32	2	1
500 852	Safety connecting leads, 32 A, yellow/ green, set of 10	1	2
726 30	Assembly Grid L130	1	1
732 203	Squirrel cage motor basic 400/690/0.3	1*	1*
731 07	Shaft end guard 0.3	1*	1*
8-2 205228-000-12-0	BS 5.228 Auxiliary contactor 230 V, 4 N/C, 4 N/O		3
8-2 205231-000-12-0	BS 5.231 Contactor 230 V		1
8-2 205351-000-12-0	BS 5.351 Pilot lamp 230 V, triple		1

Cat. No.	Description	E6.5.2.11	E6.5.2.12
726 890	DC-High Current Power Supp. 32/20		1

* additionally recommended

Contactor Controls with Modules

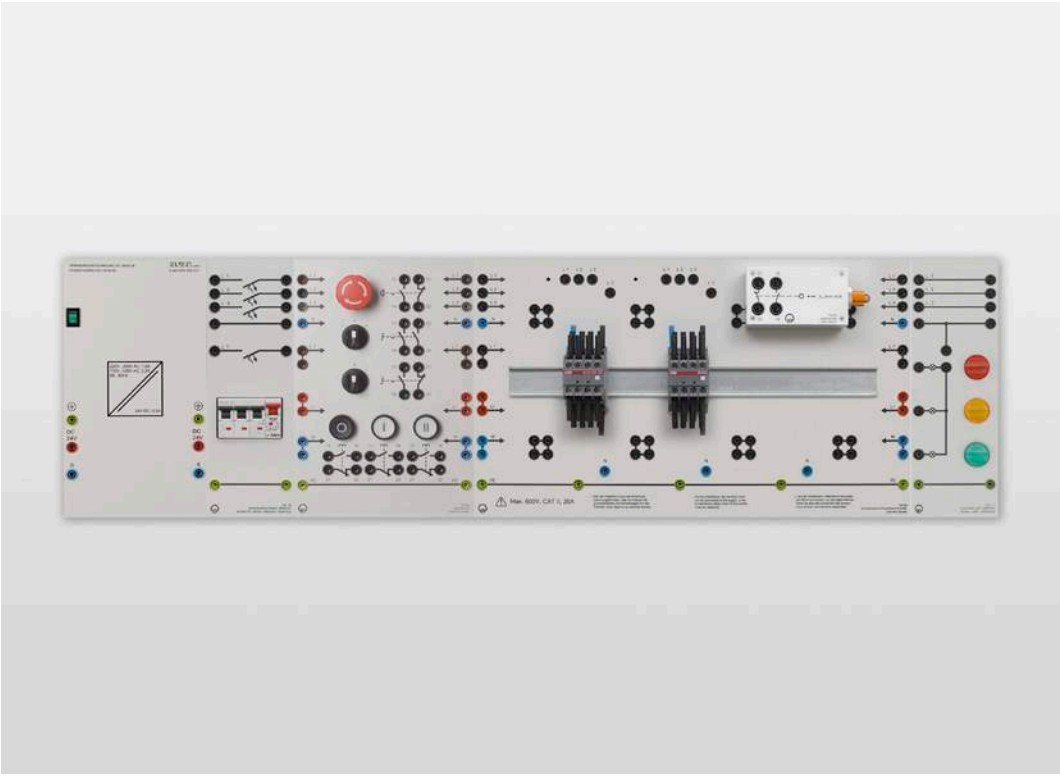
Even today, simple control circuits are still being realized economically, using contactor type circuits. But even complex PLC controls cannot be designed without external protective devices like pushbutton switch latching and contactor multiple latching. The topic Industrial Controls contains various switches, contactors, signal indicators, limit and proximity switches and can also be logically extended by the electrical machines program (E2). The assembly of control and load circuits is set up in a simple and straight forward fashion. All connections are made by 4 mm safety connecting leads. The extensive literature accompanying the equipment sets, explains the function and operation of the individual components and even includes the realization of complex machine and expert control circuits. The equipment set E6.5.2 Industrial Controls forms the foundations for more advanced training in PLC technology.

E6.5.2

INDUSTRIAL CONTROLS

E6.5.2.21
Contactor Controls
with Training Panels 24 V

E6.5.2.22
Contactor Controls
with Training Panels 230 V AC



Contactor Controls with Training Panels 24 V (E6.5.2.21)

Cat. No.	Description	E6.5.2.21	E6.5.2.22
730 002	Operating panel	1	1
730 004	Base unit control circuits	1	1
730 321	AUX. CONTACTOR 24V 4NO 4NC	3	
730 331	Power Contactor 24 V 3 Main, 3 NO, 2NC	3	
732 151	Motor Protection Relay 0.6-1	2	2
730 072	Multi-function relay	1	1
730 37	Signal Lamp 24V, Threefold	1	
730 93	Limit Switch 1NO 1NC	1	1
726 10	Panel frame T150, two-level	1	1
726 75	Three-phase supply unit with ELCB	1	1
562 793NA	Power Adapter 6...24 V	1	1
500 59	Safety bridging plugs, black, set of 10	4	4
726 890	DC-High Current Power Supp. 32/20	1	
500 591	Safety bridging plugs, yellow/green, set of 10	1	1
500 851	Safety connecting leads, 32 A, set of 32	3	3
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1
648 07	Storage tray S24-FN	1	1
732 203	Squirrel cage motor basic 400/690/0.3	1*	1*
731 07	Shaft end guard 0.3	1*	1*
730 121	Auxiliary Contactor 4NO 4NC		3
730 131	PWR Contactor 3-pole 3NC 2NO		3
730 17	Signal Lamp, Threefold		1

* additionally recommended

Contactor Controls with Training Panels

- Basic control elements with contactor
- Basic control circuits with contactor
- Basic control circuits for machines

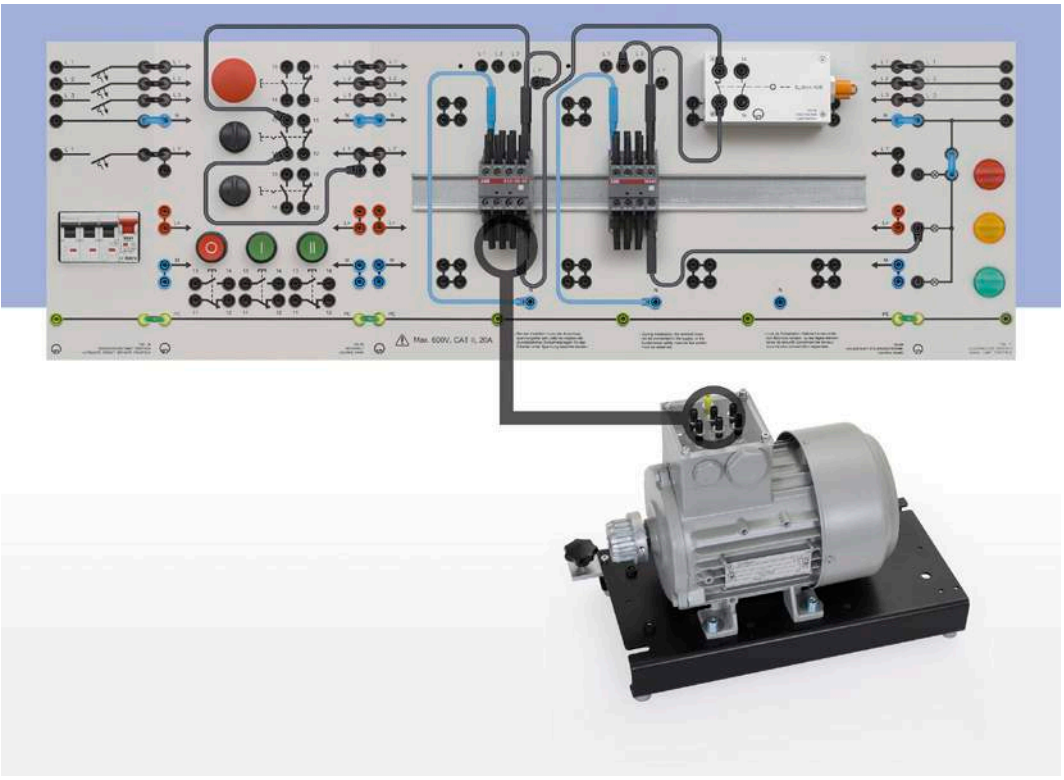
The experiment plate system is comprised of handy, robust experiment plates that are arranged on a frame in accordance with the specifications in the literature.

The industry standard equipment is affixed to the front. The operation and notification elements are installed on separate plates.

The electric components are wired directly to the corresponding safety connector using a 4 mm safety connection line for low voltage.

Topics

- Functionality of the circuits
- And-or circuits with contactors
- Motor switched on with a power contactor
- Catch of a contactor
- Locking of contactors
- Locking of buttons
- Reverse control
- etc.



E6.5.2

INDUSTRIAL CONTROLS

E6.5.2.5
Control with Limit &
Proximity Switches

Control with Limit & Proximity Switches (E6.5.2.5)

Cat. No.	Description	E6.5.2.5
730 90	Gear w.2 Switch Arms 0.1/0.3	1
731 06	Coupling 0.3	1
731 08	Coupling guard 0.3	1
732 203	Squirrel cage motor basic 400/690/0.3	1
730 93	Limit Switch 1NO 1NC	2
730 94	Ind. Proximity Switch 2-AC/DC	1
730 95	Ind. Proximity Switch 3-DC	1
730 97	Cap. Proximity Switch 3-DC	1
730 99	Opt. Proximity Switch 3-DC	1
730 381	Relais 24V 1NO 1NC	1*
562 793NA	Power Adapter 6...24 V	1
566 242	LIT: Limit and Proximity Switches T 9.2	1*

* additionally recommended

Control with Limit & Proximity Switches

- Function and end position switches
- Sensor principles: mechanic, inductive and capacitive final position switch
- Controlling systems with end position switches.
- Use of contactor technology, small controllers, or SPC

End position switches register the maximum positions in systems. Depending on the application, final position switches can be built with mechanical, inductive, or capacitive sensors. Material, touchless operation, switching operation voltages and environmental conditions are criteria that go into selection. The learning system helps students to differentiate between the individual end position switches and use them in typical experiments.

Topics

- Final position stop
- Automatic reverse switching
- Dahlander reverse switching

E6.5.2

INDUSTRIAL CONTROLS

E6.5.2.3
Control with LOGO! 8 230 V

Control with LOGO! 8 230 V (E6.5.2.3)

Cat. No.	Description	E6.5.2.3
8-2 412890	Universal Logic Module LOGO! 8 230 RCE	1
773 090	Logo! Software	1
689 3000	RJ45 crossover Cable 2m	1
	additionally required: 1 PC with Windows 7/8/10	

Control with LOGO! 8 230 V

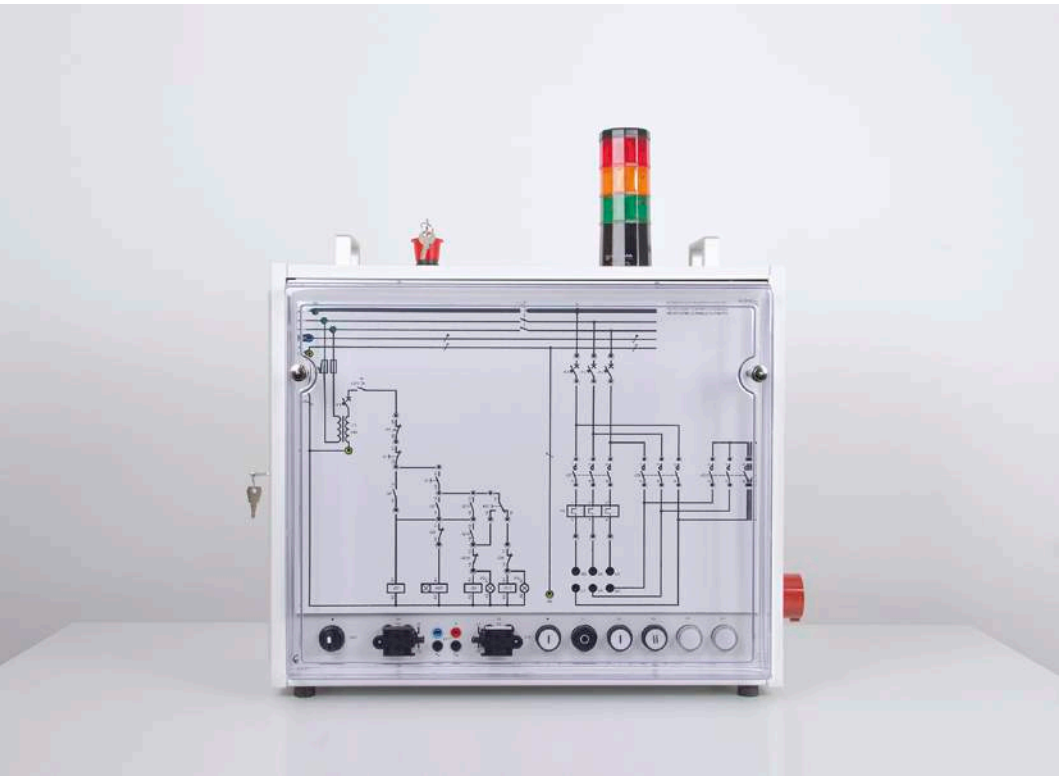
- Create programs
- Learn logistics and control functions
- Test the programs
- Configuring network connections

Programming a small controller on LOGO! 8 from Siemens. The student should learn the main functions of small controllers.

Experiment plate system with all necessary digital inputs and outputs and the necessary interfaces. The inputs can be reached via 4 mm safety connectors for 230 V and via installed circuits with notching and push function. The outputs are configured as potential-free relay contacts and are accessible via safety connectors on the front. There is the option to permanently position the connectors with bridging plugs at 230 V. The controller has an ethernet interface that is constructed as RJ 45. The control voltage amounts to 230 V AC.

Topics

- Star-delta circuit with time relay
- Reversing star/delta circuit
- Motor reverse control with cam-operated limit switch
- Slip ring rotor with stepped starter motor
- Pole-changing motor with divided coils
- Dahlander circuits
- etc.



E6.5.2

INDUSTRIAL CONTROLS

E6.5.2.4
Fault Simulator:
Contactor Circuits

Fault Simulator: Contactor Circuits (E6.5.2.4)

Cat. No.	Description	E6.5.2.4
773 030	Fault simulator for Contactor circuits	1
8-5 305062-000-10-0	LIT: Fault simulator	1
727 292	Voltage detector	1
732 203	Squirrel cage motor basic 400/690/0.3	1*
732 24	Squirrel cage motor D 0.3	1*
731 07	Shaft end guard 0.3	1*
730 90	Gear w.2 Switch Arms 0.1/0.3	1*
731 06	Coupling 0.3	1*
731 081	Coupling guard 0.3 transparent	1*
730 93	Limit Switch 1NO 1NC	2*
500 851	Safety connecting leads, 32 A, set of 32	1*
500 640	Safety connecting lead, 100 cm, yellow/green	2*

* additionally recommended

Fault Simulator: Contactor Circuits

Fault localisation in contactor circuits. Compact device with integrated fault simulation.

Educational objectives

- Function of contactor circuits
- Fault localisation in contactor circuits

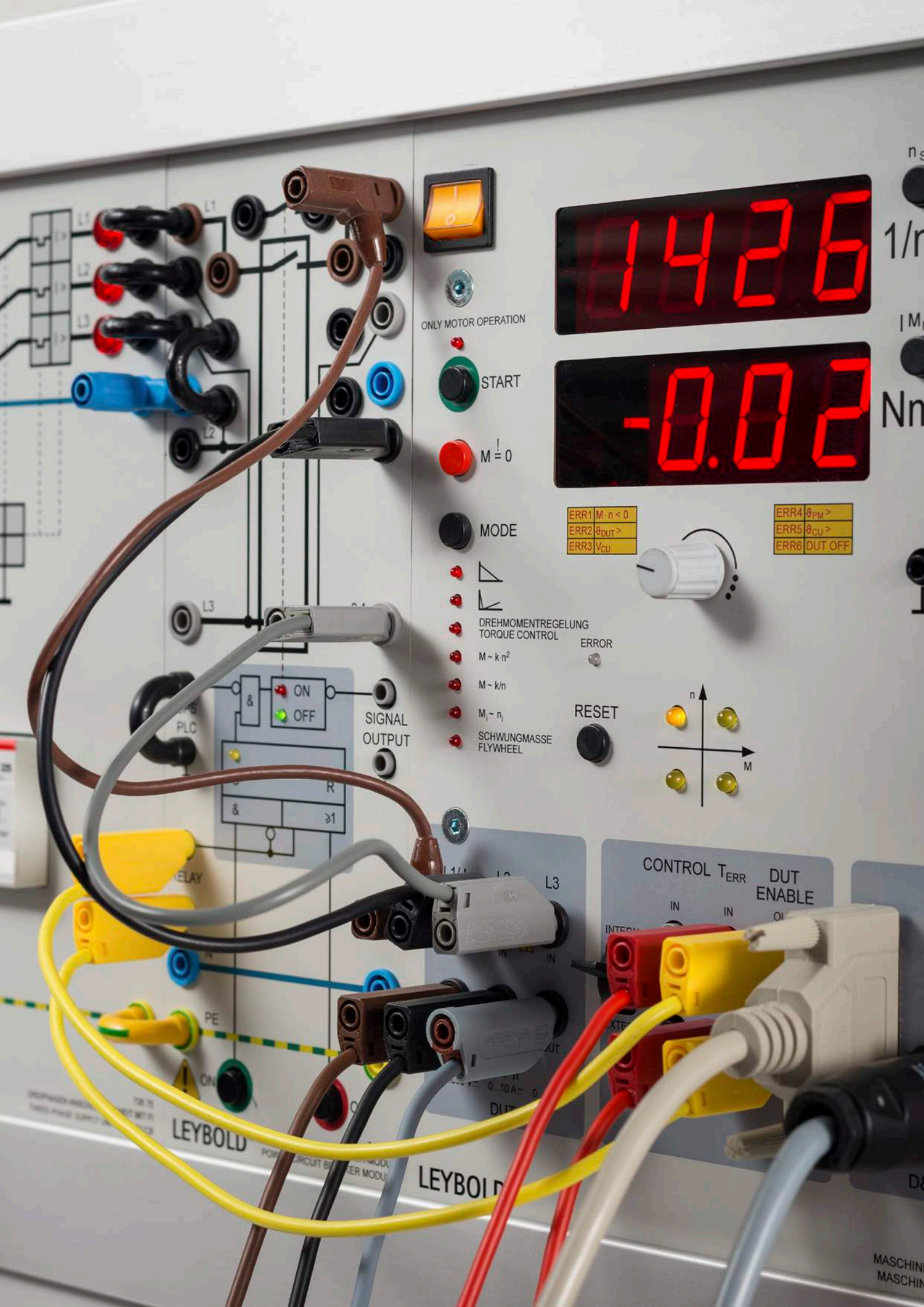
Compact device for systematic error detection in conventional contactor circuits. By masking different masks, only the measurement and connection points which are important for the circuit depicted on the mask are released.

On the left side of the device is behind a lockable door the control panel for the instructor, which contains next to the protection devices, the mask selector switch also error switch.

Students should learn a systematic error search with the help of voltage- and continuity testers.

The error analysis is carried out in 4 steps

- Description of the error
- Suppose cause
- Error detection by measurement
- Description Test method


1426
-0.02
ONLY MOTOR OPERATION
START
M ≐ 0
MODE
ERR1 M·n < 0
ERR2 ϑDUT >
ERR3 VCU
ERR4 ϑPM >
ERR5 ϑCU >
ERR6 DUT OFF
DREHMOMENTREGELUNG
TORQUE CONTROL
ERROR
M ~ k·n²
M ~ k/n
Mi ~ ni
SCHWUNGMASSE
FLYWHEEL
RESET
SIGNAL
OUTPUT
ON
OFF
CONTROL TERR
DUT
ENABLE
LEYBOLD

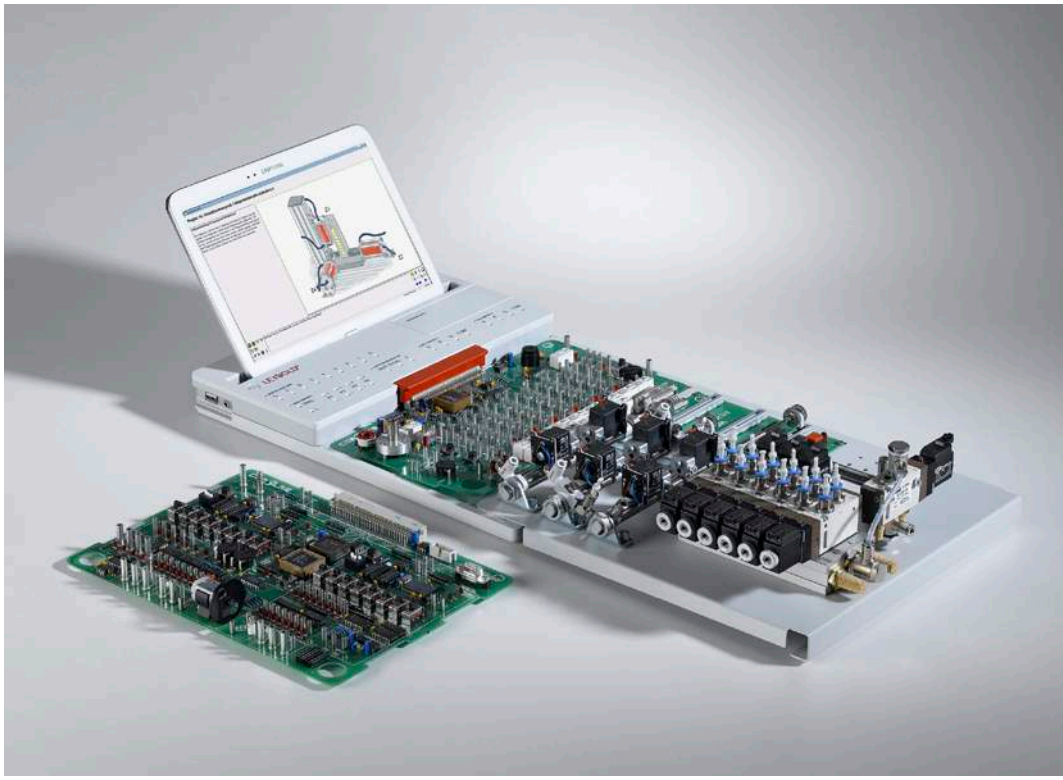
E6.6 AUTOMATION TECHNOLOGY

E6.6.1

COM3LAB MULTIMEDIA: AUTOMATION

E6.6.1.1
Basics of
Automation Technology

E6.6.1.2
Pneumatics Board



Basics of Automation Technology (E6.6.1.1)

Cat. No.	Description	E6.6.1.1	E6.6.1.2
700 3101	COM3LAB Course: Automation and Bus Technology	1	1
700 020	COM3LAB: Master Unit	1	1
700 022	Set of Safety Cables (2 mm, 16 Qty., 6 x 30 cm & 10 x 15 cm)	1	1
688 129	Mains cable with hock-proof plug and cold connector	1	1
700 00CBT	DVD: COM3LAB Software	1	1
728 871	Software: 5 Modells CBS 9 (single user)	1	
728 872	Software: 5 Models CBS 9 (licence for 25 places)	1	
730 4313	Bus connecting plug RS 485	1	
524 016S2	Profi-CASSY Starter 2	1	
700 027	COM3LAB: Suitcase	1*	1*
700 3501	COM3LAB Course: Electro Pneumatics		1
700 351	COM3LAB: Pneumatics Board		1
744 600	Low-noise Compressor		1*
744 902	Compressor Connection Hosing		1*
	additionally required: 1 PC with Windows 7/8/10		

* additionally recommended

Automation and Bus Technology

The COM3LAB course Bus and Automation technology teaches the basics of programmable logic controllers (PLC) and shows their interconnection including sensors and actuators using the PROFIBUS.

With many examples, explanations, exercises and practical tasks, the basic principles and functions of the PLC and the PROFIBUS are clearly illustrated.

The combination with external PROFIBUS components or an external system simulator enables the processes in the bus and automation technology to be illustrated and tracked as accurately as possible and without any great amount of effort.

Topics

- Motor control
- Traffic light control
- etc.

Pneumatics

The COM3LAB course Electropneumatics teaches the basics of electropneumatics using the BIBB standard tasks.

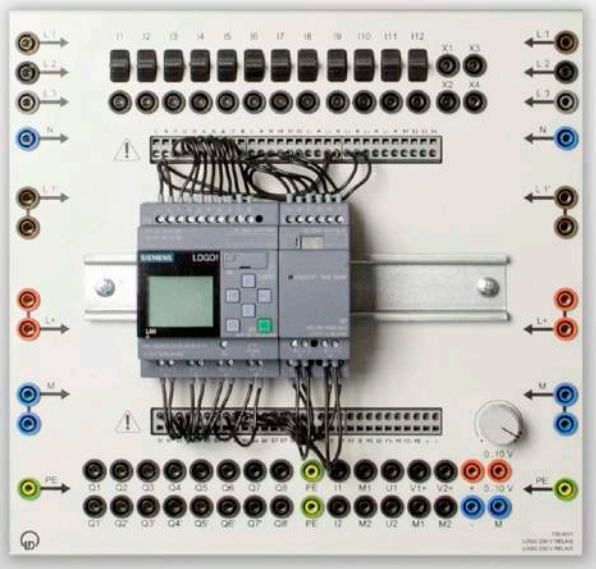
The COM3LAB course Automation technology explains the function and application of a PLC. Several examples make it easy to learn the PLC computer language.

Both courses can be combined so that complete process cycles can be executed and documented. This kind of project work supports independent and creative handling.

Topics

- Function and use of electronic and pneumatic components
- Electronic and pneumatic schematics
- etc.

Experiments are operated and evaluated with COM3LAB CBT.



E6.6.2

LOGIC CONTROLLERS & PROCESS VISUALISATION

E6.6.2.1
Basic Package LOGO! 8

E6.6.2.11
Trainer Package 6x LOGO! 8

Basic Package LOGO! 8 (E6.6.2.1)

Cat. No.	Description	E6.6.2.1	E6.6.2.11
773 041	LOGO! 8 12/24	1	
8-2 412470-100-10-1	Power supply 24 V DC, 6.5 A, for 230 V AC	1	6
689 3000	RJ45 crossover Cable 2m	1	6
773 055	HMI Touch Panel Basic	1*	6*
773 090	Logo! Software	1	
726 10	Panel frame T150, two-level	1*	6*
500 59	Safety bridging plugs, black, set of 10	1*	6
500 591	Safety bridging plugs, yellow/green, set of 10	1*	6*
773 050	ASIMA Plant Simulator II	1*	6*
700 00CBT	DVD: COM3LAB Software	1*	1*
500 614	Safety connecting lead, 25 cm, black	24*	144*
500 611	Safety connecting lead, 25 cm, red	1*	6*
500 612	Safety connecting lead, 25 cm, blue	1*	6*
773 045	LOGO! 8 12/24 TP 6 x		1
	A selection of 12 masks can be found in E6.7.1.1.	1	1

* additionally recommended

Logic Controllers & Process Visualisation

When it comes to smaller control tasks, small control systems - also called control relays or logic modules - are the perfect introduction to the world of stored program controls. It is operated with an integrated key pad and LCD display. Alternatively, control programs can also be created on the PC.

Basic functions:
AND, OR, NOT, NANO, NOR, XOR

Special functions:

Power-on delay, Power-off delay, Impulse generator, Counter (forward and backward), Time switch

The experiments are carried out with the small controller LOGO! 8 from Siemens. The logic module is set on a base plate and hung in a profile frame. The students are expected to program the LOGO! 8 and learn the main functions of small controllers in the process.

Topics

- Programming a small controller
- Logic connections
- Timer and clock timer functions
- RS components
- Measure counting and frequencies
- Analogue value processing
- etc.

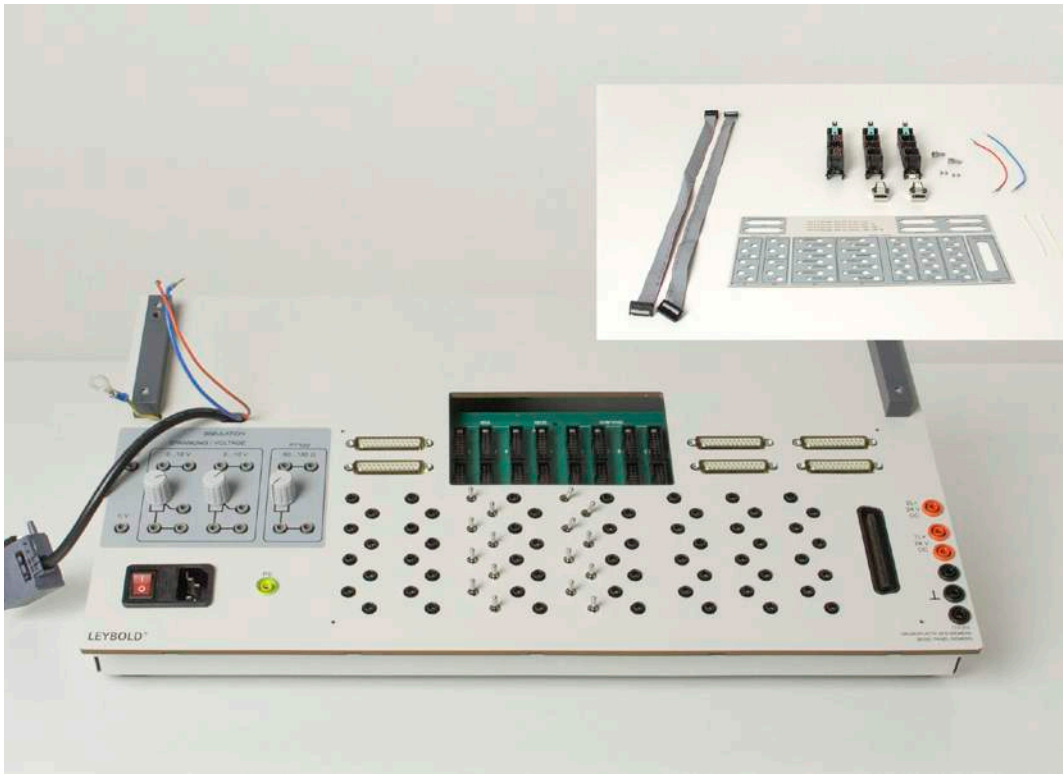
Experiments require the Siemens software LOGO! to create programs. The equipment can require additional software modules.

E6.6.3

PLC & PROCESS VISUALISATION

E6.6.3.1
Basic Package
S7-1512C-1 PN

E6.6.3.11
Trainer Package
S7-1512C-1 PN



Basis Paket S7-1512C-1 PN (E6.6.3.1)

Cat. No.	Description	E6.6.3.1	E6.6.3.11
773 070	Basic Panel Siemens	1	
773 073	Assembly set PLC S7-1512	1	
8-1 012027-000-10-0	Siemens HMI TP700	1*	1*
726 10	Panel frame T150, two-level	1*	1*
500 59	Safety bridging plugs, black, set of 10	1*	1*
773 050	ASIMA Plant Simulator II	1*	1*
700 00CBT	DVD: COM3LAB Software	1*	1*
773 072	Simatic PLC S7-1512C-1 PN TP		1
	A selection of 33 masks can be found in E6.7.1.3.	1	1

* additionally recommended

PLC & Process Visualisation

Equipment set E6.6.3.1

This course familiarises students with the most important functions of a stored program control (SPC). The basic package for the Siemens SPC S7-1512C-1 PN contains only the assembly components and accessories. The SPC is not included in the kit.

Equipment set E6.6.3.11

This course familiarises students with the most important functions of a stored program control (SPC). The trainer package for Siemens SPC S7-1512C-1 PN contains assembly parts and accessories including the necessary SPC.

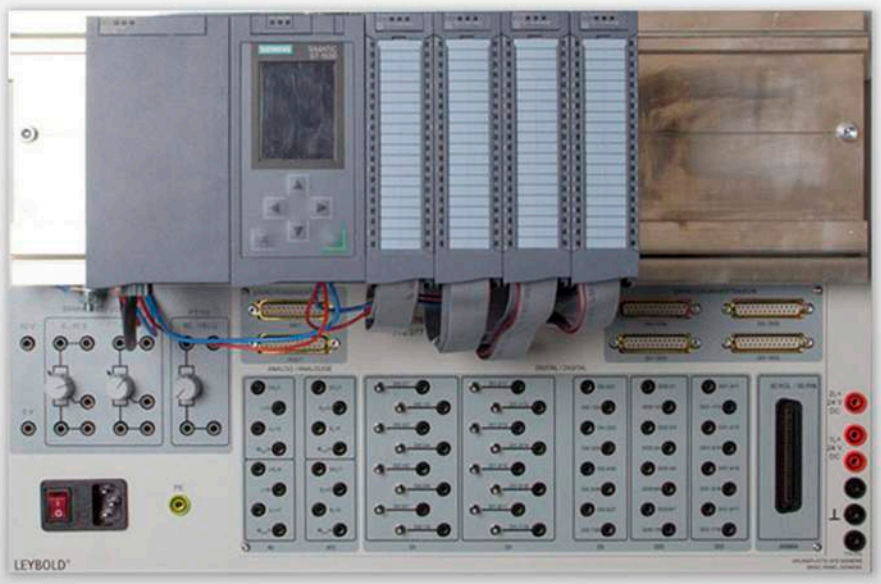
Educational objectives

- Creating programs
- Learn logistics and control functions
- Testing the programs
- Set up the network connections for Profi-Net

Topics

- Programming of an SPC
- Programming method KOP, FUP, AWL, S7-GRAPH
- Expanded program structure
- Logic connections
- Timer and clock timer functions
- etc.

Experiments require the Siemens software TIA Portal to create programs.
The equipment can require additional software modules.



E6.6.3

PLC & PROCESS VISUALISATION

E6.6.3.2
Basic Package
S7-1512C-1 PN +DP

E6.6.3.21
Trainer Package
PLC S7-1512C-1 PN +DP

Trainer Paket S7-1512C-1 PN +DP (E6.6.3.21)

Cat. No.	Description	E6.6.3.2	E6.6.3.21
773 070	Basic Panel Siemens	1	
773 073	Assembly set PLC S7-1512	1	
8-1 012027-000-10-0	Siemens HMI TP700	1*	1*
773 091	Simatic Step 7 Prof. Training 1x	1*	
726 10	Panel frame T150, two-level	1*	1*
500 59	Safety bridging plugs, black, set of 10	1*	1*
689 3000	RJ45 crossover Cable 2m	1*	
773 050	ASIMA Plant Simulator II	1*	1*
700 00CBT	DVD: COM3LAB Software	1*	1*
773 075	Simatic PLC S7-1512C-1 PN +DP TP		1
	A selection of 33 masks can be found in E6.7.1.3.	1	1

PLC & Process Visualisation

Equipment set E6.6.3.2

This course familiarises students with the most important functions of a stored program control (SPC). The basic package for the Siemens SPC S7-1512C-1 PN+DP contains only the assembly components and accessories. The SPC is not included in the kit.

Equipment set E6.6.3.21

This course familiarises students with the most important functions of a stored program control (SPC). The trainer package for Siemens SPC S7-1512C-1 PN+DP contains assembly parts and accessories including the necessary SPC.

Educational objectives

- Operating the SPC
- Creating programs
- Learn logistics and control functions
- Testing the programs

Topics

- Programming of an SPC
- Programming method KOP, FUP, AWL, S7-GRAPH
- Expanded program structure
- Logic connections
- Timer and clock timer functions
- etc.

Experiments require the Siemens software TIA Portal to create programs.

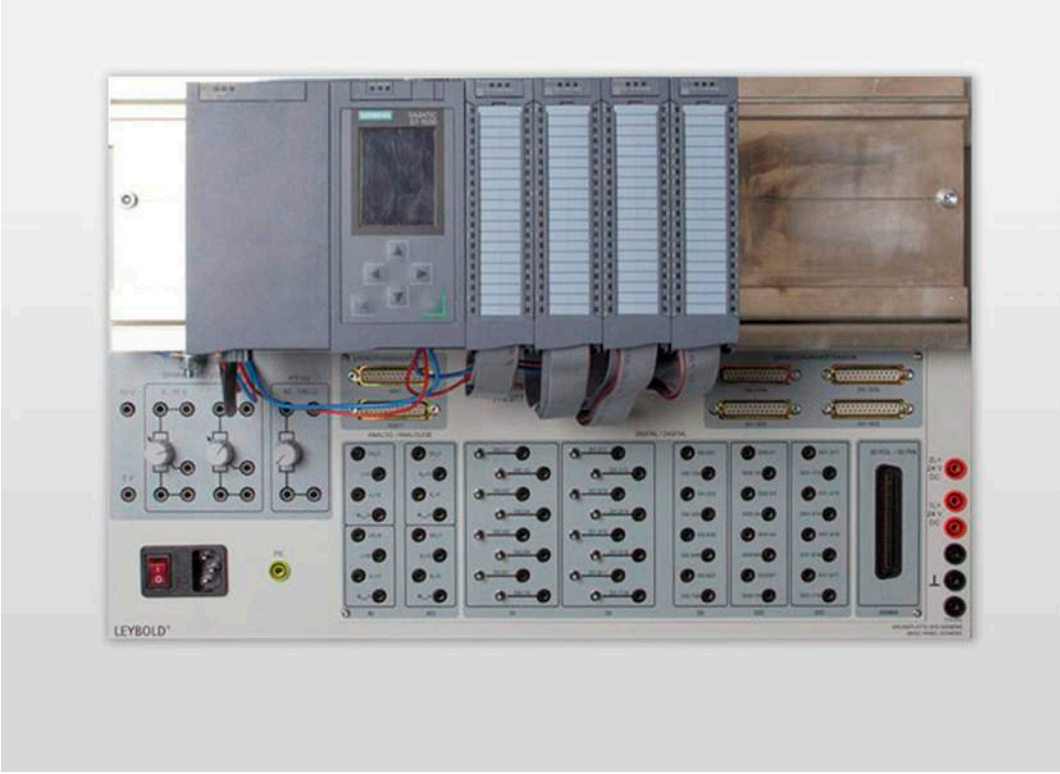
The equipment can require additional software modules.

E6.6.3

PLC & PROCESS VISUALISATION

E6.6.3.3
Basic Package
S7-1516 PN/DP

E6.6.3.31
Trainer Package
PLC S7-1516 PN/DP



Basic Package S7-1516 PN/DP (E6.6.3.3)

Cat. No.	Description	E6.6.3.3	E6.6.3.31
773 070	Basic Panel Siemens	1	
773 078	Assembly set PLC S7-1516	1	
8-1 012027-000-10-0	Siemens HMI TP700	1*	1*
773 091	Simatic Step 7 Prof. Training 1x	1*	
726 10	Panel frame T150, two-level	1*	1*
500 59	Safety bridging plugs, black, set of 10	1*	1*
689 3000	RJ45 crossover Cable 2m	1*	
773 050	ASIMA Plant Simulator II	1*	1*
700 00CBT	DVD: COM3LAB Software	1*	1*
773 077	Simatic S7-1516 PN/DP TP		1
	A selection of 33 masks can be found in E6.7.1.3.	1	1

* additionally recommended

PLC & Process Visualisation

Equipment set E6.6.3.3

This course familiarises students with the most important functions of a stored program control (SPC). The basic package for the Siemens SPC S7-1516-3 PN/DP contains only the assembly components and accessories. The SPC is not included in the kit.

Equipment set E6.6.3.31

This course familiarises students with the most important functions of a stored program control (SPC). The trainer package for Siemens SPC S7-1516-3 PN/DP contains assembly parts and accessories including the necessary SPC.

Educational objectives

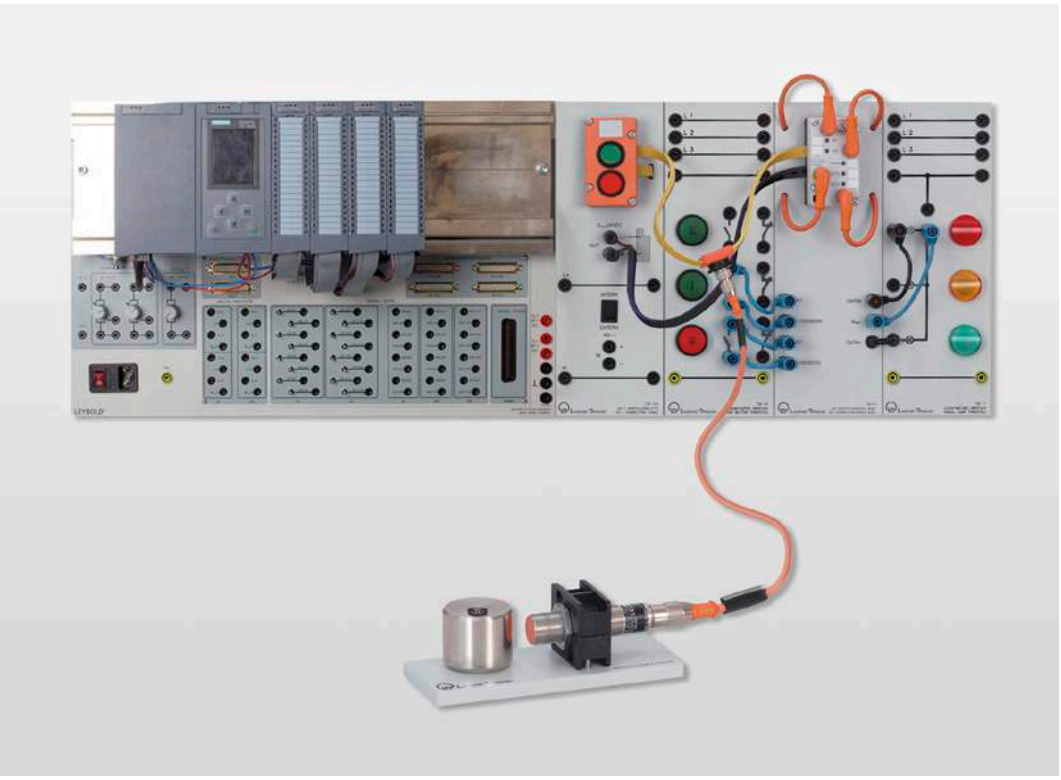
- Operate the SPC
- Create programs
- Learn logistics and control functions
- Test the programs
- Set up the network connections for Profi-Net and Profi-Bus / DP

Topics

- Programming of an SPC
- Programming method LAD, SFC, STL, S7-GRAPH
- Expanded program structure
- Logic connections
- Timer and time switch functions, fast counter
- etc.

Experiments require the Siemens software TIA Portal to create programs.

The equipment can require additional software modules.



AS-Interface (E6.6.4.1)

E6.6.4

INDUSTRIAL BUS SYSTEMS

E6.6.4.1
AS-Interface

Cat. No.	Description	E6.6.4.1
730 04	Pushbutton, Threefold	1
730 37	Signal Lamp 24V, Threefold	1
730 412	AS-I Connection Module 2E/2A	1
730 413	AS-I Set	1
730 414	AS-i Bus Testing Instrument	1
730 4312	Profibus cable	1
730 4101	DP / AS-I Communications Module	1
726 75	Three-phase supply unit with ELCB	1*
726 10	Panel frame T150, two-level	1*
500 59	Safety bridging plugs, black, set of 10	1*
500 614	Safety connecting lead, 25 cm, black	12*
500 611	Safety connecting lead, 25 cm, red	3*
500 612	Safety connecting lead, 25 cm, blue	3*
773 075	Simatic PLC S7-1512C-1 PN +DP TP	1*
773 077	Simatic S7-1516 PN/DP TP	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

AS-Interface

The student investigates the connection of sensors and actuators with the AS-i interface in the SPC. With the actuator sensor interface (AS-i), all you need is an unshielded two-wire cable to connect all sensors and actuators with the controller. The system is clearly organised and easy to install thanks to the cut-clamp technique.

Educational objectives

- Operate the SPC
- Connect the devices with the TIA portal
- Creating programs
- Connection of AS interface devices
- Testing the programs

Topics

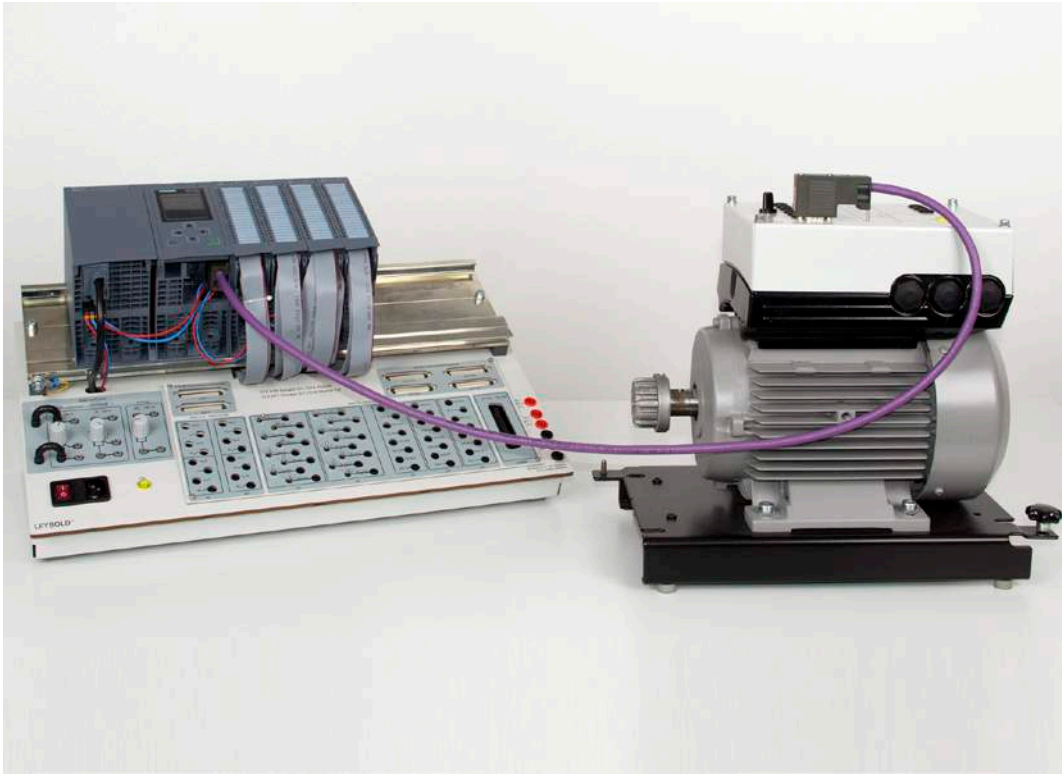
- Programming of an SPC
- Connection of AS-i components
- Programming methods LAD, SFC, STL, S7-GRAPH

Experiments require the Siemens software TIA Portal to create programs.
The equipment can require additional software modules.

E6.6.4

INDUSTRIAL BUS SYSTEMS

E6.6.4.2
PROFI-BUS



PROFI-BUS (E6.6.4.2)

Cat. No.	Description	E6.6.4.2
730 90	Gear w.2 Switch Arms 0.1/0.3	1
730 93	Limit Switch 1NO 1NC	2
730 95	Ind. Proximity Switch 3-DC	1*
730 97	Cap. Proximity Switch 3-DC	1*
732 46	Motor with FCC 0.3	1
735 314	LCP2 local control panel	1
730 431	Profibus Connection Cable	1
726 75	Three-phase supply unit with ELCB	1*
726 10	Panel frame T150, two-level	1*
500 591	Safety bridging plugs, yellow/green, set of 10	1*
500 644	Safety connecting lead, 100 cm, black	12*
500 640	Safety connecting lead, 100 cm, yellow/green	2*
500 59	Safety bridging plugs, black, set of 10	1*
773 075	Simatic PLC S7-1512C-1 PN +DP TP	1*
773 077	Simatic S7-1516 PN/DP TP	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

PROFI-Interface

Students will learn to connect outside devices (not from Siemens) to the SPC via the process field bus.

Educational objectives

- Operation of an SPC and a frequency converter
- Interpretation of GSD files
- Connect the devices with the TIA portal
- Creating SPC programs
- Connection of process field bus devices
- Testing the programs

Function

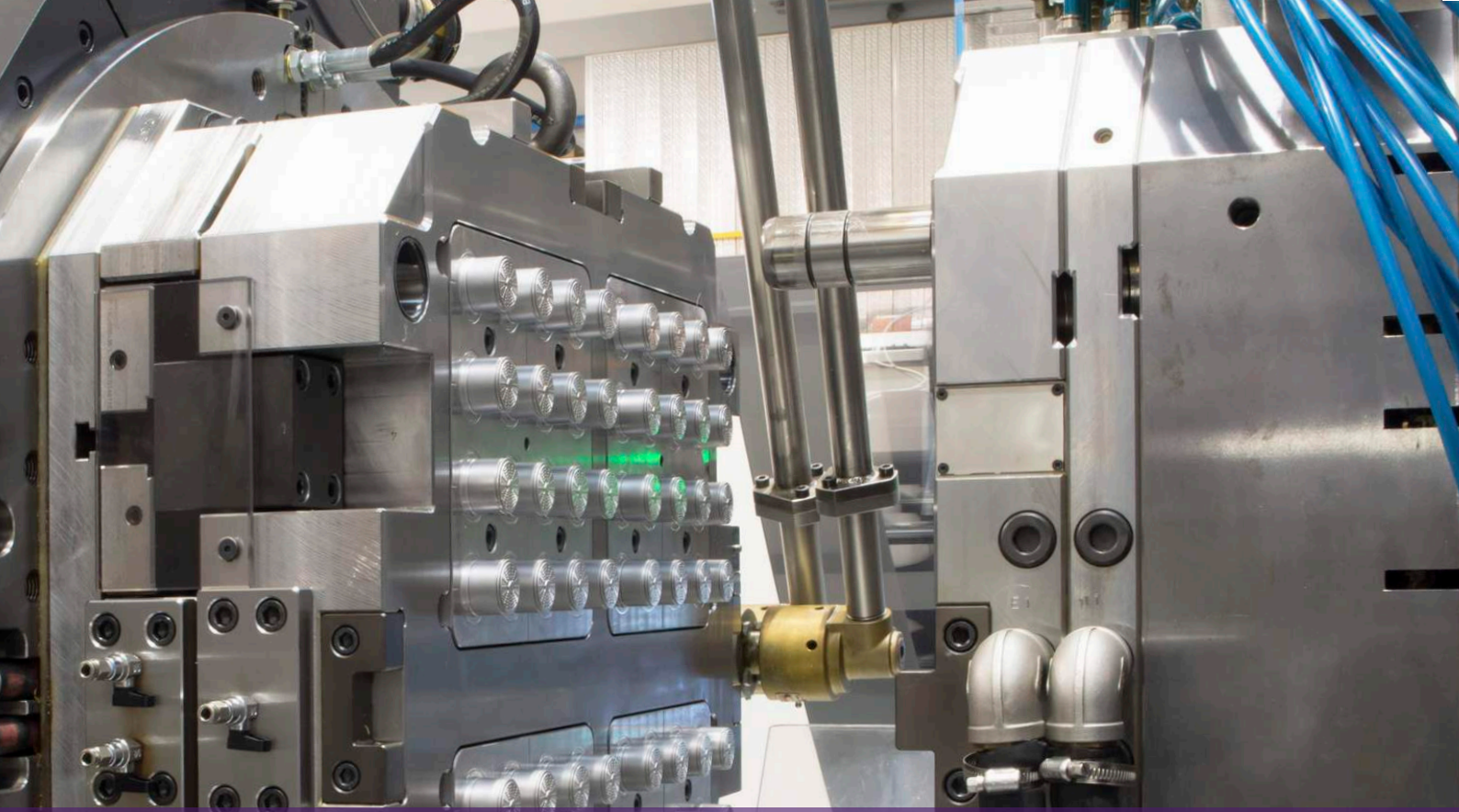
- SPS with a process field bus access
- Frequency converter with process field bus connection
- Process field bus cable
- Asynchronous machine
- Gearing with gearshift arm
- Limit switch

Topics

- Programming of an SPC
- Programming method KOP, FUP, AWL, S7-GRAPH
- Connection of PROCESS FIELD BUS devices
- Expanded program structure

Experiments require the Siemens software TIA Portal to create programs.

The equipment can require additional software modules.



E6.7 PROCESS AUTOMATION

E6.7.1 PLANT SIMULATION

- E6.7.1.1 ASIMA FOR SMALL LOGIC CONTROLLERS
- E6.7.1.2 ASIMA FOR PLC - BASIC
- E6.7.1.3 ASIMA FOR PLC - ADVANCED
- E6.7.1.4 SMALL MODELS & SOFTWARE MODELS
- E6.7.1.5 END POSITION & SPEED CONTROL

E6.7.2 MECHATRONICS

- E6.7.2.1 MCS WITH PLC FOR 3 STATIONS
- E6.7.2.2 MCS WITH PLC FOR 5 STATIONS
- E6.7.2.3 DUAL CONVEYOR BAND WITH PLC
- E6.7.2.4 ELEVATOR CONTROL WITH PLC
- E6.7.2.5 WASHING MACHINE - PLC APPLICATION
- E6.7.2.6 TRAFFIC LIGHT - PLC APPLICATION
- E6.7.2.7 PLC TRAINER

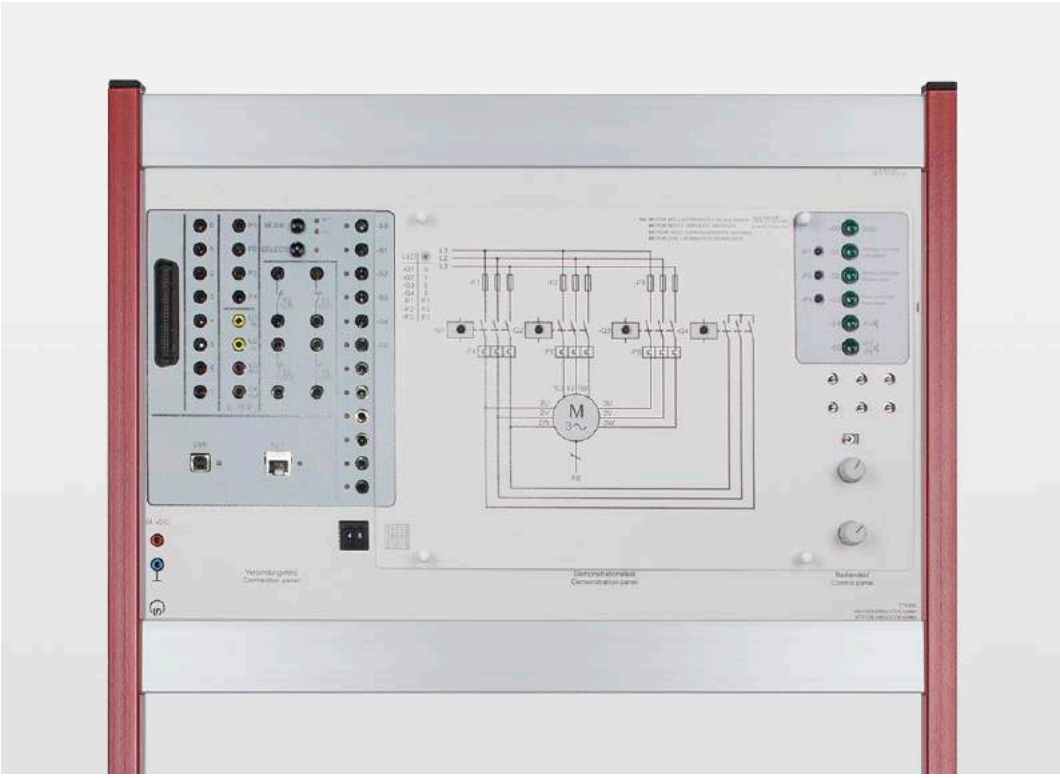
E6.7.3 CHEMICAL PROCESS ENGINEERING

- E6.7.3.1 BLUE-BOTTLE PROCESS WITH PLC

E6.7.1

PLANT SIMULATION

E6.7.1.1
ASIMA for
Small Logic Controllers



ASIMA for Small Logic Controllers (E6.7.1.1)

Cat. No.	Description	E6.7.1.1
773 050	ASIMA Plant Simulator II	1
700 00CBT	DVD: COM3LAB Software	1
8-2 412123-000-10-0	50-pole ribbon cable, 700 mm	1
8-5 212642-000-10-0	LIT: Control of system simulations	1*
8-2 412215-000-19-0	Mask M1 Logic basic functions	1
8-2 412216-000-19-0	Mask M2 Digital function modules	1
8-2 412217-000-19-0	Mask M3 Motor ON/OFF	1
8-2 412218-000-19-0	Mask M4 Reversing contactor	1
8-2 412219-000-19-0	Mask M5 Star-delta connection	1
8-2 412220-000-19-0	Mask M6 Reversing star-delta connection	1
8-2 412221-000-19-0	Mask M7 Pendulum table control	1
8-2 412222-000-19-0	Mask M8 Dahlander circuit	1
8-2 412223-000-19-0	Mask M9 Motor with 2 windings	1
8-2 412224-000-19-0	Mask M10 Motor self-starter	1
8-2 412225-000-19-0	Mask M11 Conveyor belt system	1
8-2 412226-000-19-0	Mask M12 Reactive-current compensation	1
8-2 412227-000-19-0	Mask M13 Heating control	1
8-2 600001-000-10-0	Transparent folder, 410 mm x 320 mm x 10 mm	2
726 10	Panel frame T150, two-level	1*
726 75	Three-phase supply unit with ELCB	1*
562 793NA	Power Adapter 6...24 V	1*
500 59	Safety bridging plugs, black, set of 10	1*
500 614	Safety connecting lead, 25 cm, black	24*
500 611	Safety connecting lead, 25 cm, red	1*
500 612	Safety connecting lead, 25 cm, blue	1*

Cat. No.	Description	E6.7.1.1
773 041	LOGO! 8 12/24	1*
773 045	LOGO! 8 12/24 TP 6 x	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

ASIMA for Small Logic Controllers

The System Simulator II (ASIMA) is optimally designed for operation with small controller LOGO! 8. ASIMA provides a total of 13 different applications (view summary table) for small controllers. The broad experiment spectrum ranges from testing of SPC functions through to controlling small controllers and facilitates universal use of ASIMA in education.

Educational objectives

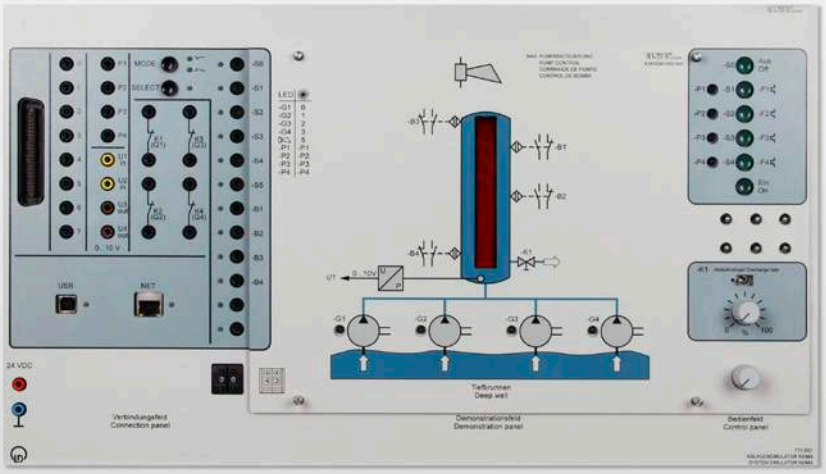
- Programming simple basic circuits.
- Programming machine circuits

Topics

- Basic logic functions
- Digital function components
- etc.

Experiments require the Siemens software TIA Portal to create programs.

The equipment can require additional software modules.



ASIMA for PLC - Basic (E6.7.1.2)

E6.7.1

PLANT SIMULATION

E6.7.1.2
ASIMA for PLC - Basic

Cat. No.	Description	E6.7.1.2
773 050	ASIMA Plant Simulator II	1
700 00CBT	DVD: COM3LAB Software	1
8-2 412123-000-10-0	50-pole ribbon cable, 700 mm	1
8-5 212642-000-10-0	LIT: Control of system simulations	1*
8-2 412215-000-19-0	Mask M1 Logic basic functions	1
8-2 412216-000-19-0	Mask M2 Digital function modules	1
8-2 412217-000-19-0	Mask M3 Motor ON/OFF	1
8-2 412218-000-19-0	Mask M4 Reversing contactor	1
8-2 412219-000-19-0	Mask M5 Star-delta connection	1
8-2 412220-000-19-0	Mask M6 Reversing star-delta connection	1
8-2 412221-000-19-0	Mask M7 Pendulum table control	1
8-2 412222-000-19-0	Mask M8 Dahlander circuit	1
8-2 412223-000-19-0	Mask M9 Motor with 2 windings	1
8-2 412224-000-19-0	Mask M10 Motor self-starter	1
8-2 412225-000-19-0	Mask M11 Conveyor belt system	1
8-2 412226-000-19-0	Mask M12 Reactive-current compensation	1
8-2 412227-000-19-0	Mask M13 Heating control	1
8-2 412228-000-19-0	Mask M14 Running light	1
8-2 412229-000-19-0	Mask M15 Tablets machine	1
8-2 412231-000-19-0	Mask M17 Coal grinder	1
8-2 412232-000-19-0	Mask M18 Embossing machine	1
8-2 412234-000-19-0	Mask M20 Traffic light for road works	1
8-2 412235-000-19-0	Mask M21 Traffic lights	1
8-2 600001-000-10-0	Transparent folder, 410 mm x 320 mm x 10 mm	2
726 10	Panel frame T150, two-level	1*

Cat. No.	Description	E6.7.1.2
726 75	Three-phase supply unit with ELCB	1*
562 793NA	Power Adapter 6...24 V	1*
500 614	Safety connecting lead, 25 cm, black	30*
500 611	Safety connecting lead, 25 cm, red	3*
500 612	Safety connecting lead, 25 cm, blue	3*
500 59	Safety bridging plugs, black, set of 10	1*
500 591	Safety bridging plugs, yellow/green, set of 10	1*
773 072	Simatic PLC S7-1512C-1 PN TP	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

ASIMA for PLC – Basic

The System Simulator II (ASIMA) is optimally suited for operation with the SPC S7-1200 and S7-1512. 19 different applications (view summary table) are available in the basics setup. The broad experiment spectrum ranges from testing of SPC functions through to controlling small controllers and facilitates universal use of ASIMA in education.

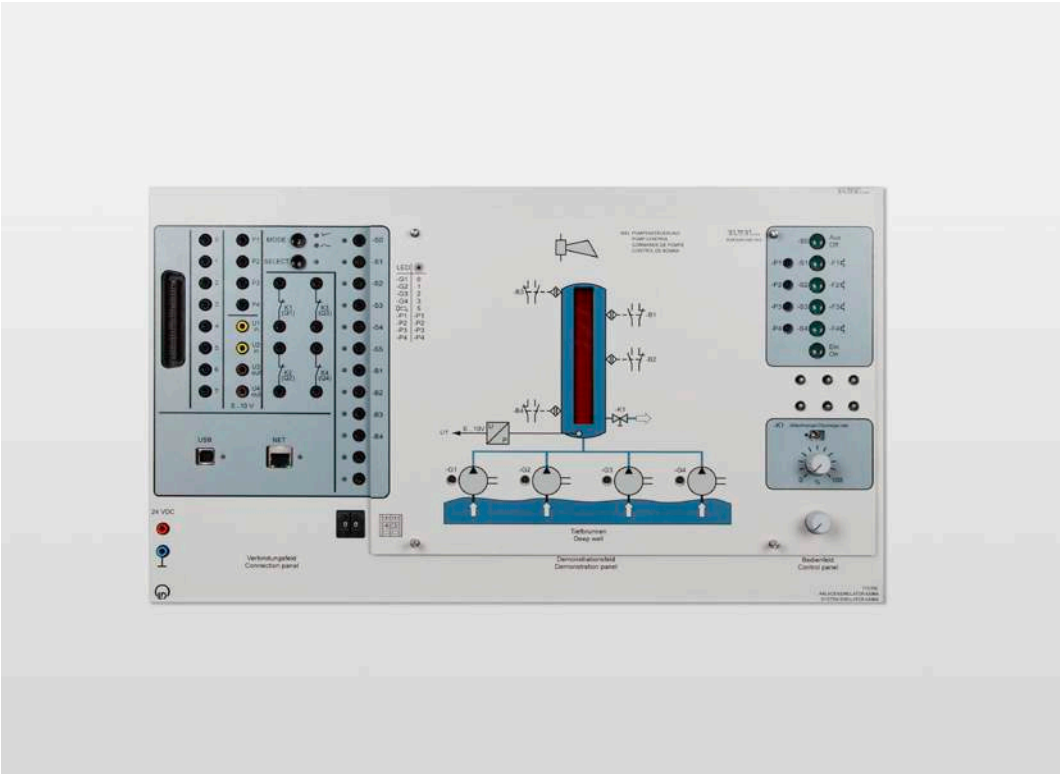
Experiments require the Siemens software TIA Portal to create programs.

The equipment can require additional software modules.

E6.7.1

PLANT SIMULATION

E6.7.1.3
ASIMA for PLC - Advanced

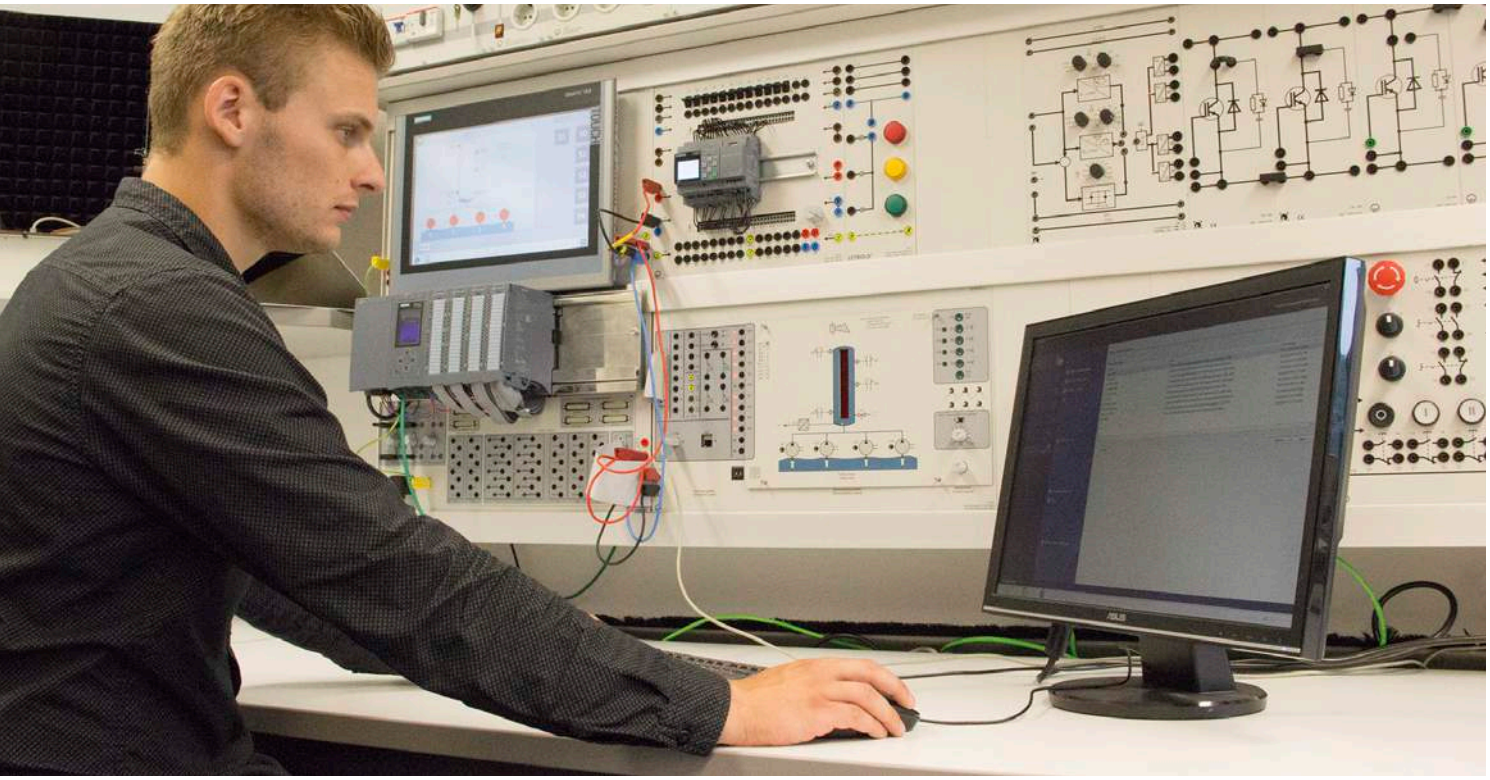


ASIMA for PLC - Advanced (E6.7.1.3)

Cat. No.	Description	E6.7.1.3
773 050	ASIMA Plant Simulator II	1
700 00CBT	DVD: COM3LAB Software	1
8-2 412123-000-10-0	50-pole ribbon cable, 700 mm	1
8-2 412215-000-19-0	Mask M1 Logic basic functions	1
8-2 412216-000-19-0	Mask M2 Digital function modules	1
8-2 412217-000-19-0	Mask M3 Motor ON/OFF	1
8-2 412218-000-19-0	Mask M4 Reversing contactor	1
8-2 412219-000-19-0	Mask M5 Star-delta connection	1
8-2 412220-000-19-0	Mask M6 Reversing star-delta connection	1
8-2 412221-000-19-0	Mask M7 Pendulum table control	1
8-2 412222-000-19-0	Mask M8 Dahlander circuit	1
8-2 412223-000-19-0	Mask M9 Motor with 2 windings	1
8-2 412224-000-19-0	Mask M10 Motor self-starter	1
8-2 412225-000-19-0	Mask M11 Conveyor belt system	1
8-2 412226-000-19-0	Mask M12 Reactive-current compensation	1
8-2 412227-000-19-0	Mask M13 Heating control	1
8-2 412228-000-19-0	Mask M14 Running light	1
8-2 412229-000-19-0	Mask M15 Tablets machine	1
8-2 412230-000-19-0	Mask M16 Tank system	1
8-2 412231-000-19-0	Mask M17 Coal grinder	1
8-2 412233-000-19-0	Mask M19 Fan control	1
8-2 412234-000-19-0	Mask M20 Traffic light for road works	1
8-2 412235-000-19-0	Mask M21 Traffic lights	1
8-2 412236-000-19-0	Mask M22 Collecting belt conveyor	1
8-2 412237-000-19-0	Mask M23 Conveyor charging system	1

Cat. No.	Description	E6.7.1.3
8-2 412232-000-19-0	Mask M18 Embossing machine	1
8-2 412240-000-19-0	Mask M40 Silo control	1
8-2 412241-000-19-0	Mask M41 Reactor	1
8-2 412242-000-19-0	Mask M42 Goods lift	1
8-2 412243-000-19-0	Mask M43 Pump control	1
8-2 412244-000-19-0	Mask M44 Dirty-water pump system	1
8-2 412245-000-19-0	Mask M45 Monitoring of 3 pumps	1
8-2 412246-000-19-0	Mask M46 Pump system (pressure)	1
8-2 412247-000-19-0	Mask M47 Drinks machine	1
8-2 412248-000-19-0	Mask M48 Mixer	1
8-2 412249-000-19-0	Mask M49 Sequence control	1
8-2 600001-000-10-0	Transparent folder, 410 mm x 320 mm x 10 mm	3
8-5 212642-000-10-0	LIT: Control of system simulations EN	1*
726 10	Panel frame T150, two-level	1*
726 75	Three-phase supply unit with ELCB	1*
562 793NA	Power Adapter 6...24 V	1*
500 59	Safety bridging plugs, black, set of 10	1*
773 075	Simatic PLC S7-1512C-1 PN +DP TP	1*
773 077	Simatic S7-1516 PN/DP TP	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended



ASIMA for PLC – Advanced

ASIMA System Simulator II is the perfect addition for the SPC S7-1516. A total of 33 different systems are available. The experiment spectrum ranges from testing of SPC functions through to complex systems with controllers and facilitates universal use of ASIMA in education.

Educational objectives

- Programming simple basic circuits
- Programming machine circuits
- Programming small systems
- Programming of complex systems and devices

The set contains the basic device ASIMA System Simulator II, including a collection of tasks on CD. ASIMA is connected with the SPC via 4 mm safety connectors or a 50-pole ribbon cable (700 mm).

The following is made available:

- 12 digital inputs, 12 digital outputs
- 2 analogue inputs, 2 analogue outputs
- 4 relay with break contact
- Control and display elements:
- 6 buttons, 6 button incremental switch, 33 LEDs
- 2 potentimeter with 0 ... 10 V DC
- 1 bar graph display comprised of 24 segments

Method

The setup is designed for students and student experiments. Practical exercises require that the learner resolve the respective controller problem with their own programming. Suggested solutions are included as a file.

Target Group

Trainees studying industrial electro technology, focusing on automation engineering are the target group being addressed. The course offers experiments for beginners and intermediate learners for trade school and vocational training.

Basic knowledge of programming principles is a minimum requirement.

Topics

The topics are handled by placing different screens on the basic ASIMA device.

For example:

- Sewage pump system
- Monitoring of 3 pumps
- Pump system (pressure)
- Beverage vending machine
- Mixing system
- Sequential control
- etc.

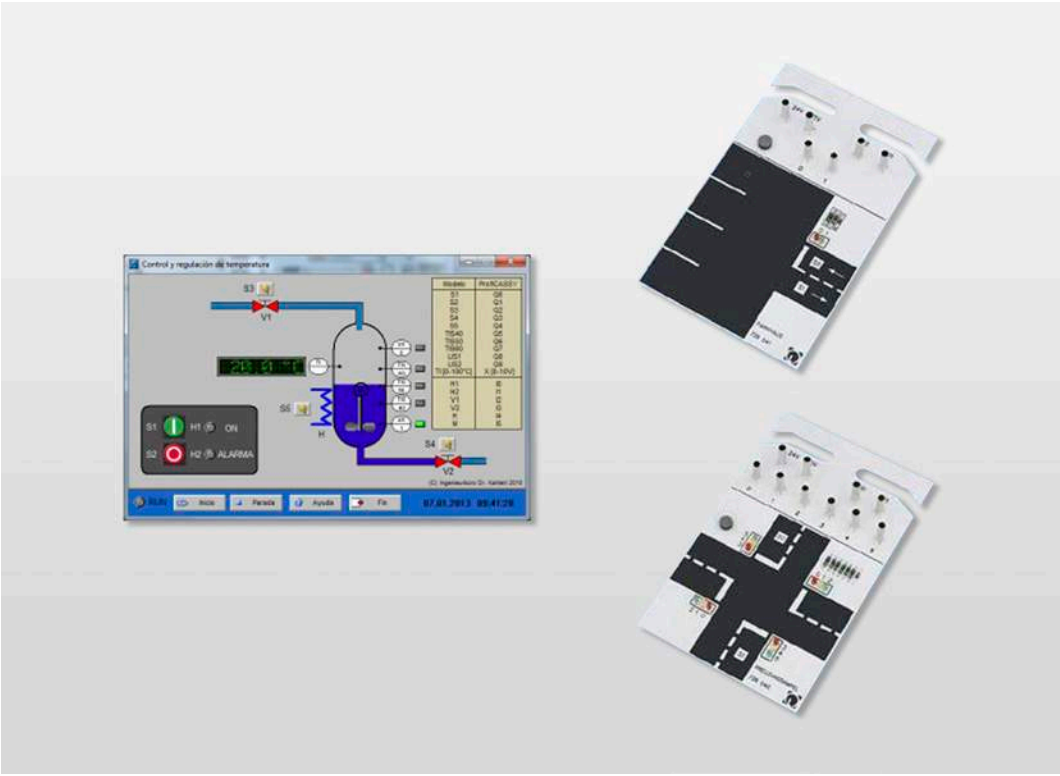
Experiments require the Siemens software TIA Portal to create programs.

The equipment can require additional software modules.

E6.7.1

PLANT SIMULATION

E6.7.1.4
Small Models &
Software Models



Small Models & Software Models (E6.7.1.4)

Cat. No.	Description	E6.7.1.4
728 740	Traffic Light Crossing, TM	1
728 741	Car Park, TM	1
728 871	Software: 5 Modells CBS 9 (single user)	1
730 431	Profibus Connection Cable	1
571 26	Adapter leads, 2/4 mm, 30 cm, blue, set of 5	2
524 016	Profi-CASSY	1
773 091	Simatic Step 7 Prof. Training 1x	1*
500 621	Safety connecting lead, 50 cm, red	2*
500 622	Safety connecting lead, 50 cm, blue	2*
773 075	Simatic PLC S7-1512C-1 PN +DP TP	1*
773 077	Simatic S7-1516 PN/DP TP	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Small Models & Software Models

The set works with SPC or small controllers. The processes to be controlled are real small models or software models. The software models are connected via the Profi-CASSY interface. When connected with the software models, the Profi-CASSY becomes a universal system simulator connected to the SPC via a PROCESS FIELD BUS or ribbon cable and to the PC via a USB. This means the PC has over 16 digital and 2 analogue inputs and outputs. There are process simulations for various systems that can be easily installed on the PC as software.

Educational objectives

- Operating the SPC
- Creating programs
- Connection of hardware and optimisation of the program using the model

Small models

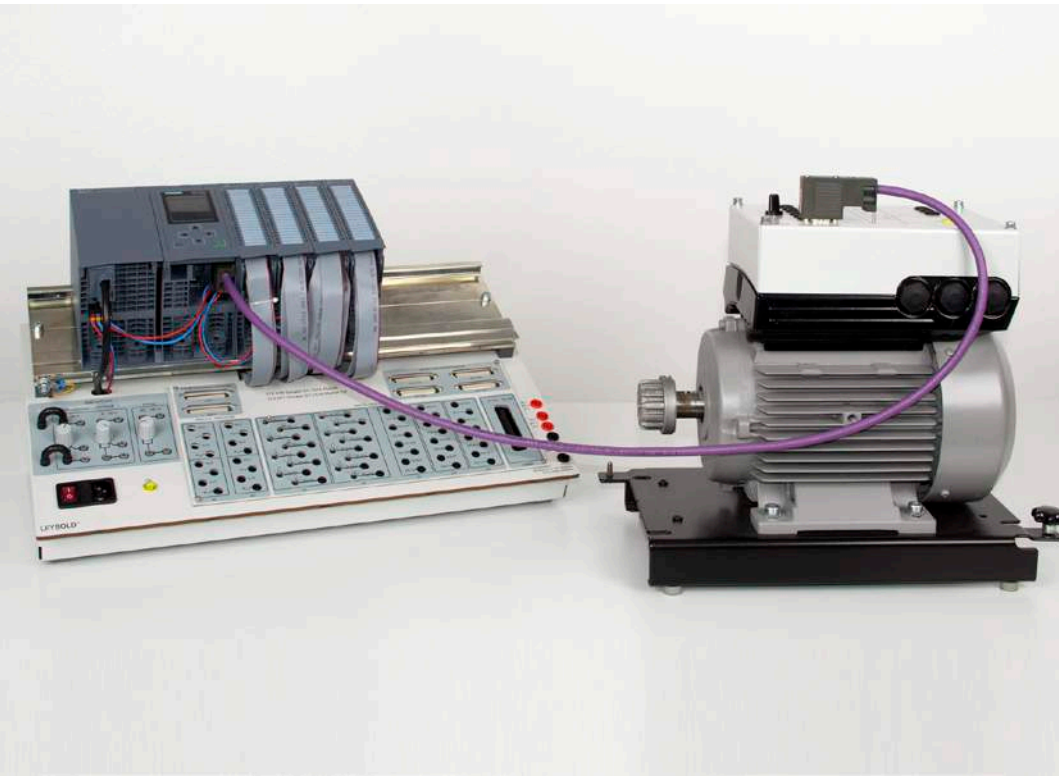
- Crosswalk light
- Parking garage

Software models

- Motor control
- Traffic light control
- Fill level control
- Service lift
- Stamp setup

Experiments require the Siemens software TIA Portal to create programs.

The equipment can require additional software modules.



End Position & Speed Control (E6.7.1.5)

E6.7.1

PLANT SIMULATION

E6.7.1.5
End Position &
Speed Control

Cat. No.	Description	E6.7.1.5
730 90	Gear w.2 Switch Arms 0.1/0.3	1
730 93	Limit Switch 1NO 1NC	1
730 95	Ind. Proximity Switch 3-DC	1
730 971	Cap. Proximity Switch	1
730 002	Operating panel	1
731 06	Coupling 0.3	1
731 081	Coupling guard 0.3 transparent	1
732 46	Motor with FCC 0.3	1
735 315USB	USB/RS 485 interface converter	1
730 431	Profibus Connection Cable	1
726 75	Three-phase supply unit with ELCB	1*
562 793NA	Power Adapter 6...24 V	1*
726 10	Panel frame T150, two-level	1*
500 59	Safety bridging plugs, black, set of 10	1*
500 640	Safety connecting lead, 100 cm, yellow/green	2*
500 644	Safety connecting lead, 100 cm, black	11*
773 075	Simatic PLC S7-1512C-1 PN +DP TP	1*
773 077	Simatic S7-1516 PN/DP TP	1*
	PC with operating system Windows 7/8/10	1

* additionally recommended

End Position & Speed Control

End positions are extreme positions that a moving workpiece can take up in a machine (electric window lifter, travelling cranes of building cranes, tool machines, etc.). In order to prevent hazards to people and machines, end positions and rotation speeds must be monitored. If the allowable limit values are exceeded, the processes are stopped by an end position switch or directly by the frequency converter.

Educational objectives

- Operating the SPC
- Connection of frequency converter to an SPC and optimisation of the program on the real system.
- Function review
- Creation of programs for machine controllers with frequency converters.
- Startup, rotation direction modification, ramp function, optimisation of SPC and frequency converter.
- Testing the programs on the hardware

Topics

- Program startup processes
- Automatic rotation direction change with frequency converters.
- Counting of revolutions during machine processes.
- etc.

Experiments require the Siemens software TIA Portal to create programs.

The equipment can require additional software modules.

E6.7.2

MECHATRONICS

E6.7.2.1
MCS with PLC for 3 Stations

E6.7.2.2
MCS with PLC for 5 Stations

MCS with PLC for 5 Stations (E6.7.2.2)

Cat. No.	Description	E6.7.2.1	E6.7.2.2
8-2 412352-000-10-0	Module FMPE: Gravity-feed Magazine with testing device	1	1
8-2 412353-000-10-0	Module SU: Swivelling Object-Transfer Device	1	1
8-2 412361-000-10-0	Module LAG03: Storage Depot with 3 stacks	1	
8-2 412357-000-10-0	Control Console BP	1	1
8-2 412362-000-10-0	Manual Service Unit	1	1
8-2 412358-000-10-0	Assortment of Small Parts and Tools	1	1
8-1 530025-000-10-0	Polyamide hose, 6/4 mm, transparent, 20 m	1	1
8-2 412470-100-10-1	Power supply 24 V DC, 6.5 A, for 230 V AC	1	
744 902	Compressor Connection Hosing	1	1
744 600	Low-noise Compressor	1	1
500 59	Safety bridging plugs, black, set of 10	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1
726 10	Panel frame T150, two-level	1	1
773 077	Simatic S7-1516 PN/DP TP	1*	1*
8-2 412374-000-10-0	STEP7 application software for MCS CD	1*	
8-2 412354-000-10-0	Module MA: Measurer / Counter, analog		1
8-2 412366-000-10-0	Module PPF02: Pick and Place, pneumatic, 2 positions		1
8-2 412355-000-10-0	Module SORT03: Sorting Station		1
8-2 412991-000-10-1	ET200S-Profibus module for two MCS-models, 4 mm safety sockets		1
730 4312	PROFIBUS cable		2

Cat. No.	Description	E6.7.2.1	E6.7.2.2
730 4313	Bus connecting plug RS 485		2
	additionally required: 1 PC with Windows 7/8/10		

* additionally recommended

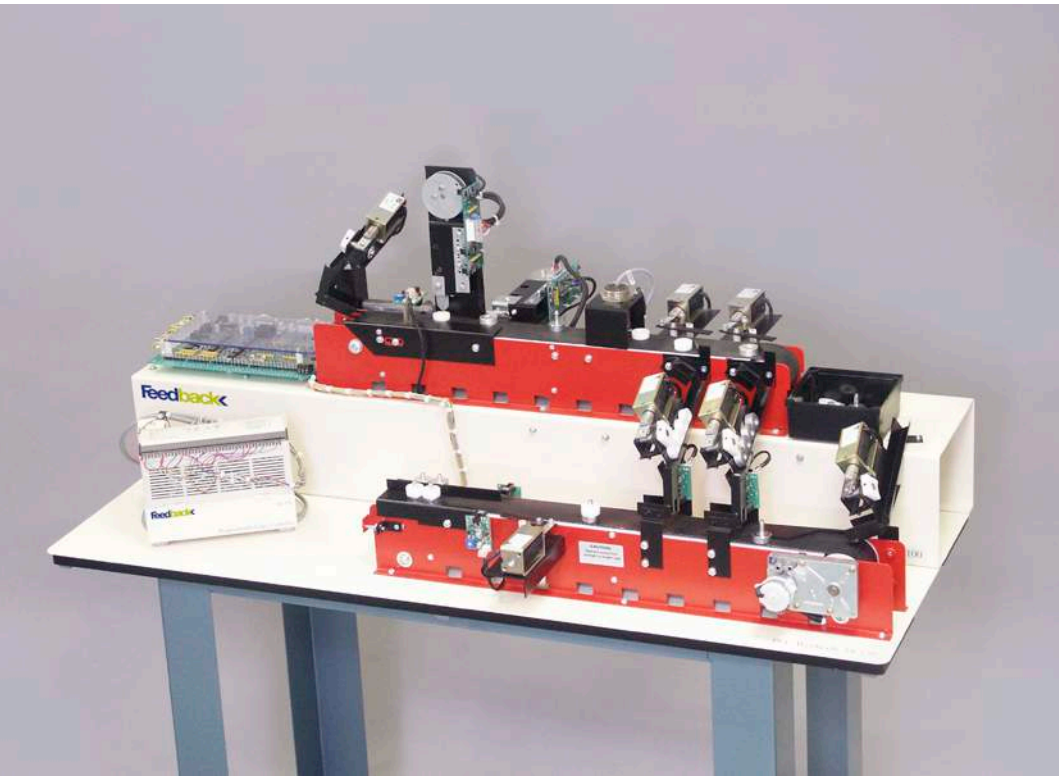
Mechatronic Compact System

The MCS (Mechatronic Compact System) is comprised of three individual systems, each with a basic mechatronic function. Connecting the systems determines the interaction of mechanics, pneumatics, electronics and SPC programming.

Topics

- Programs for process control
- Creation of sequential controls
- Differentiation of manual and automatic functions in programs.
- Plans for driving pneumatic valves.
- Collision-proof provision on a tray
- Micro switch for position recognition
- etc.

Experiments require the Siemens software TIA Portal to create programs.
The equipment can require additional software modules.



Dual Conveyor Band with PLC (E6.7.2.3)

E6.7.2

MECHATRONICS

E6.7.2.3
Dual Conveyor Band with PLC

Cat. No.	Description	E6.7.2.3
34-120-1	Dual Conveyor - PLC Application	1
34-060	Siemens PLC	1*
34-060-1	Siemens PLC I/O Pre-wired Pack	1
34-020	Mitsubishi PLC	1*
34-020-1	Mitsubishi PLC I/O Pre-wired Pack	1*
34-040	Allen Bradley PLC	1*
34-040-1	Allen Bradley PLC I/O Pre-wired Pack	1*
34-110	Diameter Gauging Unit	1*
	additionally required: 1 PC with Windows 7/8/10	

* alternative PLC

Dual Conveyor Band with PLC

Programmable Logic Controllers (PLCs) are used extensively in many manufacturing processes and control applications being readily programmed and reprogrammed when variations in the controlled process are required. This dual conveyor system allows greater study of PLCs in process control systems. More complex control scenarios can be developed using combinations of timers and counters with master and zone control functions. The self-contained unit comprises a power supply, interface board and a range of sensors and solenoid actuators and a height gauging unit. The interface circuits allow the conveyor system to be operated from any standard industrial PLC using 24 V dc logic levels.

Educational objectives

- Two complex conveying systems can be used to process complex tasks.
- Parts selection by means of logic detection and sensors.
- Test and optimize programming on a hardware

Topics

- Logic fundamentals
- Basics of PLC programming
- Developing ladder logic programs
- Programming timers
- etc.

Experiments require the Siemens software TIA Portal to create programs.
The equipment can require additional software modules.

E6.7.2

MECHATRONICS

E6.7.2.4
Elevator Control with PLC

Elevator Control with PLC (E6.7.2.4)

Cat. No.	Description	E6.7.2.4
34-150-1	Elevator - PLC Application	1
34-060	Siemens PLC	1*
34-060-1	Siemens PLC I/O Pre-wired Pack	1
34-020	Mitsubishi PLC	1*
34-020-1	Mitsubishi PLC I/O Pre-wired Pack	1*
34-040	Allen Bradley PLC	1*
34-040-1	Allen Bradley PLC I/O Pre-wired Pack	1*
	additionally required: 1 PC with Windows 7/8/10	

* alternative PLC

Elevator control with PLC

Programmable Logic Controllers (PLCs) are used extensively in many manufacturing processes and control applications being readily programmed and reprogrammed when variations in the controlled process are required. This elevator illustrates the principles of PLC interfacing & control based on a real-life and easily identified application, therefore providing excellent interest for students. Starting with simple program sequences to control elevator speed, direction and floor arrival/departure, the student can progress to advanced floor request handling and continuous (analogue) control with acceleration profiling and compensation for varying car loads. The internal motor speed controller has both logic and analogue interfaces such that a basic PLC with minimal digital I/O can be used to implement control. More sophisticated control may be developed if analogue I/O is available. The load-cell and motor position feedback signals are available to develop programs for continuous control. The load-cell indicates elevator car loading and a set of weights simulates varying numbers of car occupants. The position feedback signal allows for the development possibility of advanced control of the elevator car motion.

Function

- Fully working model of an elevator with 4 floors
- Floor sensing and visual indication of travel
- Motorised elevator car door
- Brake to hold car at desired floor
- Up/down call button at each floor
- Front panel manual switch for testing
- etc.

Topics

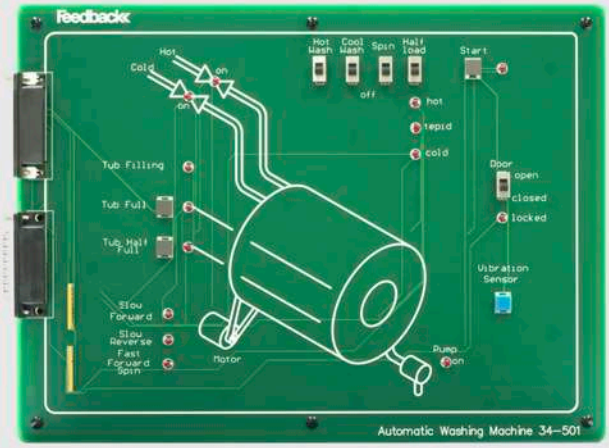
- Logic fundamentals
- Basics of PLC programming
- Developing ladder logic programmes
- Basic sequencer control
- Advanced sequence control
- etc.

Experiments require the Siemens software TIA Portal to create programs.
The equipment can require additional software modules.

E6.7.2

MECHATRONICS

E6.7.2.5
Washing machine
- PLC application



Washing machine - PLC application (E6.7.2.5)

Cat. No.	Description	E6.7.2.5
34-501	Washing Machine - PLC Application	1
34-060	Siemens PLC	1*
34-060-1	Siemens PLC I/O Pre-wired Pack	1
34-020	Mitsubishi PLC	1*
34-020-1	Mitsubishi PLC I/O Pre-wired Pack	1*
34-040	Allen Bradley PLC	1*
34-040-1	Allen Bradley PLC I/O Pre-wired Pack	1*
	additionally required: 1 PC with Windows 7/8/10	

* alternative PLC

Washing Machine – PLC Application

In this washing machine PLC application initial program conditions can be set by switched selection. This allows the development of several different programs that can be used as conditional jumps; depending on how the initial conditions have been set. Using push-button switches to simulate interrupt conditions, such as unbalanced drum load, more complex control problems can be developed.

Function

- Real-life application
- Demonstrates sequential control
- Initial process conditions can be set
- Demonstrates to use of interrupts
- Low cost PLC application
- Used with the major PLC types
- Pre-wired or „wire your own" Mitsubishi, Allen Bradley & Siemens PLCs available (supplied separately) or use your own

Topics

- Logic fundamentals
- Basics of PLC programming
- Developing ladder logic programs
- Programming timers

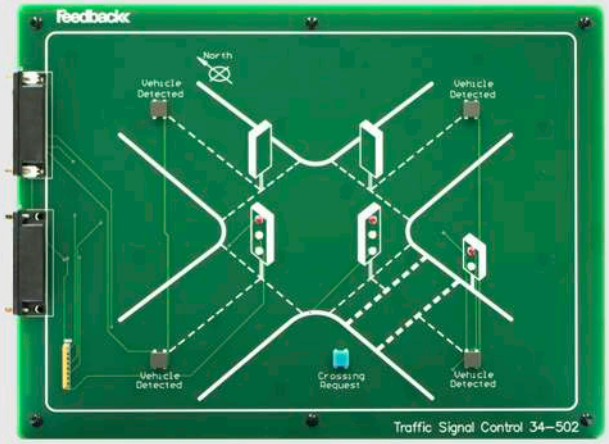
Experiments require the Siemens software TIA Portal to create programs.

The equipment can require additional software modules.

E6.7.2

MECHATRONICS

E6.7.2.6
Traffic light
- PLC application



Traffic light - PLC application (E6.7.2.6)

Cat. No.	Description	E6.7.2.6
34-502	Traffic Lights - PLC Application	1
34-060	Siemens PLC	1*
34-060-1	Siemens PLC I/O Pre-wired Pack	1
34-020	Mitsubishi PLC	1*
34-020-1	Mitsubishi PLC I/O Pre-wired Pack	1*
34-040-1	Allen Bradley PLC I/O Pre-wired Pack	1*
	additionally required: 1 PC with Windows 7/8/10	

* alternative PLC

Traffic Lights - PLC Application

This simple sequence PLC application allows traffic light control of a cross-road to be implemented on a timed sequence basis. The control program can be further developed to cope with interrupts generated from pedestrian crossing requests or off-peak vehicle detector inputs.

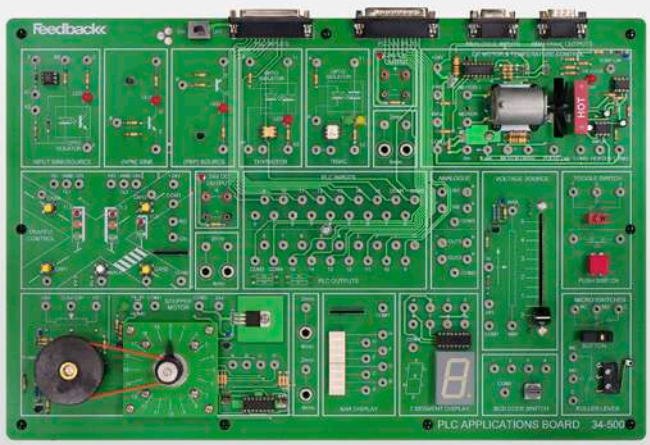
Function

- Real-life application
- Timed sequence control
- Interrupt device control
- Easy to understand process
- Low cost application
- Operates with major PLC types
- Pre-wired or „wire your own" Mitsubishi, Allen Bradley & Siemens PLCs available (supplied separately) or use your own

Topics

- Programming counters
- Setting initial conditions
- Time-based process control
- Use of interrupts & emergency stop

Experiments require the Siemens software TIA Portal to create programs.
The equipment can require additional software modules.



PLC Trainer (E6.7.2.7)

E6.7.2

MECHATRONICS

E6.7.2.7
PLC Trainer

Cat. No.	Description	E6.7.2.7
34-500	PLC Trainer	1
34-060	Siemens PLC	1*
34-060-1	Siemens PLC I/O Pre-wired Pack	1
34-020	Mitsubishi PLC	1*
34-020-1	Mitsubishi PLC I/O Pre-wired Pack	1*
34-040	Allen Bradley PLC	1*
34-040-1	Allen Bradley PLC I/O Pre-wired Pack	1*
	additionally required: 1 PC with Windows 7/8/10	

* alternative PLC

PLC Trainer

The Feedback PLC Trainer offers the training required to understand and apply both PLC hardware and software programming through the structured students' manual that provides a progressive level of learning. The manual deals with the fundamentals of PLC hardware and software through to basic program writing and more advanced applications, finally to motor control. The PLC Trainer is an A3 size board that is divided into many individual smaller areas.

Function

- Complete integrated range
- Plug and play with cabled system
- Traffic light control
- Stepper motor
- Micro-switches
- Pre-wired or „wire your own" Mitsubishi, Allen Bradley & Siemens PLCs available (supplied separately) or use your own
- etc.

Topics

- Stepper motor positioning to a desired point & home position
- Stepper motor device sequencing with counter & display
- DC motor speed PWM control
- etc.

Experiments require the Siemens software TIA Portal to create programs.
The equipment can require additional software modules.

E6.7.3

CHEMICAL PROCESS ENGINEERING

E6.7.3.1
Blue-Bottle Process with PLC

Blue-Bottle Process with PLC (E6.7.3.1)

Cat. No.	Description	E6.7.3.1
524 013	Sensor-CASSY 2	1
524 220	CASSY Lab 2	1
524 069	Immersion photometer S	1
666 425	Panel frame C50, two-level, for CPS	1
666 438	Woulff's bottle with manometer, CPS	1
667 3095	Screw cap, GL 45, with hole	1
667 3107	Silicone seal GL 45/26, 10 pcs	1
666 482	Aeration pump, controllable, CPS	1
501 44	Connecting leads, 19 A, 25 cm, red/blue, pair	1
667 7977	Electronic Balance 440-3N, 200 g : 0.01 g	1
664 157	Watch glass dish, 125 mm diam.	2
666 966	Spoon-ended spatula, PP, 180 mm	2
666 003	Pipetting ball (Peleus ball)	1
665 996	Graduated pipette, 5 ml	1
665 756	Measuring cylinder, 500 ml, with plastic base	1
604 501	PVC tubing, 7 mm diam., 1 m	1
604 460	Hose clamp, 8...12 mm	1
602 347	Laboratory bottle, 500 ml, GL 45 thread	1
673 2920	Methylene blue solution, 100 ml	1
673 6800	Sodium hydroxide, pellets, 100 g	1
672 1100	D(+)-Glucose, 100 g	1
675 3400	Water, pure, 1 l	1
500 441	Connecting lead 19 A, 100 cm, red	8
500 442	Connecting lead 19 A, 100 cm, blue	8
773 072	Simatic PLC S7-1512C-1 PN TP	1*

Cat. No.	Description	E6.7.3.1
773 075	Simatic PLC S7-1512C-1 PN +DP TP	1*
773 077	Simatic S7-1516 PN/DP TP	1*
	additionally required: 1 PC with Windows 7/8/10	

* additionally recommended

Blue-Bottle Process with PLC

The student learns to monitor and control a real chemical process in chemical engineering with a clear reaction.

Educational objectives

- Control and optimisation of a redox process
- Experimental transfer of the process into a controller
- Operation of an SPC and optimisation of the program for a real system.
- Function review

Topics

- Basics of SPC programming.
- Optimisation of process systems
- Controlling processes

Experiments are operated and evaluated with CASSY Lab 2.

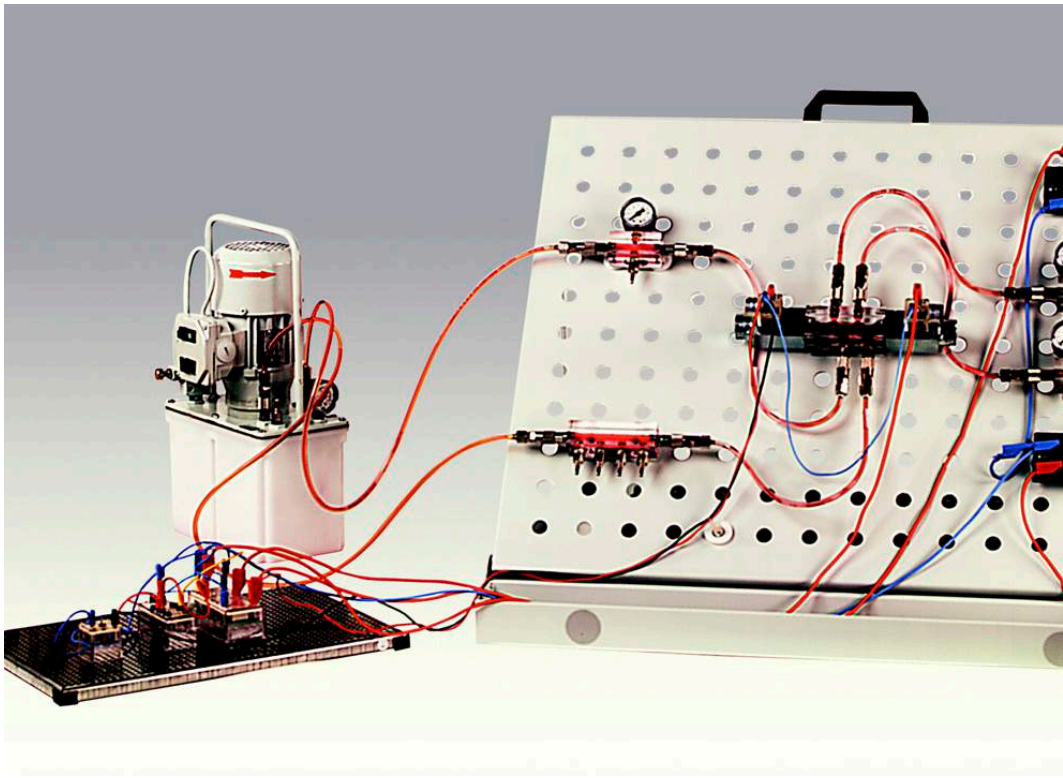
E6.8 HYDRAULICS

E6.8.1

DIDACTICAL HYDRAULICS

E6.8.1.1
Complete Set

E6.8.1.2
Basic Set



Complete Set (E6.8.1.1)

Cat. No.	Description	E6.8.1.1	E6.8.1.2
500 422	Connecting lead 19 A, 50 cm, blue	3	
500 441	Connecting lead 19 A, 100 cm, red	10	
500 442	Connecting lead 19 A, 100 cm, blue	10	
562 793NA	Power Adapter 6...24 V	1	
8-5 336022-000-10-0	LIT: Experiments electro-hydraulics with transparent components	1	
8-2 236023-000-10-0	KSS 4/2-way valve, solenoid operated	1	
8-2 236025-000-10-0	KSS 4/3-way valve, solenoid operated	1	
8-2 236029-000-10-0	KSS Pressure switch with connection cable	1	
8-2 237081-000-10-0	Limit switch with idle return roller,	1	
8-2 632057-000-10-0	Electro-power adapter, 2 sockets, yellow LED	1	
8-2 636005-100-10-0	Hydraulic power unit 8/1.0 for plexiglass units	1	1
8-2 436001-000-10-0	Hydraulics training case	1	1
8-2 632005-000-10-0	Set of plastic adapters, 25 pieces	2	2
8-2 636003-000-10-0	Transparent tube with self-locking / quick release couplings 520 mm	11	11
8-2 636004-000-10-0	Transparent Tube with self-locking / quick release couplings 350 mm	4	4
8-2 636008-000-10-0	Transparent tube with self-locking / quick release couplings 1000 mm	3	2
8-2 636016-000-10-0	6-l canister with red hydraulic oil for refilling	1	1
8-2 236038-000-10-0	KSS Double acting cylinder, stroke 100 mm	1	1
8-2 236002-000-10-0	KSS Check valve	1	1
8-2 236003-000-10-0	KSS Pressure relief valve, (poppet valve)	1	1

Cat. No.	Description	E6.8.1.1	E6.8.1.2
8-2 236004-000-10-0	KS 4/2-way valve, manually operated	1	1
8-2 236005-000-10-0	KSS Throttle valve	1	1
8-2 236006-000-10-0	KSS Manometer, 0 ... 10 bar	3	3
8-2 236007-000-10-0	KSS Distributor, 6-way	2	2
8-2 236020-000-10-0	KSS Differential-pressure valve	1	1
8-5 336002-000-10-0	LIT: Experiments hydraulics with transparent components	1	1
8-2 236009-000-10-0	KSS cylinder, single-acting	1	
8-2 236008-000-10-0	KSS Pressure relief valve (piston type valve)	1	
8-2 236010-000-10-0	KSS Pressure reducing valve, direct operated	1	
8-2 236011-000-10-0	KSS throttle check valve, manually operated	1	
8-2 236013-000-10-0	KSS Check valve, piloted	1	
8-2 236015-000-10-0	KSS Flow control valve, 2-way	1	
8-2 236012-000-10-0	KSS Shut-off valve	1	
8-2 236014-000-10-0	KSS/KS Distributor, 4-way	1	
578 51	Diode, 1N 4007, STE 2/19	4	
578 42	Capacitor (electrolytic), 1000 µF, STE 2/50	6	
579 06	Lamp holder, E10, top, STE 2/19	3	
8-5 950240-300-10-0	Incandescent lamp E 10, 24 V, 80 mA, 1.9 W	3	
649 43	Tray, 552 mm x 284 mm x 48 mm	1	
576 74	Plug-in board, DIN A4, STE	1	
500 401	Connecting lead, 19 A, 10 cm, red	14	
500 404	Connecting lead, 19 A, 10 cm, black	13	
500 402	Connecting lead, 19A, 10 cm, blue	5	
500 411	Connecting lead, 19 A, 25 cm, red	6	

Basic Set (E6.8.1.2)

Cat. No.	Description	E6.8.1.1	E6.8.1.2
500 414	Connecting lead, 19 A, 25 cm, black	27	
500 412	Connecting lead, 19 A, 25 cm, blue	3	
500 421	Connecting lead 19 A, 50 cm, red	3	
500 424	Connecting lead 19 A, 50 cm, black	6	

Didactic Hydraulics

Hydraulic elements from ELWE Technik are operated with red-coloured hydraulic oil. The white base plate further heightens the contrast. A maximum operational pressure of 10 bar (1 MPa) facilitates safe experimentation. The transparent connecting hoses and introduced air bubbles allow learners to fully follow the flow paths: from pressure connection of the pump through to the tank connection.

The learning system conveys the fundamentals of hydraulic systems on three levels. The electro-hydraulics are designed for a safe 24 V of direct current. This makes it possible to put together even simple controllers with LOGO! and SPC.

Educational objectives

- Basics of hydraulics
- Hydraulic components with special functions
- Basic hydraulic circuits

Topics

- Hydraulic unit
- Pressure limit
- Directional valve
- Cylinder
- Current regulating valve
- Pressure regulating valve
- Variables for a valve operation magnet
- Signal storage through electric catch

E6.8.1

DIDACTICAL HYDRAULICS

E6.8.1.3
Supplement Set

E6.8.1.4
Education hydraulic,
electro-hydraulics
supplement Set

Education hydraulic, electro-hydraulics supplement Set (E6.8.1.3)

Cat. No.	Description	E6.8.1.3	E6.8.1.4
8-2 236009-000-10-0	KSS cylinder, single-acting	1	
8-2 236008-000-10-0	KSS Pressure relief valve (piston type valve)	1	
8-2 236010-000-10-0	KSS Pressure reducing valve, direct operated	1	
8-2 236011-000-10-0	KSS throttle check valve, manually operated	1	
8-2 236013-000-10-0	KSS Check valve, piloted	1	
8-2 236015-000-10-0	KSS Flow control valve, 2-way	1	
8-2 236012-000-10-0	KSS Shut-off valve	1	
8-2 236014-000-10-0	KSS/KS Distributor, 4-way	1	
8-2 236023-000-10-0	KSS 4/2-way valve,solenoid operated		1
8-2 236025-000-10-0	KSS 4/3-way valve, solenoid operated		1
8-2 236029-000-10-0	KSS Pressure switch with connection cable		1
8-2 237081-000-10-0	Limit switch with idle return roller,		2
8-2 632057-000-10-0	Electro-power adapter, 2 sockets, yellow LED		3

Supplement Set
The *equipment E6.8.1.3* is part of the *complete system E6.8.1.1*. As a system, it offers the expansion modules of the manually operated hydraulics for the basic equipment.

Education hydraulic, electro-hydraulics supplement Set
The *equipment E6.8.1.4* is part of the *complete system E6.8.1.1*. As a system, it offers the expansion modules of the electro-actuated hydraulics for the basic equipment set.

Educational objectives

- Hydraulic components with special functions

E6.9 AUTOMATION SYSTEMS FOR INDUSTRY 4.0

The changes in society and the economy as a result of digitisation will dramatically affect the professional environment in many areas.

Education and training in particular are called to offer training concepts that enable trainees and skilled workers to actively follow and drive this progress. With the production system 4.0i, LD DIDACTIC offers the perfect experimental teaching and learning environment for such a concept.

A system along the production chain can perfectly illustrate the following topics within the scope of education and training:

- Material feed
- Process integration
- Process optimisation
- Service & maintenance
- Warehousing & logistics

The possibilities of digitisation will change entire corporate structures and result in completely new work requirements. Using the new production system 4.0i, this can be explained, tested, experienced and practised hands on.

PRODUCTION SYSTEM 4.0i

The modular production system has been developed for applied teaching of Industry 4.0. The system, consisting of three individual stations, focuses on the assembly of dice, from the removal from a magazine to processing and warehousing. Not only is the production system fully networked and programmable via bus systems, it also impresses with a comprehensive safety concept.

As a 3.0 system, the entire system is delivered fully assembled, installed and programmed. The 4.0 system is the expansion of this industry concept and is part of the training. (Description included with the documentation supplied.)

FUTURE-PROOF TRAINING WITH TRAINING SYSTEMS

The modular training units are a special feature of the production system 4.0i. They are precisely matched to the qualification levels of industrial and educational institutions. It covers everything around pneumatic and automation, to learn and understand all industry-relevant technologies and processes.

EXPERIENCE PRACTICE WITH SERIES COMPONENTS

This training system of mechatronics teaches

- The system is fully assembled, configured and programmed without the 4.0i extension.
- Upgrading an existing system is part of the teaching content.
- Beginners and advanced learners will gain in-depth and practical knowledge, based on industrial series components.
- Industrial controls with internationally standardised programming languages and open interfaces are ready for Industry 4.0 technology, such as Open Core Engineering.
- The production system 4.0i is a modular system that can be selected from individual assemblies, from work stations to the entire system.

PRODUCTION SYSTEM 4.0i
774 490

Would you like more informations or/and an individual offer for this product? Then send us an e-mail:

sales@ld-didactic.de

Concepted for Industry 4.0 i

The modular production system 4.0i consists of three flexibly interchangeable and expandable stations: *Magazine, processing & warehousing* for implementation of a complete automation process.

YOUR BENEFITS WITH PRODUCTION SYSTEM 4.0i:

Original series components from the industry

- DC motors
- Servomotors
- Control technology: relays, PLC, motion control, CNC
- Linear technology
- Pneumatic drives
- Sensors and RFID
- Cartesian robot or 3-axis CNC
- Standard machine control panel
- Fieldbus and Ethernet communication

MODULAR, SCALABLE TRAINING SYSTEM – FROM SINGLE ASSEMBLIES TO THE COMPLETE SYSTEM

Industry 4.0 integrate

- HMI – Human Machine Interface
- RFID – Radio Frequency Identification

Various programming

- PLC programming (in accordance with IEC 61131-3):
  - Instruction list (IL)
  - Structured text (ST)
  - Sequential function chart (SFC)
  - Function block diagram (FBD)
  - Ladder diagram (LD)
  - Continuous function chart editor (CFC)

- Open Core Engineering offers more programming options
  - Java (APP)
  - C/C++
  - C#
  - Microsoft Excel, Powerpoint
  - MATLAB™/SIMULINK®
  - and more

Other Benefits

- Optional operation with smart devices over WiFi, such as tablet, smart phone, etc.
- The conversion of a conventionally controlled part system into a CNC-controlled system is possible without hardware modifications. It merely requires adaptation of the firmware and programs. Free CNC software supports programming
- Optional expansion with different PLC systems

TECHNICAL AFTER-SALES SERVICE

You may have a technical question on one of our devices or pieces of equipment. Our service team is available by telephone at +49 2233 604-430 and by e-mail at service@ld-didactic.de.

SPARE PARTS SERVICE

You can naturally order replacement parts for your equipment.

REPAIR SERVICE

If, despite our demanding quality standards, you should find a fault in your LEYBOLD product, we will naturally repair it as soon as possible. If you still cannot make the equipment work as intended after calling our technical service, you can find help quickly and easily through our „on-site service". Our service technicians come to you, to find the appropriate technical solution on site. Alternatively, you can of course also send your device for repair by post.

REPAIR GUARANTEE FOR A MINIMUM OF 10 YEARS

Our products stand for high quality and durability. If your device should become faulty even many years after purchase, generally we will still be able to repair it. We guarantee the repair of all our devices for 10 years from the date of purchase – and for much of our products, for much longer.

PHYSICS
CHEMISTRY
BIOLOGY
ENGINEERING

LD DIDACTIC

130 8040EN 04.2017 LD
Subject to technical amendments.

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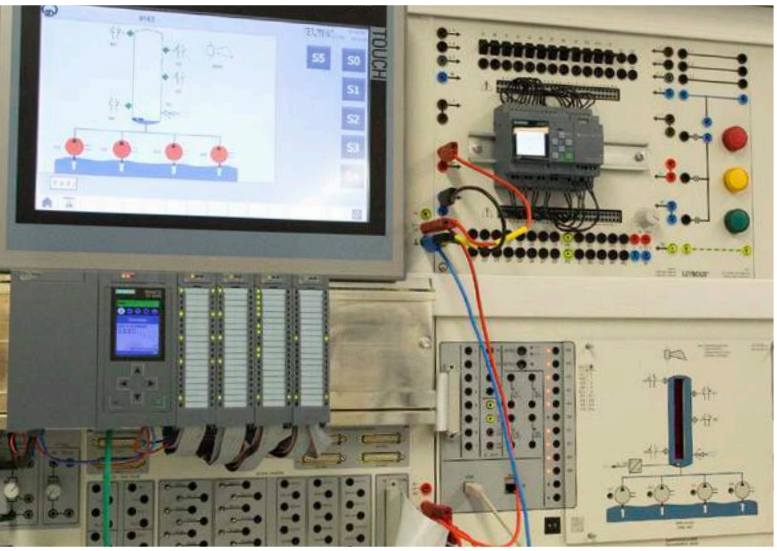

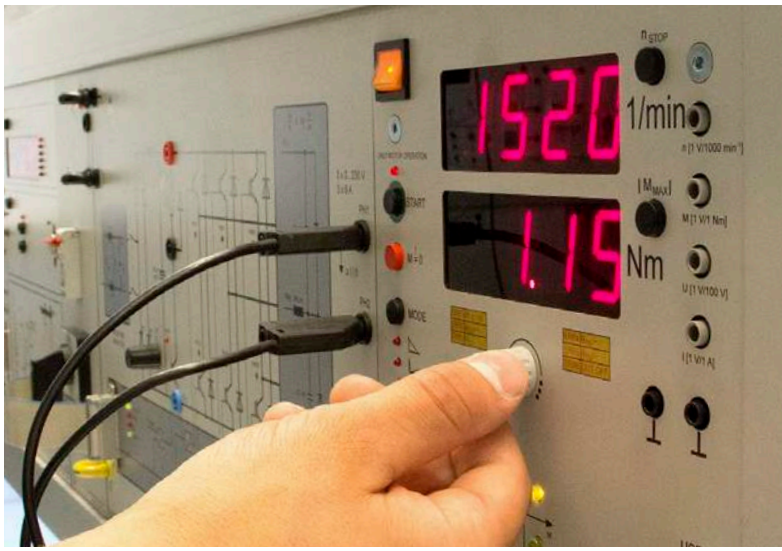

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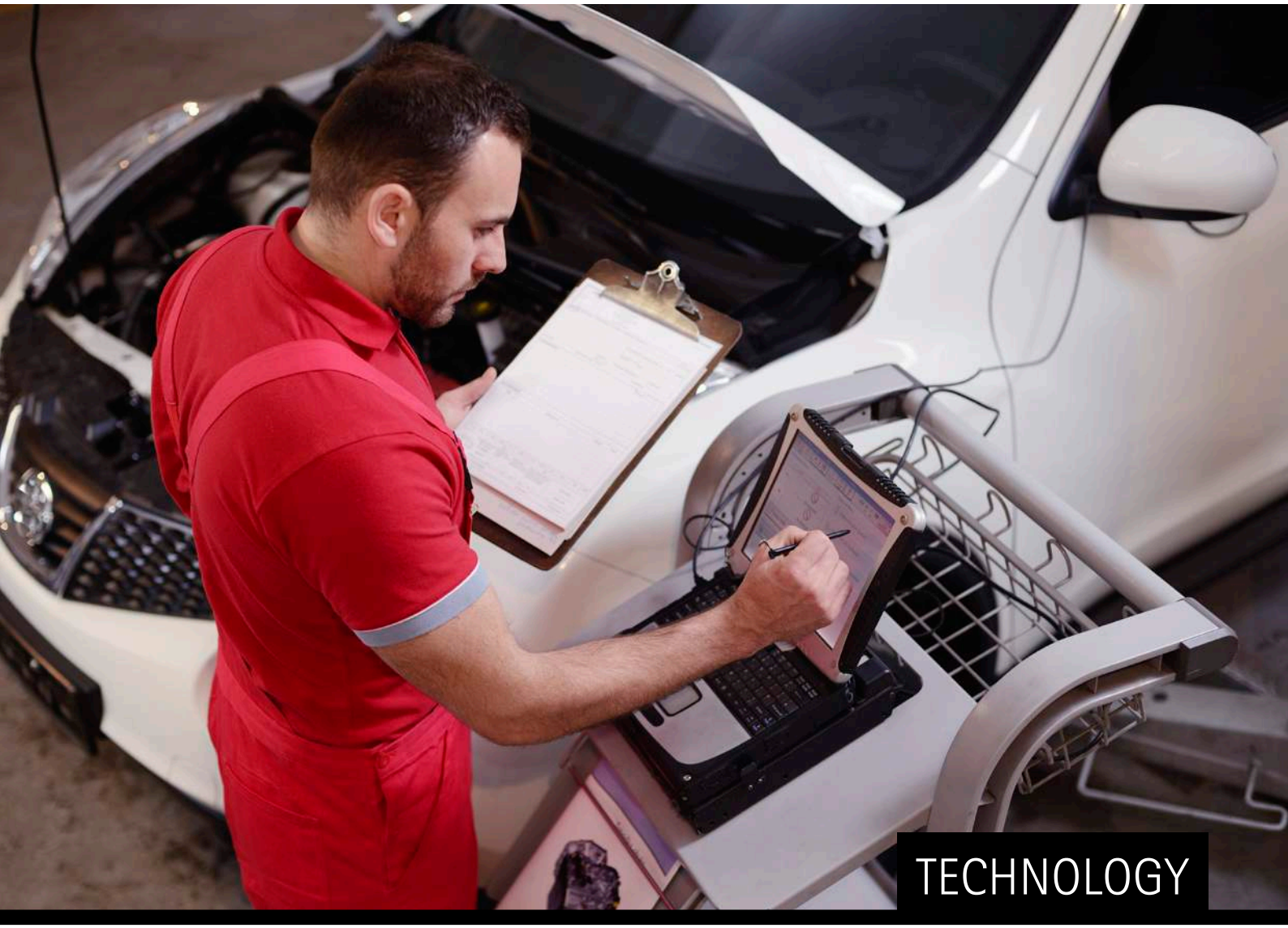
BRANDS OF THE LD DIDACTIC GROUP

LEYBOLD® Feedback ELWE® TECHNIK

LEYBOLD®

AUTOMOTIVE TECHNOLOGY



TECHNOLOGY

LD DIDACTIC

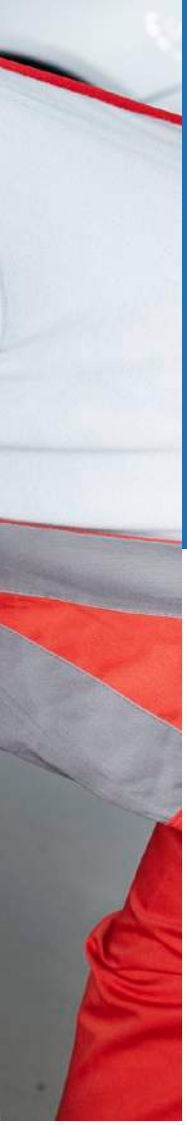
AUTOMOTIVE TECHNOLOGY

EASILY CONVEY CHALLENGING TOPICS WITH LEYBOLD'S SOLUTIONS

With LEYBOLD's solutions, your trainees and students can effectively learn the complex class subjects in the areas of motor vehicle technology and electrical engineering as well as renewable energy technology. Our didactic equipment and educational systems for technical vocational training ideally combine theory and practice and can be seamlessly integrated into the project work.

This catalog presents our educational systems in the area of motor vehicle technology. With us, you will receive customized solutions for your technology and workshop lab that are adapted to the individual fields of instruction.

LD DIDACTIC GmbH is a world leader in the production of high-grade scientific and technical educational systems for schools, universities and vocational training. LD DIDACTIC distributes its products and complete solutions under the brand name LEYBOLD.



CONTENTS

LEYBOLD SOLUTIONS AT A GLANCE

LEYBOLD®

TECHNICAL SERVICE AND CONSULTING

LEYBOLD NOT ONLY PROVIDES THE HIGHEST POSSIBLE PRODUCT QUALITY, BUT ALSO INDIVIDUAL ADVICE AND TECHNICAL AFTER-SALES SERVICE.

INDIVIDUAL ADVICE AND STOCK-TAKING

Are you planning to re-equip your laboratory or simply to add to its equipment? Our specialised advisor will be happy to give you support by suggesting a tailor-made combination suitable to your type of school.

GOODS SERVICE, INSTALLATION, COMMISSIONING AND ON-SITE BRIEFING

We would be delighted to check your new equipment on site for completeness and functionality. We can either take on the whole task of installation for you or our specialists can commission the devices and systems that you have already installed on site yourselves. We would, of course, be delighted to conduct one or more tests together with you and to explain in detail the functions of each individual device.

LEYBOLD®

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You can naturally order replacement parts for your equipment.

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REPAIR GUARANTEE FOR A MINIMUM OF 10 YEARS

Our products stand for high quality and durability. If your device should become faulty even many years after purchase, generally we will still be able to repair it. We guarantee the repair of all our devices for 10 years from the date of purchase – and for much of our products, for much longer.

PRACTICAL DEVELOPMENT

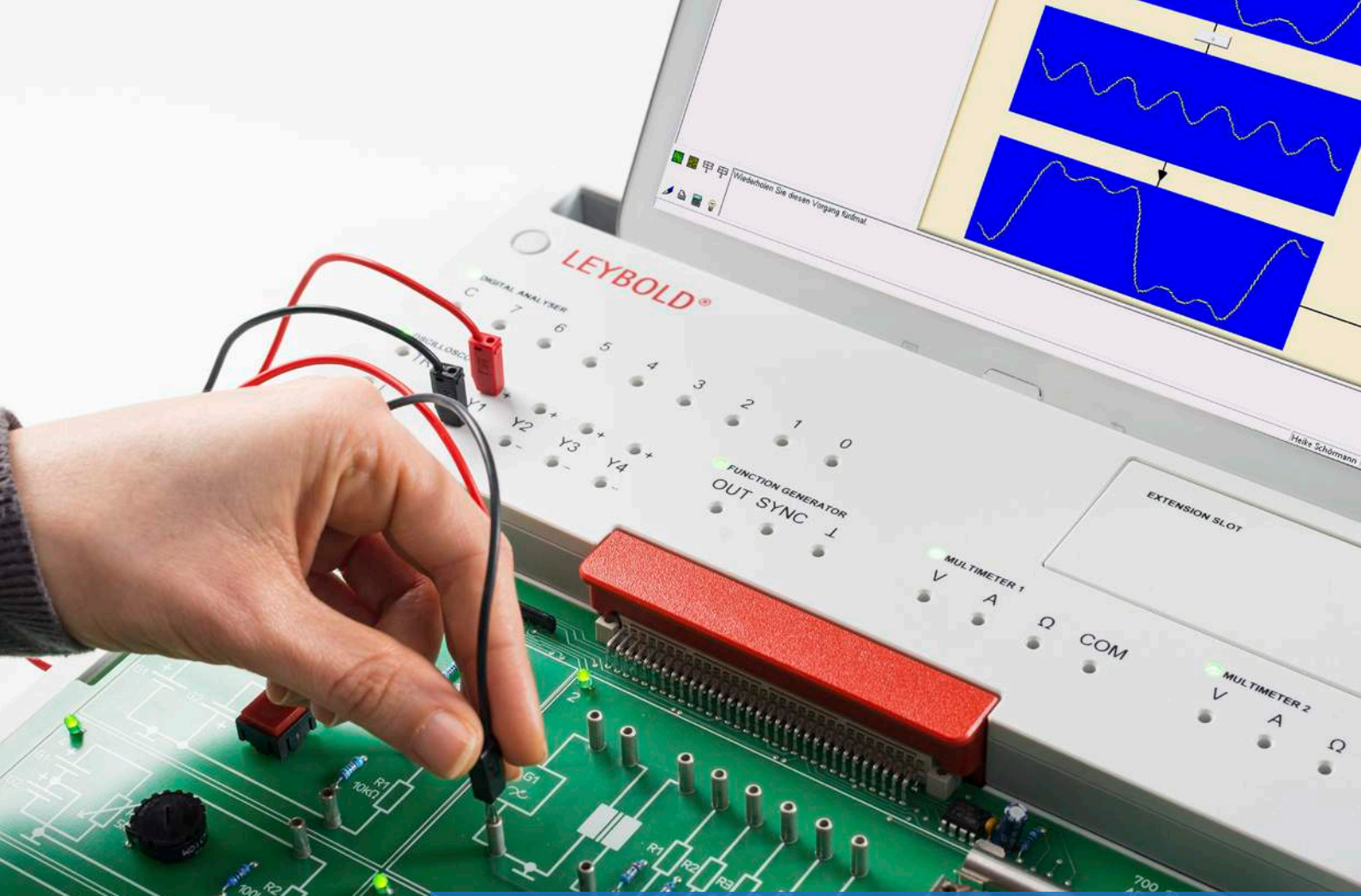
COOPERATION WITH AUDI

TRAINING PANEL LIGHTING

The training panel consists of a modern instrument panel insert with electronic immobilizer, the full steering wheel electronics, the central control module for comfort system and the electronic and electric system. The lighting system and a windshield wiper motor complete the system. The basic vehicle electronics and modern data bus systems are clearly and simply represented. This approach places great value on the use of original vehicle parts. The focus is on fault finding, analysis and correction.

We develop and produce our educational systems in tight cooperation with the automotive industry, so we can ensure our systems are very realistic and their technology constantly refined.

Since 2003, we have been developing educational systems, such as the training panel lighting, together with AUDI AG's training center. The trainees can learn the fundamentals of vehicle electronics and modern data bus systems with original parts of an AUDI A4.



COM3LAB MULTIMEDIA

The Master Unit is compatible with all of the courses and includes two multimetres interfaces, a function generator, a digital storage oscilloscope and a digital analyser. By simply inserting a different experiment board into the Master Unit a completely new topic area can be explored.

THE OPTIMUM COMBINATION OF THEORY AND PRACTICE

COM3LAB Multimedia combines training software with real hardware that can be used in schools, universities or vocational training centres in industry.

COM3LAB courses are well suited for both classroom presentation, self-directed home study or for project work. They are comprised of an electronic and an interactive instruction manual and the corresponding hardware.

ADVANTAGES AT A GLANCE

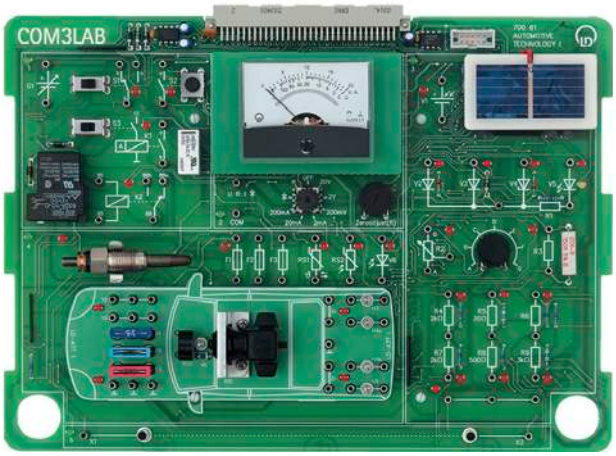
FOR INSTRUCTORS

- In-depth content
- Practically-oriented experimenting
- Visually-appealing instruction material for presentation purposes
- Documentation with solutions for flexible application in the classroom
- Time-efficient assembly

FOR STUDENTS

- Practical hands-on learning
- Results are monitored and tested
- Results are documented
- Team-based or self-study possible
- Select the language of your choice

EXEMPLARY COURSE FOR MOTOR VEHICLE TECHNOLOGY

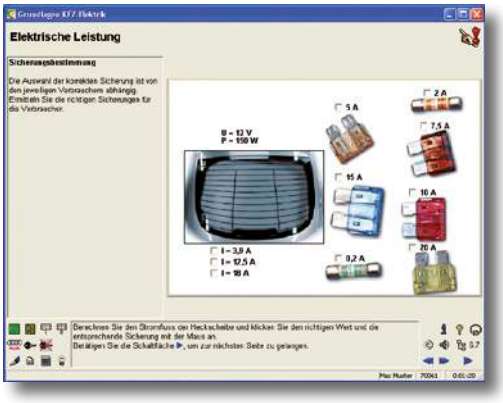


COM3LAB COURSE: AUTOMOTIVE ELECTRICS

700 6101

This COM3LAB course prepares and conveys the fundamentals of vehicle electrics/electronics in an understandable way. Physical, chemical and mathematical properties of "electricity" thereby lead to extensive understanding of electrical operating sequences and processes in motor vehicles.

Every COM3LAB course has an electronic, interactive textbook with detailed experimental instructions. Subject-specific descriptions, images, videos and animations illustrate both theory and practice. Besides this content, the textbook includes a virtual lab and a multitude of tools, e.g. to compile distinctive documentation.

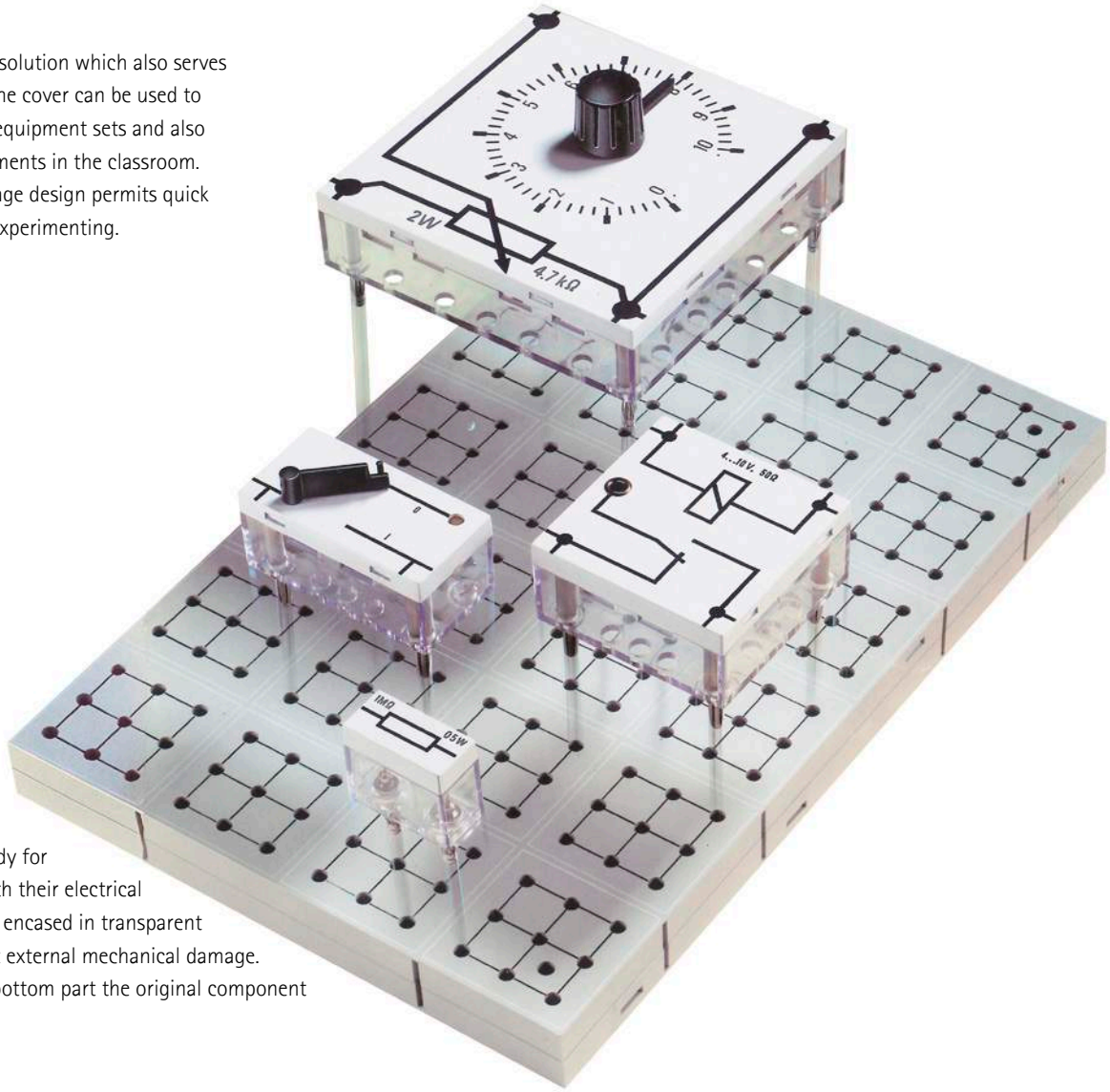


STE PLUG-IN SYSTEM

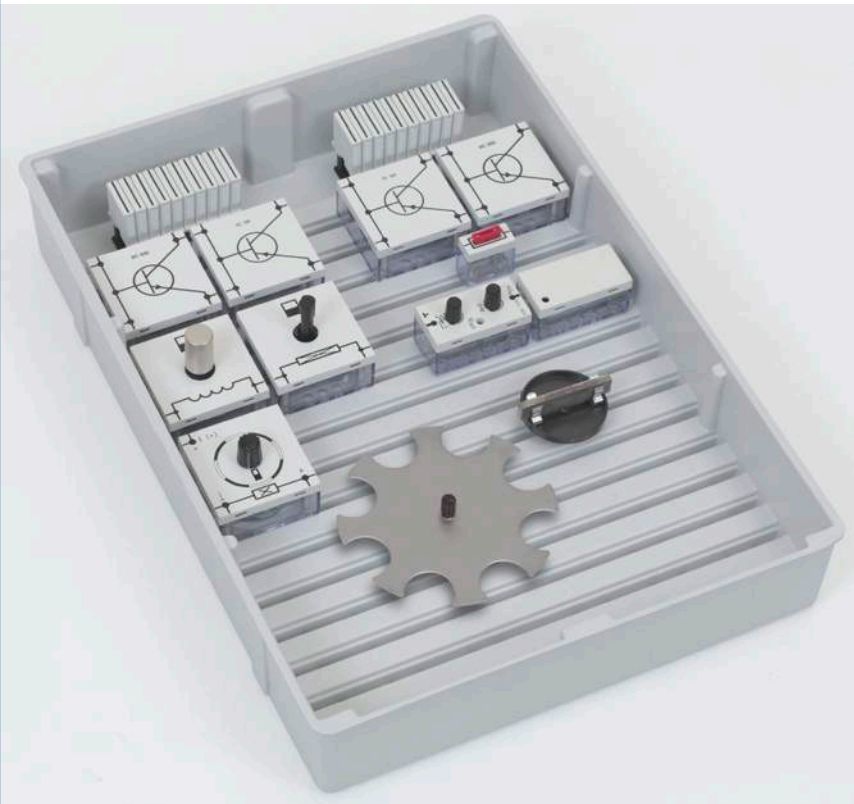
The LEYBOLD plug-in system is a tried and tested experimentation program for electrical engineering and electronics. The extensive experimentation program covers beside the basics also advanced topics, for example, communications, IT, open- and closed-loop control technology as well as areas from automotive electronics.

Instruction sheets for students and accompanying teacher information are available to assist with the performance of experiments. The printed symbols on the plug-in housing elements, connectors and training panels provide the experiment set-ups with a circuit-like appearance. This facilitates the knowledge transfer between the circuit diagrams in the text books and the circuitry being assembled and makes the documenting of the experiment set-ups easier to do and ultimately promotes circuit-based thinking, learning and experimenting.

The STE case is the storage solution which also serves as a student workstation. The cover can be used to accommodate various STE equipment sets and also assist in performing experiments in the classroom. The clearly configured storage design permits quick setup and a quick start to experimenting.



The STE elements come ready for operation and assembly with their electrical and electronic components encased in transparent housings to protect against external mechanical damage. Thanks to the transparent bottom part the original component is visible.



Stackable plastic trays offer alternatively a space saving and clear storage configuration of STE elements, components and accessories in cabinets or drawers.

PRACTICAL DIDACTIC SOLUTIONS

INCREASING DEMANDS IN TRAINING ON VEHICLES

The demands that automotive mechatronics engineers and diagnostic technicians face in their trade and in the industry are always growing in complexity: besides mastering conventional technology, they must also gain skills in the area of electronics, microprocessing and databus technology.

Only those who understand operating principles in detail and the functional relationships of electronic components like ABS, map-controlled ignition, motronics, common rail, electrical system management, etc. and the tradition mechanical, hydraulic and pneumatic components are prepared for the daily demands of the work routine. This of course includes the safe manipulation of modern diagnostic systems.

PRACTICAL DIDACTIC SOLUTIONS

LEYBOLD offers technical equipment and systems, with which trainees can effectively learn these complex subjects. These are developed in cooperation with the automotive industry and continually adjusted for technical advancements.

LOW TIME REQUIREMENT FOR LESSON PLANNING AND TEACHING

LEYBOLD solutions are not only adapted to the complex class subjects but also to the constantly increasing demands facing instructors. Lesson planning and the experimental teaching structure only require very little of their time, because the comprehensive literature accompanying the experiments provides you with a guide for demonstration experiments, which you can simultaneously hand out to your students as experimental instructions.

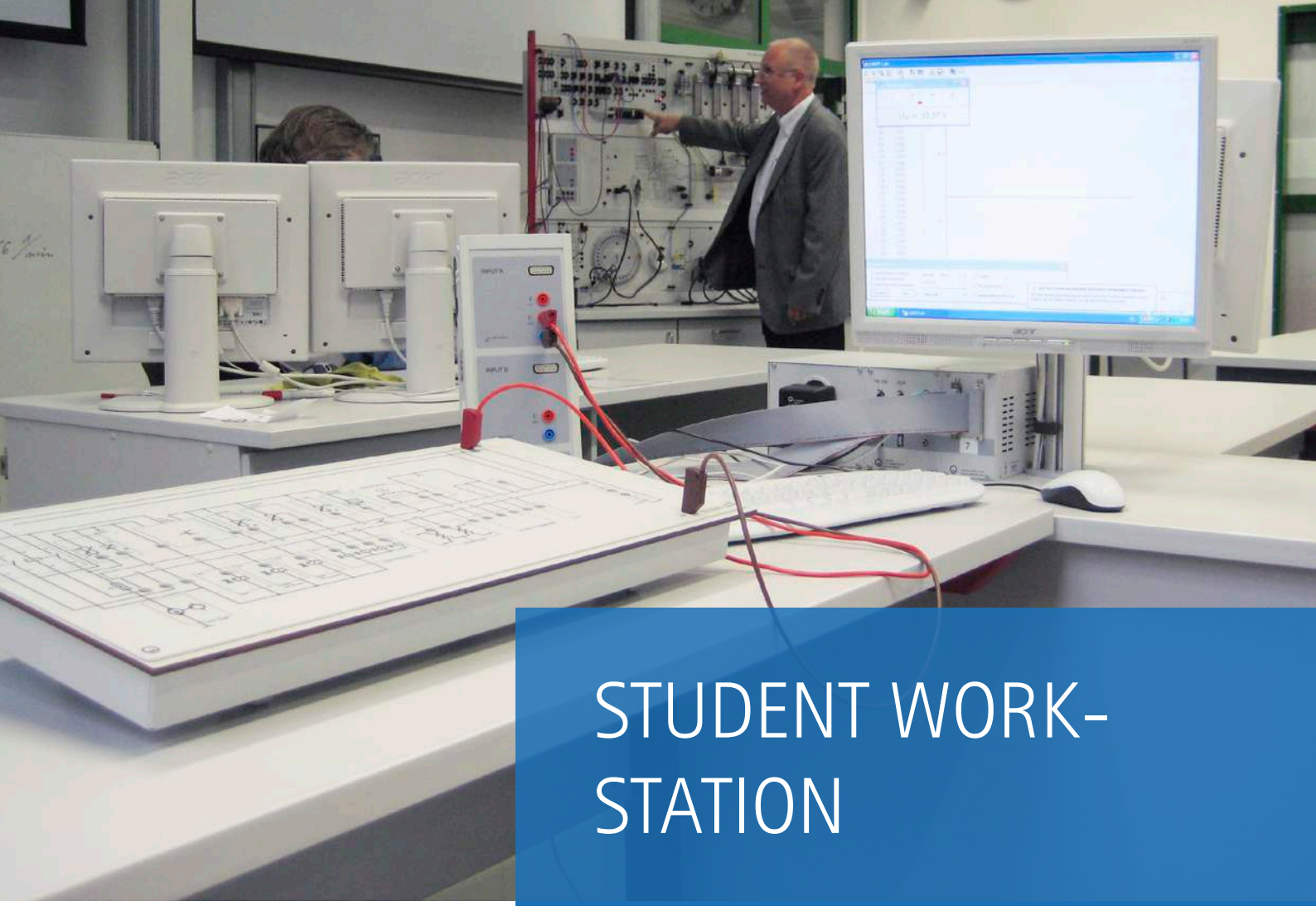
The experiments' literature prepared didactically facilitates lesson planning and teaching for instructors.

TPS - TRAINING PANEL SYSTEM

THE MODULAR TRAINING PANEL SYSTEM FOR STUDENT EXPERIMENTS AND CLASSROOM DEMONSTRATIONS

- Construction and design similar to the original vehicle
- Self-diagnostic capability
- Use of original components
- Experiment literature for classroom preparation and experiment procedures
- Featuring clearly laid out frontal panels

Thanks to the modular design, technology labs can quickly and easily be outfitted or extended using the TPS system.



STUDENT WORK-STATION

Background:
Demo system for fuel injection A2.3.2.1

Foreground:
Student Adaptor (740 050) with overlay mask LH Motronic (740 052) and Sensor-CASSY

PRACTICAL, FLEXIBLE AND MODULAR

Student measuring stations consist of a student workstation with a measuring adapter and an overlay mask suitable for the experiment setup. These measuring stations are connected by two 38-pole cables and with the teacher's training system – either in star or in series structures.

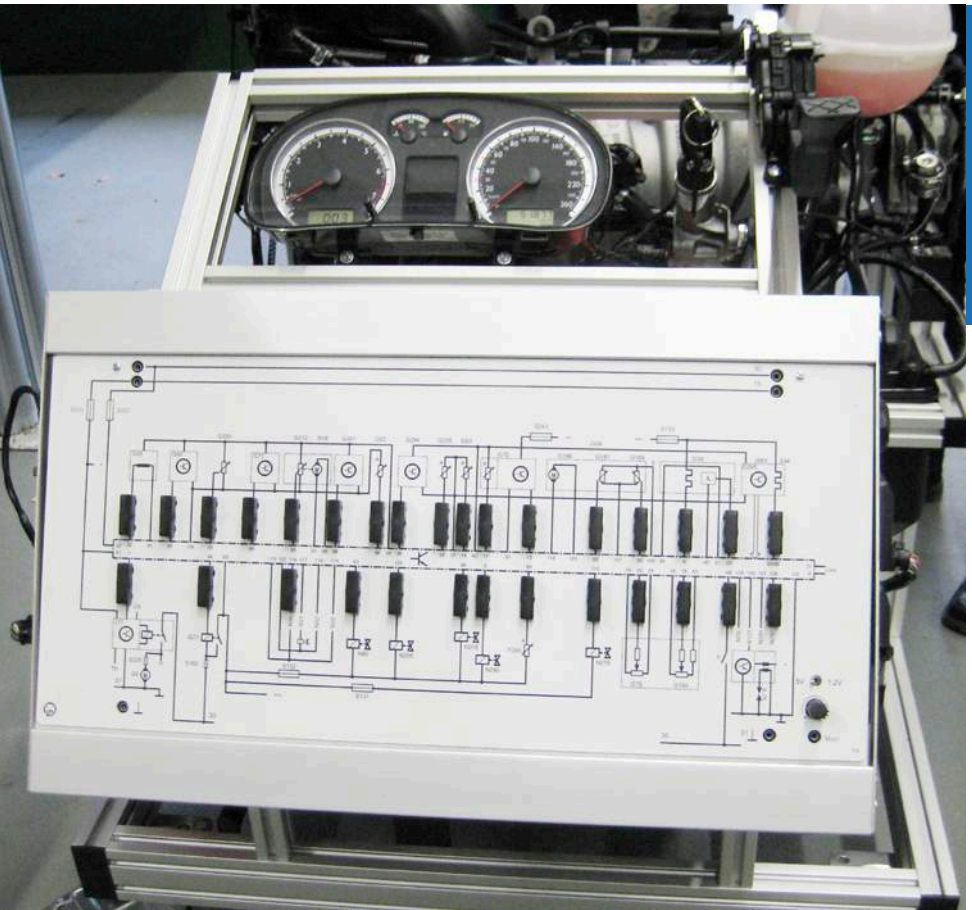
The students can record and analyze all measurements from the installation online at their workstations. Furthermore, the teacher can simulate system-specific errors to be studied metrologically at the students' workstations. The student measuring stations are decoupled in reverse so that the students cannot cause any error in the teacher's demo system.

MEASURING STATION

Catalogue No.	Designation
740 052	Mask LH Motronic (Student)
740 0551	Mask ABS/ESP
740 0531	Mask CR (student)

Space-saving storage:
Example of a storage solution for student workstations and overlay masks

- Quick setup due to simple wiring
- Compact size
- Up to 70 PINs available for use
- Original values from the vehicle or model at the student's workstation
- Short-circuit proof at the control unit
- Overlay masks with circuit diagrams for all available models and vehicles
- Measurements with original meters possible



The modular concept allows the connection of function engines.

LEYLAB

EDUCATIONAL LAB
MONITORING AND CONTROL

YOUR TECHNICAL LABORATORY FOR THE FUTURE

MULTIFUNCTIONAL LAB FURNISHINGS AND DEVICES

Our LEYLAB program offers you a wide selection of student, laboratory and computer desks. These are flexible, to be customized to your individual equipment and space requirements. Our power supply and experimental equipment is ideally adjusted to them. They can be connected to the available Ethernet and form the "networked learning environment" with the linked computer.

PARALLEL CONTROL OF THE EXPERIMENT SETUPS AND THE LABORATORY'S POWER SUPPLY

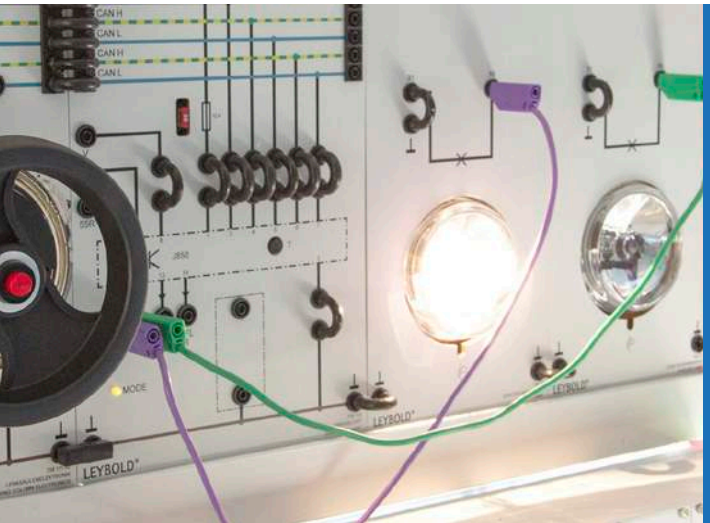
With LEYLAB, besides the laboratory's power supply, you can also control key devices in the complete experiment setups with the teacher's PC. The new LEYLAB.control software thereby has significant advantages over comparable products. For example, the instructor can protect experiment setups from incorrect voltages or activate and operate individual devices in the experimental setup as well as trigger faults.

LEYLAB.POWER

The LEYLAB.control concept can integrate the laboratory's power supply with the corresponding Ethernet interface. From the teacher's PC, the instructor thus has access at any moment to the devices and can read or change settings. To protect the connected experimental environment, parameters can additionally be limited so that the students cannot manipulate them.

LEYLAB.CONTROL

The LEYLAB.control software is the software for the central control station in the networked laboratory, and it allows actuating the linkable power supply units in the LEYLAB.power series as well as the linkable experiment boards in the TPS series. The instructor can map the laboratory in the program interface and has a graphical overview of all devices connected by Ethernet. The student PCs can have access to the individual devices and can communicate directly.



TPS.NET

Network-compatible TPS modules have an Ethernet interface, with which they can be integrated into the LEYLAB.control concept. The teacher can then access the equipment from his computer either as an observer only or actively, while the students conduct the corresponding experiments. Data acquisition, parameter and limit specifications, and (safe) intrusion of errors are thus easily possible.

FACILITY & LAB PLANNING AND INSTALLATION

YOUR NEW LEYBOLD LAB FACILITY

Based on your ideas, we team up with you and plan a lab or classroom facility that fits your syllabus. Our room planners custom design your laboratory simply by tailoring the desired experiment equipment, furniture and storage solutions to your specific needs.

Thanks to our many years of experience, we are reliable partners in all phases of project planning from conception to implementation.

EVERYTHING YOU NEED FROM A SINGLE SOURCE

LAB AND CLASSROOM PLANNING

- Furnishings designed for practical use
- In compliance with safety standards
- Blueprints and planning documents
- Specification of performance features

FURNITURE

- Customised solutions
- Networked training systems
- Storage systems designed to fit equipment and equipment sets
- Long availability & supplementation guarantee

FINANCING

Leasing offers for technical equipment and furnishings

LEYBOLD®

CASSY – COMPUTER-ASSISTED MEASUREMENT AND EVALUATION

The modular CASSY system makes computer-assisted measurement and evaluation possible for all training and educational levels up to university level.

THE CASSY SYSTEM COVERS:

1. Interface for recording measurement data
2. Comprehensive offering of sensors for the detection of electrical and non-electrical variables
3. CASSY Lab 2: The intuitive and easy-to-use software for measurement and evaluation designed to fit all of the equipment and sensors

SENSORS

Catalogue No.	Designation
524 078	CAN bus box
524 081	LIN bus box
524 076	AUTO-BOX i
524 077	AUTO-BOX Z
738 989	Standard Workshop TDC Pick-Up
738 987	Capacitive-Type Pick-Up
738 986	Inductive-Type Pulse Pick-Up
524 064	Pressure sensor S
524 044	Temperature sensor S
524 0511	Lux adapter S
666 243	Lux sensor
524 031	Current source box
524 043	30 A Box
524 0512	Optical power sensor S

SENSOR-CASSY 2

INTERFACE FOR RECORDING MEASUREMENT DATA

- For connection to the USB port of a computer, to an additional CASSY module or to the CASSY display
- Simultaneous measurement of voltage, current and two additional variables possible
- Automatic sensor box recognition
- Can be setup as table-top, console or demonstration unit (also in CPS/TPS experiment frames)

Sensor-CASSY 2 (524 013) provides two electrically separated voltage inputs, an alternative current input and two sensor box inputs parallel to this. All inputs have variable measurement ranges. Technical specs can be found in the individual component section of the catalogue.

PLUG & PLAY

Automatic detection and setting of Sensor-CASSY and sensor boxes

COMPATIBLE

with all CASSY sensor boxes and sensors

VEHICLE DIAGNOSIS

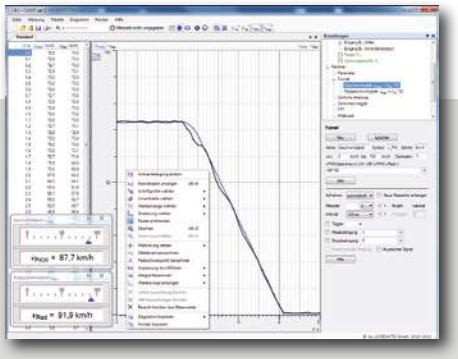
CASSY diagnosis software for the automotive field. This software provides a user interface for Sensor-CASSY, which is based on original diagnosis software.

- for Sensor-CASSY 1+2
- special functions for all high-voltage measurements
- supporting of automotive sensors
- appropriate for electromobility
- protocol analyse is for CAN, LIN, KM and SENT
- for all of your school's workstations (single license = school license)

DMM high-voltage measurements with warning

CASSY LAB 2 AND VEHICLE DIAGNOSIS

SOFTWARE TO RECORD AND ANALYZE MEASURED DATA



Graphical representation of ABS speed signals with CASSY Lab 2

CASSY LAB 2 THE ALL-PURPOSE SOFTWARE

- for all basic equipment
- for all sensors
- for all of your school's workstations (single license = school license)

CHAPTER SUMMARY

A1 FUNDAMENTALS OF CAR ELECTRIC/ELECTONICS

A2 VEHICLE TECHNOLOGY

A1
FUNDAMENTALS OF CAR ELECTRIC/ELECTONICS

A1.1 FUNDAMENTALS BRAND "LEYBOLD"

A1.1.1 FUNDAMENTALS

A1.1.1.1 FUNDAMENTALS OF ELECTRICS

A1.1.1.2 CAR SENSORS

A1.1.1.3 COMPACT SET "BASICS OF AUTOMOTIVE ELECTRICAL ENGINEERING"

A1.1.1.4 CAR ACTUATORS

A1.1.1.5 SAFEGUARDS IN AN INTRINSICALLY SAFE ELECTRIC AND HYBRID VEHICLE

A1.1.2 FUNDAMENTALS WITH COM3LAB

A1.1.2.1 AUTOMOTIVE ELECTRICS

A1.1.2.2 AUTOMOTIVE SENSORS

A1.1.2.3 FUNDAMENTALS OF DIGITAL AND DATA BUS TECHNOLOGY

A1.1.2.4 DIGITAL MEMORY CIRCUITS

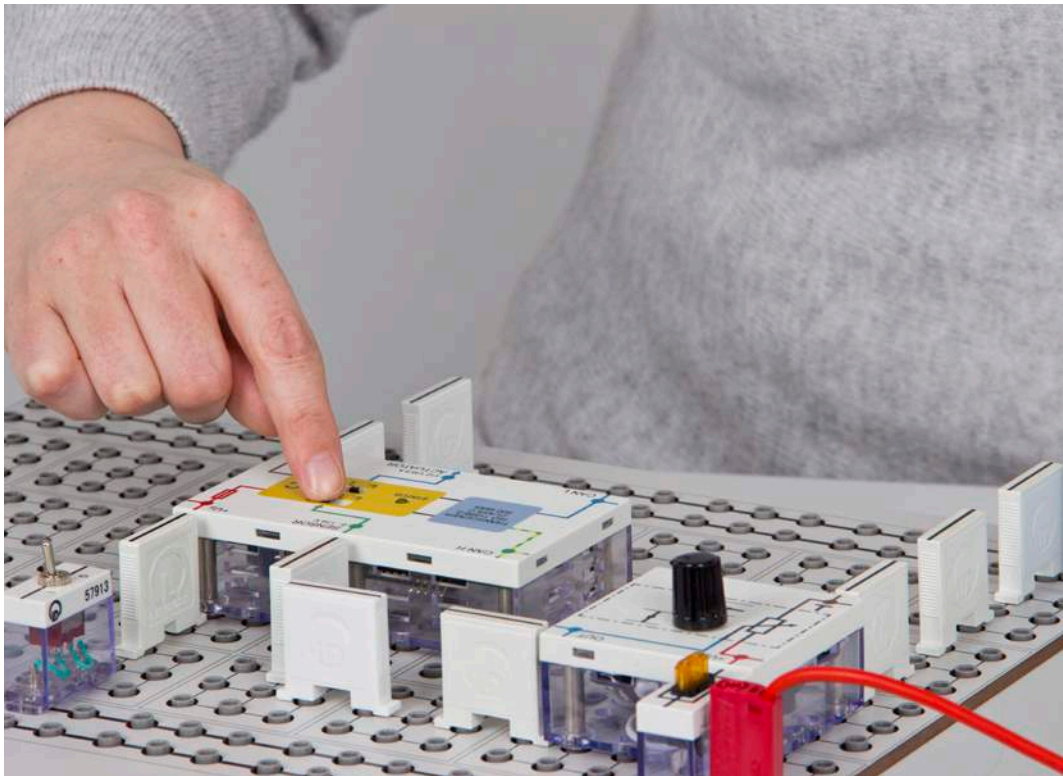
A1.1.2.5 AUTOMOTIVE DATABUSSES

A1.1.1

FUNDAMENTALS WITH STE

A1.1.1.1
Fundamentals of electrics

A1.1.1.2
Sensors in cars



Fundamentals of electrics (A1.1.1.1)

Cat. No.	Description	A1.1.1.1	A1.1.1.2
727 520N	Equipment Set A1.1.1.1, STE	1	
726 50	Plug-in board, 297 mm x 300 mm, STE	2	2
726 88	AC/DC stabilizer	1	1
726 962	Function generator 200 kHz	1	
578 774	Power Switch BTS640 12 A/12	1	
579 163	Simulation ABS/Ti	1	
582 832	STE automotive mini fuse 10A	1	
726 19	Panel frame SL85, single-level	1	
531 090	Multimeter METRAmax 12	1	
531 120	Multimeter LDanalog 20	1	
575 214	Oscilloscope 30 MHz, two-channel, analogous	1	
575 24	Screened cable, BNC/4 mm	2	
LDS 00001	Stopwatch, digital	1	
501 46	Connecting leads, 19 A, 100 cm, red/blue, pair	3	
501 48	Bridging plugs, STE 2/19, set of 10	3	
500 401	Connecting lead, 19 A, 10 cm, red	1	
500 402	Connecting lead, 19A, 10 cm, blue	1	
500 411	Connecting lead, 19 A, 25 cm, red	1	
689 0808	Set 5 automotive Mini fuses	1	
727 5185	Basic set automotive sensorics, STE		1
531 183	Digital multimeter 3340		1
727 5182	Vehicle sensors 1, STE, set		1
727 5183	Vehicle sensors 2, STE, set		1
524 013S	Sensor-CASSY 2 Starter		1

Cat. No.	Description	A1.1.1.1	A1.1.1.2
739 589	Software: Vehicle diagnosis, English		1
524 064	Pressure sensor S, ±2000 hPa		1
524 031	Current source box		1
375 58	Hand vacuum pump		1
577 42	Resistor, 680 W, STE 2/19		1
582 629	Air mass flowmeter STE 4/100/200		1
739 271	Lambda Sensor, heated		1
666 711	Butane gas burner		1
666 712ET3	Butane cartridge, 190 g, set of 3		1
300 02	Stand base, V-shaped, small		1
300 41	Stand rod, 25 cm, 12 mm Ø		1
739 835	Kelvin- sensing cable, set of 2		1
301 01	Leybold multiclamp		1
666 555	Universal clamp, 0...80 mm		1
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair		2
775 001EN	LIT: A1.1.1.2 Sensorics in the vehicle		1
689 0813	Set 12 automotive fuses		1
689 0814	Set 2 automotive automatic fuses		1
689 0815	Set of 10 magnets		1

Our plug-in equipment teaches basic knowledge of electricity, electronics and digital technology specifically in view of typical applications in vehicles and is used e. g. by Volkswagen for education.

The plug-in system represents an ideal introduction to these subjects. It also distinguishes itself by:

- conventional electronic components in see-through casing,
- typical vehicle components in see-through casing,
- a particularly robust design, and
- a layout identical to circuit diagrams on the plug-in board with
- ISO-compliant symbolic representation of the components.

Electronic components, vehicle sensors and transmitters, and their applications in a complete circuit are studied.

The following topics are covered with the equipment set A1.1.1.1:

- The electric circuit
- The ohmic resistance
- Current and voltage sources
- The capacitor
- The coil
- The transformer
- The relay
- Special resistors like NTC, PTC or LDR
- The diode
- The Z-diode
- LEDs
- The transistor, and
- The thyristor.

Finally, with this set applied circuits in vehicle electronics can be assembled, such as:

- The electronic tachometer
- The electronic voltage regulator for three-phase generators, or
- The transistor control unit for breaker-triggered ignition systems.

The basic set of automotive sensors enables the setup of practice-oriented examples of experiments for:

- The simple DC circuit
- Ohm's law
- Nonlinear resistance
- Capacitor in the DC circuit
- Use of inductors in the DC circuit
- The semiconductor diode, and
- The semiconductor LED

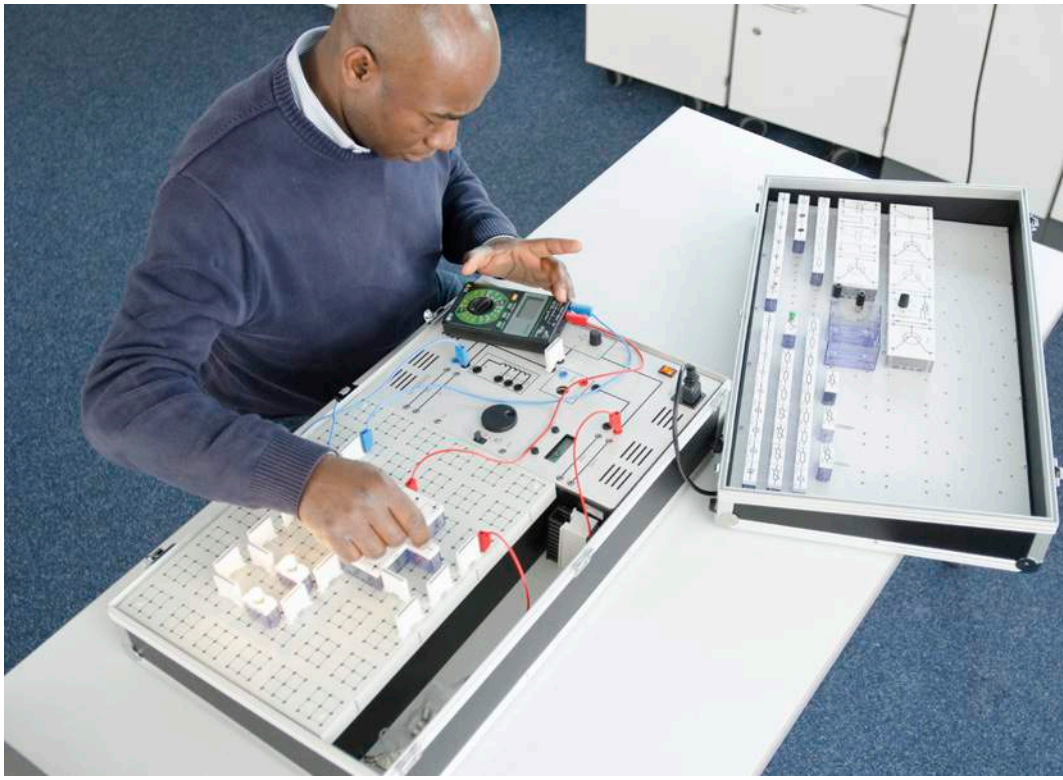
as the fundamentals of sensor circuits.

A1.1.1

FUNDAMENTALS WITH STE

A1.1.1.3
Compact set "Basics of automotive electrical engineering"

A1.1.1.4
Car actuators



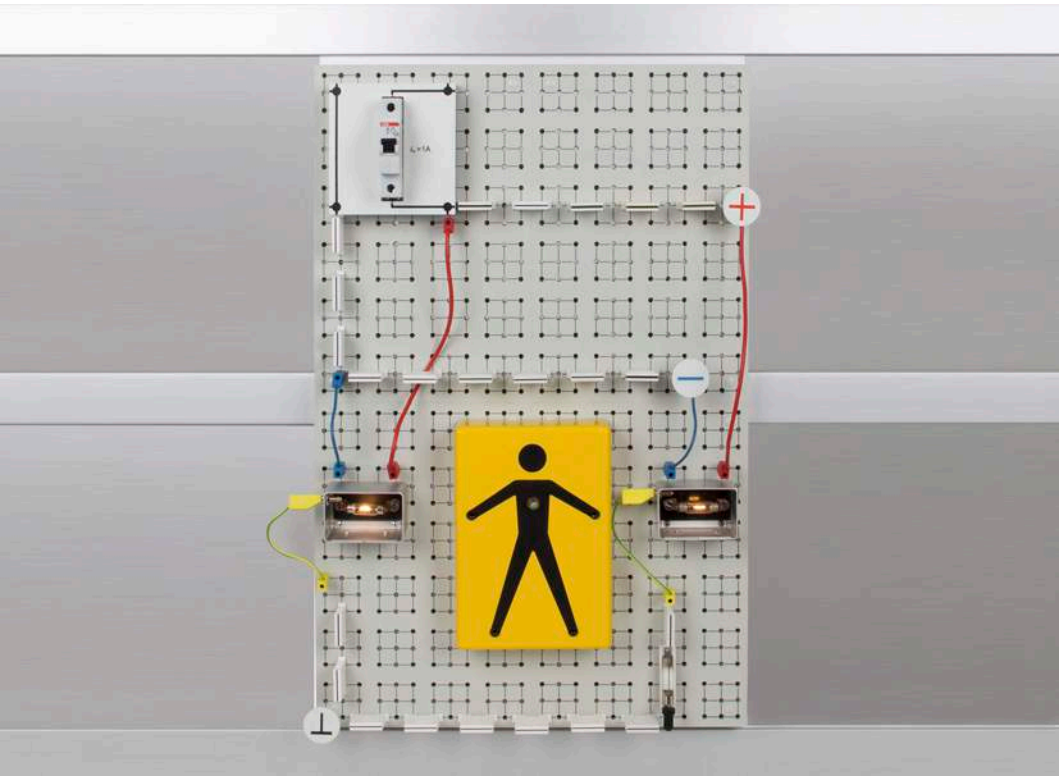
Compact set "Basics of automotive electrical engineering" (A1.1.1.3)

Cat. No.	Description	A1.1.1.3	A1.1.1.4
727 520KOF	Compact set "Basics of automobile electrical engineering" in the case	1	
531 090	Multimeter METRAmax 12	1	
531 120	Multimeter LDanalog 20	1	
575 214	Oscilloscope 30 MHz, two-channel, analogous	1	
575 24	Screened cable, BNC/4 mm	2	
LDS 00001	Stopwatch, digital	1	
501 46	Connecting leads, 19 A, 100 cm, red/blue, pair	2	
727 5186	Vehicle actuators 3, STE, set		1
727 5181	Automotive basic circuits, STE, Set		1
582 642	Pencil coil, STE 6/100/100		1
579 162	Simulation ABS/Ti, STE 2/50		1
578 31	Capacitor, 0.1 µF, STE 2/19		1
582 641	Stepping motor, STE 8/100/100		1
758 201	CAN-Databus node, STE 6/50/100		2
590 821	Coil, 250 turns, STE 2/50		1
590 83	Coil, 500 turns, STE 2/50		1
590 84	Coil, 1000 turns, STE 2/50		1
593 21	Transformer core, demountable		1
578 576	High power LED white, STE 2/19		1
578 48	Light emitting diode, red, STE 2/19		1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive		1
524 220	CASSY Lab 2		1
524 0431	30-A-Box		1
738 985	Automotive meter		1

Cat. No.	Description	A1.1.1.3	A1.1.1.4
575 303	Digital storage oscilloscope 1222		1*
726 50	Plug-in board, 297 mm x 300 mm, STE		2
501 48	Bridging plugs, STE 2/19, set of 10		2
738 027	Digital power supply 1 - 16 V/40 A		1
521 210	Transformer, 6/12 V		1
505 22ET5	Bulbs, 12 V/6 W, E10, inert gas filling, set of 5		1
650 67	Storage tray, S33, STE		1
501 532	Connecting leads, 19 A, set of 30		1

* additionally recommended

The equipment in the STE suitcase lends itself for storage and as a student's workstation. It serves as a receptacle for various STE equipment sets in its cover and can be used to conduct experiments in the classroom. The cover can be separated from the base.



A1.1.1

FUNDAMENTALS WITH STE

A1.1.1.5
Fundamentals of electrics and high voltage technology

Fundamentals of electrics and high voltage technology (A1.1.1.5)

Cat. No.	Description	A1.1.1.5
758 202	Isulation monitoring device, STE 6/100	1
758 203	Automatic circuit breaker Z 1 A, STE 4/1	1
582 85	Human model	1
582 73	Lamp, 24 V/10 W, with housing, STE 2/50	2
581 12	Variable resistor, 47 kW, STE 2/50	1
577 15	Resistor, 0.1 W, STE 2/19	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
739 835	Kelvin-sensing cable, set of 2	1
739 004	DMM for electrical vehicles	1
739 949	HV PC measurement adapter for E-Mobility	1
727 292	Voltage detector	1
666 425	Panel frame C50, two-level, for CPS	1
501 861	Crocodile-clips, polished, set of 6	1
501 48	Bridging plugs, STE 2/19, set of 10	3
726 54	Plug-in board, 634 mm x 400 mm, STE	1
500 402	Connecting lead, 19A, 10 cm, blue	3
500 412	Connecting lead, 19 A, 25 cm, blue	1
500 411	Connecting lead, 19 A, 25 cm, red	4
500 420	Connecting lead, 19 A, 50 cm, yellow/green	2
500 441	Connecting lead 19 A, 100 cm, red	2
500 442	Connecting lead 19 A, 100 cm, blue	2
726 890	DC-High Current Power Supp. 32/20	1

Our plug-in equipment teaches basic knowledge of electricity, electronics and digital technology specifically in view of typical applications in vehicles and is used e. g. by Volkswagen for education.

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- a particularly robust design, and
- a layout identical to circuit diagrams on the plug-in board with
- ISO-compliant symbolic representation of the components.

Electronic components, vehicle sensors and transmitters, and their applications in a complete circuit are studied.

A1.1.2

FUNDAMENTALS WITH COM3LAB

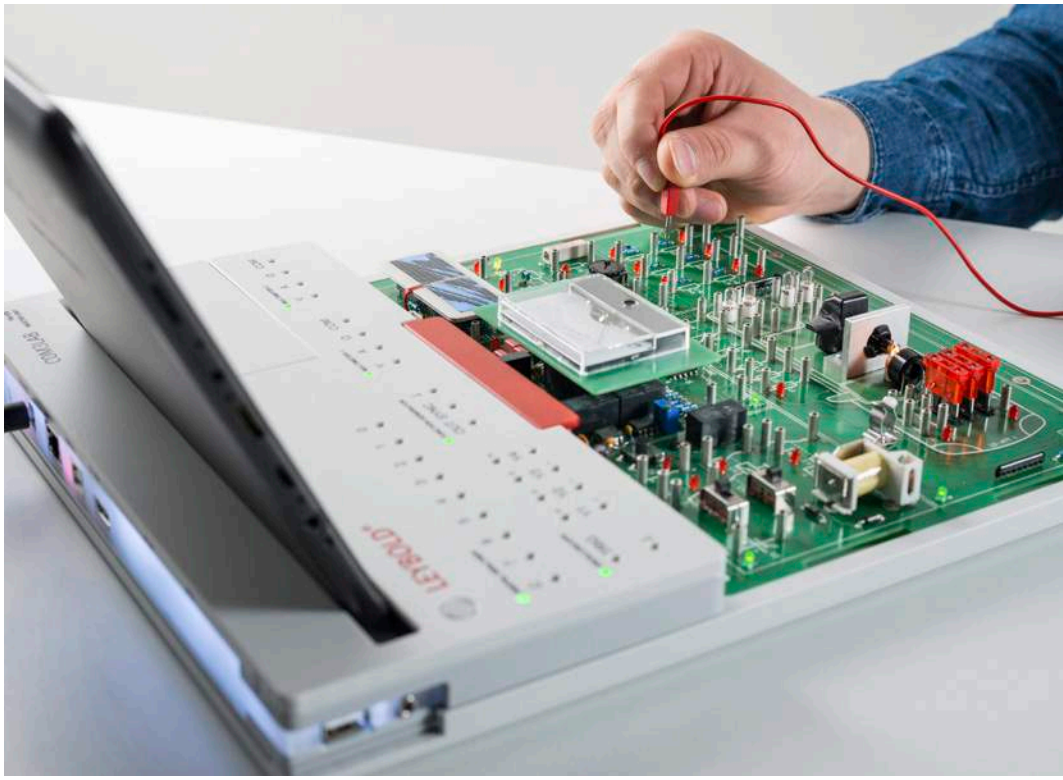
A1.1.2.1
Automotive electrics

A1.1.2.2
Automotive sensors

A1.1.2.3
Fundamentals of digital and data bus technology

A1.1.2.4
Digital memory circuits

A1.1.2.5
Automotive databusses



Automotive electrics (A1.1.2.1)

Cat. No.	Description	A1.1.2.1	A1.1.2.2	A1.1.2.3	A1.1.2.4	A1.1.2.5
700 020	COM3LAB: Master Unit	1	1	1	1	1
700 022	Set of Safety Cables (2 mm, 16 Qty., 6 x 30 cm & 10 x 15 cm)	1	1	1	1	1
700 6101	COM3LAB Course: Automotive Electrics	1				
688 129	Mains cable with hock-proof plug and cold connector	1	1	1	1	1
700 6201	COM3LAB Course: Automotive Sensor Technology		1			
700 6401	COM3LAB Course: Automotive Digital Technology I			1		
700 6501	COM3LAB Course: Automotive Digital Technology II				1	
700 6301	COM3LAB Course: Automotive Data Buses					1
739 581USB	CAN-Bus Adapter USB					1
739 588	LIN-BUS PC interface USB					1

COM3LAB is used for schooling and continuing education in electrical engineering and electronics. Electrical engineering can be taught and learned both theoretically and practically with COM3LAB. COM3LAB is the interface between theory and practice. Subject matters are not only presented theoretically but also simultaneously deepened with practical experiments.

COM3LAB consists of a master unit and several courses (experimental board + CD-ROM). The master unit is the basic device through which the software and experimental board communicate with each other.

The courses provide descriptive theory and many experiments in the widest range of subjects within electrical engineering and electronics. All experiments must be conducted personally. The measurements provide real values.

Ideal for direct transformation from theory into practice.

The COM3LAB courses Electricity and Sensors for Automotive Training formed, in cooperation with the automotive industry strategically introduce the fundamentals of electricity. The COM3LAB course "Automotive Technology I" clarifies in a comprehensible way the variables voltage, current and resistance using graphic animations and videos, and the chapter "Counting with Variables" also examines these values. Measurements on real automotive components with analog and digital meters help understand simple electrical circuits. The course "Vehicle Sensors" gives a detailed explanation of the operating principle of electric components and sensors in a motor vehicle.

The course contents are rounded off with extensive instructions for practical troubleshooting. Comprehension questions and parallel audio responses guarantee the most efficient training possible compared to traditional training methods.

A2
VEHICLE TECHNOLOGY

A2.1 ELECTRICS

A2.1.1

POWER SUPPLY

A2.1.1.1
Energy monitoring

Energy monitoring (A2.1.1.1)

Cat. No.	Description	A2.1.1.1
738 031	Battery monitoring	1
739 588	LIN BUS PC interface USB	1
737 9803	OBD Adaptor CAN+USB	1
738 04	Car battery 12V	1
738 044	AGM-battery 12V	1
738 05	Connection leads I, set	1
738 90	Parallel Glow System	1
738 963	TDI Control Relay for Preheating System	1
738 10	Ignition switch	1
738 043	Vehicle battery connecting kit	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
738 9991	DC/AC clamp-on current probe	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
500 644	Safety connecting lead, 100 cm, black	5
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1
738 01	Cable and plug box	1
500 593	Fault simulation plugs, black, set of 10	1
738 021	Battery charger, automatic	1
775 010EN	LIT: A2.1.1.1 Energy monitoring	1

The electrical system describes the energy and data management's setup and function in modern vehicles. It fuses together the power's supply and distribution, including its control and regulation.

The **car battery** is an essential component of the electrical system. The 738 031 "Battery monitoring" educational panel contains the "diagnostic interface for data bus" with the battery's energy management functionality. This consists of software and the battery data module (BDM), directly on the vehicle battery's negative pole and connected to the diagnostic interface over a LIN bus line.

The BDM determines the battery's state with sensors recording the battery's current, voltage and temperature. This continually calculates the battery's state of charge and state of wear using, among others, battery characteristics stored in the control unit.

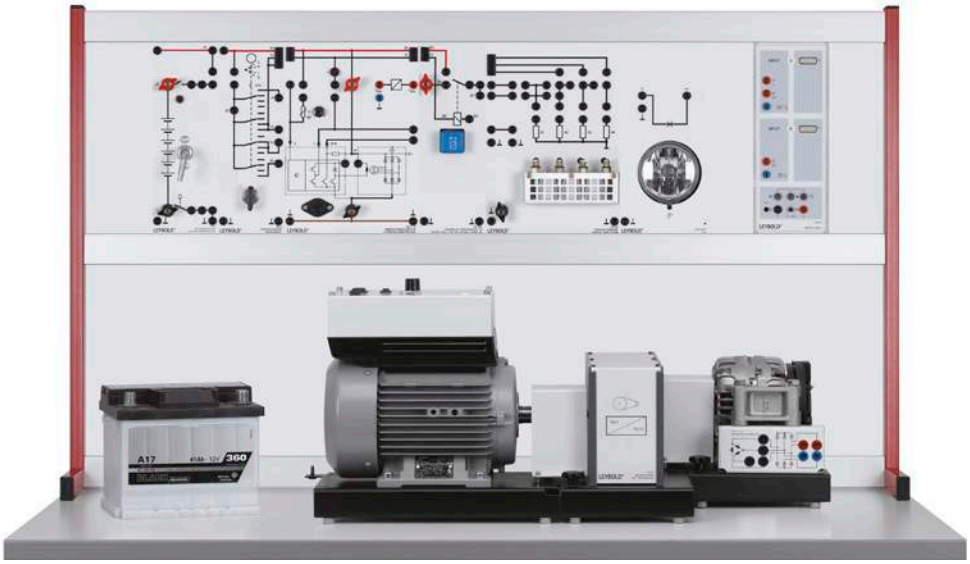
The **standby current** keeps the battery voltage from declining below a minimum value needed to start the vehicle. For example, operation of the auxiliary heating is disabled, and a display on the instrument cluster informs the driver.

The **dynamic management** distributes the energy generated while driving to the individual loads. This is especially important if the energy does is not sufficient for the demand because of the number of loads (seat heater, lights, rear window).

A2.1.1

POWER SUPPLY

A2.1.1.2
Three-phase alternator



Three-phase alternator (A2.1.1.2)

Cat. No.	Description	A2.1.1.2
738 711	Compact alternator	1
738 631	Motor f. Generator Experiments, 1.0 kW	1
738 632	Belt drive for vehicle 1:3	1
738 963	TDI Control Relay for Preheating System	1
738 90	Parallel Glow System	1
738 10	Ignition switch	1
738 18	Auxiliary headlamp	1
738 76	Field Regulator, Generator	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 013	Sensor-CASSY 2	1
738 985	Automotive meter	1
524 076	AUTO-BOX i	1
738 9991	DC/AC Clamp on current probe	1
732 56	Coupling 1,0	2
732 58	Coupling Guard 1,0	2
726 10	Panel frame T150, Two Level	1
738 03	Battery connection unit	1
738 04	Car battery 12V	1
738 043	Vehicle battery connecting kit	1
738 05	Connection leads I, set	2
500 59	Set of 10 safety bridging plugs, black	2
500 592	Safety Bridging Plugs with Tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
501 46	Connecting lead 19 A, 100 cm, red/blue, pair	1

Cat. No.	Description	A2.1.1.2
775 011EN	LIT: A2.1.1.2 Three-phase alternator	1
738 01	Cable and plug box	1
500 593	Fault simulation plugs, black, set of 10	1
738 021	Battery charger, automatic	1

The three-phase generator - also known as "alternator" - is an induction machine operated as a generator that produces a speed-dependent three-phase alternating current using an electrical field. Since the electrical system is designed as a DC power system, this three-phase voltage must still be rectified. The control technology also comes into play: the voltage level should remain constant independently of the engine speed – the hybrid multi-function controller handles this.

The excitation current and the voltage can be captured on the connection plate, and connections are available

- to the battery monitoring (sensing)
- to the load and error detection, and
- to the rotation speed detection.

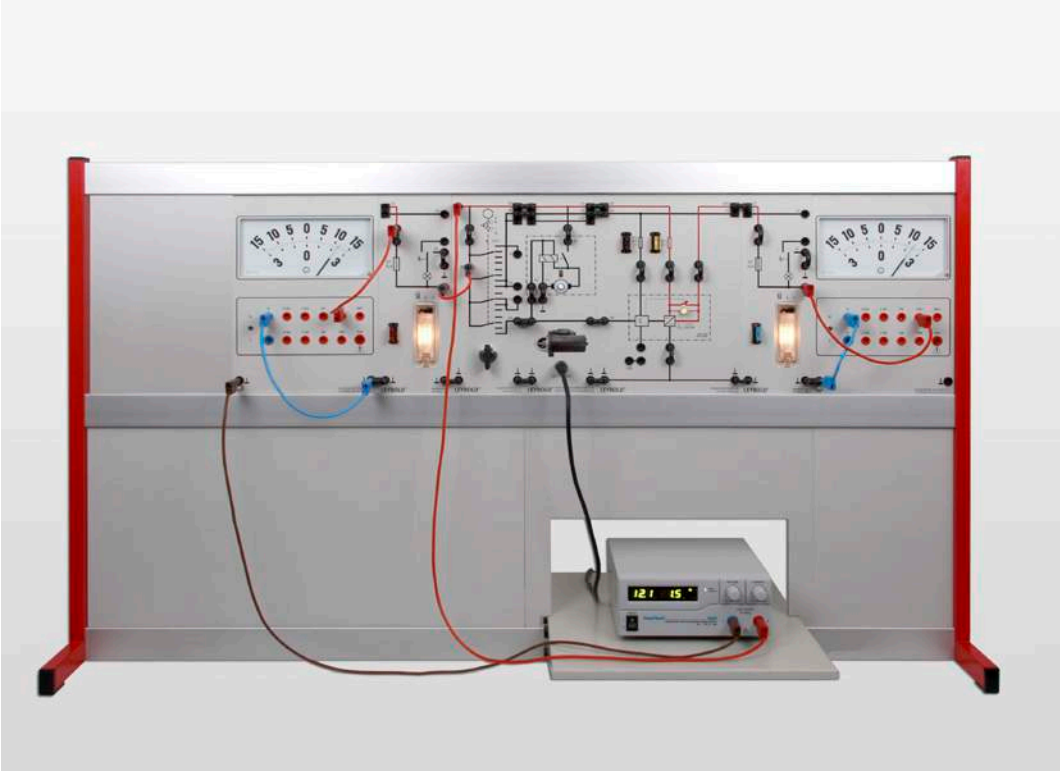
The generator's output voltage can be led as a function of temperature or by the engine control unit.

In connection with lighting components, special high-current loads and a vehicle battery, the complete electrical system can be assembled.

A2.1.1

POWER SUPPLY

A2.1.1.4
On-board supply of
start/stop systems



On-board supply of start/stop systems (A2.1.1.4)

Cat. No.	Description	A2.1.1.4
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
738 07	Interior lamp	2
738 027	Digital power supply 1 - 16 V/40 A	1
738 871	Starter substitute w. load simulation	1
738 32	Voltage stabilizer	1
727 20	Automobile Meter Zero-Left	2
775 010EN	LIT: A2.1.1.1 Energy monitoring	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
726 09	Panel frame T130, two-level	1
738 05	Connection leads I, set	1
500 441	Connecting lead, 19 A, 100 cm, red	1
500 444	Connecting lead, 19 A, 100 cm, black	1
500 412	Connecting lead, 19 A, 25 cm, blue	1
500 411	Connecting lead, 19 A, 25 cm, red	2
500 401	Connecting lead, 19 A, 10 cm, red	1
500 402	Connecting lead, 19A, 10 cm, blue	1
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1

The electrical system describes the energy and data management's setup and function in modern vehicles. It fuses together the power's supply and distribution, including its control and regulation.

The on-board power supply governs the construction and function of energy and data management in the modern vehicle. It forms a system of energy supply and distribution including drive and control.

In vehicles with start/stop systems the battery voltage will often sink below 12 V as a result of the many start processes. If a voltage stabiliser is used, the on-board voltage will remain at a constant 12 V during the starting process in order to maintain maximum convenience. The voltage stabiliser is a DC/DC transformer on the selected components, such as the instrument cluster connection to the radio as well as the ABS/ESP controller.

Suitable measures are employed in this device set to reduce the on-board power supply voltage during start processes without large currents being necessary for this. This allows the function of the stabiliser to be didactically examined by comparing the voltage in front of and after it.

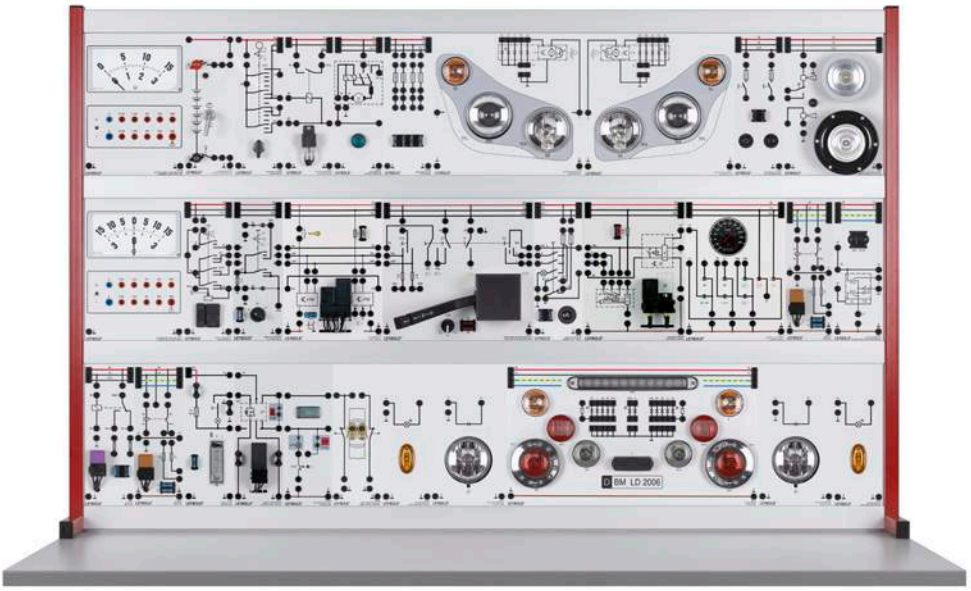
The device set will only work with 738 027 power supply.

A2.1.2

LIGHTING SYSTEMS

A2.1.2.1
Automotive lighting

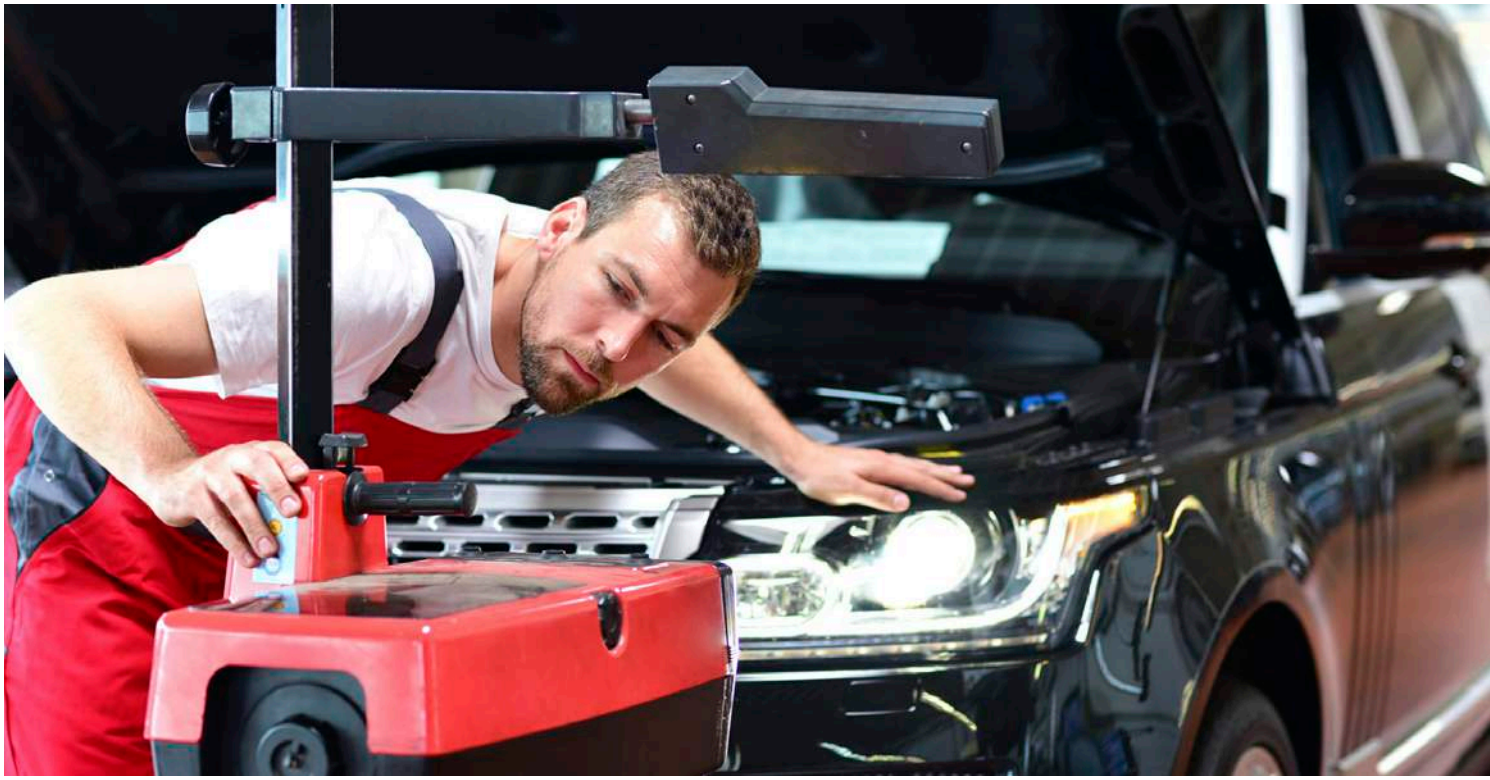
A2.1.2.2
Supplementary set "Trailer"



Automotive lighting (A2.1.2.1)

Cat. No.	Description	A2.1.2.1	A2.1.2.2
738 10	Ignition switch	1	
738 032	Battery connection with protection circuit	1	
738 151	Telltales KI	1	
738 871	Starter substitute w. load simulation	1	
738 11	Head lamp switch	1	
738 131	Stalks with with parking light	1	
738 114	Light control	1	
738 166	Headlights right	1	
738 167	Headlights left	1	
738 190	Rear lights	1	
739 573	Automotive Set Point Potentiometer	1	
738 35	Normal and High Volume Horn	1	
738 373	Turn signal control	1	
738 372	Convenience turn signal control unit	1	
738 38	Warning Lamp Switch	1	
738 361	Side turn signal light LED	2	
738 07	Interior lamp	1	
738 075	Luggage lamp	1	
738 08	Door contact switch	1	
738 311	Courtesy lamp control	1	
738 141	Fog lamp switch	1	
738 18	Auxiliary headlamp	2	
738 09	Fuse holder	1	
738 291	Relay 1NO	2	

Cat. No.	Description	A2.1.2.1	A2.1.2.2
738 28	Relieving Relay	1	
738 30	Relay 1 CO	1	
738 044	AGM-battery 12V	1	
738 043	Vehicle battery connecting kit	1	
537 32	Rheostat, 10 ohms	1	
738 12	Multi-purpose switch	1	
LDS 00001	Stopwatch, digital	1	
727 20	Automobile Meter Zero-Left	1	
727 21	Automobile Meter Zero-Center	1	
738 985	Automotive meter	2	
500 990	Adapter sockets, set of 2	1	
738 05	Connection leads I, set	1	
738 027	Digital power supply 1 - 16 V/40 A	1	
726 26	Panel frame VT180, three-level	1	
500 59	Safety bridging plugs, black, set of 10	7	1
500 592	Safety bridging plugs with tap, black, set of 10	1	
738 9831	Safety experiment cables, set of 102	1	
689 0813	Set 12 automotive fuses	1	
689 0814	Set 2 automotive automatic fuses	1	
775 012EN	LIT: A2.1.2.1 Automotive lighting	1	
738 16	Main headlamp with side lamp	2	
738 01	Cable and plug box	1	
500 593	Fault simulation plugs, black, set of 10	1	
738 021	Battery charger, automatic	1	



Cat. No.	Description	A2.1.2.1	A2.1.2.2
738 27	Trailer lights		1
738 251	Trailer Socket 13 pole		1

See and be seen - the vehicle lighting is not only designed that the driver can see the road better, but also to the fact that he is seen better. Thus, the illumination is one of the most important safety components of vehicles. For this reason, the development of improved lighting systems is still going on and has led to the use of LEDs in front and rear lights. In addition, the systems are "automated" to assist the driver in the operation.

Defined functions of the lights at the front of the vehicle, at the rear and inside are part of the vehicle's lighting technology. Even if control units activate modern lighting systems, knowing conventional circuits is indispensable.

Certain physical principles, like those of polyellipsoid headlamps, xenon lamps or LED lights must also be mastered. Vehicle lighting systems require knowledge of the stipulations in the Road Traffic Type Approval Law and their requirements with regard to mechanical layout and electrical connection of lighting components.

The modern lights is therefore now more than just a lamp and a set of ray optic devices. It is an intelligent mechatronic unit consisting of light sources, ray optics, electric motors and various control units.

With **polyellipsoid headlamps** the emitted light beams have a farther focus. Positioning a lens near it results in an exact light/dark boundary. The remaining light can then be uniformly distributed a little farther ahead on the roadway through an appropriate lens. Already shortly after exiting the ellipsoid, the bundled light beams are considerably smaller than with a paraboloid or free-form reflector. Only beyond the final lens (with a small effective reflex surface) does it grow.

For various load conditions of the vehicle, the headlamp level control should prevent blinding of oncoming traffic. The reflectors can be tilted vertically and adjusted by electric motors. If manually adjusted, these are set by a locator operated by the driver. With automatic headlamp level control, the assembly's position is detected by level sensors, and the control unit sends the corresponding signals to the electric motors.

Some provisions need to be followed, in particular with **trailers**. Correct connection of the trailer socket, monitoring of the turn-signal system and automatic shutdown of the rear fog lamps on the towing vehicle must be ensured.

Automotive lighting with CAN data bus (A2.1.3.1)

A2.1.3

NETWORKING
LIGHTING SYSTEMS

A2.1.3.1
Automotive lighting with
CAN data bus

A2.1.3.2
Supplementary set "Trailer control"

Cat. No.	Description	A2.1.3.1	A2.1.3.2
738 111	Intelligent automotive lighting management system	1	
738 1121	OBD adaptor	1	
726 256	Panel frame VT160, three-level	1	
738 291	Relay 1NO	1	
579 13	Toggle switch, STE 2/19	1	
738 10	Ignition switch	1	
738 166	Headlights right	1	
738 167	Headlights left	1	
738 361	Side turn signal light LED	2	
578 611	Phototransistor, STE 2/19	1	
738 190	Rear lights	1	
738 975	Diagnostic Plug 16 Pin	1	
738 18	Auxiliary headlamp	2	
577 79	Variable resistor, 1 kW, STE 2/19	1	
577 321	Resistor, 120 W, STE 2/19	2	
578 02	Photoresistor LDR 05, STE 2/19	1	
739 654	Steering angle sensor	1	
739 585	Fault simulator CAN Bus	1	
738 4911S	Automotive fault simulator, start	1	
739 6021	Instrument cluster unit	1	
738 03	Battery connection unit	1	
579 163	Simulation ABS/Ti	1	
739 587	Software: Databus visualisation	1	
737 9803	OBD Adaptor CAN+USB	1	

Cat. No.	Description	A2.1.3.1	A2.1.3.2
524 078	CAN bus box	1	
524 013S	Sensor-CASSY 2 Starter	1	
739 581USB	CAN databus adapter USB	1	
524 0431	30-A-Box	1	
739 589	Software: Vehicle diagnosis, German and English	1	
738 027	Digital power supply 1 - 16 V/40 A	1	
500 990	Adapter sockets, set of 2	1	
500 59	Safety bridging plugs, black, set of 10	14	3
500 592	Safety bridging plugs with tap, black, set of 10	2	1
738 9831	Safety experiment cables, set of 102	1	
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	1	
689 0813	Set 12 automotive fuses	1	
689 0814	Set 2 automotive automatic fuses	1	
775 013EN	LIT: A2.1.3.1 Automotive lighting with CAN databus	1	
738 01	Cable and plug box	1	
500 593	Fault simulation plugs, black, set of 10	1	
739 5835	DS vehicle door	1*	
739 5836	PS vehicle door	1*	
738 251	Trailer Socket 13 pole		1
738 263	CAN Trailer ECU		1
738 27	Trailer lights		1
726 09	Panel frame T130, two-level		1

* additionally recommended

With more data transmission and networking in the motor vehicle, networked control units also take over the management of the lighting and electrical system in modern passenger cars. The educational system consists of a steering column switch with control unit and the electrical system control unit to activate the front and rear lights. It can be expanded with a comfort control unit, an instrument cluster with integrated gateway and a control unit for automatic trailer detection.

The experiment can study modern control unit functions, such as

- Cold lamp monitoring
- Hot lamp monitoring
- Turn signals
- Daytime running lights
- Automatic headlights
- Automatic ambient lighting, or
- PWM-controlled taillights.

Furthermore, measurements relevant to the workshop can be executed on the low-speed and high-speed CAN data buses. The lockable fault simulator (738 585), which can override practical faults in addition to all the standardized faults per ISO, lends itself to the students' troubleshooting procedure, and so does the remote-controlled automotive fault simulator (738 491).

With lighting systems controlled by CAN bus with an electrical system control unit, the trailer socket may not simply connect in parallel to the available rear lights. In fact interconnecting an appropriate control unit and integrating it into the CAN topology is required.

A2.1.3

NETWORKING
LIGHTING SYSTEMS

A2.1.3.4
LED Headlights

LED Headlights (A2.1.3.4)

Cat. No.	Description	A2.1.3.4
738 189	LED Headlight	1
738 027	Digital power supply 1 - 16 V/40 A	1
775 015EN	LIT: A2.1.3.4 LED Headlights	1
739 588	LIN BUS PC interface USB	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
467 251	Compact spectrometer USB, physics	1*
739 580	Databus detector	1
500 644	Safety connection lead, 100 cm, black	2
500 647	Safety connection lead, 100 cm, brown	3
500 641	Safety connection lead, 100 cm, red	1
500 59	Set of 10 safety bridging plugs, black	1
500 592	Safety Bridging Plugs with Tap, black, set of 10	1
460 251	Fibre holder	1*
500 990	Adapter sockets, set of 2	1
300 11	Saddle base	1
301 339	Stand bases, pair	1
747 516	Hex Driver, 6 mm	1
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1

* additionally recommended

Once LEDs (Light Emitting Diodes) could be found in the rear of the vehicle used as "indicators", super bright LEDs can also be used in headlights as the main light for illumination purposes. LEDs offer in contrast to halogen and xenon lamps higher efficiency, longer life and above all, greater flexibility in the design of the vehicle front.

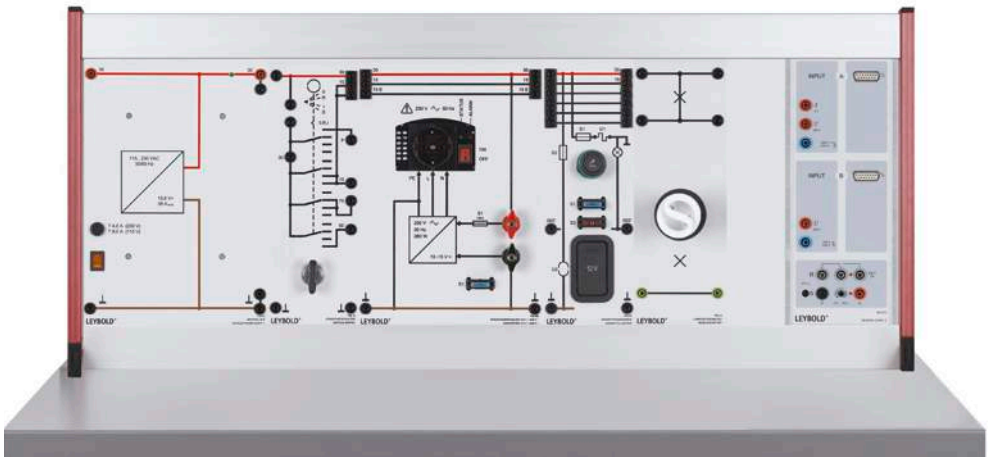
With this didactic equipment set, the following topics can be examined experimentally:

- LEDs as a lighting element
- Lighting functions (eg DRL)
- Special lighting functions (such as all-weather light)
- Headlight range adjustment
- LED lighting element according to ECE
- Legal regulations ECE
- Testing and adjustment of headlights
- Service orders and troubleshooting
- Reading circuit diagrams and diagnostic strategies
- Spectral analysis of LED light

A2.1.4

BACKFITTING ELECTRICAL SYSTEMS

A2.1.4.1
Electrical systems 230 VAC



Electrical systems 230 VAC (A2.1.4.1)

Cat. No.	Description	A2.1.4.1
738 061	Inverter 12/230 V	1
502 05	Measuring junction box	1
505 3181	Energy saving lamp, 230 V/11 W, E 27	1
729 13	Lamp Socket E27	1
738 06	12 V on-board socket	1
738 10	Ignition switch	1
738 02	Automotive power supply 13.8 V/36 A	1
500 597	Automobile protection measuring adaptor	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
726 19	Panel frame SL85, single-level	1
500 59	Safety bridging plugs, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
738 01	Cable and plug box	1*
500 593	Fault simulation plugs, black, set of 10	1*
500 592	Safety bridging plugs with tap, black, set of 10	1
775 014EN	LIT: A2.1.4 Backfitting electrical systems	1

* additionally recommended

Retrofitting electric systems is now an essential part of the automotive mechatronics engineer's training.

The motor vehicle has become part of everyday life for today's motorists. This includes numerous vehicle owners who would like to use the common, portable devices and consumer appliances even in their car. So car manufacturer optionally deliver their models with 230 V outlets already installed. Alternatively, there are various retrofitting solutions that supply 230 V - by tapping into the 12 V on-board outlet.

This situation generates brand new tasks and problems for automotive mechatronics engineers:

- May an automotive mechatronics engineer is able to retrofit such an installation?
- May he repair them to it?
- Are there any regulations to pay attention to?

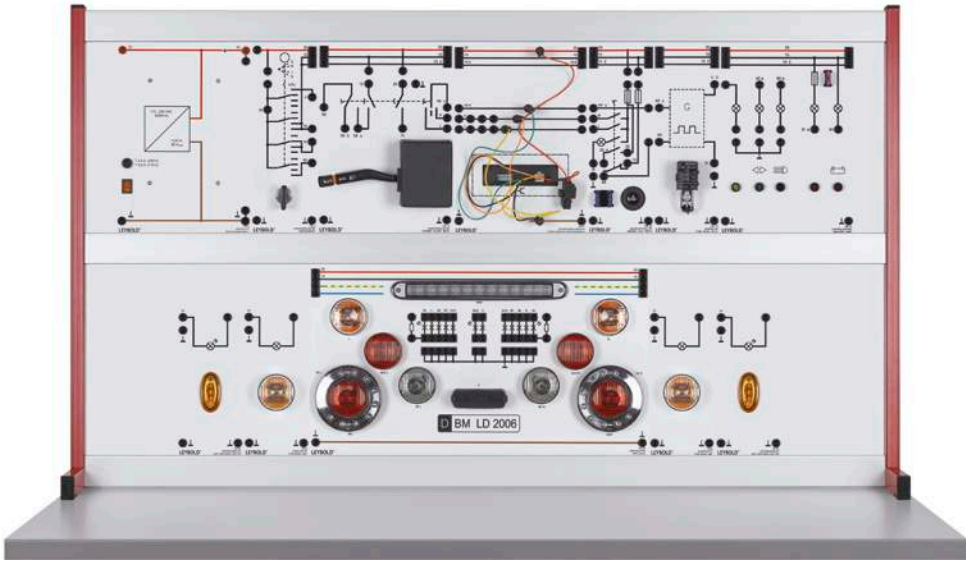
This experiment set up field of instruction exhaustively studies these questions on the one hand and of course the technology on the other hand.

- What is an inverter?
- How does it work?
- How does it relate to personal safety?
- Which faults may arise and how can they be diagnosed and corrected?

A2.1.4

BACKFITTING ELECTRICAL SYSTEMS

A2.1.4.2
Comfort system turn signal flashing



Comfort system turn signal flashing (A2.1.4.2)

Cat. No.	Description	A2.1.4.2
738 371	Automotive 1 tip/3 flash relay	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
738 131	Stalk swith with parking light	1
738 38	Warning Lamp Switch	1
738 37	Turn Signal Relay	1
738 151	Telltales KI	1
738 36	Turn Signal Lamp	2
738 361	Side turn signal light LED	2
738 190	Rear lights	1
738 02	Automotive power supply 13.8 V/36 A	1
726 10	Panel frame T150, two-level	1
500 59	Safety bridging plugs, black, set of 10	4
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
738 05	Connection leads I, set	1
500 593	Fault simulation plugs, black, set of 10	1*
738 01	Cable and plug box	1
775 014EN	LIT: A2.1.4 Backfitting electrical systems	1

* additionally recommended

That is especially convenient when passing: Lane changes as well as the return into the line of cars is clearly announced by the repeated use of turn signals, as the German Highway Code (STVO) calls for in §5. The vehicles behind receive sufficient warning, and the passing driver can fully concentrate on the flow of traffic. This "blinking sequence" is a comfort feature that is absent from many production vehicles, especially older ones, and can only be retrofitted.

This subject comprehensively and practically studies such retrofitting.

- How are the existing turn signals connected?
- How should the operating instructions' wiring diagram be read?
- And how should it be copied in the vehicle?
- Where does the aftermarket device connect?
- The module does not work – why?

To establish practical relevance, work is done with the original operating manual and the original set of cables.

A2.1.4

BACKFITTING ELECTRICAL SYSTEMS

A2.1.4.3
Cornering light

Cornering light (A2.1.4.3)

Cat. No.	Description	A2.1.4.3
738 113N	Cornering light Net	1
738 291	Relay 1NO	1
738 111	Intelligent automotive lighting management system	1
738 166	Headlights right	1
738 167	Headlights left	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
739 6021	Instrument cluster unit	1
738 02	Automotive power supply 13.8 V/36 A	1
738 190	Rear lights	1
739 654	Steering angle sensor	1
738 18	Auxiliary headlamp	2
738 361	Side turn signal light LED	2
579 163	Simulation ABS/Ti	1
775 016EN	LIT: A 2.1.4.3 Cornering Light	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
739 581USB	CAN-Bus Adapter USB	1
313 12	Digital stop-watch	1
738 9821	Safety experiment cables, set of 51	1
500 59	Safety bridging plugs, black, set of 10	10
500 592	Safety bridging plugs with tap, black, set of 10	2
577 321	Resistor, 120 W, STE 2/19	2
577 79	Variable resistor, 1 kW, STE 2/19	1
726 256	Panel frame VT160, three-level	1
738 01	Cable and plug box	1

Cat. No.	Description	A2.1.4.3
738 05	Connection leads I, set	1
725 007	Software: Leylab.control Lite	1
689 0808	Set 5 automotive Mini fuses	1

Since conventional vehicle lighting is designed for straight roads, curve or side streets are not illuminated optimally when turning. Engineers therefore developed systems that move the headlights depending on the steering wheel position at first mechanically, later electrically as well. This system is still known as "dynamic cornering lights". As an extension the "Static Cornering Light" is an additional lateral facing light to normal driving light.

The following topics can be covered:

- Additional systems / auxiliary units
- Legal regulations (ECE)
- Installation instructions
- Schematics, symbols, terminal designations
- Wires, connectors
- Electric and electronic components, assemblies and systems
- Electrical and electronic circuits, basic variables and signals
- Regulations for the testing of electrical / electronic systems
- Requirements for testing and setting of headlights
- Safety and accident prevention in dealing with electrical components

A2
VEHICLE TECHNOLOGY

A2.2 ELECTRICAL MACHINE

A2.2.1 ELECTRICAL MOTOR

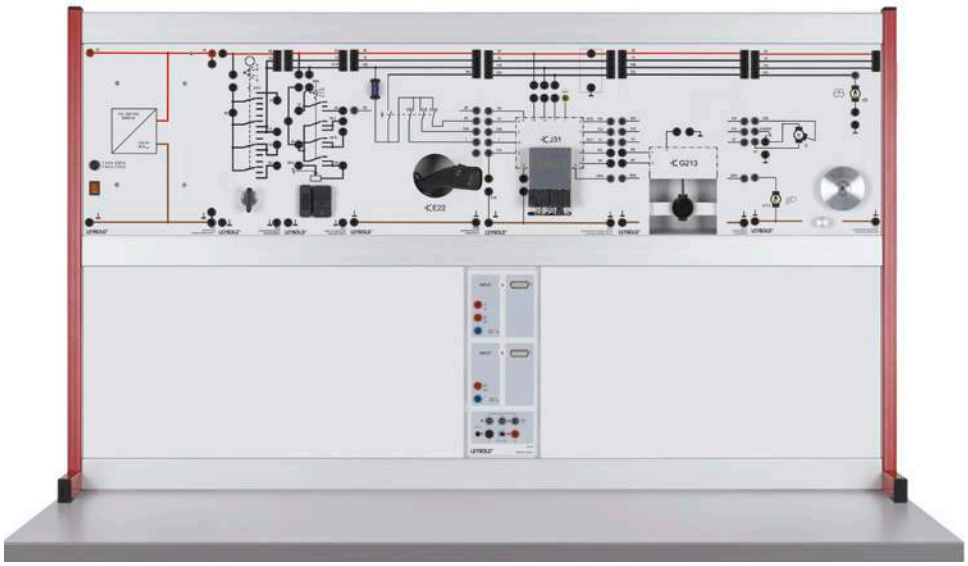
A2.2.1.1 WIPER MOTOR

A2.2.1.2 PRE-ENGAGED-DRIVE STARTERS

A2.2.1

ELECTRICAL MOTOR

A2.2.1.1
Wiper motor



Wiper motor (A2.2.1.1)

Cat. No.	Description	A2.2.1.1
738 830	Wiper Switch	1
738 831	Wipe-Wash Interval Relay	1
738 832	Rain sensor	1
738 833	Windshield Wiper Unit	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
738 11	Head lamp switch	1
309 48ET2	Fishing line, set of 2	1
315 38	Weight, 0.5 kg	1
524 013S	Sensor-CASSY 2 Starter	1
524 013	Sensor-CASSY 2	1
738 985	Automotive meter	1
524 0431	30-A-Box	1
726 09	Panel frame T130, two-level	1
738 02	Automotive power supply 13.8 V/36 A	1
738 05	Connection leads I, set	1
500 59	Safety bridging plugs, black, set of 10	3
500 641	Safety connecting lead, 100 cm, red	3
500 647	Safety connection lead, 100 cm brown	3
500 612	Safety connecting lead, 25 cm, blue	2
500 592	Safety bridging plugs with tap, black, set of 10	1
738 01	Cable and plug box	1
500 593	Fault simulation plugs, black, set of 10	1
738 4911S	Automotive fault simulator, start	1
775 021EN	LIT: A2.2.1.1 Wiper motor	1

The **windshield wiper** - clear vision, without which nothing moves in the rain! The classic windshield wiper application uses grinding machines for the front wipers. By contrast, the rear window wipers have a pole-changeable operation, since they work predominantly intermittently.

An automatic windshield wiper with rain sensor distinctly increases comfort and contributes to safety when driving.

The complete system consists of:

- a rotating windshield wiper motor
- a wipe-wash interval relay
- a washing pump simulation for the front glass
- a washing pump simulation for the headlights
- the steering column switch, and
- the rain sensor.

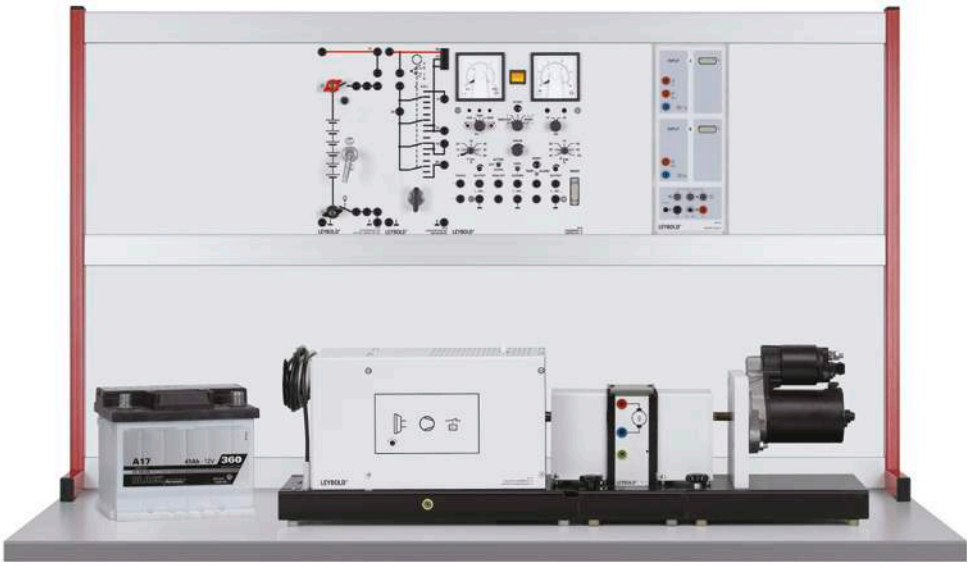
The generic term "automotive physics" refers to the system's mechanical side: the motor can be loaded precisely with a weight to determine the motor's efficiency and torque.

The rain sensor is studied in its capacity as an optical sensor and as part of the controlled system. It is assembled behind plexiglass to be activated upon sprinkling with water.

A2.2.1

ELECTRICAL MOTOR

A2.2.1.2
Pre-engaged-drive starters



Pre-engaged-drive starters (A2.2.1.2)

Cat. No.	Description	A2.2.1.2
738 851	Pre-engaged drive starter, perman.-excited	1
732 54	Magnetic Powder Brake 1.0	1
732 55	Control Unit 1.0	1
732 59	Tacho Generator 1.0	1
500 597	Automobile protection measuring adaptor	1
726 09	Panel frame T130, two-level	1
732 56	Coupling 1.0	2
732 58	Coupling guard 1.0	2
500 59	Safety bridging plugs, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
524 013S	Sensor-CASSY 2 Starter	1
738 9991	DC/AC clamp-on current probe	1
314 201	Precision dynamometer, 100.0 N	1
738 03	Battery connection unit	1
738 04	Car battery 12V	1
738 05	Connection leads I, set	1
738 10	Ignition switch	1
738 88	Connecting Leads II, set	1
738 042	Battery pole-clamp, set	1
738 89	Crocodile clip 32 A, set of 2	1
775 020EN	LIT: A2.2.1.2 Electrical starter	1

The **electric motor** - the vehicle's second torque! The principle is sound: a current flow generates a magnetic field that, together with a second magnetic field, forms energy. This process can be used to generate linear movements (e.g. valves, injectors, relays) but also rotating movements.

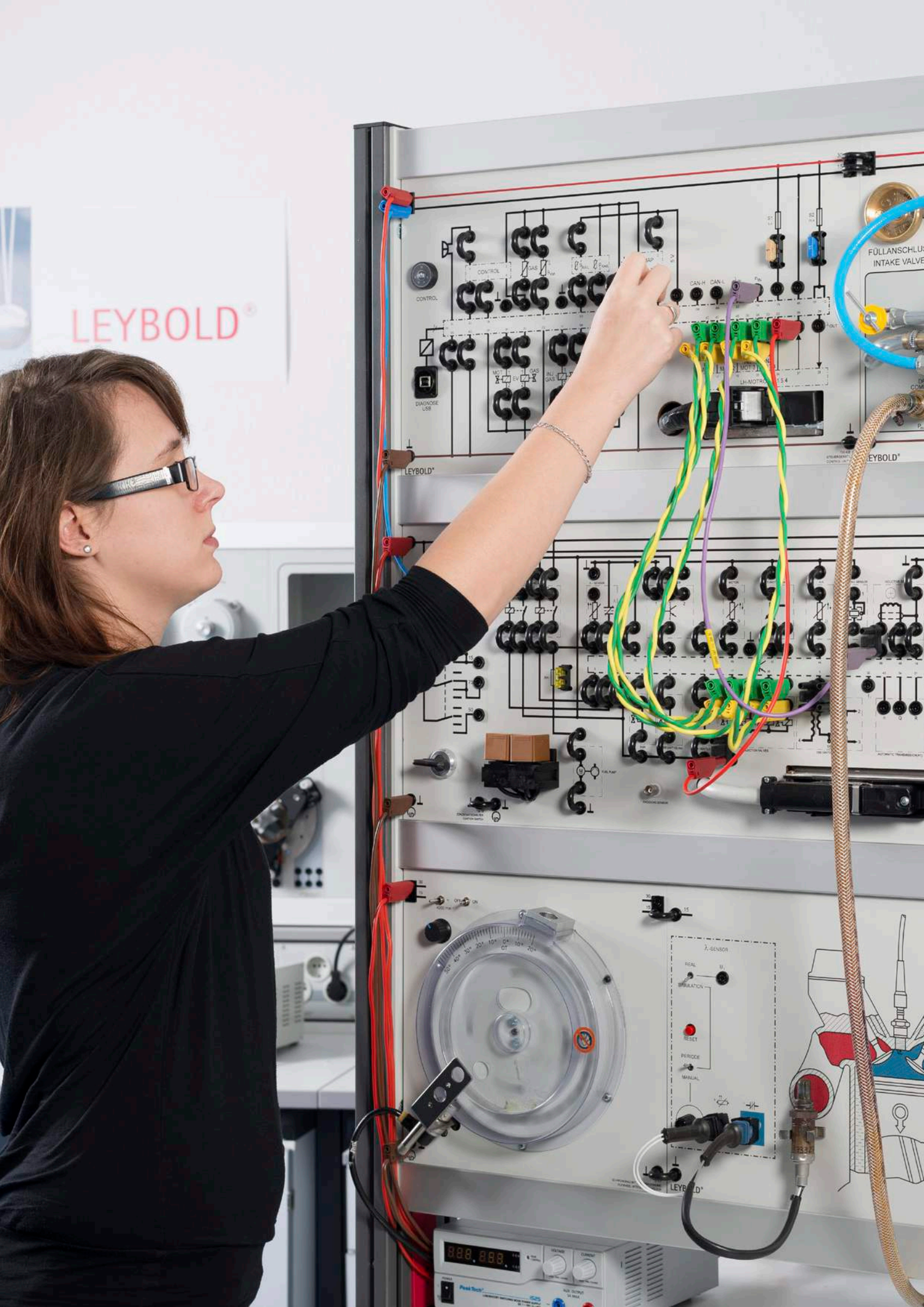
The **starter** is a DC series wound machine that can raise a sufficient torque at relatively low speeds to start the combustion engine. Maintaining the resulting power from the electric system requires correspondingly high current and conductor cross sections.

The educational system is aimed at recording the speed-torque curve. The starter is thus loaded by a magnetic powder brake.

The variables

- brake torque
- voltage
- speed, and
- current through a current probe

can be recorded with CASSY and correspondingly represented and analyzed.


LEYBOLD
CONTROL
DIAGNOSE USB
CAN-H
CAN-L
LH-MOTRONIC
FÜLLANSCHLUS
INTAKE VALVE
LEYBOLD
λ-SENSOR
REAL
SIMULATION
RESET
PERIODE
MANUAL

A2
VEHICLE TECHNOLOGY

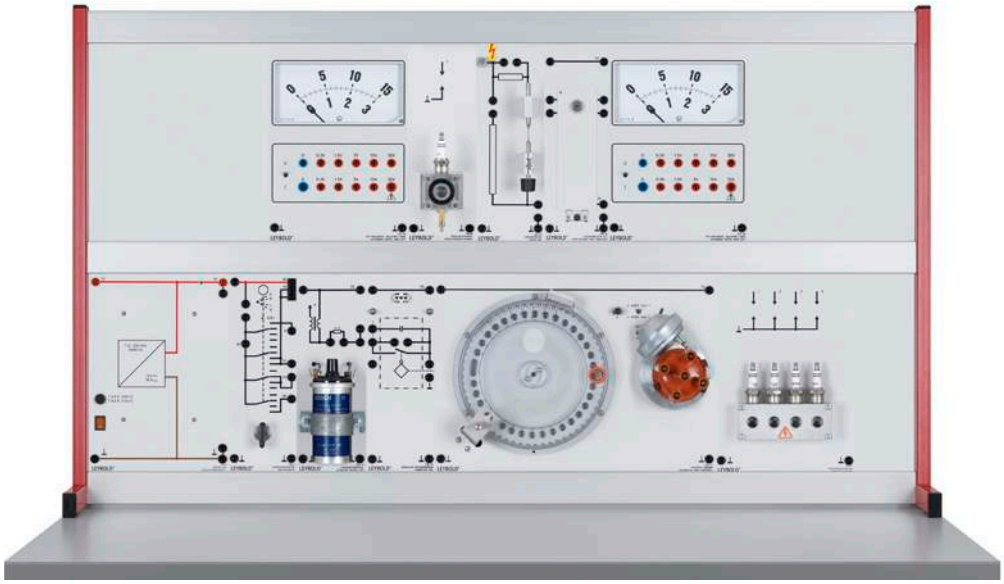
A2.3 ENGINE

A2.3.1

IGNITION SYSTEMS

A2.3.1.1
Breaker-triggered coil ignition system

A2.3.1.2
Transistorized coil ignition system



Breaker-triggered coil ignition system (A2.3.1.1)

Cat. No.	Description	A2.3.1.1	A2.3.1.2
738 40	Standard Ignition Coil	1	
738 42	Distributor Breaker-Triggered	1	
738 461	Distributor Cap, Transparent	1	
738 02	Automotive power supply 13.8 V/36 A	1	1
738 441	Spark plug holder	1	1
738 47	Coil Connector Unit	1	1
738 46	Accessory Set Ignition System	1	1
738 997	CASSY automotive measuring set	1	1
375 58	Hand vacuum pump	1	1
738 992	Ignition Timing Light	1	1
739 43	Distributor Drive Universal	1	1
726 09	Panel frame T130, two-level	1	1
738 10	Ignition switch	1	1
738 032	Battery connection with protection circuit	1	1
738 985	Automotive meter	1	1
524 064	Pressure sensor S, ±2000 hPa	1	2
727 20	Automobile Meter Zero-Left	2	2
738 49	Fault Simulator Automotive	1	1
8-1 503204-000-10-0	Distributor rotor with 68 kOhm resistor	1	
738 442	Single pressure chamber	1	1
738 998	Pressure pump, foot-operated	1	1
562 901	Magneto model	1	
604 541	Adapter, PP, T form, 6/7 mm, with nipple	1	1
604 520	Connector with nipple	1	1
604 481	Rubber tubing, 1 m x 4 mm diam., DIN 12865	1	1

Cat. No.	Description	A2.3.1.1	A2.3.1.2
500 59	Safety bridging plugs, black, set of 10	2	1
500 592	Safety bridging plugs with tap, black, set of 10	1	1
738 9821	Safety experiment cables, set of 51	1	1
738 05	Connection leads I, set	1	1
738 01	Cable and plug box	1*	1*
500 593	Fault simulation plugs, black, set of 10	1*	1*
738 50	Control Unit TI-H		1
738 51	Ignition Coil TI-H/I		1
738 54	Overlay TI-H		1
738 55	Ignition Distributor TI-I		1
738 56	Overlay TI-I		1
738 58	Control Unit TI-I, TD		1
738 531	Distributor TI-H		1

* additionally recommended

Ignition systems with rotating division – already quite rare today, but indispensable for the basic understanding of ignition!

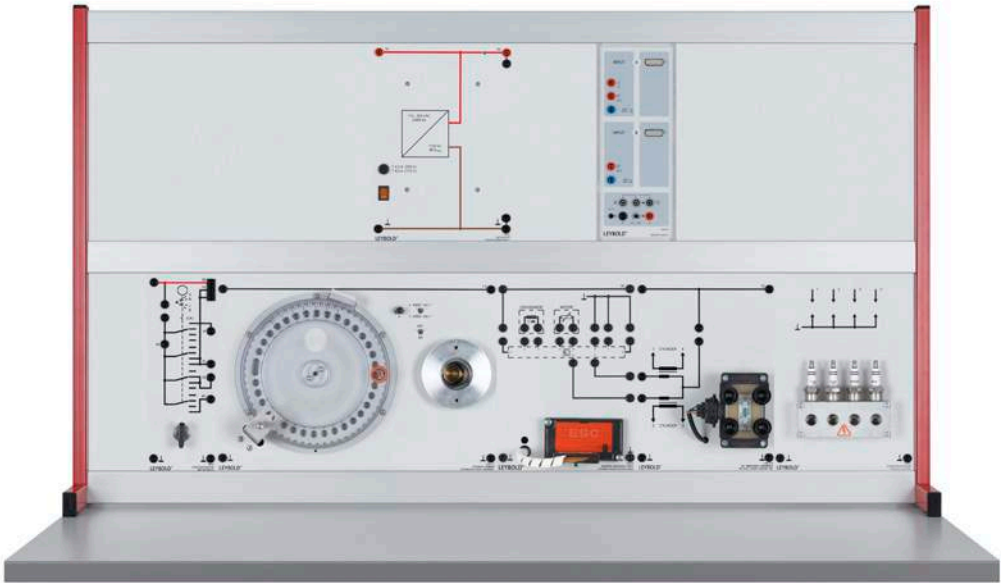
The **transistor ignition** was developed as a result of the contact breaker's limited switching power. This uses electronic high-powered switches and the corresponding control units. The contactless transistor ignition occurs with pulse pick-ups according to the

- induction principle (TI-I) and the
- Hall principle (TI-H).

A2.3.1

IGNITION SYSTEMS

A2.3.1.3
Distributorless coil ignition system (DIS)



Distributorless coil ignition system (DIS) (A2.3.1.3)

Cat. No.	Description	A2.3.1.3
738 5161	Universal ignition module (UESC)	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
739 43	Distributor Drive Universal	1
738 517	DIS-Two Spark Ignition Coil	1
738 518	DIS-Ignition Cable Set	1
738 515	Crankshaft Position Sensor (CPS)	1
738 441	Spark plug holder	1
579 06	Lamp holder, E10, top, STE 2/19	4
590 83	Coil, 500 turns, STE 2/50	2
590 84	Coil, 1000 turns, STE 2/50	2
593 21	Transformer core, demountable	2
505 36ET10	Glow lamps, 115 V, E10, set of 10	1
576 74	Plug-in board, DIN A4, STE	1
375 58	Hand vacuum pump	1
738 02	Automotive power supply 13.8 V/36 A	1
738 985	Automotive meter	1
524 031	Current source box	1
524 0431	30-A-Box	1
524 076	AUTO-BOX i	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
738 989	Standard Workshop TDC Pick-Up	1
738 986	Inductive-Type Pulse Pick-Up	1
775 031EN	LIT: A2.3.1.3/4 Distributorless coil ignition systems	1
500 59	Safety bridging plugs, black, set of 10	2

Cat. No.	Description	A2.3.1.3
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
500 596	Safety bridging plugs, STE 2/19, set of 10	1
501 48	Bridging plugs, STE 2/19, set of 10	1
501 46	Connecting leads, 19 A, 100 cm, red/blue, pair	1
726 09	Panel frame T130, two-level	1
738 05	Connection leads I, set	1
500 593	Fault simulation plugs, black, set of 10	1*
738 01	Cable and plug box	1*

* additionally recommended

Fuel-air mixing and ignition are the essential characteristics of a gasoline engine. After the fuel-air mixture is formed, it must be ignited safely and at the right time. The ignition is responsible for this.

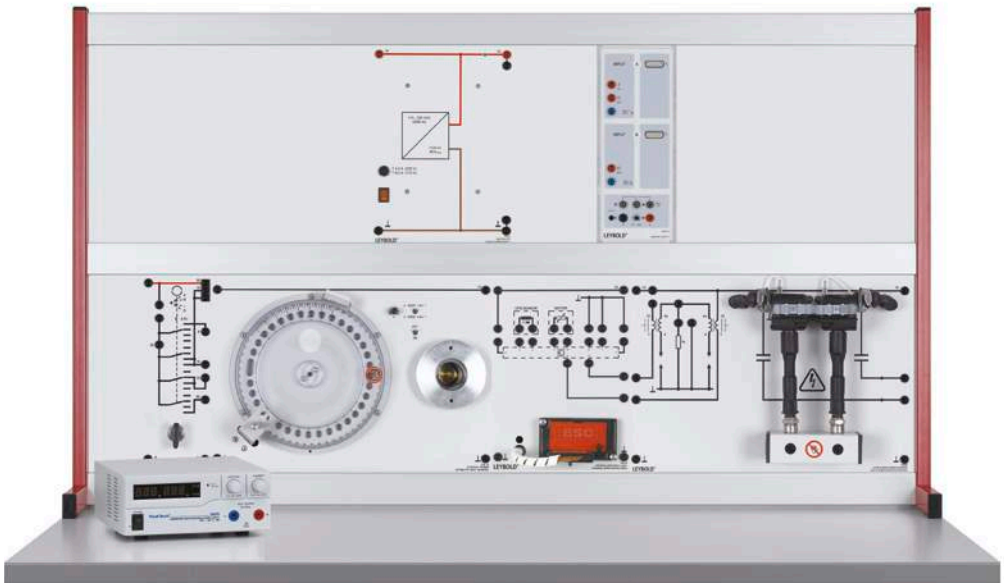
Advancements in the area of ignition from conventional coil ignition (CI) and transistor ignition (TI) to **electronic ignition** (EI) and to **fully electronic ignition** (FI) have happened since 1982. While the high-voltage distribution is still mechanical for EI, it is purely electronic in FI. The latter thus contains no parts susceptible to wear. The spark advance happens electronically, taking into account different variables such as the engine speed.

With the components of this equipment set the basics of the DIS ignition can be investigated. DIS means "distributerless ignition system" and thus describes a system without rotating distributor.

A2.3.1

IGNITION SYSTEMS

A2.3.1.4
Distributorless coil ignition system (SSI)



Distributorless coil ignition system (SSI) (A2.3.1.4)

Cat. No.	Description	A2.3.1.4
738 5161	Universal ignition module (UESC)	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
739 43	Distributor Drive Universal	1
738 515	Crankshaft Position Sensor (CPS)	1
738 481	Single Spark Ignition System (SSI)	1
738 443	Pencil coil system	2
579 06	Lamp holder, E10, top, STE 2/19	4
590 83	Coil, 500 turns, STE 2/50	2
590 84	Coil, 1000 turns, STE 2/50	2
593 21	Transformer core, demountable	2
505 36ET10	Glow lamps, 115 V, E10, set of 10	1
576 74	Plug-in board, DIN A4, STE	1
375 58	Hand vacuum pump	1
738 02	Automotive power supply 13.8 V/36 A	1
738 985	Automotive meter	2
524 031	Current source box	1
524 0431	30-A-Box	1
524 076	AUTO-BOX i	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
738 989	Standard Workshop TDC Pick-Up	1
738 986	Inductive-Type Pulse Pick-Up	1
775 031EN	LIT: A2.3.1.3/4 Distributorless coil ignition systems	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1

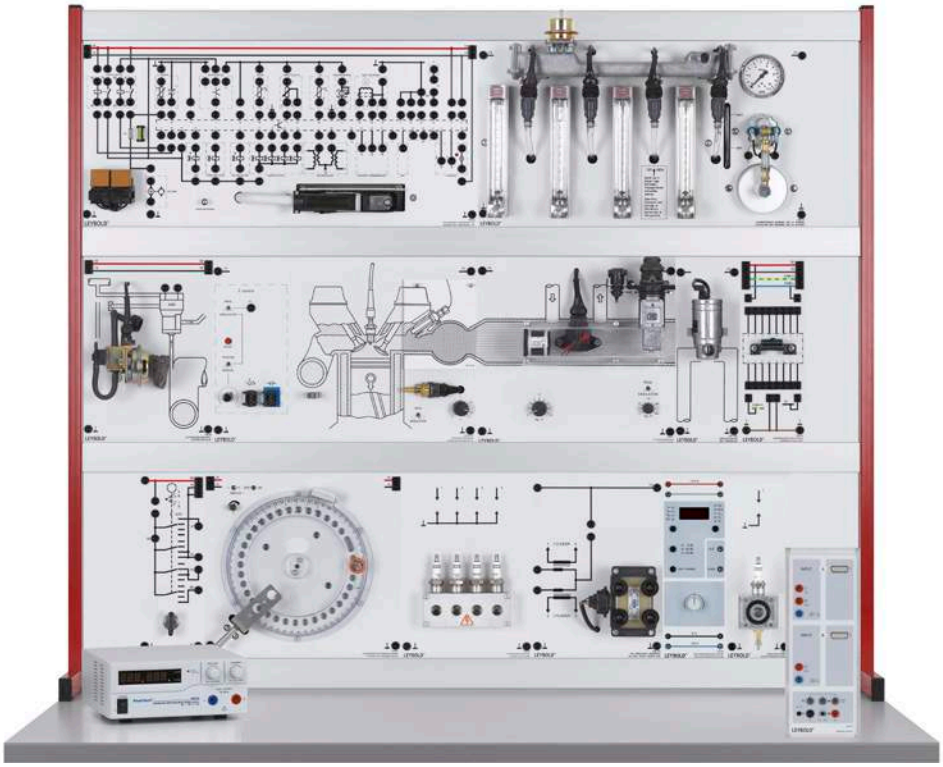
Cat. No.	Description	A2.3.1.4
738 9821	Safety experiment cables, set of 51	1
500 596	Safety bridging plugs, STE 2/19, set of 10	1
501 48	Bridging plugs, STE 2/19, set of 10	1
738 05	Connection leads I, set	1
501 46	Connecting leads, 19 A, 100 cm, red/blue, pair	1
726 09	Panel frame T130, two-level	1
500 593	Fault simulation plugs, black, set of 10	1*
738 01	Cable and plug box	1*

* additionally recommended

With the **single spark ignition coil** an ignition coil and a spark plug each form a compact unit. One side of the secondary winding goes to the ground, and the other side connects directly to the spark plug.

The core components are the single spark system and the pencil coils.

Because of the missing high voltage cable no capacitive voltage sensor can be connected to the spark plug's lead. The system panel "single spark ignition system" is therefore equipped with two test ports to record the secondary oscillogram.



Fuel injection (A2.3.2.1)

A2.3.2

MOTOR MANAGEMENT SYSTEMS PETROL

A2.3.2.1
Fuel injection

Cat. No.	Description	A2.3.2.1
739 402	Control Unit Motronic (M 1.5.4)	1
739 37	Evaluation Unit Motronic	1
738 517	DIS-Two Spark Ignition Coil	1
739 255	Electric EGR valve	1
739 191	Substitute Engine Panel	1
739 03	Knocking Sensor	1
739 42	Crank Angle Sensor	1
739 271	Lambda Sensor, heated	1
739 253	Rotary Idle Actuator	1
739 411	Air Mass Meter, LH Motronic	1
738 9811	Silicon oil M5 blue, 1 liter	2
738 9812	Silicon oil M5 remover, 100ml	1
738 431	Flywheel with Sensor Holder	1
738 441	Spark plug holder	1
726 18	Panel frame T130, three-level	1
738 027	Digital power supply 1 - 16 V/40 A	1
500 990	Adapter sockets, set of 2	1
577 80	Variable resistor, 10 kW, STE 2/19	2
577 38	Resistor, 330 W, STE 2/19	1
577 97	Resistance decade, 10 W...11.1 kW, STE 4/50/100	1
738 518	DIS-Ignition Cable Set	1
739 421	Cable for Crank Angle Sensor	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
524 013S	Sensor-CASSY 2 Starter	1
524 076	AUTO-BOX i	1

Cat. No.	Description	A2.3.2.1
738 989	Standard Workshop TDC Pick-Up	1
738 986	Inductive-Type Pulse Pick-Up	1
375 58	Hand vacuum pump	1
726 962	Function generator 200 kHz	1
738 442	Single pressure chamber	1
738 998	Pressure pump, foot-operated	1
666 712ET3	Butane cartridge, 190 g, set of 3	1
666 711	Butane gas burner	1
300 02	Stand base, V-shaped, small	1
301 01	Leybold multiclamp	1
300 41	Stand rod, 25 cm, 12 mm Ø	1
666 555	Universal clamp, 0...80 mm	1
666 733	Piezoelectric gas igniter	1
739 589	Software: Vehicle diagnosis, German and English	1
737 9807	Diagnosis adapter Opel USB	1
500 59	Safety bridging plugs, black, set of 10	6
500 592	Safety bridging plugs with tap, black, set of 10	1
739 195	Connecting Leads, set of 7	1
738 9821	Safety experiment cables, set of 51	1
665 010	Funnel, PP, 100 mm diam.	1
738 05	Connection leads I, set	1
738 01	Cable and plug box	1
738 4911S	Automotive fault simulator, start	1*
500 593	Fault simulation plugs, black, set of 10	1*
775 032EN	LIT: A2.3.2.1 Fuel injection	

* additionally recommended

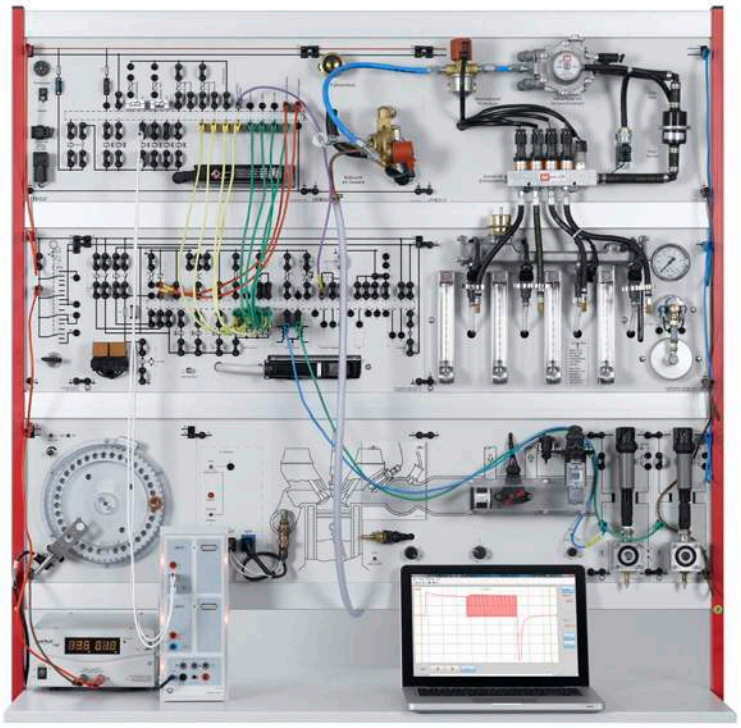
Motor management systems are responsible for combining the electronic injection with the likewise electronic ignition in a single engine control unit. Further functions are added over time:

- Idle speed control
- Lambda control
- Exhaust gas recirculation
- Knock control
- Self-diagnosis

The **LH motronic** is assembled in the classic experimental panel style with rear signal cabling. This set-up enables the study of all components of an ignition and injection control with distribution at rest and single-point injection. This includes the following sensors:

- the air mass flowmeter
- the throttle valve potentiometer
- the lambda sensor
- the motor/air temperature
- the knocking sensor
- the speed pick-up, and actuators
- idling speed positioner
- exhaust gas recirculation valve
- DIS coil ignition
- injectors.

The error diagnostics are possible with adapted tests on the OBD socket or a blink code output.



Gas drive (A2.3.2.2)

A2.3.2

MOTOR MANAGEMENT SYSTEMS PETROL

A2.3.2.2
Gas drive

Cat. No.	Description	A2.3.2.2
739 405	LPG gas system	1
738 431	Flywheel with Sensor Holder	1
739 191	Substitute Engine Panel	1
739 411	Air Mass Meter, LH Motronic	1
738 443	Pencil coil system	2
739 271	Lambda Sensor, heated	1
739 37	Evaluation Unit Motronic	1
739 402	Control Unit Motronic (M 1.5.4)	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
739 42	Crank Angle Sensor	1
739 421	Cable for Crank Angle Sensor	1
577 79	Variable resistor, 1 kW, STE 2/19	1
577 81	Variable resistor, 4.7 kW, STE 2/19	1
577 83	Variable resistor, 100 kW, STE 2/19	1
738 9811	Silicon oil M5 blue, 1 liter	2
738 9812	Silicon oil M5 remover, 100ml	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 076	AUTO-BOX i	1
737 9807	Diagnosis adapter Opel USB	1
738 975	Diagnostic Plug 16 Pin	1
738 9991	DC/AC clamp-on current probe	1
738 985	Automotive meter	1
739 406	LPG spark plugs; set 4 EA	1
747 800	Tool set spark plug	1

Cat. No.	Description	A2.3.2.2
738 05	Connection leads I, set	1
500 59	Safety bridging plugs, black, set of 10	10
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
738 027	Digital power supply 1 - 16 V/40 A	1
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1
665 010	Funnel, PP, 100 mm diam.	1
375 58	Hand vacuum pump	1
500 990	Adapter sockets, set of 2	1
726 18	Panel frame T130, three-level	1
744 600	Low-noise Compressor	1
775 036EN	LIT: A2.3.2.2 Gas drives	1*

* additionally recommended

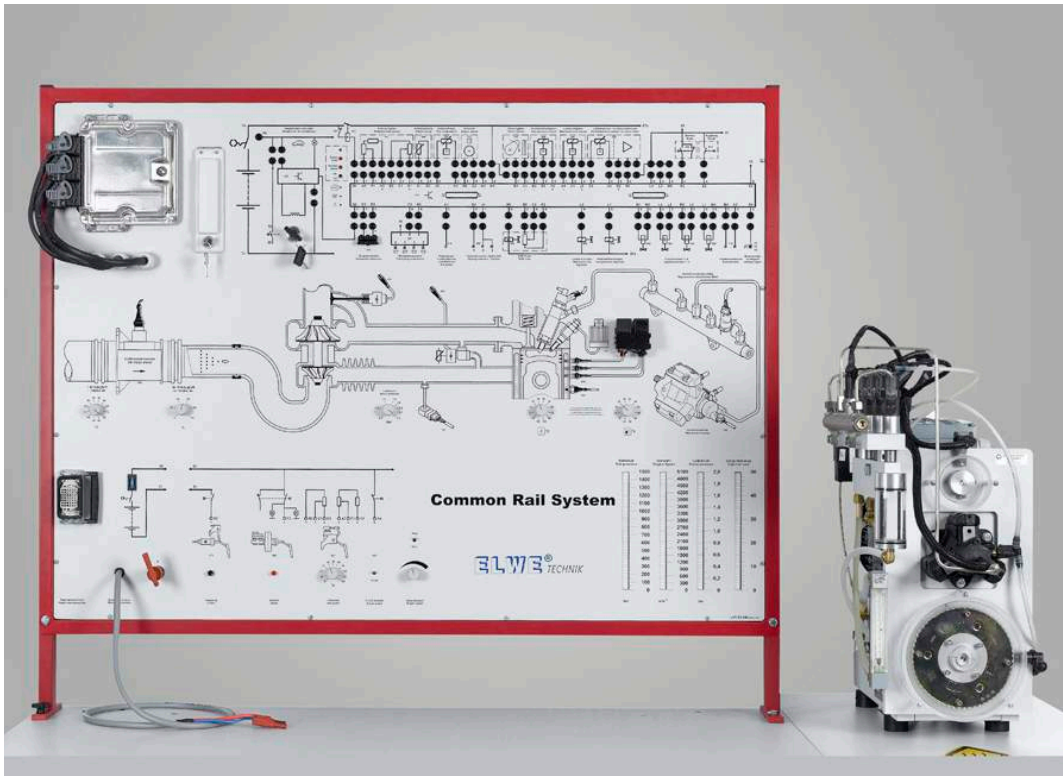
LEYBOLD provides with the system A2.3.2.1 "Fuel injection" with the LH-Motronic an equipment set that contains all the components for an upgrade with LPG.

And completely harmless: the liquid gas is simulated by a non-toxic and non-flammable substitute gas so a threat of the students is excluded.

A2.3.3

MOTOR MANAGEMENT SYSTEMS DIESEL

A2.3.3.4
Common Rail



Common Rail (A2.3.3.4)

Cat. No.	Description	A2.3.3.4
8-1 503440-001-12-0	Experiment stand "Common Rail"	1
8-1 503431-100-02-0	Hydraulic aggregat Common Rail	1
738 027	Digital power supply 1 - 16 V/40 A	1
598 141	AC electrical frame	1
738 9821	Safety experiment cables, set of 51	1
8-7 000001-000-10-0	Plastic cover for an experimental stand	1
775 037EN	LIT: A2.3.3.4 Common Rail	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 0431	30-A-Box	1
524 076	AUTO-BOX i	1
739 002	Scanner BOSCH KTS 200	1
739 004	DMM for electrical vehicles	1
739 001	Infrared-thermometer	1

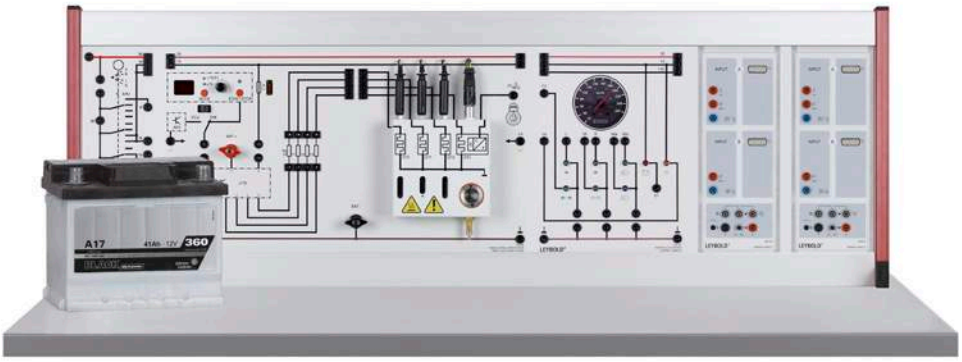
Diesel motors are piston engines with spontaneous ignition. The fuel must be injected directly into the combustion chamber to then be compressed and heated to between 700°C and 900°C. This temperature is enough to ignite the mixture. The need for constantly increasing injection pressure has led from the distributor-type fuel-injection pump to the high-pressure systems like a unit injector or common rail.

Common Rail technology is the most widespread diesel injection system currently used in automotive production world-wide. Instead of the previously used distribution pump with its complicated mechanical parts and injectors which determine the injection pressure, a high-pressure pump of much simpler construction with a pressure of up to 1200 bar and piezo-electric injectors are now used.

A2.3.3

STARTING AID FOR DIESEL ENGINES

A2.3.3.5
Diesel Quick Start System



Diesel Quick Start System (A2.3.3.5)

Cat. No.	Description	A2.3.3.5
738 10	Ignition switch	1
740 306	Diesel Quick Start System	1
738 151	Telltales KI	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 013S	Sensor-CASSY 2 Starter	1
524 0673	NiCr-Ni adapter S, type K	1
529 676	Temperature probe, NiCr-Ni, 1.5 mm, type K	1
739 580	Databus detector	1
738 044	AGM-battery 12V	1
738 043	Vehicle battery connecting kit	1
738 021	Battery charger, automatic	1
738 05	Connection leads I, set	1
505 15	Bulbs, 6 V/0.05 A, E10, set of 10	1
726 19	Panel frame SL85, single-level	1

In addition to the familiar preheating for improved starting characteristics of a compression-ignition engine, controlled post-heating quickly warms the combustion chamber, thus reducing exhaust gas emissions. A separate µC-controlled heat control unit is installed for activation of the heater plugs. This unit receives information on the time period and duration of the heating process from the engine controller. The heat control unit then activates the heater plugs and reports any possible disruptions to the engine controller using the integrated diagnostics feature. In order to minimise the power consumption during heating, the heater plugs are activated with a PWM signal with a delay.

Heater plugs with integrated pressure sensors are used to monitor the pressure in the combustion chamber. In this case the heat plug is mounted so that it exerts the force applied to the heat plug by the combustion chamber pressure to a measuring diaphragm. The pressure signal is also sent to the engine controller, where it is further processed. This way, for example, the injection period of the main injection can be changed as a corrective measure.

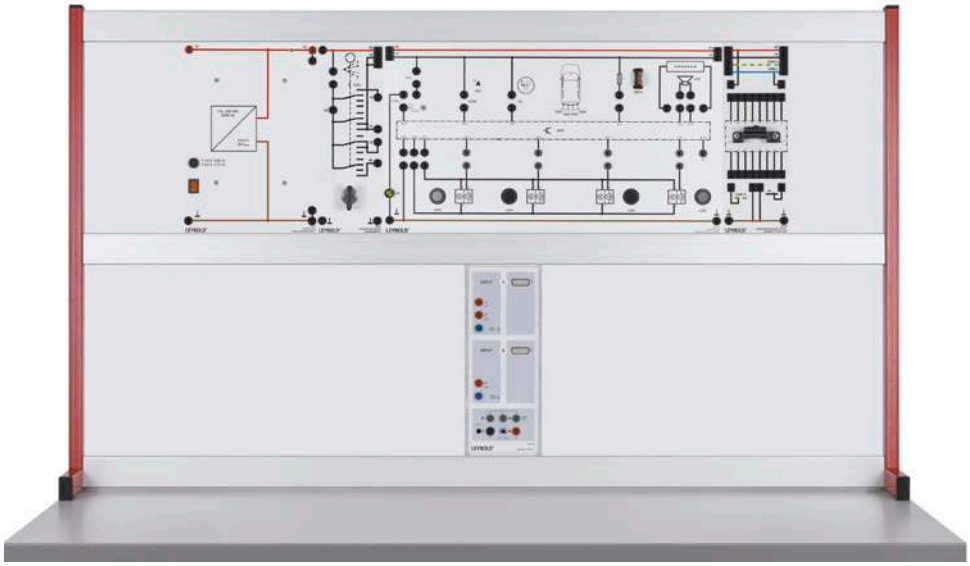

BOSCH

A2
VEHICLE TECHNOLOGY

A2.4.1

COMFORT SYSTEMS

A2.4.1.2
Parking aid



Parking aid (A2.4.1.2)

Cat. No.	Description	A2.4.1.2
739 750	Park distance control	1
416 000	Ultrasonic transducer, 40 kHz	1
726 10	Panel frame T150, two-level	1
300 02	Stand base, V-shaped, small	2
738 10	Ignition switch	1
738 02	Automotive power supply 13.8 V/36 A	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
738 975	Diagnostic Plug 16 Pin	1
737 9803	OBD Adaptor CAN+USB	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
500 644	Safety connecting lead, 100 cm, black	2
500 647	Safety Connection Lead 100 cm brown	2
500 593	Fault simulation plugs, black, set of 10	1*
738 01	Cable and plug box	1*
775 041EN	LIT: A2.4.1.2 Parking aid	1

* additionally recommended

The **park distance control** - also known as back-up warning or Park Pilot - is a useful accessory in the area of comfort electronics. Complex or closed body designs restrict sight forward and backward in many vehicles. The park distance control uses ultrasound sensors to reliably measure the distance to all kinds of obstacles, in particular to children and pedestrians. An optical and acoustic warning protects the vehicle and external objects from damage.

LEYBOLD has developed an experimental panel for the topic of park distance control, consisting of

- an original control unit
- four original ultrasound sensors, as well as
- an acoustic and
- an optical indicator.

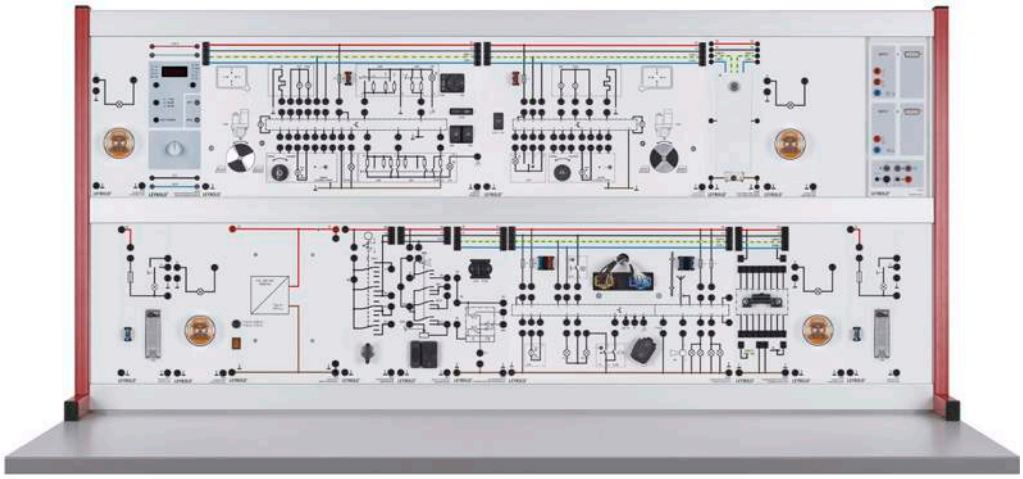
Simulated engagement in reverse gear activates the application. When switched on, the sensors – built into the vehicle's bumper – send out ultrasound signals and receive the reflected echoes. The control unit calculates the distance of an obstacle down to the centimeter. The display shows the different distance ranges with light bars of different colors or with an acoustic distance warning with changing sound sequences.

The sensor connection cables and the ground wire to the control until are brought through bridging plugs in order to simply measure voltages and currents and simulate open circuit faults.

A2.4.1

COMFORT SYSTEMS

A2.4.1.3
Comfortsystem with CAN-Bus



Comfort system with CAN-Bus (A2.4.1.3)

Cat. No.	Description	A2.4.1.3
739 58	Comfort system with CAN - Bus	1
726 10	Panel frame T150, two-level	1
738 07	Interior lamp	2
738 11	Head lamp switch	1
738 36	Turn Signal Lamp	4
739 581USB	CAN databus adapter USB	1
738 975	Diagnostic Plug 16 Pin	1
739 573	Automotive Set Point Potentiometer	1
739 585	Fault simulator CAN Bus	1
739 580	Databus detector	1
737 9803	OBD Adaptor CAN+USB	1
739 587	Software: Databus visualisation	1
738 02	Automotive power supply 13.8 V/36 A	1
726 962	Function generator 200 kHz	1
738 10	Ignition switch	1
524 013S	Sensor-CASSY 2 Starter	1
524 078	CAN bus box	1
500 59	Safety bridging plugs, black, set of 10	4
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
775 042EN	LIT: A2.4.1.3 Comfort system with CAN-Bus	1
738 01	Cable and plug box	1*
738 4911S	Automotive fault simulator, start	1*
500 593	Fault simulation plugs, black, set of 10	1*

* additionally recommended

Comfort systems, like safety systems, are part of the basic equipment in modern motor vehicles. In contrast to driver assistance systems, however, they do not actively intervene in the driving process, but they are only useful for information and comfort.

The CAN bus comfort training system is a classic! Connecting individual "islands" with as few wires as possible and full functional range – that was the CAN data bus' basic comfort application. The "islands" are car doors, each equipped with a control unit.

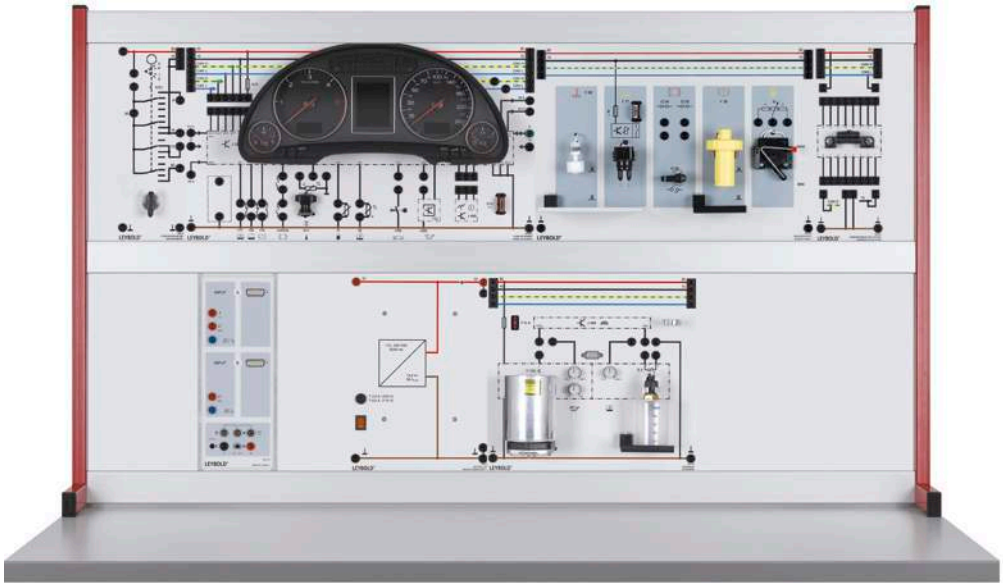
It operates the following:

- the power windows
- the central locking system
- the side mirror adjusting motors
- the side mirror heater
- the SAFE LED depending on the sensors' states
- the door lock
- the power window buttons
- the mirror adjustment buttons
- the central locking button
- the door switch.

A2.4.1

COMFORT SYSTEMS

A2.4.1.4
On-board computer



On-board computer (A2.4.1.4)

Cat. No.	Description	A2.4.1.4
739 707	Sensor panel 1	1
739 708	Sensor panel 2	1
739 706	Oil sensor	1
739 6021	Instrument cluster unit	1
738 975	Diagnostic Plug 16 Pin	1
738 10	Ignition switch	1
737 9803	OBD Adaptor CAN+USB	1
524 013S	Sensor-CASSY 2 Starter	1
739 589	Software: Vehicle diagnosis, English	1
524 031	Current source box	1
524 076	AUTO-BOX i	1
524 044	Temperature sensor S, NTC	1
773 961	CAN-Databus-Multi-Adapter	1
738 02	Automotive power supply 13.8 V/36 A	1
650 671	Storage tray, S24, STE	1*
590 48	Immersion heater	1
577 79	Variable resistor, 1 kW, STE 2/19	1
578 40	Capacitor (electrolytic), 470 µF, STE 2/19	1
577 56	Resistor, 10 kW, STE 2/19	1
578 51	Diode, 1N 4007, STE 2/19	1
578 74	Transistor, BD 138, PNP, emitter top, STE 4/50	1
579 21	Relay with change-over switch, STE 4/50	1
579 13	Toggle switch, STE 2/19	1
579 06	Lamp holder, E10, top, STE 2/19	1
505 09	Bulbs, 12 V/0,1 A, E10, set of 10	1

Cat. No.	Description	A2.4.1.4
501 48	Bridging plugs, STE 2/19, set of 10	3
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	1
726 50	Plug-in board, 297 mm x 300 mm, STE	1
521 45	DC power supply 0...±15 V	1
577 32	Resistor, 100 W, STE 2/19	1
577 321	Resistor, 100 W, STE 2/19	1
577 35	Resistor, 100 W, STE 2/19	1
577 92	Potentiometer, 1 kW, STE 4/50	1
579 163	Simulation ABS/Ti	1
739 195	Connecting Leads, set of 7	1
726 10	Panel frame T150, two-level	1
738 9821	Safety experiment cables, set of 51	1
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	2
510 48	Magnets, 35 mm Ø, pair	1
667 193	PVC tubing, 7 mm diam., 1 m	2
375 58	Hand vacuum pump	1
727 585	STE universal case	1
8-9 999803-000-10-0	Cold spray 400 ml	1
775 043EN	LIT: A2.4.1.4 Boardcomputer	1
738 01	Cable and plug box	1*
738 4911S	Automotive fault simulator, start	1*
500 593	Fault simulation plugs, black, set of 10	1*

* additionally recommended

Comfort systems, like safety systems, are part of the basic equipment in modern motor vehicles. In contrast to driver assistance systems, however, they do not actively intervene in the driving process, but they are only useful for information and comfort.

Traditional monitoring of fill levels and temperatures occurs with modern control units. Current measurements in conductor loops give information on a worn brake pad.

Moreover, various fill level sensors provide data that is shown to the driver optically and/or acoustically. The "on-board computer" educational system monitors:

- the coolant and the windshield washer fluid levels,
- the brake fluid and motor oil levels,
- the wear on the brake pads,
- the motor oil and coolant temperatures.

The oil sensor is a continually measuring thermal oil level and oil temperature sensor (TOG) that can be filled with motor oil. Optionally, regulation resistors can simulate the signals. The signal produced converts the information on the oil into a combined PWM (pulse-width modulation) and PFM (pulse-frequency modulation) signal, that Sensor-CASSY can chart, for example.

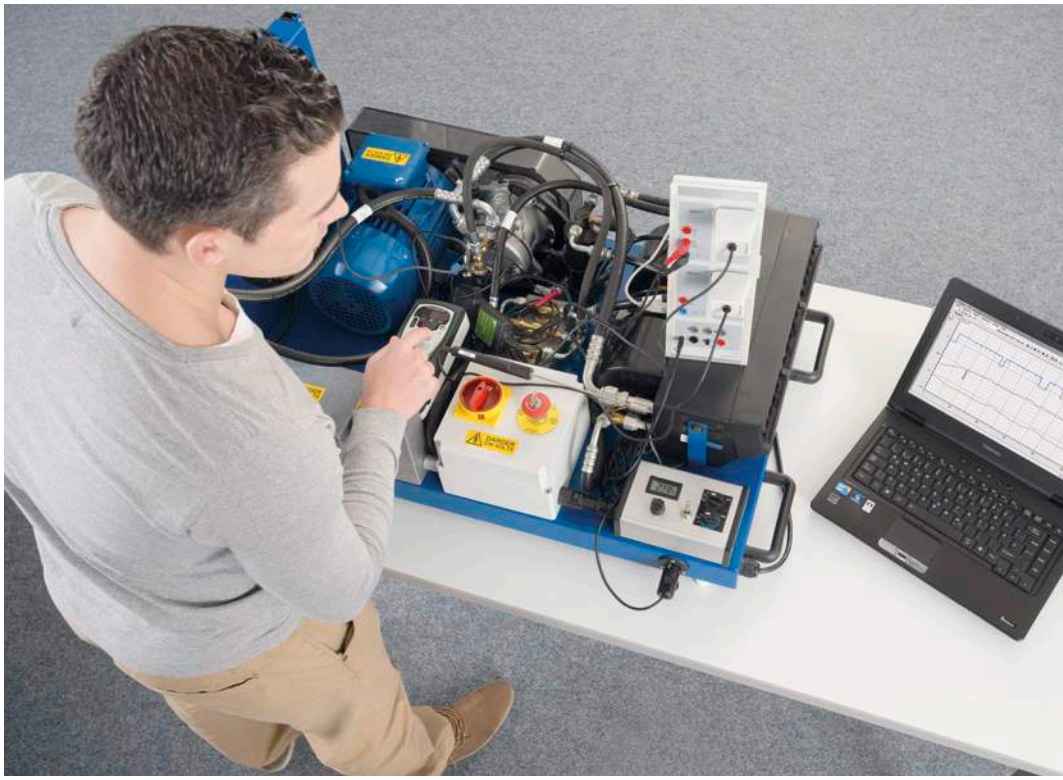
The signal from the coolant's temperature sensor can also either triggered either by immersion into warm water or by setting a potentiometer. An appropriate holder is available for parallel temperature measurement with a temperature sensor (666 212). In the uncoupled state, the real temperature and the resistance can for example be measured with Sensor-CASSY and analyzed as an NTC curve.

All values can also be displayed in the self-diagnosis with the instrument cluster's diagnosis line; linearized values for oil level and temperature and coolant temperature are available with a 9-pole socket for the oil sensor for measurements or integration into a CAN bus system.

A2.4.1

COMFORT SYSTEMS

A2.4.1.5
Air conditioning



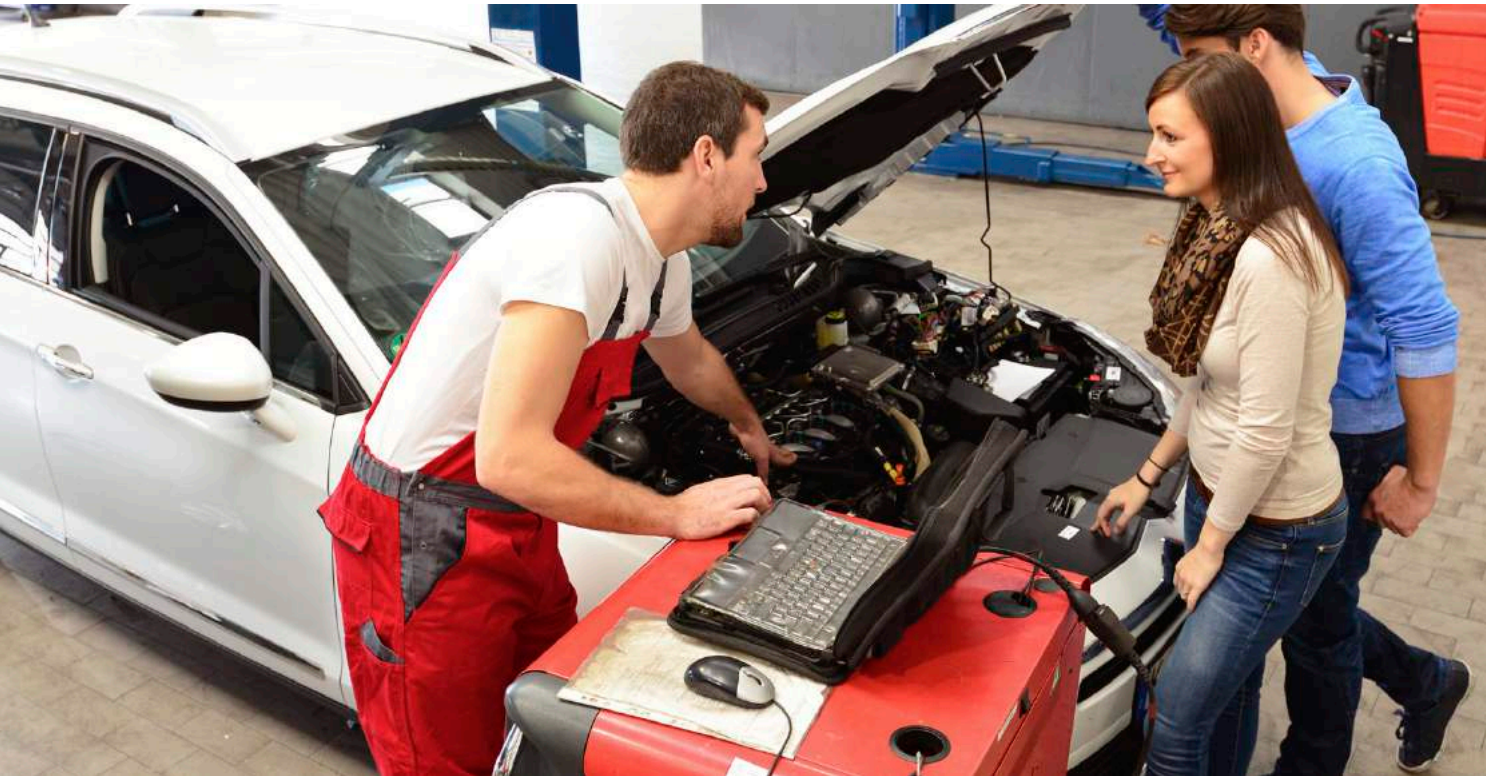
Air conditioning (A2.4.1.5)

Cat. No.	Description	A2.4.1.5
39- 305-230	Automotive Air-conditioning Trainer	1
739 001	Infrared-thermometer	1
739 005	Manifold gauge set	1*
524 013S	Sensor-CASSY 2 Starter	1*
738 9991	DC/AC clamp-on current probe	1*
524 044	Temperature sensor S, NTC	2*
775 046EN	LIT: A2.4.1.5 AirCon Trainer	1

* additionally recommended

Have you ever wondered how the air-con system in your car actually works? The automotive air conditioning trainer enables students to find out how a typical system works whilst learning the principles of refrigeration. By using authentic components, students learn how to perform fault finding and servicing using a safe and accessible system. The product has been designed specifically with hands-on training in mind and it can also be used by students to perform the safe recovery and recharging of refrigerant.

Complete with compressor, condenser, receiver dryer, expansion valve and evaporator, the unit is pre-installed with R134a type refrigerant which is an HFC non-ozone depleting gas and is in line with global emissions guidelines. The system is furnished with high and low-side pressure service ports that facilitate easy connection of a gauge set or for the recovery and recharging of refrigerant. These ports are typical quick coupler type as would be found on modern vehicles.



The speed of the motor which simulates the vehicle engine is variable by means of a electronic, digitally controlled three-phase inverter drive. This enables the demonstration of the effect that compressor speed has on the system performance. The system is designed to be bench mounted and run from either a 230 V or 110 V ac supply. There is a 12 V dc output socket which enables the connection of ancillary equipment, such as a UV leak detection lamp.

Features

- Uses actual automotive components
- Suitable for both technician and vocational teaching
- Portable design
- Uses non-ozone depleting HFC refrigerant
- Enables hands-on access to all components
- Simulates four common faults
- Variable speed motor simulates car engine
- Available for either 110 V or 230 V mains connection

The provision of a sight glass enables students to observe the state of the refrigerant in the high pressure side of the system. This assists with the diagnosis of four simulated common faults which can be applied by the instructor. The following four simulated faults can be applied by setting the fault switch on the main control panel:

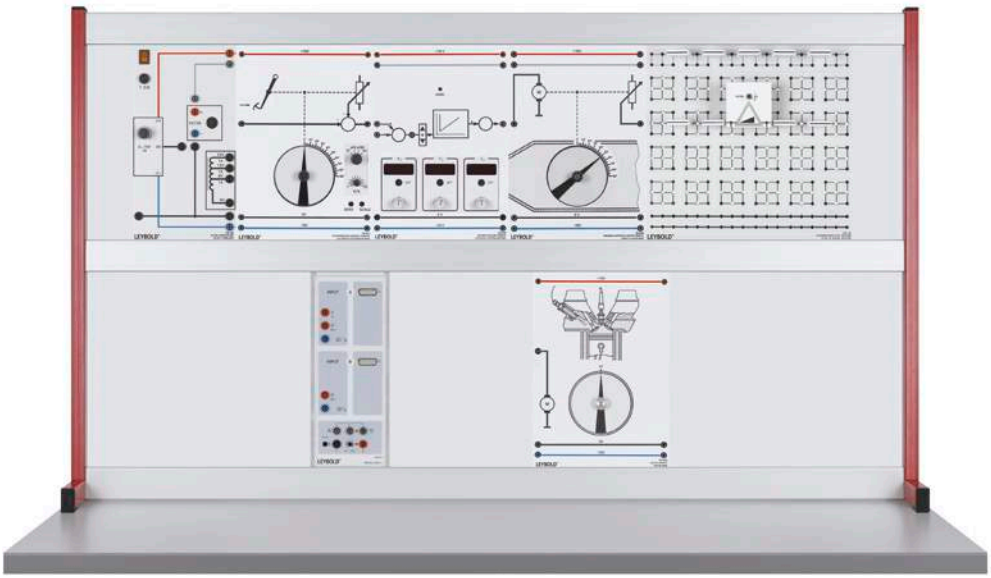
- Blocked TEV (Thermal Expansion Valve)
- Blocked receiver drier (TEV version only)
- Faulty valve plate
- Unit under condensing

The student will observe the effect of the faults by monitoring system pressure (using optional manifold gauges) changes in the cooling duty, observing changes on the digital thermometer and observing the state of the refrigerant in the sight glass. A high pressure cut-out switch shuts the compressor down if the high side pressure becomes abnormally high.

A2.4.2

DRIVER ASSISTANCE SYSTEM

A2.4.2.1
Electronic gas pedal



Electronic gas pedal (A2.4.2.1)

Cat. No.	Description	A2.4.2.1
739 56	Electronic gas pedal Accessory	1
734 064N	PID digital controller Net	1
579 161	Simulation Incline, STE 4/50	1
313 17	Hand-held stop-watch II, mechanical	1
577 32	Resistor, 100 W, STE 2/19	1
577 35	Resistor, 200 W, STE 2/19	1
577 40	Resistor, 470 W, STE 2/19	1
578 51	Diode, 1N 4007, STE 2/19	1
579 13	Toggle switch, STE 2/19	1
734 10	Servo setpoint generator	1
734 13	Power amplifier	1
734 14	DC servo	2
726 10	Panel frame T150, two-level	1
726 50	Plug-in board, 297 mm x 300 mm, STE	1
726 88	AC/DC stabilizer	1
727 20	Automobile Meter Zero-Left	1
524 013S	Sensor-CASSY 2 Starter	1
539 000	Bridging plug, BST	10
500 592	Safety bridging plugs with tap, black, set of 10	1
501 46	Connecting leads, 19 A, 100 cm, red/blue, pair	2
500 853	Safety connecting leads, set of 25	1
501 48	Bridging plugs, STE 2/19, set of 10	2
725 007	Software: Leylab.control Lite	1
775 044EN	LIT: A2.4.2.1 Electronic gaspedal	1
738 01	Cable and plug box	1*

Cat. No.	Description	A2.4.2.1
500 593	Fault simulation plugs, black, set of 10	1*
734 064	PID digital controller	1*

* additionally recommended

Controls and regulations have always had their place within motor vehicle technology. What began mechanically, e.g. with the ignition's vacuum adjustment, now works electrically/electronically as much as possible. The core curriculum states:

"[...] They (the students) distinguish between controls and regula-tions and assign hydraulic, pneumatic or electric/electronic systems to typical components and parts of vehicles. They analyze functional relationships and apply testing and measuring processes to study signal, material or energy flows."

LEYBOLD's educational system demonstrates on typical vehicle applications the fundamental theoretical relationships in control technology. Sensor-CASSY or multimeters can record the associated measurements. In particular, the following training contents are treated:

- Control technology systems' function in motor vehicles
- IPO principle: signal input, processing and output
- Control processes
- Reference variable and correcting variable
- Open and closed regulator circuits
- How the electronic throttle works
- Study of disturbances

A2
VEHICLE TECHNOLOGY

A2.5 DRIVE TRAIN

A2.5.1 BRAKING SYSTEMS

A2.5.1.1 ELECTRONIC STABILITY SYSTEM ABS/ESP

A2.5.2 GEAR

A2.5.2.2 AUTOMATIC TRANSMISSION SYSTEM

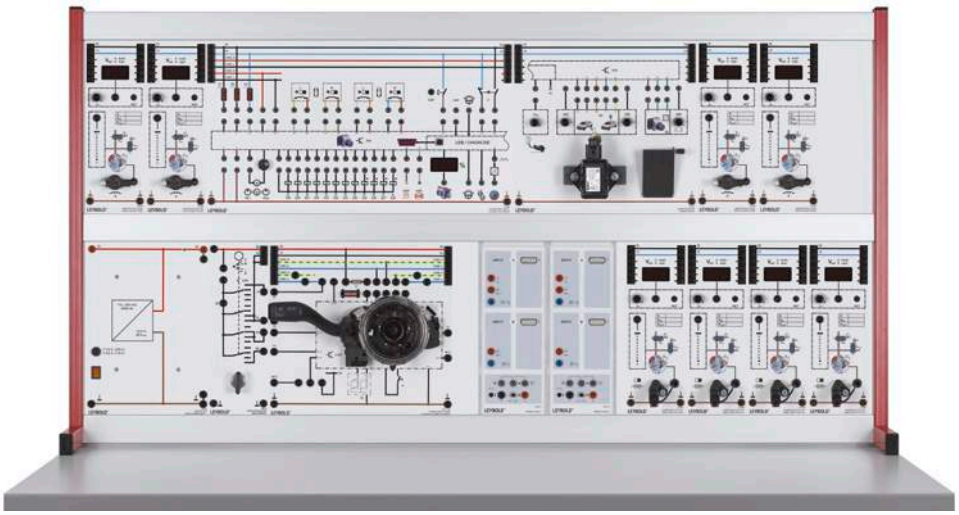
A2.5.3 STEERING SYSTEM

A2.5.3.2 ELECTRICAL ASSISTED POWER STEERING

A2.5.1

BRAKING SYSTEMS

A2.5.1.1
Electronic stability system ABS/ESP



Electronic stability system ABS/ESP (A2.5.1.1)

Cat. No.	Description	A2.5.1.1
739 650	ABS/ESP control unit	1
739 651	ABS/ESP sensors	1
739 6521	Wheel substitute panel, inductive	4
739 6531	Wheel substitute panel, Hall	4
739 654	Steering angle sensor	1
738 111-02	Steering column electronics	1
738 02	Automotive power supply 13.8 V/36 A	1
738 10	Ignition switch	1
524 013	Sensor-CASSY 2	1
524 013S	Sensor-CASSY 2 Starter	1
738 985	Automotive meter	1
726 10	Panel frame T150, two-level	1
500 59	Safety bridging plugs, black, set of 10	5
500 592	Safety bridging plugs with tap, black, set of 10	1
500 595	4 mm branching bridging plug, red	1
739 195	Connecting Leads, set of 7	1
738 9821	Safety experiment cables, set of 51	1
775 050EN	LIT: A2.5.1.1 Electronic Stability System ABS/ESP	1
738 01	Cable and plug box	1*
500 593	Fault simulation plugs, black, set of 10	1*
738 4911S	Automotive fault simulator, start	1*

* additionally recommended

The electronic stability program ESP is a control system in the brakes and in the power train that prevents the vehicle from slipping to the side. The ABS prevents the wheels from getting stuck when braking; ASR avoids wheels spinning on startup. ESP ensures that the vehicle does not "slide" or become unstable.

The wheels' rotational speed is continuously detected by sensors and analyzed by the control unit. In case the wheel sticks, there are adjusting commands at the magnetic valves. The pressurization and depressurization phases follow. The braking effect is reduced and the wheel speeds up again. Our educational system demonstrates these phases.

The signal cabling reliably works through the back side so that the front remains clear. An oscilloscope or Sensor-CASSY can record measurements.

The self-diagnosis can be executed in combination with a PC, and typical driving situations can be retraced. A software self-diagnosis and drive simulation are thus available. These can simulate the following situations:

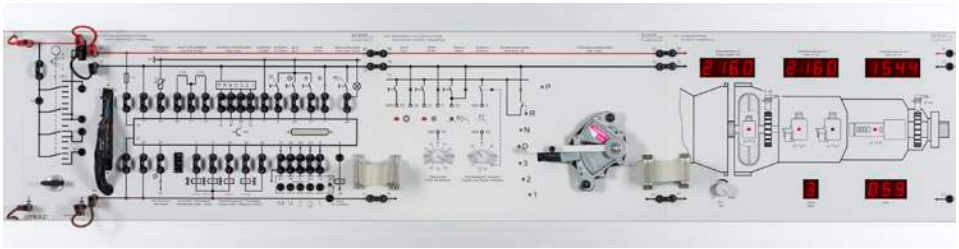
- Driving maneuver "Quick steering and countersteering"
- Driving maneuver "Lane change with emergency stop (moose test)"
- Driving maneuver "Steering and countersteering multiple times"
- Driving maneuver "Acceleration/deceleration in a tight curve"

Optionally, other student measuring stations (740 050) can be connected to the control unit. The students can record and analyze all measurements on the installation at their workstations.

A2.5.2

GEAR

A2.5.2.2
Automatic transmission system



Automatic transmission system (A2.5.2.2)

Cat. No.	Description	A2.5.2.2
8-1 003601-000-10-0	P 3.601 Control unit automatic transmission	1
8-1 003602-000-10-0	P 3.602 Operating unit for automatic transmission	1
8-1 003603-000-10-0	P 3.603 Automatic Transmission Substitute	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
737 9807	Diagnosis adapter Opel USB	1
735 290	Connecting lead universal converter	1
500 604	Safety connecting lead, 10 cm, black	3
500 624	Safety connecting lead, 50 cm, black	3
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	1
726 09	Panel frame T130, two-level	1
738 01	Cable and plug box	1*
738 027	Digital power supply 1 - 16 V/40 A	1
775 054DE	Lit: A.5.2.2: Automatic Gear; German	1

* additionally recommended

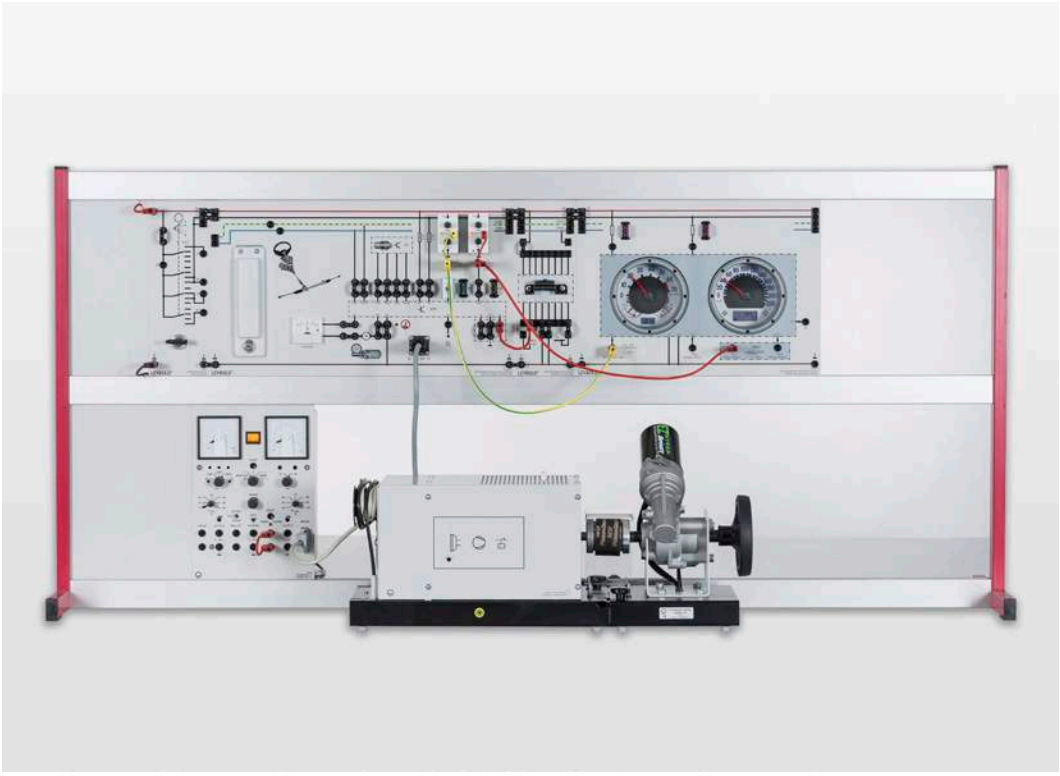
Convenience in the car: it has been a standard in the USA for a long time, whereas in other areas it only came little by little - the automatic transmission.

The educational system is equipped with a 4-speed automatic transmission and consists of the control unit, the operation unit and a gear substitute panel.

A2.5.3

STEERING SYSTEM

A2.5.3.2
Electrical assisted power steering



Electrical assisted power steering (A2.5.3.2)

Cat. No.	Description	A2.5.3.2
739 502	Electric Power Steering (EPS)	1
732 55	Control Unit 1.0	1
732 58	Coupling guard 1.0	1
732 56	Coupling 1.0	1
732 54	Magnetic Powder Brake 1.0	1
739 6023	Tachometer/Speedometer digital	1
579 163	Simulation ABS/Ti	2
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
738 027	Digital power supply 1 - 16 V/40 A	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 0431	30-A-Box	1
773 961	CAN-Databus-Multi-Adapter	1*
739 002	Scanner BOSCH KTS 200	1*
738 985	Automotive meter	1
LDS 00001	Stopwatch, digital	1
579 13	Toggle switch, STE 2/19	2*
577 30	Resistor, 62 W, STE 2/19	1
738 975	Diagnostic Plug 16 Pin	1*
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	1
501 44	Connecting leads, 19 A, 25 cm, red/blue, pair	1
738 05	Connection leads I, set	1
500 600	Safety connection lead, 10 cm, yellow/green	1
500 601	Safety connection lead, 10 cm, red	3

Cat. No.	Description	A2.5.3.2
500 620	Safety connecting lead, 50 cm, yellow/green	1
500 621	Safety connecting lead, 50 cm, red	1
500 641	Safety connecting lead, 100 cm, red	2
500 661	Safety connection lead, 200 cm, red	1
500 647	Safety connection lead, 100 cm, brown	2
500 644	Safety connecting lead, 100 cm, black	2
8-5 900088-000-10-0	Adapter 4-mm plug/4-mm socket	2
738 01	Cable and plug box	1*
726 09	Panel frame T130, two-level	1
775 053EN	LIT: A2.5.3.2 Electrical power steering	1
500 593	Fault simulation plugs, black, set of 10	1

* additionally recommended

Electromechanical power steering systems are increasingly replacing the hydraulic steering systems. On the one hand, they form the basis for central assistance functions. On the other hand energy-efficient systems must be used to reduce the electrical power consumption of a modern vehicle.

The electromechanical power steering system generates when needed - and only then - high steering assist forces from the 12-V power supply. For this purpose, a permanent-magnet DC shunt motor is used, which is located directly on the steering column. As an input signal the steering torque sensor records the torque applied by the driver on the steering wheel. For this input value a driving situation-oriented steering power is generated taking other environment variables into account, too.

A2
VEHICLE TECHNOLOGY

A2.6 NETWORKING SYSTEMS, DIGITALISATION AND DIAGNOSIS

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.1
Networking automotive systems: Lighting

Networking automotive systems: Lighting (A2.6.1.1)

Cat. No.	Description	A2.6.1.1
739 5821	Training panel lighting NG	1
738 027	Digital power supply 1 - 16 V/40 A	1
500 990	Adapter sockets, set of 2	1
738 9821	Safety experiment cables, set of 51	1
739 580	Databus detector	1
739 581USB	CAN databus adapter USB	1
739 587	Software: Databus visualisation	1
739 588	LIN BUS PC interface USB	1
737 9803	OBD Adaptor CAN+USB	1
524 013S	Sensor-CASSY 2 Starter	1
524 081	LIN bus box	1
524 078	CAN bus box	1
739 5835	DS vehicle door	1*
739 5836	PS vehicle door	1*

* additionally recommended

The **training panel in automobile electronics** consists of a modern instrument panel insert with electronic immobilizer, the full steering wheel electronics, the central control module for comfort system and the electronic and electric system. The lighting system and a windshield wiper motor round off the system. The basic vehicle electronics and modern data bus systems are clearly and simply represented. This approach places great value on the use of original vehicle parts. The focus is always on error detection, analysis and correction.

The following components are part of the training panel:

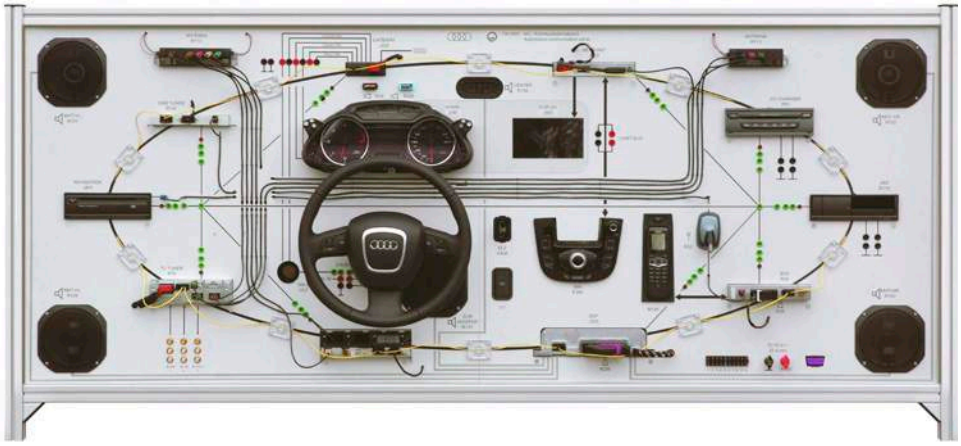
- the lighting unit
- the instrument cluster
- the electronic immobilizer
- the steering wheel electronics
- the control unit for automatic trailer detection
- a 13-pole trailer socket
- the central control module for comfort system (CAN bus)
- the electronic and electric system
- the windshield wiper motor
- the rain photosensor
- the relay strip
- the OBD diagnostic plug
- a CAN bus interface
- a fault switching box.

Models of a driver and/or passenger door can complement the training panel.

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.2
Networking automotive systems: Communication



Networking automotive systems: Communication (A2.6.1.2)

Cat. No.	Description	A2.6.1.2
739 5841	Training panel, vehicle communications	1
739 580	Databus detector	1
524 013S	Sensor-CASSY 2 Starter	1
524 078	CAN bus box	1
524 081	LIN bus box	1
739 588	LIN BUS PC interface USB	1
739 581USB	CAN databus adapter USB	1
737 9803	OBD Adaptor CAN+USB	1
740 2013	MOST PC USB Interface	1
738 027	Digital power supply 1 - 16 V/40 A	1
500 990	Adapter sockets, set of 2	1
739 587	Software: Databus visualisation	1
500 664	Safety connection lead, 200 cm, black	2
738 9821	Safety experiment cables, set of 51	1
566 078TEN	LIT: T3.2.12.8 Infotainment with MOST Bus	1

The **communications training panel** includes a complete infotainment package networked via MOST (=Media Oriented Systems Transport) bus in Audi technology.

The build includes:

- an instrument cluster and gateway
- an antenna amplifier system
- a true-color display with control unit for information
- a multimedia operating unit
- a hybrid TV tuner*
- an MP3-capable CD changer
- a navigation system*
- an analog and a digital radio receiver*
- an OBD diagnostic plug
- a mobile phone connection*
- a voice-activated steering wheel remote control
- a MOST bus interface
- a CAN and LIN bus interface
- three fault switching boxes.

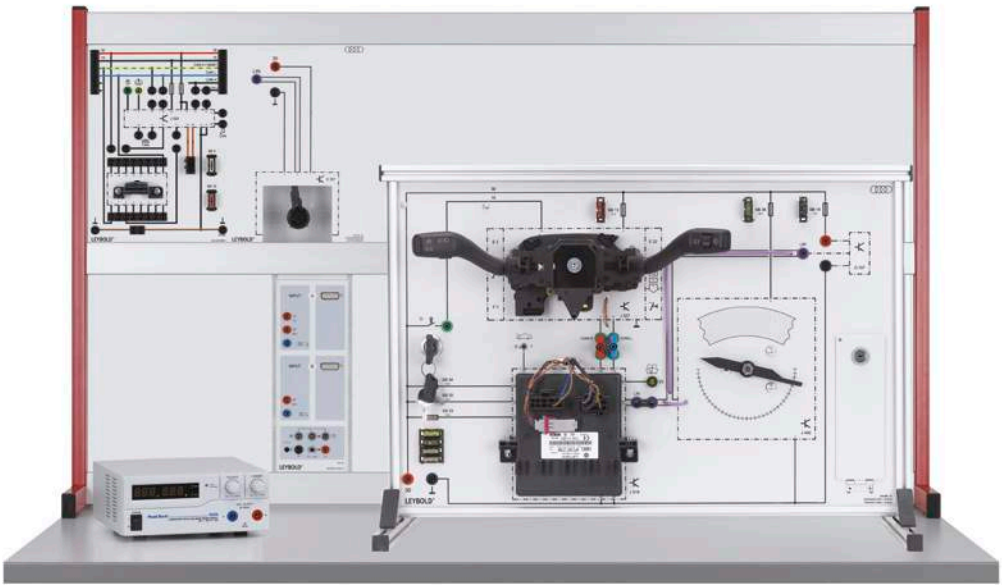
Specially for the vehicle communication electronics engineer, this board offers the possibility to record loudspeaker impedances, to determine the transmitting power of mobile phone antennas or to study AF and RF signals as well as to detect reception levels.

*the functional range may vary due to local conditions

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.3
Networking automotive systems: Comfort



Networking automotive systems: Comfort (A2.6.1.3)

Cat. No.	Description	A2.6.1.3
739 586	Training panel LIN-Bus	1
739 5861	CAN Gateway	1
301 339	Stand bases, pair	1
524 081	LIN bus box	1
524 078	CAN bus box	1
739 588	LIN BUS PC interface USB	1
739 580	Databus detector	1
737 9803	OBD Adaptor CAN+USB	1
739 587	Software: Databus visualisation	1
524 013S	Sensor-CASSY 2 Starter	1
739 581USB	CAN databus adapter USB	1
604 120	Spray bottle, 400 ml, LDPE	1
604 2303	Photographic tray , white, 24 x 30 cm	1
738 027	Digital power supply 1 - 16 V/40 A	1
500 990	Adapter sockets, set of 2	1
500 592	Safety bridging plugs with tap, black, set of 10	1
500 59	Safety bridging plugs, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
726 09	Panel frame T130, two-level	1
775 062EN	LIT: A2.6.1.3 Networking comfort	1
738 01	Cable and plug box	1*

* additionally recommended

The **LIN bus training system** - his master's voice! As "subbus" to the CAN data bus, the LIN bus is a single-wire bus that, upon request by the CAN bus master, supplies sensor data or activates actuator outputs. In automatic intermittent windshield wiper mode, the rain sensor recognizes the precipitation's intensity and sends this information via LIN bus to the electrical system control unit. This activates the wiper's motor - likewise via LIN bus - at an interval corresponding to the amount of precipitation: little rain = rare repetitions, a lot of rain = frequent repetitions of the wiper's movement. Spraying from an aerosol can activate the rain sensor.

The training system includes:

- CAN-bus-capable steering column electronics with wiper lever
- a CAN and LIN-bus-capable electrical system control unit
- a LIN-bus-capable wiper motor
- a LIN-bus-capable rain sensor
- a fault switching box (CAN and LIN faults).

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.4
Networking automotive systems: MOST bus practical exercises

Networking automotive systems: MOST bus practical exercises (A2.6.1.4)

Cat. No.	Description	A2.6.1.4
740 2081	MOST pliers set	1
740 2082	MOST Accessory set	1
576 74	Plug-in board, DIN A4, STE	1
578 486	STE MOST Transceiver	1
578 485	OWG coupler	1
577 44	Resistor, 1 kW, STE 2/19	1
740 2088	Automotive fibre optic microscope	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis, German and English	1
524 0512	Optical power sensor S	1
521 231	Low-voltage power supply, 3/6/9/12 V	1
501 46	Connecting leads, 19 A, 100 cm, red/blue, pair	1
501 48	Bridging plugs, STE 2/19, set of 10	1
775 063EN	LIT: A2.6.1.4 Practical exercises MOST-Bus	1

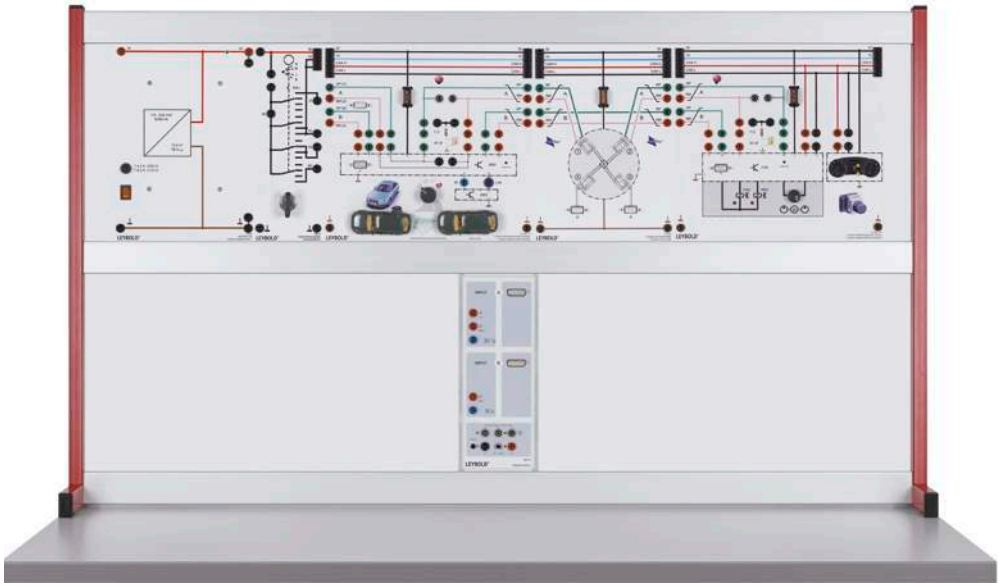
Modern vehicles can no longer do without networked systems. CAN bus, LIN bus, MOST bus and recently FlexRay command the communication between control units in the vehicle.

The equipment and part sets listed here let the students assemble fiber optic lines typical in vehicles and the teacher evaluate their results. In contrast to FO tool cases like those used with the workshops, all these "consumable components" such as FO, crimp sleeves or polishing equipment come in great quantities so that the exercises can still be executed with many students.

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.7
Networking automotive systems: Brake assist



Networking automotive systems: Brake assist (A2.6.1.7)

Cat. No.	Description	A2.6.1.7
773 958	FlexRay Brake Assist	1
773 960	FlexRay interface USB	1
773 959	FlexRay Active Star	1
738 10	Ignition switch	1
575 303	Digital storage oscilloscope 1222	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis, German and English	1
738 02	Automotive power supply 13.8 V/36 A	1
577 28	Resistor, 47 W, STE 2/19	4
577 32	Resistor, 100 W, STE 2/19	2
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
775 066EN	LIT: A2.6.1.7 Brake Assist System	1*
738 4911S	Automotive fault simulator, start	1*
500 593	Fault simulation plugs, black, set of 10	1*
726 09	Panel frame T130, two-level	1
738 01	Cable and plug box	1*

* additionally recommended

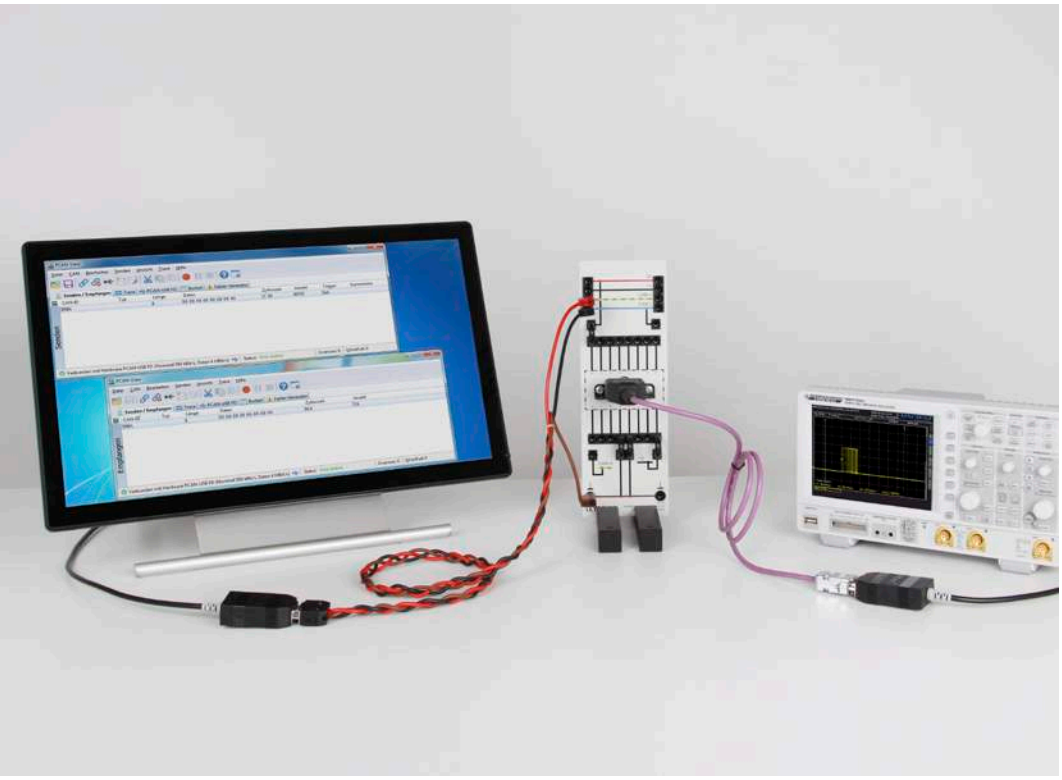
The **FlexRay training system** contains a brake assistant function. It combines the following:

- a distance sensor control unit
- a road condition sensor
- an ABS/ESP control unit, and
- an instrument cluster.

Two model cars simulate two vehicles tailgating. The FlexRay data bus transfers this state to the control unit for ABS/ESP, which then triggers the brakes to establish the safe distance again. The default value depends on the road condition (dry, wet, slick). The LIN data bus transmits the roadway's condition to the radar sensor control unit. Activating the high-pressure switch valve and the pump displays the brake's function. A high-speed CAN bus connection controls the corresponding indicator lamp in the instrument cluster.

The system can be expanded to an "active star" (773 959) with FlexRay components. The sensor control unit also has an available connection for a FlexRay/USB interface (773 960) to analyze the protocol on the computer.

The FlexRay lines can be completed with external resistors and are set for signal registration with an oscilloscope.



A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.9
Networking automotive systems: "CAN FD databus"

Networking automotive systems: "CAN FD databus" (A2.6.1.9)

Cat. No.	Description	A2.6.1.9
773 961	CAN-Databus-Multi-Adapter	2
738 975	Diagnostic Plug 16 Pin	1
577 30	Resistor, 62 W, STE 2/19	1
575 303	Digital storage oscilloscope 1222	1
775 069EN	LIT:A2.6.1.9+10 CAN FD and SENT	1
	Personal computer with operating system required !!!	1

"Evolution instead of revolution" – that is the motto of the new CAN Bus FD! It was not the integration of a completely new data bus system that was at the forefront when CAN-FD was introduced, but rather the expansion and improvement of the existing one. The result was CAN-FD: taking all known mechanisms of the CAN bus, the data transmission speed and data volume in a message were increased considerably. "FD" means "flexible data rate", which means that as a message is being transmitted, the speed of data transmission in the data field can be increased to up to 8 MBps! But that's not all: now 64 bytes instead of the previous 8 bytes can be transmitted in a message. As a result, these two characteristics mean that with CAN bus FD, a longer message will be transmitted faster than a considerably shorter message is sent with the standard motor CAN bus.

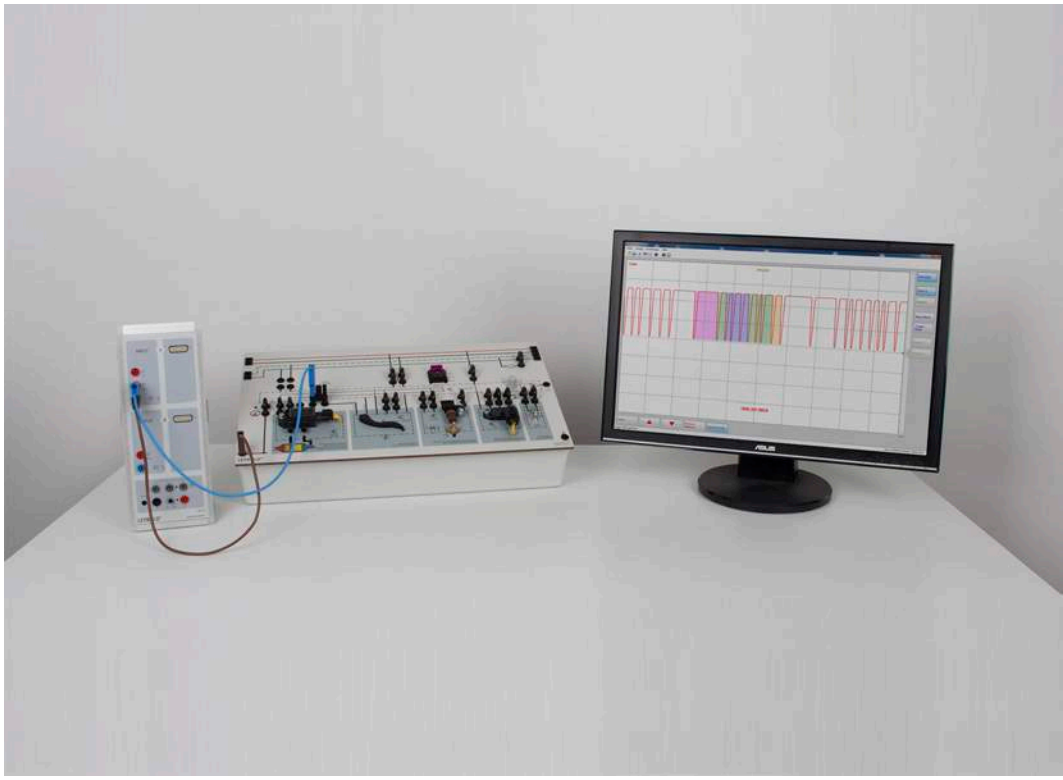
This is especially beneficial for the flash duration for controllers. Vehicle software updates can now be carried out considerably faster than before.

LEYBOLD offers a CAN FD device set with which CAN FD messages can be freely defined and transmitted. These can be recorded on the logic level on the PC and on the physical level with an oscilloscope. Of course standard CAN messages can also be produced and transmitted for comparison.

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.10
Networking automotive systems: "SENT"



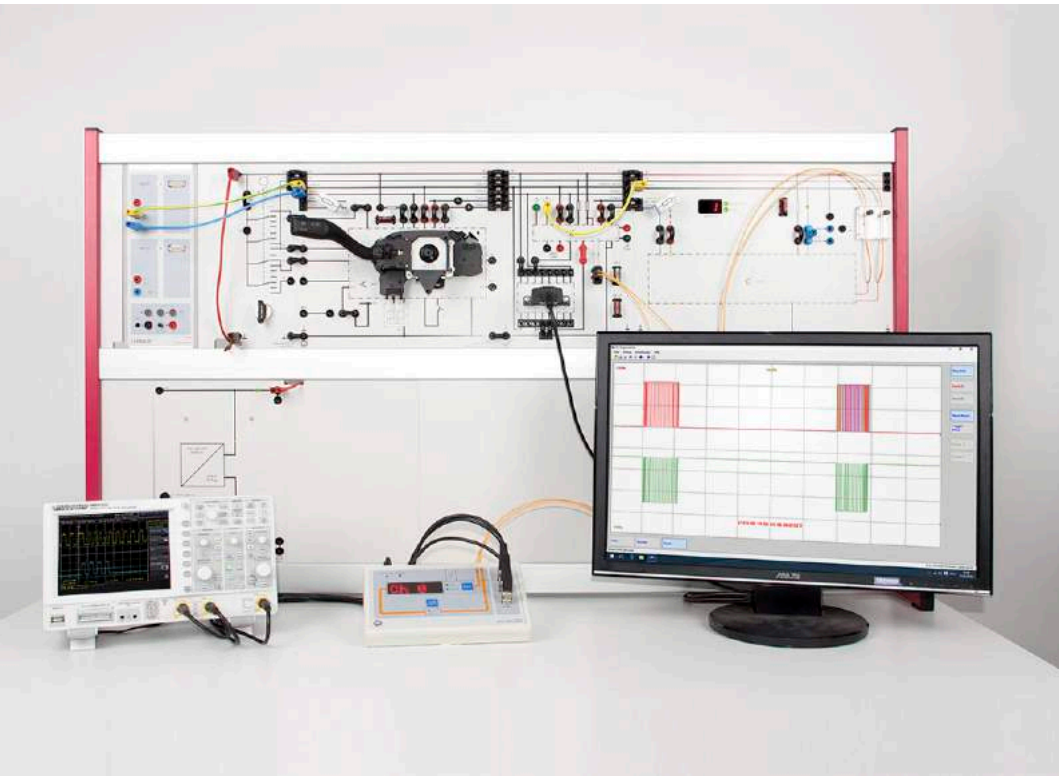
Networking automotive systems: "SENT" (A2.6.1.10)

Cat. No.	Description	A2.6.1.10
739 708	Sensor panel 2	1
738 10	Ignition switch	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis, German and English	1
773 961	CAN-Databus-Multi-Adapter	1
739 580	Databus detector	1
738 02	Automotive power supply 13.8 V/36 A	1
500 59	Safety bridging plugs, black, set of 10	2
500 601	Safety connection lead, 10 cm, red	1
500 641	Safety connecting lead, 100 cm, red	1
500 642	Safety connecting lead, 100 cm, blue	1
775 069EN	LIT:A2.6.1.9+10 CAN FD and SENT	1
726 19	Panel frame SL85, single-level	1
	Personal computer with operating system required !!!	1

"SENT" stands for "single edge nibble transmission" and is an interface for fast data exchange between a sensor or actuator and a controller. Standardised under SAE J2716, SENT has been considered an alternative to classic analogue and PDM interfaces since 2007.

As an affordable high-speed alternative to the LIN bus, it is thus advancing to enter all vehicle classes.

LEYBOLD has developed a training system that involves two conventional sensors with a SENT interface. The signals can be practically examined using a time base diagram or also theoretically using a protocol analyser.



A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.11
Networking systems: MOST Tiny

Networking systems: MOST Tiny (A2.6.1.11)

Cat. No.	Description	A2.6.1.11
740 2015	MOST Head Unit	1
740 2013	MOST PC USB Interface	1*
739 5861	CAN Gateway	1
738 10	Ignition switch	1
738 111-02	Steering column electronics	1
740 2014	MOST DAB radio	1*
740 2012-08	MOST BT Phone preparation	1*
736 415	Fiber Micropositioner	1*
575 303	Digital storage oscilloscope 1222	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis, German and English	1
739 580	Databus detector	1
577 30	Resistor, 62 W, STE 2/19	1
577 44	Resistor, 1 kW, STE 2/19	1
577 38	Resistor, 330 W, STE 2/19	1
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	1
737 9803	OBD Adaptor CAN+USB	1
666 425	Panel frame C50, two-level, for CPS	1
738 027	Digital power supply 1 - 16 V/40 A	1
738 9821	Safety experiment cables, set of 51	1

* additionally recommended

Today the fast MOST data bus is widespread in the infotainment sector of all car manufacturers. As a result, it would be impossible to imagine class without this high-performance, reliable system – especially when it comes to the digitalisation of cars.

LEYBOLD offers a device set that you can use to construct and examine a small MOST experimenting system. This system is exclusively designed for the practical examination of the MOST data bus characteristics and concentrates on typical characteristics that differentiate the MOST bus from other data bus systems.

Supplementing the examination of bus signals are the practical professional exercises for producing a fibre optic cable and troubleshooting using the self-diagnosis functions and suitable diagnosis testers.

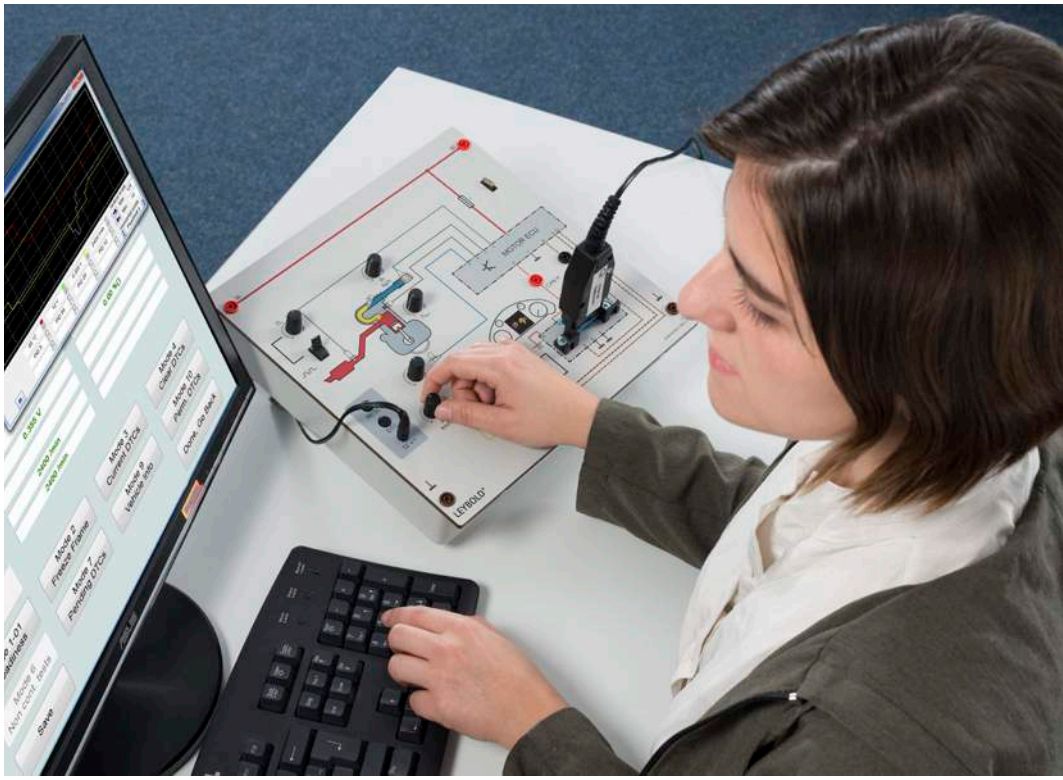
Equipment digitalisation: Networked car systems "MOST Tiny" is the perfect supplement for equipment digitalisation: Networked car systems comfort "CAN and LIN bus", A2.6.1.3. As all central devices are then present and serve as the basis for expansion of the system with a high-speed CAN bus and the MOST data bus.

A2.6.2

DIAGNOSIS

A2.6.2.1
Automotive self-diagnosis

A2.6.2.2
EOBD diagnosis



Automotive self-diagnosis (A2.6.2.1)

Cat. No.	Description	A2.6.2.1	A2.6.2.2
738 165	Headlamp level control	1	
579 163	Simulation ABS/Ti	1	
738 975	Diagnostic Plug 16 Pin	1	
737 9803	OBD Adaptor CAN+USB	1	1
738 10	Ignition switch	1	
738 02	Automotive power supply 13.8 V/36 A	1	
738 11	Head lamp switch	1	
738 1821	Xenon headlight unit	1	
524 034	Timer box	1	
524 013S	Sensor-CASSY 2 Starter	1	
726 10	Panel frame T150, two-level	1	
500 411	Connecting lead, 19 A, 25 cm, red	1	
500 59	Safety bridging plugs, black, set of 10	3	
500 592	Safety bridging plugs with tap, black, set of 10	1	
738 9821	Safety experiment cables, set of 51	1	
775 067EN	LIT: A2.6.2.1 Automotive self diagnosis	1	
738 01	Cable and plug box	1*	
738 4911S	Automotive fault simulator, start	1*	
500 593	Fault simulation plugs, black, set of 10	1*	
739 660	EOBD/OBD2 Simulator		1
737 9804	OBD data logger CAN+USB		1
562 791	Plug-in power supply, 12 V AC		1
689 0808	Set 5 automotive Mini fuses		1
775 068EN	LIT: A2.6.2.2 EOBD diagnosis		1

* additionally recommended

Engine control unit self-diagnosis and OBD2/EOBD

The legislation requires automatic headlamp level control for xenon lamps. This educational system contains an **automatic-dynamic** headlamp level control to stabilize changes in the headlamp level due to the body changing angles with the integrated acceleration/braking simulation (reversible).

The sensor inputs

- level signals of the front and rear axles and
- speed signal are detected.

This generates control signals for the actuator outputs

- headlamps' actuator and
- the malfunction indicator.

The system can self-diagnose over the K line: with a diagnostic adapter, all available measured value blocks can be displayed, and the functions

- coding
- default setting
- actuator diagnostics, and
- error logging

are executed.

A2
VEHICLE TECHNOLOGY

A2.7 ALTERNATIVE DRIVE TECHNOLOGY

A2.7.2 HYBRID DRIVES

A2.7.2.1 ELECTRICAL MACHINES IN HYBRID AND ELECTRICAL CARS

A2.7.2.2 EXPERIMENT STAND HYBRID DRIVES

A2.7.2.3 WORKSTATION VEHICLE HYBRID DRIVE

A2.7.2.4 HIGH-VOLTAGE CIRCUIT DISCONNECTION

A2.7.2.5 VEHICLE HIGH VOLTAGE TECHNOLOGY

A2.7.2

HYBRID DRIVES

A2.7.2.1
Electrical machines in hybrid and electrical cars

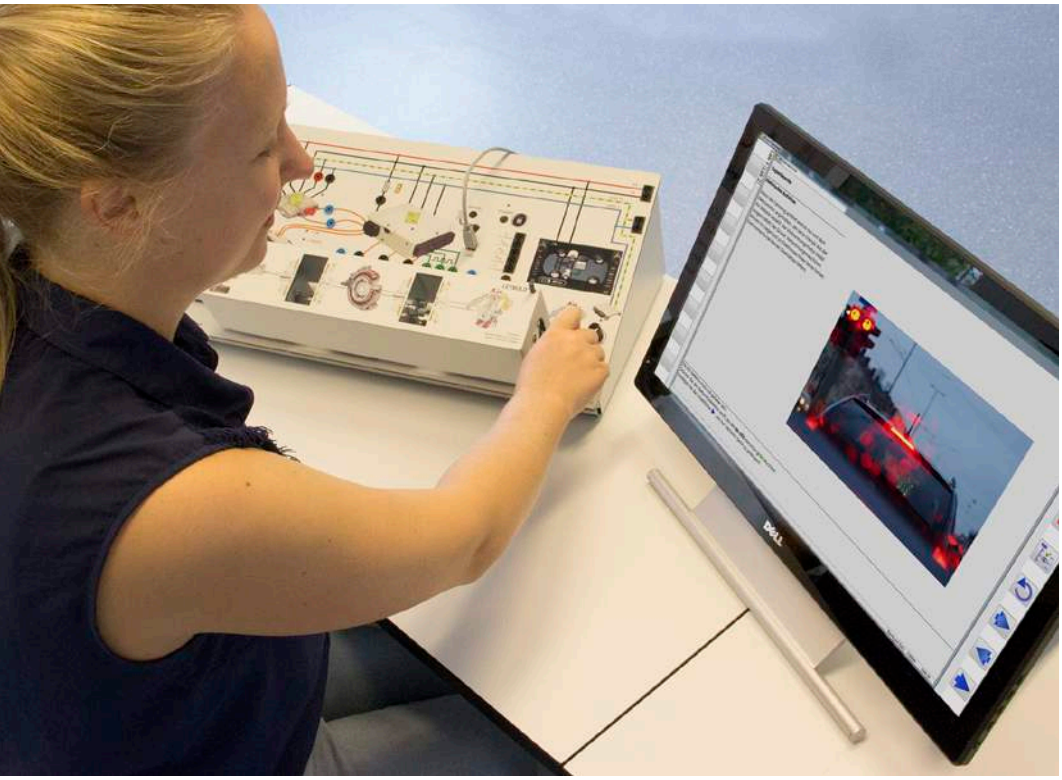
Electrical machines in hybrid and electrical cars (A2.7.2.1)

Cat. No.	Description	A2.7.2.1
300 01	Stand base, V-shaped, large	1
563 115	ELM coil, 500 turns	3
563 17	ELM centring disc	1
563 18	ELM brush holder rack	1
563 13	ELM brush	2
563 19	ELM magnet rotor	1
563 22	ELM two-pole rotor	1
563 28	ELM magnetic needle rotor	1
727 812	Rotor position pick-up	1
727 815	ELM set: Multipole stator and rotor	1
727 816	ELM PM magnet rotor with inner magnets	1
563 091	ELM pole piece for magnets	2
563 101	ELM wide pole piece for coils	3
563 251	ELM Rotating field Neodyn	1
563 291	ELM Cupper ring with iron disc	1
563 191	EMTM Magnet rotor 4 pole	1
510 48	Magnets, 35 mm Ø, pair	1
727 811	Basic machine unit	1
727 88	Drive unit	1
727 87	Star-delta load	1
727 21	Automobile Meter Zero-Center	1
727 20	Automobile Meter Zero-Left	1
579 13	Toggle switch, STE 2/19	1
524 0621	UIP sensor S	1
524 0431	30-A-Box	1

Cat. No.	Description	A2.7.2.1
524 034	Timer box	1
524 013S	Sensor-CASSY 2 Starter	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis, German and English	1
577 32	Resistor, 100 W, STE 2/19	3
577 44	Resistor, 1 kW, STE 2/19	1
578 15	Capacitor, 1 µF, STE 2/19	1
727 800	Storage ELM	1
563 16	Allen key	1
726 10	Panel frame T150, two-level	1
725 721G	Three-phase generator in case	1
563 31	Oil, 100 ml, in dropping bottle	1
738 9821	Safety experiment cables, set of 51	1
775 071EN	LIT: A2.7.2.1 Basics of automotive electrical machines	1
738 01	Cable and plug box	1

Study of the fundamentals of hybrid drive requires basic knowledge of the construction and function of electric machines. Thus, each of

- the direct current machines
- the alternating and induction machines, and
- the servomotor is among the motor and generator operation modes.



A2.7.2

HYBRID DRIVES

A2.7.2.3
Workstation vehicle hybrid drive

Workstation vehicle hybrid drive (A2.7.2.3)

Cat. No.	Description	A2.7.2.3
739 9401	Workstation vehicle hybrid drive	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
738 9821	Safety experiment cables, set of 51	1
775 073EN	LIT: A2.7.2.3 Workstation vehicle hybride drive	1
689 0808	Set 5 automotive Mini fuses	1
688 129	Mains cable with hock-proof plug and cold connector	1*

* additionally recommended

Additional knowledge of power electronics and energy storage technology allows comprehension of the new "hybrid drive technology" system.

Teachers and students must also be trained for or made aware of exposure to high voltages and the risks involved. Only then can the students be trained to become professionals skilled in electrics.

In addition to the "hybrid propulsion" demo equipment, LEYBOLD has developed a student workstation that enables the study of all essential aspects in a smaller scale. Equipped with

- a PMSM as an electric motor
- an inverter
- a dual voltage electrical system, and
- a touchscreen display for the operation and to display energy flows.

The control units are networked with the motor CAN bus.

All common operation modes are adjustable:

- Start
- Electric drive
- Boost
- Regenerative brakes

The student can independently study the complex issue of hybrid technology. Thanks to overlays, various systems can be selected. The workstation can be linked to the PC.

A2.7.2

HYBRID DRIVES

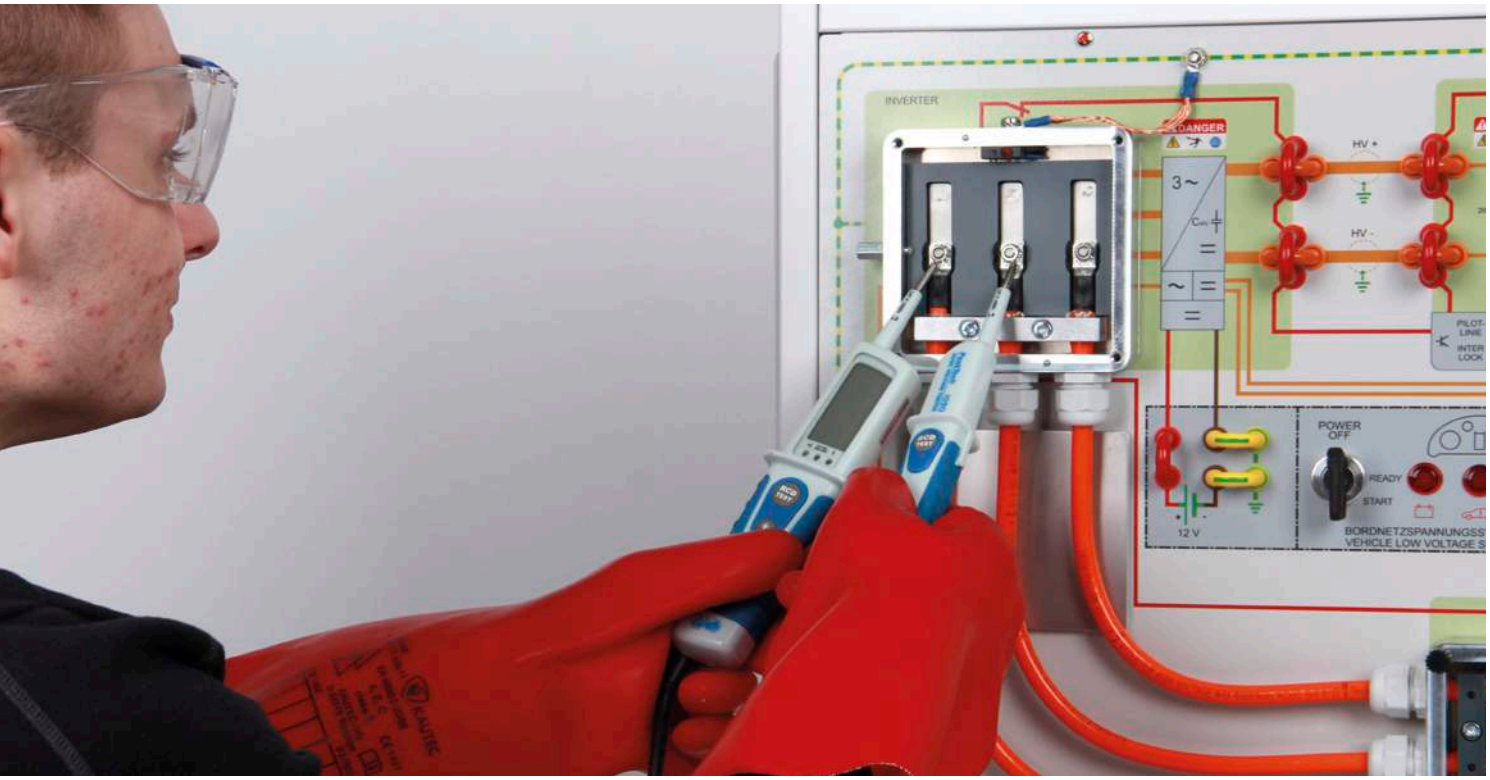
A2.7.2.5
Vehicle high voltage technology

Vehicle high voltage technology (A2.7.2.5)

Cat. No.	Description	A2.7.2.5
739 947	PEV High Voltage Trainer	1
739 948	Electric vehicle charging station	1
732 11	Squirrel cage motor 400/690/0.3	1
727 293	Digital insulation tester	1
739 004	DMM for electrical vehicles	1
739 949	HV PC measurement adapter for E-Mobility	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 013	Sensor-CASSY 2	1
739 835	Kelvin- sensing cable, set of 2	1
739 836	Milliohm meter	1
739 944	Insulating gloves 1000 V	1
689 0816	Pair of cotton gloves	1
667 6123	Roma safety goggles	1
689 0817	HV tool set	1
577 36	Resistor, 220 W, STE 2/19	1
577 46	Resistor, 1.5 kW, STE 2/19	1
578 51	Diode, 1N 4007, STE 2/19	1
739 950	Charging cable Mode 2, 1~	1
739 951	Charging cable Mode 3, 3~	1
731 07	Shaft end guard 0.3	1
610 210	Warning sign „Dangerous electrical current“	1
775 074EN	LIT: A2.7.2.5: Vehicle high voltage trainer	1
500 641	Safety connecting lead, 100 cm, red	2
500 644	Safety connecting lead, 100 cm, black	1
500 647	Safety connection lead, 100 cm, brown	1

Cat. No.	Description	A2.7.2.5
500 6481	Safety lead 100 cm grey	1
500 640	Safety connecting lead, 100 cm, yellow/green	1
500 604	Safety connecting lead, 10 cm, black	3
500 612	Safety connecting lead, 25 cm, blue	1
500 592	Safety bridging plugs with tap, black, set of 10	1
689 0820	Service Disconnect	1*
689 0818	HV cables, set of 3	1*
689 0819	HV cable	1*
689 0821	HV Safety Tape	1

* additionally recommended



As vehicle electronics have, for the most part, been harmless in the past, it is now necessary to raise awareness of hazardous live voltages and new safety measures and procedures must be conveyed in a targeted manner.

This places new demands on craftsmen, automotive mechatronics engineers, and educators in the field of electromobility. The challenge is having to work with voltage under real-world conditions while still ensuring that trainers are as safe as possible during class.

LD DIDACTIC has developed a trainer for this purpose that can be practically used to practice disconnecting electric vehicles from their power sources. The device is suitable for demonstrations carried out by the trainer/instructor, as well as for practical professional practice carried out by trainees/students. Technical service companies (e.g. ADAC), testing centres (TÜV, Dekra), rescue workers (fire department, THW), or users can also benefit from this training concept by using it to prepare their professional staff for this innovative segment of the automotive technology market.

Study of the fundamentals of hybrid drive requires basic knowledge of the construction and function of electric machines. Thus, each of

- the direct current machines
- the alternating and induction machines, and
- the servomotor is among the motor and generator operation modes.

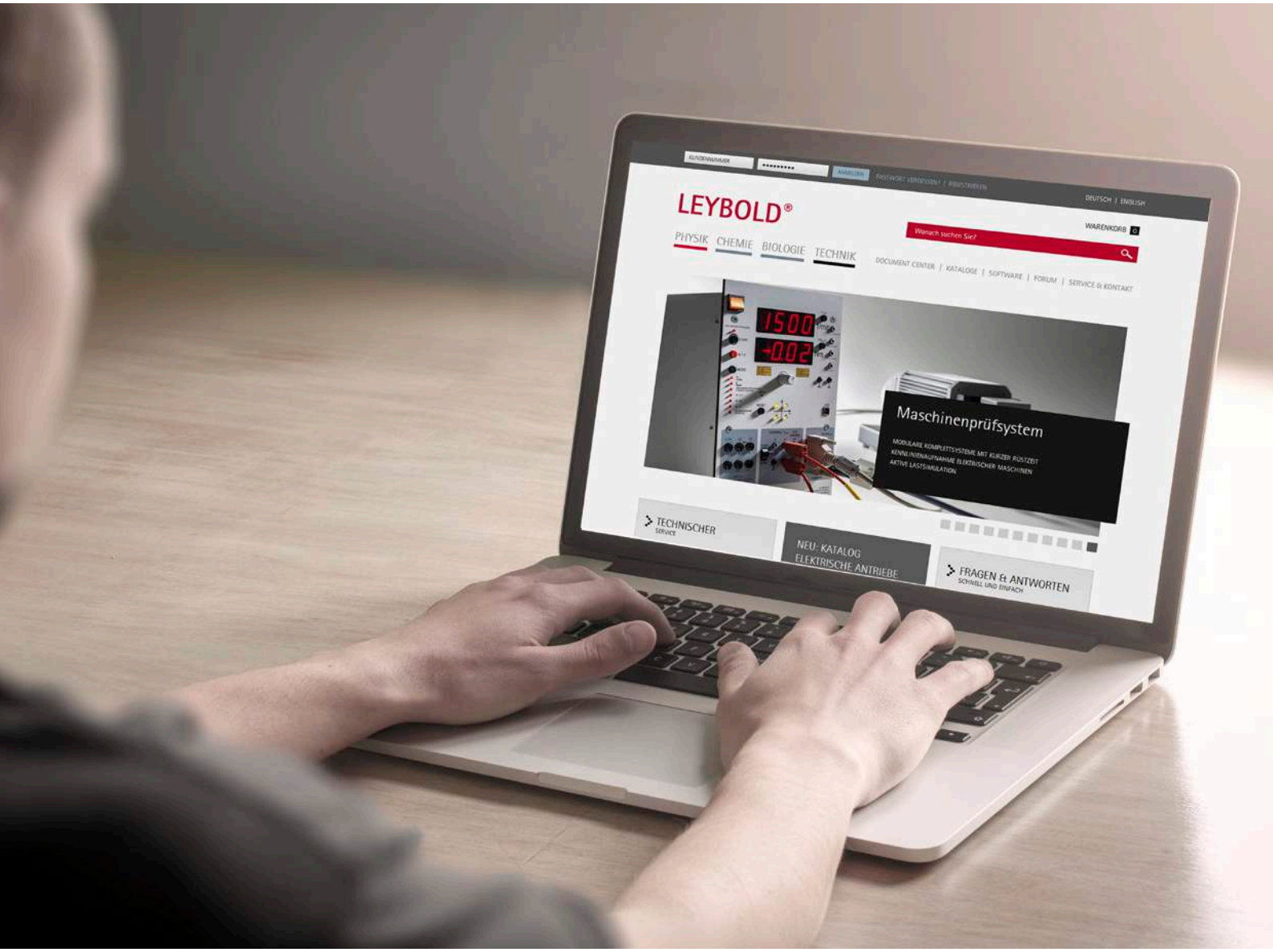
Additional knowledge of power electronics and energy storage technology allows comprehension of the new "hybrid drive technology" system.

Teachers and students must also be trained for or made aware of exposure to high voltages and the risks involved. Only then can the students be trained to become professionals skilled in electrics.

LD DIDACTIC

THE LEYBOLD WEBSHOP

Simply search, quickly navigate and request your offer!



WWW.LEYBOLD-SHOP.COM

EQUIPMENT PAGE

EQUIPMENT PAGE

PHYSICS
CHEMISTRY
BIOLOGY
ENGINEERING

LD DIDACTIC

134 01100EN 11.2016 LD
Subject to technical amendments.

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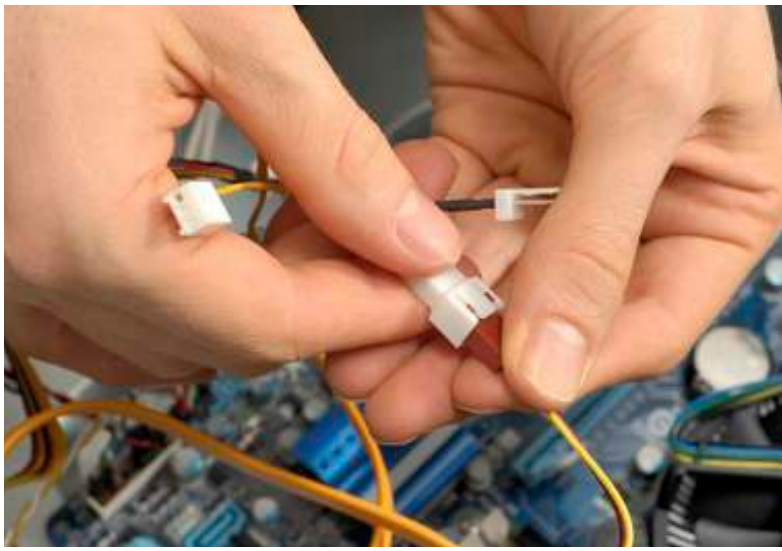


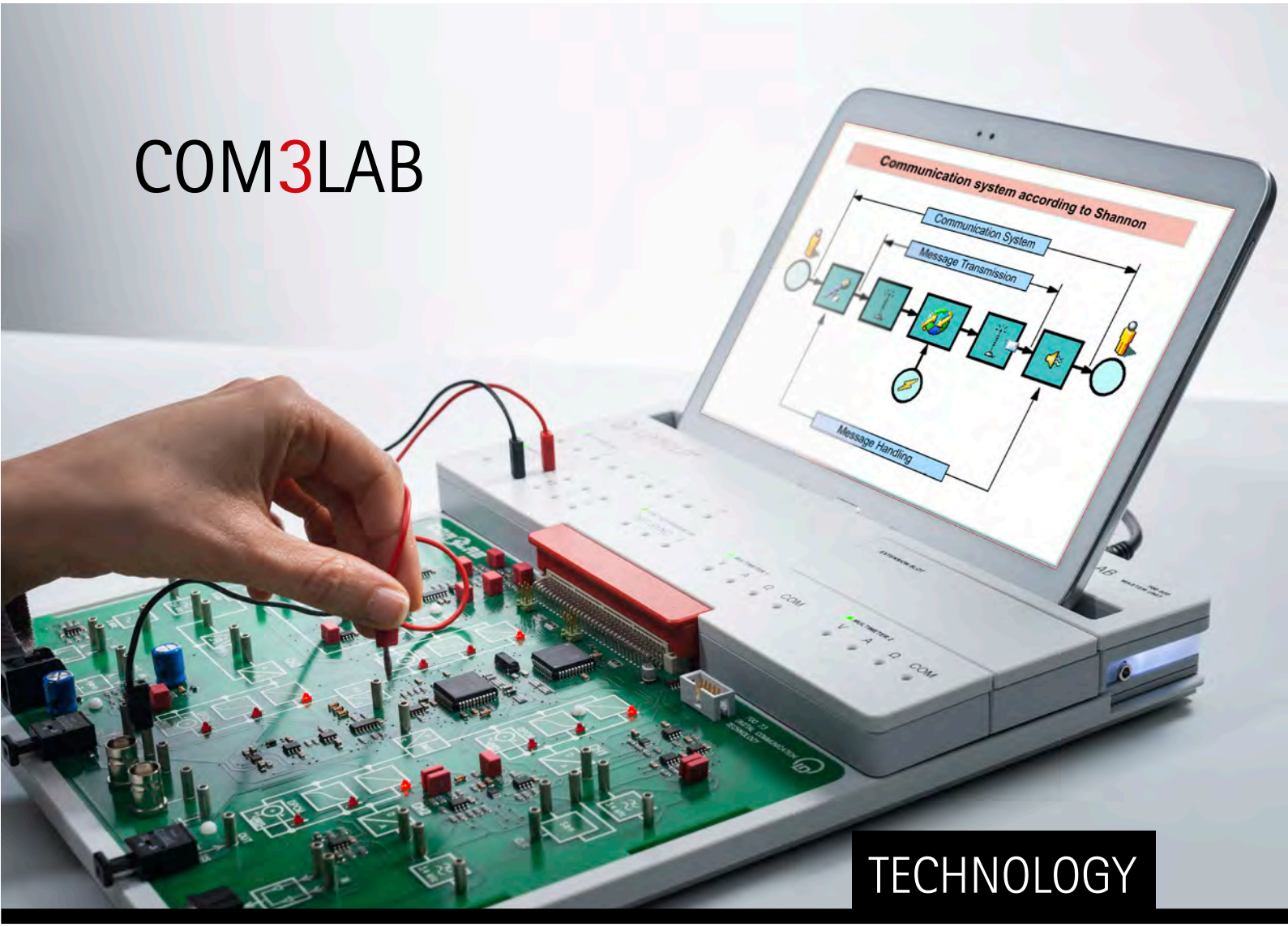
WWW.LD-DIDACTIC.COM

BRANDS OF THE LD DIDACTIC GROUP

LEYBOLD® Feedback ELWE® TECHNIK

LEYBOLD®

THE MULTIMEDIA LAB FOR ELECTRONICS AND ELECTRICAL ENGINEERING

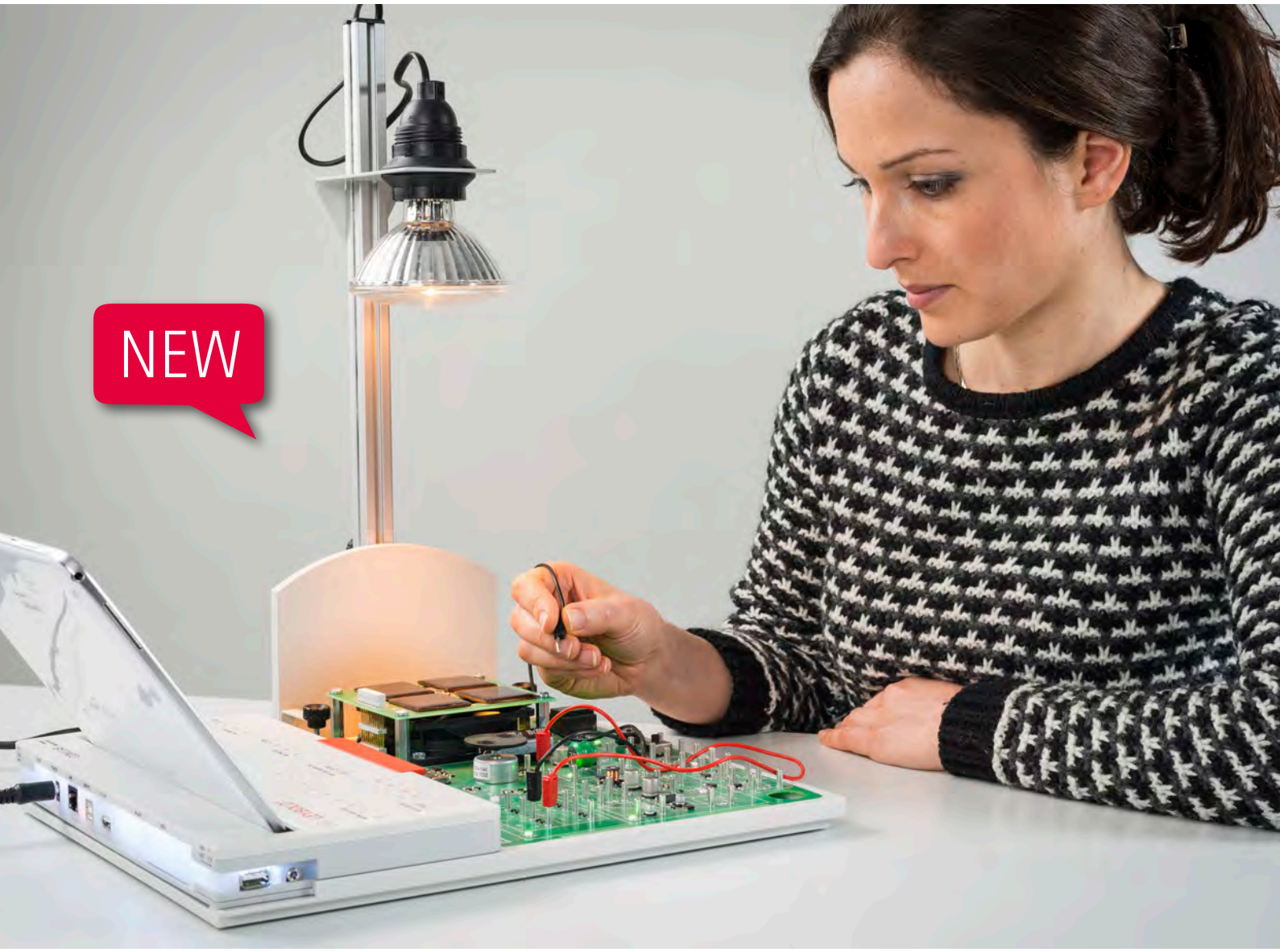


LEARNING WITH A GUARANTEE OF SUCCESS

- safe experiments
- comprehensive content
- easy handling

LD DIDACTIC

COM3LAB



THE MULTIMEDIA LAB FOR ELECTRONICS AND ELECTRICAL ENGINEERING

CONTENT

COM3LAB – THE SYSTEM AT A GLANCE

ELECTRICAL ENGINEERING

AUTOMOTIVE TECHNOLOGY

RENEWABLE ENERGY

PRODUCT SECTION

3 COMPONENTS
turn to one LABORATORY

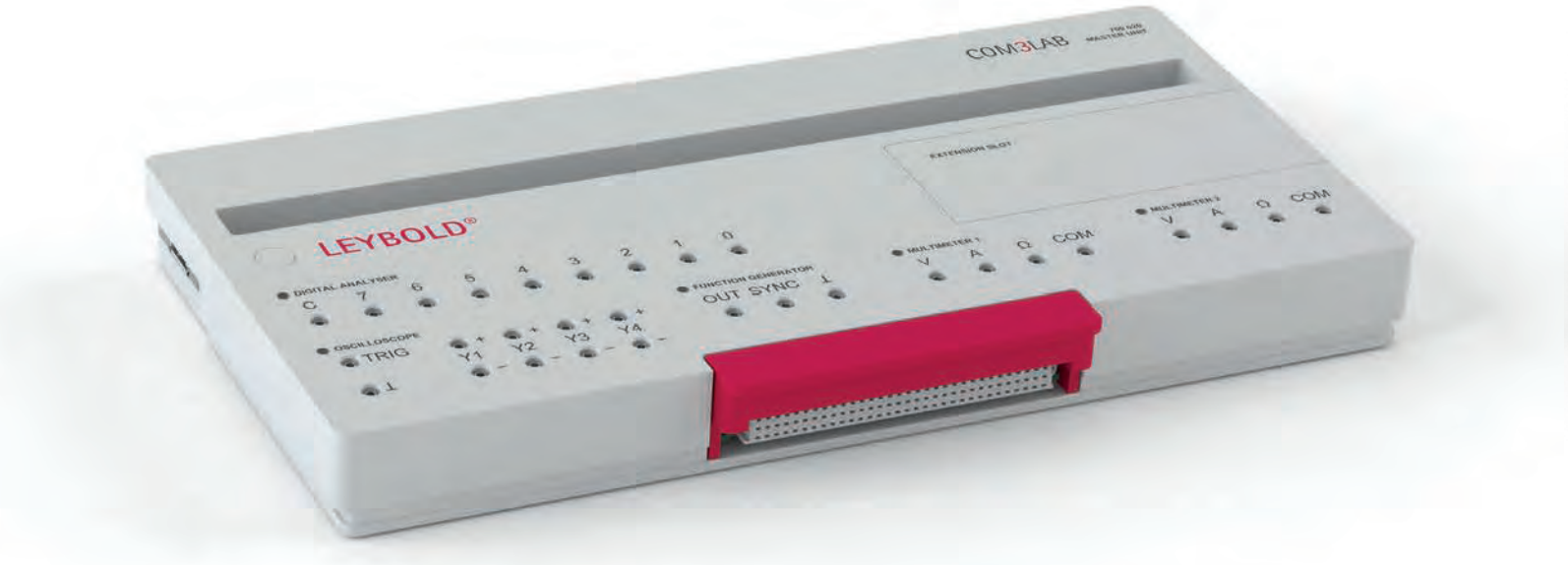
The COM3LAB learning environment combines experimentation with the advantages of interactive e-learning.

The new Master Unit is the bridge between the experimental panel and the learning software. It contains all necessary measuring instruments and power supplies.

MASTER UNIT

- clearly labelled with a functional design
- interfaces to all PC systems
- precise and rapid measuring instruments and signal generators
- robust against electromagnetic interference
- simple and safe in the hands of students
- compatible with all previous COM3LAB courses

NEW



COM3LAB

EXPERIMENT BOARD

- safe and clearly structured courses for every learning field of electrical engineering
- regular new courses on modern topics
- visible modules and realistic system components
- interactive course guidance with LEDs

INTERACTIVE LEARNING SOFTWARE

- clearly structured, simple operation
- easily understandable theoretical part
- all experiments performed under guidance with learning control tests
- multimedia support content with animations, videos, audio and real measuring instruments with virtual display

THE NEW MASTER UNIT

EVEN BETTER FOR TEACHERS AND TRAINERS

FOR TABLET, PC AND LAPTOP

No matter if and how your IT system changes tomorrow, the new Master Unit fits into any modern infrastructure. Whether USB, WiFi or Ethernet, all interfaces are supported directly, and without adapters.

Windows systems are supported natively, iOS and Android systems can be easily connected via RDP or VNC.

PROTECTION FROM DESTRUCTION

Safety features for a long service life in the teaching laboratory:

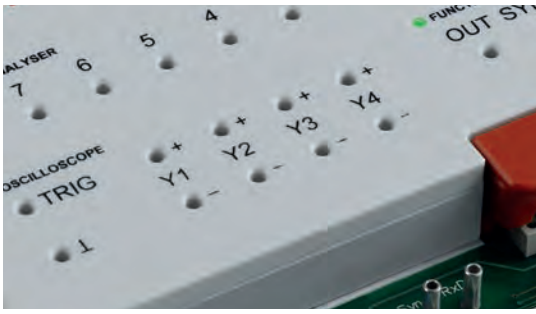
- The red security lock keeps the course board mechanically secure and if it is opened, the course board is switched off.
- To meet current regulations, 2 mm security cable can also be used.
- There is a slot for a Kensington lock on the rear side, so that your Master Unit remains in the place where you need it.
- Course board frames made from high-quality material protect the PCB and the furniture against scratches and defects.
- The use of high-quality materials.

ASSEMBLY AND DISASSEMBLY QUICK AND EASY

- The compact construction permits space-saving storage in a cupboard.
- Course boards can be connected to the new Master Unit quickly.

COM3LAB

HIGHER MOTIVATION AND GREATER LEARNING SUCCESS FOR STUDENTS



INTUITIVE LEARNING, FUNCTIONAL DESIGN

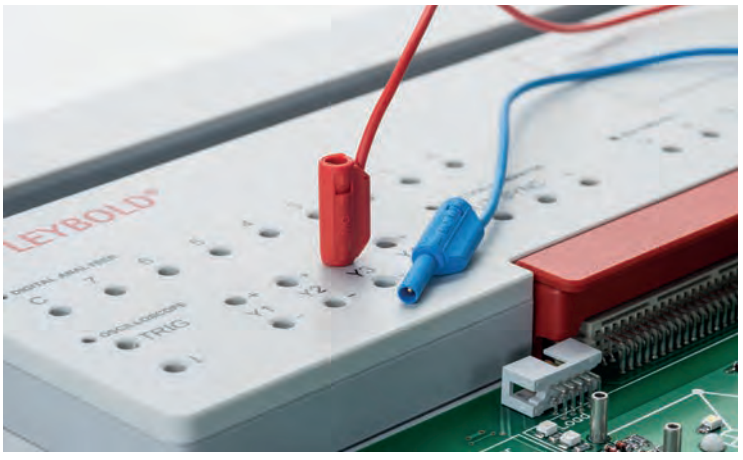
The Master Unit has been designed to allow perfect learning ergometry:

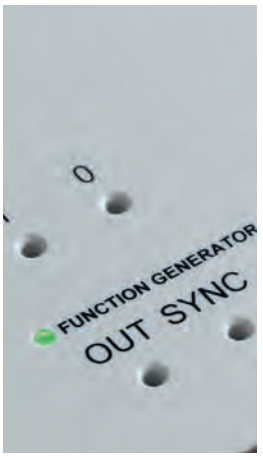
- Complete and easily readable labelling.
- Multi-coloured activity indicators for measuring instruments.
- A luminous strip indicates to the instructor(s) whether a course is being actively carried out.
- All measuring instruments can be controlled directly by the software.

NEW 4-CHANNEL OSCILLOSCOPE

The integrated oscilloscope offers many advantages:

- Four differential inputs
- Measuring rate: 2 M-samples per channel
- Resolution: 12 bits per channel
- Memory depth: 4 K-samples per channel



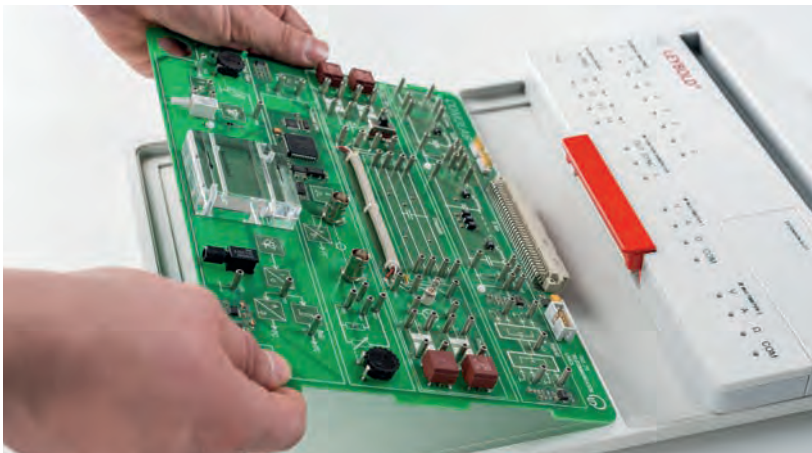


ACTIVE GUIDANCE

The relevant areas light up during the course of the experiment to guide the user through the experiment.

COMPATIBLE WITH ALL COURSE BOARDS

The course board frame acts as an "adapter" for all basic and advanced course boards. The frames can be purchased individually.



THE NEW MASTER UNIT

COMPLETELY REVISED FUNCTIONAL DESIGN

FOR TABLETS

Interfaces for many available models

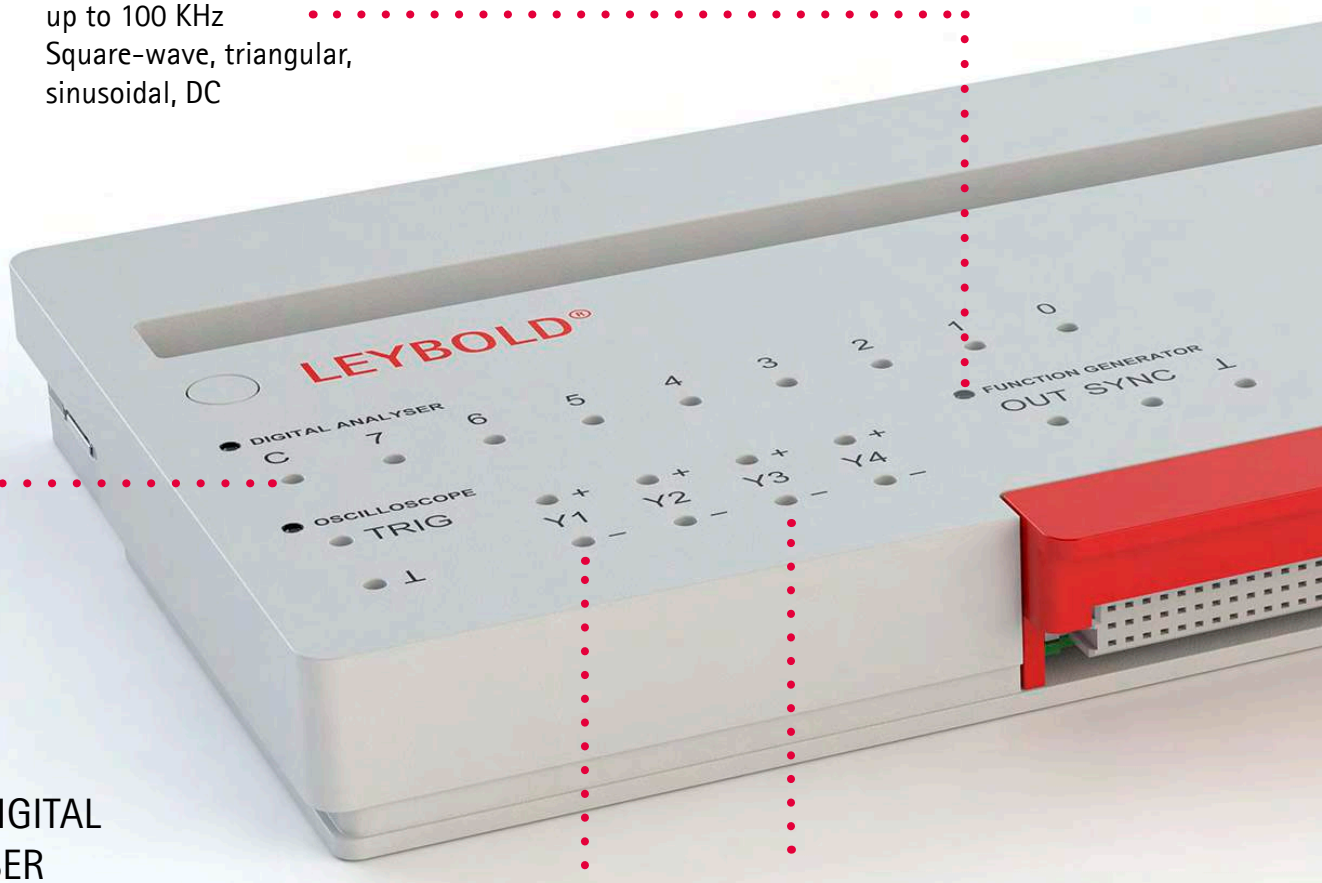
ANTI-THEFT PORT

using a Kensington lock

PC interface for controlling course boards (RJ45/USB/WLAN)

FUNCTION GENERATOR

up to 100 KHz
Square-wave, triangular, sinusoidal, DC

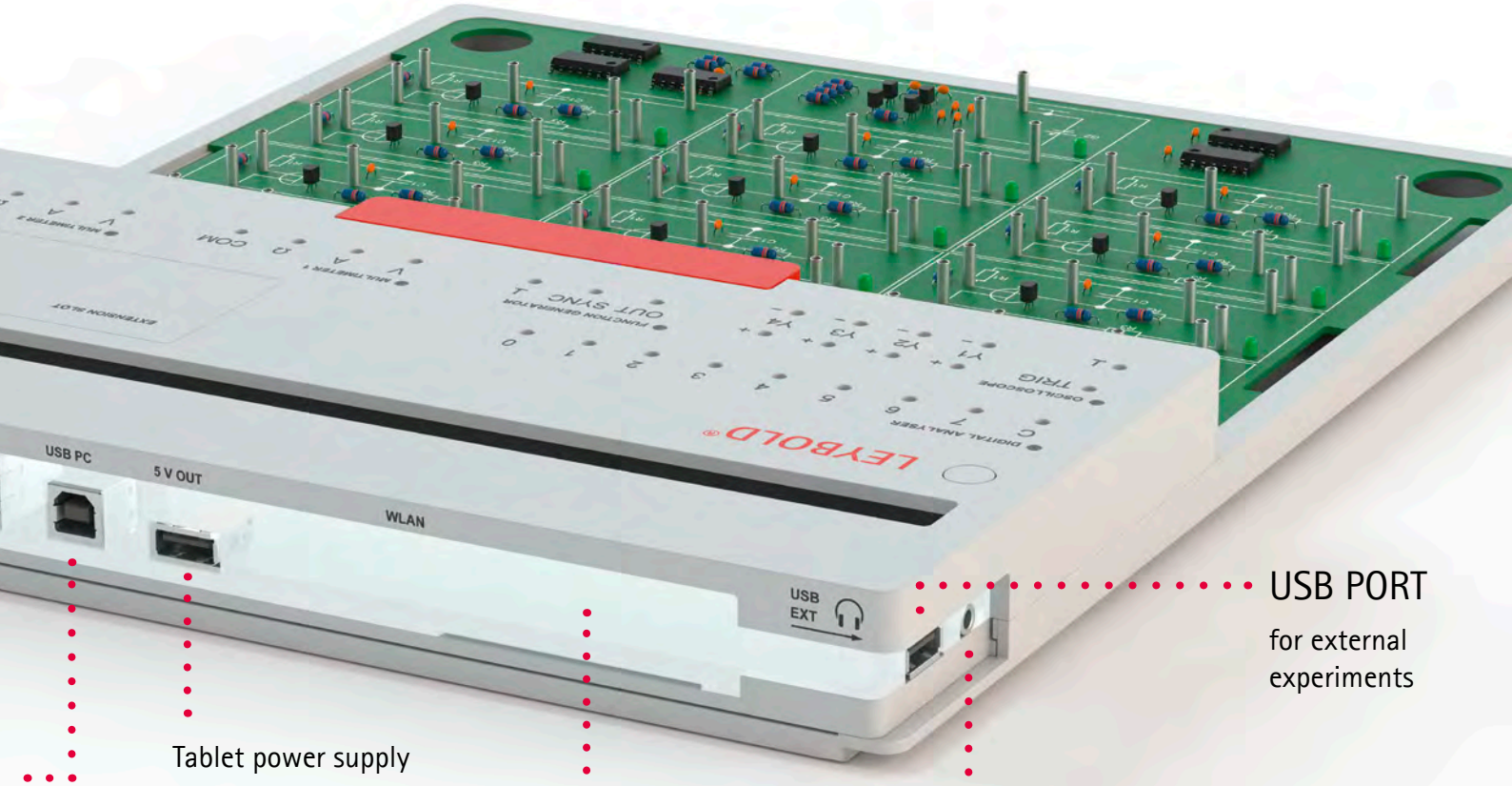


8-BIT DIGITAL ANALYSER

2 mm safety sockets

4-CHANNEL OSCILLOSCOPE

with differential inputs



Tablet power supply

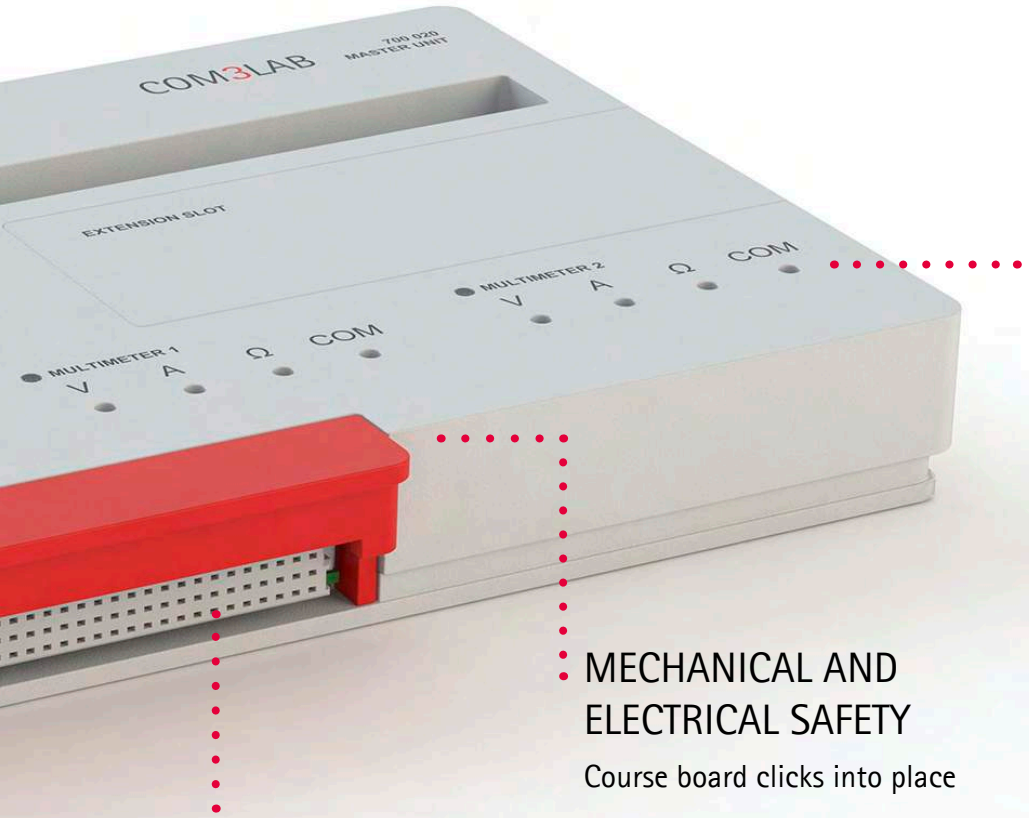
LUMINOUS STRIP

as a status indicator

USB PORT

for external experiments

One headphone socket on each side



2 x MULTIMETER

8 measurement ranges for current, voltage and resistance measurement

MECHANICAL AND ELECTRICAL SAFETY

Course board clicks into place

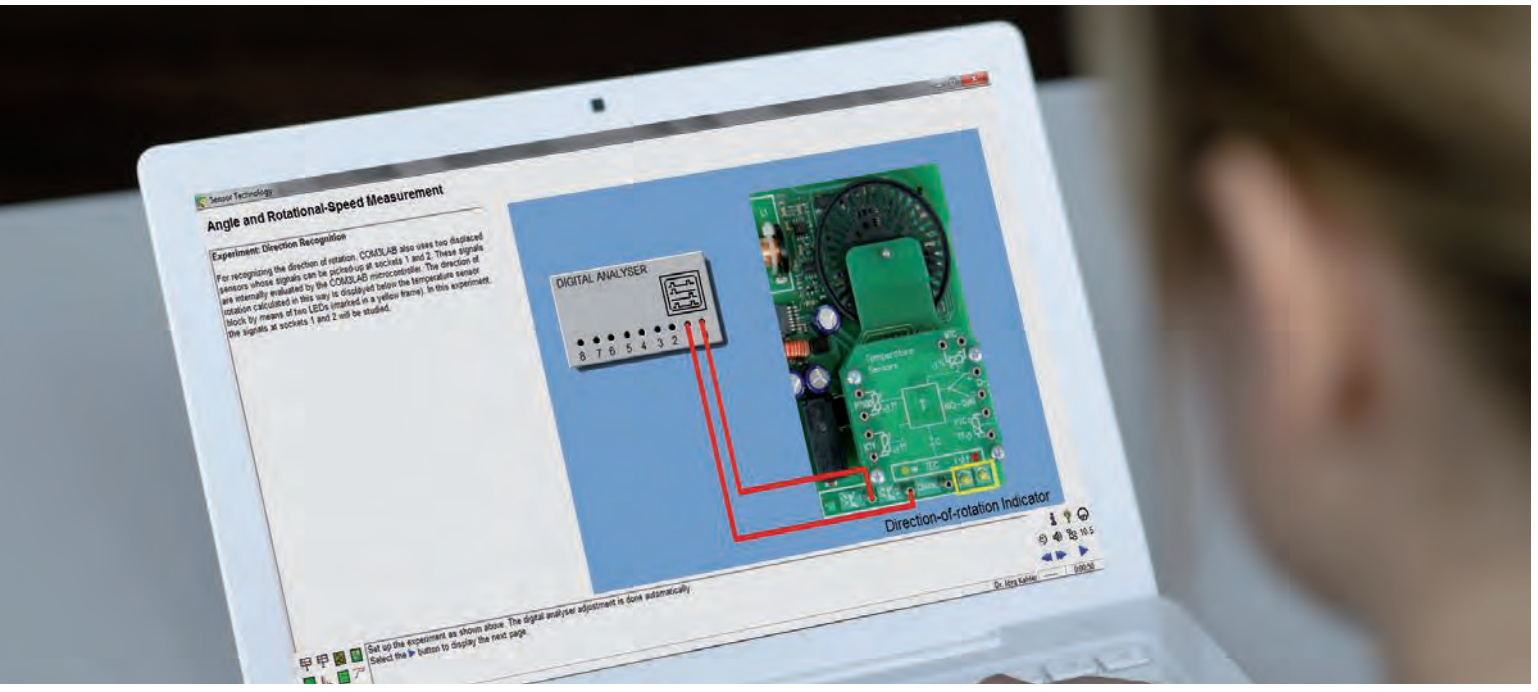
RASTER SLOT FOR EXPERIMENT BOARDS

compatible with COM3LAB 1.0

COM3LAB

COM3LAB

THE CONCEPT



INTERACTIVE LEARNING PROGRAMME TEACHES AND GUIDES THROUGH THE CONTENTS

Often copied - never equalled. Owing to the clear and consistent preparation of the teaching content, the learning software clearly and unmistakable provides guidance through the individual experiments. Every topic starts with a theoretical introduction followed by at least one topic-related, practical experiment. The COM3LAB self-assessment test ensures that the course content is absorbed and consolidated.

The interactive COM3LAB learning software is suitable for independent learning and experimenting ays well as for complete teaching units and project work. The multimedia learning environment supports the real experiments additionally with graphics, animations, videos and optionally with audio.

All courses are available not only in German and in English, but also the courses already support many other languages, such as Spanish, Russian, Polish, etc.

PRACTICE-ORIENTATED EXPERIMENTS
INCREASE LEARNING OUTCOMES

ADVANTAGES

FOR THE TEACHER

- comprehensive content
- practice-oriented experiments
- descriptive teaching materials for presentations
- documentation with solutions
- flexible application for teaching
- time-saving through quick and simple assembly

FOR THE STUDENT

- practice-oriented learning
- review of the results
- documentation of the results
- team work or independent study
- language selection
- adapted to the individual's learning speed
- promotes decision-making and responsibility

SAFETY

TWO STEPS AHEAD

A comprehensive safety concept has been developed for the new COM3LAB.

PROTECTION FROM DESTRUCTION

Apart from the careful choice of materials and a robust design, this aspect includes the protection of the course provided by the new course frameworks.

PROTECTION AGAINST DANGEROUS VOLTAGES

In all COM3LAB courses, only safe voltages and low currents are used. This rules out any hazard. In order to comply additionally with the new regulations in many teaching establishments, the courses can be operated with safety cables.

PROTECTION FROM THEFT

There is a compatible slot for a Kensington lock on the rear side of the Master Unit. In addition, every networkable Master Unit is equipped with a unique ID for easy assessment management.

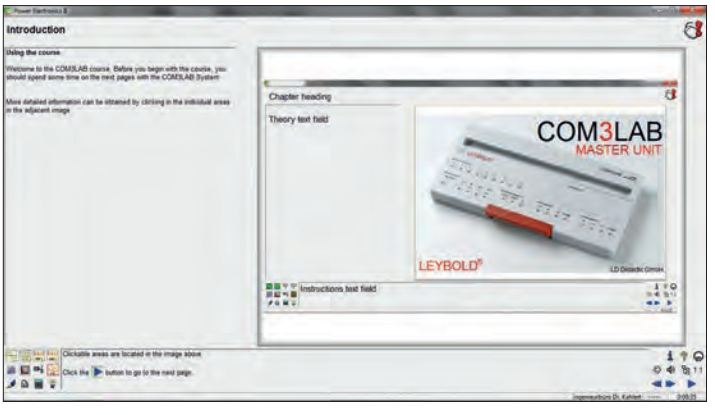
SO THAT YOU CAN CONCENTRATE ON WHAT'S IMPORTANT

SHORT PREPARATION TIME

ASSEMBLY AND DISASSEMBLY IN ONLY A FEW MINUTES

COURSE DEVICES ARE MECHANICALLY LOCKED AND AUTOMATICALLY ACTIVATED

1. OPEN THE SECURITY LOCK AND PUSH THE MASTER UNIT INTO PLACE
2. CLOSE THE SECURITY LOCK
3. SWITCH ON THE MASTER UNIT
4. START THE SOFTWARE START TRAINING



Introduction to the COM3LAB course

COMPATIBLE WITH ANY LABORATORY EQUIPMENT ...

FOR TABLETS

The slot in the Master Unit is designed to accept many available 8-10" tablets.

Simply establish a connection via WiFi, Ethernet or USB.

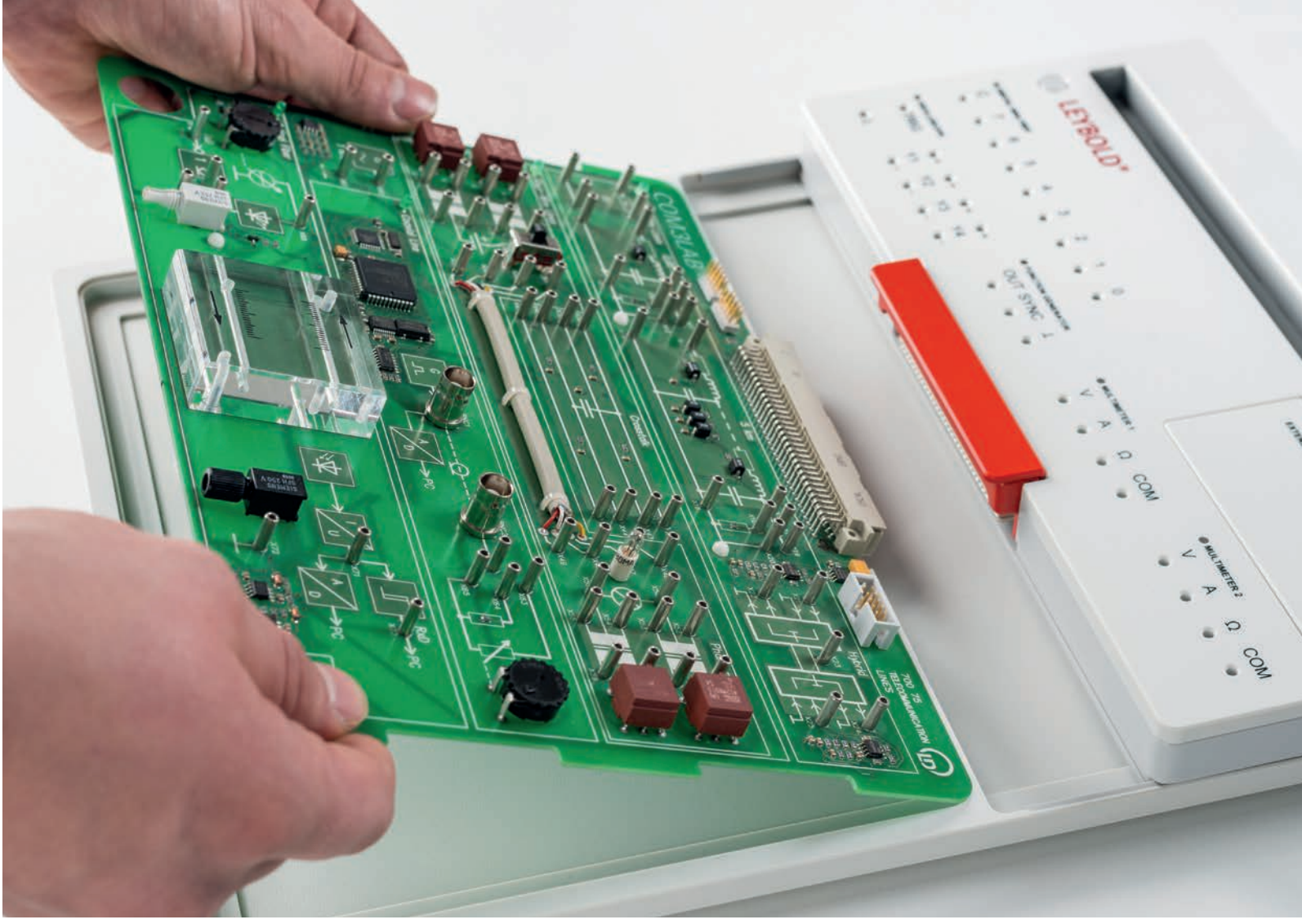
An additional charging port at the rear of the Master Unit ensures long-term learning pleasure.

LAPTOP AND PC

For use with laptops and PCs, we recommend Windows 7 or Windows 8.

Now all possibilities are open to you. For better documentation, the course pages can be saved and printed, i.e. as PDF, XPS, ...

The results of measurements can be further processed in Word and Excel.



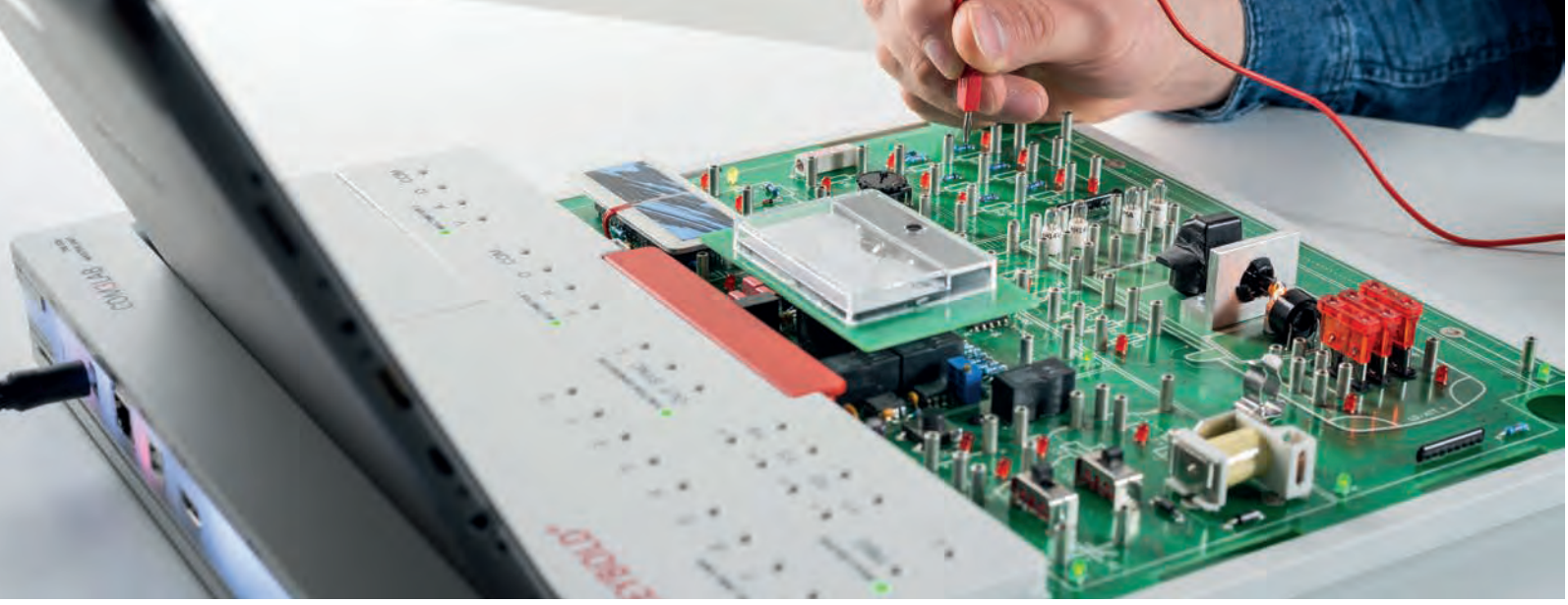
COMPATIBLE WITH OLDER
COURSE BOARDS

... AND ALL COURSE BOARD GENERATIONS

What once was good, will be further used. For this reason, the new Master Unit and also the learning software support older course boards.

All that you need is the new course board frame (700 022) which can be bought economically in sets. Click your existing experiment boards into the frames and your equipment is fit for the new learning generation with COM3LAB. The new software supports both the Master Unit 700 00USB and also the new Master Unit 700 020, so that parallel operation is possible.

COM3LAB



COURSES FOR EVERY LEVEL OF EDUCATION

Detailed descriptions of the courses are available in the product section from page 51.

ELECTRONICS TECHNICIAN FOR AUTOMOTIVE TECHNOLOGY

Topics:	7006401	7006501	7006101	7006201	7006301	7003501
Testing and maintenance of electrical and electronic systems	x	x	x			
Testing and maintenance of the power supply and starting systems				x		
Testing and maintenance of networked systems					x	
Testing and maintenance of electro-pneumatic and hydraulic systems						x

ELECTRONICS TECHNICIAN FOR AUTOMATION

Topics:	7001101	7001201	7001301	7001401	7001701	7001801	7002401	7003101	7003501	7007501	7008201
Analyse electrical systems and check functions	x	x	x	x							
Analyse and adjust controls					x	x					
Ensure electricity supply and safety of equipment							x				
Analyse and verify systems and equipment									x		
Program and implement controls for systems								x			x
Integrate control and communication systems										x	
Plan automation systems								x			
Implement automation systems								x			

ELECTRONICS TECHNICIAN FOR ENERGY AND BUILDING

Topics:	7001101	7001201	7001301	7001401	7001701	7001801	7002401	7005301	7003101	7008201
Analyse electrical systems and check functions	x	x	x	x				x		
Analyse and adjust controls					x	x				
Ensure electricity supply and safety of equipment							x			
Program and implement controls for systems									x	x

ELECTRONICS TECHNICIAN FOR DEVICES AND SYSTEMS

Topics:	7001101	7001201	7001301	7001401	7001701	7001801	7005301	7003101	7003601	70039	7008201	7008301	7003501
Analyse electrical systems and check functions	x	x	x	x			x						
Analyse and adjust controls					x	x							
Configure assemblies of hardware and software								x	x	x	x	x	
Produce equipment and check													x

ELECTRONICS TECHNICIAN FOR INFORMATION / TELECOMMUNICATIONS TECHNOLOGY

Topics:	7001101	7001201	7001301	7001401	7001701	7001801	7002401	7005301	7001901	7003101	70039	7003501	7008201
Analyse electrical systems and check functions	x	x	x	x									
Analyse and adjust controls					x	x							
Ensure electricity supply and safety of equipment							x						
Program and implement controls for systems										x			x
Select and integrate systems									x	x	x	x	

COM3LAB

TECHNICAL COLLEGE / UNIVERSITY

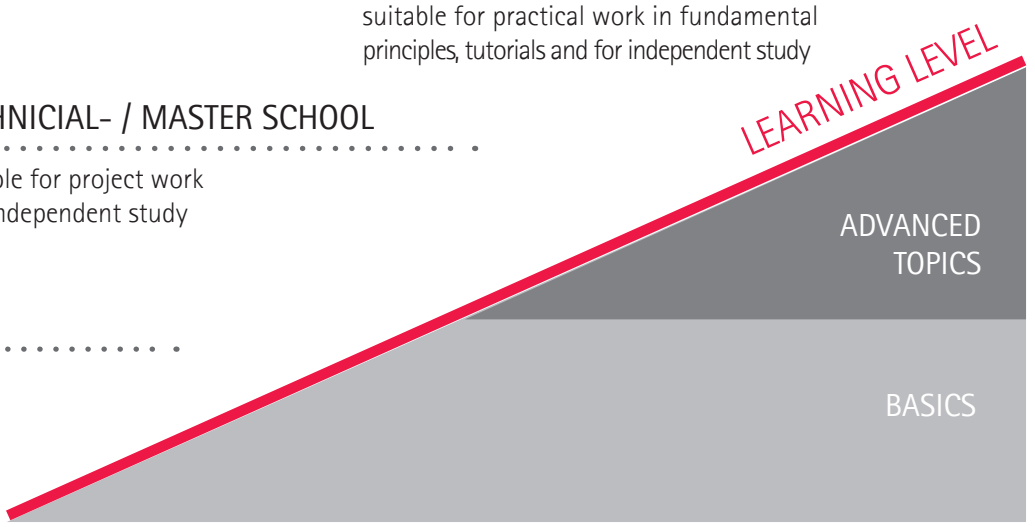
suitable for practical work in fundamental principles, tutorials and for independent study

TECHNICIAL- / MASTER SCHOOL

suitable for project work and independent study

VOCATIONAL SCHOOLS

suitable for demonstration and practical teaching



ELECTRONICS TECHNICIAN AERONAUTICAL SYSTEMS

		7001101	7001201	7001301	7001401	7001701	7001801	7003101	7003601	70039	7007101	7007201	7007401	7007501	7376001	7008201	7008301
Topics:	Analyse electrical systems and check functions	x	x	x	x												
	Analyse and adjust controls					x	x										
	Take systems and devices in aircraft in operation					x	x	x	x	x				x			
	Install and maintain information and communication systems of aircraft										x	x	x		x		
	Check and adjust automated systems in aircraft															x	x

INFORMATION ELECTRONICS TECHNICIAN

		7001101	7001201	7001301	7001401	7001501	7001601	7001701	7001801	7003601	70039	7007101	7007301	7007401	7008101	735801
Topics:	Install equipment, plant and systems of information technology	x	x	x	x											
	Capture and represent signal processing operations in information technology equipment							x	x			x	x	x	x	
	Analyse the function of selected assemblies and components of information technology equipment					x	x	x	x							
	Configure and optimize a single-user computer in line with order									x	x					
	Analyse errors on devices and systems for video, audio and data technology												x	x		
	Set up and use services and multimedia components as needed													x		x

ELECTRONICS TECHNICIAN FOR MACHINE AND DRIVE TECHNOLOGY

		7001101	7001201	7001301	7001401	7001701	7001801	7002401	7002501	7003101	7003501	7008201	7008301
Topics:	Analyse electrical systems and check functions	x	x	x	x								
	Analyse and adjust controls					x	x						
	Ensure electricity supply and safety of equipment			x	x			x					
	Analyse performance of electrical machines								x				
	Select and adjust controls and regulations for electrical machines								x	x			
	Integrate electrical machinery in technical systems								x		x	x	x

ELECTRONICS SYSTEM TECHNICIAN

		7001101	7001201	7001301	7001401	7001501	7001601	7001701	7001801	7003101	7003601	70039	7003501	7008201
Topics:	Analyse electrical systems and check functions	x	x	x	x									
	Analyse and adjust controls							x	x					
	Design, manufacture and test electronic assemblies of equipment					x	x							
	Configure assemblies of hardware and software										x	x		x
	Produce equipment and check												x	
	Set up production facilities									x	x	x	x	
	Configuring and using test systems									x	x	x		

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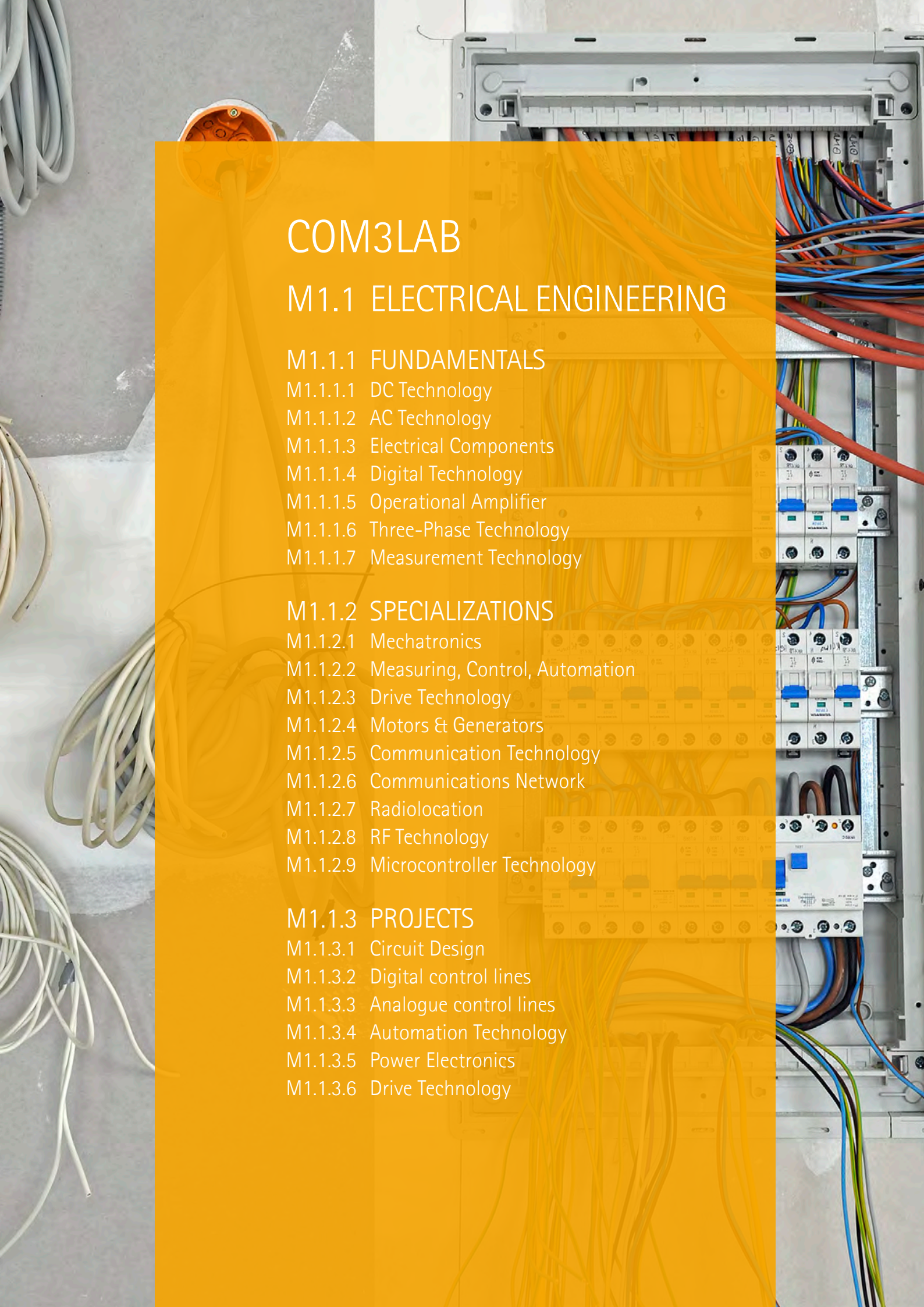


COM3LAB

M1.1 ELECTRICAL ENGINEERING

M1.1.1 FUNDAMENTALS

M1.1.1.1 DC Technology
M1.1.1.2 AC Technology
M1.1.1.3 Electrical Components
M1.1.1.4 Digital Technology
M1.1.1.5 Operational Amplifier
M1.1.1.6 Three-Phase Technology
M1.1.1.7 Measurement Technology

M1.1.2 SPECIALIZATIONS

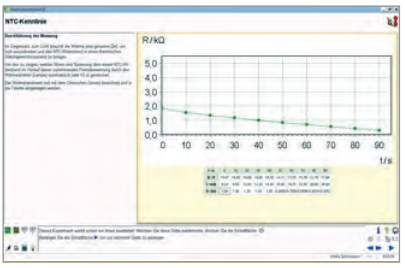
M1.1.2.1 Mechatronics
M1.1.2.2 Measuring, Control, Automation
M1.1.2.3 Drive Technology
M1.1.2.4 Motors & Generators
M1.1.2.5 Communication Technology
M1.1.2.6 Communications Network
M1.1.2.7 Radiolocation
M1.1.2.8 RF Technology
M1.1.2.9 Microcontroller Technology

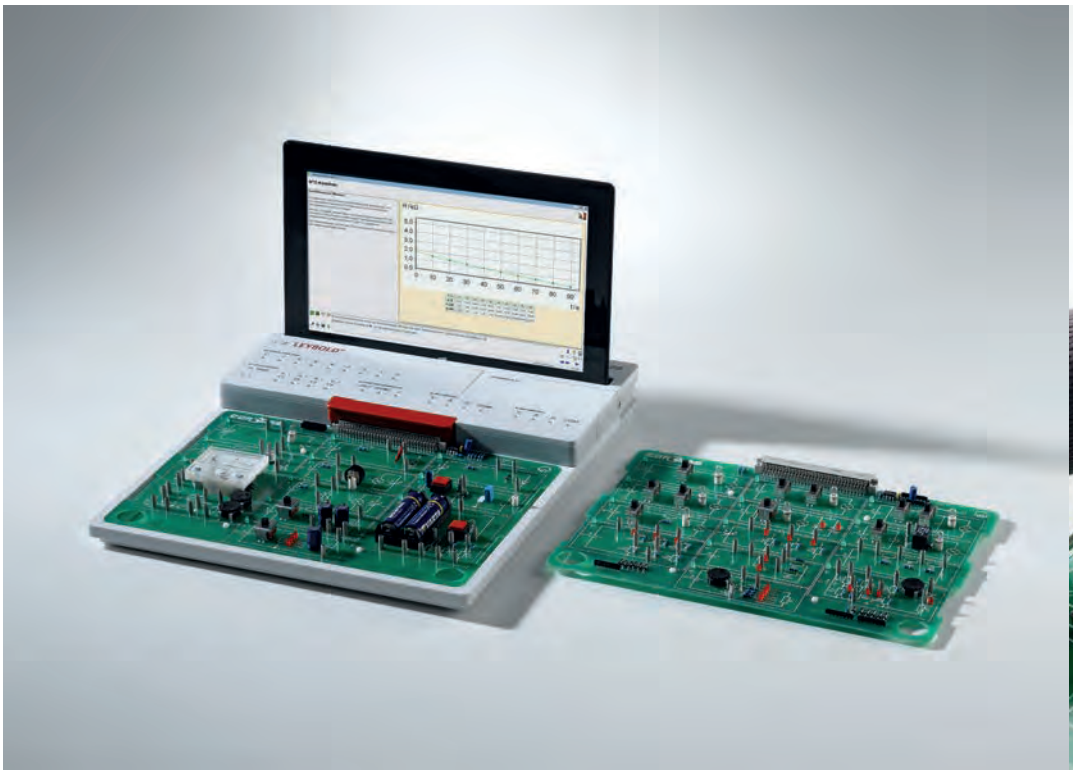
M1.1.3 PROJECTS

M1.1.3.1 Circuit Design
M1.1.3.2 Digital control lines
M1.1.3.3 Analogue control lines
M1.1.3.4 Automation Technology
M1.1.3.5 Power Electronics
M1.1.3.6 Drive Technology

M1.1.1
FUNDAMENTALS

M1.1.1.1
DC Technology





DC Technology (M1.1.1.1)

Cat. No.	Description	M1.1.1.1
700 1101	COM3LAB course: DC technology I	1
700 1201	COM3LAB course: DC technology II	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	1

The courses DC Technology I + II are the beginner courses in electrical engineering. Step by step, the fundamental terms and laws of electrical engineering are explained and developed with experiments and animations.

Learning objectives

- Layout and impact of the basic circuits
- Learning the basic laws of electrical engineering
- Recording characteristic curves of passive components

DC Technology I begins with the explanation of an electric circuit. Using theoretical and practical examples, the functionality of different basic circuits is dealt with.

DC Technology II deals with the mode of operation of passive components. With the automatic recording of characteristic curves, the behaviour of the components becomes clear very quickly.

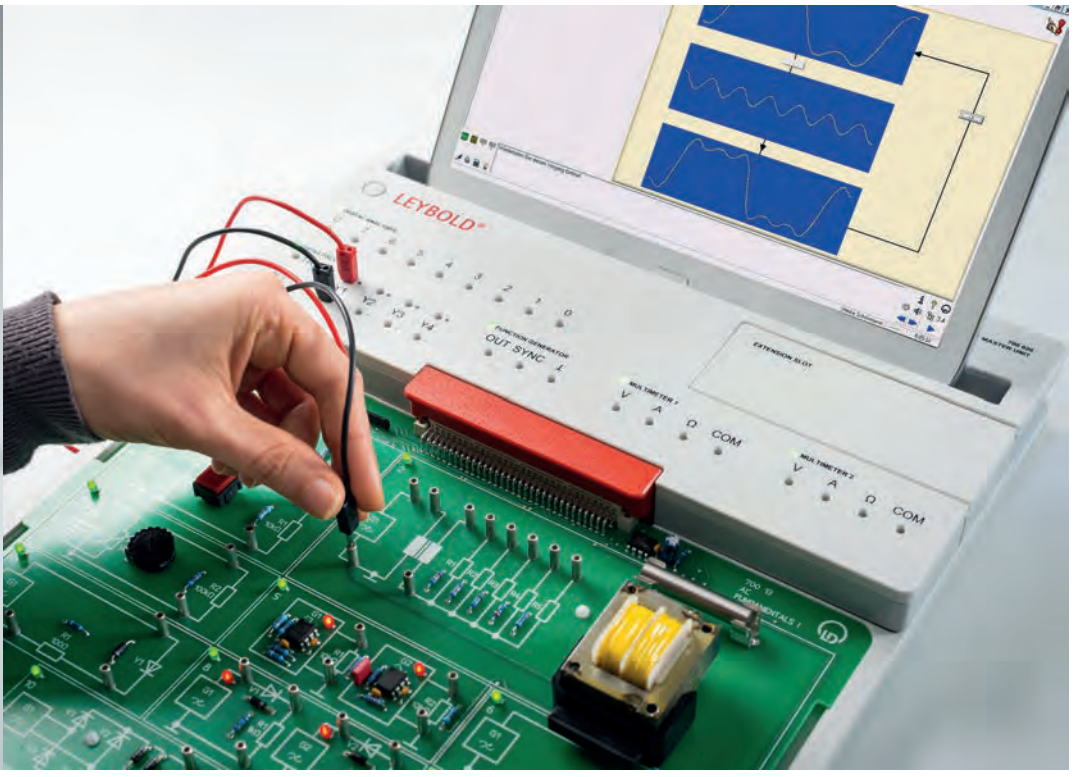
Topics*

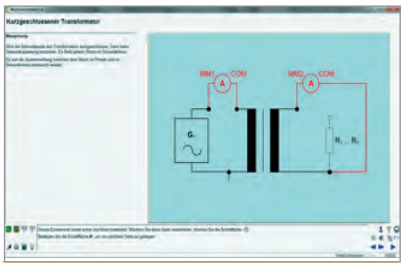
- Basic circuits
- Basic laws
- Voltage dividers
- Wheatstone bridge
- Characteristic (incandescent lamp, VDR, Diode, NTC, etc.)
- Capacitor
- Inductance
- Batteries

* you will receive further information on the course topics in the product section!

M1.1.1
FUNDAMENTALS

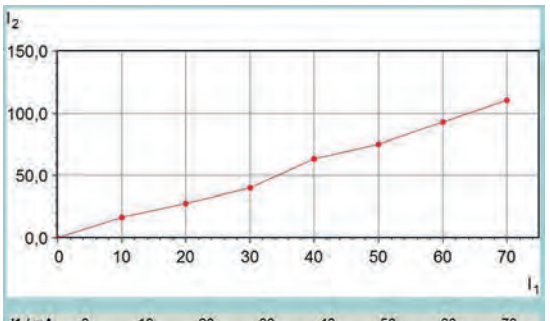
M1.1.1.2
AC Technology





AC Technology (M1.1.1.2)

Cat. No.	Description	M1.1.1.2
700 1301	COM3LAB course: AC technology I	1
700 1401	COM3LAB course: AC technology II	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	



I1 / mA	0	10	20	30	40	50	60	70
I2 / mA	0	16,40	28,00	39,80	63,40	75,10	92,80	110,50
= I_1 / I_2	-	0,6098	0,7143	0,7538	0,6309	0,6658	0,6466	0,6335

Current transformation for the short-circuited transformer

Both courses AC technology I + II deal with the function of alternating currents and voltages.

Learning objectives

- Using function generator and oscilloscope
- Principle and function of a transformer
- Key parameters and fundamentals of the AC circuits

AC I deals with e.g. the generation of an AC voltage or the function of a transformer.

AC II deals with the behaviour of passive components in different circuits. Coil, capacitor and resistor are analysed and evaluated in different circuits.

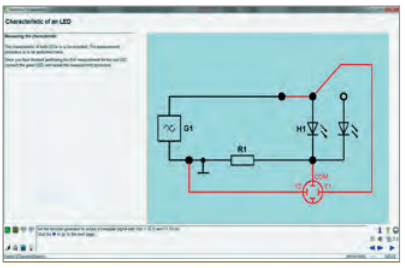
Topics*

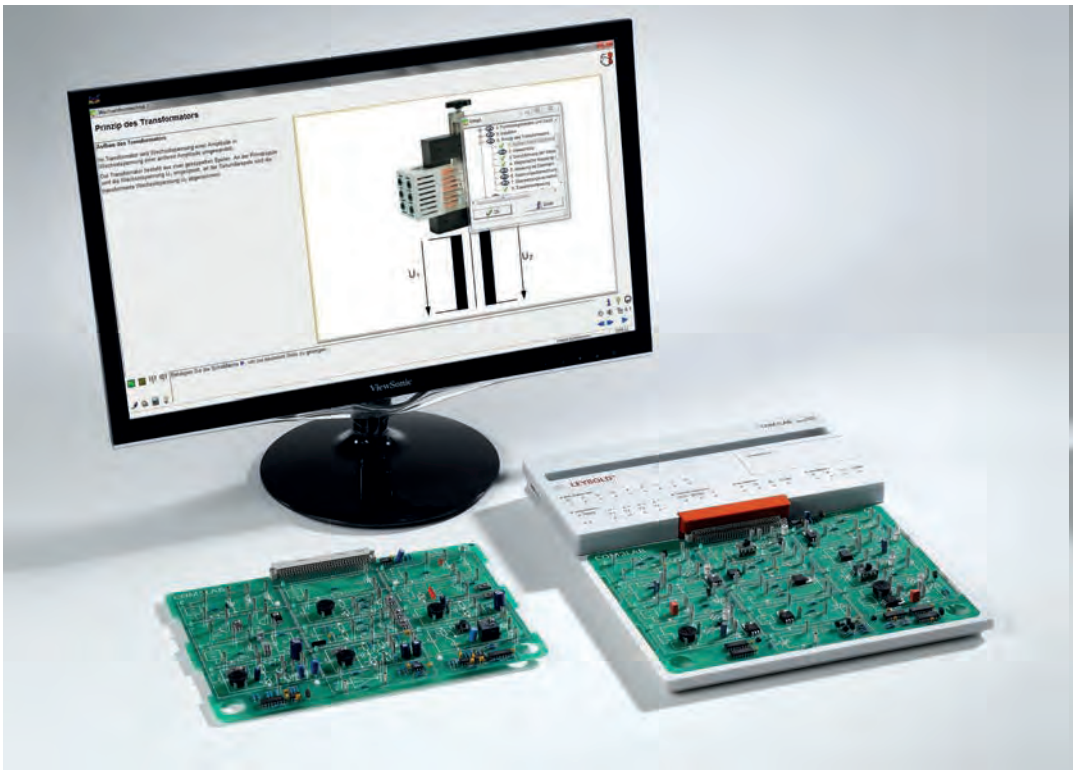
- Step voltage
- Continuous AC voltage
- Electronic generation of AC voltage
- Function generator and oscilloscope
- Induction
- Transformer
- Rectifier
- AC circuit (key parameters, resistor, coil)
- Series circuit (R/L, R/C, R/L/C)
- Parallel circuit (R/L, R/C, R/L/C)
- Capacitor
- Compensation
- Resonance

* you will receive further information on the course topics in the product section!

M1.1.1
FUNDAMENTALS

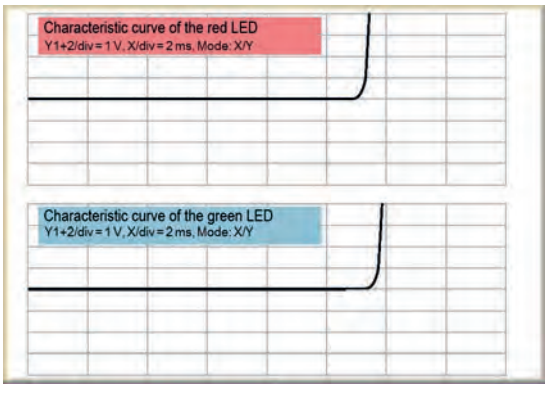
M1.1.1.3
Electrical Components





Electrical Components (M1.1.1.3)

Cat. No.	Description	M1.1.1.3
700 1501	COM3LAB Course: Electronic components I	1
700 1601	COM3LAB Course: Electronic components II	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	



Characteristic curve of an LED

A wide range of components are required for electrical and electronic circuits. The courses Electronic Components I+ II focus on active components, which act intensively or enable control.

Learning objectives

- Structure, function and use of active components
- Recording the characteristics
- Standard circuits and their areas of use

In the course Electronic Components I the most important diode types are introduced. Outlet and blockage characteristics are recorded and evaluated with the two-channel memory oscilloscope. The npn and pnp transistor is examined in its functions, circuits and characteristics.

In the course Electronic Components II special transistor types and semiconductors in power electronics are used. One of their main uses, the phase controlled modulator, is examined using the example of the thyristor and the triac.

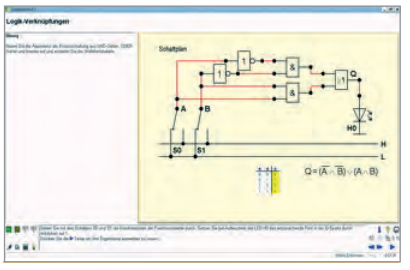
Topics*

- Characteristics (Z-diode, LED)
- Transistor: structure, function, effect
- Transistor circuits: emitter, collector, basic, Darlington
- structure, function, effect, Characteristics:
  Field effect transistor
  MOSFET
  IGBT
  DIAC
  TRIAC

* you will receive further information on the course topics in the product section!

M1.1.1
FUNDAMENTALS

M1.1.1.4
Digital Technology



Digital Technology (M1.1.1.4)

Cat. No.	Description	M1.1.1.4
700 1701	COM3LAB course: Digital technology I	1
700 1801	COM3LAB course: Digital technology II	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

The COM3LAB courses Digital Technology I + II form the foundation for the courses Microcontroller and Telecommunications.

Learning objectives

- Structure, function and effect of the individual logic elements
- Learning important laws of propositional logic
- Use of the TTL components in application circuits

In the course Digital technology I the bases and laws of switch algebra are dealt with using logic links.

In the course Digital Technology I various flip-flop applications, e.g. shift registers, parallel-serial converters or the serial data transmission are dealt with. Both courses deal extensively with troubleshooting.

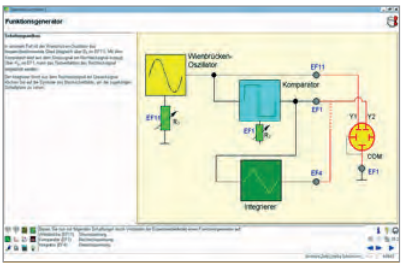
Topics*

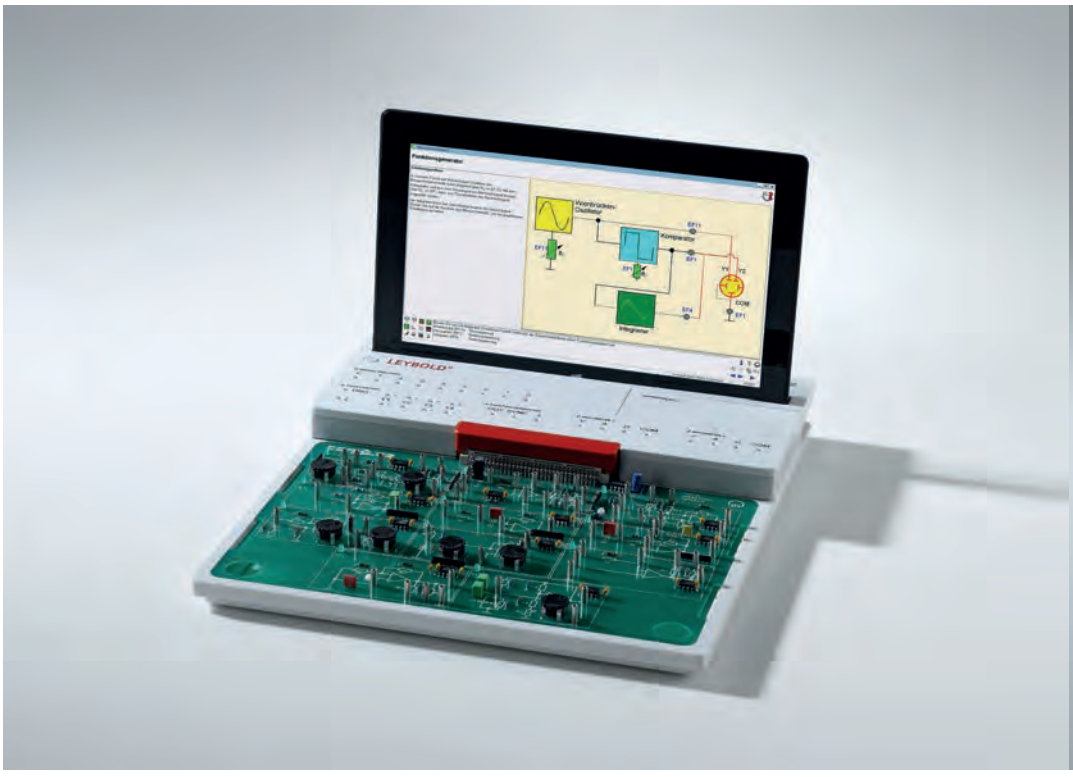
- TTL components (AND, OR, XOR)
- Link of binary inputs
- Basic laws
- Coding
- 7-segment display
- Karnaugh map
- Full-adders
- Multiplexers
- Flip-flop (RS, JK, D)
- Binary mat
- Forward and reverse counter
- BCD counter
- Synchronous counter
- Shift register
- Parallel-serial converter

* you will receive further information on the course topics in the product section!

M1.1.1
FUNDAMENTALS

M1.1.1.5
Operational Amplifier





Operational Amplifier (M1.1.1.5)

Cat. No.	Description	M1.1.1.5
700 8101	COM3LAB Course: Operational amplifier	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

This course gives you insight into the world of the operational amplifier. From the standard circuit to the implementation of a function generator, all important topic areas are dealt with. This course forms the basis for the courses of control technology.

Learning objectives

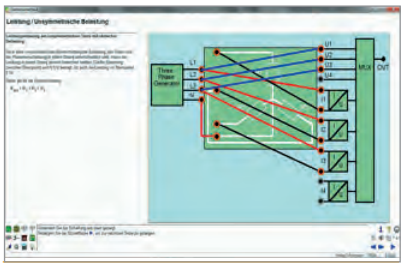
- Features and function of operational amplifier
- Use and application of operational amplifier

Topics

- Comparator
- Features of the operational amplifier
- Inverting operational amplifier
- Noninverting operational amplifier
- Fault simulation in the inverting operational amplifier
- Adder
- Integrator
- Differentiator
- Active filters
- Constant voltage source
- Constant current source
- Schmitt trigger
- Astable multivibrator
- Wien bridge oscillator
- Function generator

M1.1.1
FUNDAMENTALS

M1.1.1.6
Three-Phase Technology



Three-Phase Technology (M1.1.1.6)

Cat. No.	Description	M1.1.1.6
700 2401	COM3LAB course: Three-Phase technology	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

The COM3LAB course "Three-phase technology" deals with the bases and key parameters of three-phase current. A three-phase generator enables practical experimentation. The differences between a star and a delta circuit are analysed in various tests. Currents, voltages and outputs are measured with symmetrical and unsymmetrical load. An oscilloscope with 8 channels enables phase and line voltages / currents to be shown at the same time.

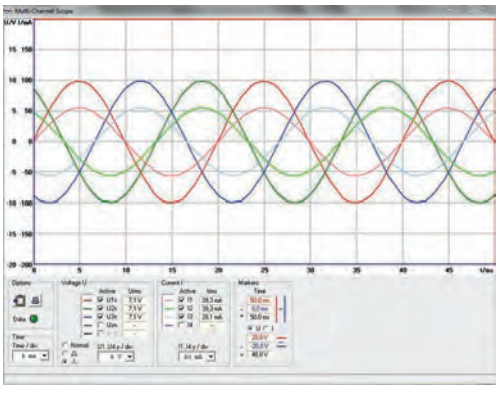
Learning objectives

- Using three-phase current

Topics*

- Key parameters of three-phase technology
- Star and triangular symmetrical load
- Star and triangular unsymmetrical load
- Power measurement
- Compensation of the phase shift
- Connection of a three-phase motor
- Rotary field measuring instrument

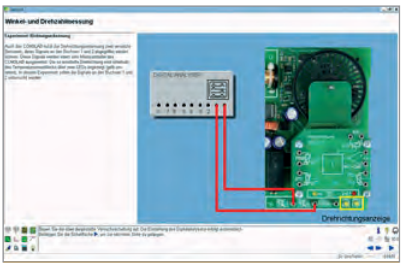
* you will receive further information on the course topics in the product section!

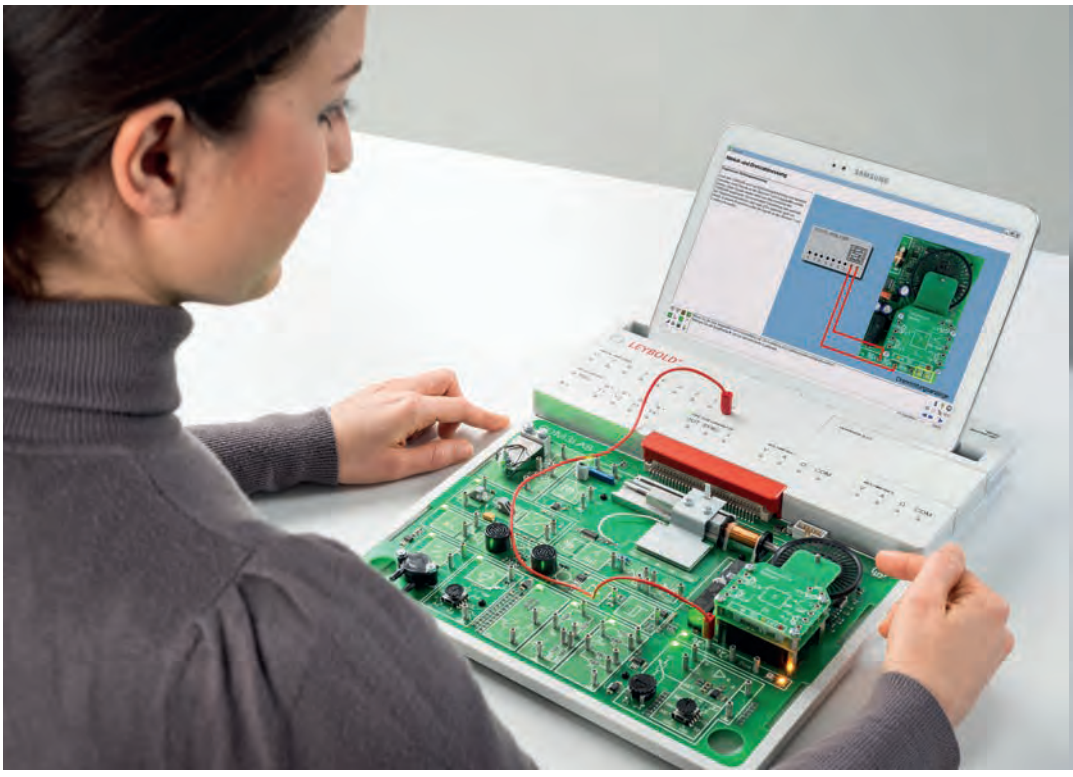


Power measurement at the unsymmetrical star with resistive load

M1.1.1
FUNDAMENTALS

M1.1.1.7
Measurement Technology





Measurement Technology (M1.1.1.7)

Cat. No.	Description	M1.1.1.7
700 8401	COM3LAB Course: Sensor technology	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

The COM3LAB course "Sensor Technology" teaches the basics of measuring non-electric quantities. With many examples, explanations, exercises and practical tasks, the principles and the function of the sensors and the associated measuring circuits are clearly illustrated.

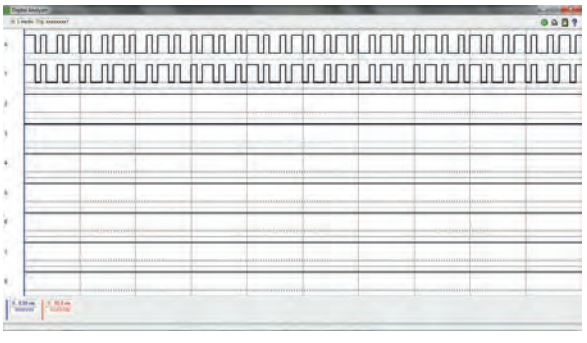
Learning objectives

- Measuring non-electric quantities
- Function of the sensors

Topics*

- Measuring circuits for measuring temperature
- Effect and characteristics of different temperature sensors: Pt 100, NTC, KTY and thermocouple
- Effect and characteristics of pressure sensors
- Force measurement with strain gauges
- Force measurement with bending bar and torsion bar
- Displacement-, angle- and speed measurement
- Resolver measurements
- Hall sensors
- Ultrasound

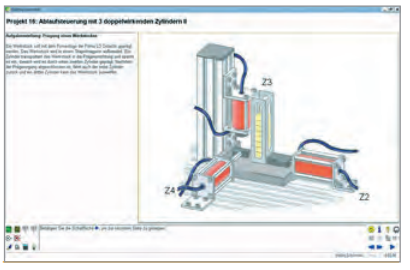
* you will receive further information on the course topics in the product section!



Speed measurement

M1.1.2
SPECIALIZATIONS

M1.1.2.1
Mechatronics



Mechatronics (M1.1.2.1)

Cat. No.	Description	M1.1.2.1
700 3501	COM3LAB Course: Electropneumatics	1
700 351	COM3LAB Course: Pneumatics Board	1
700 3101	COM3LAB Course: Automation and bus technology	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
744 902	Compressor Connection Hosing	1*
744 600	Low Noise Compressor	1*
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

* additionally required

In the field of mechatronics signals and information are automatically detected, processed and transformed into force and movement. Everyday life today would be unimaginable without mechatronic products and they are found e.g. in cars, DVD players, air planes etc. The COM3LAB courses Electropneumatics and Automation technology together provide an extensive training package, which covers both the electrical and mechanical topics.

Learning objectives

- Learning physical basic principles
- Independent formulation of development projects
- Planning, repair and execution of complete process cycles

The COM3LAB course Electropneumatics teaches the basics of electro-pneumatics using the BIBB standard tasks. The COM3LAB course Automation technology explains the function and application of a PLC. Several examples make it easy to learn the PLC computer language.

Both courses can be combined so that complete process cycles can be executed and documented. This kind of project work supports independent and creative handling.

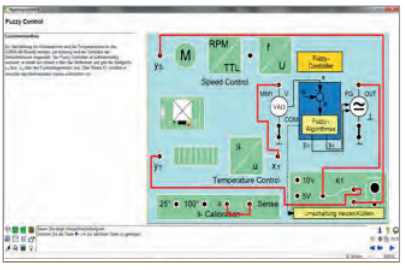
Topics*

- Function and use of electronic and pneumatic components
- Electronic and pneumatic schematics
- Various standard circuits
- Function and use of a PLC
- Programming
- Bus systems

* you will receive further information on the course topics in the product section!

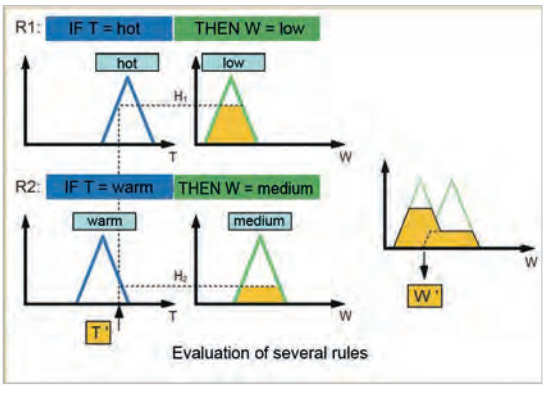
M1.1.2
SPECIALIZATIONS

M1.1.2.2
Measuring, Control, Automation



Measuring, Control, Automation (M1.1.2.2)

Cat. No.	Description	M1.1.2.2
700 8101	COM3LAB Course: Operational amplifier	1
700 8201	COM3LAB course: Control technology I	1
700 83	COM3LAB course: Control technology II	1
700 8401	COM3LAB Course: Sensor technology	1
700 3101	COM3LAB Course: Automation and bus technology	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	



FUZZY control

Measure, Actuate and Control (MSR) are terms from the field of automation. The objective is to monitor and run technical processes and production procedures through automatic control systems. Fast-spreading automation today requires profound knowledge of sensors and how to use control loops in many qualified occupations.

The MSR COM3LAB courses take this development into account. They teach applied knowledge of the measurement, actuation and control technology vividly and in detail.

Learning objectives

- Measuring non-electric quantities
- Good knowledge in the topics of operational amplifiers and sensor technology
- Good understanding of electronic control loops
- Programming and planning of a PLC

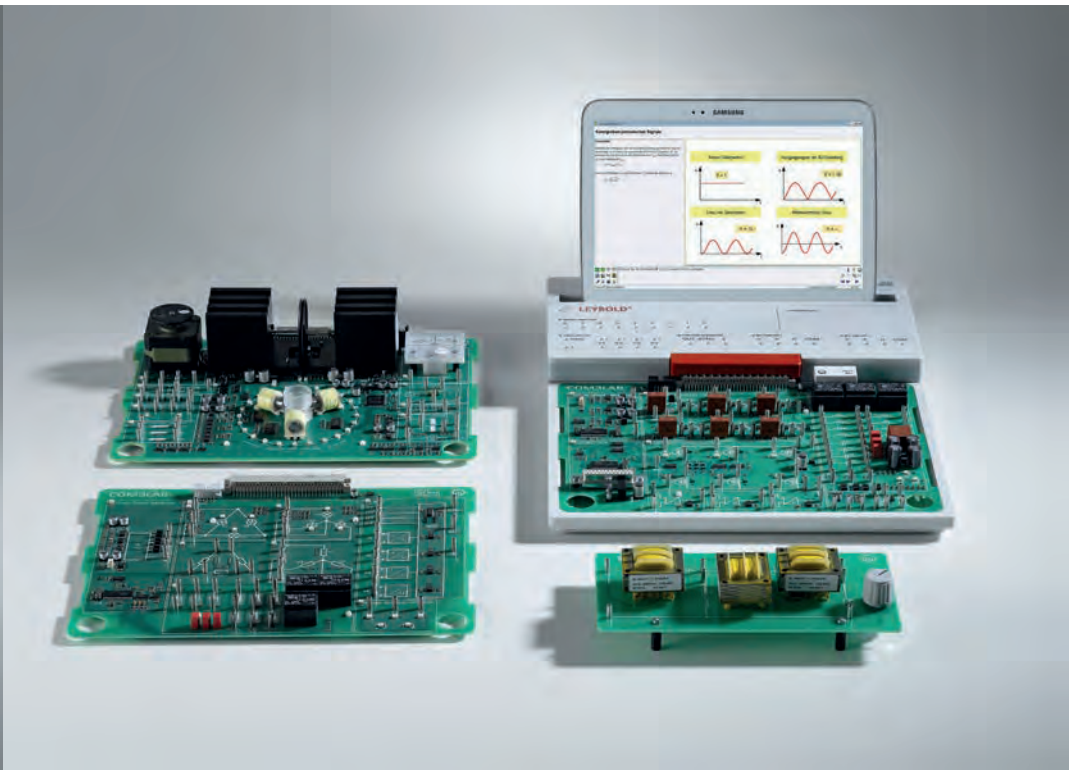
Topics*

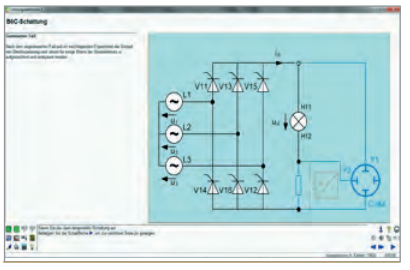
- Operational amplifier
- Control technology
- Sensor technology
- Automation technology

* you will receive further information on the course topics in the product section!

M1.1.2
SPECIALIZATIONS

M1.1.2.3
Drive Technology





Drive Technology (M1.1.2.3)

Cat. No.	Description	M1.1.2.3
700 2101	COM3LAB course: Power electronics I	1
700 22	COM3LAB course: Power electronics II	1
700 2401	COM3LAB course: Three-phase technology	1
700 2501	COM3LAB course: Electrical machines I	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

The drive technology is an application which focuses on modern power electronics. Using power electronics, speed-variable DC and three-phase four-quadrant drives can be easily implemented. Nowadays drive technology would not be imaginable without thyristor speed control units, soft-start circuits, frequency converters, servo drives etc. in industry, trade, commercial companies and households.

With the COM3LAB courses on power electronics and drive technology, the specialist knowledge can be gained graphically, both theoretically and practically.

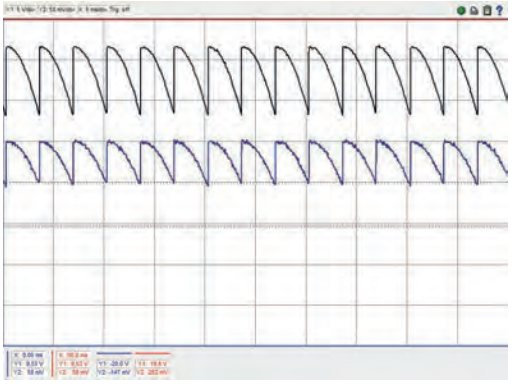
Learning objectives

- Recognizing physical basic principles
- Structure of important base circuits
- Recording machine characteristics
- Introduction to drive technology

Topics*

- Three-phase current
- Characteristics and use of power semiconductors
- Features of commutator - / three-phase machines and stepper motors
- Recording of characteristics of the most important machines

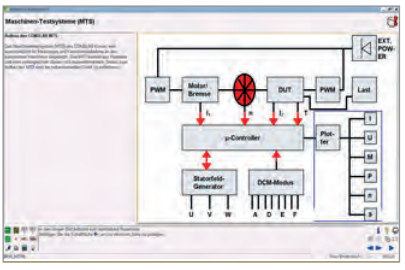
* you will receive further information on the course topics in the product section!

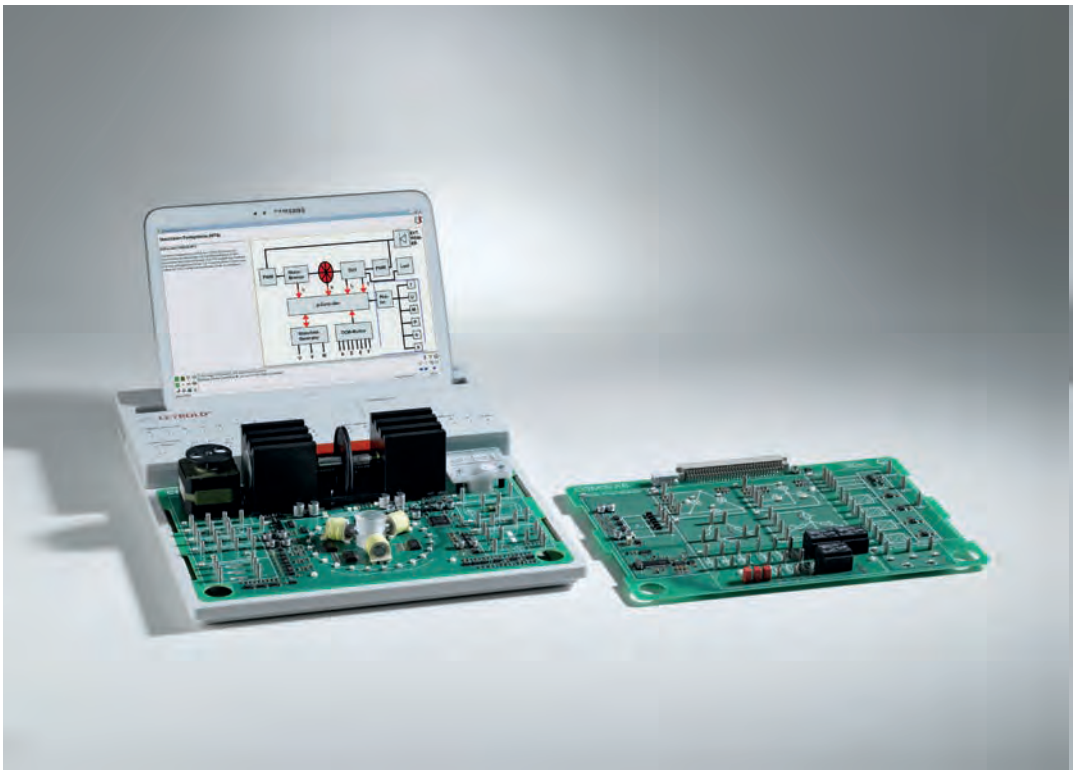


B6C - circuit: Controlled case

M1.1.2
SPECIALIZATIONS

M1.1.2.4
Motors and Generators





Motors and Generators (M1.1.2.4)

Cat. No.	Description	M1.1.2.4
700 2401	COM3LAB course: Three-phase technology	1
700 2501	COM3LAB course: Electrical machines I	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

The COM3LAB courses Electrical machines and Three-phase technology lead you through the fascinating world of electrical motors and generators.

Learning objectives

- Recognizing physical basic principles
- Recording of machine characteristics
- Introduction to drive technology

With the COM3LAB course Three-phase technology the special features of multiphase networks are discussed. It forms the basis for understanding rotary field machines like asynchronous and synchronous machines.

Topics*

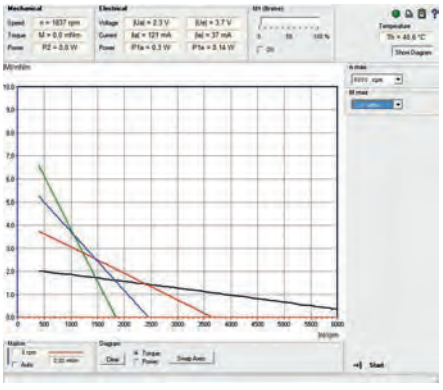
- Key parameters of the three-phase current
- Base circuits
- Applications

In the COM3LAB course Electrical machines the features of commutator machines, rotary field machines and stepper motors are developed in demanding experiments. Among other things, the course board contains a complete machine test system with which the characteristics of the most important machines are examined.

Topics*

- Machine test system
- DC machines
- Synchronous machines
- Asynchronous machines
- Recording of characteristics
- Speed adjustment

* you will receive further information on the course topics in the product section!



Characteristic curve of a separately excited DC machine

M1.1.2
SPECIALIZATIONS

M1.1.2.5
Communication Technology

Communication Technology (M1.1.2.5)

Cat. No.	Description	M1.1.2.5
700 7101	COM3LAB Course: Transmission Technology TX433	1
700 7201	COM3LAB Course: Reception Technology RX433	1
700 7301	COM3LAB Course: Digital Communication Technology	1
700 7401	COM3LAB Course: Modem Technology	1
700 7501	COM3LAB Course: Telecommunication Lines	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

The electrical communications technology mainly deals with information transmission using signals. Without communications technology there would be no internet and no mobile phones today. The communications technology occupations deal with the fields of high frequency technology, transmission technology and wiring technology.

The COM3LAB courses of communications technology teach the knowledge clearly and application-oriented using modulation, the various transmission methods, coding, line links, services, logs etc.

Learning objectives

- Learning physical basic principles
- Knowledge of various transmission methods
- Independent application and planning of transmission media

Topics*

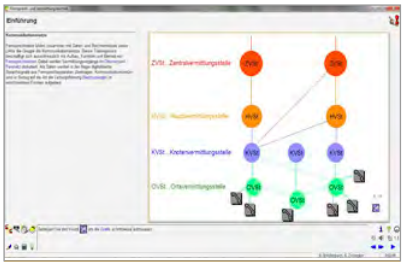
- Conception and the operating characteristics of modern data – and radio stations
- Applications of PCM Codecs in the voice – and signal transmission
- Classic shift keying also QPSK and the procedures MSK and GSMK used in the area of mobile radio
- Fault response of shift keying
- Function and use of two- / four-wire lines, coaxial cables, fibre optic lines etc.

* you will receive further information on the course topics in the product section!

M1.1.2

SPECIALIZATIONS

M1.1.2.6
Communications Networks



Communications Networks (M1.1.2.6)

Cat. No.	Description	M1.1.2.6
700 7401	COM3LAB Course: Modem Technology	1
700 7501	COM3LAB Course: Telecommunication Lines	1
735 800	COM3LAB Course: Foundations of Local & Trunk Exchange Systems	1

Communication networks describe the infrastructure for transmitting information in communications technology. For this reason, communication systems establish communication links between several terminals.

With the COM3LAB courses Communication networks the communication systems can be reproduced, projected and analysed.

Learning objectives

- Learning physical basic principles
- Knowledge of various transmission methods
- Independent application and projecting of transmission media
- Independent projecting and analysis of communications systems

Topics*

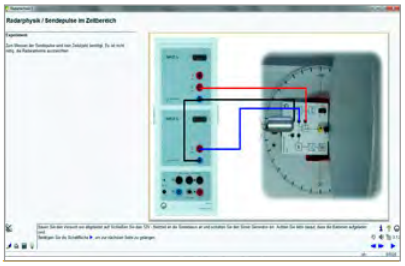
- Classic keying methods also QPSK and the procedures MSK and GSMK used in the area of mobile radio
- Fault response of shift keying
- Function and use of two- / four-wire lines, coaxial cables, fibre optic lines etc.
- Telecommunications – and switching technology in the local and long-distance network
- Voice signal coding

* you will receive further information on the course topics in the product section!

M1.1.2

SPECIALIZATIONS

M1.1.2.7
Radiolocation



Radiolocation (M1.1.2.7)

Cat. No.	Description	M1.1.2.7
737 60	COM3LAB Course: Radar Technology I	1
737 65	COM3LAB Course: Radar Technology II	1

The radar technology is a radio location procedure which identifies co-operative and noncooperative targets with echo procedures. Equipped with unique capabilities, such as independence on weather – and daylight, wide range, high measuring insensitivity etc., it is now hard to imagine the world without radar technology in military and civil applications.

The COM3LAB Radar technology courses take these high demands into account. They enable realistic experiments on radar technology in the laboratory.

Learning objectives

- Learning physical basic principles
- Function and structure of a radar
- Evaluation of a radar

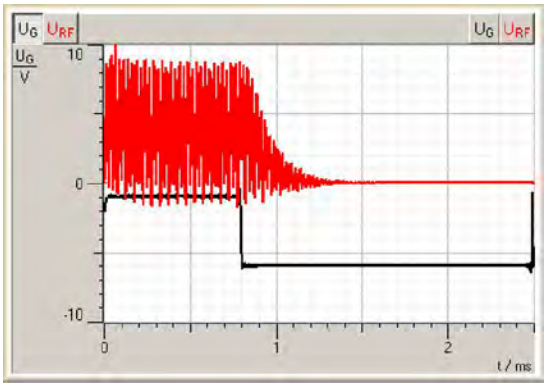
The COM3LAB course Radar technology I works with a monostatic ultrasonic radar.

The COM3LAB course Radar technology II works with an X-band microwave source. It examines the principles and applications of the Doppler effect by measurements in the time and frequency domain (FFT analysis of the Doppler spectrum in the base tape).

Topics*

- Distance measurement
- Echo representation
- Delay measurements
- Radar cross sections
- Tracking
- Target suppression
- Representation of mobile targets
- Detection of noncooperative / cooperative targets and stealth

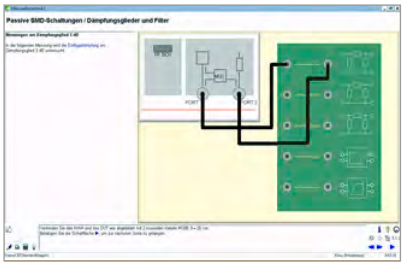
* you will receive further information on the course topics in the product section!

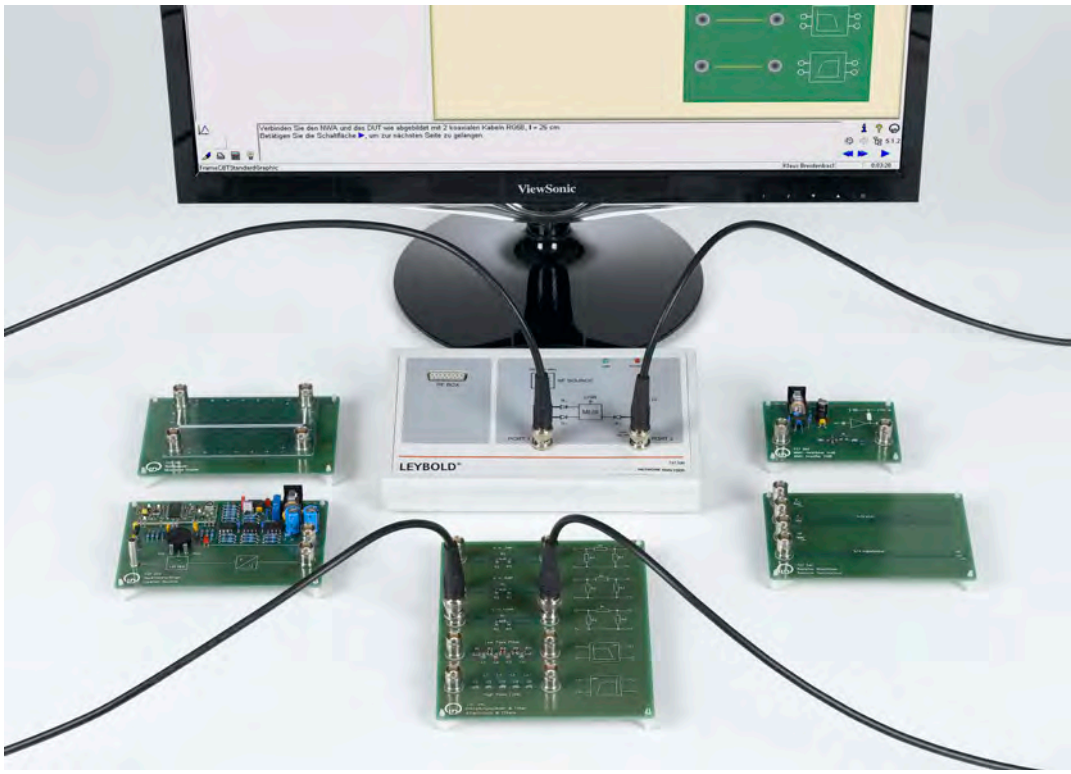


Radar physics / transmitted pulses in the time domain

M1.1.2
SPECIALIZATIONS

M1.1.2.8
RF technology





RF technology (M1.1.2.8)

Cat. No.	Description	M1.1.2.8
737 51	COM3LAB Course: Microwave Technology I	1
737 52	COM3LAB Course: Microwave Technology II	1
737 60	COM3LAB Course: Radar Technology I	1
737 65	COM3LAB Course: Radar Technology II	1

Global communication and mass transport on the street or in the air require efficient RF systems. Mobile radio networks, satellite communication, traffic control, air traffic safety, navigation services, GPS, etc. are applications which critically depend on the fault-free operation of their RF components.

The COM3LAB courses Microwave technology and Radar technology teach application-oriented knowledge on RF technology clearly and in detail.

Learning objectives

- Learning physical basic principles
- Independent use of network analysers, Smith chart and Bode plot
- Independent analysis of microwave circuits
- Knowledge of the transmission methods
- Function and structure of a radar
- Evaluation of a radar screen

The COM3LAB Microwave technology courses work with a vector network analyser and have integrated evaluation functions. the evaluations are shown in a Smith diagram and Bode plot.

Topics*

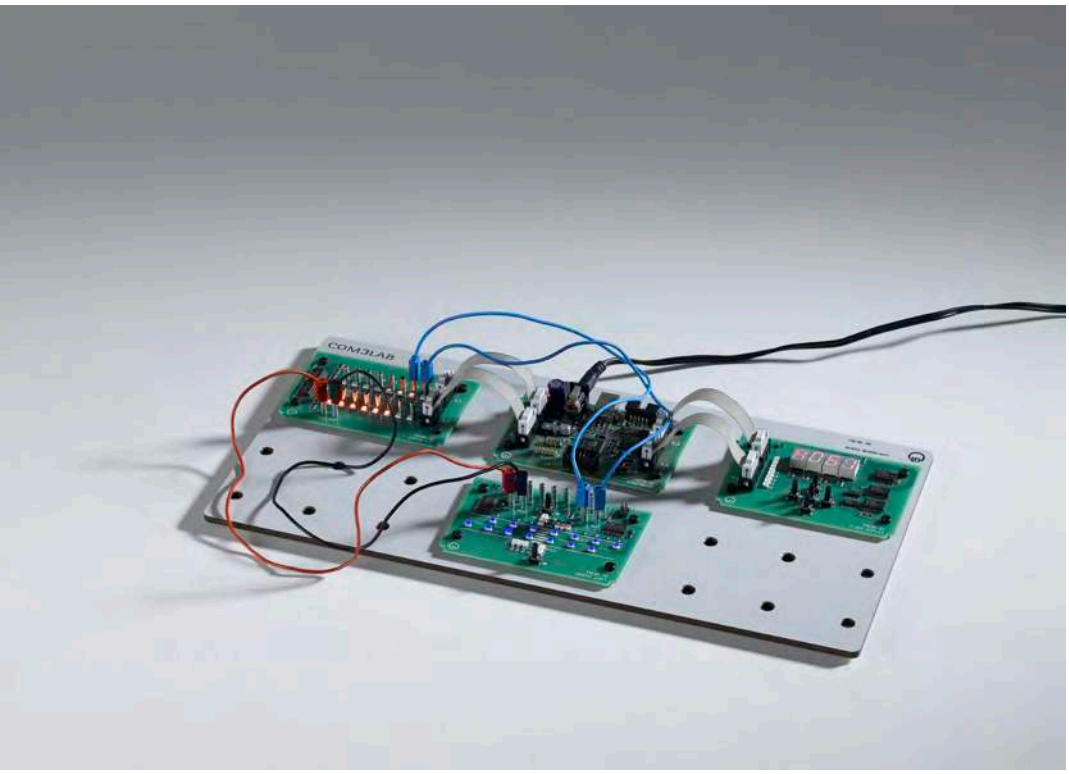
- Vector network analysis
- Measurements on the measuring line
- Passive UHF circuits in microstrip loop and SMD technology
- Active microwave components

The COM3LAB Radar technology courses examine the function and applications of modern primary and secondary radars experimentally. From the civil air traffic safety and the air surveillance with friend / foe recognition (IFF) to the coast radar and the security services, all topics are dealt with through of interesting tests.

Topics*

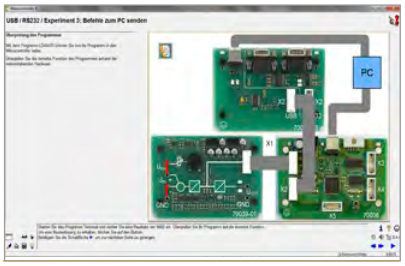
- Physical principles of radar technology
- Technical implementation of radar systems
- Tactical tests with radars.

* you will receive further information on the course topics in the product section!



M1.1.2
SPECIALIZATIONS

M1.1.2.9
Microcontroller technology



Cat. No.	Description	M1.1.2.9
700 36	COM3LAB course: Microcontroller I	1
700 39	COM3LAB course: Microcontroller II	1

Extraction from a programmer example

The COM3LAB courses Microcontroller I and II teach the programming of the microcontroller AT90CAN128 of the company Atmel in Assembler and C clearly.

Learning objectives

- Creation of a project
- Structure of a program (Assembler / C)
- Compiling
- Application-related programming

The COM3LAB course Microcontroller I deals with structure, function, commissioning and programming of the microcontroller AT90CAN128 of the company Atmel. The course teaches the programming in Assembler and in C.

The COM3LAB course Microcontroller II deepens the programming knowledge of the programming language C. The application boards Graphic LCD, Analog I/O, USB / RS232 and Project provide the user with diverse opportunities for application-oriented programming.

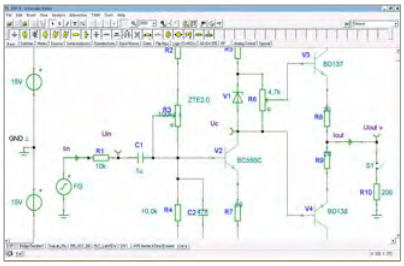
Topics*

- Basic principles (CPU, RAM, ROM, Timer, Inputs / Outputs, Interrupt etc.)
- Programming (Programming languages, software, initialization, debugger)
- AT90CAN128
- Assembler / C
- Output of a Delta voltage
- Input/Output of analog voltages
- Tests Graphic LCD
- Data transmission via USB/RS232

* you will receive further information on the course topics in the product section!

M1.1.3
PROJECTS

M1.1.3.1
Circuit Design



Circuit Design (M1.1.3.1)

Cat. No.	Description	M1.1.3.1
700 905	COM3LAB TT: AMPLIFIER CIRCUITS	1
700 908	COM3LAB TT: POWER SUPPLY CIRCUITS	1
700 9101	COM3LAB Protoboard II	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
700 901-01	Electina Standard, COM3LAB support (1 license), german	
700 901-11	Electina Design Suite, PCB, COM3LAB support (1 license), german	
700 902-01	Electina Standard, COM3LAB support (1 license), English	1
700 902-11	Electina Design Suite, PCB, COM3LAB Support (1 licence), English	
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	1

The COM3LAB Protoboard and Electina form the ideal means for carrying out project work. Schoolchildren and students receive a task and must solve it from A to Z as in their later professional life. This is a good opportunity for checking how schoolchildren implement their knowledge and where certain skills are still lacking.

The project work encourages the schoolchildren's motivation. They learn how to deal with a problem independently and solve it successfully.

Learning objectives

- Independent development of a project
- Circuit design
- Analysis
- Troubleshooting
- Circuit design
- Boosting of personal decision-making and responsibility

The subject-specific modules Amplifier circuits and power supply circuits are complete projects, which the students can either work on independently or on instruction. The subject-specific modules contain all required electronic components.

Amplifier circuits

- Single-stage amplifier using an emitter-base circuit
- Bootstrap circuit
- Darlington circuits
- Two-stage, capacitively coupled amplifier
- Two-stage, directly coupled amplifier
- Amplifier with negative feedback
- Differential amplifier
- Push-pull output stage
- Barrier junction-FET in various base circuits

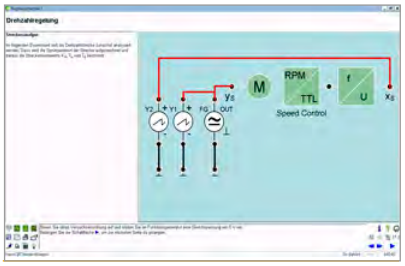
Power supply circuits

- Voltage regulation with Z diode
- Voltage regulation with Z diode and parallel transistor
- Voltage regulation with Z diode and series transistor
- Power supply with adjustable voltage and adjustable current limiting

M1.1.3

PROJECTS

M1.1.3.2
Digital control lines



Digital control lines (M1.1.3.2)

Cat. No.	Description	M1.1.3.2
700 8201	COM3LAB course: Control technology I	1
700 83	COM3LAB course: Control technology II	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
500 851	Safety connecting leads, 32 A, set of 32	1
501 511	Set of 10 bridging plugs, black	1
568 221	LIT: Fundamentals of Automatic Control Technology II, Vol. 2	1
726 09	Panel frame T130, two-level	1
726 86	Stabilised power supply ±15 V/3 A	1
734 111	Set of machines 10 W	1
734 121	Digital Temperature Controlled System	1
734 265	Digital Liquid Control System	1
775 680EN	LIT: T8.2.1.1 Temperature Control	1
775 685EN	LIT: T8.2.1.6 Drive Control	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	1

The equipment includes the COM3LAB Control technology courses and the digital controlled systems Set of machines 10W, digital temperature – and Liquid control system.

The courses COM3LAB control technology offer extensive analysis tools and setting options and enable an optimum parameterization of the controller.

Learning objectives

- Structure of control loops
- Analysis of controlled systems
- Independent evaluation of the measuring results

Liquid control system*

In this project the liquid level measurement is used in order to maintain a pre-selectable filling level height with a control loop. In the process the filling level is controlled by the digital controller of the COM3LAB control technology. The system is very clear and shows the interplay of reference and actual value on closed control loops in didactic form. Filling level and flow can both be examined on one unit.

Temperature controlled system*

The task is to control the precisely defined temperature profiles for the casting metal in its housing, in order to keep it constant. These temperature profiles are set by using the thermally quick temperature control system. The good control dynamics shorten the measuring time. The temperature control system can be actively cooled via the COM3LAB control technology and the control behaviour can be analysed using switchable disturbance variables.

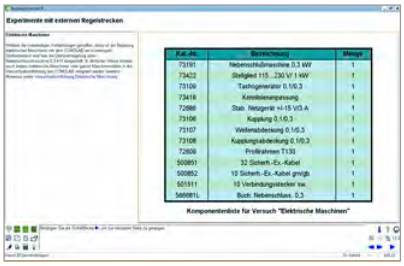
Set of machines*

With the course COM3LAB control technology, the output voltage of the generator is kept constant even when changing the load. The set of machines used here enables a multitude of experiments to be carried out. With the virtual laboratory of COM3LAB, the step response of the system can be recorded, the optimum control parameters identified or time line diagrams of the controlled system recorded.

* you will receive further information on the course topics in the product section!

M1.1.3
PROJECTS

M1.1.3.3
Analogue control lines



Analogue control lines (M1.1.3.3)

Cat. No.	Description	M1.1.3.3
700 8201	COM3LAB course: Control technology I	1
700 83	COM3LAB course: Control technology II	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
731 91	Shunt wound machine 0.3	1
731 09	Tacho generator 0.3	1
731 06	Coupling 0.3	1
731 07	Shaft end guard 0.3	1
731 08	Coupling guard 0.3	1
734 22	Actuator, 115...230 V/1 kW	1
734 19	Gain and offset adjust	1
726 86	Stabilised power supply ±15 V/3 A	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
501 511	Set of 10 bridging plugs, black	1
726 09	Panel frame T130, two-level	1
775 190DE	LIT: E2.2.2.0 DC Machines 0.3 (German)	
775 190EN	LIT: E2.2.2.0 DC Machines 0.3 (English)	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	1

With the COM3LAB Control technology course the speed control of a 300 W shunt wound machine is implemented. The digital controller is configured as a PID controller for this. The key parameters of control systems are measured and the dimensions of closed control loops experimentally illustrated.

Learning objectives

- Structure of control loops
- Analysis of control systems
- Independent evaluation of measuring results

The COM3LAB courses Control technology I + II are multimedia courses with a complete introduction to theory and practice. Experiments are carried out both on electronic control systems and on technical systems (light, speed and temperature control system).

An analog controller and a digital controller are available. Tests on frequency responses, nonlinear control and FUZZY control are also integrated in the continuing course II, an ideal course for a more in-depth introduction to the world of control technology.

Topics*

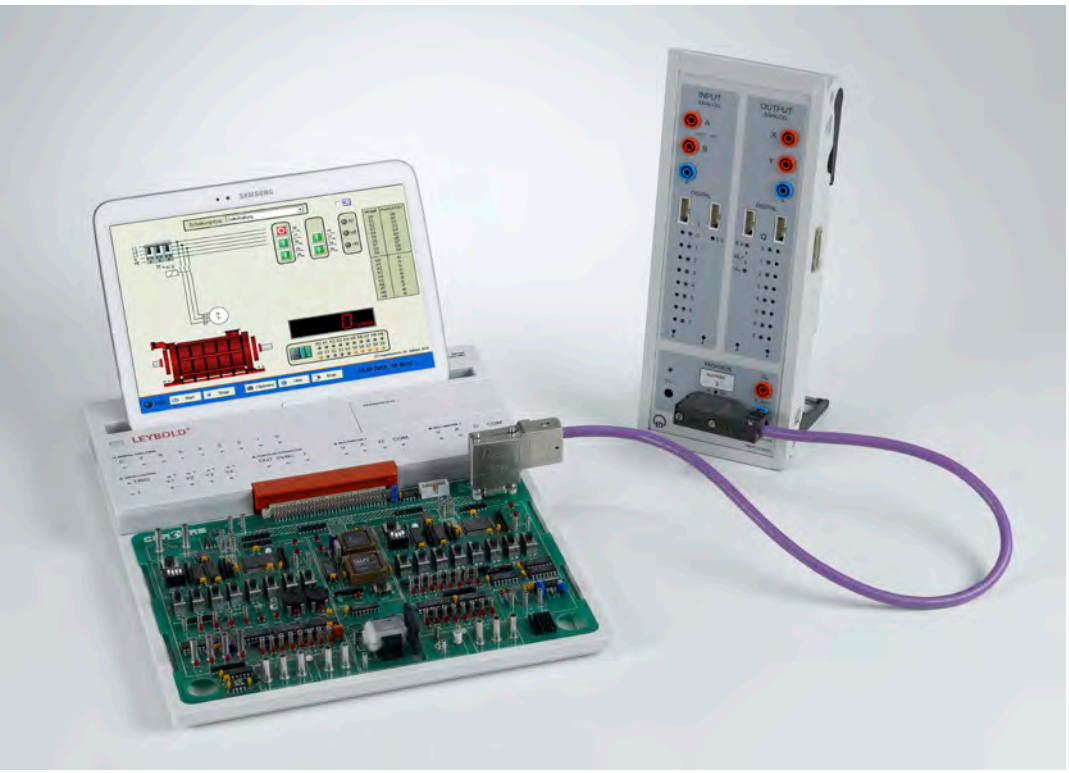
- Principles
- Control of technical systems
- Control of electronic systems
- Analog controller
- Digital controller
- FUZZY control

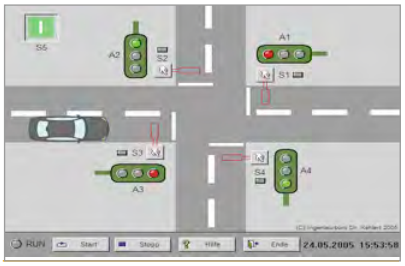
* you will receive further information on the course topics in the product section!

M1.1.3

PROJECTS

M1.1.3.4
Automation Technology





Automation Technology (M1.1.3.4)

Cat. No.	Description	M1.1.3.4
700 3101	COM3LAB Course: Automation and bus technology	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
728 871	Software: 5 Modells CBS 9 (single user)	1
728 872	Software: 5 Models CBS 9 (licence for 25 places)	1
730 4313	Bus connecting plug RS 485	1
524 016S2	PROFI-CASSY Starter 2	1
730 4312	Profibus cable	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	1

The COM3LAB course Bus and Automation technology teaches the basics of programmable logic controllers (PLC) and shows their interconnection including sensors and actuators using the PROFIBUS. With many examples, explanations, exercises and practical tasks, the basic principles and functions of the PLC and the PROFIBUS are clearly illustrated. The combination with external PROFIBUS components or an external system simulator enables the processes in the bus and automation technology to be illustrated and tracked as accurately as possible and without any great amount of effort.

Learning objectives

- Independent implementation of a project
- Programming
- Planning
- Commissioning
- Analysis
- Correction

A universal system simulator has emerged from the connection of the software models and PROFI-CASSY. On one side, the PROFI-CASSY is connected to the PLC of the COM3LAB course Automation technology via the PROFIBUS and on the other side, it is connected to the PC via USB. There are process simulations for the various systems, which are simply installed on the PC as software. The actuators and the sensors of the simulated system are hence accessible for the real external control of the COM3LAB course via PROFI-CASSY.

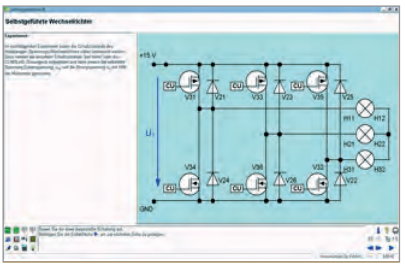
Topics*

- Motor control
- Traffic light control
- Liquid level control
- Service lift
- Stamping machine

* you will receive further information on the course topics in the product section!

M1.1.3
PROJECTS

M1.1.3.5
Power Electronics



Power Electronics (M1.1.3.5)

Cat. No.	Description	M1.1.3.5
700 2101	COM3LAB course: Power electronics I	1
700 22	COM3LAB course: Power electronics II	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
735 297	Universal converter 3 x 230 V	1
735 290	Connecting lead universal converter	1
732 104	Squirrel cage motor 230/400/0.3	1
731 07	Shaft end guard 0.3	1
726 71	Single-phase supply unit	1
500 59	Safety bridging plugs, black, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
726 19	Panel frame SL85, single-level	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	1

Power electronics is an important area within electrical engineering. It combines the areas of power engineering, control and regulation technology and electronics. The advances in the production of semiconductor power components such as diodes, thyristors, triacs and power transistors have considerably facilitated their breakthrough. The task of the power electronics is switching, controlling and converting electrical energy with the help of electronic components.

In the project work the unloaded asynchronous machine (732 104) is supplied with three-phase current 3 x 230 V via the universal converter (735 297). The converter is parameterized via an interface integrated in the board, directly from the COM3LAB course.

Learning objectives

- Independent execution of the project
- Analysis
- Parameterization
- Correction

With the COM3LAB Power engineering course the operating behaviour of the machine is examined first and the identified parameters entered into the frequency converter of the COM3LAB. You can operate your 300 W set of machines with the power universal converter connected to the COM3LAB interface.

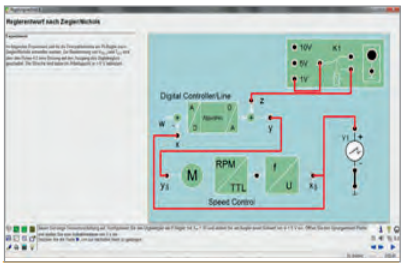
Topics*

- Semiconductor
- Circuits
- Key parameters
- Static converter

* you will receive further information on the course topics in the product section!

M1.1.3
PROJECTS

M1.1.3.6
Drive Technology



Drive Technology (M1.1.3.6)

Cat. No.	Description	M1.1.3.6
700 2501	COM3LAB course: Electrical machines I	1
700 8201	COM3LAB course: Control technology I	1
700 83	COM3LAB course: Control technology II	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
731 91	Shunt wound machine 0.3	
731 09	Tacho generator 0.3	1
731 06	Coupling 0.3	1
731 07	Shaft end guard 0.3	1
731 08	Coupling guard 0.3	1
734 22	Actuator, 115...230 V/1 kW	1
734 19	Gain and offset adjust	1
726 86	Stabilised power supply ±15 V/3 A	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
500 59	Safety bridging plugs, black, set of 10	1
726 19	Panel frame SL85, single-level	1
775 190EN	LIT: E2.2.2.0 DC Machines 0.3 (English)	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	1

The equipment includes the COM3LAB courses Electric machines I and Control technology I + II and a shunt wound machine. With these, important experiments can be carried out in the field of electric drives.

In the project work, the speed control of a commercial shunt wound machine was carried out with 300 W. For this reason it is necessary to configure the digital controller of the COM3LAB course Control technology II and to optimise it for the industrial motor.

Learning objectives

- Independent execution of a project
- Configuration of a controller
- Evaluation of the measuring results

With the COM3LAB course Electric machines I the operating performance of electrical machines will first be examined both on physical, mechanical level and by recording speed torque characteristics. Connection technologies of electrical machines, alteration of rotational direction and speed as well as the wiring of the terminal board are the subject of the experiments.

With the Control technology course the foundations of speed-controlled drives are examined. The key parameters of control systems are measured and the dimensions of closed control loops illustrated experimentally.

Topics*

- Function of electric machines
- Recording of characteristics
- Function of various controllers
- Speed control of a shunt wound machine

* you will receive further information on the course topics in the product section!

FOLLOW US!

VIDEOS ON YOUTUBE

Videos about new product features and experiments are posted regularly on the LD DIDACTIC YouTube Channel.

WWW.YOUTUBE.COM/USER/LDDIDACTIC

COM3LAB

M1.2 AUTOMOTIVE TECHNOLOGY

M1.2.1 FUNDAMENTALS

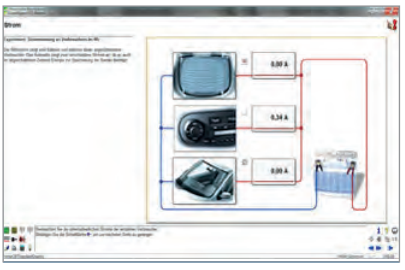
M1.2.1.1 Electrics
M1.2.1.2 Sensors
M1.2.1.3 Digital Technology

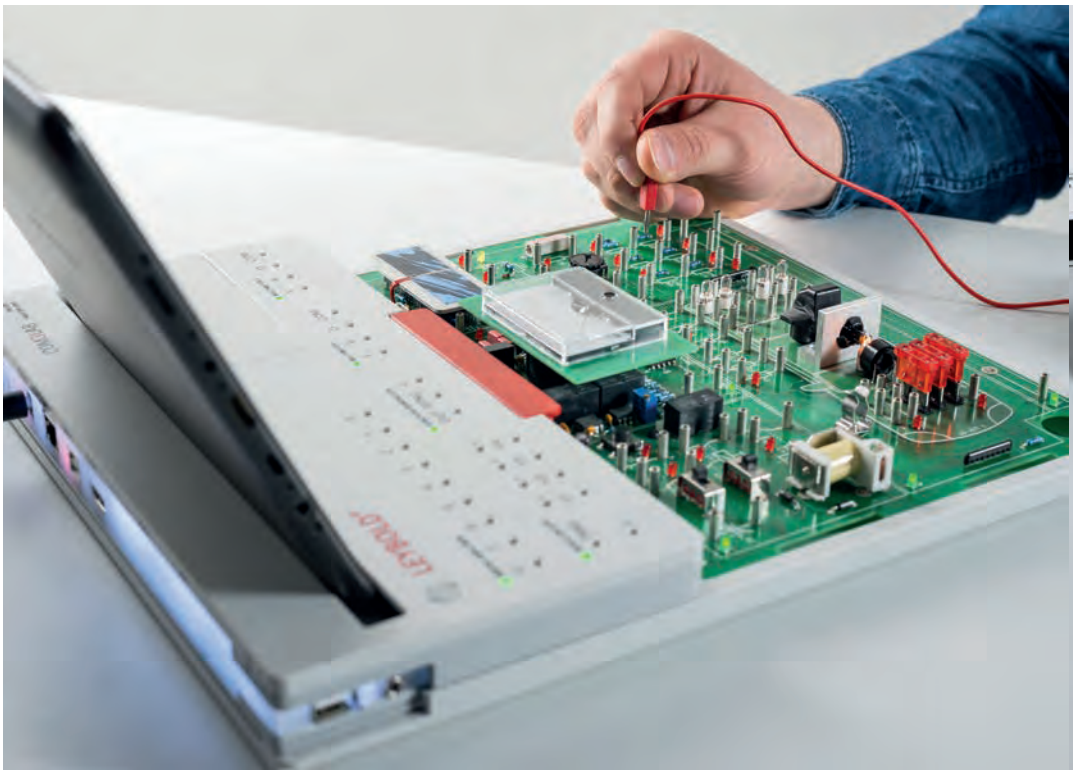
M1.2.2 SPECIALIZATIONS

M1.2.2.1 Bus Systems

M1.2.1
FUNDAMENTALS

M1.2.1.1
Electrics





Electrics (M1.2.1.1)

Cat. No.	Description	M1.2.1.1
700 6101	COM3LAB Course: Automotive technology I	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

Nowadays cars without electronics are hard to imagine. These cars would be not suitable for everyday and everyone's use in modern traffic systems. While only a few devices in the car (windscreen wipers, starter etc.) used to operate electrically, the electrics today perform control functions (engine control, air conditioning, ABS etc.). This fact requires an extensive knowledge in the field of electrics.

The COM3LAB Electrics course has been developed with the automotive industry and therefore enables a solid electrical basic training.

Learning objectives

- Learning physical basic principles
- Calculating circuits
- Measuring

In the COM3LAB course Motor vehicle electrics the parameters of voltage, current and resistance are explained in a comprehensible way and additionally considered in the chapter „Calculating with parameters" using graphic animations and videos. Measurements of real, motor vehicle-relevant components with analog and digital measuring instruments lead to the understanding of simple electrical circuits.

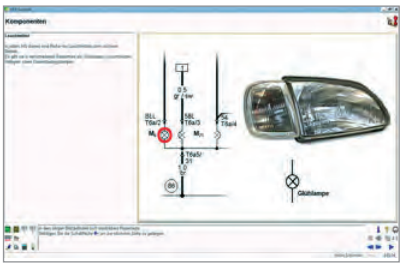
Topics

- Voltage, current, resistance
- Ohm's law
- Electrical power
- Electric circuits
- Series and parallel circuits
- Complex circuits
- General measuring instruments
- Analog/digital measuring instruments for measurements of components / vehicle electrical system

COM3LAB

M1.2.1
FUNDAMENTALS

M1.2.1.2
Sensors



Cat. No.	Description	M1.2.1.2
700 6201	COM3LAB vehicle sensors	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

Nowadays many things run fully automatically in modern vehicles. The light goes on when it gets dark, the windscreen wiper adapts its wiping speed to the amount of rain. Up to 100 sensors are installed in the vehicle for this reason. They detect physical parameters like temperatures, speeds, angles, pressures etc. and transform these non-electric parameters into electric parameters.

The COM3LAB Motor vehicle sensor system therefore deals with the electric components and sensors in the vehicle.

Learning objectives

- Learning physical basic principles
- Getting to know the most important components and sensors

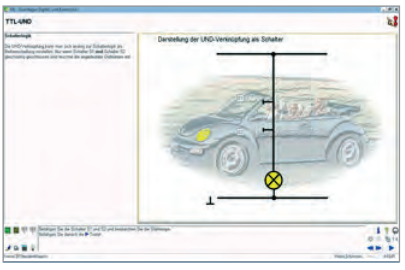
The course "Automotive Sensor Technology" explains the function of the electric components and sensors in a motor vehicle in detail. The course contents are completed by extensive instructions on practical troubleshooting. Comprehension questions and parallel voice output guarantee the greatest possible learning efficiency compared to traditional training methods.

Topics

- Lines
- Components
- Sensors
- Batteries and accumulators
- Electric fields
- Capacities
- Generators
- Motors
- Transistors in the motor vehicle

M1.2.1
FUNDAMENTALS

M1.2.1.3
Digital Technology



Digital Technology (M1.2.1.3)

Cat. No.	Description	M1.2.1.3
700 6401	COM3LAB Course: Vehicle fundamentals Digital and Bus Technology	1
700 6501	COM3LAB Course: Automotive digital technology II	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

The COM3LAB courses Digital technology I + II form the basis for data exchange in the vehicle.

Learning objectives

- Structure, function and effect of the individual logic elements
- Learning important laws
- Using TTL components in application circuits

In the COM3LAB Digital technology for motor vehicle occupations course the foundations of the switching algebra are dealt with using logic links. Animations and interactions make the foundations of modern bus systems clear. The topic areas are practical and adapted to the automotive technology in terms of application.

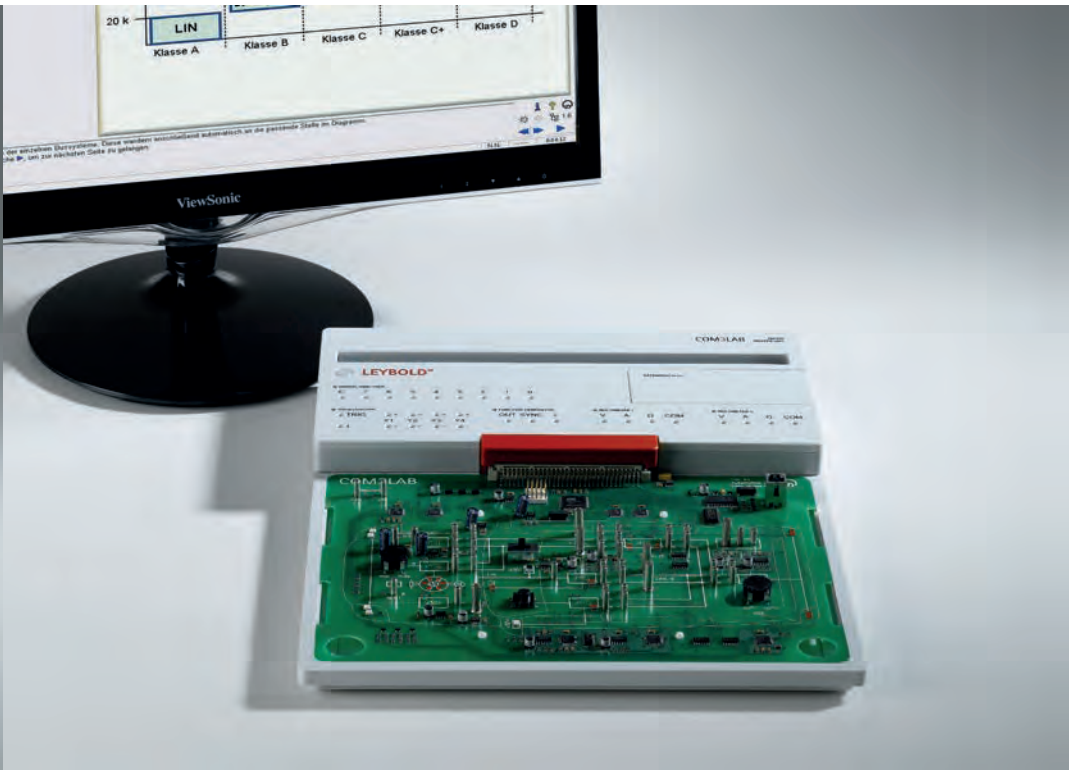
Topics

- TTL-AND
- TTL-OR
- TTL-NOT
- TTL-XOR
- TTL-NAND
- Logic links
- Coding
- Multiplexer
- Fundamentals CAN Bus

In the COM3LAB course Vehicle-digital memory circuits flip-flop circuits are introduced. Animations and interactions make the foundations of modern bus systems clear. The topic areas are practical and adapted to the automotive technology in terms of application.

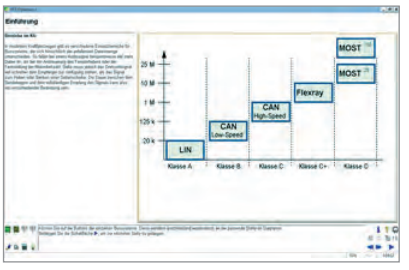
Topics:

- Flip-flop
- RS flip-flop
- JK Flip-flop
- Shift register
- Counter
- Multivibrators
- Impulse diagram



M1.2.2
SPECIALIZATIONS

M1.2.2.1
Bus Systems



Bus Systems (M1.2.2.1)

Cat. No.	Description	M1.2.2.1
700 6301	COM3LAB Course: Automotive Data Buses	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

In order to meet ever greater requirements in the vehicle of driving safety, exhaust emission characteristics, fuel consumption and comfort, information is permanently exchanged between the control units and the terminal. In order to process the abundance of information in a timely manner, data buses are used. This requires extensive knowledge of function and use in the vehicle. The COM3LAB Vehicle databuses course takes these requirements into account.

Learning objectives

- Identification and diagnosis of data buses
- Fault analysis

In the COM3LAB Vehicle data buses course the interconnected electronic systems in the automotive technology are comprehensibly prepared and taught. Learning the various bus systems and their application areas are emphasized. Here, action-oriented tasks lead to a comprehensive understanding of the connections in the vehicle. Measuring technology as well as troubleshooting and fault correction complete the learning content.

Topics

- Digital technology: Foundations of digital technology
- Bus systems: CAN, LIN, SENT
- Measuring technology: signal sequence, logs, fault analysis
- Connection with external components: Communication and control of external systems (Training card, vehicles) via bus systems
- Other applications and system components

COM3LAB

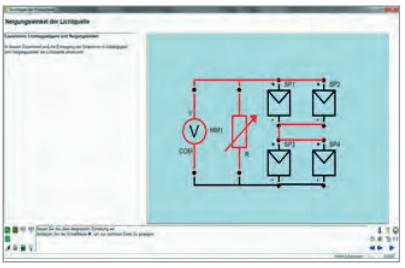
M1.3 RENEWABLE ENERGY

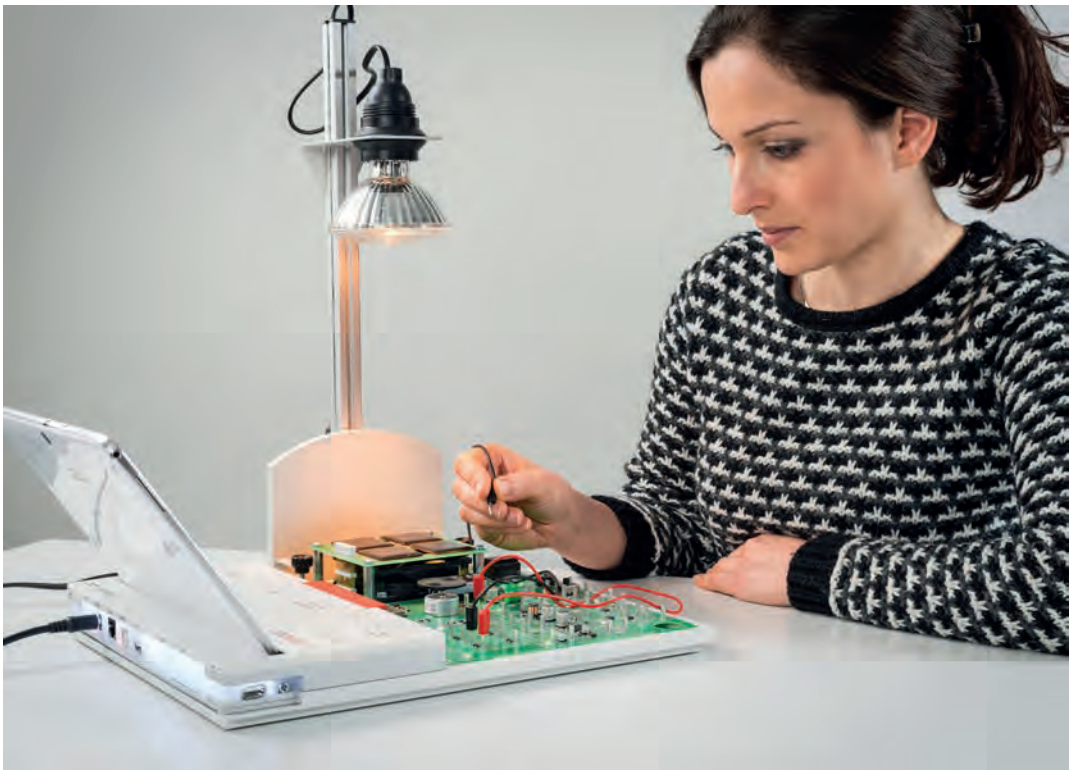
M1.3.1 FUNDAMENTALS

M1.3.1.1 Photovoltaics

M1.3.1
FUNDAMENTALS

M1.3.1.1
Photovoltaics





Photovoltaics (M1.3.1.1)

Cat. No.	Description	M1.3.1.1
700 5301	COM3LAB course: Photovoltaic	1
700 020	COM3LAB Master Unit	1
700 022	Safety cable 2mm	1
700 00CBTDE	DVD: COM3LAB software, German	
700 00CBTEN	DVD: COM3LAB software, English	1
	700 00CBTXX - The COM3LAB - Software is also available in French, Dutch, Polish, Russian, Spanish, etc.	

Photovoltaics (PV) is the direct conversion of sunlight into electrical energy through solar cells. Solar collectors today are found in industry and in the private sector, and will also play a significant role in the future.

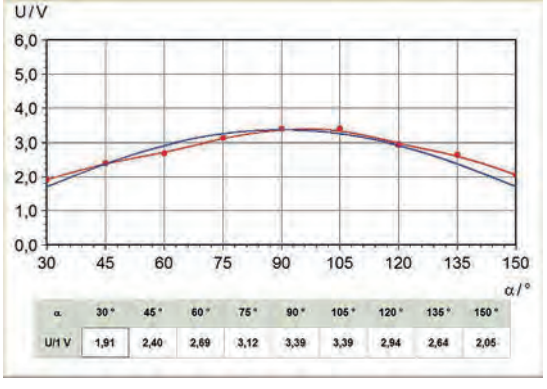
Learning objectives

- Function and application of a solar collector

The COM3LAB Photovoltaics course is a foundation course on using solar cells. It deals with the structure and the function of solar cells. Using several experiments, the function of solar modules in different conditions is examined. With animations and several illustrations, this course gives a clear introduction to the world of photovoltaic systems.

Topics

- Solar cells (features, function, etc.)
- Solar module (features, function, etc.)
- Circuit types of solar modules
- Solar characteristics
- Influence of temperature
- Influence of shades
- Charging circuit
- Solar charge controller
- Photovoltaics system
- Applications



Inclination angle of the light source

COM3LAB

PRODUCT SECTION

IN NUMERICAL ORDER

On the following pages you will find all individual components in numerical order of the catalogue numbers.

Connecting lead, 19 A, 25 cm, black

For low-voltage circuits. Copper wires with plugs at both ends and fully insulated axial plug for adding additional leads. Black.

Technical Specifications:

- Plugs and sockets: 4 mm diam.
- Cross-section of conductor: 1 mm²
- Max. continuous current: 19 A
- Length: 25 cm

500 414	Connecting lead, 19 A, 25 cm, black

Connecting lead 19 A, 100 cm, black

For low-voltage circuits. Copper wires with plugs at both ends and fully insulated axial plug for adding additional leads. Black.

Technical Specifications:

- Plugs and sockets: 4 mm diam.
- Cross-section of conductor: 1 mm²
- Max. continuous current: 19 A
- Length: 100 cm

500 444	Connecting lead 19 A, 100 cm, black

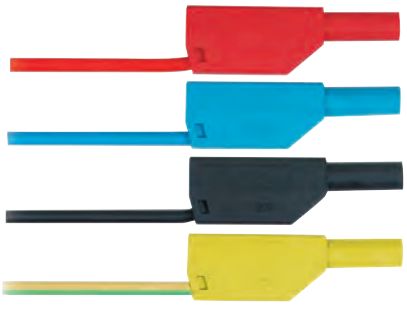
Safety bridging plugs, black, set of 10

For use in low-voltage circuits.

Technical Specifications:

- Plugs: safety plugs, 4 mm diam.
- Pin spacing: 19 mm
- Current: 25 A

500 59	Safety bridging plugs, black, set of 10



Safety connecting lead, 10 cm, black

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Black.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A
- Length: 10 cm

500 604	Safety connecting lead, 10 cm, black

Safety connecting lead, 25 cm, yellow/green

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Yellow-green.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A
- Length: 25 cm

500 610	Safety connecting lead, 25 cm, yellow/green

Safety connecting lead, 25 cm, red

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Red.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A
- Length: 25 cm

500 611	Safety connecting lead, 25 cm, red

Safety connecting lead, 25 cm, blue

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Blue.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A
- Length: 25 cm

500 612	Safety connecting lead, 25 cm, blue

Safety connecting lead, 25 cm, black

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Black.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A.
- Length: 25 cm

500 614	Safety connecting lead, 25 cm, black

Safety connecting lead, 50 cm, yellow/green

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Yellow-green.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A
- Length: 50 cm

500 620	Safety connecting lead, 50 cm, yellow/green

Safety connecting lead, 50 cm, red

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Red.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A
- Length: 50 cm

500 621	Safety connecting lead, 50 cm, red

Safety connecting lead, 50 cm, blue

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Blue.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A
- Length: 50 cm

500 622	Safety connecting lead, 50 cm, blue

Safety connecting lead, 50 cm, black

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Black.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A
- Length: 50 cm

500 624	Safety connecting lead, 50 cm, black

Safety connecting lead, 100 cm, yellow/green

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Yellow-green.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A
- Length: 100 cm

500 640	Safety connecting lead, 100 cm, yellow/green

Safety connecting lead, 100 cm, red

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Red.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A
- Length: 100 cm

500 641	Safety connecting lead, 100 cm, red

Safety connecting lead, 100 cm, blue

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Blue.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A max.
- Length: 100 cm

500 642	Safety connecting lead, 100 cm, blue

Safety connecting lead, 100 cm, black

For use in low-voltage circuits. Flexible, safety plug with axial safety socket at both ends. Black.

Technical Specifications:

- Conductor cross-section: 2.5 mm²
- Steady current: max. 32 A
- Length: 100 cm

500 644	Safety connecting lead, 100 cm, black

Safety connecting leads, 32 A, set of 32

For use in low-voltage circuits. Flexible PVC strand, safety plugs with axial safety socket at both ends.

Technical Specifications:

- Plugs and sockets: 4 mm diameter (nickel plated)
- Conductor cross-section: 2.5 mm^2
- Steady current: max. 32 A
- Contact resistance: 1.8 mΩ

Scope Of Delivery:

Count	Cat.No	Name
4	500 604	Safety connecting lead, 10 cm, black
2	500 611	Safety connecting lead, 25 cm, red
2	500 612	Safety connecting lead, 25 cm, blue
6	500 614	Safety connecting lead, 25 cm, black
2	500 621	Safety connecting lead, 50 cm, red
2	500 622	Safety connecting lead, 50 cm, blue
6	500 624	Safety connecting lead, 50 cm, black
2	500 641	Safety connecting lead, 100 cm, red
2	500 642	Safety connecting lead, 100 cm, blue
4	500 644	Safety connecting lead, 100 cm, black

500 851	Safety connecting leads, 32 A, set of 32

Safety connecting leads, 32 A, yellow/green, set of 10

For use in low-voltage circuits. Flexible, safety plugs with axial safety sockets at both ends.

Technical Specifications:

- Conductor cross-section: 2.5 mm^2
- Steady current: max. 32 A

Scope Of Delivery:

Count	Cat.No	Name
2	500 610	Safety connecting lead, 25 cm, yellow/green
4	500 620	Safety connecting lead, 50 cm, yellow/green
4	500 640	Safety connecting lead, 100 cm, yellow/green

500 852	Safety connecting leads, 32 A, yellow/green, set of 10

Connecting lead, 19 A, 25 cm, black, pair

For extra-low voltage circuits. Copper wire, equipped at both ends with a plug and fully insulated axial socket for connecting further cables.

Technical Specifications:

- Plugs and sockets: 4 mm diameter
- Conductor cross-section: 1.0 mm^2
- Continuous current: 19 A max.
- Length: 25 cm

Scope Of Delivery:

Count	Cat.No	Name
2	500 414	Connecting lead, 19 A, 25 cm, black

501 441	Connecting lead, 19 A, 25 cm, black, pair

Connecting leads, 19 A, 100 cm, black, pair

For use in extra-low voltage circuits. Copper wires, plug with fully insulated axial socket for connecting additional leads.

Technical Specifications:

- Plugs and sockets: 4 mm diam.
- Conductor cross-section: 1 mm²
- Continuous current: 19 A max.
- Length: 100 cm

Scope Of Delivery:

Count	Cat.No	Name
2	500 444	Connecting lead 19 A, 100 cm, black

501 461	Connecting leads, 19 A, 100 cm, black, pair

Set of 10 bridging plugs, black

Technical Specifications:

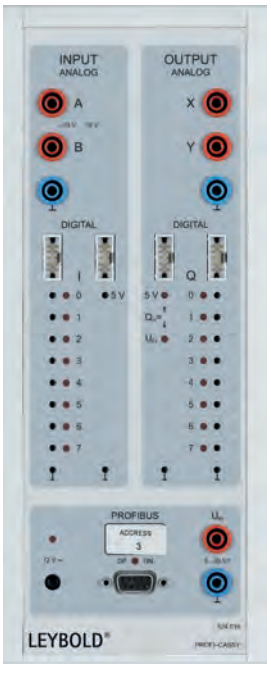
- 4-mm bridging plugs
- 19-mm spacing
- 32 A current

501 511	Set of 10 bridging plugs, black

Bridging plugs with tap, black, set of 10

4-mm bridging plugs with 19 mm spacing with 4-mm tap. Max. current 32 A.

501 512	Bridging plugs with tap, black, set of 10



Profi-CASSY Starter 2

The Profi-CASSY starter package is intended for unlimited experimentation. It consists of a Profi-CASSY module with interface (524 016), plus CASSY Lab 2 software (524 220).

Technical Specifications:

- **16 digital inputs I0 to I15**
  (5 V or 24 V logic)
  - Sampling rate: max. 100 values/s
- **16 digital outputs, Q0 to Q15**
  (5 V or 24 V logic)
  Output current: 10 mA with internal 5 V power supply, 500 mA via external power supply of up to 30 V
  - Total current: 2 A
  The digital inputs/outputs are each equipped with 10-pin plugs for direct connection to automation equipment.
  Also 8 inputs and 8 outputs are additionally equipped with 2-mm sockets and status LEDs
- **2 analog voltage inputs, A and B**
  4-mm safety sockets
  Resolution: 12 bits
  Amplitude: ±10 V
  Measuring error: ±1% plus 0.5% from the end value of range
  Input resistance: 1 MW
  Sampling rate: max. 10,000 values/s
- **2 analog outputs, X and Y**
  4-mm safety sockets
  Amplitude: ± 10 V
  Output current: max. 100 mA per Output
  Resolution: 12 bits, measuring error: ±1% plus 0.5% from the end value of range
  - Sampling rate: 10,000 values/s
- **1 PROFIBUS connection**
  9-pin DSUB socket
  Passive user (slave) on fieldbus
  PROFIBUS-DP
  Address adjustable via software with 16 digital inputs/outputs
  Transmission rate up to max. 3 Mbits/s

- **USB port**
  for connection to PC
- **1 CASSY-Bus module**
  or connection to Sensor- or Power-CASSY modules
- **Dimensions** (WxHxD): 115 mm x 295 mm x 45 mm
- **Weight:** 1 kg

Scope Of Delivery:

- 1 Profi-CASSY module
- CASSY Lab software with enable code for Windows XP/Vista/7/8 (32+64 bit) and extensive help
- 1 Installation guide
- 1 USB cable
- 1 power adapter 230/12 V/1.6 A
- 1 GSD file for simple parameter settings

524 016S2	Profi-CASSY Starter 2

Plug-in power supply, 12 V AC

Universal plug-in power supply, e.g. for CASSY, counter S, counter P, electrometer amplifier etc.

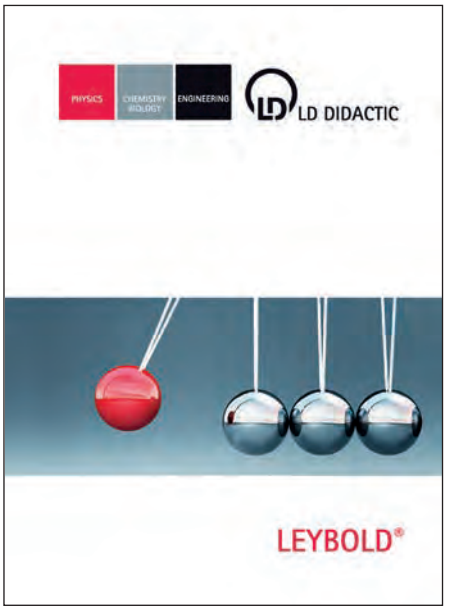
Technical Specifications:

- Primary: 230 V AC, 50/60 Hz
- Secondary: 12 V AC, 20 VA

Connection: coaxial power connector

562 791	Plug-in power supply, 12 V AC

LIT: Control of Technical Lines I



Detailed representation of experiments to Control of technical Lines (part I), included results for the teacher and Measurements with CASSY Lab 2. DIN A4, in german.

Topics:
- Temperature Control
- Liquid: Flow – Measurement &Control
- Liquid Level: Measurement &Control
- Gas flow control

564 24EN	LIT: Control of Technical Lines I

LIT: Control of technical control loops II, German

Comprehensive instructions for experiments on the closed-loop control of technical control loops (part II), including experiment results for teachers and measurements using CASSY Lab 2. DIN A4 format in German.

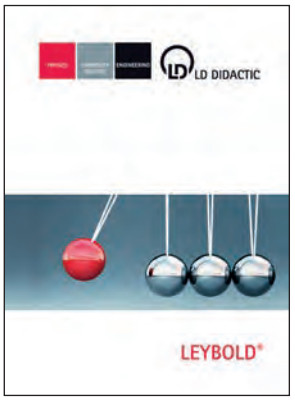
Topics:
- Closed-loop control of speed and voltage (using 10 W machine set)

564 25EN	LIT: Control of technical control loops II, German

LIT: Fundamentals of Automatic Control Technology II, Vol. 2

TECHNOLOGY II, Vol.2.
Automatic control of physical variables in the frequency range. DIN A4, in German.

568 222	LIT: Fundamentals of Automatic Control Technology II, Vol. 2



LIT: DC Machines (in German) T 10.2.1

93 Illustrations and Diagrams, 130 pages, DIN A4. Language: German.

Topics:

- Experiments with the Shunt Wound Machine
- Experiments with the Series Wound Machine
- Experiments with the Compound Wound Machine
- Experiments with the DC Multifunction Machine
- Experiments with the Universal Motor
- Refresher Questions

569 2101L	LIT: DC Machines (in German) T 10.2.1

Storage tray S24-FN

For storage of equipment, especially equipment used in students' experiments. Study construction, made of 4-mm-thick, drawn material with grooves for partitions, can be sub-divided into ten sections.

Technical Specifications:

- External dimensions: 240 mm x 460 mm x 80 mm

648 07	Storage tray S24-FN

Fits partition 648 08

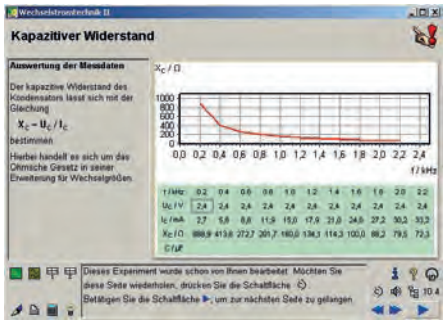
Partition ZW 24

For dividing the storage tray (648 07)

Technical Specifications:

- Width: 240 mm

648 08	Partition ZW 24



COM3LAB software

CD containing the software for all available COM3LAB courses in German. For each COM3LAB multimedia course there is an electronic, interactive instruction manual. The contents of the manual are dependent on the topic and are tailored to the hardware. The operation and function of the manuals are identical for all courses. The 32-bit user interface, into which the interactive manual, the virtual lab and the tools are integrated, also remains the same for all courses. Structure of multimedia course software:

- Electronic manual
- Virtual lab (oscilloscope, multimeters, function generator etc.)
- Tools (printers, calculators, word processing, copy function for measurement results)
- Help
- Glossary
- Table of contents

Cat.No	Description
700 00CBTDE	DVD: COM3LAB software, German
700 00CBTEN	DVD: COM3LAB software, English
700 00CBTFR	CD: COM3LAB software, French
700 00CBTIT	CD: COM3LAB software, Italian
700 00CBTNL	CD: COM3LAB software, Dutch
700 00CBTPT	CD: COM3LAB software, Portuguese
700 00CBTRU	CD: COM3LAB software, Russian
700 00CBTSP	CD: COM3LAB software, Spanish

COM3LAB Master Unit

The COM3LAB Master Unit is the multifunctional, compact measuring interface.
It is used for the operation and the power supply to the COM3LAB multimedia experiment boards and as an independent measuring laboratory.
The Master Unit is connected to the PC via USB Port, WiFi or Ethernet for the recording of measurements and for remote control of its built-in functions.
The Master Unit can be quickly assembled and dismantled and easily commissioned.
The clear and structured design of the Master Unit makes it easy and self-explanatory to operate.

Characteristics:

- 4-channel oscilloscope
- 2 digital multimeters
- Digital analyser
- Function generator
- Frequency counter
- Integrated USB interface for external measuring instruments
- USB charging socket for tablets
- Light strip and LEDs for status display
- two separate audio outputs so that two schoolchildren can work with the Master Unit at the same time (suitable for inclusion)
- Interfaces:
  Network interface 100 MBits RJ45
  WiFi
  USB
- Security lock for fastening the experimentation boards
- Anti-theft protection (Port for Kensington lock)

Software support

- Windows 8 / 8.1 32/64 Bit
- Windows 7
- Windows Vista

Integrated measuring instruments and functions:

- Two digital multimeters:
  Voltage: AC / DC / AD + DC 2/20 V
  Current: AC/DC 0,2/2 A
  Resistance: 2/20/200 kΩ, 2 MΩ
  Autoranging for all measurement ranges
- Digital Function generator:
  digitally generated signal types
  Sinusoidal, square-wave, triangular, DC
  0.5 Hz...100 kHz
  Max. ±10 V, max. 250 mA
- Digital 4-channel oscilloscope:
  4 differential inputs
  Sampling rate: 2 MSamples per channel
  Resolution: 12 Bit per channel
  Memory depth: 2 K Samples per channel
- Digital analyser:
  9 digital inputs, TTL-compatible
  Sampling frequency: 200 Hz to 2 MHz
  Triggering on any combination of the input statuses
  Memory depth 2048 words with 9 Bits

The real measuring instruments can be read out and operated via the software

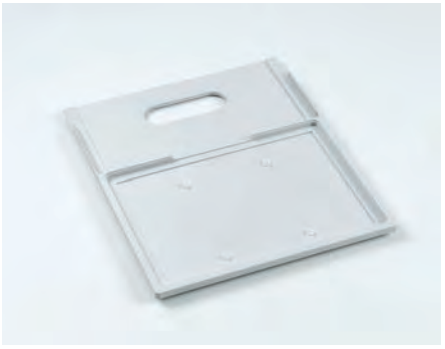
Scope of delivery

- USB cable
- Ethernet cable
- Power supply DC 15V 6A 90W
- Course framework (700 021 - for upgrading existing experimentation boards for operation with the Master Unit 700 020)

Also required

- 700 022 - 1 set of safety cables (2 mm)
  or
- 689 0600 - 1 set of standard cables (2 mm)
  700 021 - 1 course framework (700 021 - for upgrading existing experimentation boards for operation with the Master Unit 700 020)
- 700 024 - 10 course frameworks (700 021 -for upgrading existing experimentation boards for operation with the Master Unit 700 020)

700 020	COM3LAB Master Unit



COM3LAB 1 upgrade carrier standard

The COM3LAB upgrade carrier is used to insert COM3LAB experiment boards, so that they can work with the COM3LAB Master Unit 700 020.

With the new upgrade carrier, the circuit boards are better protected, easier to store and transport.

The packaging of the upgrade carrier is designed as a storage box for board and frame.

700 021	COM3LAB 1 upgrade carrier standard

Safety cable 2mm

Set of 2mm safety cables for COM3LAB Courses and the new Master Unit (700 020)

Scope Of Delivery:

2 x 150mm red
2 x 150mm blue
6 x 150mm black
2 x 300mm red
2 x 300mm blue
2 x 300mm black

700 022	Safety cable 2mm

Power supply DC 15V 6A 90W

Power Supply (Desktop Version) for COM3LAB Master Unit 700 020

Technical Specifications:
Input Voltage range: 90 VAC to 264 VAC, 127 VDC to 370 VDC
No of Outputs: 1
Output Power: 90 W
Output Voltage: 15 V
Output Current: 6 A
DC-Plug: 2.5 mm Barrel Plug

700 023	Power supply DC 15V 6A 90W

COM3LAB 8 upgrade carriers standard

Set of eight upgrade carriers in order to feature old COM3LAB work boards with the new Master Unit 700 020

700 024	COM3LAB 8 upgrade carriers standard

COM3LAB course: DC technology I

Course on the fundamentals of direct current technology, consisting of a test board with 13 different circuits.
This course introduces the basic concepts and laws of electrical engineering are explained and practically developed.

Topics:

- Circuits with switches
- Switches in series
- Switches in parallel
- Change-over switches
- Polarity reversing circuit
- Relays
- Conductivity
- Ohm's law
- Colour codes and IEC series
- Series-connected resistors
- Kirchhoff's law
- Voltage dividers
- Voltage dividers under load
- Wheatstone bridge

Virtual laboratory:

- Oscilloscope
- Function generator
- Multimeter (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The test board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments is carried out using a 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

700 1101	COM3LAB course: DC technology I

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB course: DC technology II

Course on the fundamentals of direct current technology, consisting of a test board with 11 different circuits.
In this course characteristics can be recorded and the basic types of electrical circuit can be mastered.

Topics:

- Incandescent lamp characteristic
- VDR characteristic
- Diode characteristic
- LDR characteristic
- NTC characteristic
- PTC characteristic
- Capacitors
- Capacitors connected in parallel
- Capacitors connected in series
- RC circuits
- Inductance
- Moving coil instrument
- Batteries
- Two batteries connected in parallel
- Two batteries connected in series

Virtual laboratory:

- Oscilloscope
- Function generator
- Multimeter (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The test board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments is carried out using 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

700 1201	COM3LAB course: DC technology II

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB course: AC technology I

Course on the fundamentals of alternating current technology, consisting of a test board with 11 different circuits. This course covers the production of AC voltage, transformers and rectifier circuits.

Topics:

- Step voltage
- Continuous AC voltage
- Electronic generation of AC voltage
- Function generators and oscilloscopes
- Induction
- Principle of transformers
- Short-circuited transformers
- Transformers under load
- Transformer losses
- Diodes used as current valves
- M1 rectifiers
- M2 rectifiers
- B2 rectifiers
- Symmetrical output voltage

Virtual lab:

- Oscilloscope
- Function generator
- Multimeter (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The test board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

700 1301	COM3LAB course: AC technology I

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB course: AC technology II

Course on the fundamentals of alternating current technology, consisting of a test board with 11 different circuits. This course covers the behaviour of resistance, coil and capacitor in an AC circuit.

Topics:

- Generating alternating voltages
- Key parameters of AC technology
- Ohmic resistance in an AC circuit
- Coils in an AC circuit
- Inductive reactance
- Series RL circuits
- Parallel RL circuits
- Capacitors in an AC circuit
- Capacitive reactance
- Series RC circuits
- Parallel RC circuits
- Series RLC circuits
- Parallel RLC circuits
- Series compensation
- Parallel compensation
- Voltage resonance
- Current resonance

Virtual laboratory:

- Oscilloscope
- Function generator
- Multimeter (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

700 1401	COM3LAB course: AC technology II

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, German
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Electronic components I

Course on the electronic components, consisting of a test board with 12 various circuits.
This course provides the behaviour of diodes and transistors.

Topics:

- Diode characteristics
- Characteristic of a Z diode
- Characteristic of an LED
- Diode branches in a transistor
- Input characteristic of the transistor
- Output characteristics of the transistor
- Control characteristic of the transistor
- Power dissipation of a transistor
- Characteristic of a phototransistor
- Darlington circuit
- Operating point of a transistor
- Transistor in a common emitter circuit
- Transistor in a common collector circuit
- Transistor in a common base circuit
- Transistors in timer circuits

Virtual laboratory:

- Oscilloscope
- Function generator
- Multimeter (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

700 1501	COM3LAB Course: Electronic components I

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Electronic components II

Course on the electronic components, consisting of a test board with 12 different circuits.
This course explains the behaviour of FETs, MOSFETs and IGBTs.

Topics:

- Design of the FET
- Transfer characteristic of the JFET
- Output characteristic family of a JFET
- JFET as a switch
- Characteristics of the MOSFET
- The MOSFET as a switch
- Characteristics of the IGBT
- The IGBT as a switch
- Characteristic of the DIAC
- Characteristic of the thyristor
- Thyristor in the DC circuit
- Phase angle control with a thyristor
- Characteristic of the TRIAC
- Phase angle control with a TRIAC

Virtual lab:

- Oscilloscope
- Function generator
- 2 multimeters
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

700 1601	COM3LAB Course: Electronic components II

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB course: Digital technology I

Course on the basics of digital technology (circuits), consisting of a test board with various components and logic gates. The course examines the principles and laws in digital technology.

Topics:

- TTL AND gates
- TTL OR gates
- TTL NOT gates (inverters)
- TTL XOR gates
- Boolean operations
- De Morgan's law
- TTL NAND gates
- Associative law
- Distributive law
- Karnaugh maps
- Coding
- Seven-segment displays
- Half-adders
- Full-adders
- Multiplexers/demultiplexers
- Fault simulation

Virtual laboratory:

- Oscilloscope
- Function generator
- Multimeter (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- 4 x AND, 3 x OR, 2 x XOR, 2 x NOR, 3 x NAND
- Full adder
- 7 Segment display
- Multiplexers, Demultiplexers
- 4 command switches
- 2 sensors, 2 LEDs

Scope Of Delivery:

- Set of cables consisting of 5 connecting leads 30 cm equipped with 2-mm plugs.

700 1701	COM3LAB course: Digital technology I

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB course: Digital technology II

Course on the basics of digital technology (switching networks), consisting of a test board with various circuits. The course deals with the operation and use of flip-flops.

Topics:

- Flip-flops
- RS flip-flops
- RS flip-flops with clock input
- Monostable and astable multivibrators
- Schmitt triggers
- D flip-flops
- JK flip-flops
- JK master-slave flip-flops
- Frequency dividers
- Counters
- Shift registers
- Parallel-serial converters

Virtual laboratory:

- Oscilloscope
- Function generator
- Multimeter(2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- 2 x AND, 2 x NOR, 4 x NAND
- 2 Inverter
- 1 Schmitt trigger
- 1 7-segment display
- 4 JK flip-flop
- 1 Universal shift register
- 4 command switches,
- 2 sensors, 4 LEDs

700 1801	COM3LAB course: Digital technology II

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB course: Power electronics I

Course on phase-commutated and self-commutated converter circuits, consisting of an experiment board with various circuits for mounting into the Master Unit and a multimedia CD with interactive training software.

Topics:
Introduction
- Semiconductors in power electronics
- Wiring and triggering
- Switching processes and commutation
- Uncontrolled rectifier circuits
- Parameters for periodic signals Controlled line-commutated static converters
- M1C circuit
- M3C-circuit
- B2C circuit
- B6C semi-controlled rectifiers

Virtual lab:
- Oscilloscope
- Function generator
- Multimeter (2x);
- Digital analyser
- Characteristic curve plotter
- Converter analyser
- Converter control unit

Additional functions:
- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

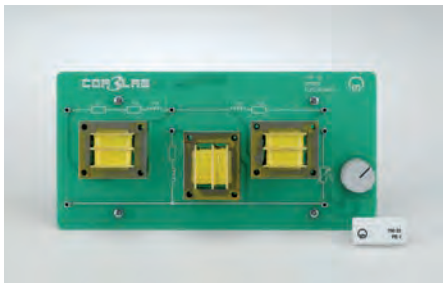
Technical Specifications:
- 1 three-phase network generator in 50 and 60 Hz
- Self-commutated and line-commutated static converter (E1 to B6 circuit) with TSE protection
- H6-MOSFET frequency converter from 1 to 120 Hz
- Three independent amperemeters
- Three incandescent lamps as ohmic load
- Inductive and capacitive loads
- 4-channel multiplexer

Scope Of Delivery:
- Set of cables consisting of 40 cm and 5 cm long connecting leads with 2-mm plugs

700 2101	COM3LAB course: Power electronics I

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8



COM3LAB course: Power electronics II

Supplementary course on power inverters, DC choppers, converters and drive technology, consisting of a dongle for the PE I experiment board and a circuit board with the equivalent circuit of a three-phase induction machine including a rotating field indicator.

Topics:

- Self-commutated converters (power inverters)
- Semiconductor switches and controllers (bidirectional static converters)
- Switches and controller for DC
- Converters
- Static converters in automatic control technology
- Static converters in drive technology

Virtual lab:

- Oscilloscope
- Function generator
- Multimeters (2x)
- Digital analyser
- Characteristic curve plotter
- Converter analyser
- Converter control unit

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The 700 22 dongle is inserted on the experiment board 700 21. This will be powered by the Master Unit.
The wiring of the experiments is carried out using 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Additionally required:

- 700 21 COM3LAB course: Power electronics I

Scope Of Delivery:

- Dongle
- Experiment board: replacement switch Asynchronous machine

700 22	COM3LAB course: Power electronics II

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 2101	COM3LAB course: Power electronics I

COM3LAB course: Three-phase technology

This COM3LAB course investigates the behaviour of three-phase systems. Practical exercises show the generation of the rotary fields or the function of the transformer. Furthermore, passive components in different circuits are discussed. Coils, capacitors and resistors are analysed and evaluated in different circuits. An 8-channel oscilloscope enables the simultaneous measurement of all voltages and currents in the three-phase system.

Topics:

- Characteristics of a three-phase system
- Representation of line diagrams and phase relationships
- Star- and delta circuits with different loads
- Measurement of phase and line voltage/current
- Ohmic load
- Symmetrical and unsymmetrical charges
- Measurement of power in the three-phase system

Virtual lab:

- Spectrum analyser (FFT module)
- Frequency counter
- Multimeters (2x)
- Function generator
- Digital memory oscilloscope
- Multiplexer for recording four voltages and four currents

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- Star circuit with resistors
- Delta circuit with resistors
- Capacitors
- Load resistors

700 2401	COM3LAB course: Three-phase technology

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

- Prerequisites: Fundamentals of AC technology

COM3LAB course: Electrical machines I

Course concerning the connection methods and the recording of characteristics for electric motors and generators. With the integrated machine test system, a multitude of experiments can be carried out, e.g. the recording of torque, power and current-locus curves.

Topics:

- Forces in a magnetic field
- Measurement of Lorentz force
- Drives
- Torque-speed characteristic
- Machine test system
- DC machines
- Speed and induced voltage with DC machines
- Torque and armature voltage with DC machines
- Torque and excitation voltage with DC machines
- DC machines with external excitation
- Reversible of direction
- Characteristics with variable armature voltage
- Characteristics with variable excitation voltage
- Shunt-wound DC machines
- Characteristics with variable operating voltage
- Series-wound DC machines
- Reversal of direction with DC machines
- Characteristics with variable operating voltage
- Generator operation of DC machines
- Drive and generator with a resistive load
- Power output of generator
- Rotating field (three-phase) machines
- Three-phase windings
- Rotating fields
- Direction of rotation with periodic swapping of phase conductors
- Direction of rotation when phase conductors are swapped
- Voltage and current in star (Y) circuits
- Voltage and current in delta circuits
- Resistance in stator winding
- Reactance of an AC winding
- Synchronous machines
- Equivalent circuit diagram for synchronous machines and how they are used
- Permanently excited synchronous machines
- Step operation of synchronous machines
- Determining rotor position in star configuration
- Determining rotor position in delta configuration
- Synchronous machine at variable speed (run-up)
- Speed measurement
- Speed setting using frequency converter
- Asynchronous machines
- Block and equivalent circuit diagrams for asynchronous machines
- Determination of slip
- Star-delta starting
- Measurement of torque and line currents during run-up
- Changing direction of asynchronous machines
- Recording of torque-speed characteristic for asynchronous machines
- Three-phase drives
- Changing speed of asynchronous machines
- How speed depends on slip
- How speed depends on stator frequency
- Stepper motors
- Full-step operation
- Half-step operation
- Changing the direction of a stepper motor

Virtual lab:

- Multi-channel oscilloscope
- Oscilloscope
- Function generator
- Multimeter (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- Synchronous machine with optical rotary field indicator and strobe for speed determination
- Induction motor with star-delta switch
- Optical tachogenerator
- DC motor
- DC generator
- Current-torque converter
- Thermometer
- Electronic load
- Three phase generator, phase voltage: 0 V. .. 10 V,
- Frequency converter, Frequency: 1 Hz - 80 Hz
- DC supplies
- Stepper motor
- Electrodynamic force meter
- Multichannel oscilloscope

Scope Of Delivery:

- Power supply 230/12 VAC

700 2501	COM3LAB course: Electrical machines I

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Automation and bus technology

The COM3LAB course automation and bus technology teaches the basic knowledge of programmable logic controller (PLC) and shows its networking including sensors and actuators by means of the PROFIBUS. With many examples, explanations, practices and practical tasks the base and mode of operation of the PLC and PROFIBUS are vividly represented.
It consists of an experiment board with various circuits for mounting into the Master Unit and a Multimedia CD with interactive training software.

Topics:

- Basics and basic terms (IEC 1131) of the PLC
- Logic connections, times, counters, data processing and program editing
- Simple sensors and signal conditioning with analogue digital transformers and multiplexers
- Projecting of an automatization system
- Programming and initiation of the PLC
- Data transfer structures and protocols
- Transfer and error analysis
- Connection of external components
- Link of PROFIBUS users (GSD)

Virtual lab:

- Oscilloscope
- Function generator
- Multimeter (2x)
- PROFIBUS analyser
- PLC Control
- PLC Program
- Process In/Out

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

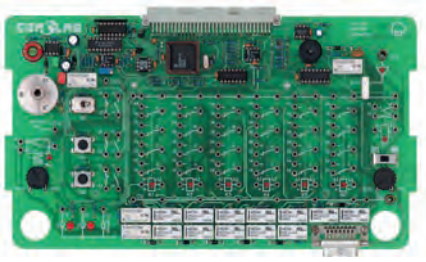
- 24 digital inputs
- 8 analog inputs
- Sensors: Temperature sensor, Photo transistor
- 20 digital outputs
- 2 analog outputs
- 1 Motor
- Dimmable incandescent lamp
- 4 mm sockets for external application
- Connection for external Profibus components
- PROFIBUS (1 Master, 2 Slaves)

700 3101	COM3LAB Course: Automation and bus technology

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Electropneumatics



The COM3LAB course electro pneumatics is designed to teach basic knowledge of pneumatics and electro pneumatics. By means of examples, explanations, exercises and the complete range of **BIBB** standard tasks the basics and the „how-to" of pneumatics and electro pneumatics are vividly illustrated.

In order to perform experiments the COM3LAB board can either be connected with industry standard valve technology or with the additionally available COM3LAB board pneumatics (700 351), which is equipped with complete hardware to perform all BIBB standard tasks. .

Topics:

- Basics of pneumatics/electro pneumatics
- Pneumatic and electric circuit diagrams
- Pilot control of a single-acting cylinder
- Pilot control of a double-acting cylinder
- Holding element control
- Basic circuit with AND function
- Basic circuit with OR function
- Basic circuit with electric latching circuits
- Displacement-dependent control
- Time-dependent control, switch-on and switch-off time delay
- Pressure-dependent control
- Sequential controls

Virtual lab:

- Oscilloscope
- Function generator
- Multimeters (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

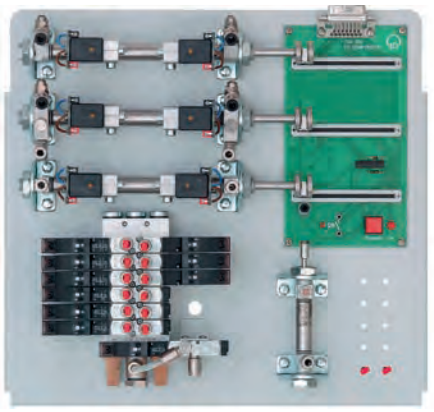
Technical Specifications:

- 6 relays, 4 changeover contacts
- 1 time relay (switch-on and switch-off time delay)
- 1 Pressure transducer
- 1 Pressure sensor 0 .. 10 bar
- Operating and monitoring elements
- 24 V voltage supply

700 3501	COM3LAB Course: Electropneumatics

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8



COM3LAB Course: Pneumatics Board

Addition to the COM3LAB course electropneumatics. The COM3Lab pneumatics board is equipped with the complete hardware to perform all **BIBB** standard tasks. It will be connected directly to the COM3LAB course electropneumatics that will monitor the components with the integrated displacement sensors of the cylinders.

Additionally required:

- 700 35 COM3LAB electropneumatics course
- Compressor with the following minimum requirements:
  Connection power: 15 W
  Pressure: 500 kPa
  Feed rate: 2 l/min
- The quiet compressor Cat. no. 744 600 is recommended.

Technical Specifications:

- 1 x single-acting cylinder, spring return with capacitive end switch
- 3 x double-acting cylinder with displacement sensor and cylinder switch
- 4 x throttle valves
- 3 x 5/2 electric displacement impulse valves
- 3 x 5/2 electric displacement valves with spring return
- 1 x central switch-on valve for pressure supply, controlled by COM3LAB
- 3 x displacement sensor for double-acting cylinders

Scope Of Delivery:

- 1 x PU Plastic hose 5m long and 2.5 mm thick
- 6 x adapter cables 2 mm on socket connectors
- 20 x blanking elements
- 10 x 2 mm cables in blue, 4 cm long
- 20 x 2 mm cables in blue, 15 cm long
- 12 x 2mm cables in red/black, different lengths
- 1 x screwdriver

700 351	COM3LAB Course: Pneumatics Board

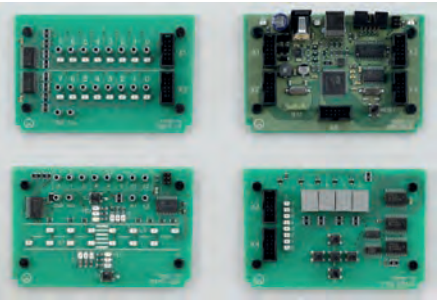
Additionally required:

Count	Cat.No	Name
1	700 3501	COM3LAB Course: Electropneumatics

Additionally recommended:

Count	Cat.No	Name
1	744 600	Low Noise Compressor

COM3LAB course: Microcontroller I



The COM3LAB course Microcontroller I deals with the construction, the function, the starting up and the programming of the microcontroller AT90CAN128 of the company Atmel. With animations and graphics the construction and the function of the AT90CAN128 is clearly described and explained.
Many examples and exercises familiarise to the computer languages assembler and C.

Topics

- Basics (CPU, RAM, ROM, timer, in/output, interrupt,...)
- Programming (computer languages, ISP and Jtag, interfaces, software, initialisation, debugger)
- AT90CAN128
- Assembler
- C
- Exercises (input, processing, output, subprograms, interrupt, timer, frequency, PWM, etc.)
- Application: traffic light control

Virtual lab:

- AVR Terminal
- LD4AVR

The microcontroller board of the COM3LAB course 700 36 Microcontroller I is directly connected to the PC via a USB cable.

Technical Specifications:

- 1 x AT90CAN128
- 1 x Module: 7-segment display
- 1 x Module: Digital I/O
- 1 x Module: traffic lights

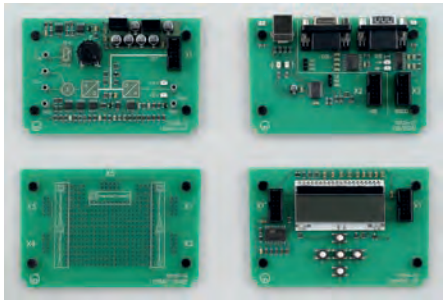
Scope Of Delivery:

- 1 x Storage tray for storing the boards
- 1 x COM3LAB MCT mounting panel
- 3 x set of connecting cables (2 mm)
- 4 x ribbon cables (10 pol)
- 1 x Plug-in unit (12V/1,65A, 230V)
- 1 x USB cable
- 1 x Course software (CD)

700 36	COM3LAB course: Microcontroller I

Additionally required:

Count	Cat.No	Name
1		PC with Windows XP/Vista/7/8



COM3LAB course: Microcontroller II

The COM3LAB course Microcontroller II continues with the subjects of the COM3LAB course Microcontroller I. On basis of many animations and pictures the knowledge in microcontroller programming is enhanced. Many examples and exercises broaden programming skills in C.

Topics:

- Initialisation and programming
- Fundamentals SPI
- Source and header files
- Projects
- Analog I/O
- Grafic display
- USB / RS232
- Projects

Virtual lab:

- AVR terminal
- LD4AVR

Technical Specifications:

- **Analog I/O**
  There are various analog components on this board, which can be operated using the microcontroller.
- **Graphic display**
  1 Graphic LCD (132 x 32 Pixel, 55 x 31 mm², Background lighting amber)
  5 sensors
- **USB / RS232**
  1 USB B connection
  1 RS232 socket (9-pole)
  1 RS232 plug (9-pole)
  (USB and RS232 can be optionally used)
- **Project**
  This board is a development board for personal projects.
  Some circuits are soldered on the board and controlled with the 70036 Microcontroller AT90CAN128.

Scope Of Delivery:

- 2 x Adapter cables (2 to 4 mm)
- 1 x V24 cable (9-pole)
- 1 x USB cable
- 1 x Course software (CD)

700 39	COM3LAB course: Microcontroller II

Additionally required:

Count	Cat.No	Name
1		PC with Windows XP/Vista/7/8

COM3LAB course: Photovoltaic

Photovoltaic bases
The COM3LAB course 700 53 photovoltaic treats the structure and the function of solar cells. Animations and illustrations give a descriptive introduction into photovoltaic systems. On basis of real experiments, the course describes the functioning of solar modules. The microcontrolled charge controller pursues the solar generator in the Maximum Power Point (MPP). Theory and experiments are accompanied and checked by the photovoltaic interactive training program.

Topics:

- Solar cell (Properties, function, etc)
- Solar module (Properties, function, etc)
- Different circuits of solar modules
- Solar characteristic
- Influence of temperature
- Influence of shadow
- Charge controller
- Solar charger controller
- Photovoltaic systems
- Applications

Virtual lab:

- Oscilloscope
- Function generator
- Multimeter (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- 1 x Halogen lamp 230 V /100 W with holder and dimmer
- 4 x Solar cells 4 V / 35 mA
- 1 x Solar charger 2.4 V / 60 mAh
- 1 x Solar controller with microcontroller
- 1 x Solar controller with IC
- 1 x Temperature sensor
- 1 x Fan 12 V
- 1 x Step-up converter
- 1 x Frequency converter
- 2 x Current/Voltage converter
- 1 x Motor
- 1 x LED 12 V
- 2 x Storage capacitors
- 1 x Ohmic load

700 5301	COM3LAB course: Photovoltaic

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Automotive technology I

This COM3LAB course prepares and teaches the basics of automotive electrics/electronics in a comprehensible manner. Physical, chemical and mathematical properties of „Electricity" lead to a comprehensive understanding of the electrical processes and events in vehicles. Measuring technology, troubleshooting and fault correction complete the learning content.

Topics:

- Electricity in the vehicle: current - voltage - resistance
- Calculating with parameters: Ohm's law - Power
- Circuits
- Series and parallel circuits - forward slope resistances

Virtual lab:

- Oscilloscope
- Function generator
- Multimeter (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- Circuit and relay
- Analog multimeter
- Resistances
- Solar cell
- Diodes
- On-board electrical system and lighting

Scope Of Delivery:

- 1 x Wire wrap panel
- 1 x Chrome nickel wire (d=0.2mm/d=3m)
- 1 x Constantan wire (d=0.2mm/l=3m)
- 1 x Iron wire (d=0.2mm/l=3m)
- 2 x Adapter cables (2 to 4 mm)
- 1 x set of connecting cables (2 mm)

700 6101	COM3LAB Course: Automotive technology I

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Vehicle Sensors

This CBT course prepares and teaches advanced principles of automotive electrics/electronics in a comprehensible manner. The physical, chemical and mathematical properties of „Electricity" lead to a comprehensive understanding of the electrical processes and events in vehicles. Measuring technology, troubleshooting and fault correction complete the learning content.

Topics:

- Components: switches, resistors, capacitors, diodes and Zener diodes, relays.
- Schematics: reading vehicle schematics
- Sensors: inductive sensors, magnetic-field sensors.
- Batteries and accumulators: Interconnecting cells, accumulator types.
- Ignition: capacitors, relays, induction, ignition coil.
- Generators and motors: rectification, three-phase generator, permanent magnet generator.
- Transistors in the vehicle: transistor, checking transistors,
- Monitoring features in vehicles, amplifier circuits, application circuits.

Virtual lab:

- Oscilloscope
- Function generator
- Multimeter (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- Components: diodes, coil,
- Capacitor, circuit, transistor
- Adjustable fan, rev counter
- Transistor circuits
- Bridge rectifier circuit
- Motor / Generator

700 6201	COM3LAB Vehicle Sensors

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Automotive Data Buses

In this CBT course, the interconnected electronic systems in automotive technology are comprehensibly prepared and taught. At the forefront of this is getting to know the various bus systems and their application areas. Here, action-oriented tasks lead to a comprehensive understanding of the connections in the vehicle. Measuring technology as well as troubleshooting and fault correction complete the learning content.

In conjunction with the *CAN databus adapter USB*, 739 581USB and the *LIN bus PC interface USB*, 739 588 the following topics can be covered:

- Digital technology: Basics of the digital technology
- Bus systems: CAN, LIN, SENT
- Measuring technology: physical signals, protocols, fault analysis
- Connection with external components feasible
- Other applications and system components

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

700 6301	COM3LAB Course: Automotive Data Buses

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/8

Available starting October 2014

COM3LAB Course: Vehicle fundamentals Digital and Bus Technology

of switch algebra are dealt with using logic links. Animations and interactions make the fundamentals of modern bus systems clear. The topic areas are practical and adapted to the automotive technology in terms of application.

Topics:

- TTL-AND
- TTL-OR
- TTL-NOT
- TTL-XOR
- TTL-NAND
- Boolean operations
- Coding
- Multiplexer
- Fundamentals CAN Bus

Virtual lab:

- Oscilloscope
- Function generator
- 2 Multimeters
- Digital analyzer

Additional function:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- 4 x AND, 3 x OR, 2 x XOR, 2 x NOR, 3 x NAND
- Full adder
- 7-segment display
- Multiplexer, Demultiplexer
- 4 command switch
- 2 sensors, 2 LEDs

Scope Of Delivery:

- Cable set consisting of 5, 30 cm connecting cables with 2 mm plugs.

700 6401	COM3LAB Course: Vehicle fundamentals Digital and Bus Technology

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Automotive Digital Technology II

In the COM3LAB course Digital technology for vehicle occupations, the fundamentals of switch algebra are dealt with using logic links. Animations and interactions make the fundamentals of modern bus systems clear. The topic areas are practical and adapted to the automotive technology in terms of application.

Topics:

- Flip-flop
- RS flip-flop
- JK flip-flop
- Shift register
- Counter
- Multivibrators
- Impulse diagram

Virtual lab:

- Oscilloscope
- Function generator
- 2 Multimeters
- Digital analyser

Additional function:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- 2 x AND, 2 x NOR, 4 x NAND
- 2 Inverter
- 1 Schmitt trigger
- 1 7-segment display
- 4 JK flip-flop
- 1 Universal shift register
- 4 Command switch,
- 2 sensors, 4 LEDs

700 6501	COM3LAB Course: Automotive Digital Technology II

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Transmission Technology TX433

Course on the fundamentals and applications of radio transmission technology and analog modulation technology, consisting of an experiment board with various circuits for mounting into the multimedia basic unit and a Multimedia CD with an interactive training software.

Topics:
- Introduction;
- Measuring techniques, spectrum and network analysis;
- Design of transmitters;
- Beats;
- Double sideband AM;
- Single sideband AM;
- Frequency modulation;
- Stereophonics and RDS;
- Coding; shift-keying ASK, FSK, PSK;
- Matching;
- The transmitting antenna, SWR measurements;
- Digital data;
- Fault simulation

In conjunction with an additional Master Unit and the receiving technology course the following experiments can also be performed:
- Signal transmission;
  - transmission of alpha-numeric data;
  - telematics,
  - telemetry,
  - cryptography

Virtual lab:
- Oscilloscope
- Function generator
- 2 Multimeters
- Digital analyser
- Spectrum analyser (FFT-module)
- Network analyser with Bode module
- SWR meter
- Frequency counter
- Data transfer module

Additional functions:
- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The test board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit. The wiring of the experiments is carried out using a 2 mm cable. Course content, experiment instructions and tasks are taught through a course-specific software.

Note
Runs under Windows 2000/XP/Vista/7/8 (32 Bit only)

Technical Specifications:
- Signal generator, Summing output stage
- Carrier oscillator, Product modulator (AM), ESB filter
- Matching element
- Stereo / Mono converter
- VCO with pre-emphasis (FM)
- Stereocoder, RDS coder
- FM transmitter in Hybrid module technology (SMD)
  - Transmission freqency: 433,75 MHz, approval-free ISM frequency
  - Power: 10 mW
- Frequency hub: adjustable, max. 75 kHz
  - Telescopic aerial, Directional coupler
  - Evaluation electronics (SWR)
  - Calibration element: 50 Ω BNC

Scope Of Delivery:
- Telescopic w with BNC socket
- BNC end-plug 50 Ohm

700 7101	COM3LAB Course: Transmission Technology TX433

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Reception Technology RX433

Expansion course to 700 71 COM3LAB course TX433 Transmitting Technology. This course contains the fundamentals and applications of radio receiving technology and analogue demodulation technology. The experiments are performed with the board of the transmitter and the receiver. The course consists of an experiment board with various circuits for mounting into the Master Unit.

Topics:

- Receiver concepts
- Measurement techniques
- Sound equalizing
- Radio receiver
- Applications of RDS, service features and information types
- Stereo reproduction
- Synchronous demodulation
- Envelope curve demodulation
- PLL
- De-emphasis
- Encoding
- Data security
- Fault simulation

In conjunction with an additional Master Unit and the transmission technology course the following experiments can also be performed:

- Demodulation of AM and FM signals
- How squelch works
- Signal transmission
- Transmission of alphanumeric data
- Telematics, telemetry, cryptography

Virtual Lab:

- Oscilloscope
- Function generator
- 2 Multimeters
- Digital analyser
- Spectrum analyser (FFT-module)
- Network analyser with Bode module
- Data transfer module

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The test board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit. The wiring of the experiments is carried out using a 2 mm cable. Course content, experiment instructions and tasks are taught through a course-specific software.

Note
Runs under Windows 2000/XP/Vista/7/8 (32 Bit only)

Technical Specifications:

- FM tuner 88...108 MHz with RDS function
- Stereo decoder
- Superhet in hybrid module technology (SMD)
- Reception frequency: 433,75 MHz, approval-free ISM frequency
- Audio bandwidth: 20 kHz
- Synchronous demodulator
- Band filter for carrier regeneration
- Variable phase shifter
- Envelope demodulator
- Demodulator low-pass
- PLL, De-emphasis
- Audio stage with sound corrector
- Output stage with loudspeaker
- Data processing unit
- Telescopic aerial

700 7201	COM3LAB Course: Reception Technology RX433

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Digital Communication Technology

The COM3LAB course: Digital Communication Technology discusses all topics of digital signal processing. Additionally attention is paid to the realisation and function of fibre optic transmission systems.
Emphasis is laid upon the applications of PCM technology, e.g.: Transmission of voice and signals with real telephones, sound cards, CD-players etc. .

Topics:

- Characteristics of pulse carriers
- Generation of PAM
- PAM (natural)
- PAM (S&H)
- PAM spectrum
- Over sampling / under sampling
- Aliasing
- Shannon theorem
- Pulse code modulation (PCM)
- Quantisation linear and nonlinear
- Compression / expanding
- Code errors
- Time division multiplexing (TDM)
- Synchronisation
- Quantisation noise
- Difference pulse code modulation (DPCM)
- Optical signal transmission
- Signal transmission by wire (coaxial line / two-wire line)
- Simplex / duplex communication

Options

- Transmission of voice (requires external signals, CD player, telephones etc.)
- Influence of the trigger and type of quantisation on the speech intelligibility
- Duplex communication (requires 2 x COM3LAB Course PCM technology, as well as external signal sources)

Virtual Lab:

- Oscilloscope
- Function generator
- 2 Multimeters
- Digital analyser
- Spectrum analyser (FFT-module)
- Frequency counter

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The test board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit. The wiring of the experiments is carried out using a 2 mm cable. Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- 2 x PAM Modulator
- 2 x PCM Modulator
- Clock-pulse generator
- 2 x PAM Demodulator
- 2 x PCM Demodulator
- Signal source Sinus, 1 kHz
- Signal source Sinus, 2 kHz
- RJ-12 socket with hybrid termination circuit
- Jack bush for connecting external signal sources
- Jack bush for connecting external active speakers
- Optical transmitter
- Optical receiver
- Fibre-optic cable with plugs, 3 m

Scope Of Delivery:

- 1 x Audio connection cable (jack bush 3.5 mm)
- 1 x fibre-optic cable (3 m)

700 7301	COM3LAB Course: Digital Communication Technology

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Modem Technology

Course on the fundamentals and applications of shift keyed signals and modems, consisting of an experiment board with various circuits for mounting into the Master Unit.

Topics:
- Introduction
- Amplitude shift keying (ASK)
- Frequency shift keying
- 2-Phase shift keying (2PSK)
- 4-Phase shift keying (4PSK)
- Difference phase coding
- Shift keyed signals in the time domain
- Shift keyed signals in the frequency domain
- Estimation of the bandwidth
- Modulation rate / data rate
- SNR and bandwidth
- Hardware of the modulators
- Hardware of the demodulators
- Carrier recovery and synchronisation of the demodulators
- Error correction
- Error detection
- Operational modes: simplex half duplex, full duplex
- NRZ Line code
- Fault simulation

Options:
- Communication of 2 PCs using modems
  A 2nd workstation with a PC with Master Unit and modem technology course (700 7401) is necessary, as well as other accessories (coaxial cable, star quad cable etc.)

Virtual Lab:
- Oscilloscope
- Function generator
- 2 Multimeters
- Digital analyser
- Spectrum analyser (FFT-module)
- Frequency counter
- Data transfer module

Additional functions:
- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The test board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit. The wiring of the experiments is carried out using a 2 mm cable. Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:
- Data source for baseband signal
- ASK Modulator
- FSK Modulator
- 2PSK Modulator
- 4PSK Modulator
- Carrier generator
- Modulation multiplexer
- Audio stage with piezo loudspeaker
- Channel level adapter
- Signal detector
- ASK demodulator
- FSK demodulator
- 2PSK demodulator
- 4PSK demodulator
- Carrier recovery

700 7401	COM3LAB Course: Modem Technology

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Telecommunication Lines

Course on the fundamentals and applications of various telecommunication line types.

Topics:

- Frequency responses of two-wire lines
- Determination of the characteristic wave impedance
- Measurement of near and far-end crosstalk
- Impulse behaviour of coaxial lines
- Mismatching
- Hybrid and phantom circuit
- Duplex transmission and remote supply
- Characteristic curves of LEDs in the optical communications engineering
- Attenuation at fibre optic lines
- Measurement of the optical power
- Coupling losses
- Bending losses

Virtual Lab:

- Oscilloscope
- Function generator
- 2 Multimeters
- Digital analyser
- FFT Spectrum analyser
- Frequency counter
- Bode module

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The test board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit. The wiring of the experiments is carried out using a 2 mm cable. Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- Equivalent circuits of two-wire lines
- Equivalent line of four-wire lines
- Star quad with phantom circuit
- Hybrid termination circuit
- Pulse generator
- Module for echo pulse evaluation
- Optical transmitter
- Optical level meter
- Shift unit for longitudinal offset on fibre-optic cable
- Signal sources 1 kHz / 2 kHz

Scope Of Delivery:

- 1 x coaxial cable, 50 m of RG 58 manufactures with BNC plug / plug
- 1 x fibre optic cable, 2 m
- 1 x fibre optic cable, 20 m

700 7501	COM3LAB Course: Telecommunication Lines

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Operational amplifier

Course on operational amplifier circuits, consisting of an experiment board with various circuits for mounting into the Master Unit.

Topics:

- The comparator
- Features of the operational amplifier
- Inverting op amp
- Noninverting op amp
- Fault simulation in inverting op amps
- Adder
- Integrator
- Differentiator
- Active filters
- Stabilised voltage source
- Stabilised current source
- Schmitt trigger
- Astable multivibrator
- Wien bridge oscillator
- Function generator

Virtual Lab:

- Oscilloscope
- Function generator
- 2 Multimeters
- Digital analyser
- FFT Spectrum analyser
- Frequency counter
- Bode module

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The test board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit. The wiring of the experiments is carried out using a 2 mm cable. Course content, experiment instructions and tasks are taught through a course-specific software.

700 8101	COM3LAB Course: Operational amplifier

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

COM3LAB course: Control technology I

Course on the fundamentals of automatic control technology, consisting of an experiment board with various circuits for mounting into the Master Unit and a Multimedia CD with an interactive training program.

Topics:

- Introduction
- Open-loop control
- Closed-loop control
- Analysis of controlled systems
- Controlled systems with/without compensation
- Controlled systems of a higher order
- Types of controllers
- P, I, PI, PID and PD control
- Automatic digital control
- Performance criteria for automatic controls
- Optimization guidelines for PID controllers
- Automatic temperature control
- Automatic speed control
- Automatic light control
- Automatic control of systems without compensation
- Automatic control with discontinuous controllers
- Fault simulation

Virtual lab:

- Oscilloscope
- Function generator
- 2 Multimeters
- Digital analyser
- Static characteristic plotter
- Step response plotter
- DDC plotter
- Controller design calculator (for optimum controller parameters)

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- Analog controller
- Summation points with disturbance inputs
- Digital controller
- Lag element
- DC signal sources 1V, 5V, 10V
- P-action element
- PT-1 elements (2 x)
- I-action element, resettable
- Nonlinear characteristic element
- Speed controlled system with optical speed sensor
- Temperature controlled system with KTY-temperature sensor
- Light controlled system with photodiode sensor and external light source (disturbance source)

700 8201	COM3LAB course: Control technology I

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

- Operating system: Windows XP/Vista/7/8
- Support for unguided, free experimentation

COM3LAB course: Control technology II

Supplementary course on the fundamentals of control technology including a dongle for the CTI experiment board.

Topics:

- Introduction
- Stability of automatic control systems
- Controller design using the Ziegler/Nichols method
- Systems with lag time
- Limiting the manipulated variable
- Cascade control
- Introduction to frequency response
- Frequency response of single basic elements
- Frequency response of combined elements
- Controller design in the frequency domain
- Fuzzy control
- Adaptive control
- Experiments with external controlled systems

Virtual lab:

- Oscilloscope
- Function generator
- 1 Multimeter
- Digital Analyser
- Static characteristic plotter
- Step response plotter
- DDC plotter
- Controller design calculator (for optimum controller parameters)

Additional Functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The 700 83 dongle is pushed onto the experiment board 700 82. This is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

700 83	COM3LAB course: Control technology II

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 82	COM3LAB course: Control technology I

- Operating system: Windows XP/Vista/7/8
- Support for unguided, free experimentation.
- Additionally required:
  700 82 COM3LAB course, Control Technology I

COM3LAB Course: Sensor technology

This COM3LAB sensor system course (700 84) teaches the basics of the measurements of non-electric quantities. With many examples, explanations and practical tasks, the function and operation of sensors and measuring circuits are investigated.

Topics:

- Electronic circuits for temperature measurement
- Function and characteristics of different temperature sensors: Pt100, NTC, KTY and thermocouple.
- Function and characteristics of pressure sensors.
- Force measurements with strain gauges.
- Force measurement with bending bar.
- Displacement-, angle- and speed measurement.
- Measurements with optical encoder.
- Hall sensors.

Virtual lab:

- Frequency counter
- 2 digital multimeters
- Function generator
- Digital memory oscilloscope

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The test board is located in a stable course frame. The Master Unit is pushed onto the course frame and connected to the board. The security lock ensures safe communication.
The experiment board is powered by the Master Unit. The wiring of the experiments is carried out using a 2 mm cable. Course content, experiment instructions and tasks are taught through a course-specific software.

Technical Specifications:

- Torque measurement using strain gauges on beams
- Temperature sensors: Pt 100,NTC, KTY, Thermocouple element
- Peltier element for recording the temperature characteristics of approx. 0° to 50°
- Differential pressure sensor
- Ohmic displacement transducer
- Capacitive displacement transducer
- Inductive displacement transducer
- Positioning using hall sensor and Reed contact
- Ultrasonic sensor with receiver
- Brightness measurement using photo diode
- Hall sensor
- Optical sensor
- Adjustable current source
- Measuring procedure with compensated lines: three-wire measurement, four-wire measurement
- 1 universal measurement amplifier
- 1 pressure sensor with pressure display
- 1 force gauge

Scope Of Delivery:

- 1 x 50 ml nozzle
- 1 x pressure gauge 1 – 1.5 bar
- 1 x hose, 6 cm long
- 1 x hose connector
- 1 x compressive force gauge, 3 bar
- 1 x compression member

700 8401	COM3LAB Course: Sensor technology

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

Electina

ELECTINA (without PCB) is a powerful and flexible training, exercise and development package to design analogue and digital electronic circuits. Circuit diagrams are created using an easy-to-use design editor. The circuit simulations and circuit analyses, virtual or real time measurements as well as mistake search can easily be carried out with the quickly learnable tools of Electina.

Plain DTP tools as well as efficient text editors and equation editors help in the production of professional teaching materials, reports and presentations.

Electina contains efficient tools to control learning with pupils, to supervise the learning success and to know the technologies in the mistake search. Above the USB interface circuits on COM3LAB Protoboard can be analysed and evaluated by Electina. Version 8.

Properties

- Simply serveable circuit draught editor
- 3D view
- Editor to the easy construction of switch symbols and components from self-sketched or imported Spice Subcircuits
- Extensive libraries with Spice to models and more than 20,000 components
- More than 20 different analysis possibilities
- Measuring instruments for the simulation and real time measurement
- Digital multimeter
- Functional generator
- Memory oscilloscope
- XY recorder
- Signal analysers
- Digital signal generator
- Logic analysator
- Bode / Nyquist diagrams
- Results of analysis
- Pol-/zero places calculation
- Errors simulation
- Test board active 3D

Cat.No	Description
700 901-01	Electina Standard, COM3LAB support (1 license), German
700 901-11	Electina Design Suite, PCB, COM3LAB support (1 license), German
700 901-14	Electina Design Suite, PCB, COM3LAB Support (School licence), German
700 902-01	Electina Standard, COM3LAB support (1 license)
700 902-04	Electina Standard, COM3LAB support (school license)
700 902-11	Electina Design Suite, PCB, COM3LAB Support (1 licence)
700 902-14	Electina Design Suite, PCB, COM3LAB Support (School licence)

COM3LAB Protoboard II

Protoboard II expands the COM3LAB Master Unit into a development platform for electronic circuits. Any type of circuit with electronic components (not included) can be set up and tested on the breadboard with 1-mm contacts.

The fixed voltage outputs and the function generator output are connected via 2-mm sockets and can be switched using slide switches. There are 2 change-over switches for any desired connections located on the prototyping board. Furthermore, standard European printed circuit boards can be connected using a 64-pin VG terminal strip. 8 relay switchover contacts are located on the VG terminal strip. 8 digital outputs can be tapped using the VG strip or via 2-mm sockets. The relay and digital outputs can be switched using software.

The power supply, the multimeter and the function generator of the Master Unit can be operated without the PC.

Scope Of Delivery:

- Software for the display of the integrated measuring instruments (multimeter, function generator, memory oscilloscope, logic analyser, frequency counter) under Windows
- 2 European grid matrix printed circuit boards with VG plug for soldering exercises and for the assembly of special circuits
- 50 wire jumpers, 1 mm, for interconnecting the components
- 20 adapter leads, 1 mm/2 mm for the connection of the measuring points to the inputs of the measuring instruments
- 5 probe tips with 2-mm terminal socket

700 9101	COM3LAB Protoboard II

Additionally required:

Count	Cat.No	Name
1	700 00CBTEN	DVD: COM3LAB software, English
1	700 020	COM3LAB Master Unit
1	700 022	Safety cable 2mm
1		PC with Windows XP/Vista/7/8

Panel frame T130, two-level

- two-level
- T-base
- without channel

Technical Specifications:

- Height: 73,0 cm
- Width: 124 cm
- Depth: 30 cm

726 09	Panel frame T130, two-level

Panel frame SL85, single-level

- Single-level frame for training panels of DIN A4 height, design with approx. 30° angle
- Two aluminium profile rails with 2 brush strips
- 2 L-shaped bases made of rectangular steel tubing

Technical Specifications:

- Table fastening with 2 M8 wing screws
- Width: 895 mm, Height: 380 mm, Depth: 250 mm

726 19	Panel frame SL85, single-level

Single-phase supply unit

To switch the mains voltage in experiments with electrical loads for AC voltage of 230 V.

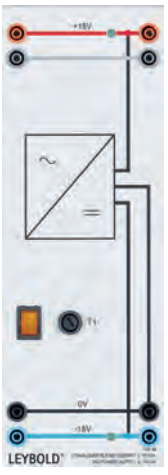
Technical Specifications:

- Cam switch, 2-pole
- Automatic circuit breaker FAZ L 10 A Phase monitor light L 1
- Phase monitor light for indication of false polarity of mains plug

Scope Of Delivery:

- Mains connecting cable with earth-contact plug

726 71	Single-phase supply unit



Stabilised power supply ±15 V/3 A

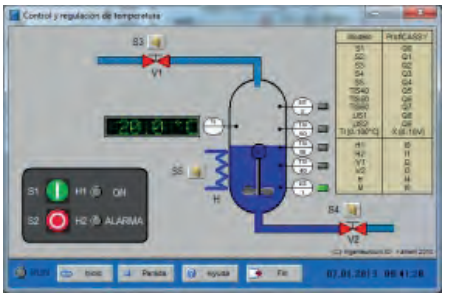
Laboratory power supply with two separate and stabilised fixed voltages for vertical assembly in panel frames or demonstration experiment frames using the plug-in system. Short-circuit-proof. Rated-voltage monitoring via two green LEDs.

Technical Specifications:

- Output voltage: ±15 V via 4-mm sockets
- Maximum load capacity: 2.4 A, short-term 3 A
- Connection voltage: 230 V, 50/60 Hz
- Fuse: T 1.0
- Power consumption: 160 VA
- Dimensions: 100 mm x 297 mm x 120 mm
- Weight: 5 kg

726 86	Stabilised power supply ±15 V/3 A

Software: 5 Models CBS 9 (single user)



Simulation that runs on the PC and contains the simulation of 5 different processes.
Using a PROFI-CASSY Interface (524 016) this simulation can be controlled by a real PLC or the COM3LAB Course "Automation and Bus technology".

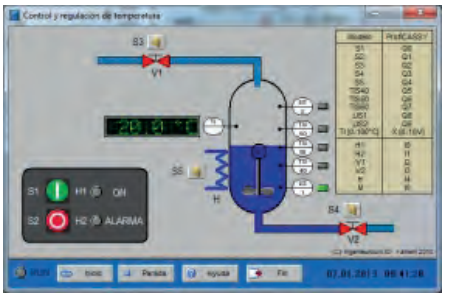
This package contains a Single user license with the following models:

- Motor control
- Traffic light control
- Liquid level control
- Service lift
- Stamping machine

728 871	Software: 5 Modells CBS 9 (single user)

Available in German or Spanish

Software: 5 Models CBS 9 (licence for 25 places)



Simulation that runs on the PC and contains the simulation of 5 different processes.
Using a PROFI-CASSY Interface (524 016) this simulation can be controlled by a real PLC or the Com3Lab Course "Automation and Bus technology".

This package contains a class room license (25 users) with the following models:

- Motor control
- Traffic light control
- Liquid level control
- Service lift
- Stamping machine

728 872	Software: 5 Models CBS 9 (licence for 25 places)

Available in German or Spanish

Profibus cable

- Standard Profibus cable, 2 wires, isolated
- Special design for quick mounting

730 4312	Profibus cable

Bus connecting plug RS 485

- Connecting plug for Profibus until 12 MBIT/s 180° cable angle
- Terminating resistor with separating function, without PG plug

730 4313	Bus connecting plug RS 485

Coupling 0.3

Rubber coupling sleeve for mechanical connection of two electrical machines of the 0.1 kW or 0.3 kW series.

731 06	Coupling 0.3

Shaft end guard 0.3

Attachable guard for protection against contact with electrical machine rotating parts of the 0.1 kW or 0.3 kW series.

731 07	Shaft end guard 0.3

Coupling guard 0.3

Attachable guard for protection against contact with electrical machine rotating parts of the 0.1 kW or 0.3 kW series.

731 08	Coupling guard 0.3

Tacho generator 0.3

For registering the speed of electrical machines in the 0.1 kW and 0.3 kW series.

Technical Specifications:

- Output voltage: ±1 V/1000 rpm

731 09	Tacho generator 0.3

Shunt wound machine 0.3

DC shunt wound machine for motor and generator operation. All windings are separately connected to 4 mm safety sockets.

Technical Specifications:

- Class: 0.3
- Power: 0.3 kW
- Voltage: 220 V
- Current: 1.8 A
- Excitation voltage: 220 V
- Excitation current: 0.25 A
- Speed: 2000 rpm
- International protection code: IP 20
- Insulation system: B/F

731 91	Shunt wound machine 0.3

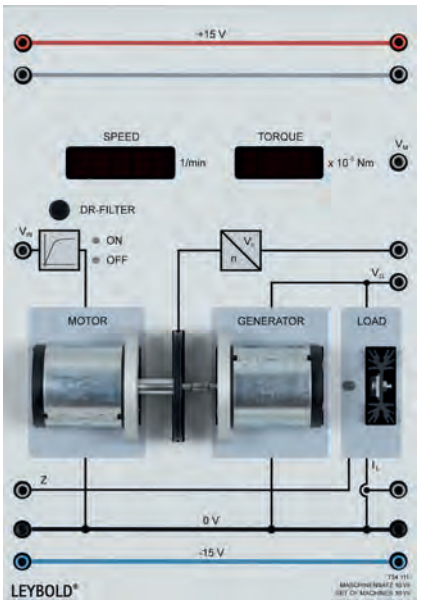
Squirrel cage motor 230/400/0.3

Three-phase asynchronous motor with squirrel cage rotor, industrial design with one shaft end.

Technical Specifications:

- Class: 0.3
- Power: 0.25 kW
- Voltage: 400 /230V, Y/ Δ
- Current: 0.76 /1.32 A
- Frequency: 50 Hz
- Power factor: 0.79
- Design: 4-pole
- Speed: 1350 rpm
- International protection code: IP 20
- Insulation system: F

732 104	Squirrel cage motor 230/400/0.3



Set of machines 10 W

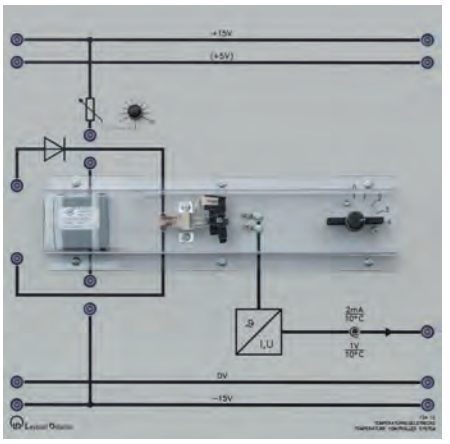
The set of 10 W machines is a technical controlled system for experiments on speed and voltage control. It consists of an electrical drive including digital speed sensing, a generator machine and an electronic load. Using the adjustable load, real generator operation can be investigated. The machine set makes it possible to measure the load characteristic of the generator and the dynamic behaviour of systems of higher order. A microprocessor controlled power module supplies the drive machine. Thus no external power amplifier is required. The set of machines comes with 7-segment displays for the measurement of speed and torque.

Technical Specifications:

- Speed: 3000 rpm max.
- Control voltage: ±10 V
- Tachogenerator: ±10 V
- Switchable prefilter, time constant T = 800 ms
- Power consumption: 10 W max.
- Generator efficiency: 40%
- Supply voltage: ± 15 V DC

734 111	Set of machines 10 W

Temperature Control System



For the investigation of continuous and discontinuous control loops.
Unipolar heat source (max. 20 W for 20 V) with temperature sensor, thermal protection switch, ventilator motor and „throttle flap", built into a transparent air channel.

Controlled system output signal (controlled variable) switchable 2 mA/10 °C or 1 V/10 °C as desired.

Two possibilities for controlled system disturbance:

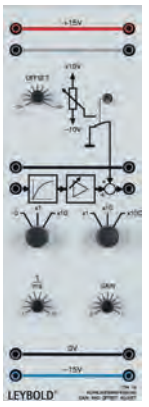
- via ventilator motor, internally with speed setter 1...10 or from an external signal source max. 20 V
- via „throttle flap", position 0 (closed) up to position 4 (open)

Controlled system data:

- Temperature: max. 100 °C
- Delay time T_U: approx. 10 s
- Compensation time T_S: approx. 120 s
- Supply voltage: ± 15 V DC

734 12	Temperature Control System

Gain and offset adjust



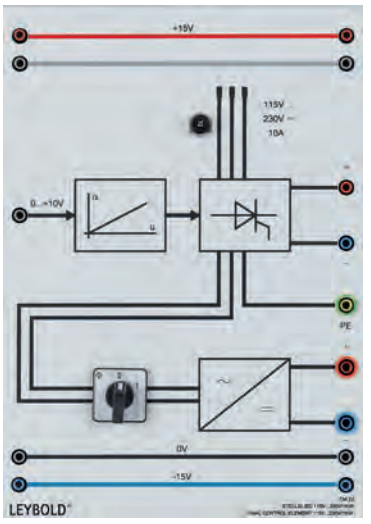
For the adjustment and matching of external signals to the normal voltage used in automatic control systems.

Technical Specifications:

- Input voltage range: -50 V...+50 V
- Level matching via adjustable gain: 0...1, 0...10, 0...100
- Smoothing of pulsating signals: Time constants τ: 0.1...10 ms, 10...100 ms
- Offset voltage, switchable: -10 V...+10 V
- Coarse setting via rotary switch
- Fine setting via potentiometer
- Supply voltage: ±15 V DC

734 19	Gain and offset adjust

Actuator, 115...230 V/1 kW



For the connection of mains-operated DC motors 0.1 kW...1.0 kW. Electrical isolation between the control and the load side.

Technical Specifications:

- Signal voltage range (manipulated variable): 0...+10 V
- Output voltage of the thyristor half-bridge: 0...V_{mains} with a max. load of 1.0 kW
- Built-in automatic circuit-breaker (T 10 A) triggered thermally and for overcurrent
- Output voltage for excitation: $V_{DC} = f(V_{mains})$, max. 10 A
- Outputs: 4-mm safety sockets
- Mains connection for thyristor half-bridge: 115...230 V, 48...62 Hz
- Supply voltage: ±15 V DC

Scope Of Delivery:

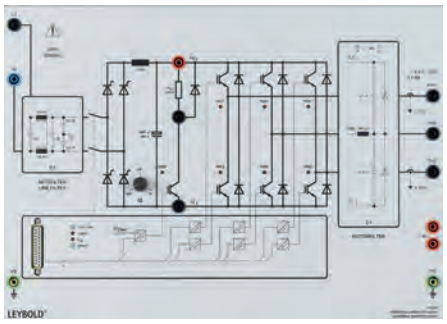
- Mains lead and earth-contact plug

734 22	Actuator, 115...230 V/1 kW

Connecting lead universal converter

25-pole sub-D connecting lead with two plugs, shielded, soft rubber and uncrossed design, length 2 m to connect the COM3LAB Power Electronics Board with the 3 x 230 V universal converter, cat. no 735 297.
For use in COM3LAB course PE II, cat. no. 700 22.

735 290	Connecting lead universal converter



Universal converter 3 x 230 V

Transistor pulse converter with voltage link for the generation of a three-phase, frequency and amplitude-variable output voltage from an AC mains. This unit in conjunction with the corresponding control unit is used to assemble a frequency converter or servo amplifier.

Description:

- Single-phase mains connection
- Variable link voltage via fully controllable B2C rectifier bridge circuit
- Three-phase inverter built with IGBT (insulated gate bipolar transistor)
- Maximum operating frequency 20 kHz, resulting in good approximation of sinusoidal current as well as low noise build-up in the machine
- Output short-circuit proof, earth-fault proof and switch proof
- Interface for connection of the control unit (25-pole sub-D socket, TTL level)
- Each individual transistor can be switched on and off via the interface and is protected from damage with an interlocking device
- The respective activated IGBT's are displayed via LEDs
- Monitoring of the variable link voltage, machines and converter excess temperature, excess currents in the rectifier and inverter. Output of the switching status via interface and display via LEDs
- Integrated brake chopper
- Safe separated extra-low voltage (SELV) between the power component and the control unit
- Output currents are detected via Hall generators. Electrically separated output via interface
- 2 stage mains filter for the reduction of the line-bound interference
- 3-phase motor filter for the reduction of the edge steepness of the pulse voltages at the converter output to values < 250 V/µs

Technical Specifications:

- Output voltage (V_{out}): 3 x 0...230 V
- Output current (I_A): max. 3 x 8 A
- Supply voltage: 200...240 V, 50/60 Hz via 4-mm safety sockets

Scope Of Delivery:

- 25-pole connecting cable

735 297	Universal converter 3 x 230 V

COM3LAB Course: Foundations of Local & Trunk Exchange Systems

The equipment set gives deep insight into the complete telephone and exchange technology in local and trunk exchange systems. Emphasis is laid upon the digital principles of TST switching networks, the implementation of service features and the voice signal coding.

Technical Specifications:

- Calling number display: 7-segment, 4 digits
- PC connection: USB

Scope Of Delivery:

- 4 switchboard modules
- 4 telephones same as RJ12
- 4 USB cable
- 1 CBT prospectus (LETS)
- 1 case

735 800	COM3LAB Course: Foundations of Local & Trunk Exchange Systems

Additionally required:

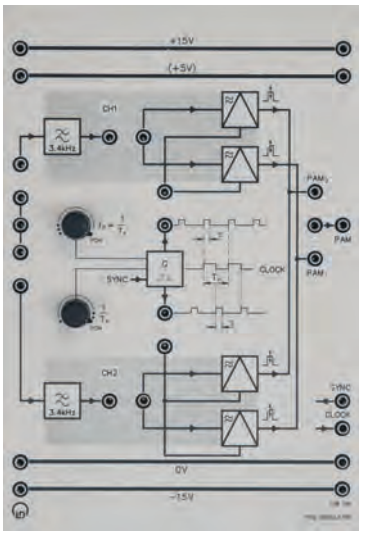
Count	Cat.No	Name
1		PC with Windows XP/Vista/7/8

Additionally required:

- 1 PC with (at least) 4 USB connections, 1GHz, Pentium
- 1 monitor
- (1) printer

The COM3LAB course 735 800 fundamentals of the local and toll exchange requires no Master Unit (700 00USB). The course hardware is directly connected to the PC.

PAM Modulator



Pulse amplitude modulation (PAM) is achieved by sampling an analog signal. It serves as a preliminary stage for generating PCM signals. The sampling procedure itself supplies PAM of the first type (natural PAM). A sample&hold stage is required additionally for generating PAM of the second type. The training panel contains all the units required for setting up a 2-channel time-MUX system:

- 2 x anti-aliasing filters
- 2 x samplers
- 2 x s&h stages
- 1 x multiplex control

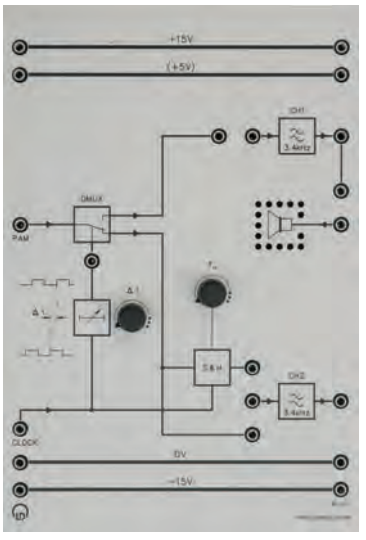
A variable duty cycle and a freely selectable sampling frequency allow practical measurements of pulse sequences. Verification of the sampling theorem after Shannon including a display of oversampling and undersampling. Investigation of multiplex control in 2-channel mode is possible.

Technical Specifications:

- Cut-off-frequency of the low-pass filters: 3,4 kHz
- Sampling frequency: 1 kHz...10 kHz
- Duty cycle: 0,1...0,9
- Input voltage: -10 V...+ 10 V
- Outputs: PAM1, PAM2, clock generator
- Supply voltage: +/- 15 V DC

736 061	PAM Modulator

PAM Demodulator



Due to their spectral characteristics, PAM signals are demodulated with low-pass filters. The duty cycle is often increased in a series-connected sample&hold stage.
The training panel contains all the receiving components required for setting up a 2-channel time-MUX system:

- 2 x low-pass demodulators
- 1 x S&H stage
- 1 x Demultiplex control

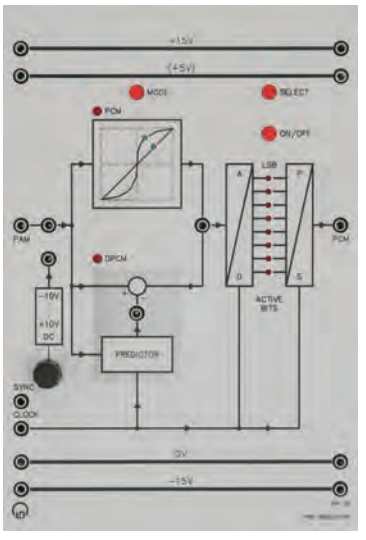
A connectable speaker is integrated to allow an acoustic examination of the effects of sampling.

Technical Specifications:

- Cut-off frequency of the low-pass filters: 3.4 kHz
- Duty cycle: 0.1...0.9
- Input voltage: -10 V...+10 V
- Outputs: Channel 1, channel 2, clock generator
- Supply voltage: ± 15 V DC

736 071	PAM Demodulator

PCM Modulator



The sampled, discrete-time signal is quantized and coded in the PCM modulator. A fully digital (discrete time and value) signal is generated from the analog input signal of the PAM modulator. The PCM modulator allows an investigation of linear and nonlinear quantizing. The training panel also allows an investigation of DPCM (difference pulse code modulation) signals.

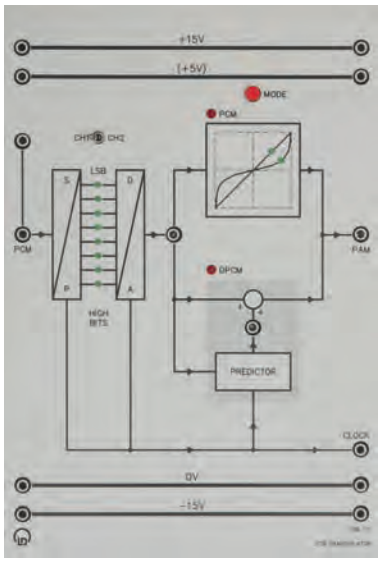
The device contains:

- 8-bit A/D converters
- LEDs for simultaneous display of all active bits
- Parallel/serial converters
- 13-segment compressor
- Predictor
- Clock control
- DC voltage source for coding experiments

Technical Specifications:

- Resolution: max. 8 bits, each bit can be deactivated individually
- Prediction (DPCM): previous sample prediction
- DC voltage source: -10 V...+10 V, with 10-turn potentiometer
- Input voltage: -10 V...+10 V
- Output: TTL level
- Supply voltage: ±15 V DC

736 101	PCM Modulator



PCM Demodulator

The PCM demodulator receives the transmitted data and the clock signal serially via a common data line (transmission channel) from the PCM modulator. The PCM demodulator converts the received data back into a PAM signal. Experiments on companding can be performed together with the compressor of the PCM modulator. The training panel also allows the demodulation of DPCM signals.

The device contains:

- Serial/parallel converters
- LEDs for simultaneous display of the bits set high
- 13-segment expander
- D/A converter
- Predictor

Technical Specifications:

- Prediction (DPCM): previous sample predictions
- Input voltage: TTL level
- Output: -10 V...+10 V
- Supply voltage: ± 15 V DC

736 111	PCM Demodulator

Gunn oscillator

The Gunn oscillator serves to generate microwave power. It has a modular design and can be broken down into the following components:

- Gunn diode module, length approx. 27 mm
- Rear housing wall
- Diaphragm with aperture, 8 mm diameter
- Waveguide adapter, 32 mm

Aluminium Gunn-diode module, Waveguide adapter with LD quick connectors.

Technical Specifications:

- Operating voltage: 8...10 V DC
- Current consumption: approx. 120 mA
- Operating frequency: 9.40 GHz
- Microwave power: > 10 mW, typically 15 mW
- Connection: BNC socket
- Waveguide type: R100

737 01	Gunn oscillator

Gunn Power Supply with SWR Meter

The Gunn power supply delivers the DC and control voltages required for the operation of the Gunn oscillator and PIN modulator and enables the demodulated microwave signal to be quantitatively evaluated. Furthermore, this unit has various inputs and outputs for experiments on modulation and characteristics.

Design: 19" table-top unit with stand.

Technical Specifications:
Gunn Power Supply

- Gunn voltage: - 10 V < U_G < 0 V adjustable via 10-turn potentiometer, short-circuit proof
- Gunn current: max. 200 mA
- Display: 0...10 V, 0...200 mA, LED display for selected scale
- Movement: class 1.5 with mirror scale
- Outputs/inputs:
  - GUNN: DC supply of the Gunn oscillator
  - X/Y: for recording characteristics using an XY recorder
  - DOPPLER OUT: for experiments with Doppler radar
  - MOD IN: for direct modulation of the Gunn oscillator, input signal max. ± 10 V

PIN Modulator

- Clock oscillator: 976 Hz, 0...5 V, 0...10 mA, short-circuit proof
- Outputs/inputs:
  - PIN: toggle switch position determines internal modulation through the clock oscillator or for external modulation
  - MOD: for external modulation of the PIN modulator, input signal max ± 10 V

Homodyne SWR Meter

- Principle: Lock-in detection with internal synchronization through the clock oscillator
- Dynamic range: 0...55 dB can be set in 12 steps, additional 5 dB available via variable gain
- Sensitivity: 1 μV_{rms} for full scale deflection
- Accuracy: ± 0.3 dB over the whole range
- Mid-frequency: 976 Hz
- Bandwidth: 10 Hz
- Display:
  - Power scale: + 0.5 dB...- 20 dB (calibrated in dB for square-law detectors)
  - SWR scale: 1.00...5
  - Linear scale: 0...100 % (0 dB corresponds to 100 %)
  - Movement: class 1.5 with mirror scale
- Inputs/outputs:
  - INPUT: unbiased, impedance 10 kΩ
  - AMP. OUT: DC output for the measurement voltage

Mod

- Inputs/outputs:
  - Input: jointly for ANALOG and TTL, impedance 50 Ω
  - Analog Out: analog signal max. ± 2 V, bandwidth 1 MHz, gain approx. 30
  - TTL Out: TTL level
  - All in-/outputs are connected with BNC sockets
- Mains connect.: 115/230 V, 50 Hz, approx. 20 VA with mains connection cable and earthing-pin plug
- Dimensions: 500 x 330 x 150 mm (L x W x H)
- Weight: approx. 8 kg

737 021	Gunn Power Supply with SWR Meter

PIN Modulator

The microwave signal is amplitude-modulated using the PIN modulator. When limited to a modulation frequency, detection can be carried out in very narrow bandwidths. The effects of noise and interference remain small, the sensitivity of the measurements is improved. The PIN modulator can be used in the linear characteristic range as an analog amplitude modulator and in switching mode for digital modulation.

Design:
Aluminium module with LD quick connectors.

Technical Specifications:
For f_0 = 9.40 GHz:

- Insertion loss a_t: approx. 1 dB
- Back reflection loss a_R: approx. 15 dB
- Operation voltage: 0...1.0 V DC
- Current consumption: 0...10 mA
- Modulation frequency: > 5 MHz
- Connection: BNC socket
- Waveguide type: R100

737 05	PIN Modulator

Unidirectional Line

The isolator (unidirectional line) is one of the nonreciprocal microwave components. Whereas a microwave travelling in the forward direction is subject to practically no attenuation, a wave travelling in the reverse direction is strongly absorbed. This component functions according to the field displacement law and is preferred for the decoupling of the oscillator from the rest of the measurement circuit.

Design: Waveguide built of aluminium.

Technical Specifications:
At f_0 = 9.40 GHz

- Isolation: > 20 dB
- Insertion loss: < 1.5 dB
- SWR: < 1.25
- Waveguide type: R100
- Length: 13 mm
- Weight: 50 g

737 06	Unidirectional Line

Waveguide Detector

The waveguide detector is used for detecting and mixing microwave energy.

Design:
Aluminium module with LD quick connectors. With short-circuit plate and 2 screws.

Technical Specifications:

- Connection: BNC socket
- Waveguide type: R100

737 08	Waveguide Detector

3-Screw Transformer

The 3-screw transformer is used to reduce mismatching, e.g. when matching horn antennas or other loads. It is also important for the generation of arbitrary reflections. As reactive elements the screws carry out the desired impedance transformation. The arrangement of the probes is slightly asymmetrical with respect to the flange planes. This enables better tuning in individual cases.

Design:
Aluminium module with LD quick-release connectors.

On the wide side of a rectangular waveguide there are 3 screws arranged along the centre line at a distance of 3/8 * LAMBDA. The screws act as probes and can be screwed completely into the waveguide. There is an insert nut provided in the base section for mounting a support.

Technical Specifications:

- Frequency range: 8.2 GHz...12.4 GHz
- Waveguide type: R100
- Length: 45 mm
- Weight: 150 g

737 135	3-Screw Transformer

Small Horn Antenna

Horn antenna used as feeding radiator for dish antennas, and for antenna gain measurements.

Design:

- Aluminium, red lacquer finish
- Dimensions (WxHxL): 54x31x39 (mm)
- Frequency range: 8 GHz...12 GHz
- Gain: 10 dB at 10 GHz
- Waveguide type: R100
- Incl. two thumb screws M4

737 20	Small Horn Antenna

Large horn antenna

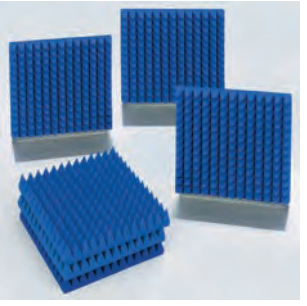
Horn antenna use as feeding radiator for dish antennas, and for antenna gain measurements.

Technical Specifications:

- Frequency range: 8 GHz ... 12 GHz
- Gain: 15 dB at 10 GHz
- Waveguide type: R 100

737 21	Large horn antenna

Set of Microwave Absorbers



When conducting experiments in free space, especially when recording directional diagrams in antenna technology, a reflection-free measurement area is indispensable. With the aid of the absorbers an effectively anechoic chamber can be set-up with very little effort due to the small free space wavelength in the microwave range.

Consisting of:

- 6 absorbers approx. 500 x 500 x 60 (mm)
- 3 of them mounted on metal stands

737 390	Set of Microwave Absorbers

Dish Antenna

The quasi-optical properties of microwaves permit effective beam focusing using reflector antennas. The main reflector of the parabolic antenna can be fed by various primary radiators, e.g. horn antenna, dipoles or yagi antennas. The dish antenna is used in experiments with the rotating antenna platform (737 405) and in microwave radio links (T 7.4.8). Primary radiators are not contained in the equipment set.

Consisting of:

- 1 main reflector, diameter 400 mm, f/D = 0.4
- 1 holder for main reflector with stand for primary radiator
- 1 stand rod 245 mm, M6
- 1 thumb screw M5x40
- 2 thumb screw M6x17

737 452	Dish Antenna

COM3LAB Course: Microwave Technology I

The COM3LAB Course Microwave Technology I gives an introduction into vector analysis. Additionally measurements using the measuring line are carried out. Devices under test are passive UHF circuits in microstrip- and SMD technology.

Topics:

- Display formats for network analysers, Smith chart and Bode plot
- Reference measurements and SOLT calibration
- Pi filters
- Stubs as reactive elements
- Return loss of resistive terminations
- Frequency response of reflection-free termination and mismatch
- The λ /4 stub and the λ /4 transformer
- Matching with open end parallel stub
- Line resonators
- Equivalent circuits and simulation with microwave CAD
- Standing wave effect for different line terminations
- Assessing wavelength through open/short comparison
- Shifting the standing wave by elongation of the line
- Measuring wavelength for different frequencies
- Phase trend in a standing wave
- Wilkinson dividers and resistive dividers
- Insertion loss of power dividers
- Insertion/coupling loss and isolation of the rat race coupler
- Directional coupler investigations (main branch/auxiliary branch)

Virtual laboratory:

- Network analyser
- Bode diagram
- Smith chart

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

Technical Specifications:

- Network analyser
  Frequency range: 260 MHz ... 520 MHz Frequency resolution:10 kHz ... 10 MHz
  Phase resolution: 1°
  Output power: Port 1 approx. +3 dBm (2 mW) Input power: Port 2 max. +17 dBm
  Dynamics: S11 > 25 dB, S21 > 50 dB
  Operating modes: Sweep / CW / Stationary waves / HF circuit
  Evaluations: average values, markers, zoom
  Presentation formats: Bode diagram with separate plots for quantity/phase in Cartesian coordinates. Quantity in lin/log presentation.
  Smith Chart, the circuit diagram with joint
  Display of quantity and phase. Tabular listing of the measured values. Display of complex reflection factor Γ and complex impedence Z.
  Supply voltages: +5 V, +/- 15 V
  Dimensions: 210 mm x 135 mm x 45 mm
  Mass: 400 g
  Power supply: 100-240 VAC, 50/60 Hz
- Attenuator and filter
- Resistive terminations
- Complex terminations
- UHF measuring line
- Power splitter
- Hybrid ring coupler
- Directional coupler
- Ring resonator
- Digital Hand measurement unit

Scope Of Delivery:

Count	Cat.No	Name
1	737 530	Network Analyser
1	737 531	Network Analysis Accessories
1	737 540	Attenuators & Filters
1	737 541	Resistive Terminations
1	737 542	Complex Terminations
1	737 543	UHF Measuring Line
1	737 544	Power Divider
1	737 545	Rat Race Coupler
1	737 546	Directional Coupler
1	737 547	Ring Resonator

- 1 x Mounting panel
- 1 x Case for storage
- 2 x BNC plugs, 50 Ohm
- 6 x HF cables
- 2 x BNC T adapters
- 1 x Multimeter
- 1 x Measuring tape

737 51	COM3LAB Course: Microwave Technology I

Additionally required:

Count	Cat.No	Name
1		PC with Windows XP/Vista/7/8

COM3LAB Course: Microwave Technology II

Supplementary course to 737 51 COM3LAB Course Microwave Technology I. The equipment set gives insight into active microwave components and a ferrite element.

Topics:

- Determining the resonance of rod antennas
- Insertion loss and stop band attenuation of the circulator
- Circulator bandwidth
- Short-circuited parallel stubs
- Transformation behaviour of long lines
- Attenuation of coaxial lines
- Frequency dependency of line attenuation
- Calculation of dielectric constants from phase measurements
- Gain and return loss of an MMIC amplifier
- SPST and SPDT switches with PIN diodes
- PIN diode switching behaviour
- Microwave transmission links
- U/f and f/U converter characteristics
- Capture range of the superhet

Virtual lab:

- Network analyser
- Bode diagram
- Smith diagram

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

Technical Specifications:

- 1 UHF aerials
- 1 3gate circulator
- 1 MMIC amplifier +10 dB
- 1 VCO
- 1 UHF Superhet receiver
- 1 HF circuit

Scope Of Delivery:

Count	Cat.No	Name
2	562 791	Plug-in power supply, 12 V AC
1	737 548	UHF Antennas
1	737 549	3 Port Circulator
1	737 550	MMIC Amplifier +10 dB
1	737 551	VCO
1	737 552	UHF Superhet Receiver
1	737 553	RF Switch

- 2 plug-in power supply units 230/12 VAC
- Telescopic aerials

737 52	COM3LAB Course: Microwave Technology II

Additionally required:

Count	Cat.No	Name
1	737 51	COM3LAB Course: Microwave Technology I
1		PC with Windows XP/Vista/7/8

Network Analyser

For automatic testing and the PC based representation of vector S-Parameters of one and multiport devices.

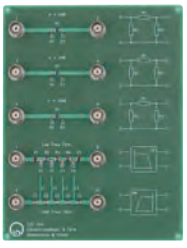
- Frequency range: (250...500) MHz
- Incl. control- & evaluation software. With plug-in unit: 230 V / 12 V, 1600 mA, 50 Hz.
- PC necessary.

737 530	Network Analyser

Network Analysis Accessories

The accessories set comprises:
1x Mounting panel 737 5311
1x Calibration board 737 5312
1x Plug box NWA 524 079
2x BNC termination, 50 Ohm
4x Coax-cables, BNC male / male, L = 0,25 m
1x Coax-cables, BNC male / male, L = 1 m
1x Coax-cables, BNC male / male, L = 2 m
2x BNC-T connectors
1x Autorange Multimeter
1x Ruler

737 531	Network Analysis Accessories



Attenuators & Filters

Unit containing fixed attenuators in pi configuration with 3/6/10 dB as well as a low pass filter and a high pass filter of higher order.

737 540	Attenuators & Filters

Resistive Terminations

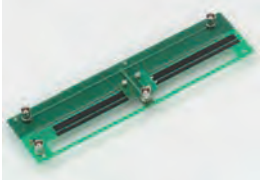
For investigation of matching this unit contains different resistive loads (ohmic terminations) as well as lambda/4-stub and lambda/4-transformer.

737 541	Resistive Terminations

Complex Terminations

The unit contains an ohmic load (2R) matched by an open stub, a capacitive coupled line resonator (2 line sections) and a complex test load (RC).

737 542	Complex Terminations



UHF Measuring Line

Measuring line with integrated displacement transducer for investigation of mismatching in the UHF range. Printed cm scale for step to step measurements. For operation the NWA Box of „Network Analysis Accessories" (737 531) is required. Measuring range: 30 cm

737 543	UHF Measuring Line

Power Divider

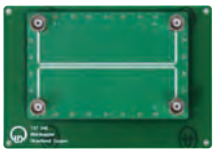
Power dividers are used to split incident RF power into several outputs and vice versa. The unit comprises 2 different splitters: a Wilkinson and a resistive power divider.

737 544	Power Divider

Rat Race Coupler

Device used for decoupling of UHF components. Includes ground plane for telescope antenna.

737 545	Rat Race Coupler



Directional Coupler

Device used for the separation of outgoing and reflected waves in reflectometers as well as probing RF power.

737 546	Directional Coupler

Ring Resonator

Resonator in form of a closed microstrip loop.

737 547	Ring Resonator

UHF Antennas

Set of UHF antennas comprising a telescopic antenna with BNC plug and a telescopic antenna with 4mm plug.
Operating frequency: 200 MHz -500 MHz.

737 548	UHF Antennas

3 Port Circulator

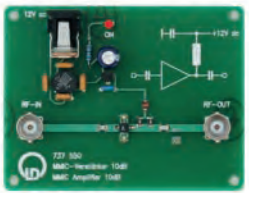
Circulators are nonreciprocal components. Their function is ruled by anisotropic properties of ferrite materials. Circulators are used for decoupling microwave loads and sources.

737 549	3 Port Circulator

MMIC Amplifier +10 dB

UHF-amplifier for use in UHF- and microstrip circuits. Gain:+10 dB
Max. output power: 50 mW

737 550	MMIC Amplifier +10 dB



VCO

UHF Oscillator with modulation input (VCO) and V/f converter used for the transmission of measuring voltages.
Centre frequency: 433.92 MHz
Power: > 5 dBm

737 551	VCO

UHF Superhet Receiver

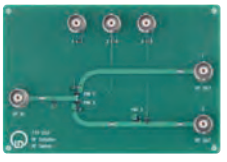
UHF Superhet Receiver used for reception of signals from 737551 VCO.
Input frequency: 433.92 MHz

737 552	UHF Superhet Receiver

RF Switch

With PIN diodes in serial and parallel configuration it is possible to realise different types of switches (SPST and SPDT). Insertion - and isolation losses are compared as function of the control current.

737 553	RF Switch



COM3LAB Course: Radar Technology I

The course COM3LAB Radar Technology I works with a mono-static ultrasonic radar.

Topics:

- Distance measurement
- Echo representation
- Delay measurements
- Scattering areas
- Tracking,
- Target suppression
- Representation of mobile targets
- Detection of noncooperative / cooperative targets and stealth.

The system works with a PC-controlled base station with current Bluetooth Wireless data transfer.

Virtual lab:

- Binary close echo attenuation (STC) with close / far range
- Discriminator fire control radar with optical / acoustic lost / found detector

The hardware is connected to the PC via Bluetooth. Course content, experiment instructions and tasks are taught via a course-specific software.

Technical Specifications:

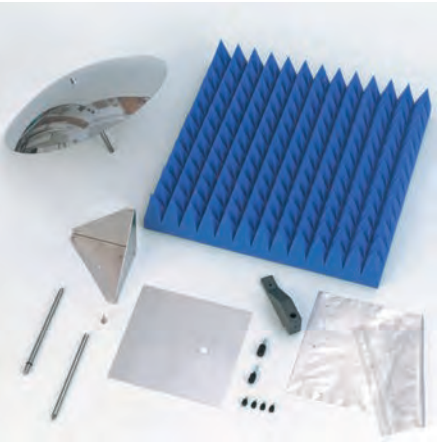
- **Principle**
  Monostatic ultrasonic pulse sonar
- **Radar type**
  Incoherent radar on multiprocessor basis,
  Carrier frequency: 40 kHz, ADC sampling rate: 20 kHz,
  Range > 10 m, Distance resolution < 1 cm,
  Data transmission: Bluetooth
  Transmitter pulse power: 120 dBSPL
  Receiver echo resolution: max. 500 measuring points Echo quantisation: 17 Bit
  Duplexer: PC-controlled
  Gate generator: Pulse control factor 1 % Number of carrier fluctuations adjustable: n = 1...32
  Logarithmic amplifying dynamic: > 100 dB
- **Radar aerial**
  Parabol, 400 mm, 29 dB, Aerial resolver with angle resolution: 0.5°/1°/2°
- **Display mode / display units**
  Radar image processor with binary target extractor
  A scope: Logarithmic 0...-100dB
  Linear 100% ...0,001%
  PPI:
  Classic with decision threshold
  Digital: colour-coded echo amplitude measurement
  PPI plot with offset display and echo zoom PPI display: monochrome, colour
- **Primary radar (PR)**
  Operating modes: Tracking, Scanning (Sector Scan, Full Scan), manual positioning
- **Secondary radar (SSR)**
  Transponder with automatic switch-off delay (15 min) Operating modes: Radar beacon, Friend/foe recognition (IFF). Editable transponder list with flight data simulator for flight height, direction, speed
- **Collision prevention:**
  TCAS with two-zone monitor tracking

Scope Of Delivery:

- 1 Sonar Base 737 605
- 1 Sonar Pulse Generator 737 606
- 1 Set passive targets 737 610
- 2 Transponders 737 620
- 2 Camera tripods 300 59
- 2 Storage trays 240x460x80 mm
- 5 Partitions ZW 24
- Incl. power supply, battery charger, cable, accessories and multimedia CBT program.

737 60	COM3LAB Course: Radar Technology I

Passive targets, set



Passive reflectors, scatterers and absorbers of different geometrical form and radar cross section for investigations in radar and antenna systems.

The equipment includes:

- 1 x corner reflector, edge length approx. 180 mm
- 1 x square reflector approx. 200x200
- 1 x spherical reflector (segment) diameter approx. 370 mm
- 1 x absorber record 500x500x100
- 1 x plastic bag, DIN A4
- 2 x holder for reflectors
- 1 x pencil with record
- 1 x stand rod 180 mm, M6
- 1 x stand rod 205 mm, M6
- 4 x knurled-head screw M4
- 1 x knurled-head screw M5
- 1 x knurled-head screw M6

737 610	Passive targets, set

Doppler Converter

For the supply of the Doppler module. The Doppler module (radar transmitter / receiver) consists of the Gunn Oscillator 737 01 with horn antenna. The Doppler converter generates a Doppler signal by mixing the transmitter's output signal with the backscattered echo from the target. The Doppler signal is filtered and downconverted into the baseband. The analysis of the Doppler signal in the time- and frequency domain can be performed using the Sensor-CASSY. The Doppler converter is optimised for experiments with the track and trolley for low speeds typical in laboratory environments.

Contains:

- 1 x Doppler converter
- 4 x Stand rod 245 mm, M6

Technical Specifications:

- Supply voltage: 12 VAC
- Gunn supply: 8 V, 150 mA
- Doppler output: 5... 500 Hz

737 615	Doppler Converter

MTI simulator

The MTI simulator consists of a Doppler target and a target control. It allows the quantitative investigation of Doppler radar experiments with a stationary Doppler target. The Doppler target contains a metal membrane which is able to vibrate with a backscatter area of approx. 0.2m^2. The radar signals reflected by the Doppler target cover a frequency range corresponding to typical speeds of moving targets in laboratory experiments. Three speed ranges can be set:
0,8 cm/s ... 8 cm/s
8 cm/s ... 80 cm/s
80 cm/s ... 8 m/s

The target control includes fine adjusters for matching the frequency and the amplitude.

Target frequency: 5 Hz... 500 Hz
Membrane amplitude: ca. 5 mm
Radar cross section: 0,2 m² for f=9.40GHz
Supply voltage: 12V AC

Dimensions:
Target control: 115mm x 115mm x 60mm
Doppler target: diameter 150mm, length ca. 315mm

Mass:
Target control: ca. 300g
Doppler target: ca. 1000g

Contains:
1x Doppler target
1x Target control unit
1x Stand rod 215 mm, M6

737 630	MTI simulator

COM3LAB Course: Radar Technology II

The course COM3LAB Radar Technology II works with a X-band microwave source. It examines the principles and applications of the Doppler effect by measurements in the time- and frequency domain (FFT analysis of the Doppler spectrum in the base tape).

Topics:

- Approach detector (Intrusion Detection)
- Speedometer
- Door opener
- Damping of electromagnetic waves

Technical Specifications:

- 1 Gunn oscillator
- 1 Large horn aerial
- 1 Set of passive targets
- 1 Doppler converter
- 1 MTI simulator
- 1 Set of nep absorbers

Scope Of Delivery:

Count	Cat.No	Name
2	562 791	Plug-in power supply, 12 V AC
2	648 07	Storage tray S24-FN
5	648 08	Partition ZW 24
1	737 01	Gunn oscillator
1	737 21	Large horn antenna
1	737 390	Set of Microwave Absorbers
1	737 610	Passive targets, set
1	737 615	Doppler Converter
1	737 630	MTI simulator

- 2 Plug-in power supply units 230 V / 12 V AC
- 2 storage trays (240x460x80) mm
- 5 partitions ZW 24

737 65	COM3LAB Course: Radar Technology II

additionally required:

Count	Cat.No	Name
1		PC with Windows XP/Vista/7/8

LIT: E2.2.2.0 DC Machines 0.3 (German)

775 190DE	LIT: E2.2.2.0 DC Machines 0.3 (German)

COM3LAB

INDEX

IN ALPHABETICAL ORDER

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TECHNICAL SERVICE AND CONSULTING

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We would be delighted to check your new equipment on site for completeness and functionality. We can either take on the whole task of installation for you or our specialists can commission the devices and systems that you have already installed on site yourselves. We would, of course, be delighted to conduct one or more tests together with you and to explain in detail the functions of each individual device.

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REPAIR GUARANTEE FOR A MINIMUM OF 10 YEARS

Our products stand for high quality and durability. If your device should become faulty even many years after purchase, generally we will still be able to repair it. We guarantee the repair of all our devices for 10 years from the date of purchase – and for much of our products, for much longer.

PHYSICS CHEMISTRY BIOLOGY ENGINEERING

LD DIDACTIC

GENERAL TERMS AND CONDITIONS OF SALE

as of: 09.01.2012

1. General

1.1 The following terms of sale apply exclusively for all deliveries, services and offers made by LD Didactic GmbH (hereinafter: LD) with respect to entrepreneurs, legal entities under public law or public separate assets (hereinafter: buyer). An entrepreneur is any natural or legal person exercising his/her commercial or independent occupational interests by concluding a legal transaction. Buyer conditions which are contrary to, or deviate from, these terms of sale are only recognized if they have been given express consent. The buyer's general terms of business shall also not be deemed applicable even though these General Terms and Conditions provide no applicable stipulation, are incomplete or ineffective.

1.2 These terms and conditions of sale shall also apply to all future business with the buyer to the extent they represent legal transactions of a related nature, even then when they have not again been expressly agreed.

2. Offer and acceptance period

2.1 Offers made by LD are subject to change and non-binding. An agreement between LD and the buyer materializes only then when LD accepts the buyer's order.

2.2 LD reserves the right to accept buyer orders within a period of three weeks after receipt of the buyer's order. With acceptance of the offer a binding contract is concluded.

3. Scope of performance

3.1 The quality as stated in the order confirmation (performance specification) is completely and finally determinant for the characteristics of the subject of delivery. In particular, the general public statements made by LD or the statements made by a supplier, his vicarious agents or any third party do not represent any supplementary or modifying description of the delivery subject.

3.2 Details contained in catalogues, brochures and quotation documents are non-binding to the extent they are not explicitly designated as binding.

3.3 In individual cases LD is entitled to structural modifications and the use of different materials when these measures are not adverse to any buyer interests meriting protection.

3.4 LD retains the property and proprietary rights to all documents furnished in conjunction with the buyer's order; such as calculations, drawings and so forth. These documents may not be made available to third parties without the written consent of LD.

3.5 Upon request, all documents which were furnished by LD shall be returned without delay. It shall not be necessary to request the return of such documents in the event the order is not issued to LD or LD declines order confirmation.

4. Pricing and terms of delivery

4.1 Prices shall be understood to be ex-works (INCOTERMS 2000). Installation and commissioning as well as additional deliveries and services will be additionally charged at cost price.

4.2 For orders delivered within Germany, shipping charges will be waived if the order amount equals or exceeds €150. For orders delivered within Germany amounting to less than €150, a flat rate of €15 net for shipping and handling will apply.

4.3 It should be noted that for foreign orders (i.e. outside Germany), the shipment to foreign delivery addresses and bank transfers for payment may result in additional taxes or costs which are not collected by LD or placed in the invoice.

4.4 LD shall additionally charge transaction taxes (turnover tax, etc.) in accordance with the given effective legal regulations.

4.5 Notwithstanding an express agreement to the contrary, LD shall, at the buyer's expense, insure ordered goods against the standard transport risks, including damage by breakage. Insofar as assembly, assembly supervision or commissioning is to be performed, the relevant LD terms and conditions shall apply additionally.

5. Transfer of risk

5.1 Upon contractual delivery, the risk of accidental deterioration or accidental destruction shall pass to the buyer.

5.2 In the event of a sale to destination according to buyer's instructions, the risk of accidental loss or deterioration shall pass to the buyer along with transfer to the person responsible for transport but not later than departure of the goods from the plant/warehouse. This also applies in the case of partial deliveries and when LD has assumed responsibility for other services.

5.3 If shipping is delayed due to circumstances for which LD is not responsible, the risk shall pass to the buyer when he is notified the delivery is ready for shipment.

6. Terms of delivery

6.1 Delivery dates or periods can be agreed in writing as binding or non-binding. Disregard for the written form has no influence on the effectiveness of the agreement. LD may exceed non-binding delivery periods by up to six weeks. LD is only in delay of performance after the six week grace period if a reminder is received from the buyer. If subsequent order changes are agreed then a new delivery date must also be agreed. Otherwise the delivery period shall be deemed extended for a reasonable amount of time.

6.2 The delivery period only begins after all commercial and technical prerequisites for executing the order have been clarified with the buyer, any documents to be procured by the buyer have been received by LD, any necessary permits and releases have been issued, and agreed advance payments have been credited to an LD bank account. The delivery deadline shall be deemed met when, up to its expiration – providing the buyer has fulfilled the above contractual obligations – the delivery item is turned over to the first carrier or the buyer has been advised the delivery is ready for shipment. Partial deliveries shall be admissible unless they are of no interest to the buyer. Delivered items, even when they exhibit minor defects, are to be accepted by the buyer; the delivery deadlines are thus deemed as met.

6.3 Delivery and performance delays due to Acts of God, natural catastrophes or because of blameless work conflicts, blameless transportation or business disturbances, blameless material defects, export permits not issued, and similar grounds at LD and/or its suppliers entitle LD to rescind the order completely or in part or to postpone the delivery deadline until the cause of delay has been alleviated – but not longer than two months – without recourse for the buyer against LD for neglect of duty. The buyer is entitled to withdraw from the order if the aforementioned grounds persist for longer than two months. The buyer remains free to exercise his legal rights of cancellation at an earlier point in time – for instance due to frustration of contract or blameless impossibility of performance on the part of LD.

7. Terms of payment

7.1 The net invoice amount is payable, without any discount, immediately upon receipt of invoice unless another payment period has been explicitly agreed. Partial deliveries shall entitle LD to invoice the respective partial delivery.

7.2 If the order purchase price is over €20,000 the buyer shall make a down payment equal to 50 % of the purchase price. If the order purchase price is over €50,000 the buyer shall make full payment in advance.

7.3 The buyer is in default, without reminder, 14 days after the due date of LD entitlement and receipt of the invoice or delivery. In the event of default, LD is entitled, to demand interest at a rate of eight percentage points over the base interest rate of the European Central Bank. Proof of even higher damages incurred by LD is permissible anytime. The buyer is at liberty to prove the damages incurred by LD were lower.

7.4 Payments shall be effected exclusively to one of the appointed LD payment offices. They are to be effected on the date due on a postage- and expense-free basis without any deductions. Charges, expenses or other costs which may be incurred by LD in consequence of a separately agreed acceptance of bill of exchanges or checks shall be debited to the buyer. For payments of any kind, the day upon which LD is able to dispose over the amount in question shall be deemed the date of performance.

7.5 Offsetting balances and rights of lien may only be asserted with indisputable or legally established counterclaims.

7.6 LD is entitled to assign its claims against a buyer arising from a contract relationship in advance and/or subsequently, in particular for financing purposes.

8. Retention of title

8.1 Delivered items remain the property of LD until such time as all liabilities arising from the business relationship, including future or conditional claims, have been settled in full. In the event the buyer defaults on payment, LD is entitled to repossess the delivery item at issue (hereinafter: conditional commodity) without issuing a payment reminder demand. Insofar as the validity of retention of title is subject to mandatory special or legal prerequisites, the buyer shall ensure they are fulfilled.

8.2 To the extent he is not in default, the buyer shall be entitled dispose over the delivery item in the ordinary course of business. Claims which accrue to the buyer during the period of retention of title on the basis of resale or other legal grounds (including all balance receivables in current accounts) shall irrevocably be ceded in full amount to LD in advance as a form of security. Subject to revocation by LD, the buyer is empowered to collect such claims on a trust basis.

8.3 At the request of the buyer, LD shall undertake to release securities to which it is entitled, provided the value of such securities exceeds the unsettled claims to be secured by more than ten one-hundredths.

8.4 The buyer shall process and treat the delivery item on behalf of LD without giving rise to any obligation on the part of LD. If the delivery item is treated or combined, mixed or blended with objects which do not belong to LD (§§ 947 et seq. German Civil Code), LD shall be entitled to a co-ownership share in the new object at the ratio of the value of the delivery item to the other processed goods at the point in time before they were treated, combined mixed or blended. If the buyer acquires sole ownership pursuant to law, he hereby grants LD an appropriate co-ownership share or preserves the object for LD to this end. The provisions contained in item 8 also apply respectively to such co-ownership share.

8.5 The buyer shall immediately inform LD about any levy of distress or third party seizures with respect to the conditional commodities.

8.6 During retention of title, the buyer is obliged to adequately insure the delivery item at his own expense against theft, breakage, fire and water damage and, at the request of LD, furnish evidence to this effect. In the requested evidence is not presented within a reasonable period, LD shall be entitled to insure the delivered item at the expense of the buyer.

9. Warranty

9.1 For defects in the delivery item detected prior to the transfer of risk, LD is, at its own option, entitled to either rectify such defects or make a replacement delivery (supplementary performance). The buyer shall bear the cost of return shipment for the defective item insofar as this cost is not disproportionate to the value of the item.

9.2 If supplementary performance proves to be unsuccessful, the buyer is entitled to request cancellation of sale or reduction of purchase price without prejudice to potential damage compensation claims. Supplementary performance is deemed to have failed when the defect has not been remedied after the third supplementary performance attempt.

9.3 Notification about defects must be made upon delivery without delay. Notification about hidden defects shall take place promptly after their discovery. Such notifications shall state which defects have been detected and whether they were noticed immediately or only after further processing of the parts at issue. LD is entitled to have their own personnel inspect the deficiency.

9.4 When a claim for damage compensation is not involved, defect claims become time-barred after 24 months for users and after 12 months for companies, both stated periods beginning with delivery of the goods. Claims for damage compensation as a consequence of redhibitory defects lapse 12 months after delivery of the goods except in cases of personal injury damages, deliberate neglect of duty or gross neglect of duty. The statutory limit for legal claims under a right of recourse remains unaffected.

9.5 The buyer does not have the right to withdraw from contract except in the case of neglect of duty for which LD is blameless. The right of termination pursuant to § 649 German Civil Code remains unaffected. If LD is to carry out an adaptation of performance in order to comply with the buyer's order requirements (contract for work), the buyer must provide adequate compensation if he chooses to withdraw from the contract by termination. The amount of compensation shall be commensurate with the necessary overhead already exerted at the point in time the declaration of withdrawal is made, maximum compensation being the agreed contract price. The purchaser is at liberty to prove that less overhead was incurred.

10. Liability for usage other than originally intended

10.1 None of the products sold by LD are intended for private consumers (private end users) but rather intended exclusively for use in educational institutions such as general and vocational schools, technical colleges, universities, private or public training centers and industrial operations (intended use).

10.2 If the buyer allows third-party private usage of the goods, either occasionally or continuously, regardless of the manner or lawful reason then the buyer has abandoned intended use.

10.3 In this case the buyer releases LD from all contractual or legal obligations, claims and duties, including claims under the product liability law, that were associated with original intended use.

11. Liability for property right infringements

11.1 Insofar as LD makes no special notification, the delivery item is deemed to be free of third party property rights with respect to awareness of state-of-the-art technology in the Federal Republic of Germany. However, if the delivery item or a part of the same should, at the point in time of contract conclusion, infringe on a property right which has already been issued and published in the Federal Republic of Germany, or if the delivery item explicitly incorporates a particular protected procedural right or infringes on a corresponding procedural right, and consequently results in the instigation of legal proceedings against the buyer then, at its own option and within a reasonable period, LD shall either obtain for the buyer the right of continued utilization, modify the delivery item, part or procedure such that an infringement of third-party rights no longer exists, or withdraw from the contract. LD does not accept any further liability, particularly for procedures, applications and products, etc. Claims against LD for liability due to property right infringements are limited to foreseeable damages.

11.2 In the event third-party property rights are infringed upon by drawings or details furnished by the buyer, the buyer shall be responsible for such infringement and indemnify LD against claim.

12. Repairs

Repairs and returns will be handled by LD exclusively under the following conditions. LD does not recognize any deviating buyer conditions.

12.1. Order / cost estimate / repair

12.1.1 LD will perform repairs only after receiving a written order.

12.1.2 LD will issue an order confirmation for the device received.

12.1.3 Cost estimates will only be created at the express request of the ordering party. A cost estimate lump-sum fee of 51.00 Euro will be levied for devices having a replacement value less than 500.00 Euro and 151.00 Euro when replacement value is over 500,00 Euro. When a repair order is issued the cost estimate lump-sum fee will be waived.

12.1.4 Repairs made under guarantee will only be performed if a completely filled out return form accompanies the repair return shipment. In this case, the established General Standard Terms and Conditions shall apply.

12.1.5 Necessitated by organisational grounds, LD reserves the right to delegate repair work to an LD authorized contract workshop.

12.1.6 Repair orders are accepted subject to the procurement of replacement parts.

12.2. Shipment

12.2.1 If an order is not placed within one month of the date when the cost estimate is issued, the device will be returned without repair.

12.2.2 Incurred shipping charges for devices returned without repair, when neither a cost estimate nor a repair order has been issued, shall be borne by the recipient.

12.2.3 Return shipment of all devices is carried out at the expense and risk of the customer. On request, LD will insure the device against transport damage and loss at the customer's expense. If transport damage or breakage is determined, application is to be made to the carrier for an assessment of facts. Entitlement to claims for damage will otherwise be lost. 12.3 Defect claims and liability

12.3.1 Repair service defects apparent within a period of limitation which were already present prior to the transfer of risk will be reworked by LD within a reasonable time at no charge.

12.3.2 If the rework fails, the buyer can withdraw from the contract or reduce remuneration.

12.3.3 Entitlement to make defect claims expires 12 months after acceptance.

12.3.4 After the transfer of risk, there is no entitlement to defect claims for normal wear, for damage ensuing from excessive stresses, for unsuitable equipment or for damage due to exceptional external influences for which the contract has no provisions.

12.3.5 If the buyer or third parties make unauthorized modifications or repairs then there shall be no recourse to defect claims arising from these or any consequences thereof.

12.3.6 Buyer claims for damage and reimbursement of expenses are excluded, regardless of legal grounds, but in particular with respect to pre-contractual breach of duty, breach of duty arising from indebtedness and tortuous liability. This does not apply insofar as liability is mandatory, e.g. in cases of intent and gross neglect, with respect to harm of life, limb or health and for violation of essential contract obligations. However, damage claim compensation for violation of essential contract obligations is limited to contract-typical foreseeable damages insofar as intent or gross negligence is not given.
The above provisions do not imply a change in the burden of proof to the detriment of the buyer.

12.3.7 No liability is accepted for consumables included with delivery, such as film material, batteries, etc.

13. Other liabilities / liability exclusions

13.1 With respect to breaches of contractual and extra-contractual obligations, particularly due to impossibility, delay, and tortuous trade, LD – and/or its vicarious agents – shall be liable only in cases of intent and gross negligence, limited to contract-typical damage foreseeable when the contract was concluded.

13.2 These limitations do not apply for culpable breach of essential contractual obligations by LD, if fulfilment of the purpose of the contract is endangered, in cases of mandatory liability under the product liability law, by harm to life, limb or health (personal injury), and also not then when LD has deceitfully concealed defects or guaranteed their absence. The rules of burden of proof remain unaffected by this. Essential contract obligations are those LD obligations that enable proper execution of the contract in the first place and on whose observance the buyer can generally expect to have trust.

14. Place of performance, jurisdiction, severability clause

14.1 The place of performance shall be Hürth, Germany, unless specified to the contrary in the order confirmation.

14.2 The place of jurisdiction is that of the business headquarters for LD Didactic GmbH, currently Hürth, Germany.

14.3. Should a provision of these Terms and Conditions or a condition in the context of other agreements be or become invalid, this shall not impair the validity of all remaining provisions or agreements.

15. Applicable law

The laws of the Federal Republic of Germany shall apply. The application of the standard UN Convention on Contracts for the International Sale of Goods (CISG) is excluded.

Note pursuant to the Federal Data Protection Act LD stores and processes customer data.

LD Didactic GmbH

GENERAL INFORMATION

Customer desk	+ (49) 22 33 / 604 – 430
	Order processing
	Available Mon.-Thur. from 8.00 am- 4.00 pm and Fr. from 8.00 am - 2.45 pm
Order fax	+ (49) 22 33 / 604 - 193
Help-Line	+ (49) 22 33 / 604 - 301
	Technical support for queries, advice on equipment or experiments
	Available Tues. from 10.00 am - 12.00 pm and Thur. from 2.00 pm - 4.00 pm
E-mail	info@ld-didactic.de
Internet	WWW.LD-DIDACTIC.COM WWW.LEYBOLD-SHOP.COM

INFORMATION CONCERNING TENDERS

Your contact partners Mr. Kattwinkel and Mr. Schilling are at your disposal from Mon.-Thur. from 8.00 am to 4.00 pm and Fr. 8.00 am to 2.45 pm.

Contact data:

Achim Kattwinkel
Telefon + (49) 22 33 / 604 - 272
E-mail akattwinkel@ld-didactic.de

Hans Peter Schilling
Telefon + (49) 22 33 / 604 - 305
E-mail pschilling@ld-didactic.de

TECHNICAL SERVICE

Should you have any questions regarding a component or an equipment set: Our service team is at your disposal by phone at + (49) 22 33 604 - 430 and per E-mail under service@ld-didactic.de.

YOUR PERSONAL TECHNICAL ADVISOR

You can find the contact data of the technical advisor you need on our internet page.

PHYSICS
CHEMISTRY
BIOLOGY
ENGINEERING

LD DIDACTIC

1308012 06.2014 LD
Technical details subject to change without notice

CONTACT

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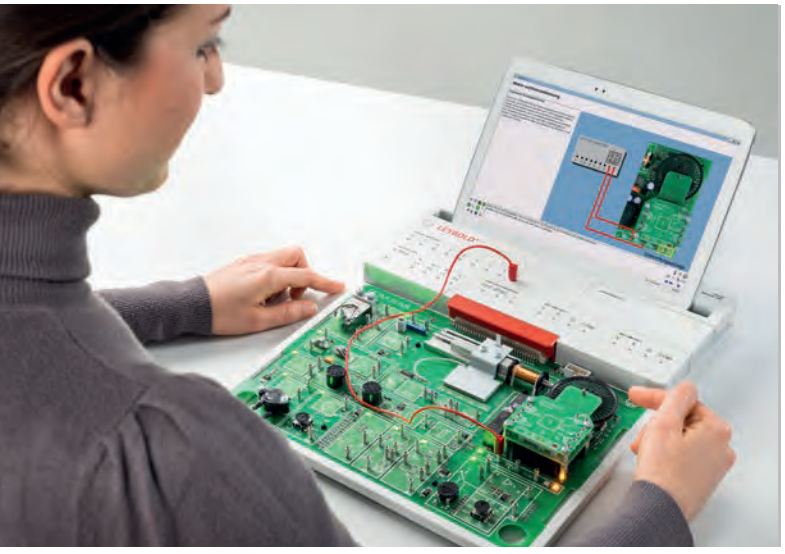
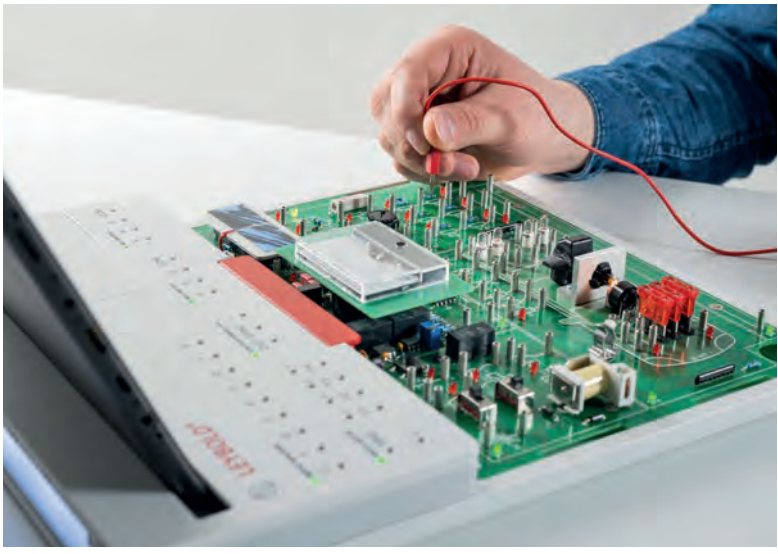
Fax: +49 2233 604 222
Email: info@ld-didactic.de
www.ld-didactic.com





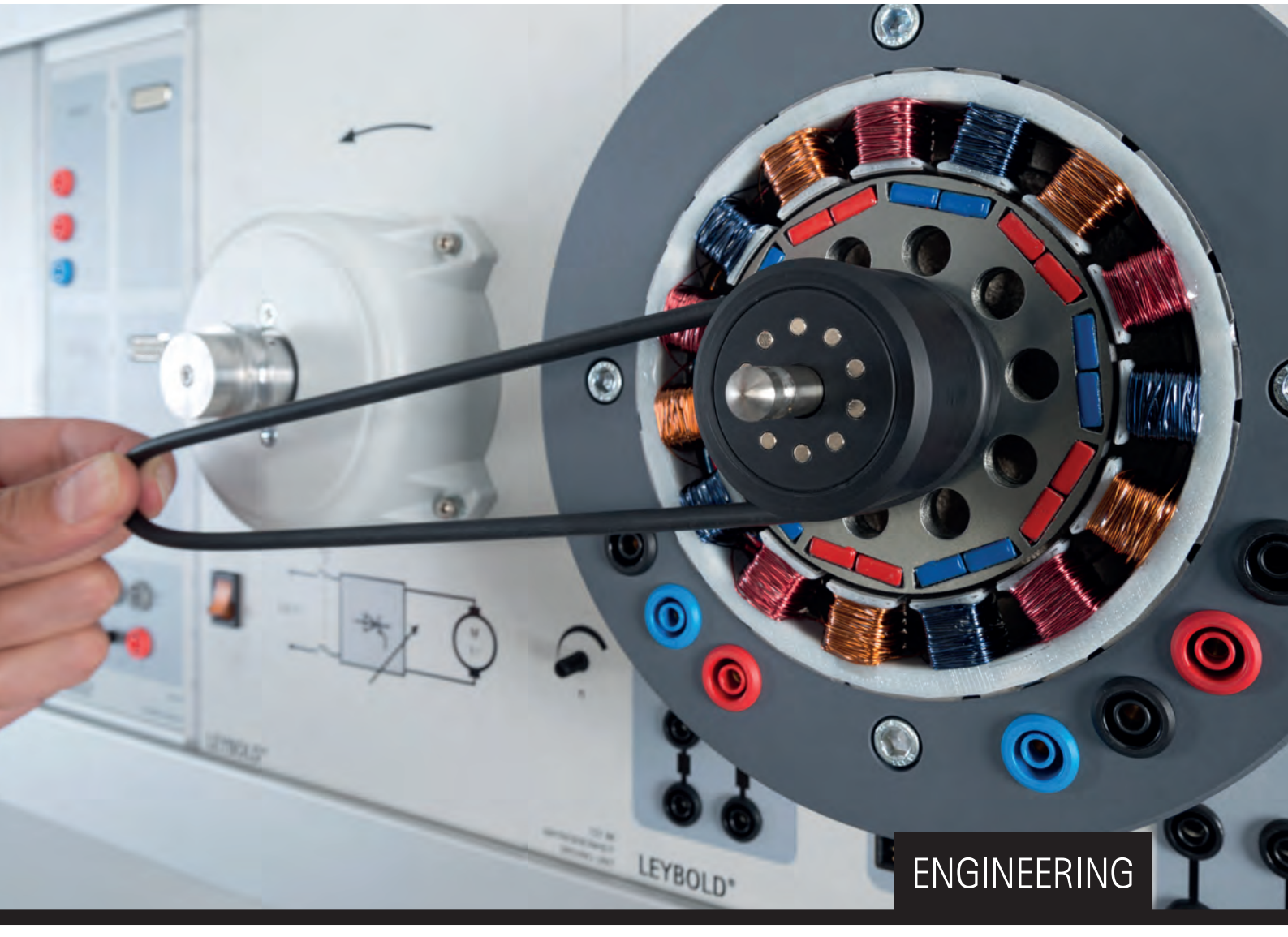
WWW.LD-DIDACTIC.COM

BRANDS OF THE LD DIDACTIC GROUP

LEYBOLD® Feedback ELWE® TECHNIK

LEYBOLD®

ELECTRICAL DRIVES



ENGINEERING

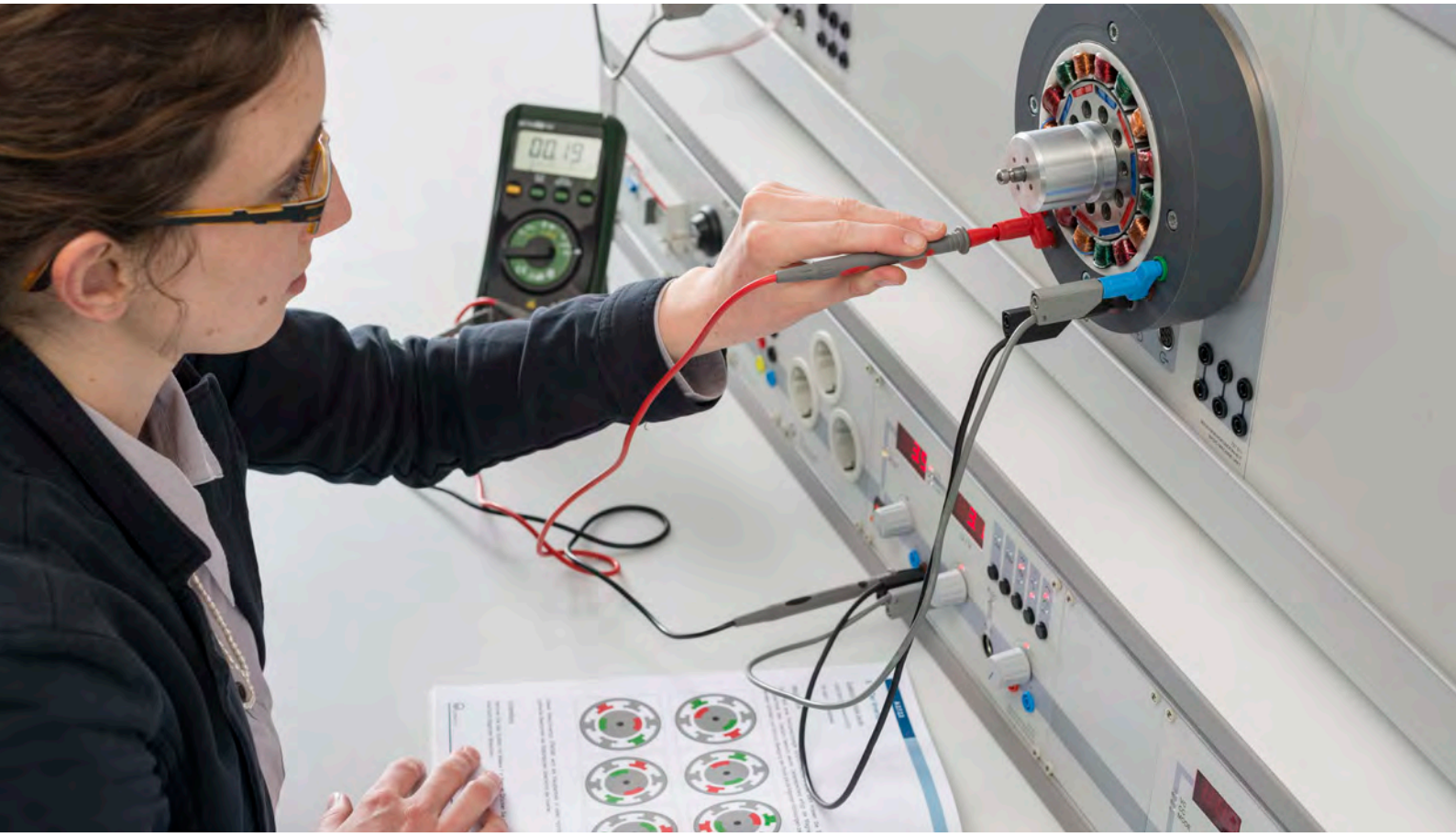
SYSTEMS FOR EDUCATION AND VOCATIONAL TRAINING

- Electrical machines
- Power electronics
- Drive and servo technology

LD DIDACTIC

ELECTRICAL DRIVES

TRAINING SYSTEMS FOR VOCATIONAL AND ADVANCED TRAINING



Use LEYBOLD training systems to impart to your students and trainees a multitude of training subjects in the areas of automotive, electrical engineering as well renewable energy technology. Our educationally-designed equipment and systems for technical vocational training combine theory and practical applications in an ideal manner and can be integrated perfectly into project work.

In this catalogue we will be presenting our training systems from the drive technology area. You are at the right address when it comes to obtaining customised solutions for your technology and workshop laboratory, designed especially for specific fields of training.

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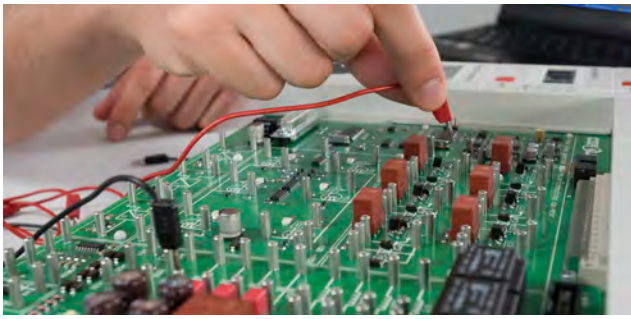

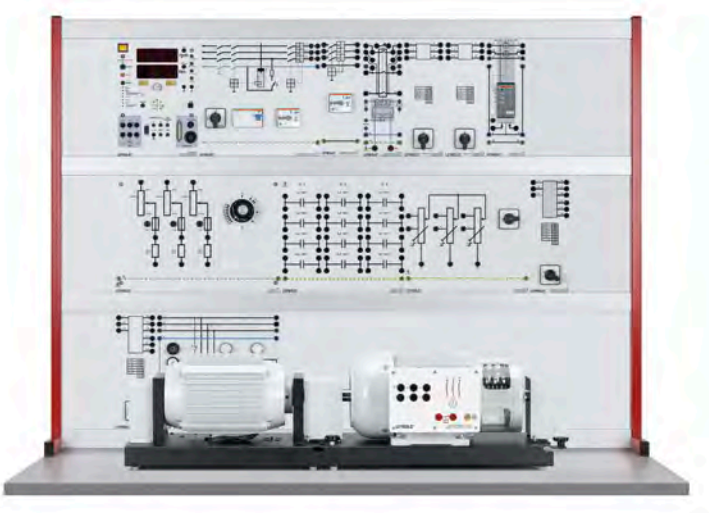

EQUIPMENT SETS ACCORDING TO TOPIC

COMPLETE EQUIPMENT SETS TAILORED TO THE TRAINING CONTENT CAN BE FOUND

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INDIVIDUAL COMPONENTS

TECHNICAL DETAILS ON INDIVIDUAL COMPONENTS IN EQUIPMENT SETS CAN BE FOUND

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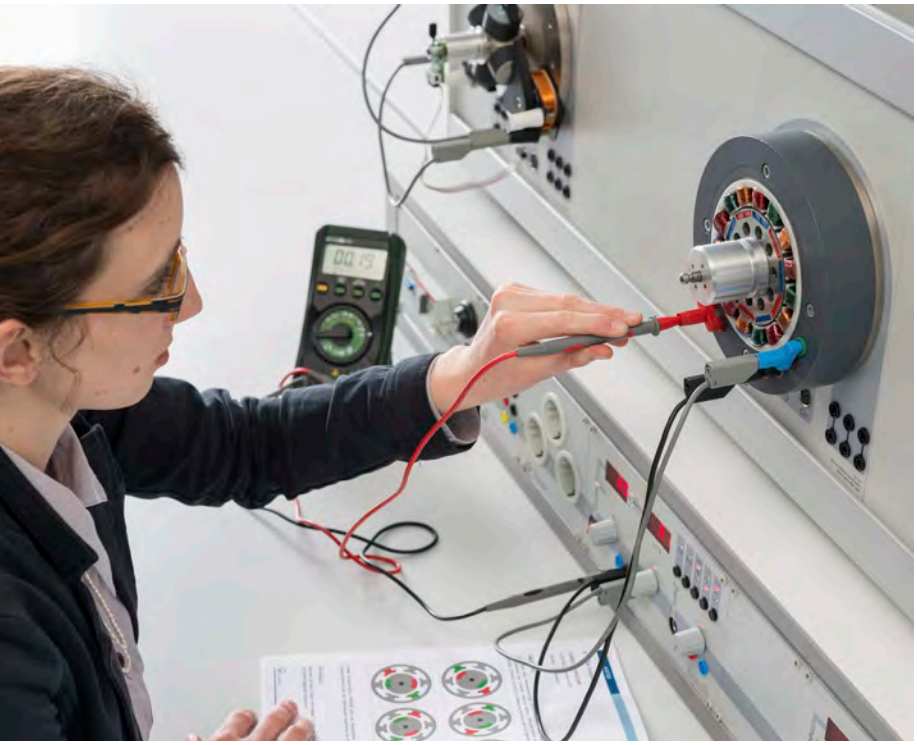


ENERGY-EFFICIENT ELECTRICAL MACHINES

Now this topic can also be investigated using the new LEYBOLD components for electrical machine teaching models.

By mounting a multipole stator and a rotor equipped with permanent magnets on our tried and true platform, it is now possible to cover completely new uses and applications during instruction.

Now for the first time, the topics of highly-efficient motor and generator operation can be investigated using this stator/rotor combination.

NEW

PERMANENT MAGNET ROTOR

SUPPLEMENT TO THE ELECTRICAL MACHINE TEACHING MODEL

FEATURES ELECTRICAL MACHINES

- Vertical electrical machine setup
- Three-phase stator with colour-coded windings
- Coloured rotor magnets
- Synchronous machine (PMSM)
- BLDC drive system or
- Modern type generator

727 815	ELM multipole stator rotor kit
727 816	ELM PM rotor magnets (internal)

Stator with two rotors
for the machine model

NEW

MACHINES WITH INTERCHANGEABLE ROTORS

Machine models for mains voltage consist of a stator and various, interchangeable rotors. Once the stator and rotor have been assembled, a fully operational electrical machine of the 300 W class is realised.

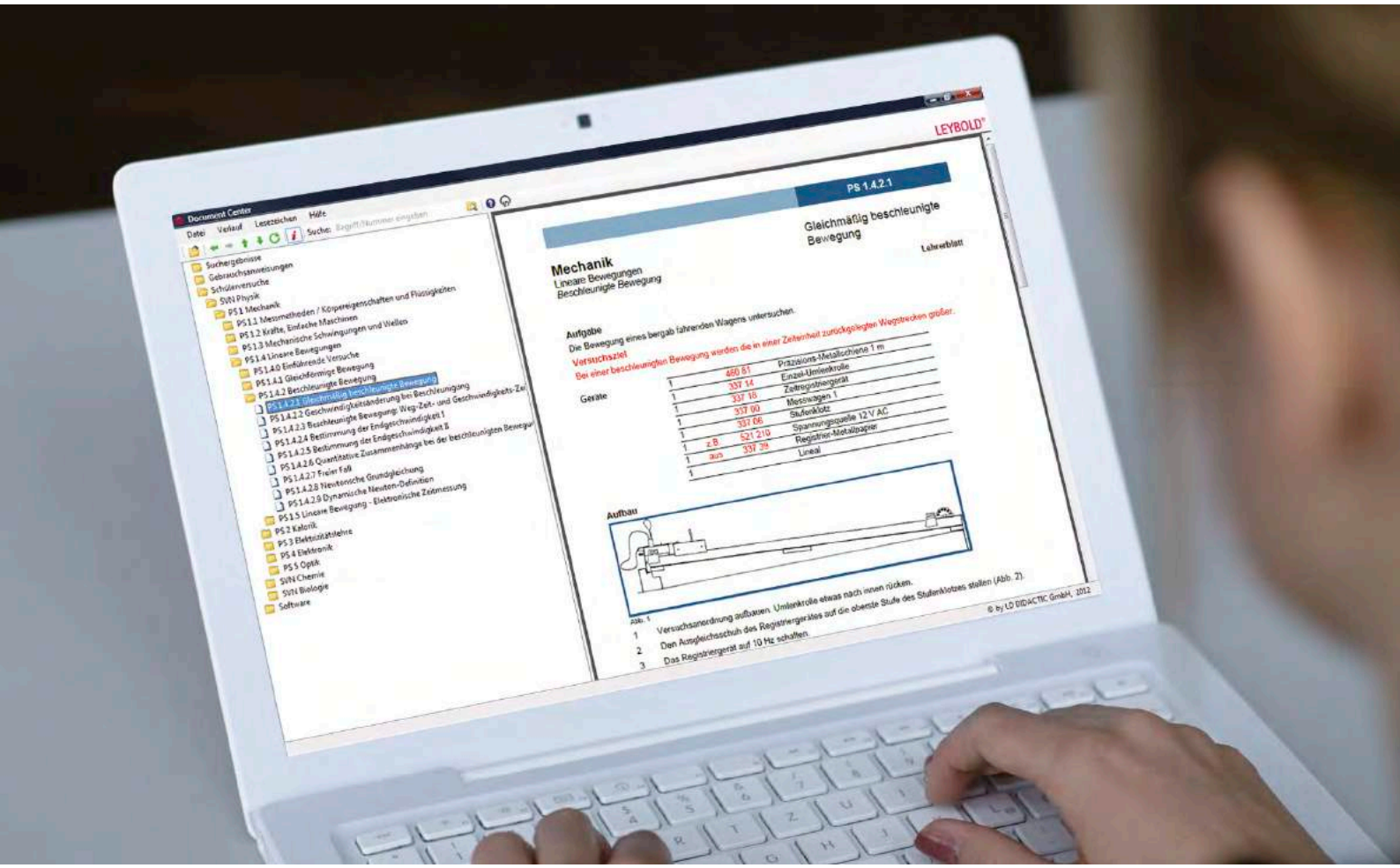
The stator housing is mounted on a base and can be connected directly to the machine testing system 0.3 (731 989 USB). The star-shaped tie-bolts are responsible not only for the secure connection of the stator and the rotor but also the quick exchange of rotors. The rotors are equipped with B-type end shields, fan impellers, jackets and possibly slip-rings, brushes etc. In conjunction with the machine testing system, the machine characteristics can be traced back to particular features of the specific rotor. Depending on the rotor in use the machine model demonstrates the typical properties of induction (asynchronous) or synchronous machines.

747 720	Three-phase stator
747 721	Squirrel cage rotor

Additional rotors can be found in the catalogue section devoted to single components.

MACHINES WITH INTERCHANGEABLE ROTORS

DOCUMENT CENTER



Download the
Document Center
free at:
www.ld-didactic.com

LEYBOLD'S ELECTRONIC LIBRARY

- Display and manage student experiment literature, demonstration experiment instructions or operating instructions in one program
- Automatically update all documents thanks to free online updates
- Benefit from convenient, fault-tolerant keyword and catalogue number search features

THE DAYS OF ENDLESS SEARCHING ARE OVER

The time consuming search for experiment instructions in folders is finally over. The new and free-of-charge Document Center saves you valuable class preparation time. With the new Document Center you have digital access to all the technical documentation which we have placed at your disposal (partially free-of-charge) in the form of extensive literature packets.

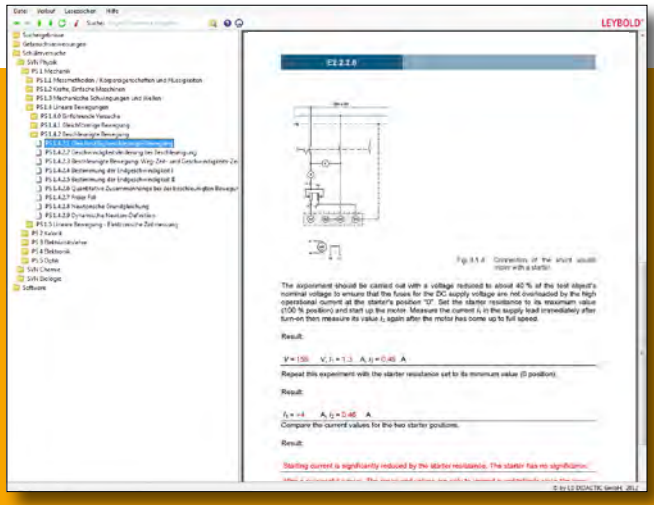
Once installed, you can set the documents to automatically update to the latest versions. The literature packets are clearly displayed in the form of a table of contents that also guides you intuitively to the desired document. The more literature packets you have installed, the more entries you will have in your table of contents.

Using the fault-tolerant search function you can quickly and easily find the correct document. Here again, the more literature packets installed, the more powerful the search function becomes.

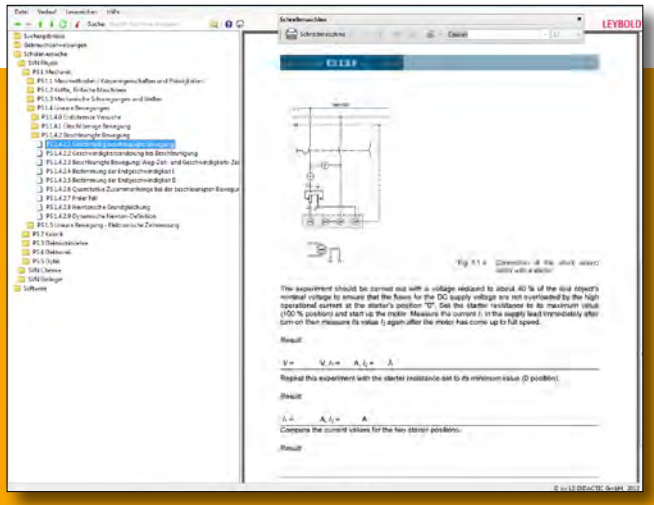
CONDUCT EXPERIMENTS INTERACTIVELY AND LOG THE RESULTS DIGITALLY

Literature packets not only contain documents but also application data. Thus, for example, it is possible to take settings and examples from one of the experiment descriptions included in the literature packet and load this data into CASSY Lab with a simple click of the mouse.

If student and teacher versions from a packet are installed, switching back and forth between versions is also as easy as a mouse click. Student documents can be filled out in the Document Center and logged findings saved or printed out as a hardcopy.

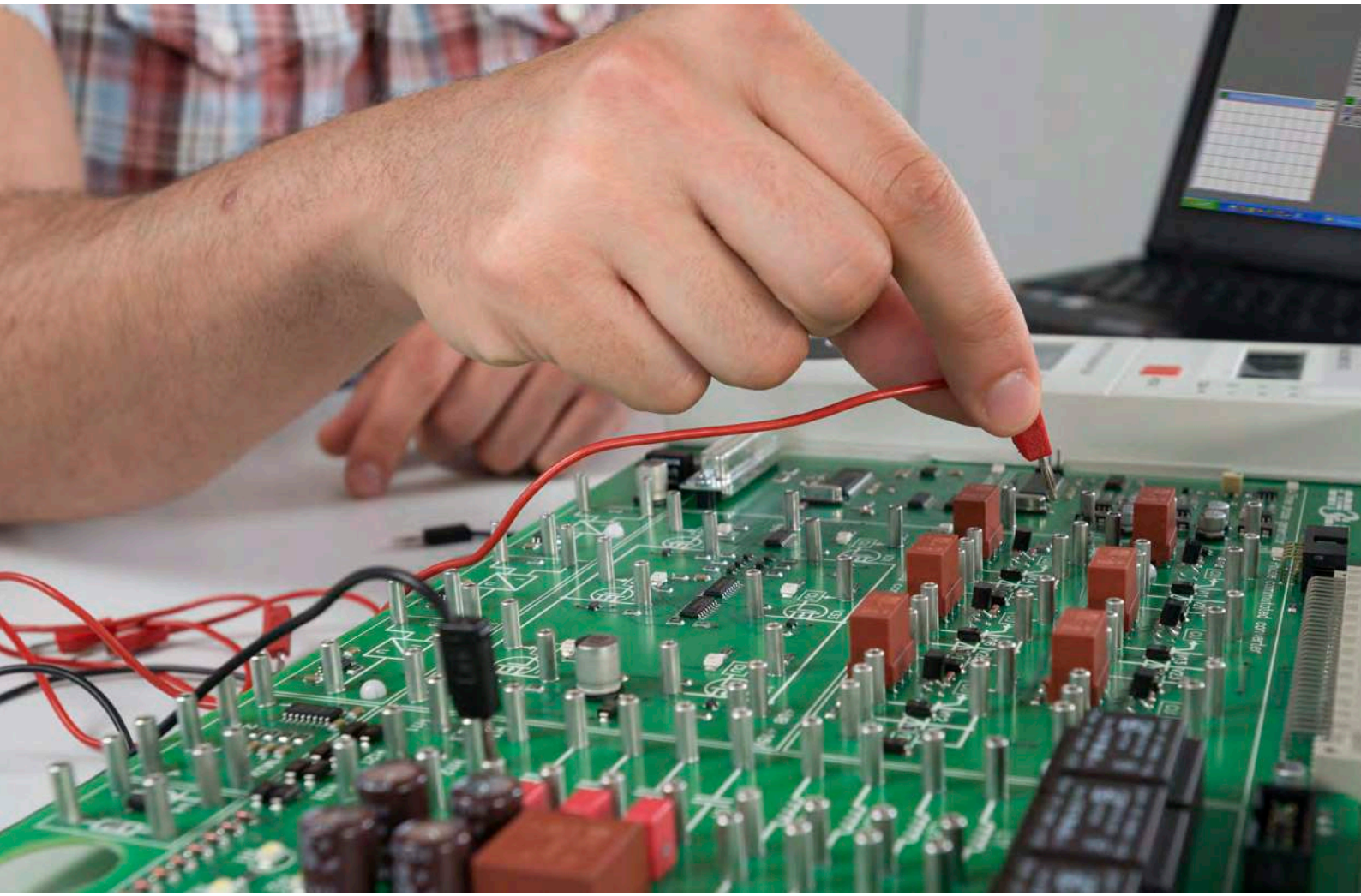


Teacher version



Student version

COM3LAB MULTIMEDIA



The master unit is compatible with all of the courses and includes two digital multimetres, a function generator, a digital storage oscilloscope and a digital analyser. By simply inserting a different experiment board into the Master Unit a completely new topic area can be explored.

New courses in the area of power electronics and electrical machines impart the subject's fundamentals and support the practical hands-on experimentation with measureable learning results.

THE OPTIMUM COMBINATION OF THEORY AND PRACTICE

COM3LAB Multimedia combines training software with real hardware that can be used in schools, universities or vocational training centres in industry.

COM3LAB courses are well suited for both classroom presentation, self-directed home study or for project work. They are comprised of an electronic and an interactive instruction manual and the corresponding hardware.

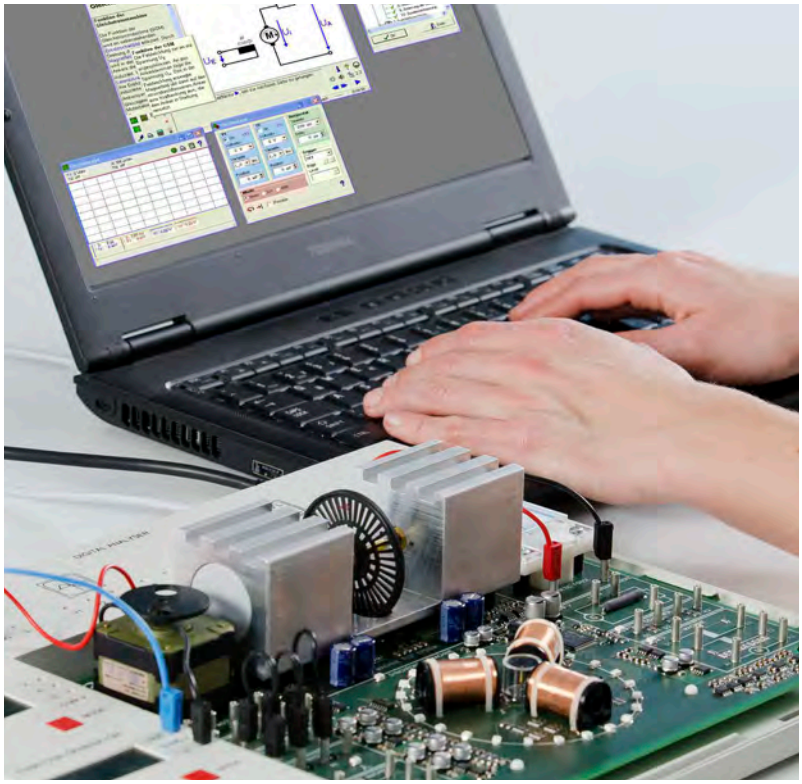
ADVANTAGES AT A GLANCE

FOR INSTRUCTORS

- In-depth content
- Practically-oriented experimenting
- Visually-appealing instruction material for presentation purposes
- Documentation with solutions for flexible application in the classroom
- Time-efficient assembly

FOR STUDENTS

- Practical hands-on learning
- Results are monitored and tested
- Results are documented
- Team-based or self-study possible
- Select the language of your choice



COM3LAB COURSE: ELECTRICAL MACHINES

RECORDING CHARACTERISTICS AND CONNECTION TECHNIQUES OF ELECTRICAL MOTORS AND GENERATORS

- The most compact solution on the market for the topic of electrical machines
- Intelligent microcontroller permits a multitude of experiments and even includes an integrated machine testing system
- COM3LAB Multimedia combines training software with real hardware and can be used in schools, universities or vocational training centres in industry.

NEW

Drive technology is an important aspect of any technical education. With the COM3LAB courses the following, essential training fields are covered:

- Electronics for machines and drive technology
- Electronics for automation engineering

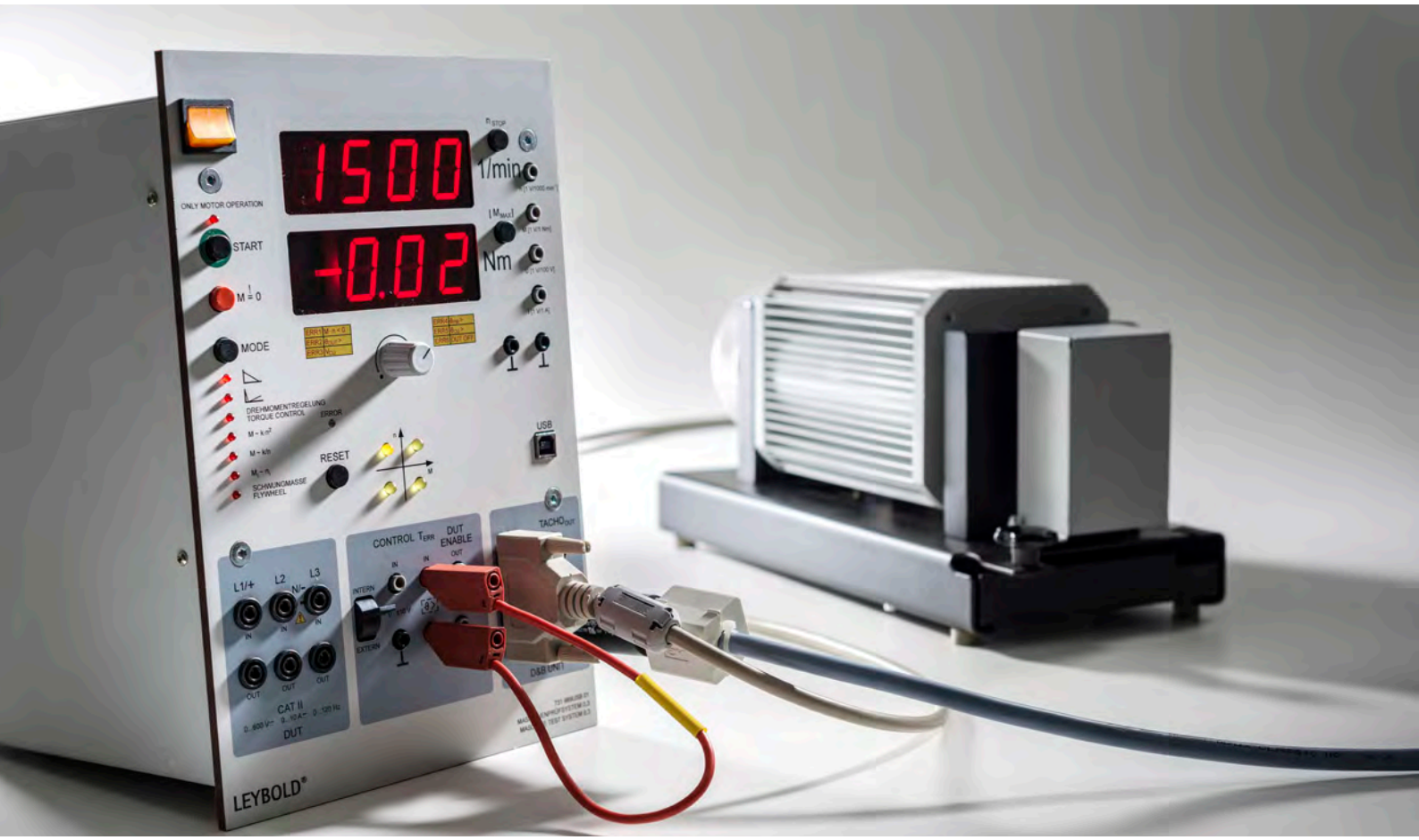
In this COM3LAB course, the basics of drive technology are presented and conveyed in an understandable way. The highlight of the course is the integrated machine testing system. This system allows you to really measure and compare the characteristics of all standard electrical motors.

There is an electronic, interactive text book included with each COM3LAB course each containing in-depth experiment instructions featuring technical specifications, images, videos and animations to support both theoretical and practical applications. Besides all of this material, the text book also contains a virtual laboratory and a large number of tools, e.g. for creating documentation.

700 25	COM3LAB Course: Electrical machines I

COM3LAB COURSE ELECTRICAL MACHINES I

MACHINE TESTING SYSTEMS



TOPICS

RECORDING THE CHARACTERISTICS OF ELECTRICAL MACHINES

- DC, AC and three-phase machines
- Investigating machines operating in motor and generator modes
- Plotting the locus diagrams for (asynchronous) induction motors (Heyland or circle diagrams)

ACTIVE LOAD SIMULATION

- Fan characteristic, winder characteristic
- Flywheel
- User-defined load characteristics

FEATURES OF THE MACHINE TEST SYSTEM

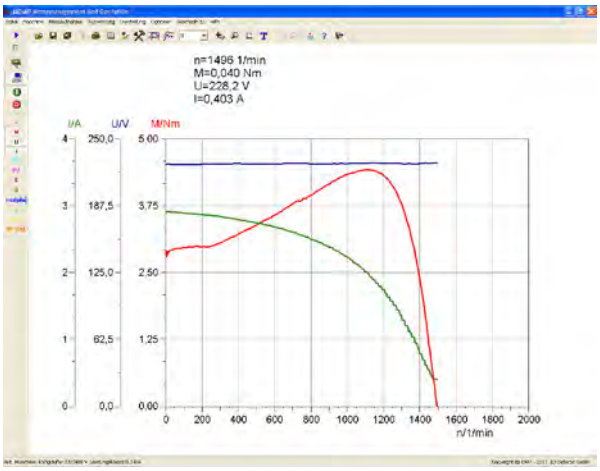
- Simple operation also without a PC
- Modular system configuration with short set-up time
- Test machines in 300 W or 1 kW power classes
- Protection for man and machine thanks to integrated temperature sensor and shaft-end monitoring of all machines
- Compare several characteristics on a single diagram
- Calculate mechanical and electrical characteristics
- Manage characteristic curves in table form
- Recording curves in both standardised and absolute plotted diagrams
- Blocking student access to select curves

SAFETY

- Monitoring shaft-end guard
- Temperature monitoring of the DUT

LEYBOLD MACHINE TEST SYSTEM PERFORMS IMPORTANT TASKS IN THE EXPERIMENT SET-UP:

- Regulated control of a motor braking system
- Measurement and processing of real-time data for computer-assisted characteristic evaluation
- Controlled drive of generators and drive gears



Torque-speed characteristic

This makes the recording of important characteristics of real motors and generators easy to do even for trainees and students.

In vocational training, the mechanical and electrical variables of electrical machines need to be measured and evaluated. To do this, the AC, DC or three-phase machine is securely and mechanically coupled to the drive and load unit of the machine test system. During the measurement the drive unit of the machine testing system continuously records the torque and speed of the machine under test.

Recording and evaluating characteristics is carried out by computer control using the CBM 10 software. Based on the torque, speed, current and voltage parameters measured directly, additional variables can be deduced, e.g. the power output and consumption, degree of efficiency, power factor cos ϕ.

STE PLUG-IN SYSTEM

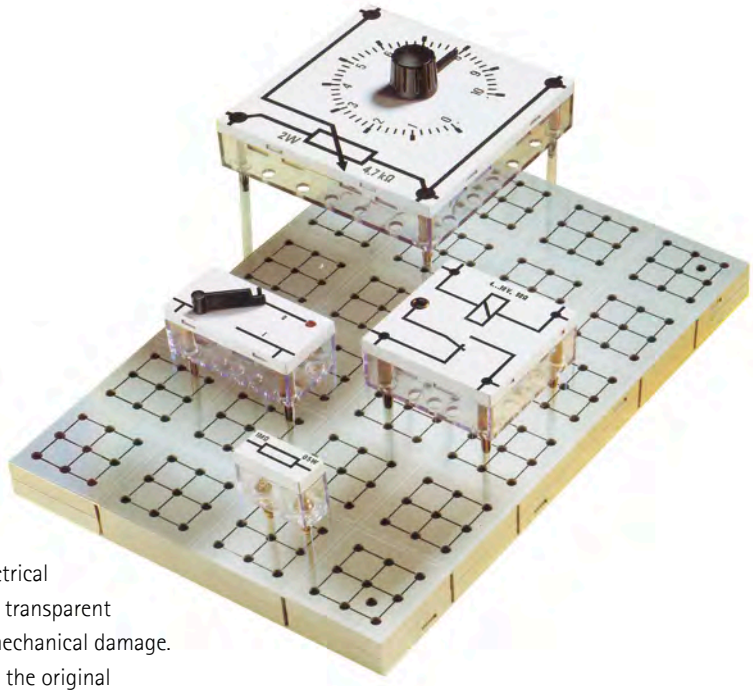
The LEYBOLD plug-in system is a tried and tested experimentation program for electrical engineering and electronics. The extensive experimentation program covers beside the basics also advanced topics, for example, communications, IT, open- and closed-loop control technology as well as areas from automotive electronics.

Instruction sheets for students and accompanying teacher information are available to assist with the performance of experiments. The printed symbols on the plug-in housing elements, connectors and training panels provide the experiment set-ups with a circuit-like appearance. This facilitates the knowledge transfer between the circuit diagrams in the text books and the circuitry being assembled and makes the documenting of the experiment set-ups easier to do and ultimately promotes circuit-based thinking, learning and experimenting.

The STE case is the storage solution which also serves as a student workstation. The cover can be used to accommodate various STE equipment sets and also assist in performing experiments in the classroom. The clearly configured storage design permits quick setup and a quick start to experimenting.

ADVANTAGES

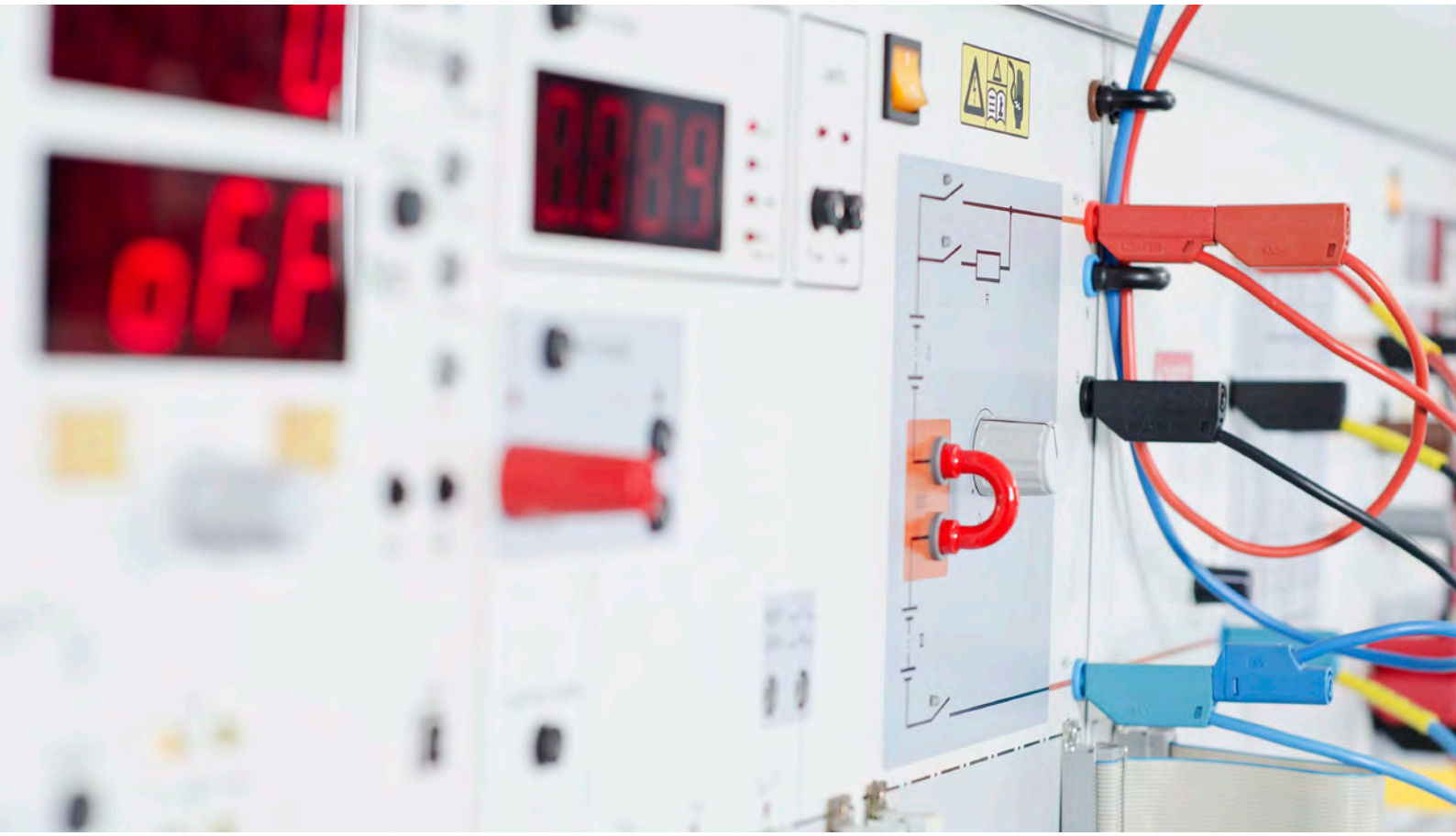
- Modular system
- Comfortable storage solutions for rapid assembly and disassembly
- Easy to expand
- Variety of A4 base panels, A3 available for vertical assemblies
- Clearly printed circuit symbols and designations



The STE elements come ready for operation and assembly with their electrical and electronic components encased in transparent housings to protect against external mechanical damage. Thanks to the transparent bottom part the original component is visible.

Stackable plastic trays offer alternatively a space saving and clear storage configuration of STE-elements, components and accessories in cabinets or drawers.

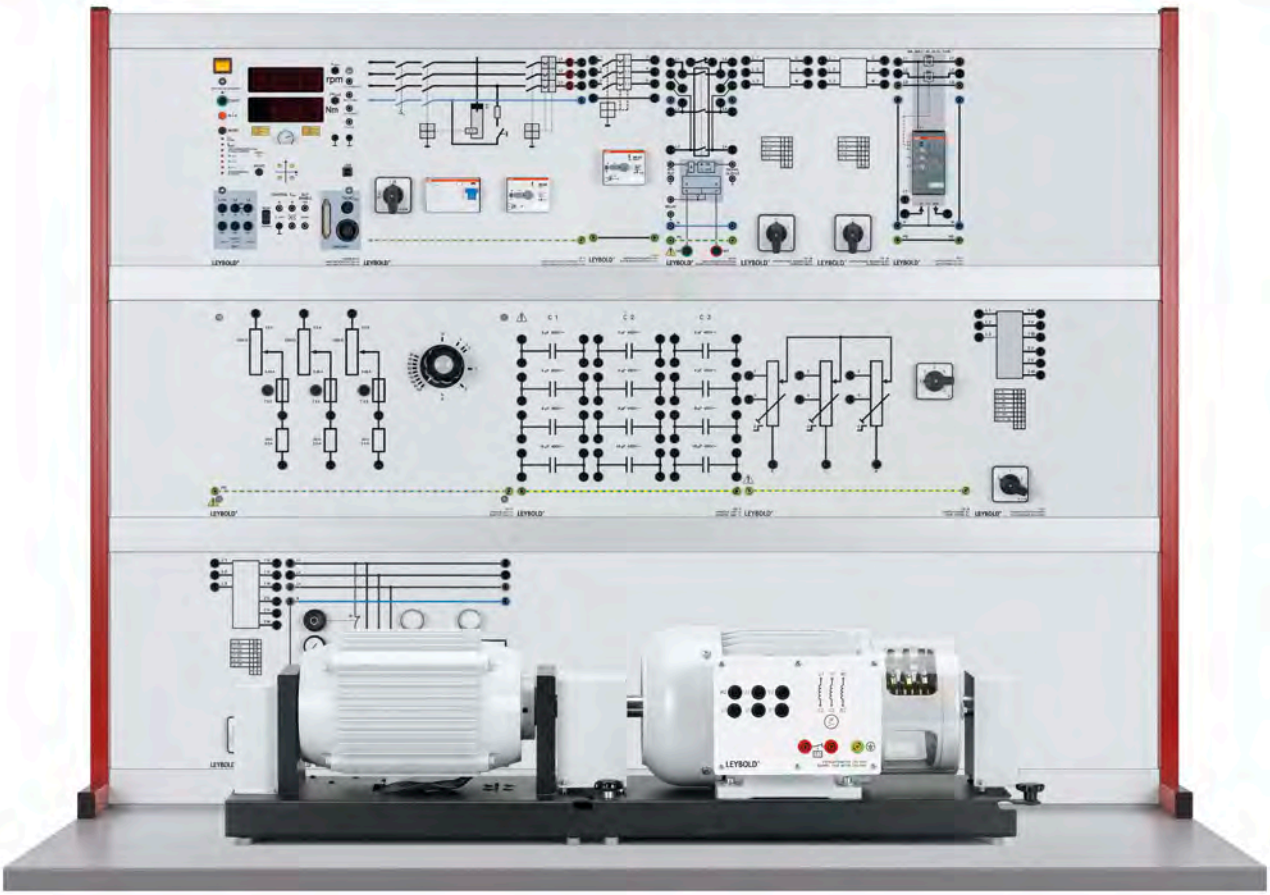
TPS – TRAINING PANEL SYSTEM



The LEYBOLD training panels are the centerpiece of the successful training systems. The equipment set configurations feature an outstanding modular design. All of the required training fields can be covered in their respective training topic areas using the TPS training panel equipment sets.

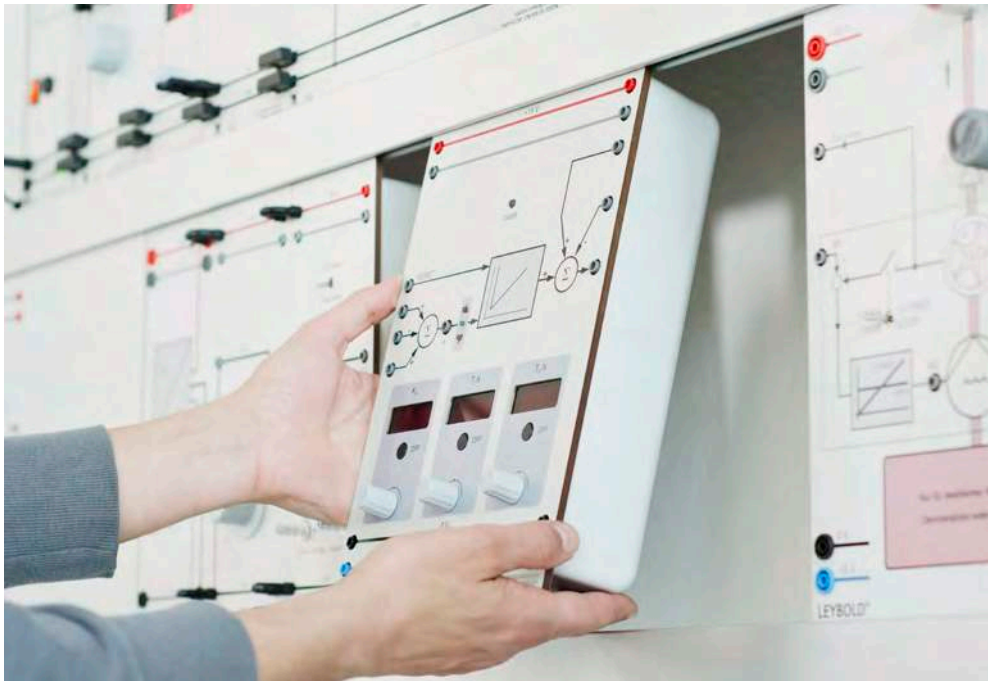
THE MODULAR TRAINING PANEL SYSTEM FOR STUDENT EXPERIMENTS AND CLASSROOM DEMONSTRATIONS

- Use of original components
- Experiment literature for classroom preparation and experiment procedures
- Featuring clearly laid out frontal panels



The systematic use of 4-mm safety sockets, cables and bridging plugs (jumpers), ensure that the experiment procedures are carried out safely. With the support of extensive experiment instructions and literature the students and trainees have lots of opportunities to acquire knowledge and new skills while at the same time deepening what they have already learned previously.

The proven TPS training panel system is also perfectly suited for instructors who have to demonstrate complex experiments. The additional TPS.NET and CASSY technologies offer the option of conducting all experiments with computer assistance. This builds a bridge between traditional learning and new technologies.

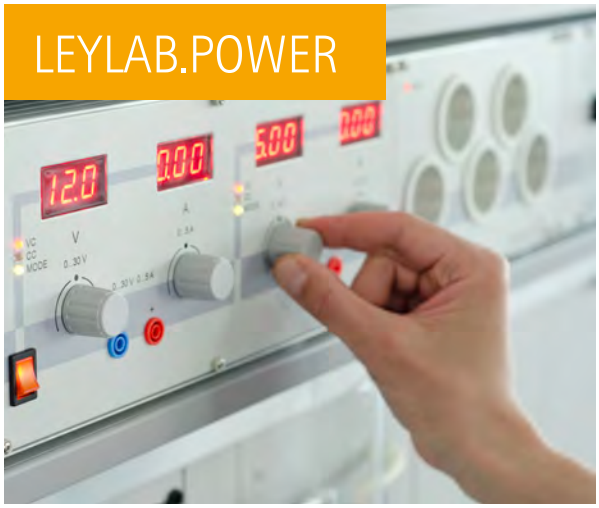


Thanks to the modular design, technology labs can quickly and easily be outfitted or extended using the TPS system.

LEYLAB

SAFETY FOR STUDENTS AND EQUIPMENT ALIKE

LEYLAB.POWER



CONTROL AND REGULATE POWER SUPPLIES USING LAN AND WLAN

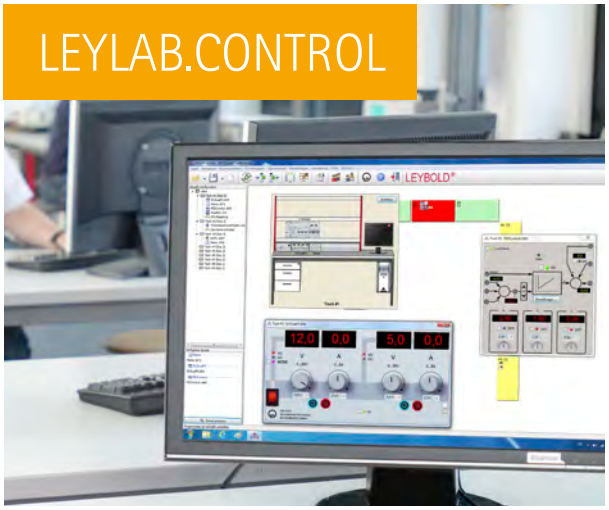
From the teacher's PC, the instructor has password protected access to all of the equipment and can take readings and change settings at any time.

Furthermore, for the protection of the connected training environment, maximum parameter limits can be set which the students cannot manipulate.

CENTRAL CONTROL AND REGULATION FROM TEACHER'S PC

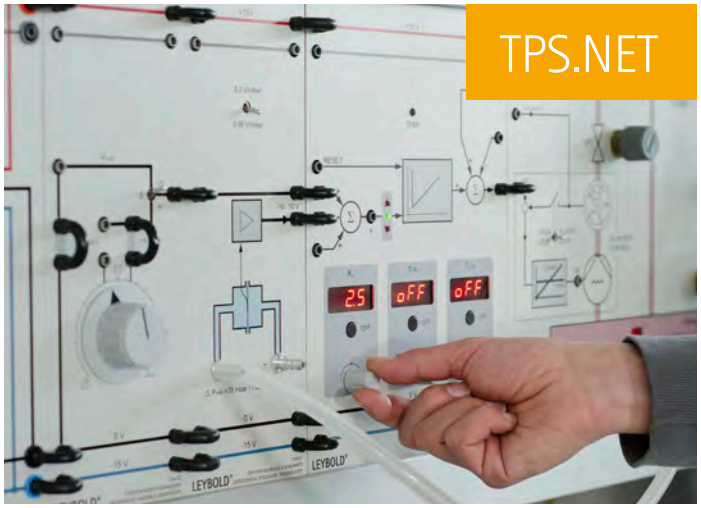
FAULT SIMULATION INITIATED FROM TEACHER'S PC

LEYLAB.CONTROL



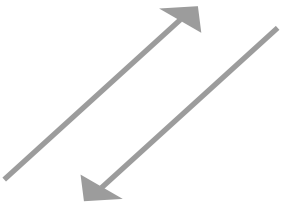
THE CUSTOMISED, INTERACTIVE TECHNOLOGY LAB OF THE FUTURE

MONITOR AND CHECK ON STUDENTS



NETWORK-CAPABLE EXPERIMENTING MODULES

Network-capable TPS modules are equipped with an Ethernet port so that they can be integrated into the LEYLAB.control concept. While the students are busy conducting experiments, the teacher can either monitor or actively access their equipment from his or her computer. Measurement data acquisition, the setting of parameters and limiting values and safe fault simulation are thus possible.



REMOTE CONTROL OF ALL LABORATORY EQUIPMENT

The LEYLAB.control software is the control centre at the heart of the networked laboratory and permits the switching and activation of interconnected power supply units of the LEYLAB.power series as well as the networkable training panels of the TPS series.

The instructor can map out his or her laboratory on the program interface and thus obtain a graphic overview of all the equipment connected via Ethernet.

DIRECT COMMUNICATION WITH STUDENT PC AND THE EXPERIMENT MODULES

FACILITY & LAB PLANNING AND INSTALLATION

YOUR NEW LEYBOLD LAB FACILITY

Based on your ideas, we team up with you and plan a lab or classroom facility that fits your syllabus. Our room planners custom design your laboratory simply by tailoring the desired experiment equipment, furniture and storage solutions to your specific needs.

Thanks to our many years of experience, we are reliable partners in all phases of project planning from conception to implementation.

EVERYTHING YOU NEED FROM A SINGLE SOURCE

LAB AND CLASSROOM PLANNING

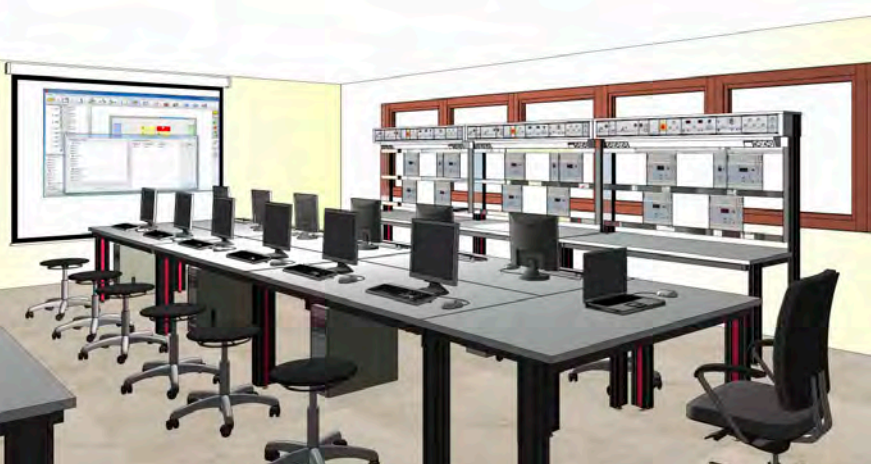
- Furnishings designed for practical use
- In compliance with safety standards
- Blueprints and planning documents
- Specification of performance features

FURNITURE

- Customised solutions
- Networked training systems
- Storage systems designed to fit equipment and equipment sets
- Long availability & supplementation guarantee

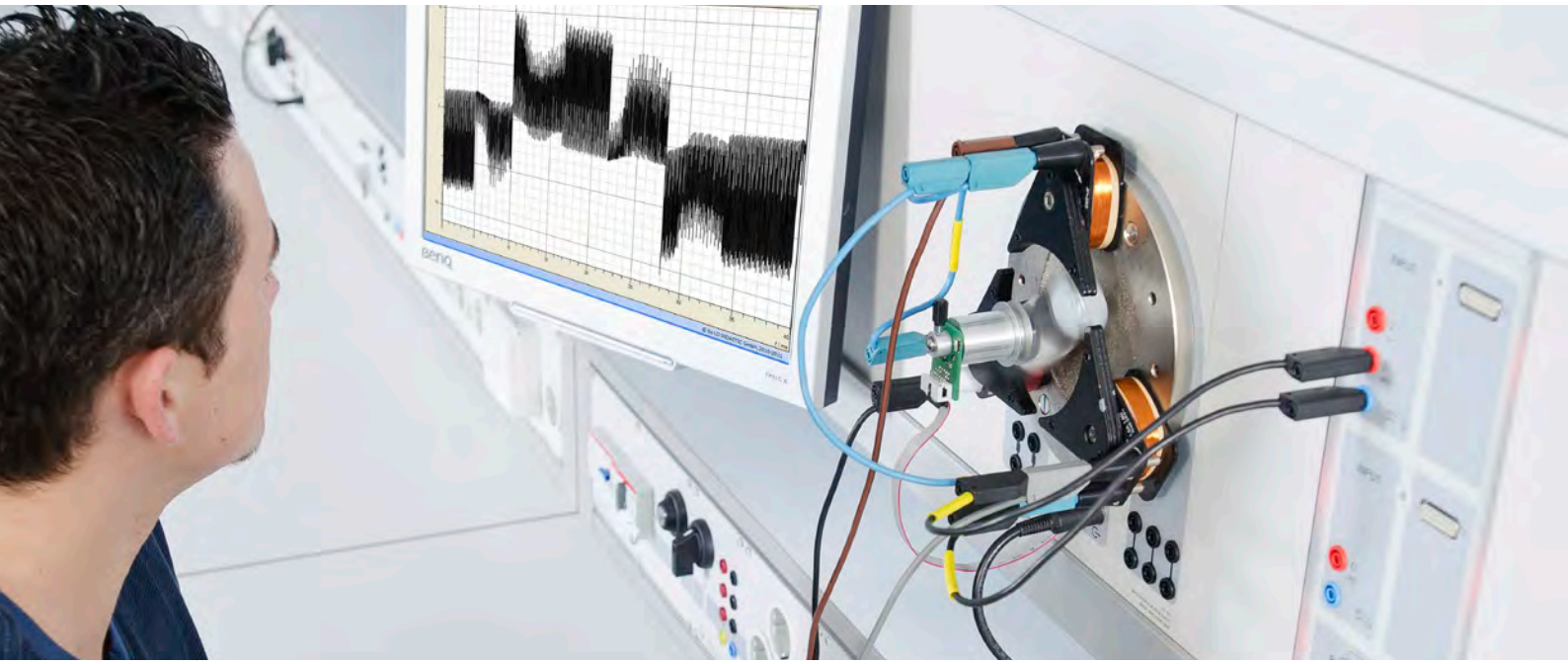
FINANCING

Leasing offers for technical equipment and furnishings



LEYBOLD®

CASSY - COMPUTER-ASSISTED MEASUREMENT AND EVALUATION



The modular CASSY system makes computer-assisted measurement and evaluation possible for all training and educational levels up to university level.

THE CASSY SYSTEM COVERS:

1. Interface for recording measurement data
2. Comprehensive offering of sensors for the detection of electrical and non-electrical variables
3. CASSY Lab 2: The intuitive and easy-to-use software for measurement and evaluation designed to fit all of the equipment and sensors

SENSORS (SELECTION)

Catalogue No.	Designation
738 987	Capacitive-type pick-up
738 986	Inductive-type pulse pick-up
524 064	Pressure sensor S
524 044	Temperature sensor S
524 0511	Lux adapter S
666 243	Lux sensor
524 031	Current source box
524 043	30 A box
524 0512	Optical performance sensor

SENSOR-CASSY 2

INTERFACE FOR RECORDING MEASUREMENT DATA

- For connection to the USB port of a computer, to an additional CASSY module or to the CASSY display
- Simultaneous measurement of voltage, current and two additional variables possible
- Automatic sensor box recognition
- Can be setup as table-top, console or demonstration unit (also in CPS/TPS experiment frames)

PLUG & PLAY

Automatic detection and setting of Sensor-CASSY and sensor boxes

COMPATIBLE

with all CASSY sensor boxes and sensors

Sensor-CASSY 2 (524 013) provides two electrically separated voltage inputs, an alternative current input and two sensor box inputs parallel to this. All inputs have variable measurement ranges. Technical specs can be found in the individual component section of the catalogue.

PROFI-CASSY

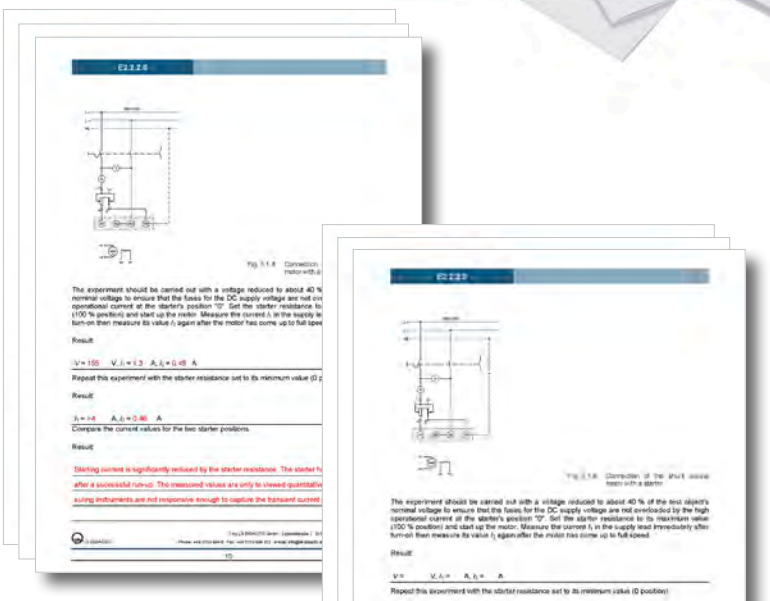
INTERFACE FOR ALL AREAS OF ELECTRICAL ENGINEERING

- For connection to the USB port of a computer
- Microcontroller-controlled with the CASSY-operating system (upgrades and expansions can be easily updated anytime via software)
- Variable set-up as table-top, console or demonstration device (also in CPS/TPS experiment frames)

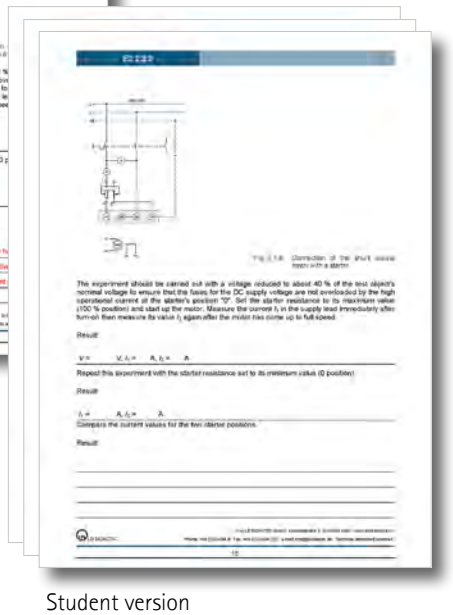
Technical data for the Profi-CASSY (524 016) can be found in the individual component section of the catalogue.

SAVE TIME AND EFFORT DURING CLASS PREPARATION AND EXPERIMENT PROCEDURES

LEYBOLD solutions are not only tailored for complex training subjects but also for the continuously growing demands being placed on teachers and instructors. You will only have to invest a short amount of time in preparing your classes or to set up your experiments. This is because with the extensive experiment literature accompanying our systems, you receive guidelines for demonstration experiments that can also serve as experiment instructions and exercise handouts for your students.



Teacher version



Student version

LITERATURE

THE EXPERIMENT LITERATURE HAS BEEN WRITTEN WITH SPECIAL EDUCATIONAL CONSIDERATIONS TO SIMPLIFY AND FACILITATE CLASSROOM AND EXPERIMENTATION PREPARATION FOR INSTRUCTORS.

GENERAL INFORMATION

Customer desk	+ (49) 22 33 / 604 – 430
	Order processing
	Available Mon.-Thur. from 8.00 am- 4.00 pm and Fr. from 8.00 am - 2.45 pm
Order fax	+ (49) 22 33 / 604 - 193
Help-Line	+ (49) 22 33 / 604 - 301
	Technical support for queries, advice on equipment or experiments
	Available Tues. from 10.00 am - 12.00 pm and Thur. from 2.00 pm - 4.00 pm
E-mail	info@ld-didactic.de
Internet	www.ld-didactic.de

INFORMATION CONCERNING TENDERS

Your contact partners Mr. Kattwinkel and Mr. Schilling are at your disposal from Mon.-Thur. from 8.00 am to 4.00 pm and Fr. 8.00 am to 2.45 pm.

Contact data:

Achim Kattwinkel
Telefon + (49) 22 33 / 604 - 272
E-mail akattwinkel@ld-didactic.de

Hans Peter Schilling
Telefon + (49) 22 33 / 604 - 305
E-mail pschilling@ld-didactic.de

TECHNICAL SERVICE

Should you have any questions regarding a component or an equipment set: Our service team is at your disposal by phone at + (49) 22 33 604 - 430 and per E-mail under service@ld-didactic.de.

YOUR PERSONAL TECHNICAL ADVISOR

You can find the contact data of the technical advisor you need on our internet page.

EQUIPMENT SETS
ELECTRICAL DRIVES

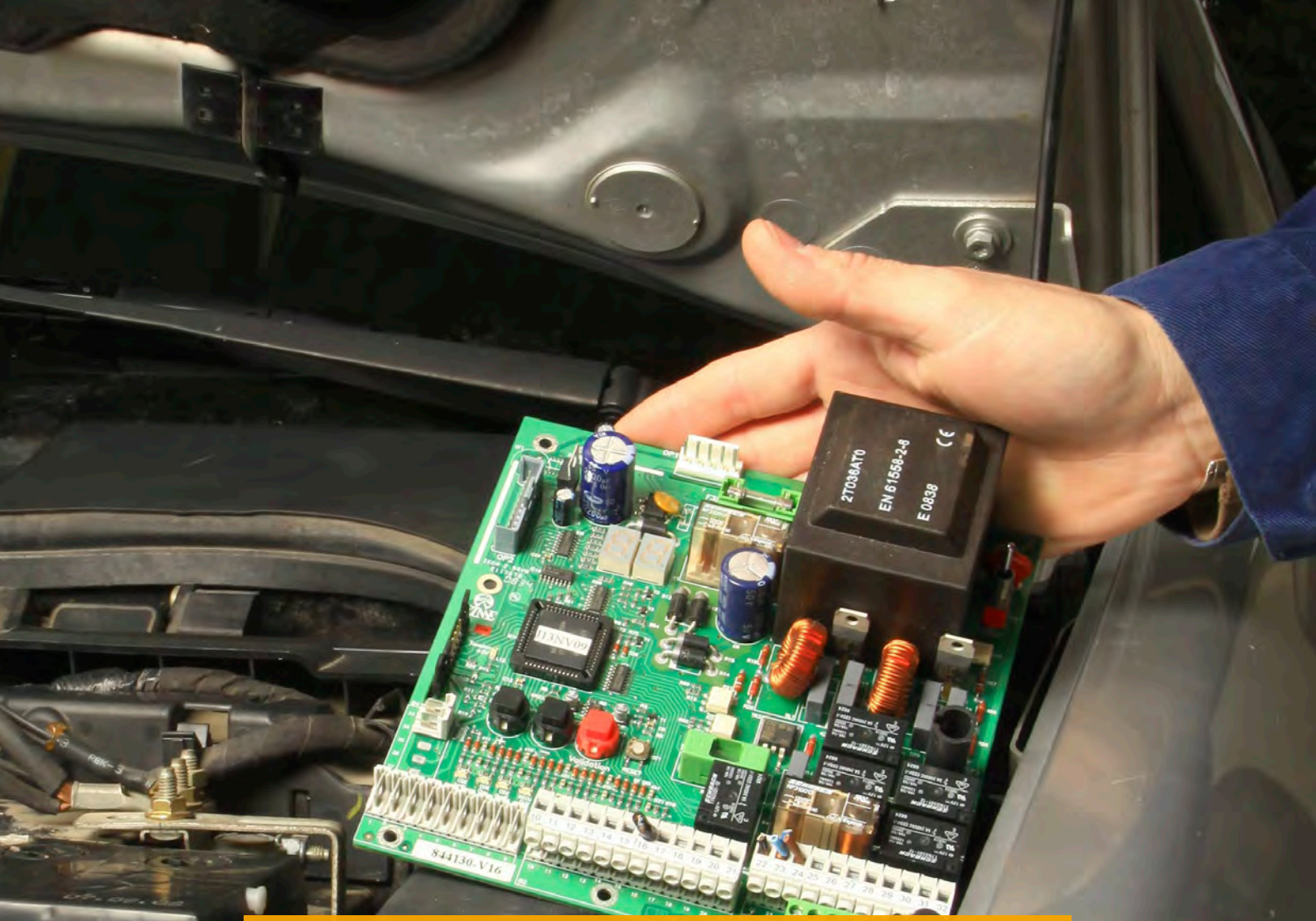
On the following pages, we present a collection of stand-alone and fully-operational experiment set-ups. These contain individual units, instrumentation, software and teachware. The equipment sets are based on training fields currently required in standard training and education.

Of course, the modular solutions of these equipment sets can be adapted to your specific needs. We are happy to advise you, just ask us!

The following pages present our extensive offering of electrical drives. A brief definition of the term "drive" should help to explain the structure of this catalogue. A drive always comprises two machines coupled together. The motor or driving machine generates the required speed or torque and the working machine absorbs the mechanical energy required to perform the desired process. In the case of an electrical drive the motor is an electrical machine. In modern, electrical drives, the energy-efficient supply of electrical power is performed using power electronics components, e.g. power converters and frequency converters. When high demands are being made on the electrical drive's speed and torque stability, additional automatic control technology is then required. One special area of control applications for closed-loop electrical drives includes positioning or servo drives. For that reason, the catalogue has been arranged in the following topic areas:

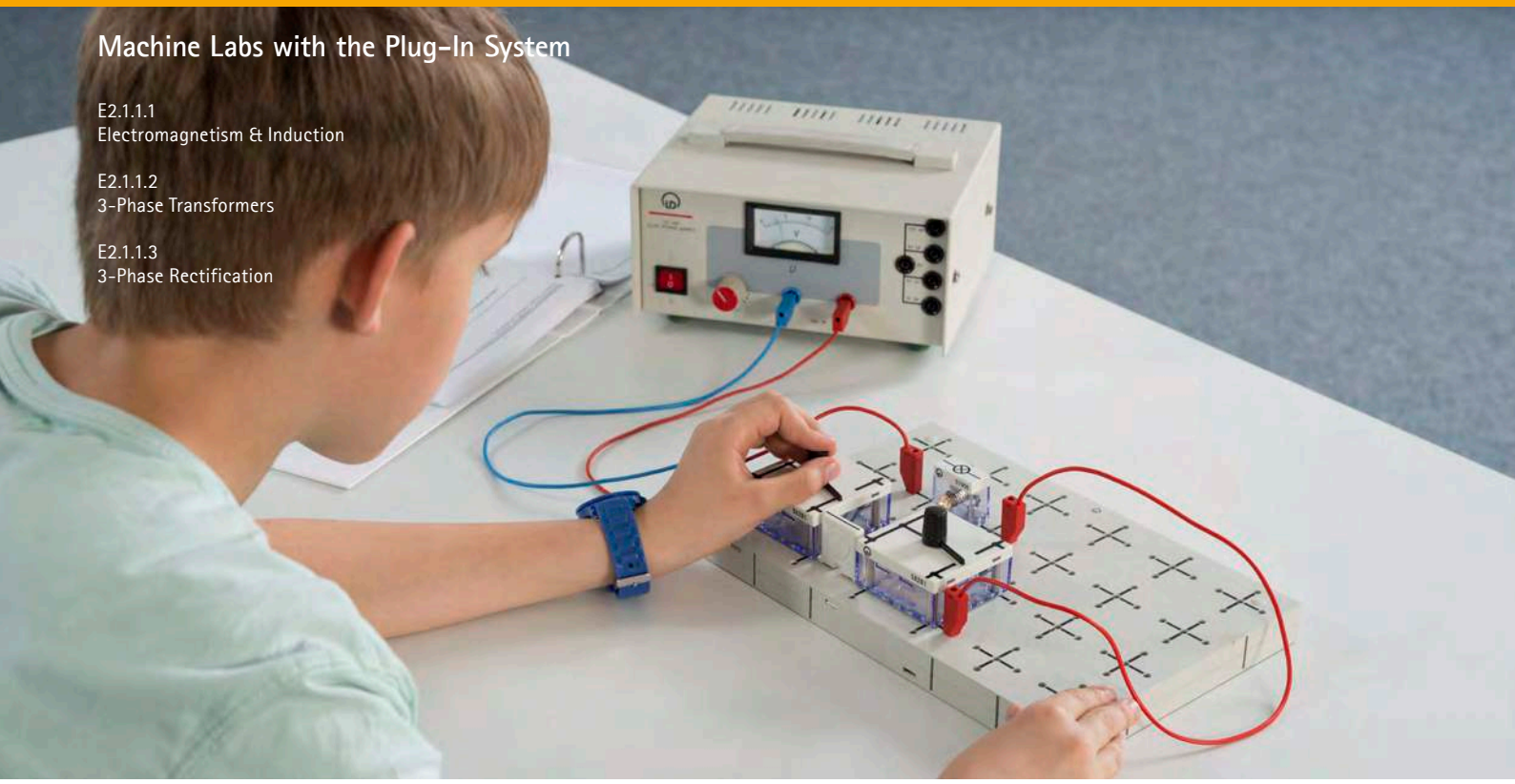
Detailed information on our equipment sets can also be found at our webpage.

E2 ELECTRICAL DRIVES



E2 ELECTRICAL DRIVES

E2.1 EDUCATIONALLY DESIGNED MACHINES



Machine Labs with the Plug-In System

E2.1.1.1
Electromagnetism & Induction

E2.1.1.2
3-Phase Transformers

E2.1.1.3
3-Phase Rectification

Electromagnetism & Induction (E2.1.1.1)

Cat. No.	Description	E2.1.1.1	E2.1.1.2	E2.1.1.3
588 871S	Advanced Science Kit - Set BEL	1		
588 875S	Advanced Science Kit - Set ELI 1	1		
588 876S	Advanced Science Kit - Set ELI 2	1		
521 485	AC/DC power supply, 0...12 V/3 A	1		
685 48ET5	Batteries 1.5 V (D, mono), set of 5	1		
531 120	Multimeter LDanalog 20	2		
459 32	Candles, set of 20	1		
505 07	Bulbs, 4 V/0.16 W, E10, set of 10	1		
505 08	Bulbs, 12 V/3 W, E10, set of 10	1		
505 11	Bulbs, 2.5 V/0.25 W, E10, set of 10	1		
550 42	Constantan resistance wire, 0.35 mm diameter, 100 m	1		
550 46	Chrome-nickel resistance wire, 0.25 mm diameter, 100 m	1		
550 47	Chrome-nickel resistance wire, 0.35 mm diameter, 100 m	1		
550 51	Iron resistance wire, 0.2 mm diameter, 100 m	1		
578 39	Capacitor (electrolytic), 100 µF, STE 2/19	1		
578 40	Capacitor (electrolytic), 470 µF, STE 2/19	1		
667 017	Scissors, 125 mm, round-ended	1		
501 44	Connecting leads, 19 A, 25 cm, red/blue, pair	3		
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	1		
501 441	Connecting lead, 19 A, 25 cm, black, pair	1		
588 35DE	LIT: PS3.5 STM Electricity - Electromagnetism	1		
588 34DE	LIT: PS3.4 STM Electricity - Basic electric circuits	1		
588 35EN	LIT: PS3.5 STM Electricity, Electro-magn	1*		
588 34EN	LIT: PS3.4 STM, Basic electric circuits	1*		
727 514	Basic set T 2.4.1, STE		1	1
576 74	Plug-in board, DIN A4, STE		1	2
578 795	Three-phase voltage supply, 3×12 V, STE 6/100		1	1
562 791	Plug-in power supply, 12 V AC		1	1
501 641	Two-way adapters, red, set of 6		3	3
524 013S	Sensor-CASSY 2 Starter		1	1
575 212	Two-channel oscilloscope 400		1*	1*
575 231	Probe 100 MHz, 1:1 / 10:1		2*	2*

Cat. No.	Description	E2.1.1.1	E2.1.1.2	E2.1.1.3
531 282	Multimeter Metrahit Pro		2*	2*
501 23	Connecting lead, 32 A, 25 cm, black		9	12
501 28	Connecting lead, 32 A, 50 cm, black		6	9
501 26	Connecting lead, 32 A, 50 cm, blue		2	2
501 30	Connecting lead, 32 A, 100 cm, red		2	4
501 33	Connecting lead, 32 A, 100 cm, black		2	4
501 48	Bridging plugs, STE 2/19, set of 10		2	3
565 641L	LIT: Three-phase transformers and three-phase transformer circuits, T 2.4.1 (German)		1	
565 641S	LIT: Three-phase transformers and three-phase transformer circuits T 2.4.1 (German)		1	
565 642	LIT: Three-phase transformers and three-phase transformer circuits T 2.4.1 (English)		1*	
727 515	Basic set T 2.4.2, STE			1
524 013	Sensor-CASSY 2			1
501 02	BNC cable, 1 m			2*
565 651L	LIT: Three-phase rectifier circuits, T 2.4.2 (German)			1
565 651S	LIT: Three-phase rectifier circuits, T 2.4.2 (German)			1
565 652	LIT: Three-phase rectifier circuits T 2.4.2 (English)			1*

* additionally recommended

The experiments are carried out using the STE plug-in system Electricity/Electronics.

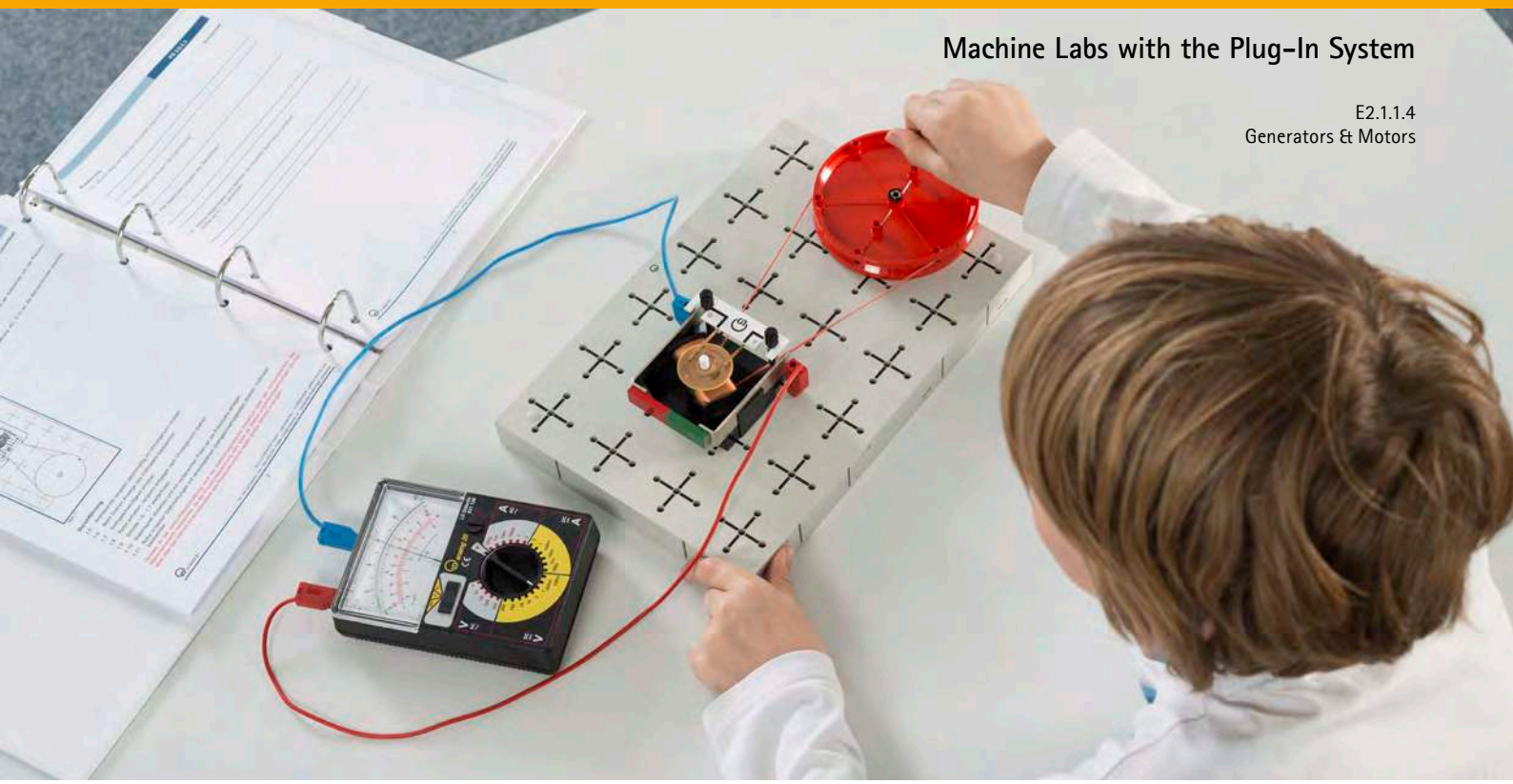
Objectives

- Recognition of basic physical principles
- Implementation of electrical circuits according to circuit diagrams

The target group is made up of students in general or vocational education. The experiments are designed as an introduction at a simple level of understanding.

Topics (selection)

- Circuits, conductors and insulators
- Change-over / two-way circuits
- AND and OR circuits
- Measurement of current, voltage etc.
- Star / delta configuration
- Vector groups for three phase transformers
- Power for three-phase loads
- Diodes with R and RL loads
- Circuits: M2U, M3U, M6U, B2U, B6U



Machine Labs with the Plug-In System

E2.1.1.4
Generators & Motors

Generators & Motors (E2.1.1.4)

Cat. No.	Description	E2.1.1.4
588 871S	Advanced Science Kit - Set BEL	1
588 875S	Advanced Science Kit - Set ELI 1	1
588 876S	Advanced Science Kit - Set ELI 2	1
588 877S	Advanced Science Kit - Set ELI 3	1
521 485	AC/DC power supply, 0...12 V/3 A	1
522 621	Function generator S 12	1
685 48ET5	Batteries 1.5 V (D, mono), set of 5	1
531 120	Multimeter LDanalog 20	2
459 32	Candles, set of 20	1
505 07	Bulbs, 4 V/0.16 W, E10, set of 10	1
505 08	Bulbs, 12 V/3 W, E10, set of 10	1
505 11	Bulbs, 2.5 V/0.25 W, E10, set of 10	1
550 42	Constantan resistance wire, 0.35 mm diameter, 100 m	1
550 46	Chrome-nickel resistance wire, 0.25 mm diameter, 100 m	1
550 47	Chrome-nickel resistance wire, 0.35 mm diameter, 100 m	1
550 51	Iron resistance wire, 0.2 mm diameter, 100 m	1
578 39	Capacitor (electrolytic), 100 µF, STE 2/19	1
578 40	Capacitor (electrolytic), 470 µF, STE 2/19	1
667 017	Scissors, 125 mm, round-ended	1
340 900	Rubber rings, set of 50	1
340 811ET2	Plug-in axles, set of 2	1
340 921ET2	Pulley 100 mm Ø, plug-in, pair, set of 2	1
501 44	Connecting leads, 19 A, 25 cm, red/blue, pair	3
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	2
501 441	Connecting lead, 19 A, 25 cm, black, pair	1
588 36DE	LIT: PS3.6 Electricity, Motors (German)	1
588 36EN	LIT: PS3.6 Electricity, Motors	1*

* additionally recommended

Self-assembly of electrical machines is particularly effective for building understanding of how motors and generators work. For example, the process of commutation and the forces involved in it can be grasped intuitively and is especially clear when machines are rotating slowly.

The equipment set incorporates student experiments which can be carried out in a laboratory safely using safety extra-low voltage. Experiment instructions are contained in a manual in either printed or digital form.

For more advanced work, the following sets are recommended:

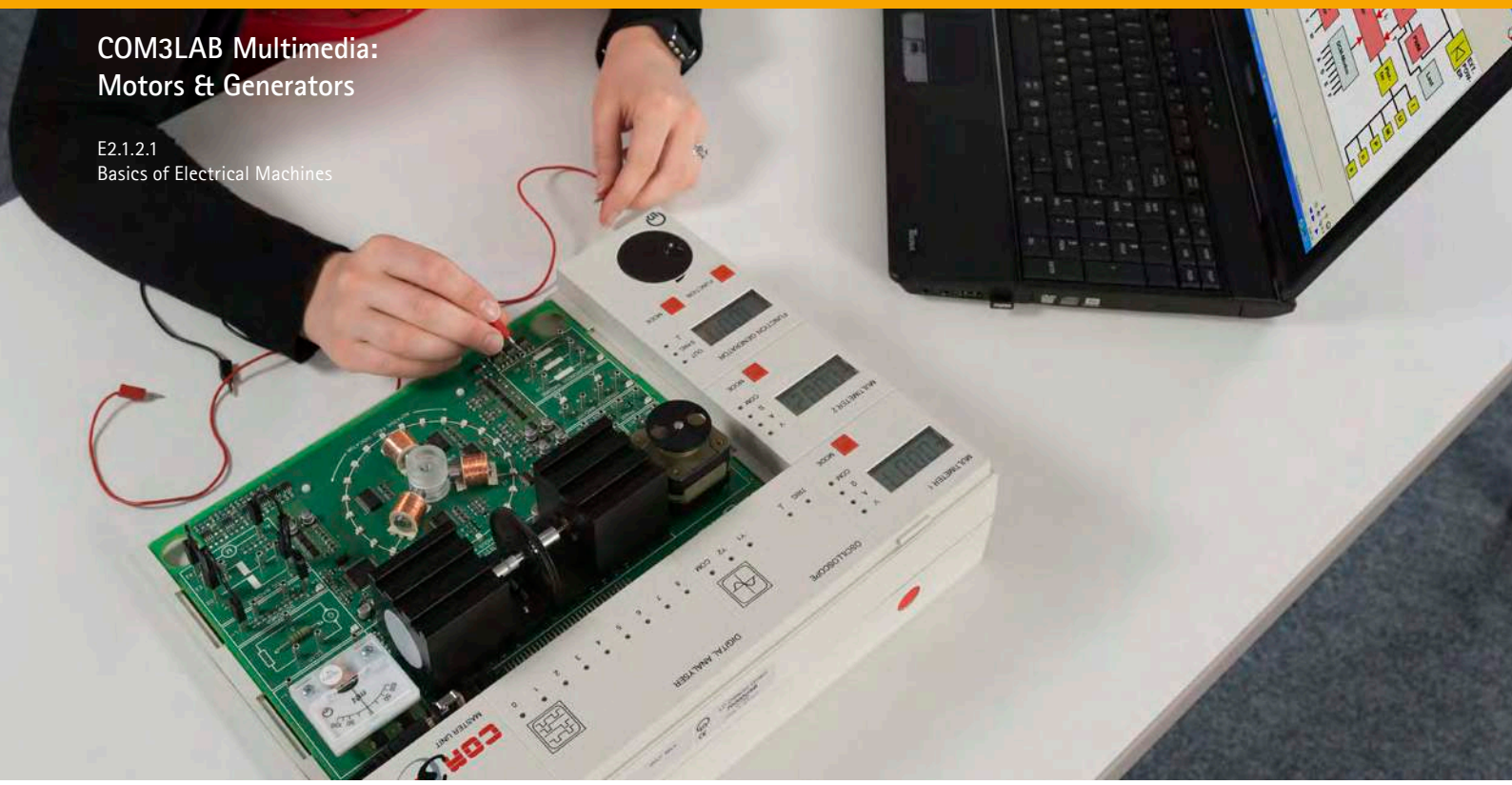
- E2.1.1.1 Electromagnetism & induction
- E2.1.1.2 Three-phase transformers
- E2.1.1.3 Three-phase rectification

Topics

- Magnetic field of a stator
- Magnetic fields of rotors
- How rotors respond in the magnetic field of a stator
- Electromagnetic induction using a bar magnet and a coil
- Dynamos
- Universal generators – functioning principle/operating properties
- Power station generators
- AC/DC generators with electromagnetic stator
- DC motors - functioning principle/power consumption
- DC motors with electromagnetic stator
- Shunt-wound universal motors
- Series-wound universal motors - functioning principle/power consumption
- Synchronous motors
- Electronic motors

COM3LAB Multimedia: Motors & Generators

E2.1.2.1
Basics of Electrical Machines



Basics of Electrical Machines (E2.1.2.1)

Cat. No.	Description	E2.1.2.1
700 24	COM3LAB course: Three-phase technology	1
700 25	COM3LAB course: Electrical machines I	1
700 00USB	COM3LAB master unit (USB)	1
700 00CBTDE	CD: COM3LAB software, German	1
700 00CBTEN	CD: COM3LAB software	1*

* additionally recommended

The experiments are carried out using the multimedia training system COM3LAB.

The COM3LAB course Electrical machines I guides you through the fascinating world of electric motors and generators. Challenging experiments work through the topics of commutator machines, three-phase machines and stepper motors. The board for the course includes a complete machine testing system with which the characteristics of the most important machines can be investigated. The COM3LAB course Three-phase technology discusses the features of multi-phase networks. It forms a basis for understanding three-phase machines such as asynchronous (induction) and synchronous machines.

Objectives

- Recognising basic physical principles
- Recording machine characteristics
- Introduction to drive technology

The equipment set allows students to experiment themselves in a lab equipped with PCs using safety extra-low voltage, which presents no hazard. It is also suitable for demonstration experiments by teachers. Multimedia software explains and monitors how the experiments are carried out.

The target group is made up of commercial apprentices and students of electrical machine technology. The course offers introductory experiments at a simple level and more advanced topics for undergraduate education.

Topics

- Lorentz force
- Machine test system
- Torque/speed characteristics
- DC machines
- Separate excitation/shunt-wound/series-wound machines
- Generator operation
- Power characteristics
- Three-phase machines
- Three-phase windings
- Current and voltage in delta and star (Y) circuits
- Reactance of an AC winding
- Power for a three-phase winding
- Synchronous machines
- Function of a stroboscope
- Asynchronous (induction) machines
- Start-up procedure for three-phase machines
- Manual loading above limit of stability
- Power consumption
- Three-phase drives
- Changing speed by altering stator voltage
- Changing speed by altering synchronous speed
- Changing speed by use of V/f operation
- Stepper motors
- Full steps/half steps

Machine Assembly Kits

E2.1.3.1
ELM Basic Machines
for Extra-Low Voltage

E2.1.3.2
ELM Efficiency Machines
for Extra-Low Voltage

E2.1.3.3
Electrical Machine
Teaching Models
for Extra-Low Voltage

ELM Basic Machines for Extra-Low Voltage (E2.1.3.1)

Cat. No.	Description	E2.1.3.1	E2.1.3.2	E2.1.3.3
563 11	ELM coil, 250 turns	6		6
563 12	ELM squirrel-cage rotor	1		1
563 13	ELM brush	5		5
563 16	Allen key	1	1	1
563 17	ELM centring disc	1		1
563 18	ELM brush holder rack	1		1
563 22	ELM two-pole rotor	1		1
563 23	ELM three-pole rotor	1		1
563 24	ELM drum rotor	1		1
563 25	ELM rotating field attachment and squirrel cage ring	1		1
563 28	ELM magnetic needle rotor	1		1
563 29	ELM aluminium ring with iron disc	1		1
563 31	Oil, 100 ml, in dropping bottle	1	1	1
727 811	Basic machine unit	1	1	1
727 82	Basic terminal unit	1	1	1
727 83	Set of masks	1	1	1
727 85	Starter	1		1
727 86	Field regulator	1		1
727 87	Star-delta load	1	1	1
727 88	Drive unit	1	1	1
685 96	Driving belt, long for drive unit 72788	1	1	1
563 091	ELM pole piece for magnets	2		2
563 101	ELM wide pole piece for coils	3		3
563 115	ELM coil, 500 turns	2		2
563 201	ELM narrow pole piece for coils	6		6
563 211	ELM split pole piece for coils	2		2
505 171	Bulbs, 6 V/1.1 W, E10, set of 10	3		3
505 191	Bulbs, 15 V/2 W, E10, set of 5	3		3
510 48	Magnets, 35 mm Ø, pair	1	1	1
578 16	Capacitor, 4.7 µF, STE 2/19	3		3
579 06	Lamp holder, E10, top, STE 2/19	3	3	3

Cat. No.	Description	E2.1.3.1	E2.1.3.2	E2.1.3.3
579 10	Push button (NO), STE 2/19	1		1
579 13	Toggle switch, STE 2/19	1		1
313 20	Digital hand-held speedometer	1*	1*	1*
524 013S	Sensor-CASSY 2 Starter	1*	1*	1*
531 282	Multimeter Metrahit Pro	2	2	2
726 09	Panel frame T130, two-level	1	1	1
725 721G	Three-phase generator in case	1*	1	1
725 579G	Three-phase supply / experiment transformer	1		1*
563 04	Storage tray for ELM apparatus	1	1	1
500 59	Safety bridging plugs, black, set of 10	1	1	1
500 592	Safety bridging plugs with tap, black, set of 10	1	1	1
501 532	Connecting leads, 19 A, set of 30	1	1	1
775 115DE	LIT: E2.1.3.3 Electrical Machines Teaching Models (German)	1	1	1
775 115EN	LIT: E2.1.3.3 Electrical Machines Teaching Models	1*	1*	1*
727 91	Linear motor basic unit		1	1
727 92	Linear motor with coil assembly		1	1
727 815	ELM set: Multipole stator and rotor		1	1
727 816	ELM PM magnet rotor with inner magnets		1	1
727 812	Rotor position pick-up		1	1

* additionally recommended

The experiments use components from the electrical machine teaching models system and utilise safety extra-low voltage. All machines are mounted on a base unit which is set up vertically in a training panel frame.

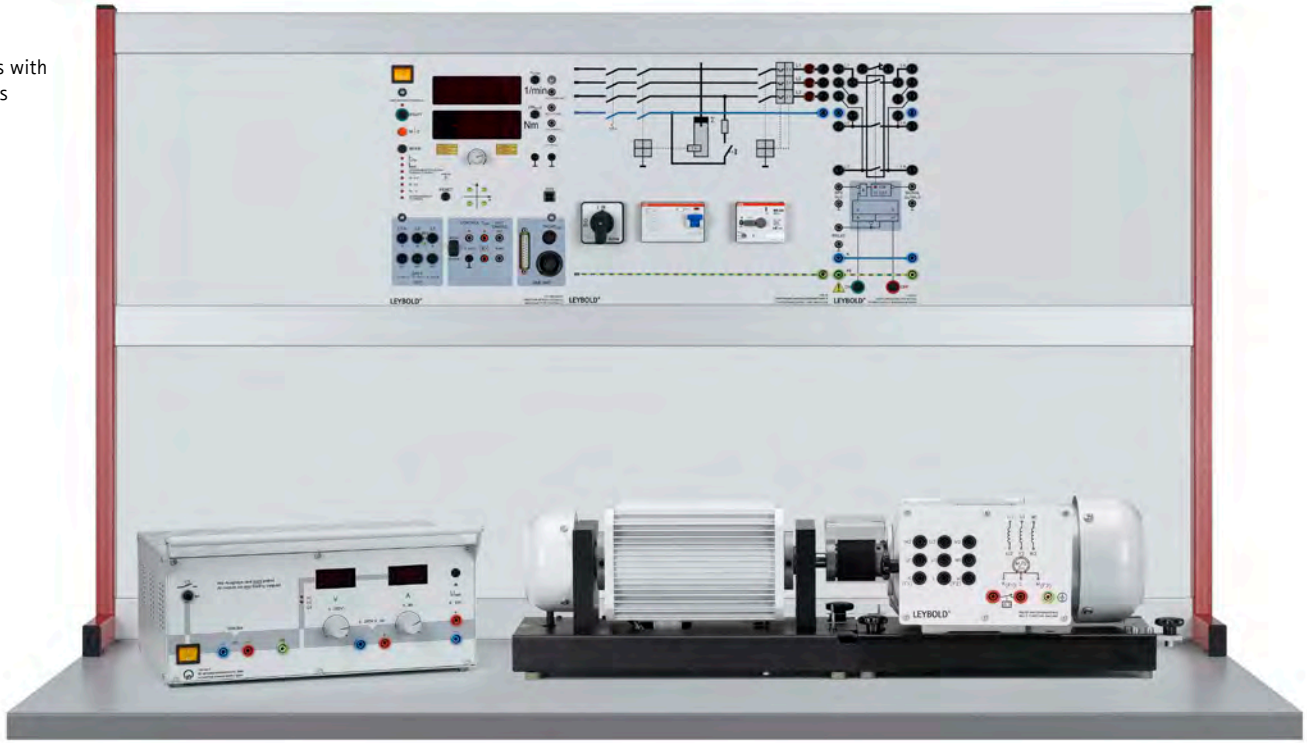
Objectives

- Recognising basic physical principles
- Recording machine characteristics
- Introduction to drive technology
- Use of simple tools (spanners, oil cans etc.)

The knowledge gained from these experiments can be directly applied to the area of industrial machines. The electrical machine teaching models for safety extra-low voltage are therefore the ideal preparation for experimenting with commercial industrial machines.

Machine Assembly Kits

E2.1.3.4
Machines with
Rotor Kits



Machines with Rotor Kits (E2.1.3.4)

Cat. No.	Description	E2.1.3.4
747 720	3 phase stator	1
747 721	Squirrel cage rotor	1
747 722	Slip-ring rotor	1
747 723	Salient pole rotor	1
747 724	Smooth core rotor	1
747 725	Reluctance rotor	1
747 726	DC shunt stator	1
747 728	DC rotor	1
747 729	Efficiency rotor	1
731 989USB	Machine test system 0.3	1
728 421	CBM10 MOMO/FCCP	1
531 282	Multimeter Metrahit Pro	3
726 09	Panel frame T130, two-level	1
725 852DG	DC machine supply 0.3	1
726 75	Three-phase supply unit with ELCB	1
745 561	Power circuit breaker module	1
731 06	Coupling 0.3	1
731 07	Shaft end guard 0.3	1
731 081	Coupling guard 0.3 transparent	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 190DE	LIT: E2.2.2.0 DC Machines 0.3 (German)	1
775 190EN	LIT: E2.2.2.0 DC Machines 0.3	1*

* additionally recommended

The experiments are carried out with the industrial machine assembly kits.

Objectives

- Protective measures and electrical safety
- Recording machine characteristics
- Set-up of various electrical machines

Machines with interchangeable rotors consist of a stator and various replaceable rotors. An electrical machine in the 300 W power range only comes into existence when the stator and rotor are put together. The stator has a 4-pole three-phase winding to generate the machine flux, along with a drive-end cap and a terminal box. The stator housing is mounted on a base and can be directly connected to the Machine test system 0.3 (731 989USB). A secure connection between stator and rotor is achieved by means of star-grip bolts, which allow for rapid changing of the rotors. No tools are needed. The rotors are equipped with non-drive-end caps, fan, cover and some include slip-rings, brushes etc. In conjunction with the machine testing system, the model machines then exhibit the typical properties of both synchronous and asynchronous (induction) machines. A DC stator with the relevant rotor is also available.

Highlights

- Comparison of efficiencies and characteristics of machines with different rotors
- Simple assembly for rapid set-up and time-effective lab experiments
- Experiments on high-efficiency rotors

The equipment set is suitable both for student experiments in a lab using low voltage (400 V three-phase) and on a mobile trolley for demonstrations by teachers in a classroom. The experiment procedures are contained in a printed manual.

The target group is made up of commercial apprentices and students of electrical machine construction. The course offers experiments at an intermediate level and also allows for the necessary insight into machine behaviour for scientific interpretation at undergraduate level.

Topics

- Recording of torque-speed characteristic
- Determination of nominal ratings for an electrical machine
- Comparison of efficiency for various machines

Machine Assembly Kits

E2.1.3.5
Electrical Machines
Training System

Electrical Machines Training System (E2.1.3.5)

Cat. No.	Description	E2.1.3.5
762 101	System: Electrical machines training system	1
762 102	MPS set: Electrical machines training system*	1

*The MPS set „Electrical machines training system" (762 102) is not available in all countries. Please contact your local dealer.

Equipment set above: Electrical Machines Training System (E2.1.3.5)

Equipment set left hand: Machines with Rotor Kits (E2.1.3.4)

The experiments are carried out using assembly kits for the educationally designed electrical machines. This requires simple tools such as screwdrivers and pliers.

Objectives

- Explanation of the components of an electric motor
- Fundamentals of electromagnetism
- DC motors
- Generators
- Series-wound, shunt-wound and compound-wound motors
- Single-phase and three-phase AC motors and generators
- Series-wound, universal and single-phase capacitor motors
- Repulsion, split-phase, shaded-pole and stepper motors
- Faults with electric motors

This training system allows electrical machines to be assembled from individual components and investigated. The topics are highly varied and range from the fundamentals of magnetic fields to commutator and three-phase machines. All the relevant components are visible and only need to be mechanically assembled or electrically connected.

The electrical machine training system utilises the modular concept of the electrical machine teaching models system but using mains voltage (three-phase 400 V). This allows small commercial machines to be assembled step by step in practical laboratory experiments and their ratings can then be determined using the Machine test system 0.3. The procedures for the experiments are contained in a printed manual.

The target group is made up of commercial apprentices and students of power engineering. The course offers experiments at an intermediate level for vocational colleges and undergraduate level.

Topics

- Recording of torque-speed characteristic
- Determination of nominal ratings for an electrical machine
- Comparison of efficiency for various machines

E2 ELECTRICAL DRIVES

E2.2 INDUSTRIAL MACHINES 300 W

E2.2.1 TRANSFORMERS 300 W
E2.2.1.0 Transformers 0.3
E2.2.1.1 3-Phase Transformer 0.3
E2.2.1.2 Scott Transformer 0.3
E2.2.1.3 AC Transformer 0.3
E2.2.1.4 AC Toroidal Core Transformer 0.3
E2.2.1.5 AC Autotransformer 0.3

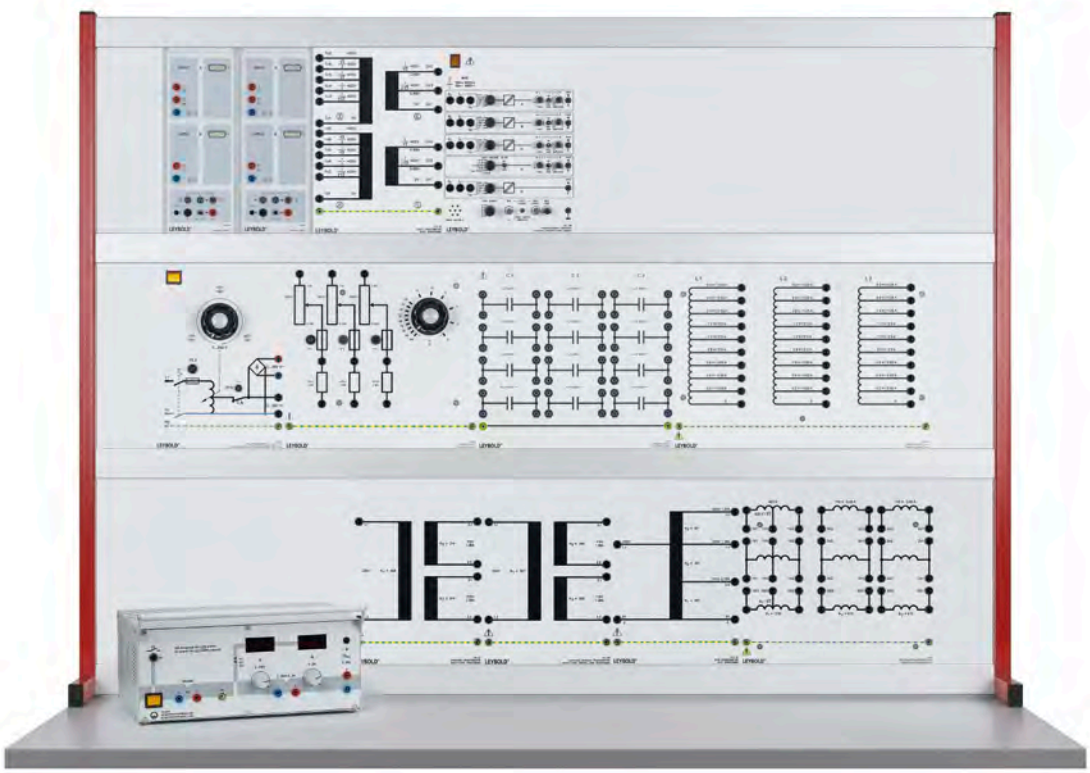
E2.2.2 DC MACHINES 300 W
E2.2.2.0 DC Machines 0.3
E2.2.2.1 DC Compound Machine 0.3
E2.2.2.2 Universal Motor 0.3

E2.2.3 AC MACHINES 300 W
E2.2.3.0 AC Machines 0.3
E2.2.3.1 Universal Motor 0.3
E2.2.3.2 Capacitor Motor R 0.3
E2.2.3.3 Capacitor Motor CS Basic 0.3

E2.2.4 3-PHASE INDUCTION MACHINES 300 W
E2.2.4.0 Induction Machines 0.3
E2.2.4.1 Squirrel Cage Motor 400/600 0.3
E2.2.4.2 Squirrel Cage Motor 230/400 0.3
E2.2.4.3 Slip Ring Motor 0.3
E2.2.4.4 Squirrel Cage Motor D 0.3
E2.2.4.5 Squirrel Cage Motor SW 0.3
E2.2.4.6 Squirrel Cage Motor 400/690 Basic 0.3
E2.2.4.7 Squirrel Cage Motor 230/400 Basic 0.3
E2.2.4.8 Squirrel Cage Motor 230/400 Brake Basic 0.3

E2.2.5 3-PHASE SYNCHRONOUS MACHINES 300 W
E2.2.5.0 Synchronous Machines 0.3
E2.2.5.1 Salient Pole Rotor 0.3
E2.2.5.2 Smooth Pole Rotor 0.3

E2.2.6 MECHATRONIC MOTORS 300 W
E2.2.6.1 Motor with Frequency Converter 0.3
E2.2.6.2 Brushless DC Machine 0.3



Transformers 0.3 (E2.2.1.0)

Similar to illustration

Transformers 300 W

E2.2.1.0
Transformers 0.3

E2.2.1.1
3-Phase Transformer 0.3

E2.2.1.2
Scott Transformer 0.3

E2.2.1.3
AC Transformer 0.3

E2.2.1.4
AC Toroidal Core Transformer 0.3

E2.2.1.5
AC Autotransformer 0.3

Cat. No.	Description	E2.2.1.0	E2.2.1.1	E2.2.1.2	E2.2.1.3	E2.2.1.4	E2.2.1.5
733 90	Three-phase transformer 0.3	1	1				
733 93	Scott transformer	1		1			
733 97	Single-phase transformer 0.3	1			1		
733 98	AC toroidal core transformer 0.3	1				1	
733 99	AC autotransformer 0.3	1					1
732 40	Resistive load 0.3	1	1	1	1	1	1
732 41	Capacitive load 0.3	1	1	1	1	1	1
732 42	Inductive load 0.3/1.0	1	1	1	1	1	1
531 282	Multimeter Metrahit Pro	3	3	3	3	3	3
727 12	Power factor meter	1	1	1	1	1	1
575 212	Two-channel oscilloscope 400	1	1	1			
575 231	Probe 100 MHz, 1:1 / 10:1	2	2	2			
735 261	Isolation amplifier, four channel	1	1	1			
726 09	Panel frame T130, two-level	1	1	1	1	1	1
726 85	Adjustable transformer 0...260 V	1			1	1	1
725 442DG	Three-phase voltage supply 400 V/2.5 A	1	1	1			
500 59	Safety bridging plugs, black, set of 10	2	2	2	2	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1	1	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1	1	1	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1	1	1	1	1
775 185DE	LIT: E2.2.1.0 Transformers 0.3 (German)	1	1	1	1	1	1
775 185EN	LIT: E2.2.1.0 Transformers 0.3	1*	1*	1*	1*	1*	1*

* additionally recommended

The experiments are carried out using transformers on training panels in panel frames.

Objectives

- Protective measures and electrical safety
- Set-up of power generation systems according to circuit diagrams
- Use of commercial measuring instruments, hand-held multimeters, oscilloscopes, measuring interfaces

Transformers are magnetically coupled systems used for transforming AC voltages or matching impedance. Transformers can therefore be used primarily for measurement or generation of electric power. These practical exercises study exclusively transformers used in energy generation. Transformer power ratings can range from a few mVA up to several MVA. The size and design also have an important effect on the transformer ratings. Transformers are regarded as electrical machines even though they contain no moving parts. The windings of three-phase transformers can be connected in a variety of circuit configurations.

Students carry out the experiments as specified in the printed manual. Hand-held multimeters are used to measure the characteristics of the transformers. Display of current or voltage against time is particularly interesting for three-phase equipment, although it is not essential. If this aspect is not required, then it is possible to dispense with the oscilloscope, isolating amplifier etc. or Sensor-CASSY. In this case multimeters are sufficient for measuring RMS values.

The target group is made up of commercial apprentices and students of power engineering. The course offers experiments at an intermediate level for vocational colleges and undergraduate level.

The complete equipment set allows for experiments on all the most important types of transformer in the 300 W rating class.

Topics

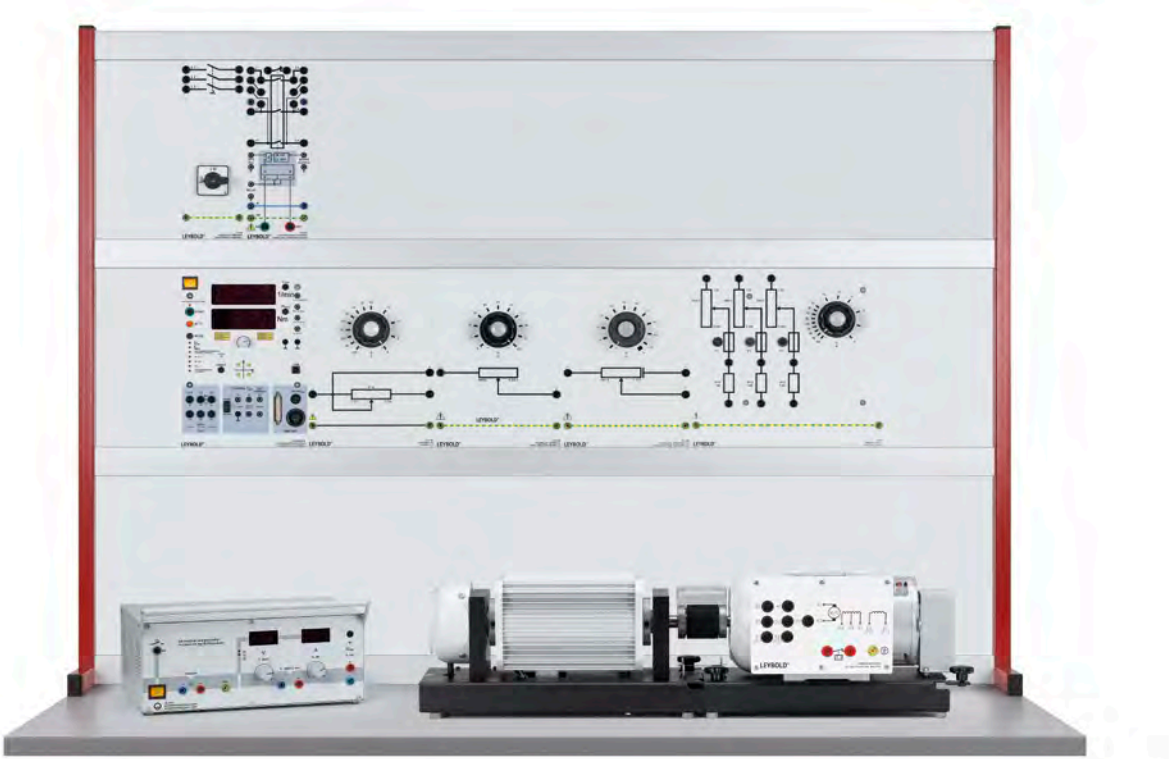
- Voltage equation and equivalent circuit
- Measurement without load, with load and with a short circuit
- Determination of self-inductance, magnetic coupling and leakage
- Losses, changes in voltage and efficiency

DC Machines 300 W

E2.2.2.0
DC Machines 0.3

E2.2.2.1
DC Compound Machine 0.3

E2.2.2.2
Universal Motor 0.3



DC Machines 0.3 (E2.2.2.0)

Cat. No.	Description	E2.2.2.0	E2.2.2.1	E2.2.2.2
731 86	DC compound machine 0.3	1	1	
732 00	Universal motor 0.3	1		1
731 94	Starter 0.3	1	1	1
732 40	Resistive load 0.3	1	1	1
731 42	On/off switch, three-pole	1	1	1
745 561	Power circuit breaker module	1	1	1
731 95	Field regulator, motor 0.3	1	1	
731 96	Field regulator, generator 0.3	1	1	
731 989USB	Machine test system 0.3	1	1	1
728 421	CBM10 MOMO/FCCP	1	1	1
531 282	Multimeter Metrahit Pro	3	3	2
726 09	Panel frame T130, two-level	1	1	1
725 852DG	DC machine supply 0.3	1	1	1
731 06	Coupling 0.3	1	1	1
731 07	Shaft end guard 0.3	1	1	1
731 081	Coupling guard 0.3 transparent	1	1	1
500 59	Safety bridging plugs, black, set of 10	2	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1	1
775 190DE	LIT: E2.2.2.0 DC Machines 0.3 (German)	1	1	1
775 190EN	LIT: E2.2.2.0 DC Machines 0.3	1*	1*	1*
732 44	Flywheel 0.3		1*	

* additionally recommended

The experiments are carried out using industrial-design machines. All the test machines possess a special base for connecting the Machine test system 0.3. The testing system can be used to record the characteristics of the machines under test. Power for the machines is supplied by special laboratory power supplies.

Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics

Features

- In order to protect against overheating, the stator windings of the test machines are equipped with temperature sensors
- Should overheating occur, the machine testing system automatically shuts down the machine under test, thus preventing any damage to it.
- The test machines are equipped with an educationally designed terminal board with the winding configuration printed on it.
- The ends of all the windings are connected to the terminal board and can be accessed via 4-mm safety sockets
- Computer-supported acquisition of measurement data provides for meaningful measurement results.

The complete set is equally suitable for student experiments in laboratories with low voltage supplies (230 V AC) and for setting up on a mobile trolley for demonstration by teachers in a classroom. The procedures for the experiments are provided in a printed manual.

The target group is made up of commercial apprentices and students of electrical machine construction. The course offers experiments at an intermediate level and also allows for the necessary insight into machine behaviour for scientific interpretation at undergraduate level.

Topics

- Design and function of DC machines
- Armature reaction and commutation
- Series-wound machines
- Possibilities for changing speed
- Energy conversion
- Shunt-wound machines
- Operation at constant speed
- Self-excitation, etc.

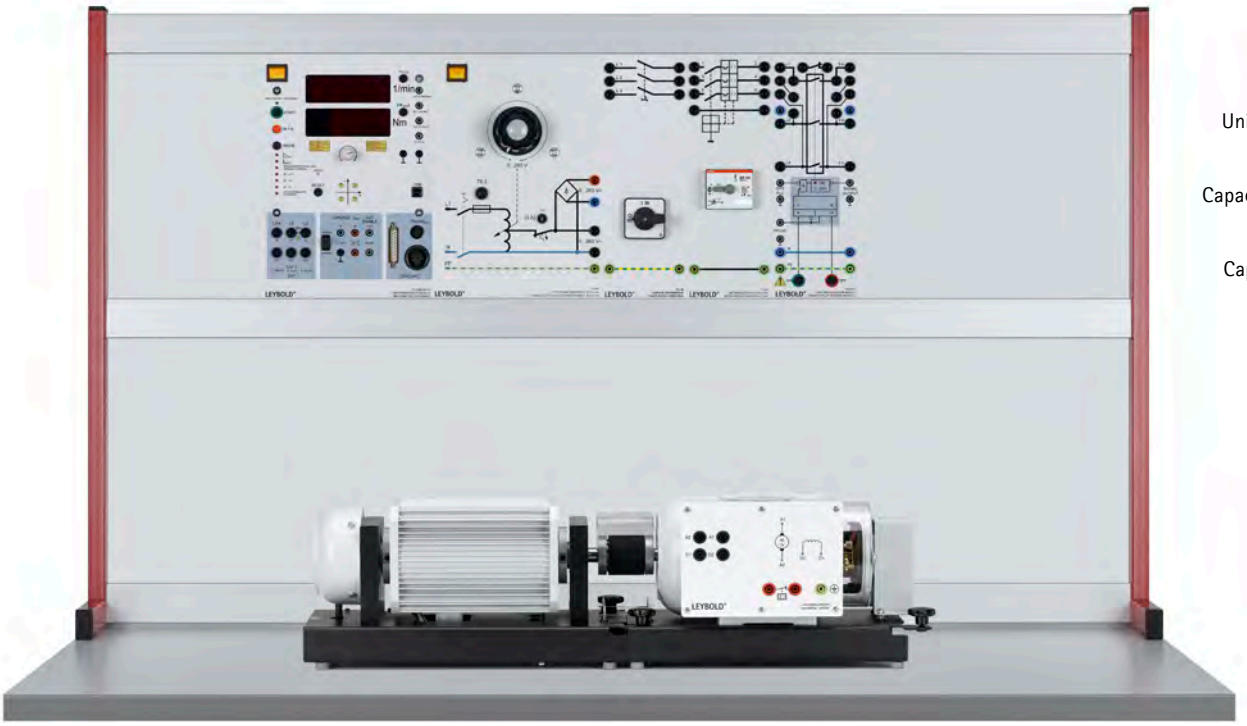
AC Machines 300 W

E2.2.3.0
AC Machines 0.3

E2.2.3.1
Universal Motor 0.3

E2.2.3.2
Capacitor Motor R 0.3

E2.2.3.3
Capacitor Motor CS
Basic 0.3



AC Machines 0.3 (E2.2.3.0)

Cat. No.	Description	E2.2.3.0	E2.2.3.1	E2.2.3.2	E2.2.3.3
732 00	Universal motor 0.3	1	1		
732 04	Capacitor motor R 0.3	1		1	
732 204	Capacitor motor CS basic 0.3	1			1
732 14	Motor protection switch, 1-1.6 A	1	1		
732 83	Motor protection switch, 1.6-2.4 A	1		1	1
731 42	On/off switch, three-pole	1	1	1	1
745 561	Power circuit breaker module	1	1	1	1
731 989USB	Machine test system 0.3	1	1	1	1
728 421	CBM10 MOMO/FCCP	1	1	1	1
531 282	Multimeter Metrahit Pro	2	2	2	2
727 12	Power factor meter	1	1	1	1
726 09	Panel frame T130, two-level	1	1	1	1
726 85	Adjustable transformer 0...260 V	1	1	1	1
731 06	Coupling 0.3	1	1	1	1
731 07	Shaft end guard 0.3	1	1	1	1
731 081	Coupling guard 0.3 transparent	1	1	1	1
500 59	Safety bridging plugs, black, set of 10	2	2	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1	1	1
775 195DE	LIT: E2.2.3.0 AC Machines 0.3 (German)	1	1	1	1
775 195EN	LIT: E2.2.3.0 AC Machines 0.3	1*	1*	1*	1*

* additionally recommended

The experiments are carried out using machines of industrial manufacture. All the test machines are equipped with a special base for attachment to the Machine test system 0.3. The system allows the characteristics of the machines under test to be recorded. Power for the machines under test is provided via a variable transformer.

Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics

Features

- In order to protect against overheating, the stator windings of the test machines are equipped with temperature sensors
- Should overheating occur, the machine testing system automatically shuts down the machine under test, thus preventing any damage to it.
- The test machines are equipped with an educationally designed terminal board with the winding configuration printed on it.
- The ends of all the windings are connected to the terminal board and can be accessed via 4-mm safety sockets
- Computer-supported acquisition of measurement data provides for meaningful measurement results.

The complete set is equally suitable for student experiments in laboratories with low voltage supplies (230 V AC) and for setting up on a mobile trolley for demonstration by teachers in a classroom. The procedures for the experiments are provided in a printed manual.

The target group is made up of commercial apprentices and students of electrical machine construction. The course offers experiments at an intermediate level and also allows for the necessary insight into machine behaviour for scientific interpretation at undergraduate level.

In addition to the machines included in the equipment sets, the individual component section of the catalogue also includes special machines such as repulsion motors and auxiliary phase motors, which are available on request.

Topics

- Connection and operation of AC machines
- Reversing direction of rotation
- Measurement of efficiency
- Characteristics of motors
- Load characteristics, etc.

3-Phase Induction Machines 300 W

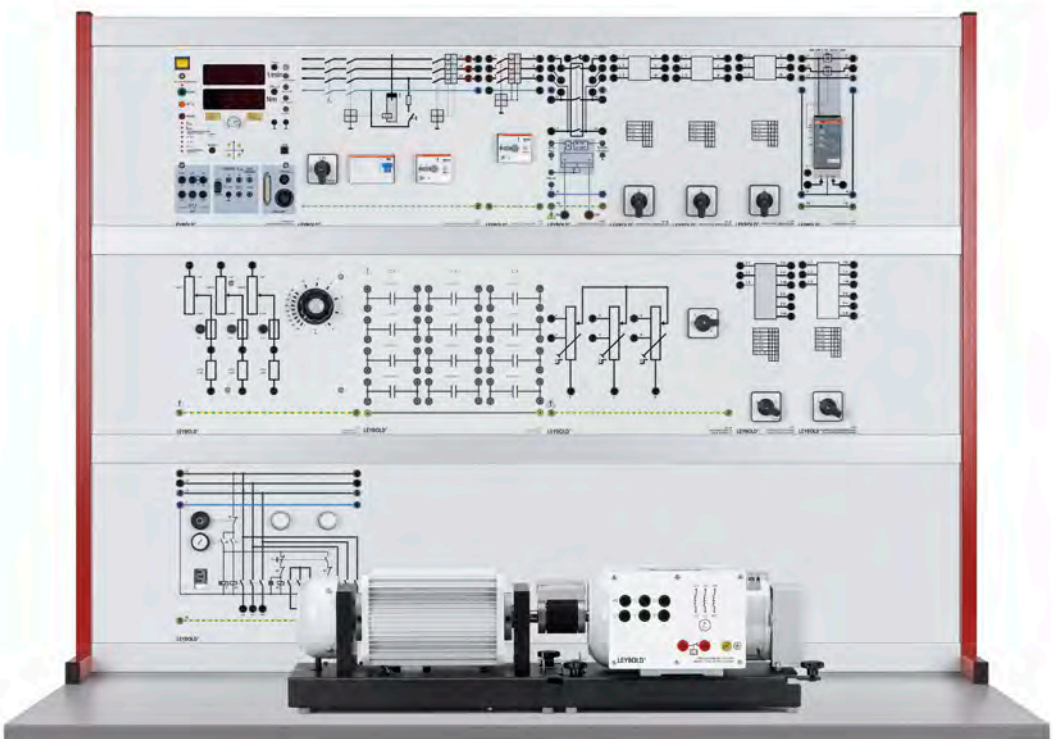
E2.2.4.0
Induction Machines 0.3

E2.2.4.1
Squirrel Cage Motor 400/600 0.3

E2.2.4.2
Squirrel Cage Motor 230/400 0.3

E2.2.4.3
Slip Ring Motor 0.3

E2.2.4.4
Squirrel Cage Motor D 0.3



Induction Machines 0.3 (E2.2.4.0)

Similar to illustration

Cat. No.	Description	E2.2.4.0	E2.2.4.1	E2.2.4.2	E2.2.4.3	E2.2.4.4
732 11	Squirrel cage motor 400/690/0.3	1	1			
732 104	Squirrel cage motor 230/400/0.3	1		1		
732 33	Slip ring motor 0.3	1			1	
732 28	Multi-function machine 0.3	1*				
732 24	Squirrel cage motor D 0.3	1				1
732 26	Squirrel cage motor SW 0.3	1				
732 203	Squirrel cage motor basic 400/690/0.3	1				
732 201	Squirrel cage motor basic 230/400/0.3	1				
732 202	Squirrel cage motor basic 230/400, brake 0.3	1				
726 75	Three-phase supply unit with ELCB	1	1	1	1	1
732 14	Motor protection switch, 1-1.6 A	1	1	1	1	1
731 42	On/off switch, three-pole	1	1	1	1	1
745 561	Power circuit breaker module	1	1	1	1	1
732 40	Resistive load 0.3	1	1	1		
732 41	Capacitive load 0.3	1	1	1	1	
731 47	Star-delta switch	1	1			
731 48	Star-delta reversing switch	1	1*			
731 49	Reversing switch	1	1	1	1*	
731 50	Star-delta starter	1	1*			
731 51	Soft starter 0.3 /1.0	1	1	1	1	
732 29	Rotor starter 0.3	1			1	
731 55	Pole reverser, Dahlander	1				1
731 57	Pole reverser SW	1				
731 65	Blocking gear 0.3	1			1	
731 391	Squirrel cage fault simulator	1*	1	1		
731 989USB	Machine test system 0.3	1	1	1	1	1
728 421	CBM10 MOMO/FCCP	1	1	1	1	1
531 282	Multimeter Metrahit Pro	2	2	2	2	2
727 12	Power factor meter	1	1	1	1	1
531 600	Insulation tester Metriso C	1*	1	1		
726 09	Panel frame T130, two-level	1	1	1	1	1

Cat. No.	Description	E2.2.4.0	E2.2.4.1	E2.2.4.2	E2.2.4.3	E2.2.4.4
731 06	Coupling 0.3	1	1	1	1	1
731 07	Shaft end guard 0.3	1			1	
731 081	Coupling guard 0.3 transparent	1	1	1	1	1
500 59	Safety bridging plugs, black, set of 10	2	2	2	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1	1	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1	1	1	1
775 200EN	LIT: E2.2.4.0 Induction Machines 0.3	1*	1*	1*	1*	1*
775 200DE	LIT: E2.2.4.0 Induction Machines 0.3 (German)	1	1	1	1	1

* additionally recommended

The experiments are carried out using machines of industrial manufacture. All the test machines are equipped with a special base for attachment to the Machine test system 0.3. The system allows the characteristics of the machines under test to be recorded. Power for the machines under test is provided either directly from the mains or via special laboratory power supplies.

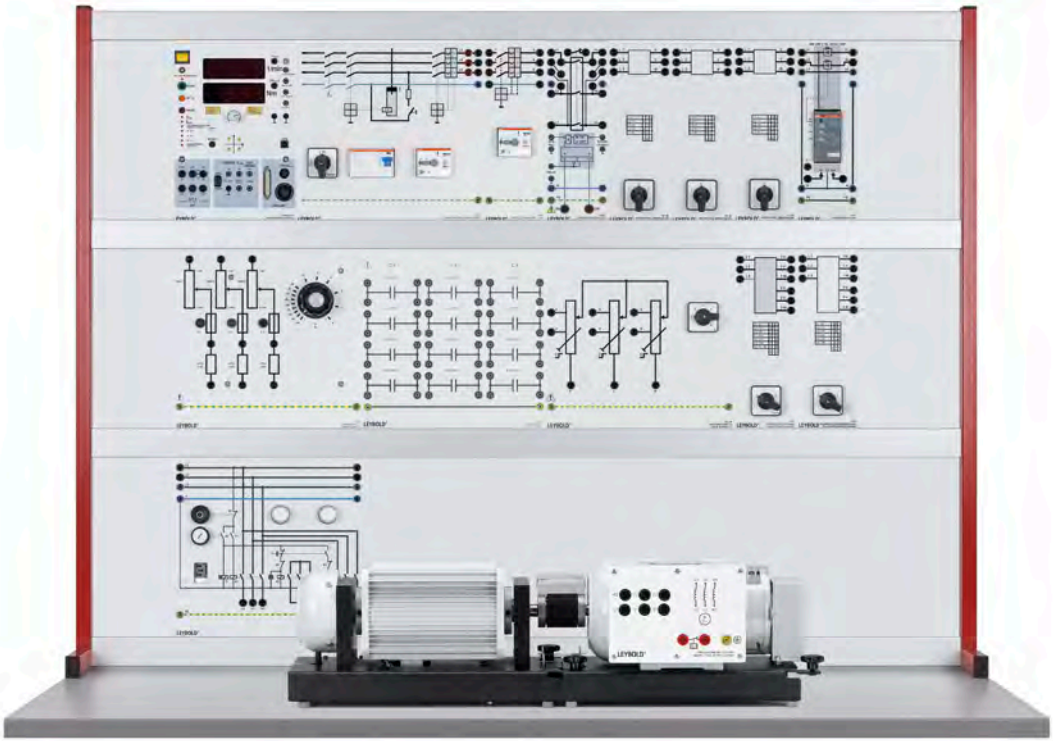
Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics

Features

- In order to protect against overheating, the stator windings of the test machines are equipped with temperature sensors
- Should overheating occur, the machine testing system automatically shuts down the machine under test, thus preventing any damage to it.
- The test machines are equipped with an educationally designed terminal board with the winding configuration printed on it.
- The ends of all the windings are connected to the terminal board and can be accessed via 4-mm safety sockets
- Computer-supported acquisition of measurement data provides for meaningful measurement results.

3-Phase Induction Machines 300 W



Induction Machines 0.3 (E2.2.4.0)

Similar to illustration

E2.2.4.5
Squirrel Cage Motor SW 0.3

E2.2.4.6
Squirrel Cage Motor 400/690
Basic 0.3

E2.2.4.7
Squirrel Cage Motor 230/400
Basic 0.3

E2.2.4.8
Squirrel Cage Motor 230/400 Brake
Basic 0.3

Cat. No.	Description	E2.2.4.5	E2.2.4.6	E2.2.4.7	E2.2.4.8
732 26	Squirrel cage motor SW 0.3	1			
726 75	Three-phase supply unit with ELCB	1	1	1	1
732 14	Motor protection switch, 1-1.6 A	1	1	1	1
731 42	On/off switch, three-pole	1	1	1	1
745 561	Power circuit breaker module	1	1	1	1
731 57	Pole reverser SW	1			
731 989USB	Machine test system 0.3	1	1	1	1
728 421	CBM10 MOMO/FCCP	1	1	1	1
531 282	Multimeter Metrahit Pro	2	2	2	2
727 12	Power factor meter	1	1	1	1
726 09	Panel frame T130, two-level	1	1	1	1
731 06	Coupling 0.3	1	1	1	1
500 59	Safety bridging plugs, black, set of 10	2	2	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1	1	1
775 200DE	LIT: E2.2.4.0 Induction Machines 0.3 (German)	1	1	1	1
775 200EN	LIT: E2.2.4.0 Induction Machines 0.3	1*	1*	1*	1*
732 203	Squirrel cage motor basic 400/690/0.3		1		
732 40	Resistive load 0.3		1	1	1
732 41	Capacitive load 0.3		1	1	1
731 47	Star-delta switch		1		
731 48	Star-delta reversing switch		1*		
731 49	Reversing switch		1	1	1
731 50	Star-delta starter		1*		
731 51	Soft starter 0.3 /1.0		1	1*	1
731 081	Coupling guard 0.3 transparent		1	1	1
732 201	Squirrel cage motor basic 230/400/0.3			1	
732 202	Squirrel cage motor basic 230/400, brake 0.3				1

* additionally recommended

Basic Drive

- Squirrel cage motors in the Basic Drive class are industrial machines which are supplied with the manufacturers' original terminal board. An illustration of the winding configuration has been deliberately omitted.
- The safety sockets on the terminal board are safely accessible behind a plexiglass pane.
- The winding terminals are labelled according to international standards.
- Basic Drive machines are supplied with no temperature sensors and need to be protected from overloading by means of a motor protection circuit breaker. The experiments are therefore very similar to industrial practice.
- Basic Drive machines are available exclusively in the 300 W rating class.

The individual equipment set is equally suitable for student experiments in laboratories with low voltage supplies (400 V three-phase) and for setting up on a mobile trolley for demonstration by teachers in a classroom. The procedures for the experiments are provided in a printed manual.

Topics

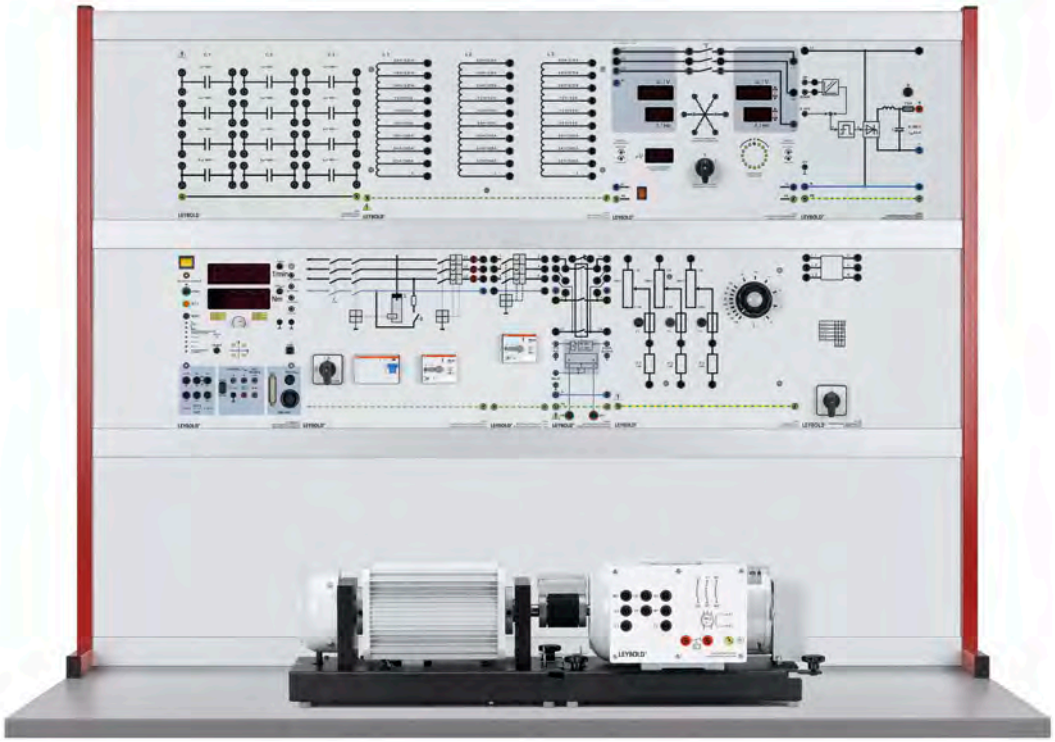
- Operation of a switchable pole motor with separate windings at low speed and high speed
- Connection and operation of a switchable pole motor with the help of a pole change-over switch
- Recording of characteristics at low speed and high speed
- Design and function
- Characteristics during motor operation
- Starting
- Star-delta starting
- Stator resistance starting circuit
- Braking
- Power performance of an ideal rotating field machine
- Power flux
- Open-circuit experiment
- Short-circuit load experiment
- Design and function of three-phase generator
- Characteristics during generator operation
- Generator slip
- Self-excitation of an induction generator
- Voltage stability
- Insular operation

3-Phase Synchronous Machines 300 W

E2.2.5.0
Synchronous Machines 0.3

E2.2.5.1
Salient Pole Rotor 0.3

E2.2.5.2
Smooth Pole Rotor 0.3



Synchronous Machines 0.3 (E2.2.5.0)

Cat. No.	Description	E2.2.5.0	E2.2.5.1	E2.2.5.2
732 36	Synchronous machine SP 0.3	1	1	
732 37	Synchronous machine SR 0.3	1		1
732 28	Multi-function machine 0.3	1*		
732 40	Resistive load 0.3	1	1	1
732 41	Capacitive load 0.3	1	1	1
732 42	Inductive load 0.3/1.0	1	1	1
726 75	Three-phase supply unit with ELCB	1	1	1
745 05	Manual synchronisation unit	1	1	1
732 14	Motor protection switch, 1-1.6 A	1	1	
745 561	Power circuit breaker module	1	1	1
531 282	Multimeter Metrahit Pro	3	3	3
727 32	Moving iron meter, 2.5 A	1	1	1
727 12	Power factor meter	1	1	1
731 989USB	Machine test system 0.3	1	1	1
728 421	CBM10 MOMO/FCCP	1	1	1
726 09	Panel frame T130, two-level	1	1	1
725 852DG	DC machine supply 0.3	1	1	1
725 352DG	Extra-low voltage supply 24/4	1*		
731 06	Coupling 0.3	1	1	1
731 07	Shaft end guard 0.3	1	1	1
731 081	Coupling guard 0.3 transparent	2	1	1
500 59	Safety bridging plugs, black, set of 10	1	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1	1
775 205DE	LIT: E2.2.5.0 Synchronous Machines 0.3 (German)	1	1	1
775 205EN	LIT: E2.2.5.0 Synchronous Machines 0.3	1*	1*	1*
731 49	Reversing switch			1

* additionally recommended

The experiments are carried out using machines of industrial manufacture. All the test machines are equipped with a special base for attachment to the Machine test system 0.3. The system allows the characteristics of the machines under test to be recorded. Power for the machines under test is provided either directly from the mains or via special laboratory power supplies.

Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics

Features

- In order to protect against overheating, the stator windings of the test machines are equipped with temperature sensors
- Should overheating occur, the machine testing system automatically shuts down the machine under test, thus preventing any damage to it.
- The test machines are equipped with an educationally designed terminal board with the winding configuration printed on it.
- The ends of all the windings are connected to the terminal board and can be accessed via 4-mm safety sockets
- Computer-supported acquisition of measurement data provides for meaningful measurement results.

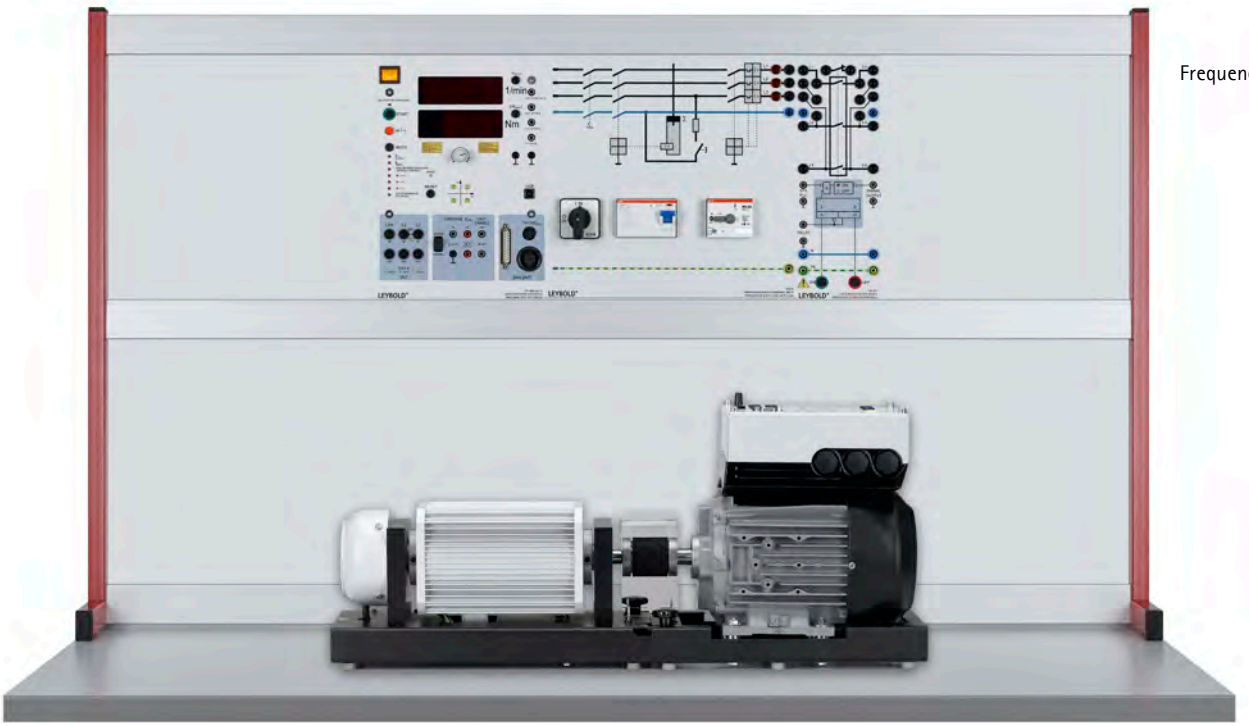
Synchronous motor topics

- Non-salient-pole and salient-pole rotors
- Voltage equations
- Equivalent circuit and vector diagram
- Operation with no-load and with a permanent three-pole short-circuit
- Locus diagrams and control characteristics
- Torque and loading
- Potier diagram and armature reaction
- Synchronisation and use of multiple machines in parallel
- Starting methods for synchronous motors
- Control of reactive power
- Power performance

Synchronous generator topics

- Voltage generation
- Excitation of synchronous machines
- Operating response
- Armature current and torque
- Braking operation and locus diagrams
- Starting and synchronisation
- Single-phase generators

Mechatronic Motors 300 W



E2.2.6.1
Motor with
Frequency Converter 0.3

Motor with Frequency Converter 0.3 (E2.2.6.1)

Similar to illustration

Cat. No.	Description	E2.2.6.1
732 46	Frequency converter motor 0.3	1
735 314	LCP2 local control panel	1
531 282	Multimeter Metrahit Pro	3
731 989USB	Machine test system 0.3	1
728 421	CBM10 MOMO/FCCP	1
726 09	Panel frame T130, two-level	1
726 75	Three-phase supply unit with ELCB	1
731 06	Coupling 0.3	1
731 081	Coupling guard 0.3 transparent	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 854	Safety leads, set of 20	1
735 315USB	USB/RS 485 interface converter	1*
775 350DE	LIT: E2.2.6.1 Motor with Frequency Converter 0.3 (German)	1
775 350EN	LIT: E2.2.6.1 Motor with Frequency Converter 0.3	1*

* additionally recommended

The experiments are carried out using machines of industrial manufacture. All the test machines are equipped with a special base for attachment to the Machine test system 0.3. The system allows the characteristics of the machines under test to be recorded. Power for the machines under test is provided either directly from the mains or via special laboratory power supplies.

Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics

The machine to be tested is an industrial frequency converter motor consisting of a four-pole asynchronous three-phase motor with a power rating of 0.55 kW including an integrated frequency converter. The motor and the converter are optimally fine-tuned to one another. The experiment investigates the features of the operating response in comparison to other types of machine without built-in power electronics. More advanced topics such as positioning control or non-linear load characteristics (winding machines, fans etc.) are investigated in E2.6, Servo technology.

Features

- In order to protect against overheating, the stator windings of the test machines are equipped with temperature sensors
- Should overheating occur, the machine testing system automatically shuts down the machine under test, thus preventing any damage to it.
- The test machines are equipped with an educationally designed terminal board with the winding configuration printed on it.
- The ends of all the windings are connected to the terminal board and can be accessed via 4-mm safety sockets
- Computer-supported acquisition of measurement data provides for meaningful measurement results.

The individual equipment set is equally suitable for student experiments in laboratories with low voltage supplies (400 V three-phase) and for setting up on a mobile trolley for demonstration by teachers in a classroom. The procedures for the experiments are provided in a printed manual.

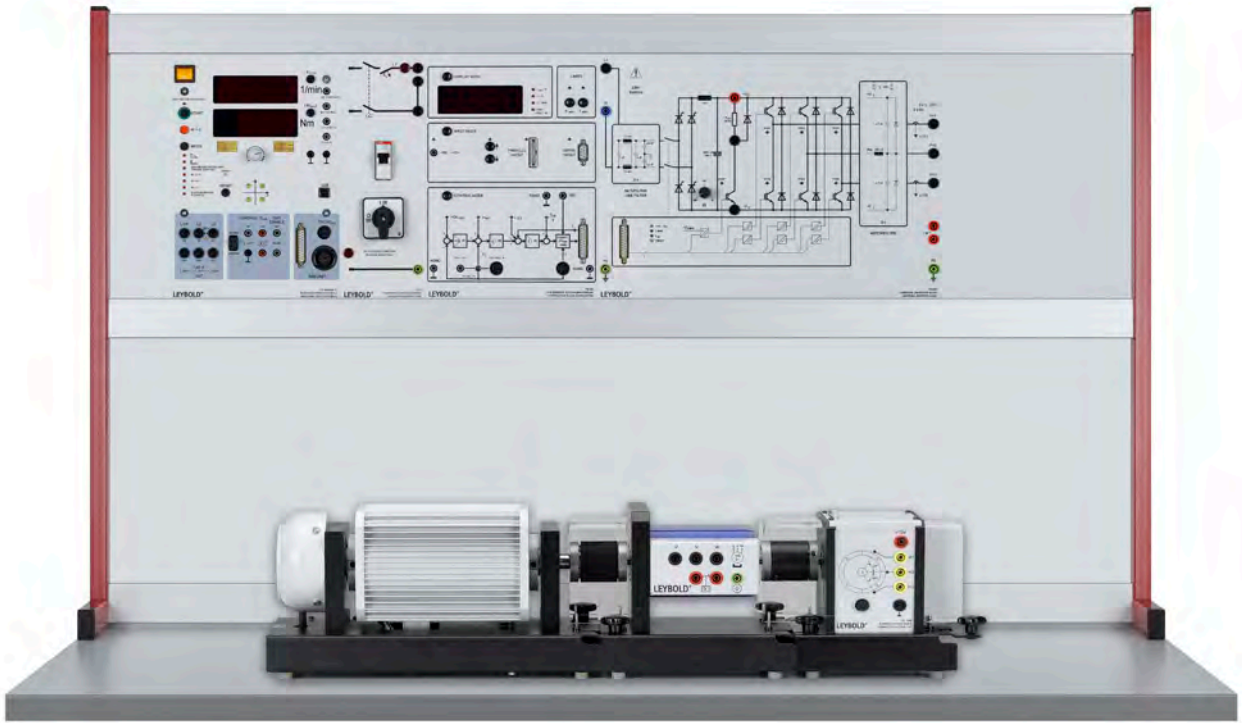
The target group is made up of commercial apprentices and students of electrical machine construction. The course offers experiments at an intermediate level and also allows for the necessary insight into machine behaviour for scientific interpretation at undergraduate level.

Topics

- Design and function of a frequency converter controlled motor
- Operation with a power amplifier
- Run-up and operating characteristics
- How speed depends on frequency
- How speed depends on load: fan, pump, winding machine, flywheel

Mechatronic Motors 300 W

E2.2.6.2
Brushless
DC Machine 0.3



Brushless DC Machine 0.3 (E2.2.6.2)

Cat. No.	Description	E2.2.6.2
731 096	Commutation pick-up 0.3	1
731 994	AC servo motor 0.3	1
735 292	Control unit block commutation	1
735 297	Universal converter 3 x 230 V	1
537 35	Rheostat, 330 ohms	1
531 282	Multimeter Metrahit Pro	2
731 989USB	Machine test system 0.3	1
728 421	CBM10 MOMO/FCCP	1
726 09	Panel frame T130, two-level	1
726 75	Three-phase supply unit with ELCB	1
731 06	Coupling 0.3	1
731 07	Shaft end guard 0.3	1
731 081	Coupling guard 0.3 transparent	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 305DE	LIT: E2.6.2.1 AC Servo with Block Commutation (German)	1
775 305EN	LIT: E2.6.2.1 AC Servo with Block Commutation	1*

* additionally recommended

The experiments are carried out using machines of industrial manufacture. All the test machines are equipped with a special base for attachment to the Machine test system 0.3. The system allows the characteristics of the machines under test to be recorded. Power for the machines under test is provided either directly from the mains or via special laboratory power supplies.

Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics

Mechatronics machines are used in the field of automation. They are distinguished by their area of application, whereby the physical operating principle is unimportant. AC servo motors (synchronous machine) and frequency converter motors (asynchronous machine) are both used. Mechatronics machines of small to medium power carry out positioning tasks. Control of the machines always requires power electronics components.

Features

- In order to protect against overheating, the stator windings of the test machines are equipped with temperature sensors
- Should overheating occur, the machine testing system automatically shuts down the machine under test, thus preventing any damage to it.
- The test machines are equipped with an educationally designed terminal board with the winding configuration printed on it.
- The ends of all the windings are connected to the terminal board and can be accessed via 4-mm safety sockets
- Computer-supported acquisition of measurement data provides for meaningful measurement results.

The individual equipment set is equally suitable for student experiments in laboratories with low voltage supplies (400 V three-phase) and for setting up on a mobile trolley for demonstration by teachers in a classroom. The procedures for the experiments are provided in a printed manual.

The target group is made up of commercial apprentices and students of electrical machine construction. The course offers experiments at an intermediate level and also allows for the necessary insight into machine behaviour for scientific interpretation at undergraduate level.

Topics

- Design and function
- Operation with a power amplifier
- How current and voltage change over time
- Load characteristics
- Automatic or closed-loop current, speed and positioning control
- Dynamics and changing direction of rotation
- Variable speed and load

E2 ELECTRICAL DRIVES

E2.3 INDUSTRIAL MACHINES 1 KW

E2.3.1 TRANSFORMERS 1 KW
E2.3.1.0 Transformers1.0
E2.3.1.1 3-Phase Transformer 1.0
E2.3.1.2 Scott Transformer 0.3
E2.3.1.3 AC Transformer 0.3
E2.3.1.4 AC Toroidal Core Transformer 0.3
E2.3.1.5 AC Autotransformer 0.3

E2.3.2 DC MACHINES 1 KW
E2.3.2.0 DC Machines 1.0
E2.3.2.1 DC Compound Machine 1.0
E2.3.2.2 Universal Motor 1.0

E2.3.3 AC MACHINES 1 KW
E2.3.3.0 AC Machines 1.0
E2.3.3.1 Universal Motor 1.0
E2.3.3.2 Capacitor Motor R 1.0

E2.3.4 3-PHASE INDUCTION MACHINES 1 KW
E2.3.4.0 Induction Machines 1.0
E2.3.4.1 Squirrel Cage Motor 400/600 1.0
E2.3.4.2 Squirrel Cage Motor 230/400 1.0
E2.3.4.3 Slip Ring Motor 1.0
E2.3.4.4 Squirrel Cage Motor D 1.0
E2.3.4.5 Squirrel Cage Motor SW 1.0

E2.3.5 3-PHASE SYNCHRONOUS MACHINES 1 KW
E2.3.5.0 Synchronous Machines 1.0
E2.3.5.1 Salient Pole Rotor 1.0
E2.3.5.2 Smooth Core Rotor 1.0

E2.3.6 MECHATRONIC MOTORS 1 KW
E2.3.6.1 Motor with Frequency Converter 1.0

Transformers 1 kW

E2.3.1.0
Transformers 1.0

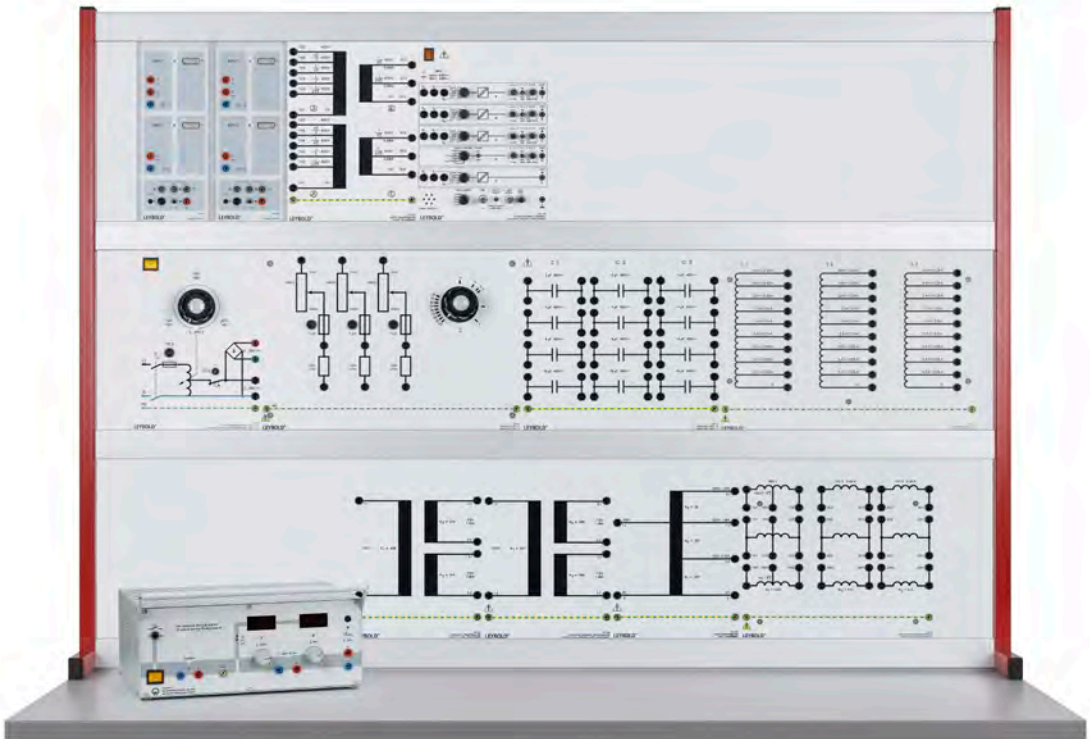
E2.3.1.1
3-Phase Transformer 1.0

E2.3.1.2
Scott Transformer 0.3

E2.3.1.3
AC Transformer 0.3

E2.3.1.4
AC Toroidal Core Transformer 0.3

E2.3.1.5
AC Autotransformer 0.3



Transformers 1.0 (E2.3.1.0)

Similar to illustration

Cat. No.	Description	E2.3.1.0	E2.3.1.1	E2.3.1.2	E2.3.1.3	E2.3.1.4	E2.3.1.5
733 91	Three-phase transformer 1.0	1	1				
733 93	Scott transformer	1		1			
733 97	Single-phase transformer 0.3	1			1		
733 98	AC toroidal core transformer 0.3	1				1	
733 99	AC autotransformer 0.3	1					1
733 10	Resistive load 1.0	1	1	1	1	1	1
732 41	Capacitive load 0.3	1			1	1	1
732 42	Inductive load 0.3/1.0	1			1	1	1
531 282	Multimeter Metrahit Pro	3	3	3	3	3	3
727 12	Power factor meter	1	1	1	1	1	1
575 212	Two-channel oscilloscope 400	1	1	1			
575 231	Probe 100 MHz, 1:1 / 10:1	2	2	2			
735 261	Isolation amplifier, four channel	1	1	1			
726 09	Panel frame T130, two-level	1	1	1	1	1	1
725 442DG	Three-phase voltage supply 400 V/2.5 A	1	1	1			
500 59	Safety bridging plugs, black, set of 10	2	2	2	2	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1	1	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1	1	1	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1	1	1	1	1
775 220DE	LIT: E2.3.1.0 Transformers 1.0 (German)	1	1	1*	1*	1*	1*
775 220EN	LIT: E2.3.1.0 Transformers 1.0	1*	1*				
726 85	Adjustable transformer 0...260 V				1	1	1

* additionally recommended

The experiments are carried out using transformers on training panels in panel frames.

Objectives

- Protective measures and electrical safety
- Set-up of power generation systems according to circuit diagrams
- Use of commercial measuring instruments, hand-held multimeters, oscilloscopes, measuring interfaces

Transformers are magnetically coupled systems used for transforming AC voltages or matching impedance. Transformers can therefore be used primarily for measurement or generation of electric power. These practical exercises study exclusively transformers used in energy generation. Transformer power ratings can range from a few mVA up to several MVA. The size and design also have an important effect on the transformer ratings. Transformers are regarded as electrical machines even though they contain no moving parts. The windings of three-phase transformers can be connected in a variety of circuit configurations.

Students carry out the experiments as specified in the printed manual. Hand-held multimeters are used to measure the characteristics of the transformers. Display of current or voltage against time is particularly interesting for three-phase equipment, although it is not essential. If this aspect is not required, then it is possible to dispense with the oscilloscope, isolating amplifier etc. or Sensor-CASSY. In this case multimeters are sufficient for measuring RMS values.

The target group is made up of commercial apprentices and students of power engineering. The course offers experiments at an intermediate level for vocational colleges and undergraduate level.

The complete equipment set allows for experiments on all the most important types of transformer.

Topics

- Voltage equation and equivalent circuit
- Measurement without load, with load and with a short circuit
- Determination of self-inductance, magnetic coupling and leakage
- Losses, changes in voltage and efficiency

DC Machines 1kW

E2.3.2.0
DC Machines 1.0

E2.3.2.1
DC Compound Machine 1.0

E2.3.2.2
Universal Motor 1.0

DC Machines 1.0 (E2.3.2.0)

Cat. No.	Description	E2.3.2.0	E2.3.2.1	E2.3.2.2
732 60	DC multi-function machine 1.0	1	1	
733 14	Flywheel 1.0	1*	1*	1*
732 70	Universal motor 1.0	1		1
733 10	Resistive load 1.0	1	1	
732 64	Starter 1.0	1	1	
732 65	Field regulator, motor 1.0	1	1	
732 66	Field Regulator Generator 1.0	1	1	
731 42	On/off switch, three-pole	1	1	1
745 561	Power circuit breaker module	1	1	1
531 282	Multimeter Metrahit Pro	3	3	2
732 689USB	Machine test system 1.0	1	1	1
728 421	CBM10 MOMO/FCCP	1	1	1
726 09	Panel frame T130, two-level	1	1	1
725 862DG	DC machine supply 1.0	1	1	1
732 56	Coupling 1.0	1	1	1
732 57	Shaft end guard 1.0	1	1	1
732 58	Coupling guard 1.0	1	1	1
500 59	Safety bridging plugs, black, set of 10	2	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1	1
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	1	1	1
775 225DE	LIT: E2.3.2.0 DC Machines 1.0 (German)	1	1	1
775 225EN	LIT: E2.3.2.0 DC Machines 1.0	1*	1*	1*

* additionally recommended

The experiments are carried out using industrial-design machines. All the test machines possess a special base for connecting the Machine test system 1.0. The testing system can be used to record the characteristics of the machines under test. Power for the machines is supplied either via the mains or by special laboratory power supplies.

Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics

Features

- In order to protect against overheating, the stator windings of the machines to be tested are equipped with temperature sensors
- Should overheating occur the machine testing system automatically shuts down the test machine, thus preventing any damage to it.
- The machines to be tested are equipped with an educationally designed terminal board with the winding configuration printed on it.
- The ends of all the windings are connected to the terminal board and can be accessed via 4-mm safety sockets
- Computer-supported acquisition of measurement data provides for meaningful measurement results.
- Machines in the 1 kW rating class have a powerful and realistic operating response
- In comparison to smaller machines, their characteristics display distinctive features related to the design.

Topics

- Design and function of DC machines
- Armature reaction and commutation
- Series-wound machines
- Possibilities for changing speed
- Energy conversion
- Shunt-wound machines
- Operation at constant speed
- Self-excitation
- Current-voltage characteristics
- Load characteristics
- Possibilities for changing speed and adjusting for load
- Starting and braking
- Characteristics of generators
- Power performance

AC Machines 1 kW

E2.3.3.0
AC Machines 1.0

E2.3.3.1
Universal Motor AC 1.0

E2.3.3.2
Capacitor Motor R 1.0

AC Machines 1.0 (E2.3.3.0)

Cat. No.	Description	E2.3.3.0	E2.3.3.1	E2.3.3.2
732 70	Universal motor 1.0	1	1	
732 74	Capacitor motor R 1.0	1		1
733 14	Flywheel 1.0	1	1*	1*
731 42	On/off switch, three-pole	1	1	1
745 561	Power circuit breaker module	1	1	1
733 54	Motor protection switch, 6-10 A	1	1	1
531 282	Multimeter Metrahit Pro	2	2	2
727 12	Power factor meter	1	1	1
732 689USB	Machine test system 1.0	1	1	1
728 421	CBM10 MOMO/FCCP	1	1	1
726 09	Panel frame T130, two-level	1	1	1
726 85	Adjustable transformer 0...260 V	1	1	
732 56	Coupling 1.0	1	1	1
732 57	Shaft end guard 1.0	1	1	1
732 58	Coupling guard 1.0	1	1	1
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	5	5	5
500 59	Safety bridging plugs, black, set of 10	2	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1	2
775 230DE	LIT: E2.3.3.0 AC Machines 1.0 (German)	1	1	1
775 230EN	LIT: E2.3.3.0 AC Machines 1.0	1*	1*	1*
726 71	Single-phase supply unit			1

* additionally recommended

The experiments are carried out using industrial-design machines. All the machines under test possess a special base for connecting the Machine test system 1.0. The testing system can be used to record the characteristics of the machines under test. Power for the machines is supplied either via a variable transformer.

Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics

Features

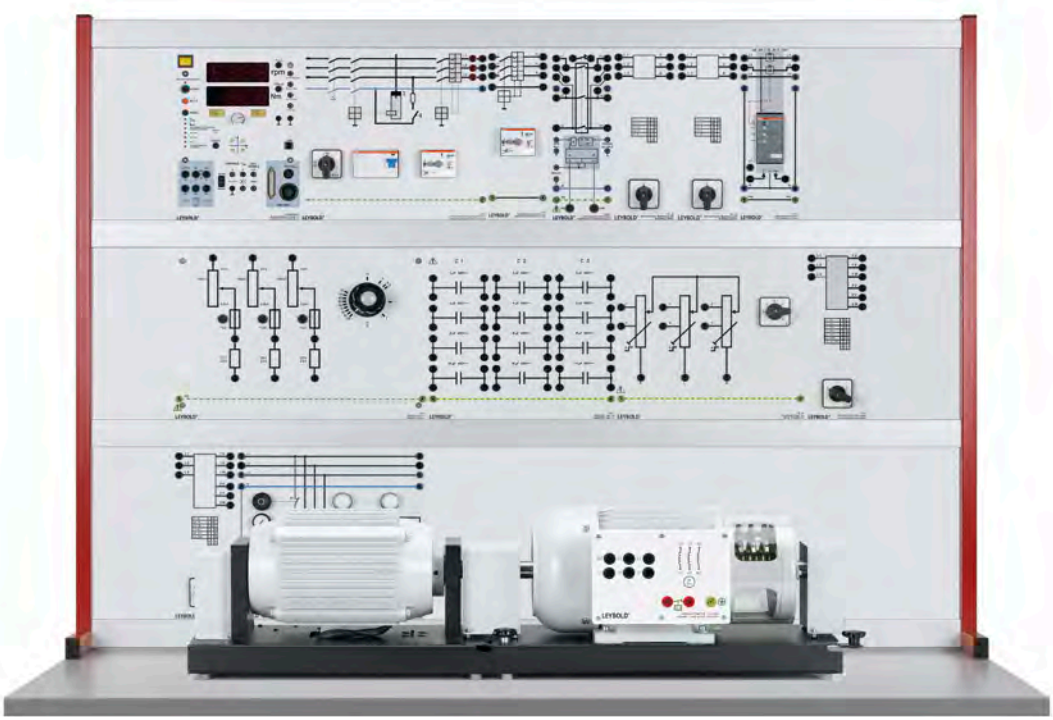
- In order to protect against overheating, the stator windings of the machines to be tested are equipped with temperature sensors
- Should overheating occur the machine testing system automatically shuts down the test machine, thus preventing any damage to it.
- The machines to be tested are equipped with an educationally designed terminal board with the winding configuration printed on it.
- The ends of all the windings are connected to the terminal board and can be accessed via 4-mm safety sockets
- Computer-supported acquisition of measurement data provides for meaningful measurement results.
- Machines in the 1 kW rating class have a powerful and realistic operating response
- In comparison to smaller machines, their characteristics display distinctive features related to the design.

The complete equipment set is equally suitable for student experiments in laboratories with low voltage supplies (400 V three-phase) and for setting up on a mobile trolley for demonstration by teachers in a classroom. The procedures for the experiments are provided in a printed manual.

Topics

- Connection and operation of AC machines
- Reversing direction of rotation
- Measurement of efficiency
- Characteristics of motors
- Load characteristics

3-Phase Induction Machines 1 kW



E2.3.4.0
Induction Machines 1.0

E2.3.4.1
Squirrel Cage Motor 400/600 1.0

E2.3.4.2
Squirrel Cage Motor 230/400 1.0

E2.3.4.3
Slip Ring Motor 1.0

E2.3.4.4
Squirrel Cage Motor D 1.0

E2.3.4.5
Squirrel Cage Motor SW 1.0

Induction Machines 1.0 (E2.3.4.0)

Cat. No.	Description	E2.3.4.0	E2.3.4.1	E2.3.4.2	E2.3.4.3	E2.3.4.4	E2.3.4.5
732 81	Squirrel cage motor 400/690 1.0	1	1				
732 804	Squirrel cage motor 230/400 1.0	1		1			
733 03	Slip ring motor 1.0	1			1		
732 94	Squirrel cage motor D 1.0	1				1	
732 96	Squirrel cage motor SW 1.0	1					1
731 50	Star-delta starter	1	1*				
731 47	Star-delta switch	1	1				
731 48	Star-delta reversing switch	1	1*				
731 49	Reversing switch	1	1	1			
731 55	Pole reverser, Dahlander	1				1	
731 57	Pole reverser SW	1					1
732 99	Rotor starter 1.0	1			1		
733 10	Resistive load 1.0	1	1	1			
733 11	Capacitive load 1.0	1	1	1			
733 05	Blocking Gear Mechanism 1.0	1			1		
731 391	Squirrel cage fault simulator	1	1*	1*			
731 51	Soft starter 0.3 /1.0	1	1				
745 561	Power circuit breaker module	1	1	1	1	1	1
732 83	Motor protection switch, 1.6-2.4 A	1		1		1	1
531 600	Insulation tester Metriso C	1	1*	1*			
531 282	Multimeter Metrahit Pro	3	2	2	3	2	2
727 12	Power factor meter	1	1	1	1	1	1
732 689USB	Machine test system 1.0	1	1	1	1	1	1
728 421	CBM10 MOMO/FCCP	1	1	1	1	1	1
726 75	Three-phase supply unit with ELCB	1	1	1	1	1	1
726 09	Panel frame T130, two-level	1	1	1	1	1	1
732 56	Coupling 1.0	1	1	1	1	1	1
732 57	Shaft end guard 1.0	1	1	1	2	1	1
732 58	Coupling guard 1.0	1	1	1	1	1	1
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	5	5	5	5	5	5

Cat. No.	Description	E2.3.4.0	E2.3.4.1	E2.3.4.2	E2.3.4.3	E2.3.4.4	E2.3.4.5
500 59	Safety bridging plugs, black, set of 10	2	2	2	2	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1	1	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1	1	1	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1	1	1	1	1
775 235DE	LIT: E2.3.4.0 Induction Machines 1.0 (German)	1	1	1	1	1	1
775 235EN	LIT: E2.3.4.0 Induction Machines 1.0	1*	1*	1*	1*	1*	1*
732 84	Motor protection switch, 2.4-4 A		1	1	1		

* additionally recommended

The experiments are carried out using industrial-design machines. All the test machines possess a special base for connecting the Machine test system 1.0. The testing system can be used to record the characteristics of the machines under test. Power for the machines is supplied either via the mains or by special laboratory power supplies.

Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics

Topics for motor operation

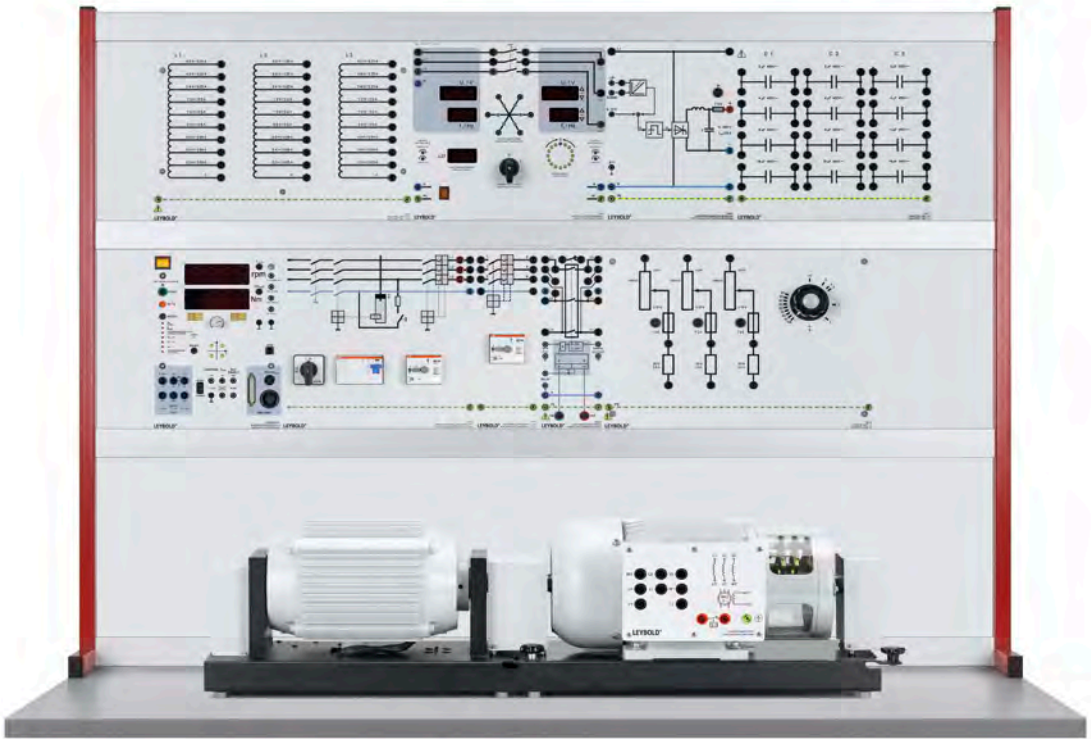
- Design and function
- Operating characteristics
- Starting: slip-ring rotors, deep-bar squirrel cage rotors, star-delta starting, switching via a starting transformer, stator resistance starting circuit
- Braking: regenerative braking, DC braking, dynamic lowering circuit
- Power performance of an ideal rotating field machine
- Power flux
- Locus (Heyland circle) diagram
- Experiment without any load
- Short-circuit load experiment

3-Phase Synchronous Machines 1 kW

E2.3.5.0
Synchronous Machines 1.0

E2.3.5.1
Salient Pole Rotor 1.0

E2.3.5.2
Smooth Core Rotor 1.0



Synchronous Machines 1.0 (E2.3.5.0)

Cat. No.	Description	E2.3.5.0	E2.3.5.1	E2.3.5.2
733 06	Synchronous machine SP 1.0	1	1	
733 07	Synchronous machine SC 1.0	1		1
745 05	Manual synchronisation unit	1	1	1
733 10	Resistive load 1.0	1	1	1
733 11	Capacitive load 1.0	1	1	1
732 42	Inductive load 0.3/1.0	1	1	1
745 561	Power circuit breaker module	1	1	1
732 83	Motor protection switch, 1.6-2.4 A	1	1	1
727 32	Moving iron meter, 2.5 A	1	1	1
531 282	Multimeter Metrahit Pro	3	3	3
727 12	Power factor meter	1	1	1
732 689USB	Machine test system 1.0	1	1	1
728 421	CBM10 MOMO/FCCP	1	1	1
726 75	Three-phase supply unit with ELCB	1	1	1
725 862DG	DC machine supply 1.0	1	1	1
726 09	Panel frame T130, two-level	1	1	1
732 56	Coupling 1.0	1	1	1
732 57	Shaft end guard 1.0	1	1	1
732 58	Coupling guard 1.0	1	1	1
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	5	5	5
500 59	Safety bridging plugs, black, set of 10	2	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1
500 851	Safety connecting leads, 32 A, set of 32	1	1	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1	1	1
775 240DE	LIT: E2.3.5.0 Synchronous Machines 1.0 (German)	1	1	1
775 240EN	LIT: E2.3.5.0 Synchronous Machines 1.0	1*	1*	1*
731 42	On/off switch, three-pole			1

* additionally recommended

The experiments are carried out using industrial-design machines. All the test machines possess a special base for connecting the Machine test system 1.0. The testing system can be used to record the characteristics of the machines under test. Power for the machines is supplied either via the mains or by special laboratory power supplies.

Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics

Features

- In order to protect against overheating, the stator windings of the machines to be tested are equipped with temperature sensors
- Should overheating occur the machine testing system automatically shuts down the test machine, thus preventing any damage to it.
- The machines to be tested are equipped with an educationally designed terminal board with the winding configuration printed on it.
- The ends of all the windings are connected to the terminal board and can be accessed via 4-mm safety sockets
- Computer-supported acquisition of measurement data provides for meaningful measurement results.
- Machines in the 1 kW rating class have a powerful and realistic operating response
- In comparison to smaller machines, their characteristics display distinctive features related to the design.

Synchronous motor topics

- Non-salient-pole and salient-pole rotors
- Voltage equations
- Equivalent circuit and vector diagram
- Operation with no-load and with a permanent three-pole short-circuit
- Locus diagrams and control characteristics
- Torque and loading
- Potier diagram and armature reaction
- Synchronisation and use of multiple machines in parallel
- Starting methods for synchronous motors
- Control of reactive power
- Power performance

Synchronous generator topics

- Voltage generation
- Excitation of synchronous machines
- Operating response
- Armature current and torque
- Braking operation and locus diagrams
- Starting and synchronisation
- Single-phase generators

Mechatronic Motors 1 kW

E2.3.6.1
Motor with
Frequency Converter 1.0

Motor with Frequency Converter 1.0 (E2.3.6.1)

Cat. No.	Description	E2.3.6.1
732 49	Motor with FCC 1.0	1
735 314	LCP2 local control panel	1
732 689USB	Machine test system 1.0	1
728 421	CBM10 MOMO/FCCP	1
726 09	Panel frame T130, two-level	1
726 75	Three-phase supply unit with ELCB	1
732 56	Coupling 1.0	1
732 58	Coupling guard 1.0	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 854	Safety leads, set of 20	1
735 315USB	USB/RS 485 interface converter	1*
775 355DE	LIT: E2.3.6.1 Motor with Frequency Converter 1.0 (German)	1
775 355EN	LIT: E2.3.6.1 Motor with Frequency Converter 1.0	1*

* additionally recommended

The experiments are carried out using industrial-design machines. All the test machines possess a special base for connecting the Machine test system 1.0. The testing system can be used to record the characteristics of the machines under test. Power for the machines is supplied either via the mains or by special laboratory power supplies.

Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics

The test machine is an industrial frequency converter motor consisting of a four-pole asynchronous three-phase motor with a power rating of 1.1 kW and an integrated frequency converter. The motor and the converter are optimally fine-tuned to one another. The experiment investigates the features of the operating response in comparison to other types of machine without built-in power electronics. More advanced topics such as positioning control or non-linear load characteristics (winding machines, fans etc.) are investigated in E2.6 Servo technology using 300 W machines.

Features

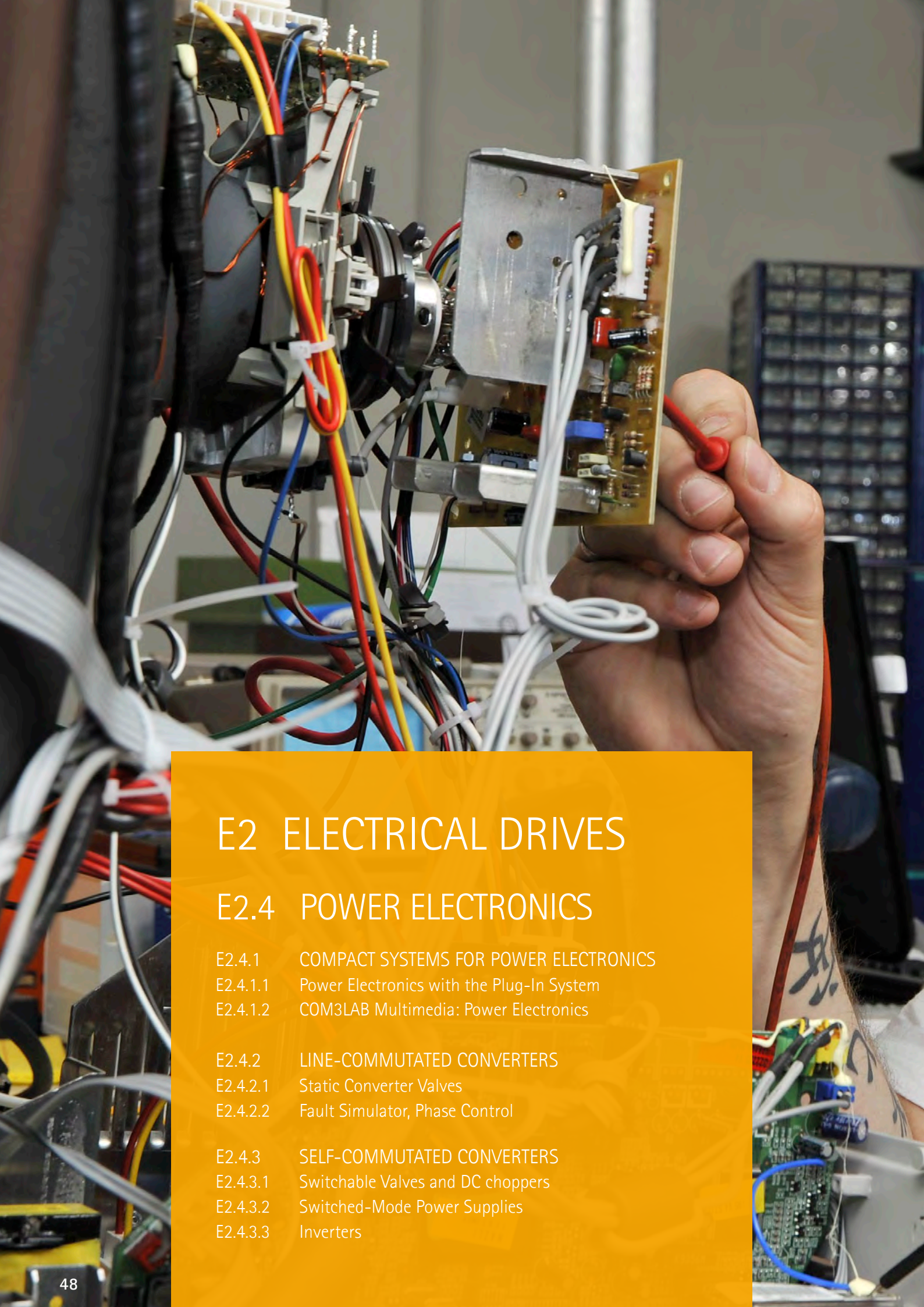
- In order to protect against overheating, the stator windings of the machines to be tested are equipped with temperature sensors
- Should overheating occur the machine testing system automatically shuts down the test machine, thus preventing any damage to it.
- The machines to be tested are equipped with an educationally designed terminal board with the winding configuration printed on it.
- The ends of all the windings are connected to the terminal board and can be accessed via 4-mm safety sockets
- Computer-supported acquisition of measurement data provides for meaningful measurement results.
- Machines in the 1 kW rating class have a powerful and realistic operating response
- In comparison to smaller machines, their characteristics display distinctive features related to the design.

The equipment set is suitable both for student experiments in a lab using low voltage (400 V three-phase) and on a mobile trolley for demonstrations by teachers in a classroom. The experiment procedures are contained in a printed manual.

The target group is made up of commercial apprentices and students of electrical machine construction. The course offers experiments at an intermediate level and also allows for the necessary insight into machine behaviour for scientific interpretation at undergraduate level.

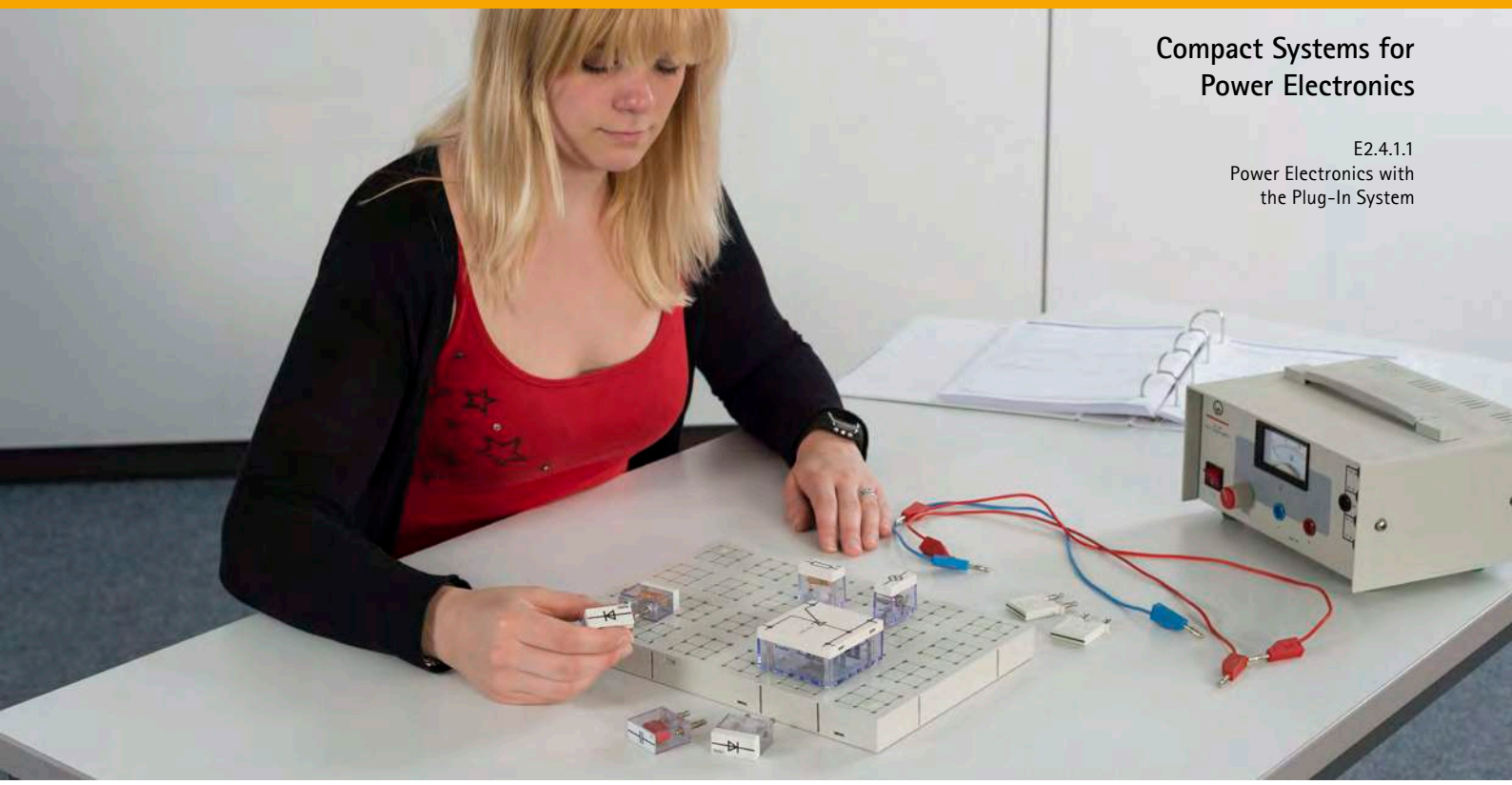
Topics

- Design and function of a frequency converter controlled motor
- Operation with a power amplifier
- Run-up and operating characteristics
- How speed depends on frequency
- How speed depends on load: fan, pump, winding machine, flywheel



E2 ELECTRICAL DRIVES

E2.4 POWER ELECTRONICS



Compact Systems for Power Electronics

E2.4.1.1
Power Electronics with the Plug-In System

Power Electronics with the Plug-In System (E2.4.1.1)

Cat. No.	Description	E2.4.1.1
727 531N	Basic set STE 6.1.1	1
727 657N	Supplementary set T 6.1.18	1
726 50	Plug-in board, 297 mm x 300 mm, STE	1*
521 485	AC/DC power supply, 0...12 V/3 A	1
522 621	Function generator S 12	1
726 962	Function generator 200 kHz	1*
562 791	Plug-in power supply, 12 V AC	1*
531 57	Multimeter METRAport 3A	1*
531 282	Multimeter Metrahit Pro	1*
531 172	Digital multimeter DMM120	1
575 212	Two-channel oscilloscope 400	1
575 231	Probe 100 MHz, 1:1 / 10:1	2
501 48	Bridging plugs, STE 2/19, set of 10	3
501 532	Connecting leads, 19 A, set of 30	1
726 19	Panel frame SL85, single-level	1*
726 88	AC/DC stabilizer	1*
727 510N	Complete equipment set DC/AC/EL	1*
775 175DE	LIT: E2.4.1.1 STE Power Electronics (German)	1
775 175EN	LIT: E2.4.1.1 STE Power Electronics	1*

* additionally recommended

The experiments are carried out using the STE plug-in system Electricity/Electronics.

Objectives

- Recognition of basic physical principles
- Implementation of electrical circuits according to circuit diagrams

The power electronics is an important area within electrical engineering. It links power engineering with control technology and electronics. The advances in the production of semiconductor power devices such as diodes, thyristors, triacs and power transistors have essentially promoted their breakthrough. The main task of power electronics is the switching, controlling and transforming of electrical energy with the help of electronic components.

Student experiments with the plug-in system for power electronics investigate the characteristics of power semiconductors as well as basic standard circuits. All experiments work with single-phase, safety extra-low voltage. The necessary prerequisites for sucessful running the course are knowledge of AC theory, semiconductor technology and experience in handling the oscilloscope.

The target group is made up of students in general or vocational education. The experiments are designed as an introduction at a simple level of understanding.

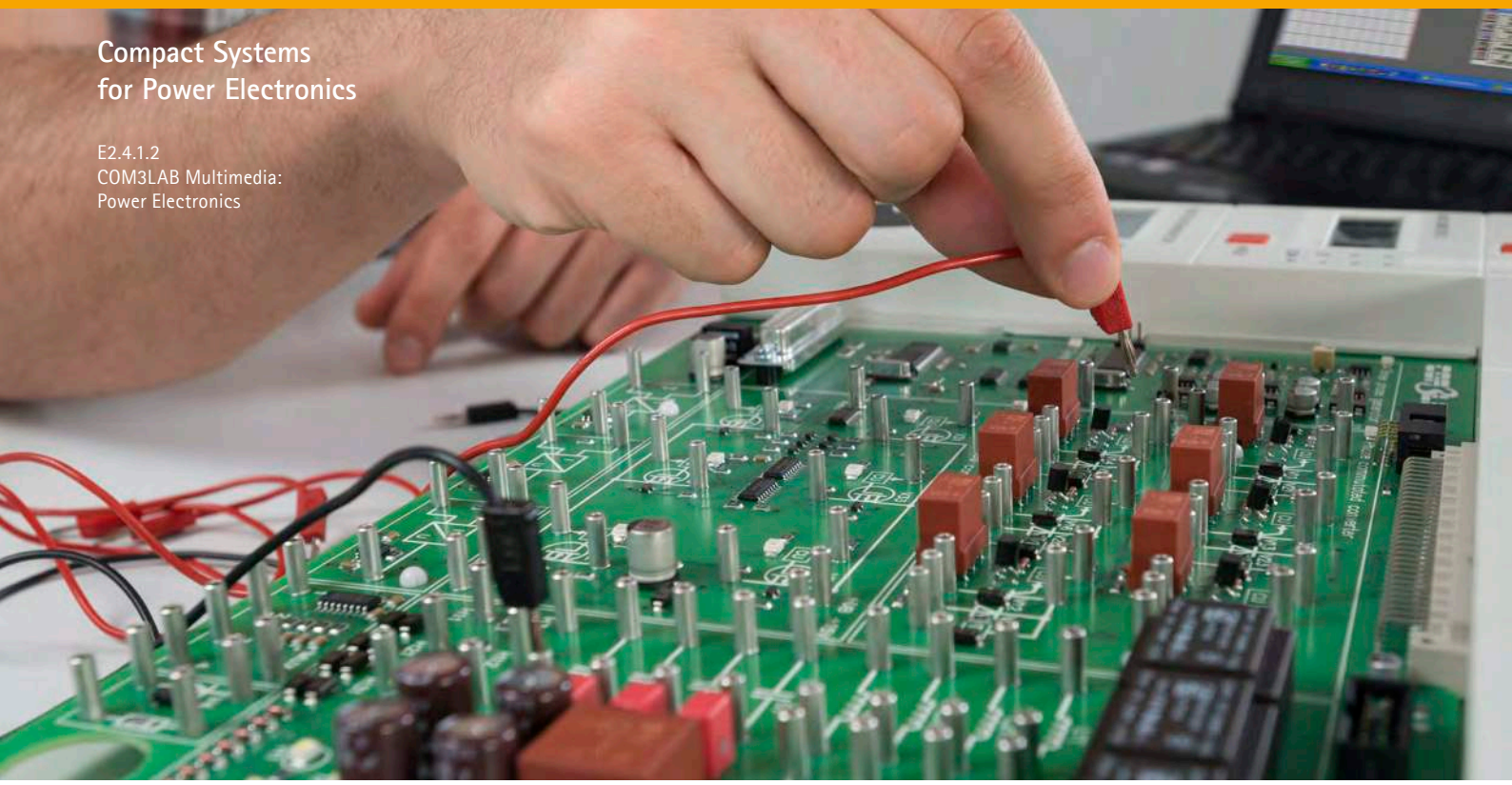
To gain a deeper understanding, experiments with the compact system E2.4.2.1, static converter valves and the COM3LAB courses on power electronics are ideal.

Topics

- Components of power electronics
- Characteristics of thyristors, triacs and diacs
- Thyristors used as DC switches and choppers
- Pulse generators and trigger circuits
- Phase angle control
- Circuits with thyristor trigger components
- Circuits with dimmers: touch dimmers, light dimmers
- Thyristor DC quenching
- Zero-voltage switches
- Full-wave control

Compact Systems for Power Electronics

E2.4.1.2
COM3LAB Multimedia:
Power Electronics



COM3LAB Multimedia: Power Electronics (E2.4.1.2)

Cat. No.	Description	E2.4.1.2
700 21	COM3LAB course: Power electronics I	1
700 22	COM3LAB course: Power electronics II	1
700 00USB	COM3LAB master unit (USB)	1
700 00CBTDE	CD: COM3LAB software (German)	1*
700 00CBTEN	CD: COM3LAB software	1
735 297	Universal converter 3 x 230 V	1*
735 290	Connecting lead universal converter	1*
732 104	Squirrel cage motor 230/400/0.3	1*
731 07	Shaft end guard 0.3	1*
726 71	Single-phase supply unit	1*
500 59	Safety bridging plugs, black, set of 10	1*
500 851	Safety connecting leads, 32 A, set of 32	1*
726 19	Panel frame SL85, single-level	1*

* additionally recommended

The COM3LAB courses on power electronics convey the topic in concentrated form to deepen understanding. Characteristics of power semiconductors and the basic standard circuits are investigated. All the experiments work with single-phase safety extra-low voltage, which is non-hazardous. Only small amounts of materials and little space are needed for the experiments. A student desk with a PC is entirely sufficient.

Objectives

- Basic physical principles of power semiconductors
- Design of key basic circuits for power electronics
- Assessment of properties of rectifiers and converters

The equipment set allows students to experiment themselves in a lab equipped with PCs using safety extra-low voltage, which presents no hazard. It is also suitable for demonstration experiments by teachers. Multimedia software explains and monitors how the experiments are carried out.

The target group mainly consists of trainee industrial or jobbing electricians. The systems can also be used for vocational further education.

To gain a deeper understanding, experiments with the compact system E2.4.2.1, Static converter valves, is ideal.

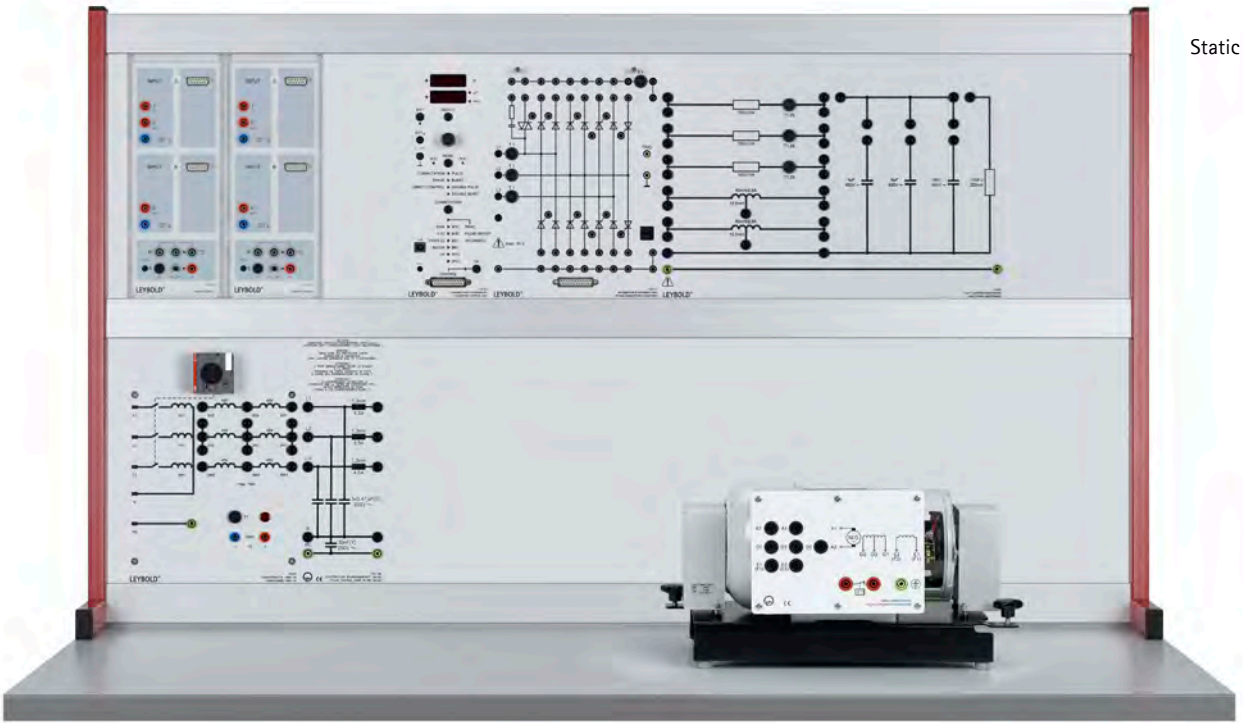
In project lessons an asynchronous machine (732 104) is operated without a load and supplied with three-phase power (3 x 230 V) via a universal converter (735 297) The parameters for the converter can be set via an interface panel on the board itself which connects directly to the COM3LAB course.

Topics

- Semiconductors in power electronics
- Wiring and control
- Switching processes and commutation
- Uncontrolled rectifier circuits
- Characteristic values for periodic signals
- Controlled line-commutated converters
- Circuits: M1C, M3C, B2C, B6C
- Semi-controlled rectifiers
- Self-commutated converters
- Semiconductor switches and choppers
- Switches and actuators for DC
- Inverters
- Static converters for closed-loop control
- Static converters for drive technology

Line-Commutated Converters

E2.4.2.1
Static Converter Valves



Static Converter Valves (E2.4.2.1)

Cat. No.	Description	E2.4.2.1
735 09	Load for power electronics	1
735 012	Line-commutated converter	1
735 122	Converter controller unit	1
735 190	Phase control noise filter 3 x 4.5 A	1
524 013S	Sensor-CASSY 2 Starter	1
524 013	Sensor-CASSY 2	1
531 282	Multimeter Metrahit Pro	2
726 09	Panel frame T130, two-level	1
726 80	Transformer, 45/90, 3 N	1
500 59	Safety bridging plugs, black, set of 10	2
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 250DE	LIT: E2.4.2.1 Static Converter Valves (German)	1
731 07	Shaft end guard 0.3	2*
731 86	DC compound machine 0.3	1*
775 250EN	LIT: E2.4.2.1 Static Converter Valves	1*

* additionally recommended

The experiments are set up with the help of training panels in panel frames. The static converters with overlay masks show the block circuit diagram and a signal flow plan. They also allow the experiment circuits to be set up in clear fashion. The central, microprocessor-monitored trigger lines allow the converter circuits to be changed quickly.

Objectives

- Measurement of characteristic variables such as average and root-mean-square values, form factor and ripple
- Phase angle control or pulse group control
- Protective equipment, commutation, control characteristics

Power electronics has developed from the technology of static converters to become one of the most important and all-encompassing areas of electrical engineering. The job of power electronics is to switch, control and convert electrical energy using power semiconductors with the best possible efficiency. One key application is drive technology. With the help of modern power electronics it is possible to construct variable-speed drives in DC and three-phase circuits for 4-quadrant operation. Nowadays thyristor speed regulation equipment, smooth starting circuits, frequency converters, servo drives etc. are indispensable in industry, skilled electrical work or households.

The equipment set is suitable both for student experiments in a lab using low voltage (400 V three-phase) and on a mobile trolley for demonstrations by teachers in a classroom. The experiment procedures are contained in a printed manual.

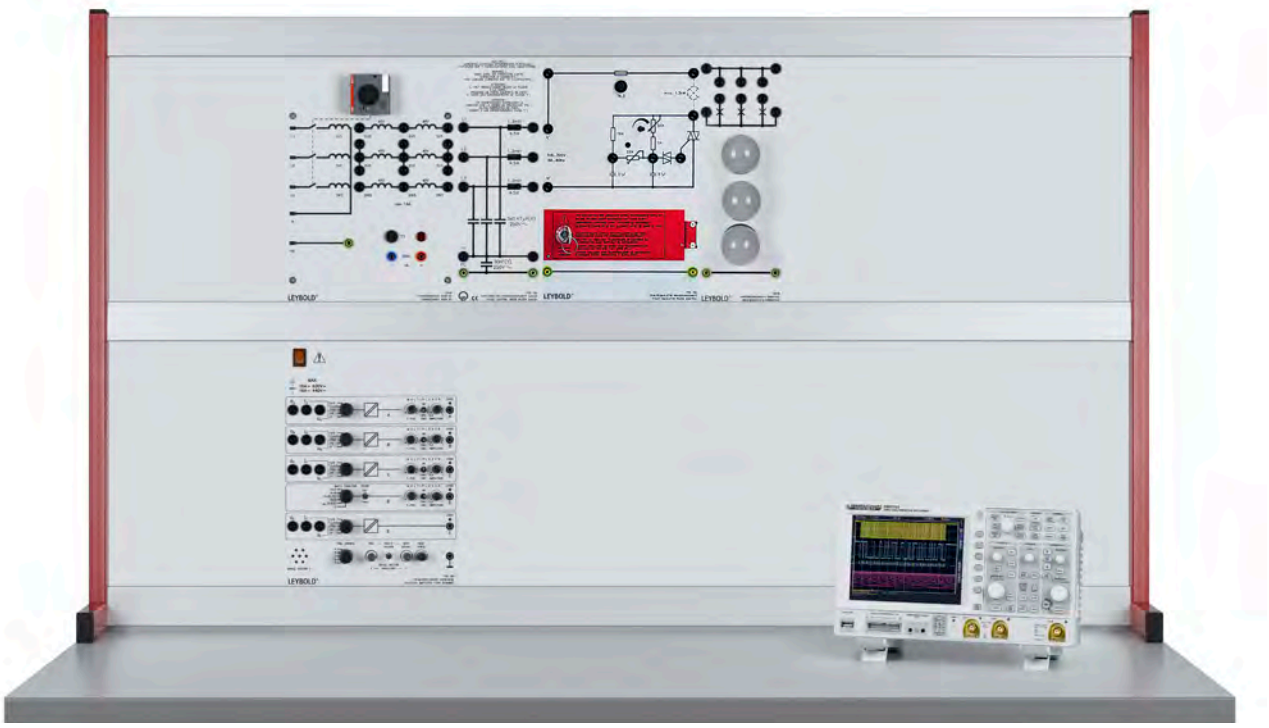
The target group is made up of commercial apprentices and students of electrical machine technology. The course offers introductory experiments at a simple level and more advanced topics for undergraduate education.

Topics

- Single static converters and bidirectional static converters with various loads (R, L, RL)
- Resistive-inductive load with freewheeling diode
- Resistive-inductive load with reverse voltage
- Resistive-capacitive load
- Triac AC power controller
- Fully controlled three-phase power controller
- Semi-controlled three-phase power controller
- Three-phase power controller with two bidirectional pairs
- Controlled rectifier mid-point circuits
- Two-pulse centre-tap control
- Controlled six-pulse centre-tap control, M6
- M6 circuit with resistive load
- M6 circuit with resistive-inductive load
- Controlled bridge rectifier circuits with various loads
- Two-pulse bridge circuit
- Six-pulse bridge circuit
- Fully controlled two-pulse bridge circuit, B2C

Line-Commutated Converters

E2.4.2.2
Fault Simulator,
Phase Control



Fault Simulator, Phase Control (E2.4.2.2)

Cat. No.	Description	E2.4.2.2
735 390	Fault simulator for phase control	1
505 27	Bulb, 230 V/40 W, E14	3
729 09	Lamp sockets E14, set of three	1
735 190	Phase control noise filter 3 x 4.5 A	1
501 02	BNC cable, 1 m	2
531 282	Multimeter Metrahit Pro	1
735 261	Isolation amplifier, four channel	1
575 231	Probe 100 MHz, 1:1 / 10:1	2
575 230	Digital storage oscilloscope 722	1
726 09	Panel frame T130, two-level	1
726 80	Transformer, 45/90, 3 N	1
500 59	Safety bridging plugs, black, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 255DE	LIT: E2.4.2.2 Fault Simulator, Phase Control (German)	1
775 255EN	LIT: E2.4.2.2 Fault Simulator, Phase Control	1*

* additionally recommended

The experiments are carried out on training panels in panel frames.

Objectives

- Protective measures and electrical safety
- Finding and analysing faults in phase angle control circuits
- Use of commercial measuring instruments: hand-held multimeters and oscilloscopes

The fault simulator is a standard dimmer for a resistive load (P = max. 1.2 kW) pre-calibrated for minimum value. Various measuring points allow for systematic troubleshooting. There are a total of 20 faults which can be switched and which are of the following categories:

- Breaks
- Short circuits
- Wrong components
- Component faults

The faults are activated by slider switches located behind a lockable cover.

The equipment set is designed for student experiments in a laboratory using low voltage (230 V AC). Experiment procedures are provided in a printed manual.

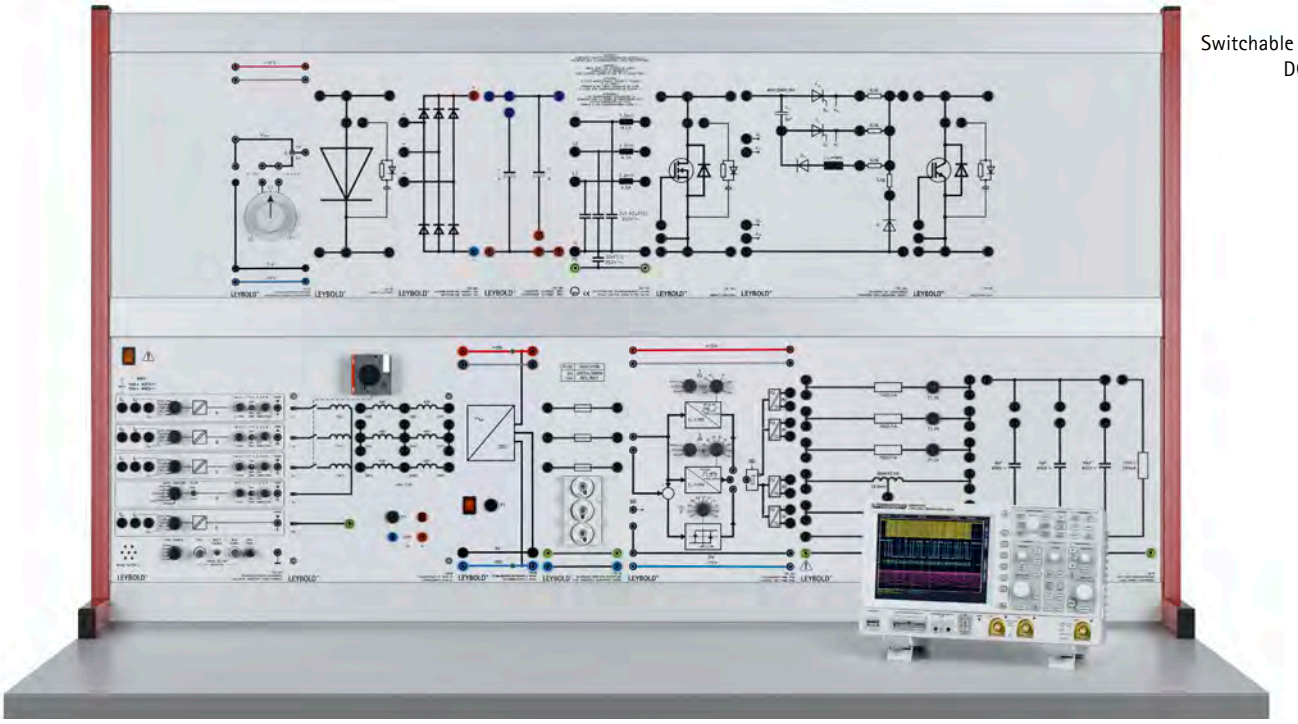
The target group is students in vocational colleges. The experiments are intended as an introduction at a simple level.

Topics

- Investigation of a circuit with some 20 different faults
- Component faults (short circuits, high resistance)
- Breaks in conductors
- High or low-resistance connections within the circuit
- Wrong or missing components (e.g. incorrect values)

Self-Commutated Converters

E2.4.3.1
Switchable Valves and
DC choppers



Switchable Valves and DC choppers (E2.4.3.1)

Cat. No.	Description	E2.4.3.1
734 02	Reference variable generator	1
735 02	Diode, 1000 V/10 A	1
735 09	Load for power electronics	1
735 18	Fuses, ultra-rapid set of 3	1
735 065	Rectifier B6, 3X400 V/10 A	1
735 095	Capacitors 2x 1000 µF, 385 V	1
735 190	Phase control noise filter 3 x 4.5 A	1
735 341	Control unit PWM; PFM	1
735 342	MOSFET 500 V/10 A	1
735 343	Thyristor with turn-off circuit 230 V/8 A	1
735 346	IGBT 1000 V/10 A	1
501 02	BNC cable, 1 m	2
531 282	Multimeter Metrahit Pro	2
575 231	Probe 100 MHz, 1:1 / 10:1	2
575 230	Digital storage oscilloscope 722	1
735 261	Isolation amplifier, four channel	1
726 09	Panel frame T130, two-level	1
726 86	Stabilised power supply ±15 V/3 A	1
726 80	Transformer, 45/90, 3 N	1
537 34	Rheostat, 100 ohms	1
537 35	Rheostat, 330 ohms	1
731 91	Shunt wound machine 0.3	1*
731 07	Shaft end guard 0.3	2*
500 59	Safety bridging plugs, black, set of 10	2
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 260DE	LIT: E2.4.3.1 Switchable Valves and DC Choppers (German)	1
775 260EN	LIT: E2.4.3.1 Switchable Valves and DC Choppers	1*

* additionally recommended

The experiments are carried out on training panels in panel frames.

Objectives

- Protective measures and electrical safety
- Circuit assembly and wiring according to circuit diagrams
- Use of commercial measuring instruments: hand-held multimeters and oscilloscopes

Static converter valves with gate turn-off can be used to assemble a variety of DC choppers (DC/DC converters). Three different control methods are used for this:

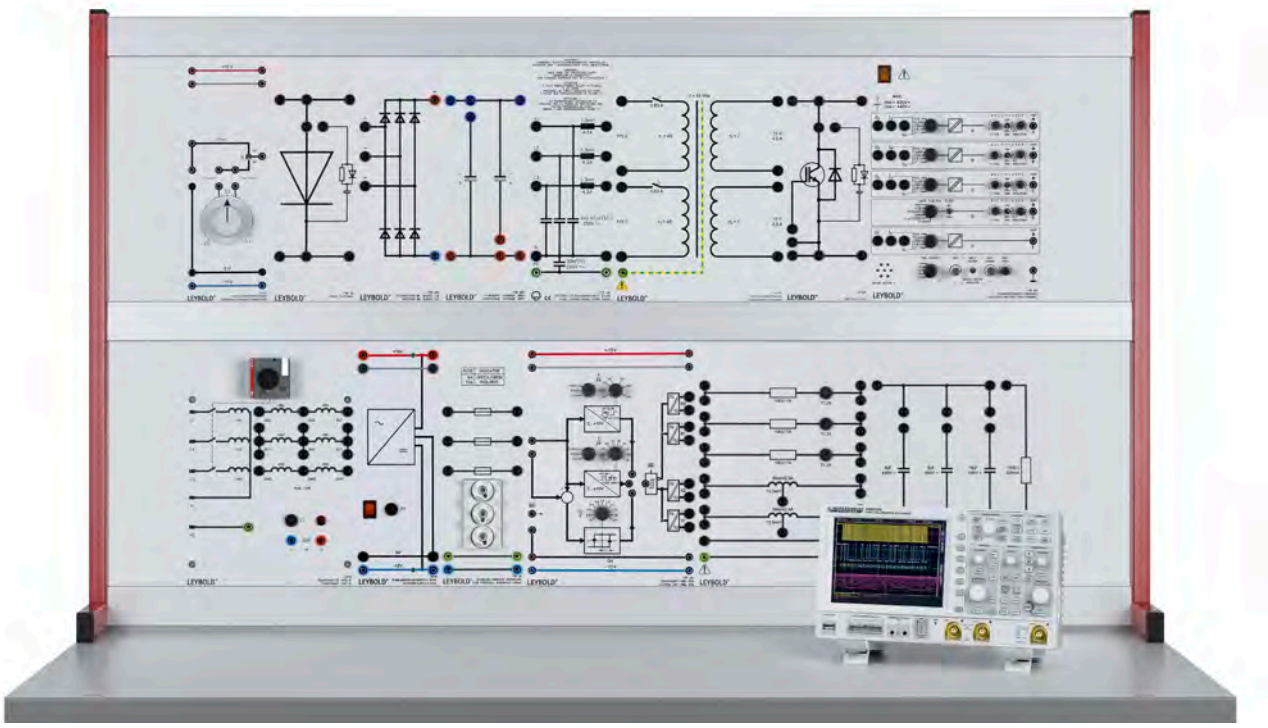
- Pulse width modulation
- Pulse sequence modulation
- Two position control

Topics

- Thyristor with quenching circuit
- Power MOSFETs
- Insulated gate bipolar transistors (IGBTs)
- On-state characteristics
- Off-state and switching properties
- Control of DC choppers
- Step-up and step-down converters
- DC choppers using a thyristor with quenching circuit, PWM
- Control characteristic for constant load current
- DC chopper using MOSFETs, PWM, PFM and two-position control
- Single-ended forward and push-pull converters
- Half-bridge and full-bridge forward converters
- DC choppers used for step-up conversion, PWM and two-position control
- Energy recovery operation with PWM
- Energy recovery operation with two-position control
- Characteristics with variable current setpoints
- DC choppers with IGBT used as inverting step-up/step-down controllers with PWM

Self-Commutated Converters

E2.4.3.2
Switched-Mode
Power Supplies



Switched-Mode Power Supplies (E2.4.3.2)

Cat. No.	Description	E2.4.3.2
734 02	Reference variable generator	1
735 02	Diode, 1000 V/10 A	4
735 09	Load for power electronics	1
735 18	Fuses, ultra-rapid set of 3	1
735 065	Rectifier B6, 3X400 V/10 A	1
735 095	Capacitors 2x 1000 µF, 385 V	1
735 105	Transformer for SMPS	1
735 190	Phase control noise filter 3 x 4.5 A	1
735 341	Control unit PWM; PFM	1
735 346	IGBT 1000 V/10 A	3
501 02	BNC cable, 1 m	2
531 282	Multimeter Metrahit Pro	2
575 231	Probe 100 MHz, 1:1 / 10:1	2
575 230	Digital storage oscilloscope 722	1
735 261	Isolation amplifier, four channel	1
726 09	Panel frame T130, two-level	1
726 86	Stabilised power supply ±15 V/3 A	1
726 80	Transformer, 45/90, 3 N	1
500 59	Safety bridging plugs, black, set of 10	2
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 265DE	LIT: E2.4.3.2 Switched-Mode Power Supplies (German)	1
775 265EN	LIT: E2.4.3.2 Switched-Mode Power Supplies	1*

* additionally recommended

The experiments are carried out on training panels in panel frames.

Objectives

- Protective measures and electrical safety
- Circuit assembly and wiring according to circuit diagrams
- Use of commercial measuring instruments: hand-held multimeters and oscilloscopes

Power electronics allows for power supplies to be built which are characterised by high efficiency and compact size. This is achieved using switching components and switching frequencies which are as high as possible. The following experiments on primary switched-mode power supplies can be set up and their properties investigated:

- Single-ended forward converters
- Push-pull converters
- Asymmetric half-bridge forward converters
- Full-bridge forward converters
- Flyback converters

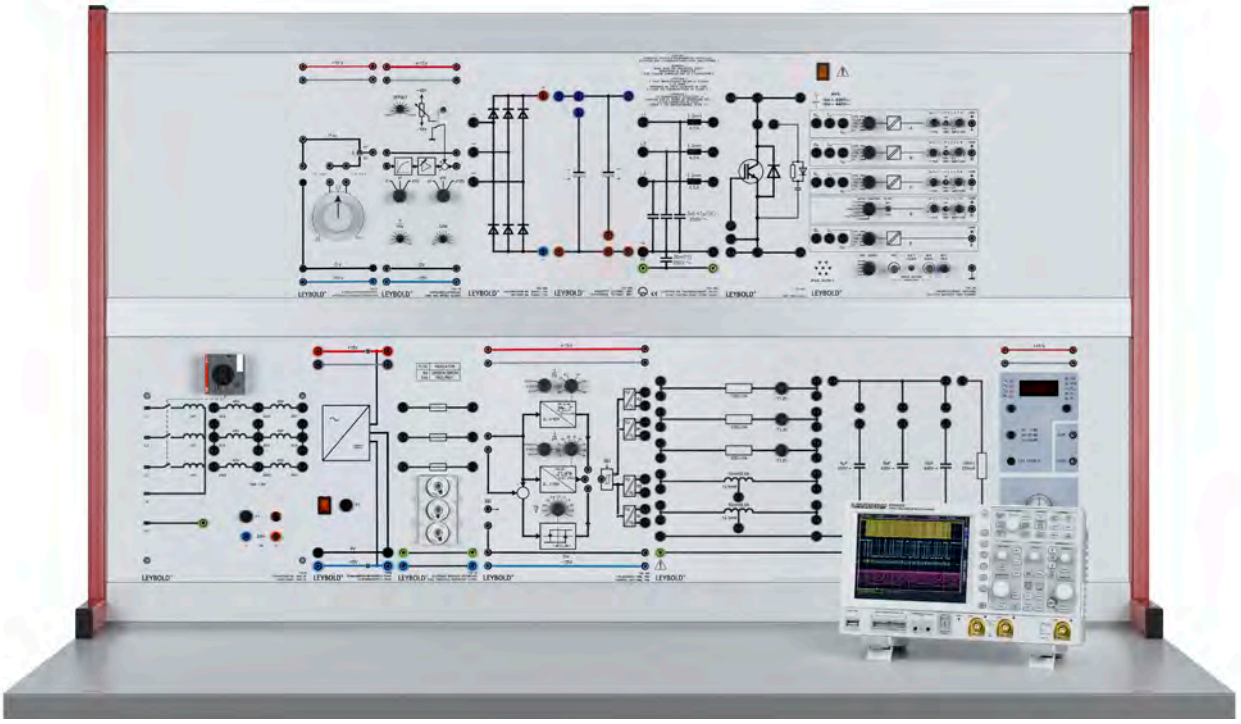
The equipment set is suitable both for student experiments in a lab using low voltage (400 V three-phase) and on a mobile trolley for demonstrations by teachers in a classroom. The experiment procedures are contained in a printed manual.

Topics

- Step-down converters with various loads
- Control of average values for voltage and current using PWM
- How voltage and current change over time with a resistive load
- How voltage and current change over time with a resistive-inductive load
- Resistive-inductive load with freewheeling diode and smoothing capacitor
- Step-down converter with V_I = 110 V, losses, efficiency
- Step-up/step-down converters
- Control of average values for voltage and current using PWM
- Measurement of voltage and current over time when V_I = 15 V
- Measurement of voltage and current over time when V_I = 110 V
- Measurement with intermittent choke current
- Step-up/step-down converters with power factor correction
- Effect of hysteresis
- Flyback converters
- Control of average values for voltage and current using PWM
- Measurement of voltage and current over time when V_I = 15 V
- Effect of RCD protective circuitry
- Measurement of voltage and current over time when V_I = 110 V

Self-Commutated Converters

E2.4.3.3
Inverters



Inverters (E2.4.3.3)

Cat. No.	Description	E2.4.3.3
734 02	Reference variable generator	1
735 09	Load for power electronics	1
735 18	Fuses, ultra-rapid set of 3	1
726 962N	Function generator 200 kHz net	1
725 007	Software: Leylab.control Lite	1
734 19	Gain and offset adjust	1
735 065	Rectifier B6, 3X400 V/10 A	1
735 095	Capacitors 2x 1000 µF, 385 V	1
735 190	Phase control noise filter 3 x 4.5 A	1
735 341	Control unit PWM; PFM	1
735 346	IGBT 1000 V/10 A	4
501 02	BNC cable, 1 m	2
531 282	Multimeter Metrahit Pro	2
575 231	Probe 100 MHz, 1:1 / 10:1	2
575 230	Digital storage oscilloscope 722	1
735 261	Isolation amplifier, four channel	1
726 10	Panel frame T150, two-level	1
726 86	Stabilised power supply ±15 V/3 A	1
726 80	Transformer, 45/90, 3 N	1
500 59	Safety bridging plugs, black, set of 10	2
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 270DE	LIT: E2.4.3.3 Inverters (German)	1
775 270EN	LIT: E2.4.3.3 Inverters	1*

* additionally recommended

The experiments are carried out on training panels in panel frames.

Objectives

- Protective measures and electrical safety
- Circuit assembly and wiring according to circuit diagrams
- Use of commercial measuring instruments: hand-held multimeters and oscilloscopes

Self commutated inverters are used in frequency converters, uninterruptible power supplies, mains coupling equipment for photovoltaic systems etc. This equipment set makes it possible to construct a single-phase AC inverter to create an AC voltage of variable frequency and amplitude.

The equipment set is suitable both for student experiments in a lab using low voltage (400 V three-phase) and on a mobile trolley for demonstrations by teachers in a classroom. The experiment procedures are contained in a printed manual.

The target group is made up of commercial apprentices and students of electrical machine construction. The course offers experiments at an intermediate level and also allows for the necessary insight into machine behaviour for scientific interpretation at undergraduate level.

Topics

Single ended forward converters

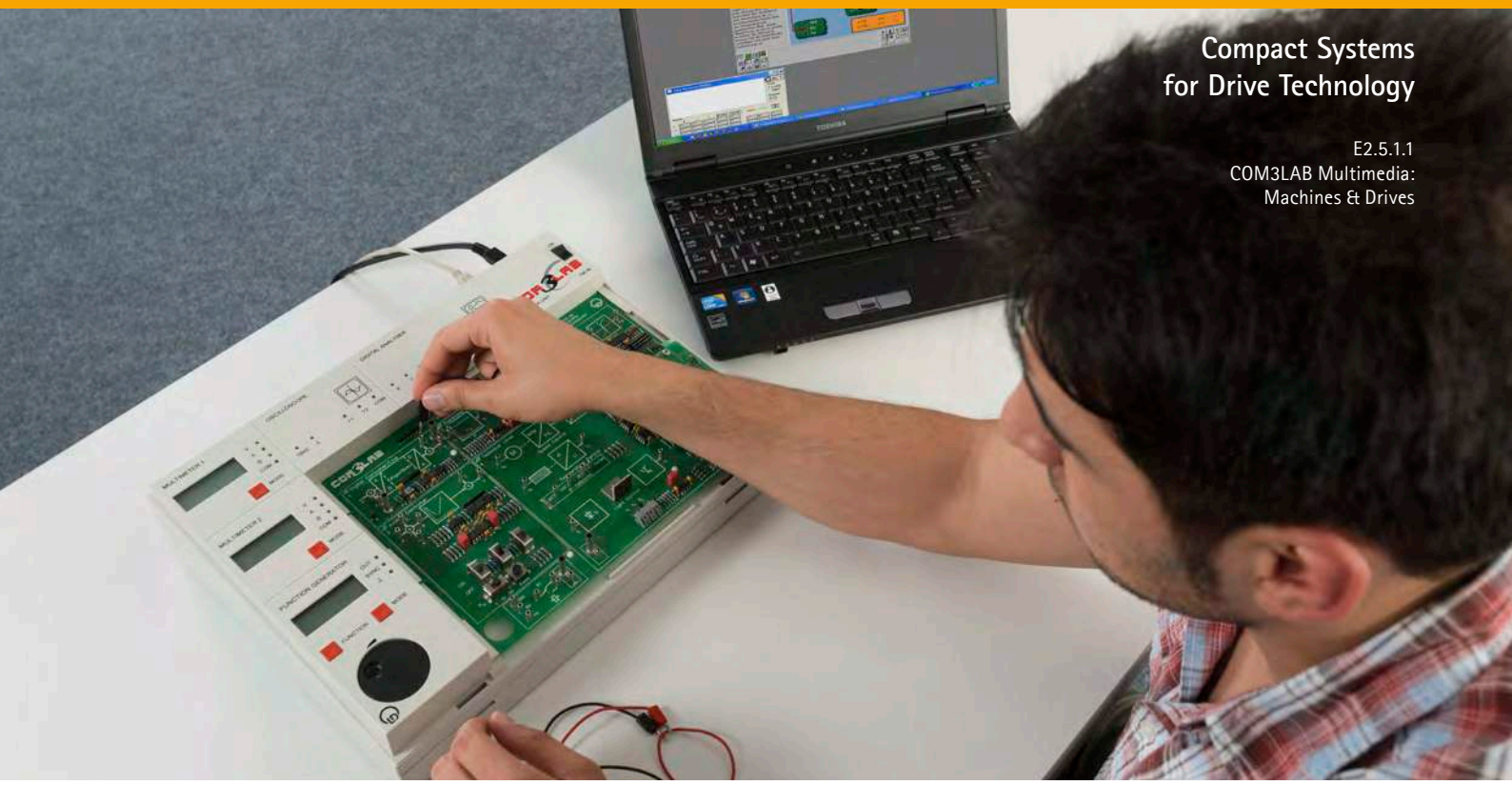
- Control of average values for voltage and current using PWM
- Measurement of voltage and current over time when V_I = 30
- Measurement of voltage and current over time when V_I = 115
- Measurement of efficiency and voltage stability

Asymmetric half-bridge forward converter

- Control of average values for voltage and current using PWM
- Time characteristic when v = 0.75
- Time characteristic when v = 0.50
- Time characteristic with duty cycle switch-over
- Time characteristic for sinusoidal inverter
- Inverter with V_I = 115 V
- Inverter with V_I = 115 V, f = 5 kHz

E2 ELECTRICAL DRIVES

E2.5 DRIVE TECHNOLOGY



Compact Systems for Drive Technology

E2.5.1.1
COM3LAB Multimedia: Machines & Drives

COM3LAB Multimedia: Machines & Drives (E2.5.1.1)

Cat. No.	Description	E2.5.1.1
700 25	COM3LAB course: Electrical machines I	1
700 82	COM3LAB course: Control technology I	1
700 00USB	COM3LAB master unit (USB)	1
700 00CBTEN	CD: COM3LAB software	1*
700 83	COM3LAB course: Control technology II	1*
731 91	Shunt wound machine 0.3	1*
731 09	Tacho generator 0.3	1*
731 06	Coupling 0.3	1*
731 07	Shaft end guard 0.3	1*
731 08	Coupling guard 0.3	1*
734 22	Actuator, 115...230 V/1 kW	1*
734 19	Gain and offset adjust	1*
726 86	Stabilised power supply ±15 V/3 A	1*
500 851	Safety connecting leads, 32 A, set of 32	1*
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1*
500 59	Safety bridging plugs, black, set of 10	1*
726 19	Panel frame SL85, single-level	1*
775 190DE	LIT: E2.2.2.0 DC Machines 0.3 (German)	1*
775 190EN	LIT: E2.2.2.0 DC Machines 0.3	1

* additionally recommended

The experiments are carried out using the multimedia training system COM3LAB.

Objectives

- Recognising basic physical principles
- Recording machine characteristics
- Introduction to drive technology

The equipment set includes the COM3LAB courses, Electrical machines I and Closed-loop control. This allows important experiments to be conducted in the field of electrical drives. The operating response of electrical machines is investigated in terms of physics and mechanics and by means of speed-torque characteristics. The experiments explore how electrical machines are connected, as well as reversal of direction and adjustment of speed, plus wiring of the terminal board. The closed-loop control course investigates the fundamentals of variable speed drives. The characteristic parameters for control loops are measured and the design of closed control loops is shown experimentally.

Features

- Compact, highly integrated machine course
- Integrated machine test system
- Extensive charting of technical control loops using DDC controllers

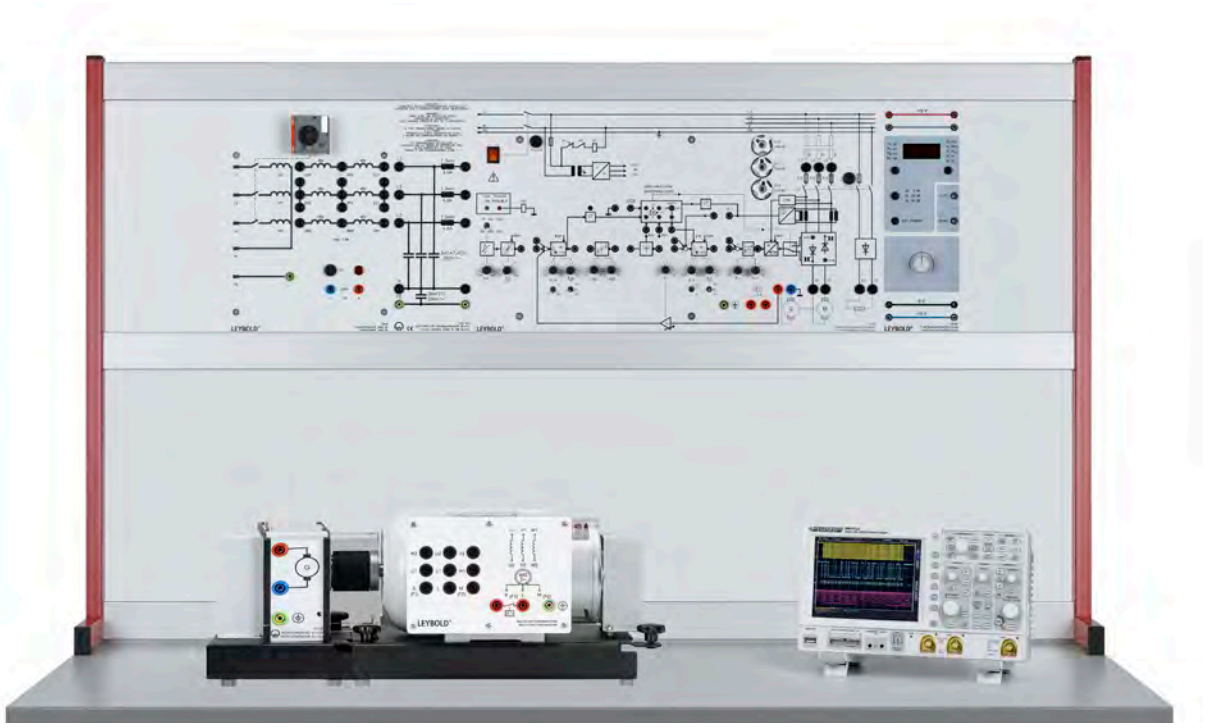
The speed control of a commercially available shunt-wound machine rated at 300 W is investigated as part of a project lesson. It is necessary to use the digital controller from the COM3LAB course, Closed-loop control II, in order to configure and optimise this for the industrial motor.

Topics

- Lorentz force
- Commutator machines
- Series-wound and shunt-wound machines
- Separately excited DC machines
- Adjustment of speed
- Reversal of rotation
- Terminal boards
- Three-phase machines
- Synchronous machines
- Starting response
- Measurement of speed using a stroboscope
- Asynchronous (induction) machines
- Three-phase drives
- V/f mode
- Characteristics, determination of breakdown torque
- Thermal effects
- Measurement of slip
- Stepper motors
- Half- and full-step operation
- PID controllers
- Step responses
- Control errors

Compact Systems for Drive Technology

E2.5.1.2
Drive Control with
Training Panels



Drive Control with Training Panels (E2.5.1.2)

Cat. No.	Description	E2.5.1.2
734 02	Reference variable generator	1
734 064N	PID digital controller Net	1
725 007	Software: Leylab.control Lite	1
734 111	Set of machines 10 W	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
726 86	Stabilised power supply ±15 V/3 A	1
500 59	Safety bridging plugs, black, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1
501 532	Connecting leads, 19 A, set of 30	1
734 481	WinFACT COM3LAB/CASSY edition, german	1
575 685DE	LIT: Drive Control (German)	1
575 685EN	LIT: Drive Control	1*

* additionally recommended

The experiments are carried out using training panels in panel frames.

Objectives

- Experiment set-up and wiring according to circuit diagrams
- How to handle closed-loop control systems
- Use of computer-controlled measuring interfaces
- Integration of block-oriented software in practical applications of closed-loop control

The equipment set is mainly concerned with the closed-loop control aspects of electrical drives. In addition, various machine characteristics are measured. The main training system is the 10 W machine set, which makes up a coupled motor-generator system. An integrated electronic load can be connected to the generator. This allows the effects of load fluctuations to be checked.

Features

- Compact machine set with integrated power amplifier
- Integrated electronic load with visual display of power which has been converted into heat
- Integrated measuring instruments for speed and torque
- Pre-filter which can be activated/deactivated to change the systems's order

The equipment set incorporates student experiments which can be carried out in a laboratory safely using safety extra-low voltage. Experiment instructions are contained in a manual in either printed or digital form.

The target group is made up of commercial apprentices and students of power engineering. The course offers experiments at an intermediate level for vocational colleges and undergraduate level.

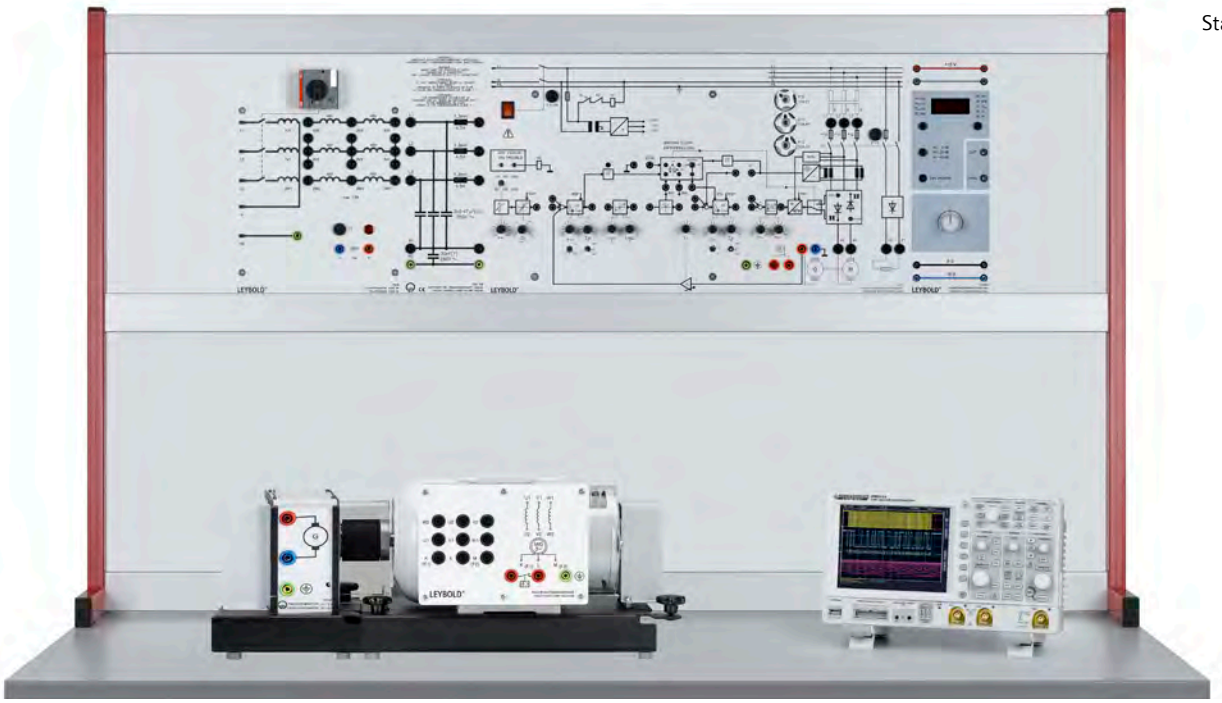
Topics

- Speed-torque characteristic
- Characteristic for generator voltage
- Step response of motors
- Load-dependent step responses
- Automatic speed control using digital controllers
- Closed-loop control of generator voltage
- Steady-state control deviation using P-control
- Aperiodic and oscillating control response
- Determination of optimum operating point
- Control errors due to limiting of manipulated variable
- Effects of dead-time and saturation
- Automatic speed control using software controller
- Setpoint control
- Disturbance control

The PID digital controller Net (734 064N) can be incorporated into a network. The basic software *LEYLAB.control Lite* or the full version *LEYLAB.control* (725 006) is needed to operate the equipment. An optional non-networkable version is also available.

Industrial DC Drives

E2.5.2.1
Static Converter Drive
with DC Machines



Static Converter Drive with DC Machines (E2.5.2.1)

Cat. No.	Description	E2.5.2.1
735 32	Thyristor speed control unit	1
731 09	Tacho generator 0.3	1
731 86	DC compound machine 0.3	1
735 190	Phase control noise filter 3 x 4.5 A	1
531 282	Multimeter Metrahit Pro	2*
575 231	Probe 100 MHz, 1:1 / 10:1	2
575 230	Digital storage oscilloscope 722	1
726 09	Panel frame T130, two-level	1
726 80	Transformer, 45/90, 3 N	1
726 962N	Function generator 200 kHz net	1
562 791	Plug-in power supply, 12 V AC	1
725 007	Software: Leylab.control Lite	1
731 06	Coupling 0.3	1
731 07	Shaft end guard 0.3	2
731 08	Coupling guard 0.3	1
500 59	Safety bridging plugs, black, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 280DE	LIT: E2.5.2.1 Static Converter Drive with DC Machines (German)	1
775 280EN	LIT: E2.5.2.1 Static Converter Drive with DC Machines	1*

* additionally recommended

Traditionally, DC machines were used for variable speed drives. By adjusting the armature voltage or by armature field weakening, the speed can be altered and by changing the polarity of the armature or the excitation voltage, it is possible to reverse the direction of rotation. Whereas in times past electro-mechanical components were used for this, such as starters, field regulators or pole change-over switches, nowadays such things are handled almost exclusively by static converters. Converter-fed DC drives are a popular form of controlled electrical drives. The reasons for their popularity are the reliable, tough and inexpensive speed controllers and the excellent control dynamics of the overall system.

The experiments are carried out using DC machines of industrial manufacture. The power is supplied to the machine under test via a thyristor speed controller.

Objectives

- Protective measures and electrical safety
- Setting up variable speed DC drives and putting them into operation
- Assessment of control response

The equipment set is suitable both for student experiments in a lab using low voltage (400 V three-phase) and on a mobile trolley for demonstrations by teachers in a classroom. The experiment procedures are contained in a printed manual.

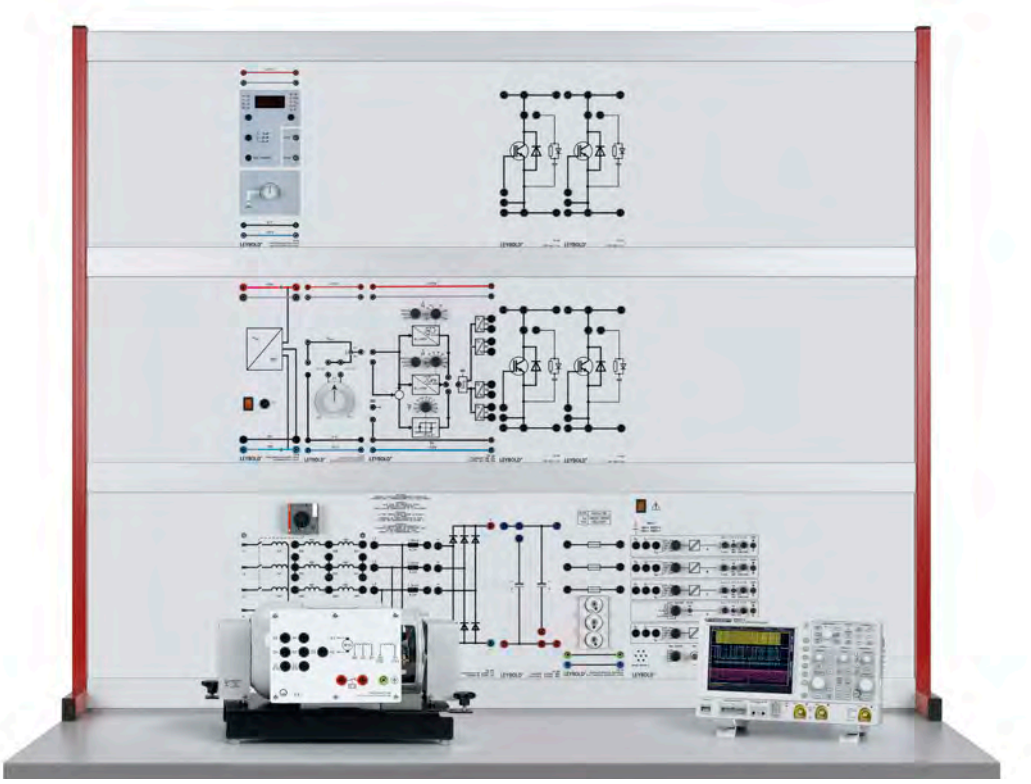
Topics

- Automatic control of multi-quadrant drive
- Introduction to the requirements
- Analysis of controlled systems
- Analysis of actuating static converters
- Optimisation of the current control loop
- Recording of armature circuit constants
- Adaptation of current controller
- Adjustment of current limiting
- Optimisation of speed control loop
- Putting thyristor speed control in the first quadrant into operation
- Setting of DC chopper and inverter stability limits
- Recording of static converter control characteristic
- Determination of armature circuit constants
- Recording of the transient function of the controlled variable, armature current
- Recording of the transient function of the controlled variable, armature current, with and without adaptive controller
- Switchover of static converters
- Setting current limiting
- Determination of the integral-action coefficient for the drive
- Determination of the transient of the controlled variable, speed
- Recording a switching diagram

The Function generator 200 kHz Net (726 962N) can be incorporated into a network. The basic software *LEYLAB.control Lite* (725 007) or the full version *LEYLAB.control* (725 006) is needed to operate the equipment. An optional non-networkable version is also available.

Industrial DC Drives

E2.5.2.2
DC-Chopper Drive with DC Machines



DC-Chopper Drive with DC Machines (E2.5.2.2)

Cat. No.	Description	E2.5.2.2
731 86	DC compound machine 0.3	1
726 80	Transformer, 45/90, 3 N	1
734 02	Reference variable generator	1
726 86	Stabilised power supply ±15 V/3 A	1
726 962N	Function generator 200 kHz net	1
725 007	Software: Leylab.control Lite	1
735 341	Control unit PWM; PFM	1
735 346	IGBT 1000 V/10 A	4
735 02	Diode, 1000 V/10 A	1
735 065	Rectifier B6, 3X400 V/10 A	1
735 095	Capacitors 2x 1000 µF, 385 V	1
735 18	Fuses, ultra-rapid set of 3	1
735 190	Phase control noise filter 3 x 4.5 A	1
531 282	Multimeter Metrahit Pro	2
575 231	Probe 100 MHz, 1:1 / 10:1	2
575 230	Digital storage oscilloscope 722	1
731 07	Shaft end guard 0.3	2
501 02	BNC cable, 1 m	2
735 261	Isolation amplifier, four channel	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
500 59	Safety bridging plugs, black, set of 10	3
775 280DE	LIT: E2.5.2.1 Static Converter Drive with DC Machines (German)	1
775 280EN	LIT: E2.5.2.1 Static Converter Drive with DC Machines	1*

* additionally recommended

The experiments are carried out using training panels in panel frames along with a DC machine of industrial design.

Objectives

- Protective measures and electrical safety
- Experiment set-up and wiring according to a circuit diagram
- Setting up industrial commutator machines and putting them into operation
- Use of computer-assisted measurement interfaces

This equipment set allows you to set up a modern drive system in order to adjust the speed. The power electronics is implemented in the form of circuits using modular, discrete components. The load used is a DC machine operating without a load. The chopper allows for the speed to be set by limiting trigger angle and for the direction of rotation to be reversed. The trigger response of thyristors to pulse and burst control is investigated along with the resulting effects on the effects on the running characteristics of the machine.

The equipment set is suitable both for student experiments in a lab using low voltage (400 V three-phase) and on a mobile trolley for demonstrations by teachers in a classroom. The experiment procedures are contained in a printed manual.

The target group is made up of commercial apprentices and students of electrical machine construction. The course offers experiments at an intermediate level and also allows for the necessary insight into machine behaviour for scientific interpretation at undergraduate level.

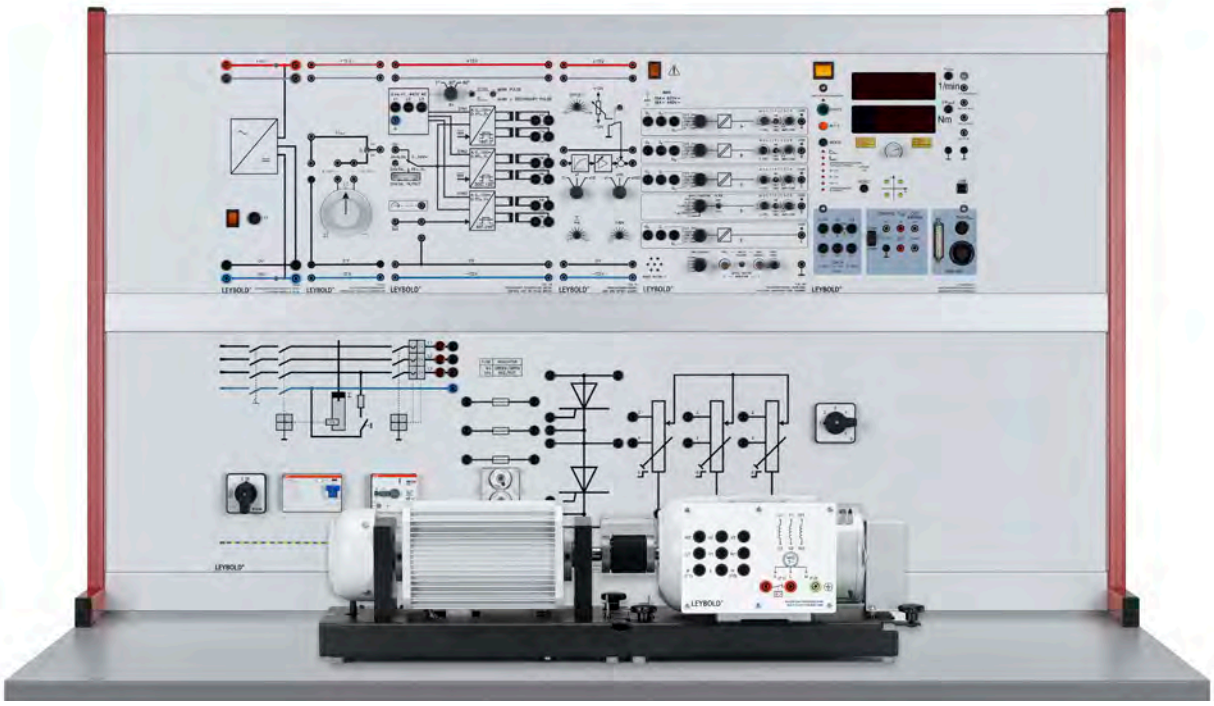
Topics

- Set-up of an H-bridge
- Full-bridge converter
- Reversal of voltage
- Reversal of current
- Setting the speed for DC machines

The Function generator 200 kHz Net (726 962N) can be incorporated into a network. The basic software *LEYLAB.control Lite* (725 007) or the full version *LEYLAB.control* (725 006) is needed to operate the equipment. An optional non-networkable version is also available.

Industrial 3-Phase Drives

E2.5.3.1
Drives with
Induction Machines



Drives with Induction Machines (E2.5.3.1)

Cat. No.	Description	E2.5.3.1
734 02	Reference variable generator	1
734 19	Gain and offset adjust	1
735 07	Thyristor branch pair, 1000 V/12 A	3
735 09	Load for power electronics	1
735 17	Run-up control unit	1
735 18	Fuses, ultra-rapid set of 3	2
735 20	Trigger point limiter	1
734 064N	PID digital controller Net	1
725 007	Software: Leylab.control Lite	1
735 065	Rectifier B6, 3X400 V/10 A	1
735 135	Control unit six pulse, digital	1
735 190	Phase control noise filter 3 x 4.5 A	1
735 341	Control unit PWM; PFM	1
735 346	IGBT 1000 V/10 A	1
732 28	Multi-function machine 0.3	1
731 09	Tacho generator 0.3	1
732 29	Rotor starter 0.3	1
531 282	Multimeter Metrahit Pro	2
727 11	Power meter	1
575 231	Probe 100 MHz, 1:1 / 10:1	2
575 230	Digital storage oscilloscope 722	1
735 261	Isolation amplifier, four channel	1
501 02	BNC cable, 1 m	2
731 989USB	Machine test system 0.3	1
728 421	CBM10 MOMO/FCCP	1
726 09	Panel frame T130, two-level	1
726 86	Stabilised power supply ±15 V/3 A	1
726 75	Three-phase supply unit with ELCB	1
726 80	Transformer, 45/90, 3 N	1
731 06	Coupling 0.3	2
731 07	Shaft end guard 0.3	2
731 081	Coupling guard 0.3 transparent	2
500 59	Safety bridging plugs, black, set of 10	2

Cat. No.	Description	E2.5.3.1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 285DE	LIT: E2.5.3.1 Drives with Induction Machines (German)	1
775 285EN	LIT: E2.5.3.1 Drives with Induction Machines	1*
	The PID digital controller Net (734 064N) can be incorporated into a network. The basic software *LEYLAB.control Lite* or the full version *LEYLAB.control* (725 006) is needed to operate the equipment. An optional non-networkable version is also available.	1

* additionally recommended

The power electronics part of this lab practical uses training panels. The electrical machine employed is an industrial machine on a base, whereby the characteristics of the machine can be determined using the Machine test system 0.3. Power is supplied to the machine under test via a static converter, which obtains its power from the (three-phase) mains network.

Objectives

- Protective measures and electrical safety
- Set-up of power generating systems according to circuit diagrams
- Putting electrical drives into operation
- Recording of load characteristics with various operating parameters
- Achieving skills in measuring electrical machines
- Automatic speed control for an asynchronous (induction) machine

This equipment set allows experiments on how the speed of asynchronous (induction) machines can be modified using line-commutated static converters. The speed of the machine depends on the stator voltage and rotor impedance and can be adjusted in the experiment by changing these two variables. As well as putting the machine into operation and setting its parameters, the main thing considered is the change in the response of the machine. This involves recording load characteristics and determining key parameters. Addition of a PID controller allows the experiment set-ups to be enhanced into variable-speed drives with closed-loop speed control.

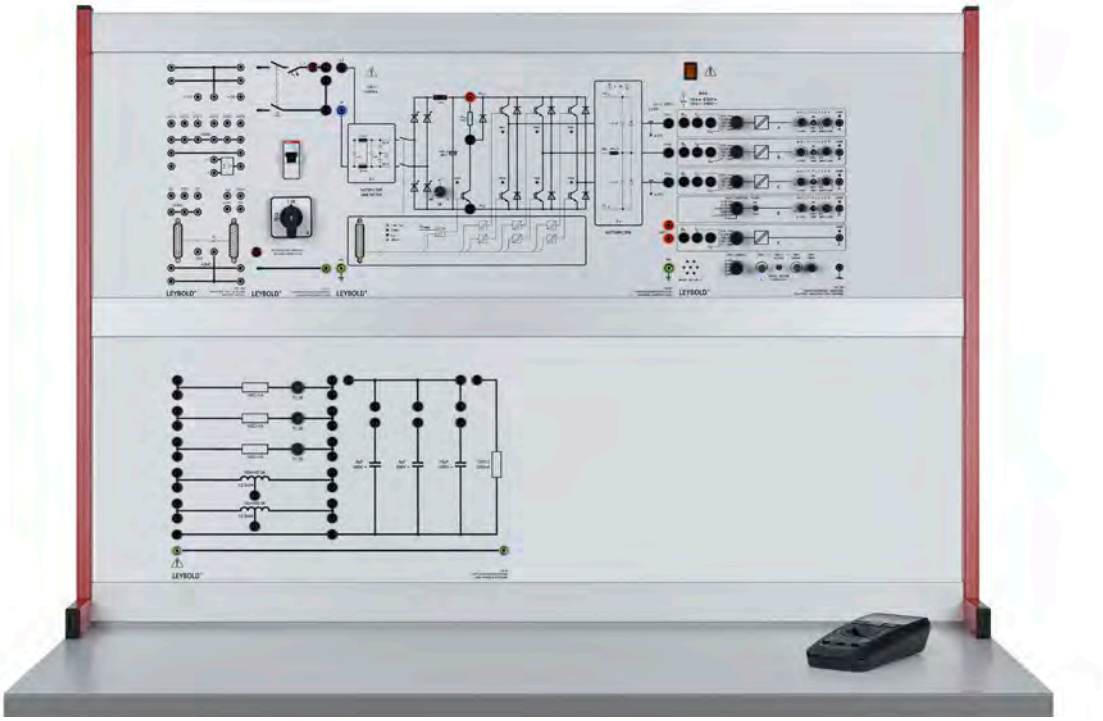
Students work in the power engineering lab with mains voltage. Experiments procedures are contained in a printed manual. The experiments are designed for intermediate and advanced levels.

Topics

- Drives using motors with slip-ring rotors and three-phase power controllers
- Drives using motors with slip-ring rotors and pulse-controlled rotor impedance
- Drives using motors with slip-ring rotors and static converter cascades

Industrial 3-Phase Drives

E2.5.3.2
Basics of Frequency Converters



Basics of Frequency Converters (E2.5.3.2)

Cat. No.	Description	E2.5.3.2
735 297	Universal converter 3 x 230 V	1
735 09	Load for power electronics	1
735 296	Converter input/output	1
501 02	BNC cable, 1 m	2
531 282	Multimeter Metrahit Pro	1
575 231	Probe 100 MHz, 1:1 / 10:1	2
575 230	Digital storage oscilloscope 722	1
735 261	Isolation amplifier, four channel	1
726 09	Panel frame T130, two-level	1
726 71	Single-phase supply unit	1
500 59	Safety bridging plugs, black, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 286DE	LIT: E2.5.3.2 Basics of Frequency Converters (German)	1
775 286EN	LIT: E2.5.3.2 Basics of Frequency Converters	1*

* additionally recommended

This laboratory practical utilises training panels in panel frames. The power is supplied to the frequency converter directly from the mains (mains voltage, 230 V).

Objectives

- Protective measures and electrical safety
- Components of a frequency converter with variable voltage link
- Setting parameters for frequency converters
- Gaining skill in measurement techniques

This equipment set offers an insight into the circuitry of frequency converters with variable voltage link. Measurements are made on the components of a frequency converter especially designed for educational purposes. The experiments use a static electronic load, which facilitates the evaluation of current and voltage curves. A rotating field with variable frequency is also investigated. The following components can be accessed:

- Input bridge rectifier with link capacitor
- Brake chopper
- Power inverter

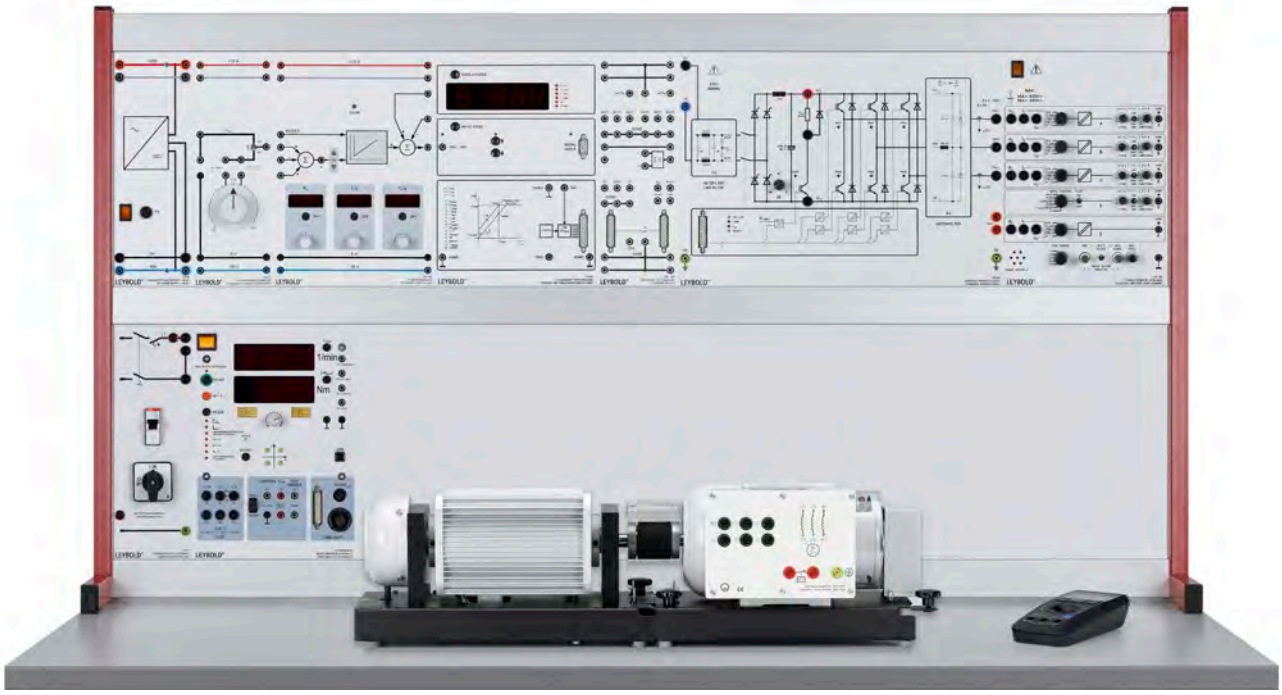
Students work in the power engineering lab with mains voltage. Experiments procedures are contained in a printed manual. The experiments are designed for intermediate and advanced levels.

Topics

- Rotating field and space vectors
- Feeding a sinusoidal signal from the normal three-phase mains network
- Representation of space vectors
- Generation of a rotating field from a DC voltage
- Putting a converter into operation
- Fault-free activation of the mains voltage
- Activation of the input rectifier
- Switching off the converter
- Discharging the buffer capacitor
- Investigation of input rectifier
- Response with zero-delay angle setting, CI = 00
- Control characteristic
- Loading
- Control via external control voltage
- Investigation of output inverter
- Control of individual power transistors
- Generation of rotating field
- Loading with resistive load

Industrial 3-Phase Drives

E2.5.3.3
Drives with
Educational
Frequency
Converter



Drives with Educational Frequency Converter (E2.5.3.3)

Cat. No.	Description	E2.5.3.3
735 297	Universal converter 3 x 230 V	1
735 296	Converter input/output	1
731 09	Tacho generator 0.3	1*
732 104	Squirrel cage motor 230/400/0.3	1
734 02	Reference variable generator	1*
734 19	Gain and offset adjust	1*
734 064N	PID digital controller Net	1*
725 007	Software: Leylab.control Lite	1*
734 064	PID digital controller	1*
735 291	Control unit PWM	1
501 02	BNC cable, 1 m	2
531 282	Multimeter Metrahit Pro	1
575 231	Probe 100 MHz, 1:1 / 10:1	2
575 230	Digital storage oscilloscope 722	1
735 261	Isolation amplifier, four channel	1
731 989USB	Machine test system 0.3	1
728 421	CBM10 MOMO/FCCP	1
524 004	Adapter, USB port/serial port	1
729 769	RS-232 cable, 9-pole	1
726 09	Panel frame T130, two-level	1
726 86	Stabilised power supply ±15 V/3 A	1
726 71	Single-phase supply unit	1
731 06	Coupling 0.3	1
731 07	Shaft end guard 0.3	1
731 081	Coupling guard 0.3 transparent	1
500 59	Safety bridging plugs, black, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 300DE	LIT: E2.5.3.3 Drives with Educational Frequency Converter (German)	1
775 300EN	LIT: E2.5.3.3 Drives with Educational Frequency Converter	1*

* additionally recommended

The power electronics part of this lab practical uses training panels. The electrical machine employed is an industrial machine on a base, whereby the characteristics of the machine can be determined using the Machine test system 0.3. Power is supplied to the machine under test via an educationally designed frequency converter, which obtains its power from the normal mains (mains voltage, 230 V).

Objectives

- Protective measures and electrical safety
- Set-up of power generating systems according to circuit diagrams
- Putting electrical drives into operation
- Recording of load characteristics with various operating parameters
- Achieving skills in measuring electrical machines
- Automatic speed control for an asynchronous (induction) machine

Power electronics has developed from the technology of static converters to become one of the most important and all-encompassing areas of electrical engineering. The job of power electronics is to switch, control and convert electrical energy using power semiconductors with the best possible efficiency. One key application is drive technology. With the help of modern power electronics, it is possible to construct variable speed drives in DC and three-phase circuits for 4-quadrant operation. In this equipment set, a universal converter is used for open- and closed-loop control of speed for a squirrel cage motor.

Students work in the power engineering lab with mains voltage. Experiments procedures are contained in a printed manual. The experiments are designed for intermediate and advanced levels.

Topics

- Rotating field and space vectors
- Modulation types: square, trapezoidal, sinusoidal, pulse width modulation (PWM)
- Voltage vector control VVC
- Magnetisation with a linear V/f characteristic
- Boosting of magnetisation by means of the start voltage
- Optimisation of load characteristics by means of IxR compensation
- Slip compensation
- Operation of the motor in a star configuration
- Computer-assisted measurement and evaluation using CBM 10 software
- Recording a load characteristic
- Comparison of multiple load characteristics
- Brake choppers
- Variable-speed drives

Industrial 3-Phase Drives

E2.5.3.4
Drives with Industrial Frequency Converter 0.3

Drives with Industrial Frequency Converter 0.3 (E2.5.3.4)

Similar to illustration

Cat. No.	Description	E2.5.3.4
735 312	Industrial frequency converter 0.3	1
732 104	Squirrel cage motor 230/400/0.3	1
531 282	Multimeter Metrahit Pro	1
731 989USB	Machine test system 0.3	1
728 421	CBM10 MOMO/FCCP	1
735 314	LCP2 local control panel	1
726 10	Panel frame T150, two-level	1
731 06	Coupling 0.3	1
731 07	Shaft end guard 0.3	1
731 081	Coupling guard 0.3 transparent	1
500 59	Safety bridging plugs, black, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1*
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
775 290DE	LIT: E2.5.3.4 Drives with Industry Frequency Converter 0.3 (German)	1
775 290EN	LIT: E2.5.3.4 Drives with Industry Frequency Converter 0.3	1*

* additionally recommended

The power electronics part of this lab practical uses training panels. The electrical machine employed is an industrial machine on a base, whereby the characteristics of the machine can be determined using the Machine test system 0.3. Power is supplied to the machine under test via an industrial frequency converter, which obtains its power from the normal mains power supply (mains voltage, 230 V).

Objectives

- Protective measures and electrical safety
- Set-up of power generating systems according to circuit diagrams
- Putting electrical drives into operation
- Recording of load characteristics with various operating parameters
- Achieving skills in measuring electrical machines
- Automatic speed control for an asynchronous (induction) machine

Using switchable converter valves, it is possible to set-up three-phase networks with variable frequency and amplitude. The speed of asynchronous (induction) machines is then variable with practically no losses over a broad range. In this lab, machines in the power class 0.3 kW are used. The equipment set includes an industrial compact converter. The experiments focus on putting converters into operation, setting their parameters and investigating machine response.

Students work in the power engineering lab with mains voltage. Experiments procedures are contained in a printed manual. The experiments are designed for intermediate and advanced levels.

Topics

- Fundamentals of three-phase machines
- Equivalent circuit for an asynchronous (induction) motor
- Torque, efficiency and optimum magnetisation
- Circuit wiring and connection of components
- Setting up a drive and testing its operation
- Parameter setting for a frequency converter
- Learning the key menus
- Measurement of converter output voltage
- Effect of start voltage
- Effect of start compensation (IxR compensation)
- Response of the machine in the absence of starting voltage and compensation
- Effect of slip compensation
- Recording of V/f characteristic for a machine operating without a load, with and without compensation of the frequency converter

Industrial 3-Phase Drives

E2.5.3.5
Drives with Industrial
Frequency Converter 1.0

Drives with Industrial Frequency Converter 1.0 (E2.5.3.5)

Cat. No.	Description	E2.5.3.5
735 3101	Industrial frequency converter 400 V	1
732 81	Squirrel cage motor 400/690 1.0	1
531 282	Multimeter Metrahit Pro	1
732 689USB	Machine test system 1.0	1
728 421	CBM10 MOMO/FCCP	1
726 10	Panel frame T150, two-level	1
732 56	Coupling 1.0	1
732 57	Shaft end guard 1.0	1
732 58	Coupling guard 1.0	1
500 592	Safety bridging plugs with tap, black, set of 10	1*
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
775 295DE	LIT: E2.5.3.5 Drives with Industry Frequency Converter 1.0 (German)	1
775 295EN	LIT: E2.5.3.5 Drives with Industry Frequency Converter 1.0	1*

* additionally recommended

The power electronics part of this lab practical uses training panels. The electrical machine employed is an industrial machine on a base, whereby the characteristics of the machine can be determined using the Machine test system 1.0. Power is supplied to the machine under test via an industrial frequency converter, which obtains its power from the normal (three-phase) mains.

Objectives

- Protective measures and electrical safety
- Set-up of power generating systems according to circuit diagrams
- Putting electrical drives into operation
- Recording of load characteristics with various operating parameters
- Achieving skills in measuring electrical machines
- Automatic speed control for an asynchronous (induction) machine

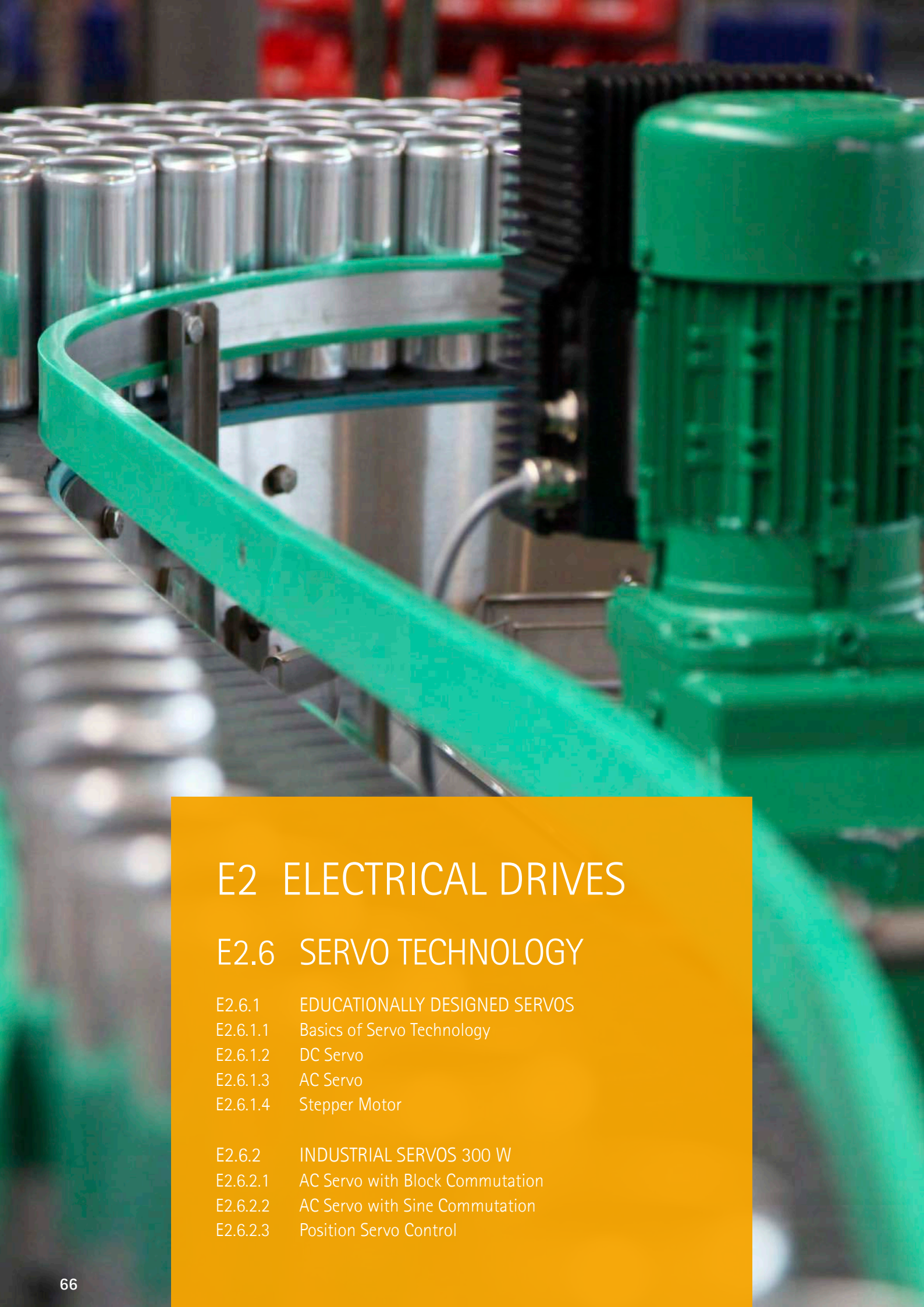
Using switchable converter valves, it is possible to set-up three-phase networks with variable frequency and amplitude. The speed of asynchronous (induction) machines is then variable with practically no losses over a broad range. Motors in the 1.0 kW rating class are used in this practical. The equipment set includes an industrial compact converter. The experiments focus on putting converters into operation, setting their parameters and investigating machine response.

Students work in the power engineering lab with mains voltage. Experiments procedures are contained in a printed manual.

The experiments are designed for intermediate and advanced levels.

Topics

- Fundamentals of three-phase machines
- Equivalent circuit for an asynchronous (induction) motor
- Torque, efficiency and optimum magnetisation
- Circuit wiring and connection of components
- Setting up a drive and testing its operation
- Parameter setting for a frequency converter
- Learning the key menus
- Measurement of converter output voltage
- Effect of start voltage
- Effect of start compensation (IxR compensation)
- Response of the machine in the absence of starting voltage and compensation
- Effect of slip compensation
- Recording of V/f characteristic for a machine operating without a load, with and without compensation of the frequency converter

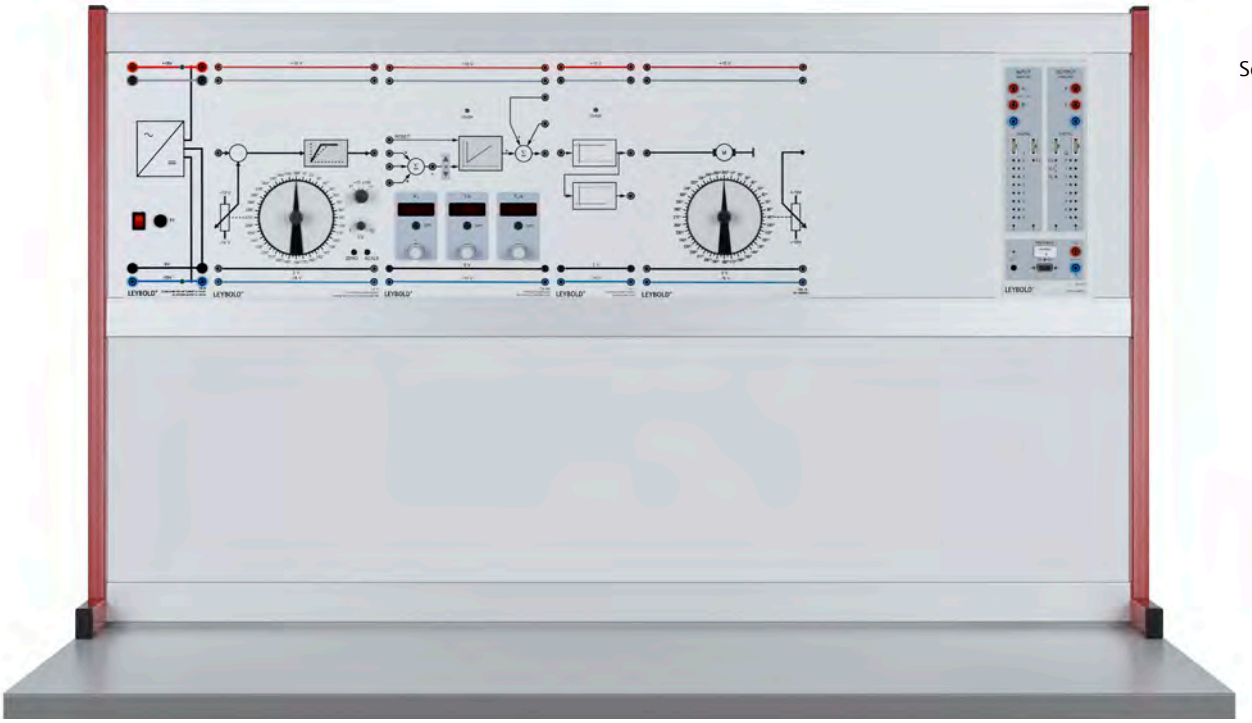


E2 ELECTRICAL DRIVES

E2.6 SERVO TECHNOLOGY

Educationally Designed Servos

E2.6.1.1
Basics of
Servo Technology



Basics of Servo Technology (E2.6.1.1)

Cat. No.	Description	E2.6.1.1
579 13	Toggle switch, STE 2/19	1
734 10	Servo setpoint generator	1
734 13	Power amplifier	1
734 14	DC servo	1
734 064N	PID digital controller Net	1
725 007	Software: Leylab.control Lite	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
726 86	Stabilised power supply ±15 V/3 A	1
500 59	Safety bridging plugs, black, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
775 320DE	LIT: E2.6.1.1 Basics of Servo technology (German)	1
775 320EN	LIT: E2.6.1.1 Basics of Servo Technology	1*

* additionally recommended

Servos are drives used for open- and closed-loop control of position, speed or torque. In manufacturing, servos are often used as auxiliary drives for positioning items being worked on by machines. Servos are used in that sphere in CNC machines or robots. The requirements for servos demand high accuracy, dynamic properties and resilience to overloading.

The experiments are carried using training panels in panel frames.

Objectives

- Experiment set-up and wiring according to circuit diagrams
- Working with closed-loop control systems
- Optimisation of servo systems
- Use of computer-controlled measuring interfaces

The equipment set incorporates student experiments which can be carried out in a laboratory safely using safety extra-low voltage. Experiment instructions are contained in a manual in either printed or digital form.

The target group is made up of commercial apprentices and students of power engineering and mechatronics. The course offers introductory experiments at an intermediate level for vocational schools and colleges.

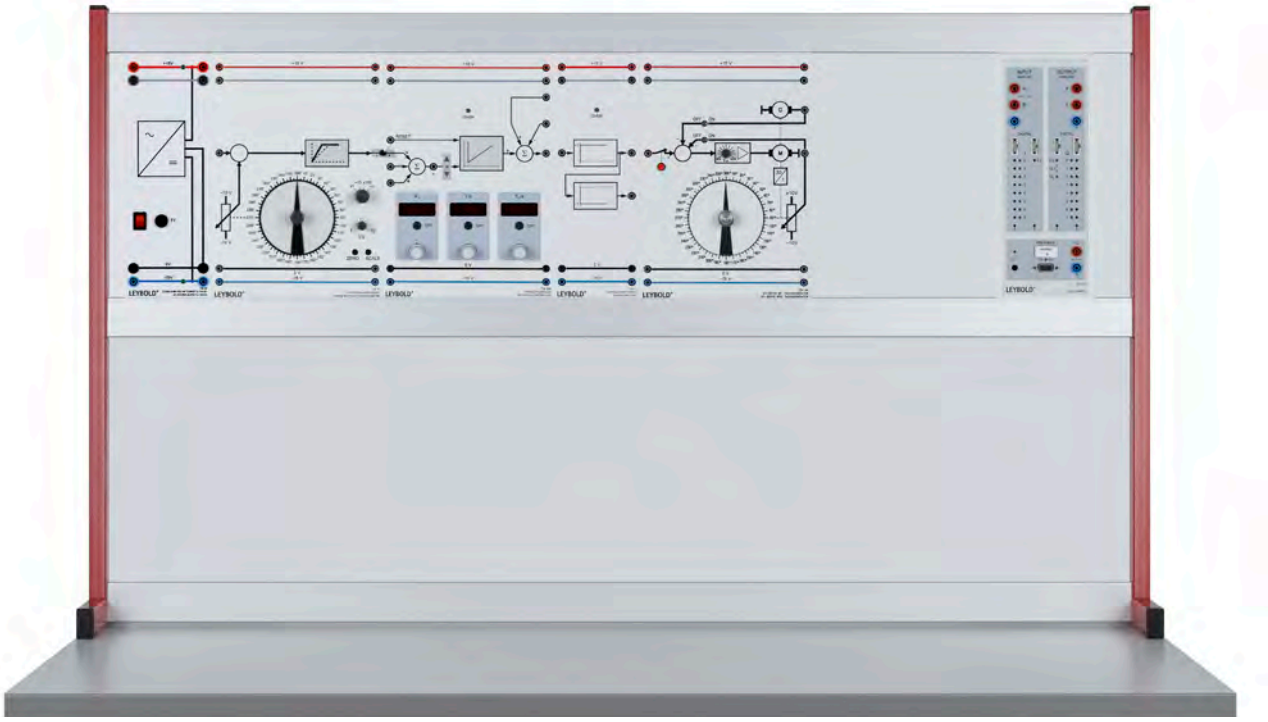
Topics

- Operation with a P-controller : determination of system deviation (error signals) or oscillation
- Operation with a PI-controller : elimination of system deviation (error signals), overshoot and tracking error
- Operation with a PID-controller : optimisation of system deviation (error signals) and oscillation

The Function generator 200 kHz Net (726 962N) can be incorporated into a network. The basic software *LEYLAB.control Lite* (725 007) or the full version *LEYLAB.control* (725 006) is needed to operate the equipment. An optional non-networkable version is also available.

Educationally Designed Servos

E2.6.1.2
DC Servo



DC Servo (E2.6.1.2)

Cat. No.	Description	E2.6.1.2
734 10	Servo setpoint generator	1
734 13	Power amplifier	1
734 44	DC servo with tachogenerator	1
734 064N	PID digital controller Net	1
725 007	Software: Leylab.control Lite	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
726 86	Stabilised power supply ±15 V/3 A	1
579 13	Toggle switch, STE 2/19	1
734 36	Weight disc with hook	1
500 59	Safety bridging plugs, black, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
775 325DE	LIT: E2.6.1.2 DC Servos (German)	1
775 325EN	LIT: E2.6.1.2 DC Servos	1*

* additionally recommended

Servos are drives used for open- and closed-loop control of position, speed or torque. In manufacturing, servos are often used as auxiliary drives for positioning items being worked on by machines. Servos are used in that sphere in CNC machines or robots. The requirements for servos demand high accuracy, dynamic properties and resilience to overloading.

The experiments are carried using training panels in panel frames.

Objectives

- Experiment set-up and wiring according to circuit diagrams
- Working with closed-loop control systems
- Optimisation of servo systems
- Use of computer-controlled measuring interfaces

The equipment set incorporates student experiments which can be carried out in a laboratory safely using safety extra-low voltage. Experiment instructions are contained in a manual in either printed or digital form.

The target group is made up of commercial apprentices and students of power engineering and mechatronics. The course offers introductory experiments at an intermediate level for vocational schools and colleges.

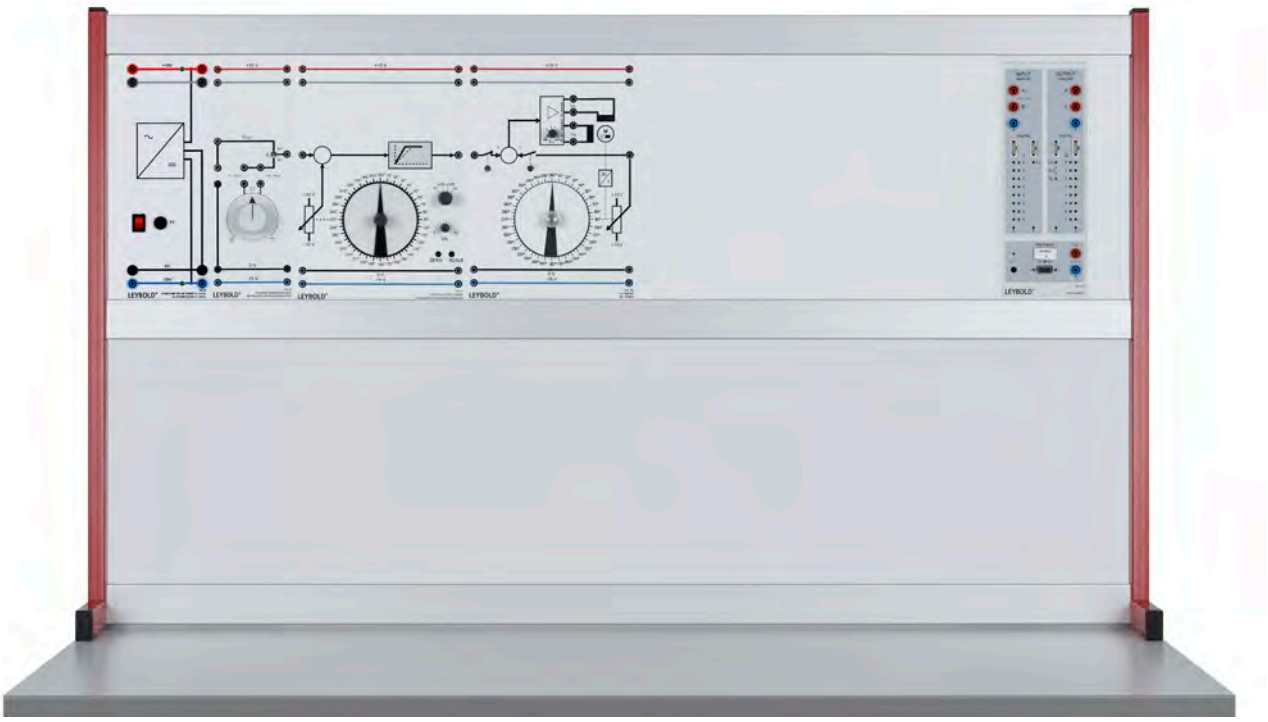
Topics

- Recording of step response
- Determination of K_{pcrit} und T_{crit} and calculation of settings for P, PI and PID systems
- Closed-loop step response for P-controller
- Correction for K_p with respect to integral-action systems
- Step response for PID-controller
- Determination of limiting frequency of servos
- Use of measurement interfaces

The PID digital controller Net (734 064N) can be incorporated into a network. The basic software *LEYLAB.control Lite* or the full version *LEYLAB.control* (725 006) is needed to operate the equipment. An optional non-networkable version is also available.

Educationally Designed Servos

E2.6.1.3
AC Servo



AC Servo (E2.6.1.3)

Cat. No.	Description	E2.6.1.3
734 10	Servo setpoint generator	1
734 45	AC servo	1
734 36	Weight disc with hook	1
579 13	Toggle switch, STE 2/19	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
726 86	Stabilised power supply ±15 V/3 A	1
500 59	Safety bridging plugs, black, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
775 330DE	LIT: E2.6.1.3 AC Servos (German)	1
775 330EN	LIT: E2.6.1.3 AC Servos	1*

* additionally recommended

Servos are drives used for open- and closed-loop control of position, speed or torque. In manufacturing, servos are often used as auxiliary drives for positioning items being worked on by machines. Servos are used in that sphere in CNC machines or robots. The requirements for servos demand high accuracy, dynamic properties and resilience to overloading.

The experiments are carried using training panels in panel frames.

Objectives

- Experiment set-up and wiring according to circuit diagrams
- Working with closed-loop control systems
- Optimisation of servo systems
- Use of computer-controlled measuring interfaces

The equipment set incorporates student experiments which can be carried out in a laboratory safely using safety extra-low voltage. Experiment instructions are contained in a manual in either printed or digital form.

The target group is made up of commercial apprentices and students of power engineering and mechatronics. The course offers introductory experiments at an intermediate level for vocational schools and colleges.

Topics

- Open control loops
- Display of voltage across main and auxiliary coils when moving clockwise or anti-clockwise
- Frequencies, synchronous speeds and potentiometer speeds for various desired setpoint values
- Calculation of gear reduction
- Experiments on closed control loops
- Operation with a setpoint integrator
- Response to reversal as a function of the rate of rise in the setpoint
- Response to reversal as a function of the controller gain K_P

Educationally Designed Servos

E2.6.1.4
Stepper Motor

Stepper Motor (E2.6.1.4)

Cat. No.	Description	E2.6.1.4
728 55	Stepper motor	1
524 016S2	Profi-CASSY Starter 2	1
726 09	Panel frame T130, two-level	1
726 86	Stabilised power supply ±15 V/3 A	1
726 962N	Function generator 200 kHz Net	1
725 007	Software: Leylab.control Lite	1
500 59	Safety bridging plugs, black, set of 10	1
500 641	Safety connecting lead, 100 cm, red	1
500 644	Safety connecting lead, 100 cm, black	1
775 345DE	LIT: E2.6.1.4 Stepper Motors (German)	1
775 345EN	LIT: E2.6.1.4 Stepper Motors	1*

* additionally recommended

For industrial robots, packing machines, NC tooling machines and similar applications, servo drives are needed which are very fast but also very precise in their positioning. These are automatic position-controlled electrical drives, which usually consist of a permanently excited synchronous rotor, a frequency converter with a variable voltage link circuit and digital closed-loop control. A sensor detects the angular position of the motor shaft and uses the information to control the converter.

The experiments are carried using training panels in panel frames.

Objectives

- Experiment set-up and wiring according to circuit diagrams
- Working with closed-loop control systems
- Optimisation of servo systems
- Use of computer-controlled measuring interfaces

Stepper motors are a special variety of synchronous motor with a large number of pole pairs. The rotor follows the stator field in steps, the size of which is determined by the number of poles. With normal loading, the angular position of the rotor can be determined precisely. If overloaded, however, step losses arise and information about the current position of the rotor is lost. Stepper motors can be wired to operate in both half-step and full-step modes. Due to their discontinuous operation, stepper motors are the ideal drive systems for digital servo systems.

The equipment set incorporates student experiments which can be carried out in a laboratory safely using safety extra-low voltage. Experiment instructions are contained in a manual in either printed or digital form.

The target group is made up of commercial apprentices and students of power engineering and mechatronics. The course offers introductory experiments at an intermediate level for vocational schools and colleges.

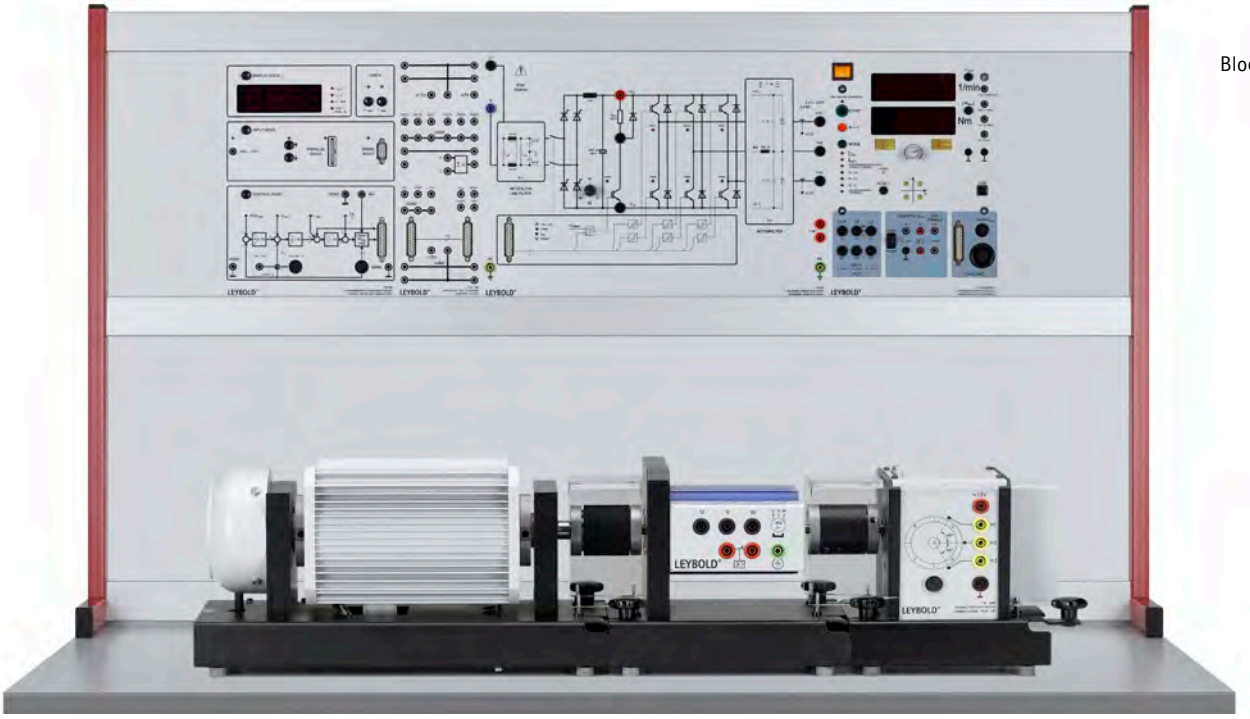
Topics

- Operation of a simple stepper motor: half-step, full-step
- Design of a stepper motor: function, step angle
- Control methods for bipolar and unipolar stepper motors
- Control program for full and half steps using a unipolar stepper motor
- Control logic with external control
- Dynamic response
- Time constants of the windings
- Rate of rise in current as a function of the clocking frequency
- Starting/stopping regions: start frequencies
- Mechanical resonances: effect of load coupling
- Response as a function of clock frequency

The Function generator 200 kHz Net (726 962N) can be incorporated into a network. The basic software *LEYLAB.control Lite* (725 007) or the full version *LEYLAB.control* (725 006) is needed to operate the equipment. An optional non-networkable version is also available.

Industrial Servos 300 W

E2.6.2.1
AC Servo with
Block Commutation



AC Servo with Block Commutation (E2.6.2.1)

Similar to illustration

Cat. No.	Description	E2.6.2.1
734 02	Reference variable generator	1
731 092	Incremental tacho 0.3	1
731 096	Commutation pick-up 0.3	1
731 994	AC servo motor 0.3	1
735 292	Control unit block commutation	1
735 296	Converter input/output	1
735 297	Universal converter 3 x 230 V	1
501 02	BNC cable, 1 m	2
531 282	Multimeter Metrahit Pro	1
575 231	Probe 100 MHz, 1:1 / 10:1	2
575 230	Digital storage oscilloscope 722	1
735 261	Isolation amplifier, four channel	1
731 989USB	Machine test system 0.3	1
728 421	CBM10 MOMO/FCCP	1
728 410	CBC 12.5 Servo technology	1
726 09	Panel frame T130, two-level	1
726 71	Single-phase supply unit	1
726 86	Stabilised power supply ±15 V/3 A	1
731 06	Coupling 0.3	3
731 07	Shaft end guard 0.3	2
731 081	Coupling guard 0.3 transparent	3
500 59	Safety bridging plugs, black, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
524 004	Adapter, USB port/serial port	1
729 769	RS-232 cable, 9-pole	1
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	1
775 305DE	LIT: E2.6.2.1 AC Servo with Block Commutation (German)	1
775 305EN	LIT: E2.6.2.1 AC Servo with Block Commutation	1*

* additionally recommended

For industrial robots, packing machines, NC tooling machines and similar applications, servo drives are needed which are very fast but also very precise in their positioning. These are automatic position-controlled electrical drives, which usually consist of a permanently excited synchronous rotor, a frequency converter with a variable voltage link circuit and digital closed-loop control. A sensor detects the angular position of the motor shaft and uses the information to control the converter.

Power electronics, control equipment, etc. are set up in training panel frames. The servo machine used here is a dynamic industrial machine with a particularly small moment of inertia. The load characteristics can be recorded using the Machine test system 0.3. Power is supplied to the machine under test via a frequency converter especially designed for educational purposes which obtains its power from the mains (mains voltage, 230 V).

Objectives

- Protective measures and electrical safety
- Set-up of power generating systems according to circuit diagrams
- Putting electrical drives into operation
- Recording of load characteristics with various operating parameters
- Achieving skills in measuring electrical machines
- Automatic speed control for an AC servo machine

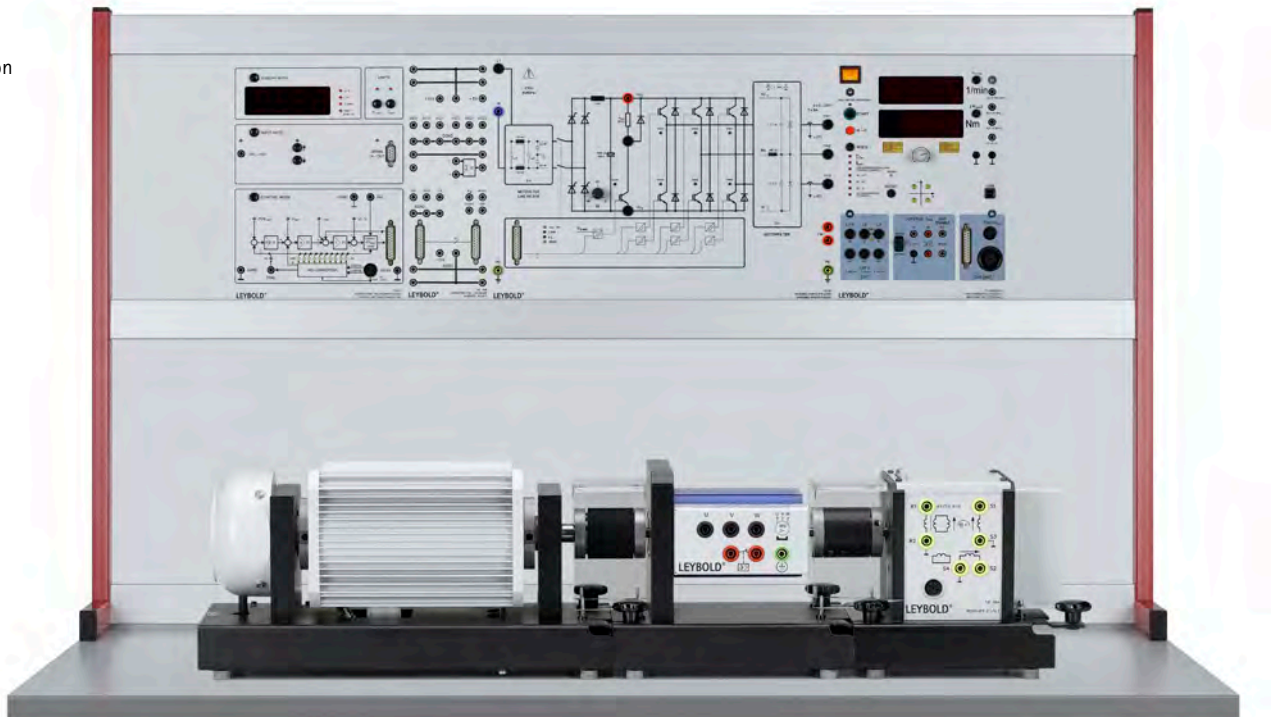
An AC servo consists of a permanently excited synchronous rotor, a frequency converter with a variable voltage link circuit and digital closed-loop control. A sensor detects the angular position of the motor shaft and uses the information to control the converter. This equipment set investigates AC servos with block commutation. Advanced experiments can be found in the equipment set E2.6.2.3 Position Servo Control.

Topics

- Coupling of motor and commutation sensor
- Steady-state response
- Load characteristics
- Measurement of motor current
- Variation of duty cycle
- Variation variable voltage link
- Variation of commutation angle
- Dynamic response
- Structure of the controlled system
- Stress cycle with servo position control

Industrial Servos 300 W

E2.6.2.2
AC Servo with
Sine Commutation



AC Servo with Sine Commutation (E2.6.2.2)

Similar to illustration

Cat. No.	Description	E2.6.2.2
734 02	Reference variable generator	1
731 094	Resolver 0.3	1
731 994	AC servo motor 0.3	1
735 293	Control unit sine commutation	1
735 297	Universal converter 3 x 230 V	1
735 296	Converter input/output	1
501 02	BNC cable, 1 m	2
531 282	Multimeter Metrahit Pro	1
575 231	Probe 100 MHz, 1:1 / 10:1	2
575 230	Digital storage oscilloscope 722	1
735 261	Isolation amplifier, four channel	1
731 989USB	Machine test system 0.3	1
728 421	CBM10 MOMO/FCCP	1
728 410	CBC 12.5 Servo technology	1
726 09	Panel frame T130, two-level	1
726 71	Single-phase supply unit	1
731 06	Coupling 0.3	3
731 07	Shaft end guard 0.3	2
731 081	Coupling guard 0.3 transparent	3
500 59	Safety bridging plugs, black, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	5
524 004	Adapter, USB port/serial port	1
729 769	RS-232 cable, 9-pole	1
775 310DE	LIT: E2.6.2.2 AC Servo with Sine Commutation (German)	1
775 310EN	LIT: E2.6.2.2 AC Servo with Sine Commutation	1*

* additionally recommended

Power electronics, control equipment, etc. are set up in training panel frames. The servo machine used here is a dynamic industrial machine with a particularly small moment of inertia. The load characteristics can be recorded using the Machine test system 0.3. Power is supplied to the machine under test via a frequency converter especially designed for educational purposes which obtains its power from the mains (mains voltage, 230 V).

Objectives

- Protective measures and electrical safety
- Set-up of power generating systems according to circuit diagrams
- Putting electrical drives into operation
- Recording of load characteristics with various operating parameters
- Achieving skills in measuring electrical machines
- Automatic speed control for an AC servo machine

Sinusoidally commutated drives are more complex to implement than block-commutated drives, but they do have advantages which can justify the extra complexity. The sensor system uses a so-called resolver, which not only provides very accurate information on the absolute position of the rotor, it also outputs a speedometer voltage reflecting the motor speed. From information on the displacement or angle, signals can be derived which can then be used directly for positioning.

Students work in the power engineering lab with mains voltage. Experiments procedures are contained in a printed manual.

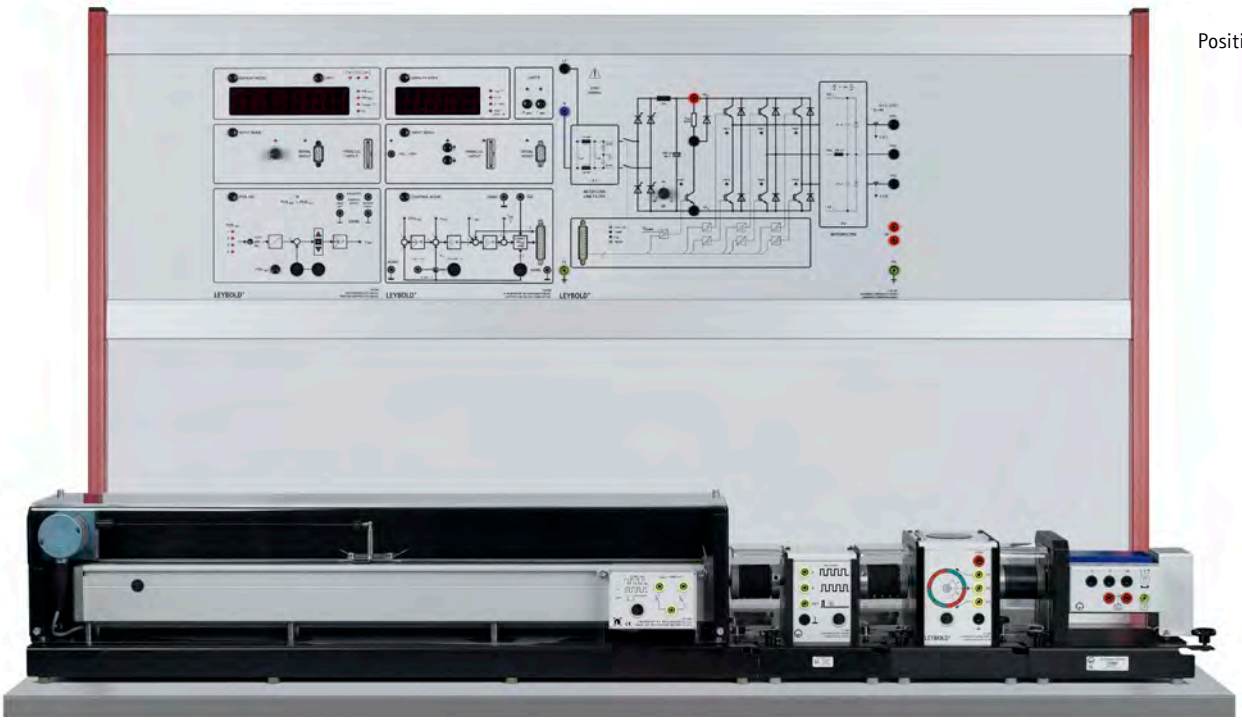
The experiments are designed for intermediate and advanced levels.

Topics

- Coupling of motor and commutation sensor
- Steady-state response
- Load characteristics
- Measurement of motor current
- Variation of peak voltage
- Variation variable voltage link
- Variation of commutation angle
- Dynamic response
- Structure of the controlled system
- Stress cycle with servo position control

Industrial Servos 300 W

E2.6.2.3
Position Servo Control



Position Servo Control (E2.6.2.3)

Cat. No.	Description	E2.6.2.3
734 02	Reference variable generator	1
735 299	Position controller, digital	1
731 075	Gearbox 36:1 / 0.3	1
731 089	Potentiometric angle transducer 0.3	1
731 092	Incremental tacho 0.3	1
731 096	Commutation pick-up 0.3	1
731 994	AC servo motor 0.3	1
735 292	Control unit for block commutation	1
735 297	Universal converter 3 x 230 V	1
735 296	Converter input/output	1
731 085	Linear unit 0.3	1*
734 064N	PID digital controller Net	1
725 007	Software: Leylab.control Lite	1
731 086	Linear unit with position encoder 0.3	1*
735 293	Control unit for sine commutation	1*
731 094	Resolver 0.3	1*
500 621	Safety connecting lead, 50 cm, red	3*
500 622	Safety connecting lead, 50 cm, blue	3*
728 410	CBC 12.5 Servo technology	1
726 09	Panel frame T130, two-level	1
726 71	Single-phase supply unit	1
500 59	Safety bridging plugs, black, set of 10	1
500 851	Safety connecting leads, 32 A, set of 32	1
500 852	Safety connecting leads, 32 A, yellow/green, set of 10	1
531 282	Multimeter Metrahit Pro	1
729 769	RS-232 cable, 9-pole	1
524 004	Adapter, USB port/serial port	1
731 07	Shaft end guard 0.3	2
731 081	Coupling guard 0.3 transparent	4
731 06	Coupling 0.3	4

Cat. No.	Description	E2.6.2.3
775 315DE	LIT: E2.5.2.3 Position Servo Control (German)	1
775 315EN	LIT: E2.6.2.3 Position Servo Control	1*

* additionally recommended

Inverters, control units etc. are mounted in panel frames. The servo machine is a dynamic industrial machine with a particularly small moment of inertia. The power supply for the test machine comes from a didactic frequency converter, which is fed from the mains power source (mains voltage 230 V).

Objectives

- Protective measures and electrical safety
- Set-up of power generating systems according to circuit diagrams
- Putting electrical drives into operation
- Achieving skills in measuring electrical machines
- Automatic speed control for an AC servo machine

Topics

- Dynamic response of AC servo drives with block commutation
- Dynamic response of AC servo drives with sinusoidal commutation
- Investigation of angular acceleration as a function of the maximum current
- Closed-loop position control with or without secondary current and speed controllers
- Investigation of the time needed for position and of overshoot as a function of speed and maximum current as well as ramp time
- Investigation of tracking (delay) errors
- Direct and indirect servo position control using a linear unit
- Direct servo position control via external analog position controller and potentiometric angle sensor
- Simulation of a work process
- Comparison of AC servo drives with block and sinusoidal commutation

The PID digital controller Net (734 064N) can be incorporated into a network. The basic software *LEYLAB.control Lite* or the full version *LEYLAB.control* (725 006) is needed to operate the equipment. An optional non-networkable version is also available.

INDIVIDUAL COMPONENTS

IN NUMERICAL ORDER

On the following pages you will find all individual components in numerical order of the catalogue numbers.

Digital hand-held tachometer

For contact-type measurements, battery operated, built-in memory function.

Technical data:

- Range: 1 to 25,000 rpm
- Accuracy: ±1 rpm
- Display: 5 digits, large 7-segment LCD
- Dimensions: 133 mm x 74 mm x 32 mm
- Weight: 200 g including batteries

Scope of delivery:

Complete with carrying case, 3 batteries, 2 conical adapters and 1 funnel-shaped, 1 measurement disc for the measurement of circumferential velocity, 0.1 m.

313 20	Digital hand-held speedometer

Plug-in axles, set of 2

Designed to act as the fulcrum about which a lever can rotate (340 831).

Technical data:

- Diameter of axle: 4 mm
- Diameter of plug pin: 4 mm
- Total length: 5.5 cm

340 811ET2	Plug-in axles, set of 2

Rubber rings, set of 50

Circumference (loose): 30 cm each

340 900	Rubber rings, set of 50

Pulley 100 mm Ø, plug-in, pair, set of 2

With cord groove, friction bearing, axial plug-in pin and socket. Plug and socket diameter: 4 mm each

Technical data:

- Effective pulley diameter: 100 mm
- Sockets on pulley disc: 4 in 25 mm

340 921ET2	Pulley 100 mm Ø, plug-in, pair, set of 2

Necessary for block and tackle:

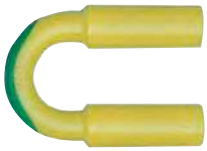
1	Set of 2 pulleys, 50 mm		340 911ET2
1	Set of 2 pulleys, 100 mm		340 921ET2
1	Set of 2 pulley blocks		340 930ET2
1	1 Load hook	from	340 87ET2
1	1 Support clip, plug-in	from	314 04ET5
1	1 Demonstration line		309 50

Candles, set of 20

Technical data:

- Length: 15.5 cm
- Diameter: 1.2 cm

459 32	Candles, set of 20



Bridging plugs

Cat.-No.	Designation
500 59	Safety bridging plugs, black, set of 10
500 591	Safety bridging plugs, yellow/green, set of 10
500 592	Safety bridging plugs with tap, black, set of 10
501 48	Bridging plugs, STE 2/19, set of 10

Connecting leads

Cat.-No.	Designation
500 621	Safety connecting lead, 50 cm, red
500 622	Safety connecting lead, 50 cm, blue
500 641	Safety connecting lead, 100 cm, red
500 644	Safety connecting lead, 100 cm, black
500 851	Safety connecting leads, 32 A, set of 32
500 852	Safety connecting leads, 32 A, yellow/green, set of 10
501 44	Connecting leads, 19 A, 25 cm, red/blue, pair
501 441	Connecting lead, 19 A, 25 cm, black, pair
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair

BNC cable, 1 m

Technical data:

- Plugs: BNC/BNC
- Impedance: 50 Ω

501 02	BNC cable, 1 m

Connecting leads, 19 A, set of 30

For extra-low voltage circuits. Copper wire, equipped at both ends with a plug and fully insulated axial socket for connecting further cables, with tension relief.

Technical data:

- Plugs and sockets: 4 mm diameter (nickel coated)
- Conductor cross section: 1.0 mm²
- Continuous current: 19 A max.
- Contact resistance: 1.8 mΩ

Scope of delivery:

Count	Cat.-No.	Name
3	500 411	Connecting lead, 19 A, 25 cm, red
3	500 412	Connecting lead, 19 A, 25 cm, blue
6	500 414	Connecting lead, 19 A, 25 cm, black
4	500 421	Connecting lead 19 A, 50 cm, red
4	500 422	Connecting lead 19 A, 50 cm, blue
4	500 424	Connecting lead 19 A, 50 cm, black
2	500 441	Connecting lead 19 A, 100 cm, red
2	500 442	Connecting lead 19 A, 100 cm, blue
2	500 444	Connecting lead 19 A, 100 cm, black

501 532	Connecting leads, 19 A, set of 30

Light

Cat.-No.	Designation
505 07	Bulbs, 4 V/0.16 W, E10, set of 10
505 08	Bulbs, 12 V/3 W, E10, set of 10
505 11	Bulbs, 2.5 V/0.25 W, E10, set of 10
505 171	Bulbs, 6 V/1.1 W, E10, set of 10
505 191	Bulbs, 15 V/2 W, E10, set of 5

Bulb, 230 V/40 W, E14

Technical data:

- Voltage: 230 V
- Current: 0.18 A
- Power: 40 W
- Socket: E 14

505 27	Bulb, 230 V/40 W, E14

Magnets, 35 mm Ø, pair

Cylindrical magnets (ferrite) with axial bore and coloured north-pole marking.

Technical data:

- Bore diameter: 6.2 mm
- Poles: colour coded
- Diameter: 35 mm
- Height: 20 mm

510 48	Magnets, 35 mm Ø, pair

AC/DC power supply, 0...12 V/3 A

With variable and regulated output voltage and analog display instrument, additional 4 AC voltage outputs. AC and DC voltage outputs electrically isolated, therefore especially suitable for students and practical experiments.

Technical data:

- Output voltages: 0 - 12 V DC, continuously adjustable
  3, 6, 9, 12 V AC
- Output current: Max. 3 A
- Stabilisation: < 1%
- Residual ripple: 2 mV approx.
- Overload protection, short circuit-proofed by means of multifuses, safe from external voltage
- Primary fuse: T 1
- Connections: 4-mm safety sockets
- Connection voltage: 230 V, 50/60 Hz
- Dimensions: 23 cm x 12 cm x 19 cm
- Weight: 5.2 kg

521 485	AC/DC power supply, 0...12 V/3 A

Function generator S 12

Sine, triangle and square-wave generator, continuous frequency adjustment in six decade ranges, with built-in power amplifier. Ideal for students' experiments because of its small footprint and low-profile design. Safety extra-low voltage power supply.

Technical data:

- Signal waveforms:
- Sinusoidal, triangular, square-wave
- Frequency range: 0.1 Hz to 20 kHz
- Power output for all types of signal (switchable):
  0 to 12 V_{pp} across 8 Ω, continuously adjustable, via 4-mm sockets
- Distortion (sine-wave): < 3% (1 kHz)
- Mark-to-space (square-wave): 1:1
- Rise time (square-wave): 2 µs
- Supply voltage: 12 V AC 50/60 Hz (via power supply unit, included)
- Power consumption: 20 VA
- Dimensions: 6 cm x 12 cm x 7 cm
- Weight: 0.5 kg

522 621	Function generator S 12

Adapter, USB port/serial port

For connecting LD equipment with a serial port to computers with USB ports. Especially tested for ease of operation with CASSY and COM3LAB, including driver CD for Windows and MacOS.

524 004	Adapter, USB port/serial port

Sensor-CASSY 2

Cascadable interface device for recording measurement data

- For connection to the USB port of a computer, another CASSY module or the CASSY display (524 020USB
- Sensor-CASSY (524 010), Sensor-CASSY 2 and Power-CASSY (524 011USB) can be mixed in cascades
- 3-fold electrical isolation (4-mm inputs A and B, relay R)
- Measurement possible simultaneously at 4-mm inputs and sensor box connector sites (4 channels)
- Cascading of up to 8 CASSY modules possible (to expand the inputs and outputs)
- Up to 8 analog inputs can be provided by adding Sensor-CASSY sensor boxes
- Automatic sensor box detection (plug and play) by CASSY Lab 2 (524 220)
- Microprocessor-controlled with CASSY operating system (easily updatable via software for function enhancements)
- For use as a bench-top, console or demonstration unit (also in CPS/TPS panel frames)
- Voltage supply 12 V AC/DC via cannon plug or adjacent CASSY module
- Developer Information and LabVIEW™ driver available through our internet homepage

Technical data:

- **5 analog inputs**
  2 analog voltage inputs A and B on 4-mm safety sockets (electrically isolated)
  Resolution: 12 bits
  Measuring ranges: ±0.1/±0.3/±1/±3/±10/±30/±100/±250 V
  Measurement error: ±1% plus 0.5% of range end value
  Input resistance: 1 MΩ
  Scanning rate: up to 1 MHz per input
  Amount of measured values: nearly unlimited (dependent on PC) up to 10,000 values/s,
  at higher measuring rate max. 200,000 values
  Pre-trigger: up to 50,000 values per input
  1 analog current input A on 4-mm safety sockets (alternatively to voltage input A)
  Measuring ranges: ±0.03/±0.1/±0.3/±1/±3 A
  Measurement error: voltage error plus 1%
  Input resistance: < 0.5 Ω

Scanning rate: up to 1 MHz per input
See voltage inputs for further data
2 analog inputs at sensor box connector sites A and B
(All CASSY sensor boxes and sensors can be connected)
Measuring ranges: ±0.003/±0.01/±0.03/±0.1/±0.3/±1 V
Input resistance: 10 kΩ
Scanning rate: up to 500 kHz per input
See voltage inputs for further data
The technical data will change depending on a connected sensor box. In this case CASSY Lab 2 automatically detects the possible measurement quantities and ranges when a sensor box is attached.

- **4 timer inputs** with 32-bit counters at sensor box sites A and B (e.g. for GM box, timer box or Timer S)
  Counting frequency: max. 1 MHz
  Time resolution: 20 ns
- **5 LED status indicators** for analog inputs and USB-port
  Colours: red and green, according to status
  Light intensity: adjustable
- **1 change-over relay** (switching indication via LED)
  Range: max. 250 V/2 A
- **1 analog output** (LED switching state indicator, e.g. for holding magnet or supplying experiment)
  Variable voltage range: max. 16 V/200 mA (load ≥ 80Ω)
- **12 digital inputs** (TTL) on sensor box sites A and B (at present only used for automatic sensor box detection)
- **6 digital outputs** (TTL) on sensor box sites A and B (at present only used for automatic switching of a sensor box measuring range)
- **1 USB port** for connection to a computer
- **1 CASSY bus** for connecting additional CASSY modules
- Dimensions (WxHxD): 115 mm x 295 mm x 45 mm
- Weight: 1.0 kg

Scope of delivery:

- Sensor-CASSY 2
- CASSY Lab 2 software, without activation code, with comprehensive help function (16 full-functionality sessions free, then usable as demo version)
- USB cable
- Plug-in supply unit 230 V, 12 V/1.6 A

524 013	Sensor-CASSY 2

Sensor-CASSY 2 Starter

Voltage and current input are already integrated into the Sensor-CASSY module. Therefore following experiments can be implemented **without additional sensors**:

- Voltage and current measurement
- Ohm's law
- Electric oscillations
- Characteristic curves
- AC circuit
- Active power

Scope of delivery:

Count	Cat.-No.	Name
1	524 013	Sensor-CASSY 2
1	524 220	CASSY Lab 2

524 013S	Sensor-CASSY 2 Starter

Profi-CASSY Starter 2

The Profi-CASSY starter package is intended for unlimited experimentation. It consists of a Profi-CASSY module with interface (524 016), plus CASSY Lab 2 software (524 220).

Technical data:

- **16 digital inputs I0 to I15**
  - (5 V or 24 V logic)
  - Sampling rate: max. 100 values/s
- **16 digital outputs, Q0 to Q15**
  (5 V or 24 V logic)
  Output current: 10 mA with internal 5 V power supply, 500 mA via external power supply of up to 30 V
  - Total current: 2 A
  The digital inputs/outputs are each equipped with 10-pin plugs for direct connection to automation equipment. Also 8 inputs and 8 outputs are additionally equipped with 2-mm sockets and status LEDs
- **2 analog voltage inputs, A and B**
  4-mm safety sockets
  Resolution: 12 bits
  Amplitude: ±10 V
  Measuring error: ±1% plus 0.5% from the end value of range
  Input resistance: 1 MΩ
  Sampling rate: max. 10,000 values/s
- **2 analog outputs, X and Y**
  4-mm safety sockets
  Amplitude: ± 10 V
  Output current: max. 100 mA per Output
  Resolution: 12 bits, measuring error: ±1% plus 0.5% from the end value of range
  - Sampling rate: 10,000 values/s
- **1 PROFIBUS connection**
  9-pin DSUB socket
  Passive user (slave) on fieldbus
  PROFIBUS-DP
  Address adjustable via software with 16 digital inputs/outputs
  Transmission rate up to max. 3 Mbits/s
- **USB port**
  for connection to PC
- **1 CASSY-Bus module**
  or connection to Sensor- or Power-CASSY modules
- **Dimensions** (BxHxT): 115 mm x 295 mm x 45 mm
- **Weight:** 1 kg

Scope of delivery:

- 1 Profi-CASSY module
- CASSY Lab software with enable code for Windows XP/Vista/7/8 (32+64 bit) and extensive help
- 1 Installation guide
- 1 USB cable
- 1 power adapter 230/12 V/1.6 A
- 1 GSD file for simple parameter settings

524 016S2	Profi-CASSY Starter 2

Multimeter LDanalog 20

High overload-capacity measuring instrument with integrated protection against damage due to improper handling, specially designed for student's and practical experiments. The moving coil instrument is protected against damage with two diodes connected in opposing directions. Automatic battery cut-out after approx. 45 min.

Technical data:

- DC voltage ranges: 0.1 ... 300 V (8 ranges)
- AC voltage ranges: 3 ... 300 V (5 ranges)
- DC current ranges: 0.1 mA to 3 A (6 ranges)
- AC current ranges: 0.1 mA to 3 A (5 ranges)
- Internal resistance: 10 MΩ/V (=)/6.67 kΩ/V (~)
- Accuracy: class 2/3~
- Zero point: left/centre (switchable)
- Mirror scale: yes
- Batteries (included): 9 V, 6 x F22 (685 45ET5)
- Overload capacity/fuses: F 3.15 A/300 V fuses
- Dimensions: 10 cm x 14 cm x 3.5 cm
- Weight: 270 g

531 120	Multimeter LDanalog 20

Digital multimeter DMM120

Compact multimeter with large-format 3 ¾ digit display, automatic or manual range selection, backlit display, automatic display of function symbols and low-battery indication, automatic cut-off, 1 impact-resistant case, 1 set of test leads with probes (red/black).

Technical data:

- 5 DC voltage ranges: 0.1 mV to 600 V
- 5 AC voltage ranges: 0.1 mV to 600 V
- 5 DC current ranges: 0.1 µA to 10 A DC
- 5 AC current ranges: 0.1 µA to 10 A
- Internal resistance: 10 MΩ DC/AC
- 6 resistance ranges: 0.1 Ω to 40 MΩ
- 5 capacitance ranges: 0.01 nF to 100 µF
- 6 frequency ranges: 0.01 Hz to 20 MHz
- Continuity test/diode test
- HOLD measured value memory
- DC voltage accuracy: ±0.5% + 2 digits
- AC voltage accuracy: ±1.0% + 4 digits
- DC current accuracy: ±1.2% + 2 digits
- AC current accuracy: ±1.5% + 4 digits
- Batteries: 2 x 1.5 V, IEC R6
- Overload capacity: 500 V rms
- Fuses: 500 mA/250 V (5x20 mm) and 10 A, HP 600 V
- Vmax CAT II: 600 V
- Dimensions: 16.5 cm x 8.5 cm x 4.0 cm
- Weight: 260 g

531 172	Digital multimeter DMM120

Digital multimeter 3315

Digital multimeter with 3¾-digit CD display (3999 max.), 40 segment bar graph and function symbols.
Special features: USB and RS232 ports, measurement of capacitance, frequency and temperature, diode- and continuity-testing functions plus signal output and buzzer, Data, Min, Max, Rel. functions, auto shut-off (time selectable).
Safety: TÜV/GS, IEC-1010-1; CAT III 1000 V, CAT IV 600 V.

Technical data:

Measuring ranges:

- DC voltage: 400 mV/4/40/400/1000 V, ±0.8% + 1 digit
- AC voltage: 4/40/400/750 V, ±1.0% + 5 digit
- DC vurrent: 400 µA/4/40/400 mA/10 A, ±1% + 2 digit
- AC vurrent: 400 µA/4/40/400 mA/10 A, ±1.5% + 5 digit
- Resistance: 400 Ω/4/40/400 kΩ/4/40 MΩ, ±1% + 2 digits
- Capacity: 4/40/400 nF/4/40/400 µF/4/40 mF; ±4% + 3 digits
- Frequency: 4/40/400 kHz/4/40/400 MHz, ±0.1% + 3 digis
- Temperature: -40 ... +1000°C ±1% + 3 digits
- Dimensions (WxHxD): 100 x 210 x 45 mm
- Weight: 0.33 kg

Scope of delivery:

- Test leads
- testing terminal
- battery
- Type K - Thermocouple
- interface cable USB and RS 232
- software for Windows 95/98/2000/XP/NT
- operating instructions

531 2741	Digital multimeter 3315

Multimeter Metrahit Pro

Special features:

- Automatic socket blocking prevents the measuring leads from being inserted into the wrong sockets.
- Automatic and manual battery cut-off
- Safety warning for fuse triggering and overload
- Automatic and manual range selection
- True root mean square measurement: TRMS
- Digital display: 65 mm x 36 mm
  4 ½ digits ±12000 maximum readings
- Automatic scaling of analog display
- Electromagnetically compatible design (EMC)
- Set of safety leads

Technical data:

- DC voltage ranges: 100 mV ...1000 V
- AC voltage ranges: 100 mV...1000 V
- DC current ranges: 1 A ... 10 A
- AC current ranges: 1 A ... 10 A
- Resistance measuring ranges: 100 Ω ...40 MΩ
- Frequency: 100 Hz ... 30 kHz
- Temperature: -250 ... +1372°C
- Resolution: 10 µV; 100 µA; 10 mW; 0.01 Hz; 0.1°C
- Continuity/diode test: yes
- TRMS: AC and AC+DC, 10 kHz
- Inherent discrepancy in DC voltage: 0.05% of measured value/±3 digits
- Batteries (included): 2 x AA IEC LR6
- Overload capability:
  Voltage ranges: 1000 V
  Current: 10 A
- Fuses FF (UR) 10A/1000 V AC/DC
- Dimensions 87 mm x 200 mm x 45 mm
- Weight: approx. 400 g

531 282	Multimeter Metrahit Pro

Multimeter METRAport 3A

Multimeter with high overload capacity and special built-in protection against damage resulting from incorrect use; with integrated measuring amplifier for accurate measurements. Control and display fields are each located in different halves of the hinged housing. Closing the housing automatically switches off the battery. The user can tilt the hinged meter display to achieve the optimum viewing angle.

Technical data:

- DC voltage ranges: 0.1 V to 1000 V (9 ranges)
- AC voltage ranges: 0.1 V to 1000 V (9 ranges)
- DC current ranges: 10 µA to 10 A (7 ranges)
- AC current ranges: 10 µA to 10 A (7 ranges)
- Resistance ranges: 1 Ω to 20 MΩ (5 ranges)
- Other measuring ranges: Level (dB scale)
- Internal resistance: 10 MΩ (const.)
- Accuracy: class > 1.5 DC , class 2.5 AC
- Zero point: left
- Mirror scale
- Battery (included): 9 V/IEC 6 F 22 (685 45)
- Overload capacity: all ranges up to 250 V
- Fuses: FF 1.6 G/250 V
- Dimensions: 14.6 cm x 11.8 cm x 4.4 cm
- Weight: 450 g

531 57	Multimeter METRAport 3A

Insulation tester Metriso C

Battery operated insulation tester as per VDE 0413, Part 1, for testing equipment and systems up to 500 V voltage rating.

Technical data:

Measurement ranges:

- Insulating resistance:
  - 0..500 kΩ
  - 0.4..20 MΩ
- Resistance: 0...1000 Ω (V_0 370 V DC approx.) with audible signal
- Voltage: 0...500 V AC/DC
- For insulation testing:
  Voltage rating: 500 V
  Current rating: 1.06 mA
  Open-circuit voltage: 700 V DC approx.
- Accuracy:
  Insulation resistance: class 1.5 as per DIN 43 780 or ±30% of reading as per VDE 0413
  Resistance: class 2.5
  Voltage: class 2.5
- Overload-protected in all ranges
- Power supply: 4 x mignon (AA) cell, 1.5 V, IEC R6

531 600	Insulation tester Metriso C

Batteries not included

Rheostat, 100 ohms

Resistance wires wound on a special cement core, perforated cover for touch protection, electrical connections via three safety sockets allowing applications as fixed resistor, variable resistor and potentiometer.

Technical data:

- Connection: 4-mm safety sockets
- Resistance: 100 Ω
- Resistor tolerance: 10%
- Max. load:
  Current (sustained): 1.8 A
  $Current_{max}$ (15 mins.): 2.5 A
- Dimensions: 450 x 95 x 150 mm

537 34	Rheostat, 100 ohms

Rheostat, 330 ohms

Resistance wires wound on a special cement core, perforated cover for touch protection, electrical connections via three safety sockets allowing applications as fixed resistor, variable resistor and potentiometer.

Technical data:

- Connection: 4-mm safety sockets
- Resistance: 330 Ω
- Resistor tolerance: 10%
- Max. load:
  Current (sustained): 1.0 A
  $Current_{max}$ (15 mins.): 1.4 A
- Dimensions: 450 x 95 x 150 mm

537 35	Rheostat, 330 ohms

Resistance wires

To examine the dependence of electric resistances on material, length and cross section of the wire used.

Cat.-No.	Diameter	Length	Cross section	Specific resistor	Material
550 35	0,2 mm	100 m	0,03 mm²	0,6 Ω/m	Copper
550 39	0,5 mm	50 m	0,2 mm²	0,4 Ω/m	Brass
550 40	0,2 mm	100 m	0,03 mm²	15,4 Ω/m	Constantan
550 41	0,25 mm	100 m	0,05 mm²	10,4 Ω/m	Constantan
550 361	0,3 mm	100 m	0,07 mm²	7,7 Ω/m	Constantan
550 42	0,35 mm	100 m	0,1 mm²	5 Ω/m	Constantan
550 43	0,4 mm	50 m	0,12 mm²	4 Ω/m	Constantan
550 44	0,5 mm	50 m	0,2 mm²	2,5 Ω/m	Constantan
550 443	0,7 mm	20 m	0,4 mm²	1,3 Ω/m	Constantan
550 445	1 mm	20 m	0,8 mm²	0,6 Ω/m	Constantan
550 45	0,2 mm	100 m	0,03 mm²	34,5 Ω/m	Chrome-nickel
550 46	0,25 mm	100 m	0,05 mm²	21,3 Ω/m	Chrome-nickel
550 47	0,35 mm	100 m	0,1 mm²	11 Ω/m	Chrome-nickel
550 48	0,4 mm	50 m	0,12 mm²	8,2 Ω/m	Chrome-nickel
550 49	0,5 mm	50 m	0,2 mm²	5,4 Ω/m	Chrome-nickel
550 51	0,2 mm	100 m	0,03 mm²	3,3 Ω/m	Iron

Plug-in power supply, 12 V AC

Universal plug-in power supply, e.g. for CASSY, counter S, counter P, electrometer amplifier etc.

Technical data:

- Primary: 230 V AC, 50/60 Hz
- Secondary: 12 V AC, 20 VA
- Connection: co-axial power connector

562 791	Plug-in power supply, 12 V AC

Storage tray for ELM apparatus

Specially moulded for apparatus.

Technical data:

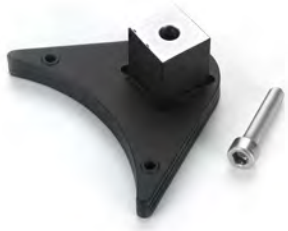
- Dimensions: 55 cm x 28.5 cm x 5 cm

563 04	Storage tray for ELM apparatus

ELM pole piece for magnets

With ground, magnetic contact surface and recessed borehole for attachment. Complete with hexagon socket (M6 x 35).

563 091	ELM pole piece for magnets



ELM wide pole piece for coils

For two- and three-pole stator assemblies

563 101	ELM wide pole piece for coils

ELM coil, 250 turns

Technical data:

- Number of turns: 250
- Resistance: 1.8 Ω
- Impedance: 6.7 Ω (at 50 Hz)
- Max. current: 1.5 A

563 11	ELM coil, 250 turns

ELM coil, 500 turns

For use with pole pieces.

Technical data:

- Current: 0.7 A
- Connection: 4-mm sockets
- Dimensions: 50 mm x 60 mm x 20 mm

563 115	ELM coil, 500 turns

ELM squirrel-cage rotor

Technical squirrel-cage rotor of disc design with pulley, rotor: 90 mm diameter.

563 12	ELM squirrel-cage rotor

ELM brush

Hard carbon contact with press-on spring, cable and 4-mm plug, for connecting to the commutator and slip rings of the coil rotors.

Technical data:

- Max. current: 1.5 A

563 13	ELM brush

Allen key

For fastening the pole piece with a magnet or a coil to a base plate.

563 16	Allen key

ELM centring disc

For optimising the distance between the pole pieces and rotors.

563 17	ELM centring disc

ELM brush holder rack

For securing the rotor on the axle of a base plate, for 5 brushes. Complete with retaining screw.

563 18	ELM brush holder rack

ELM narrow pole piece for coils

With spigot, for use with coils.

Technical data:

- Allen screw, M6 x 35
- Dimensions: 42 mm x 52 mm x 30 mm

563 201	ELM narrow pole piece for coils

ELM split pole piece for coils

With spigot, for use with coils.

Technical data:

- Allen screw, M6 x 35
- Dimensions: 83 mm x 60 mm x 30 mm

563 211	ELM split pole piece for coils

ELM two-pole rotor

Coil rotor on iron cores consisting of packed laminated sheets to eliminate eddy currents, with a pivot bearing, pulley and cable drum.

Technical data:

- Number of turns: 2 x 380
- Ohmic resistance: 1.3 Ω
- Impedance: 5.9 Ω
- Max. current: 1.5 A
- Commutator: two-pole
- Slip rings: 2 (180°)

563 22	ELM two-pole rotor

ELM three-pole rotor

Coil rotor on iron cores consisting of core sheet sections free of eddy currents, with a pivot bearing, pulley and cable drum

Technical data:

- Number of turns: 3 x 340
- Resistance: 1.6 Ω
- Impedance: 7 Ω
- Max. current: 1.5 A
- Commutator: three-pole
- Slip rings: 3 (120°)

563 23	ELM three-pole rotor

ELM drum rotor

12 T armature with belt disc.

Technical data:

- Number of turns: 12 x 90
- Current: max. 1.5 A
- Speed: max. 5000 rpm
- Rotor: 90 mm diam.

563 24	ELM drum rotor

ELM rotating field attachment and squirrel cage ring

With two threaded bores for attaching magnets and pole pieces for generating a rotating magnetic field. The squirrel cage ring can be plugged into the collectors of the coil rotors to make them act as squirrel cage rotors.

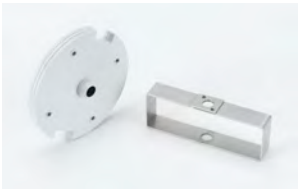
563 25	ELM rotating field attachment and squirrel cage ring

ELM magnetic needle rotor

Magnetic needle with pivot bearing, for demonstrating slowly rotating fields.

563 28	ELM magnetic needle rotor

ELM aluminium ring with iron disc



Rectangular frame made of aluminium with matching iron disc. Model of a short-circuit rotor; D = 90 mm.

563 29	ELM aluminium ring with iron disc

Oil, 100 ml, in dropping bottle

Acid-free machine oil.

563 31	Oil, 100 ml, in dropping bottle

Two-channel oscilloscope 400

Particularly suitable for demonstration and practical experiments. Includes instruction manual. Probes not included.

Technical data:

- Bandwidth: 0...40 MHz (-3 dB)
- Input impedance: 1 MΩ, 15 pF, max. 400 V
- Screen: 8 x 10 cm with internal graticule
- Vertical deflection: 1 mV/cm...20 V/cm (14 steps)
- Time bases: 100 ms/div...0.2 s/div with X-axis magnification x10 to 10 ns/division
- Trigger sources: Ch1, Ch2, line, ext.
- Operating modes: Ch1, Ch2, Ch1+Ch2 (alternate or chopped), Ch1/Ch2 sum or difference
- XY mode
- Built-in component tester
- Dimensions (WxHxD): 28.5 x 12.5 x 38.0 cm
- Mains supply: 105...253 V, 50/60 Hz ±10%, Cat II

575 212	Two-channel oscilloscope 400

Probe 100 MHz, 1:1 / 10:1

For measurements on high-impedance voltage sources in conjunction with oscilloscopes, frequency-compensated. Range selection by switch. Including a spring-loaded hook, trimmer key, BNC adapter, probe tip, insulating cover for the probe tip or for IC measurements, 4-mm adapter, ground lead.

Technical data:

- Input resistance: 1 MΩ and 10 MΩ (at 10 MΩ oscilloscope input)
- Bandwidth: 10 MHz or 100 MHz
- Input voltage: 600 V DC including AC peak
- Connection: BNC plug
- Lead length: 1.2 m
- Ground lead length: 30 cm

575 231	Probe 100 MHz, 1:1 / 10:1

Digital storage oscilloscope 722

Technical data:

- Bandwidth: 0...70 MHz (-3 dB)
- Input impedance: 1 MΩ, 14 pF, max. 200 V
- Display: 16.5 cm, VGA Colour TFT
- Storage operation modes: refresh, average, envelope, peak-detect, roll (unsolicited/triggered), filter, HiRes
- Cursor measurement: ΔV, Δt, Δf , peak-to-peak, mean value, RMS value, etc.
- Dual interface USB B/RS232, 2 x USB A
- Vertical sensitivity: 1 mV/div...10 V/div (1 - 2 - 5 progression)
- DC amplification accuracy: 2%
- Time base: 2 ns/div...50 s/div
- Accuracy: 50 ppm
- Trigger operating mode: flank, video, pulse length, logic, delayed, event
- Trigger source: CH1, Ch2, CH1 and Ch2 alternate, line and external
- Component tester
- Mains supply: 100...240 V, 50...60 Hz, Cat. II
- Protection class I (EN61010-1)
- Dimensions: 28.5 cm x 17.5 cm x 14.0 cm
- Weight: < 2.5 kg
- Without probes

575 230	Digital storage oscilloscope 722

Plug-in board, DIN A4, STE

For assembling electric and electronic experiment circuits for students' and training experiments. The experimenting surface has sufficient capacity for transistor circuits with up to three stages consisting of small plug-in elements in 2/19, 2/50 and 4/50 formats. Also suitable for extending the base and work panels for the electric machine teaching models.

Technical data:

- 24 socket grids
- Front equipped with 24 conductor intersections and 120 sockets
- Rear equipped with 24 conducting squares and 216 sockets
- Dimensions: 30 cm x 20 cm x 2.4 cm

576 74	Plug-in board, DIN A4, STE

Resistor, 4.7 kΩ, STE 2/19

Technical data:

- Load capacity: 2 W
- Tolerance: 5%

577 52	Resistor, 4.7 kΩ, STE 2/19

Resistor, 39 kΩ, STE 2/19

Technical data:

- Load capacity: 0.5 W
- Tolerance: 1%

577 62	Resistor, 39 kΩ, STE 2/19

Capacitor, 4.7 µF, STE 2/19

Technical data:

- Max. allowable voltage: 63 V
- Tolerance: 5%

578 16	Capacitor, 4.7 µF, STE 2/19

Capacitor (electrolytic), 100 µF, STE 2/19

Technical data:

- Max. allowable voltage: 40 V
- Tolerance: 20%

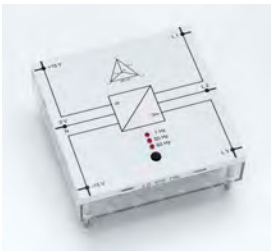
578 39	Capacitor (electrolytic), 100 µF, STE 2/19

Capacitor (electrolytic), 470 µF, STE 2/19

Technical data:

- Max. allowable voltage: 16 V
- Tolerance: 20%

578 40	Capacitor (electrolytic), 470 µF, STE 2/19



Three-phase voltage supply, 3×12 V, STE 6/100

Plug-in element for generation of a three-phase, alternating sinusoidal voltage.

Technical data:

- Input voltage: ±15 V DC or 12 V AC
- Output frequency: 1, 50 or 60 Hz
- Output voltage: 3×12 V Δ
- Output current: 3×0.2 A

578 795	Three-phase voltage supply, 3×12 V, STE 6/100

Lamp holder, E10, top, STE 2/19

Lamp holder with an E 10 screw thread. The lamp is screwed on and placed at the side for the direct, lateral illumination of opto-receivers like photoresistors, photodiodes and photoelements.

579 06	Lamp holder, E10, top, STE 2/19

Push button (NO), STE 2/19

Mechanical push button with 2 positions.

Technical data:

- Switching functions: ON-OFF

579 10	Push button (NO), STE 2/19

Toggle switch, STE 2/19

Mechanical switch with 2 positions.

Technical data:

- Switching functions: ON-OFF

579 13	Toggle switch, STE 2/19

Advanced Science Kit – Set BEL

15 pieces of basic equipment for one working group to do experiments on electricity and electronics, in pre-formed storage tray.

Scope of delivery:

Count	Cat.-No.	Name
2 out of	340 89ET5	Coupling plugs, 4 mm, set of 5
1	501 48	Bridging plugs, STE 2/19, set of 10
2 out of	501 861	Crocodile-clips, polished, set of 6
1	576 74	Plug-in board, DIN A4, STE
1	576 77	Board holders, STE, pair
2	576 86	Monocell holder STE 2/50
1	577 28	Resistor, 47 Ω, STE 2/19
2	577 32	Resistor, 100 Ω, STE 2/19
2	579 05	Lamp holder, E10, lateral, STE 2/19
1	579 13	Toggle switch, STE 2/19

588 871S	Advanced Science Kit - Set BEL

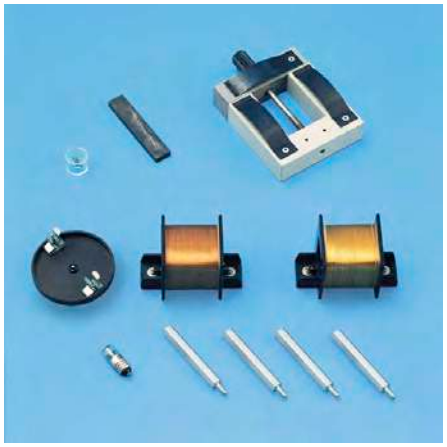
Advanced Science Kit – Set ELI 1

8 pieces of supplementary equipment for one working group to do experiments on optics using a ray box. To be stored in the tray for set S24-FN (648 07).

Scope of delivery:

Count	Cat.-No.	Name
1	567 06	Conductors/insulators, set of 6
1	567 18	Wrapping plate for wires
2	579 331	Plug-in holder, STE
1 out of	579 332ET	Leaf spring with contact strip and bimetallic strip
2	582 81	Change-over switch, STE 4/50

588 875S	Advanced Science Kit - Set ELI 1



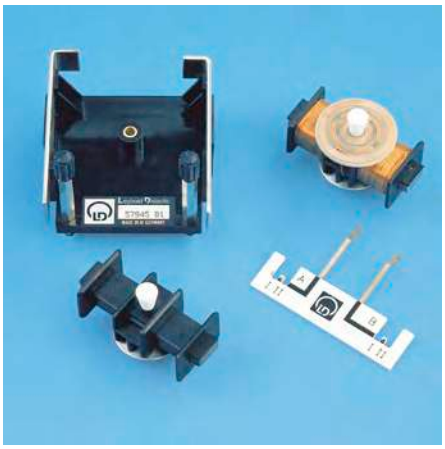
Advanced Science Kit – Set ELI 2

8 pieces of supplementary equipment for one working group to do experiments on electromagnetism and induction. To be stored in the tray for electricity set 1 (588 871S).

Scope of delivery:

Count	Cat.-No.	Name
1 out of	505 36ET10	Glow lamps, 115 V, E10, set of 10
1 out of	510 50ET2	Bar magnets, 60 x 13 x 5 mm, set of 2
1	510 51	Rotary support
1 out of	510 53	Plotting compasses, pair
1 out of	510 54ET2	Magnetisable rods, set of 8
1	590 83	Coil, 500 turns, STE 2/50
1	590 84	Coil, 1000 turns, STE 2/50
1	593 21	Transformer core kit

588 876S	Advanced Science Kit - Set ELI 2



Advanced Science Kit – Set ELI 3

4 pieces of supplementary equipment for one working group to do experiments on motors and generators. To be stored in the tray for electricity set 1 (588 871S).

Scope of delivery:

Count	Cat.-No.	Name
1	579 45	Stator, STE 4/50
1	579 46	Coil rotor, STE
1	579 47	Brush yoke, STE
1	579 48	Magneto inductor, STE

588 877S	Advanced Science Kit - Set ELI 3

Scissors, 125 mm, round-ended

Rounded ends.

Technical data:

- Length: 125 mm

667 017	Scissors, 125 mm, round-ended

Batteries, 1.5 V (AA), set of 4

Technical data:

- Voltage: 1.5 V
- Battery type: IEC R6
- Dimensions: 50 mm x 14 mm diameter

685 44ET4	Batteries, 1.5 V (AA), set of 4

Batteries 1.5 V (D, mono), set of 5

Lengths include pole terminals.

Technical data:

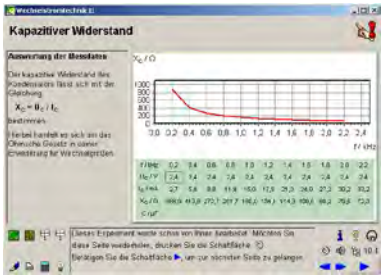
- Voltage: 1.5 V
- Battery type: IEC R20
- Dimensions: 60 mm x 33 mm diameter

685 48ET5	Batteries 1.5 V (D, mono), set of 5

USB cable, 3 m

689 0605	USB cable, 3 m

COM3LAB software



Cat.-No.	Designation
700 00CBTDE	CD: COM3LAB software, German
700 00CBTEN	CD: COM3LAB software, English
700 00CBTFR	CD: COM3LAB software, French
700 00CBTIT	CD: COM3LAB software, Italian
700 00CBTPT	CD: COM3LAB software, Portuguese
700 00CBTRU	CD: COM3LAB software, Russian
700 00CBTSP	CD: COM3LAB software, Spanish

COM3LAB master unit (USB)

For the mounting and supply of power to the COM3LAB multimedia experiment boards. The master unit is connected to the USB Port of a personal computer for the recording of measurements and for remote control of its built-in functions. All the necessary instruments (multimeters, oscilloscope, function generator and digital analyser are built-into the master unit. The master unit itself can be assembled and disassembled quickly. The handy lid protects the master unit and makes it stackable.

Technical data:

- Dimensions: 380 x 282 x 65 mm (L x W x H)

Integrated measuring instruments and functions:

- Two digital multimeters:
  Voltage: AC/DC 2/20 V
  Current: AC/DC 0.2/2 A
  Resistance: 2/20/200 kΩ, 2 MΩ
  Auto-ranging for all measurement ranges
  Single button operation
  Liquid crystal display, 3.5 digits with special characters
- Digital function generator:
  Digitally generated signal types
  Sinusoidal, square-wave, triangular, DC
  0.5 Hz...100 kHz
  Max. ±10 V, max. 250 mA
  Operation via two push buttons and incremental indicator
  Liquid crystal display, 4-digit with special characters

The following devices have no display of their own and are operated remotely by the connected PC and through the training programs. The measured values are displayed on the PC monitor.

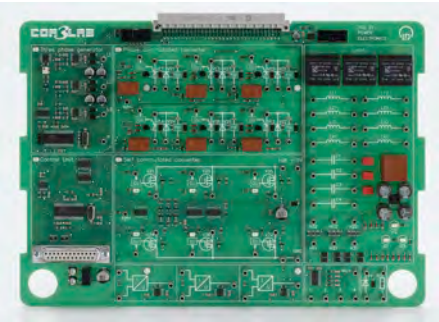
- Digital storage oscilloscope:
  Two differential voltage inputs with 8-bit A/D converter
  Measuring ranges: 20/50/100/200/500 mV, 1/2/5 V per division
  Sampling frequency: 200 Hz to 1 MHz
  Digital trigger with pre- and post-function
- Digital analyser:
  Three digital inputs, TTL compatible
  Sampling frequency: 200 Hz to 1 MHz, up to 4 MHz with limited trigger resolution
  Triggering from any combination of input states
  Memory depth 2048 9-bit words

Oscilloscope and analyser can be used in alternation. All of the measuring equipment and function generator are connectable via 2-mm sockets.
USB port included for connection to PC.

Scope of delivery:

- 1 USB cable
- 1 Set of leads consisting of :
  Connecting leads of 40 cm and 5 cm length equipped with 2-mm plugs
- 1 Table-top power supply, 100...250 V, 50...60 Hz, with mains lead and earth-contact plug for supply of power to the master unit

700 00USB	COM3LAB master unit (USB)



COM3LAB course: Power electronics I

Course on line-commutated and self-commutated static converter circuits, consisting of an experiment board with various circuits for mounting into the master unit and a multimedia CD with interactive training software.

Topics:

- Introduction
- Semiconductors in power electronics
- Wiring and triggering
- Switching processes and commutation
- Uncontrolled rectifier circuits
- Parameters for periodic signals Controlled line-commutated static converters
- M1C circuit
- M3C-circuit
- B2C circuit
- B6C semi-controlled rectifiers

Virtual lab:

- Oscilloscope
- Function generator
- Multimeters (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

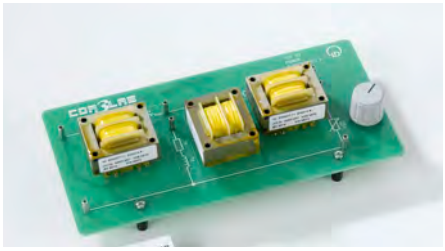
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Scope of delivery:

- Set of cables consisting of 40 cm and 5 cm long connecting leads with 2-mm plugs

700 21	COM3LAB course: Power electronics I

- Operating system: Windows 2000/XP/Vista/7



COM3LAB course: Power electronics II

Supplementary course on power inverters, DC choppers, static converters and drive technology, consisting of a dongle for the PE I experiment board and a multimedia CD with interactive training software.

Topics:

- Self-commutated static converters (power inverters)
- Semiconductor switches and controllers (bidirectional static converters)
- Switches and controller for DC
- Converters
- Static converters in automatic control technology
- Static converters in drive technology

Virtual lab:

- Oscilloscope
- Function generator
- Multimeters (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

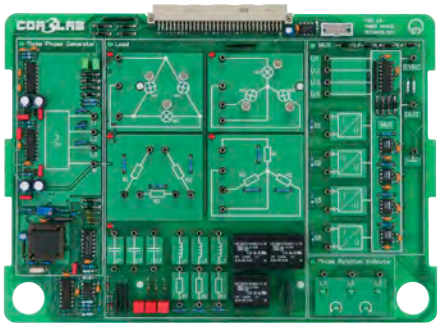
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

700 22	COM3LAB course: Power electronics II

Additionally required:

Count	Cat.-No.	Name
1	700 21	COM3LAB course: Power electronics I
1		PC with Windows XP/Vista/7

COM3LAB course: Three-phase technology



This COM3LAB course investigates the behaviour of three-phase systems. Practical exercises show the generation of the rotary field or the function of a transformer. Furthermore, passive components in different circuits are discussed. Coils, capacitors and resistors are analysed and evaluated in different circuits.

Topics:

- Characteristics of a three-phase system
- Representation of line diagrams and phase relationships
- Star-delta circuits with different loads
- Measurement of phase and line voltage/current
- Resistive loads
- Capacitive loads
- Symmetrical and unsymmetrical charges
- Measurement of power in the three-phase system

Virtual lab:

- Spectrum analyser (FFT module)
- Frequency counter
- Multimeters (2x)
- Function generator
- Digital storage oscilloscope

Additional functions:

- Web-based training
- You can write yout own pages and experiments
- Access to external programs (as for example Excel, Word).
- Subsequent processing of measured data using external programs (as for example Excel, Word).
- You can produce your own documents.
- The software contains a text editor and allows for free experimentation.

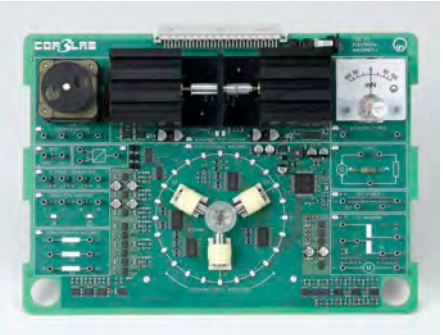
Technical data:

- Star circuit with resistors
- Delta circuit with resistors
- Capacitors
- Load resistors

700 24	COM3LAB course: Three-phase technology

- Prerequisites: Fundamentals of AC technology

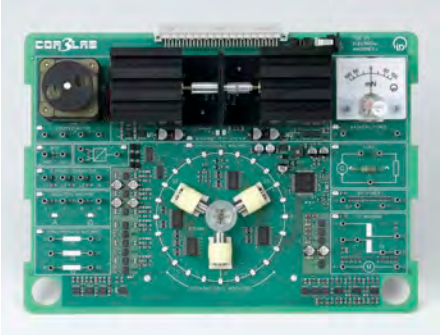
COM3LAB course: Electrical machines I



Course concerning the connection methods and the recording of characteristics for electric motors and generators. With the integrated machine test system, a multitude of experiments can be carried out, e.g. the recording of torque, power and current-locus curves.

Topics:

- Forces in a magnetic field
- Measurement of Lorentz force
- Drives
- Torque-speed characteristic
- Machine test system
- DC machines
- Speed and induced voltage with DC machines
- Torque and armature voltage with DC machines
- Torque and excitation voltage with DC machines
- DC machines with external excitation
- Reversible of direction
- Characteristics with variable armature voltage
- Characteristics with variable excitation voltage
- Shunt-wound DC machines
- Characteristics with variable operating voltage
- Series-wound DC machines
- Reversal of direction with DC machines
- Characteristics with variable operating voltage
- Generator operation of DC machines
- Drive and generator with a resistive load
- Power output of generator
- Rotating field (three-phase) machines
- Three-phase windings
- Rotating fields
- Direction of rotation with periodic swapping of phase conductors



- Direction of rotation when phase conductors are swapped
- Voltage and current in star (Y) circuits
- Voltage and current in delta circuits
- Resistance in stator winding
- Reactance of an AC winding
- Synchronous machines
- Equivalent circuit diagram for synchronous machines and how they are used
- Permanently excited synchronous machines
- Step operation of synchronous machines
- Determining rotor position in star configuration
- Determining rotor position in delta configuration
- Synchronous machine at variable speed (run-up)
- Speed measurement
- Speed setting using frequency converter
- Asynchronous machines
- Block and equivalent circuit diagrams for asynchronous machines
- Determination of slip
- Star-delta starting
- Measurement of torque and line currents during run-up
- Changing direction of asynchronous machines
- Recording of torque-speed characteristic for asynchronous machines
- Three-phase drives
- CHanging speed of asynchronous machines
- How speed depends on slip
- How speed depends on stato rfrequency
- Stepper motors
- Full-step operation
- Half-step operation
- Changing the direction of a stepper motor

Virtual lab:

- Multi-channel oscilloscope
- Oscilloscope
- Function generator
- Multimeter (2x)
- Digital analyser

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical data:

- Synchronous machine with optical rotary field indicator and strobe for speed determination
- Induction motor with star-delta switch
- Optical tachogenerator
- DC motor
- DC generator
- Current-torque converter
- Thermometer
- Electronic load
- Three phase generator, phase voltage: 0 V. .. 10 V,
- Frequency converter, Frequency: 1 Hz - 80 Hz
- DC supplies
- Stepper motor
- Electrodynamic force meter
- Multiplexer

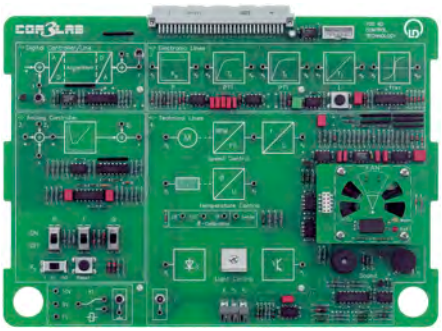
Scope of delivery:

- Board for course
- CD with software and documentation
- Power supply, 230/12 VAC

700 25	COM3LAB course: Electrical machines I

- Working through this course requires the COM3LAB Master Unit 70000USB.
- Also required is a PC running Windows XP, 7 or 8.
- Prerequisites: Fundamentals of AC and three-phase technology

COM3LAB course: Control technology I



Course on the fundamentals of automatic control technology, consisting of an experiment board with various circuits for mounting into the master unit and a Multimedia CD with an interactive training program.

Topics:

- Introduction
- Open-loop control
- Closed-loop control
- Analysis of controlled systems
- Controlled systems with/without compensation
- Controlled systems of a higher order
- Types of controllers
- P, I, PI, PID and PD control
- Automatic digital control
- Performance criteria for automatic controls
- Optimisation guidelines for PID controllers
- Automatic temperature control
- Automatic speed control
- Automatic light control
- Automatic control of systems without compensation
- Automatic control with discontinuous controllers
- Fault simulation

Virtual lab:

- Oscilloscope
- Function generator
- 2 multimeters
- Digital analyser
- Static characteristic plotter
- Step response plotter
- DDC plotter
- Controller design calculator (for optimum controller parameters)

Additional functions:

- Word processing
- Printer
- Pocket calculator
- Free experimentation
- Glossary

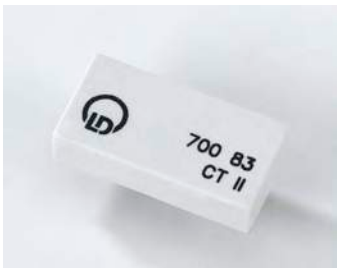
The experiment board is powered by the Master Unit.
The wiring of the experiments carried out over 2 mm cable.
Course content, experiment instructions and tasks are taught through a course-specific software.

Technical data:

- Analog controller
- Summation points with disturbance inputs
- Digital controller
- Lag element
- DC signal sources 1V, 5V, 10V
- P-action element
- PT-1 elements (2 x)
- I-action element, resettable
- Non-linear characteristic element
- Speed controlled system with optical speed sensor
- Temperature controlled system with KTY-temperature sensor
- Light controlled system with photodiode sensor and external light source (disturbance source)

700 82	COM3LAB course: Control technology I

- Operating system: Windows XP/Vista/7
- Support for unguided, free experimentation



COM3LAB course: Control technology II

Supplementary course on the fundamentals of control technology including a dongle for the CTI experiment board.

Topics:

- Introduction
- Stability of automatic control systems
- Controller design using the Ziegler/Nichols method
- Systems with lag time
- Limiting the manipulated variable
- Cascade control
- Introduction to frequency response
- Frequency response of single basic elements
- Frequency response of combined elements
- Controller design in the frequency domain
- Fuzzy control
- Adaptive control
- Experiments with external controlled systems

Virtual lab:

- Static characteristics plotter
- Step response plotter
- DDC plotter
- Frequency response plotter
- Controller design calculator (for optimum controller parameters)

700 83	COM3LAB course: Control technology II

- Operating system: Windows 2000/XP/Vista/7
- Support for unguided, free experimentation.
- Additionally required: 70082COM3LAB course, Control Technology I

Extra-low voltage supply 24/4

Complete power supply in a 19" casing for supplying DC and AC voltage in the extra-low voltage range.

Technical data:

- Mains switch, illuminated
- Outputs are switchable:
  AC voltage: 0...24 V/4 A, floating earth
  DC voltage: 0...24 V/4 A floating earth (full-wave rectifier)
  Output protection: thermal circuit-breaker, 4 A
  Display: 2 digital indicators for RMS value (digit height 12.4 mm) for indication of current and voltage
  Outputs: 2 x 4-mm safety sockets
- Width: 42 PU

725 352DG	Extra-low voltage supply 24/4

Similar to illustration

Three-phase voltage supply 10/17.3

Complete power supply in a 19" casing for extra-low three-phase voltage.

Technical data:

- Mains switch: cam switch, 3-pole
- Mains voltage: 3 x 400 V ±10%, 50...60 Hz
- Outputs:
  3 x 17.3 V (delta), floating earth
  3 x 10 V (star), floating earth
- Output protection: 3 x thermal circuit-breakers, 5 A
- Outputs: 4 x 4-mm safety sockets
- Width: 42 PU

725 432G	Three-phase voltage supply 10/17.3

Three-phase voltage supply 400 V/2.5 A

Complete power supply in a 19" casing for variable three-phase voltage.

Technical data:

- Mains switch: 4-pole cam switch
- Mains voltage: 3 x 400 V ±10%, 50 - 60 Hz
- Outputs:
  - 3 x 0 - 400 V AC
  - 1 x 0 - 250V DC (full-wave rectified)
  2.5 A, short-term 3 A
- Output protection: 3 x protective circuit breakers Outputs via five 4-mm safety sockets
- Display: 2 digital indicators (digit height 12.4 mm)
  to display current for L1, L2, L3 (switchable) and voltage
  Switchable between:
  Live conductors/neutral conductor
  Live conductor/live conductor
- 3 x phase indicator lamps
- Width: 70 PU

725 442DG	Three-phase voltage supply, 400 V/2.5 A

Similar to illustration

Three-phase supply / experiment transformer

Complete power supply in a 19" casing for experiments with variable transformer voltages and for extra-low three-phase voltage.

Technical data:

Variable transformer with three taps

- Mains switch, illuminated
- Outputs:
  0...24 V/2 A AC voltage, floating earth
  0...12 V/4 A AC voltage, floating earth
  0...6 V/8 A AC voltage, floating earth
  0...3 V/16 A AC voltage, floating earth
- Bridge rectifier 35 A, for all ranges
- Protection: thermal circuit-breaker, 1.2 A, in the primary circuit of the output transformer
- Outputs: 8 x 4 mm safety sockets

Power supply unit for extra-low three-phase voltage

- Mains switch: cam switch, 3-pole
- Mains voltage: 3 x 400 V ±10%, 50...60 Hz
- Outputs:
  3 x 17.3 V (delta), floating earth
  3 x 10 V (star), floating earth
- Output protection: 3 x thermal circuit-breakers, 5 A
- Outputs: 4 x 4 mm safety sockets
- Width: 84 PU

725 579G	Three-phase supply / experiment transformer

Similar to illustration

Three-phase generator in case

For generating DC, AC or three-phase AC voltages for the ELM system. Complete power supply in a 19" housing equipped with illuminated mains switch.

Technical data:

- Output voltage, AC: 0...15 V/ 1.5 A
- Output voltage, DC: 0...15 V/ 1.5 A
- Input: 6 pole DIN socket for rotor position pick-up
- Outputs: six 4-mm-safety sockets
- Display: 2 digital displays (digit height 12.4 mm) to display voltage, frequency, speed or position
- Width: 49 PU
- Power supply: 230 V, 50/60 Hz

725 721G	Three phase generator in case

DC machine supply 0.3

Complete power supply in a 19" casing for recording the constant-current characteristic of electrical machines with a constant voltage in the power category up to 0.3 kW.

Technical data:

- Mains switch, illuminated
- Output: 40 - 250 V/0 - 6 A DC voltage and current adjustable, stabilised, short circuit-proof, with power factor adjustment
- Output: 220 V/2 A direct current (full-wave rectifier)
- Protection: circuit breaker, 2 A
- Outputs: 4 x 4-mm safety sockets
- Display: 2 digital displays (digit height: 12.4 mm) for indicating current and voltage
- Current overload indicator: 1 red LED
- Change-over switch: V/V ext. (constant), with mode indicator, 1 green LED
- External constant-voltage power supply: (0 - 10 V DC) via 2 x 4-mm safety sockets
- Width: 63 PU

725 852DG	DC machine supply 0.3

DC machine supply 1.0

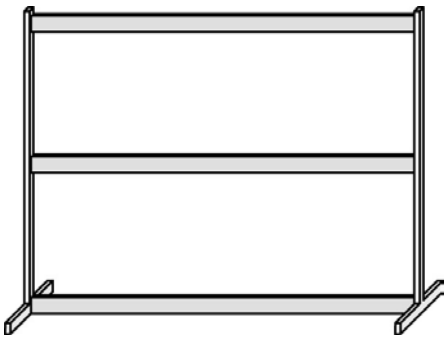
Complete power supply in a 19" casing for recording the constant-current characteristic of electrical machines with a constant voltage in the power category up to 1.0 kW.

Technical data:

- Mains switch, illuminated
- Output: 40 - 250 V/0 - 6 A DC voltage and current adjustable, stabilised, short circuit-proof, with power factor adjustment
- Output: 220 V/2 A direct current (full-wave rectifier)
- Protection: circuit breaker, 2 A
- Outputs: 4 x 4-mm safety sockets
- Display: 2 digital displays (digit height:12.4 mm) for indicating current and voltage
- Current overload indicator: 1 red LED
- Change-over switch: V/V ext. (constant), with mode indicator, 1 green LED
- External constant-voltage power supply: (0 - 10 V DC) via 2 x 4-mm safety sockets
- Width: 84 PU

725 862DG	DC machine supply 1.0

Similar to illustration



Experiment frames

Cat.-No.	Designation	Stand	Execution
726 09	Panel frame T130, two-level	T-Base	standard
726 10	Panel frame T150, two-level	T-Base	standard
726 11	Panel frame T180, two-level	T-Base	standard
726 18	Panel frame T130, three-level	T-Base	standard
726 19	Panel frame SL85, single-level	L-Base	angled
726 256	Panel frame VT160, three-level	T-Base	heavy duty
726 26	Panel frame VT180, three-level	T-Base	heavy duty

Plug-in board, 297 mm x 300 mm, STE

For suspending directly in panel frames (726 03) or demonstration experiment frames (301 300).

Technical data:

- 24 Socket grids with 24 conducting squares and 216 sockets
- 6 Socket grids with 36 sockets
- 2 Conducting paths with 18 sockets each
- Dimensions: 297 mm x 300 mm x 24 mm

726 50	Plug-in board, 297 mm x 300 mm, STE

Single-phase supply unit

To switch the mains voltage in experiments with electrical loads for AC voltage of 230 V.

Technical data:

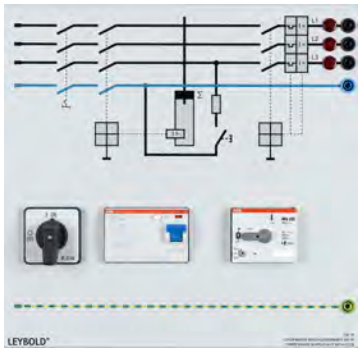
- Cam switch, 2-pole
- Automatic circuit breaker FAZ L 10 A Phase monitor light L 1
- Phase monitor light for indication of false polarity of mains plug

Scope of delivery:

- Mains connecting cable with earth-contact plug

726 71	Single-phase supply unit

Three-phase supply unit with ELCB



To switch the 3-phase supply in experiments with electrical loads for line voltages of 400 V.

Technical data:

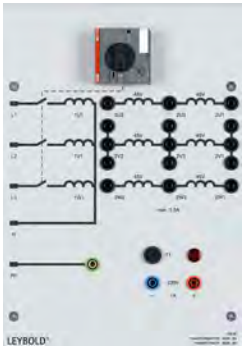
- Cam switch, 4 pole
- Earth-leakage circuit breaker, 30 mA
- Motor protection switch, 6-10 A
- Phase indicator lamps L1, L2, L3

Scope of delivery:

- Mains lead with Cekon plug

726 75	Three-phase supply unit with ELCB

Transformer, 45/90, 3 N



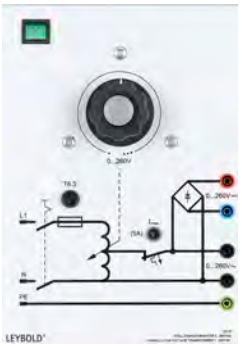
Power supply and experiment unit for the area of power electronics.

Technical data:

- Mains switch: cam switch, 3-pole
- Mains voltage: 3 x 400 V, ±10 %, 50...60 Hz
- Outputs:
  3 x 90 V/1.5 A AC with 3 centre taps, 45 V
  1 x 230 V/1 A DC
- Motor protection switch 0.63....1 A (prim.)
- Outputs: via eighteen 4-mm safety sockets.
- Mains lead and 16-A Cekon plug

726 80	Transformer, 45/90, 3 N

Adjustable transformer 0...260 V



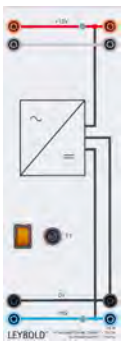
Power supply and experiment unit for the area of electrical machines and energy technology.

Technical data:

- Mains voltage: 230 V, ±10 %, 50...60 Hz
- Output: 1 x 260 V / 4 A AC, short-term 5 A
- 1 Thermomagnetic circuit breaker, 5 A (sec.)
- Output: 2 x 4-mm safety sockets with connecting leads and earth-contact plug, 16 A

726 85	Adjustable transformer 0...260 V

Stabilised power supply ±15 V/3 A

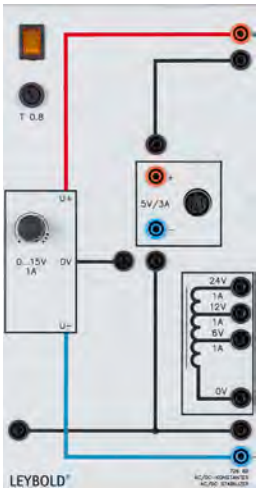


Laboratory power supply with two separate and stabilised fixed voltages for vertical assembly in panel frames or demonstration experiment frames using the plug-in system. Short-circuit-proof. Rated-voltage monitoring via two green LEDs.

Technical data:

- Output voltage: ±15 V via 4-mm sockets
- Maximum load capacity: 2.4 A, short-term 3 A
- Connection voltage: 230 V, 50/60 Hz
- Fuse: T 1.0
- Power consumption: 160 VA
- Dimensions: 10 cm x 30 cm x 12 cm
- Weight: 5 kg

726 86	Stabilised power supply ±15 V/3 A



AC/DC stabilizer

Lab power supply unit with DC and AC voltage outputs. For supplying power to logic components of the SIMULOG LS-TTL range in experiments set up vertically in panel frames or demonstration experiment frames.

Technical data:

- Illuminated mains switch
- DC Outputs:
  Fixed voltage: 5 V/3 A, floating ground
  Residual ripple: 1 mV_{rms}
  Tracking stabiliser: ±0...15 V/1 A,
  Floating ground
  Residual ripple: < 3 mV_{rms}
- AC Outputs: 6/12/24 V/1 A, floating ground
  Outputs: via 4 mm sockets and 6pin DIN socket for adapter/clock
- Mains connecting cable with earth-contact plug
- Dimensions: 15 cm x 30 cm x 12 cm
- Weight: 4 kg

726 88	AC/DC stabilizer

Function generator 200 kHz

Microprocessor controlled signal generator for experiments on training panels.

Technical data:

- Function: Sine/triangle/square/DC
- Square-wave signal: duty cycle 10 %...90 %, adjustable in steps of 5 %
- Frequency range: 100 mHz...200 kHz
- Resolution: 1 mHz...100 Hz, depending on frequency
- Output voltage: 0...20 V_{pp} continuous
- DC offset: ±10 V
- Display: four-digit 7-segment display for signal parameters and functions
- Attenuation: 0 dB, -20 dB, -40 dB
- output impedance: 50 Ω
- Trigger output: TTL level
- Outputs: 4-mm safety sockets
- Power supply: +/-15 V DC or plug-in adapter, 12 V AC (562 791)

726 962	Function generator 200 kHz

Function generator 200 kHz Net

Microprocessor controlled signal generator for experiments on training panels. Equipped with an RJ 45 socket for connection to a local area network (LAN). Can be controlled by *LEYLAB.control* 725006 or *LEYLAB.control Lite* 725007 software, allowing parameters to be read or modified and disturbance variables to be introduced. The equipment can be used in the patented „Networked worlds of learning" system.

Technical data:

- Function: Sine/triangle/square/DC
- Square-wave signal: duty cycle 10%...90%, adjustable in steps of 5%
- Frequency range: 100 mHz...200 kHz
- Resolution: 1 mHz...100 Hz, depending on frequency
- Output voltage: 0...20 V_{pp} continuous
- DC offset: ±10 V
- Display: four-digit 7-segment display for signal parameters and functions
- Attenuation: 0 dB, -20 dB, -40 dB
- output impedance: 50 Ω
- Trigger output: TTL level
- Outputs: 4-mm safety sockets
- Power supply: +/-15 V DC or plug-in adapter, 12 V AC (562 791)

726 962N	Function generator 200 kHz Net

RMS meter

Demonstration meter for measuring true RMS voltages and currents.

- Types of measurement:
  RMS - AC + DC, overall true RMS
  RMS - AC, alternating true RMS
  AV - AC + DC arithmetic average value

It is possible to switch between all ranges and types of measurement at any time.

Technical data:

Measurement ranges for all types of measurement:

- Voltage: 3/10/30/100/300/1000 V, R_i = 10 MΩ
- Current: 0.1/0.3/1/3/10/30 A, R_i = 10 mΩ
- AV-Polarity indicator: 2 LEDs
- Instrument:
  Moving coil
  Class 2.5
  192 x 96 mm (W x H)
  Scale division: 0...10 and 0...3
  Scale length: 119 mm
- Continuous overload protection in all measurement ranges up to 1000 V and 30 A
- Mains supply: 110/230 V, 50 Hz*
- Weight: 1.4 kg

727 10	RMS meter

*60 Hz on request

Power meter

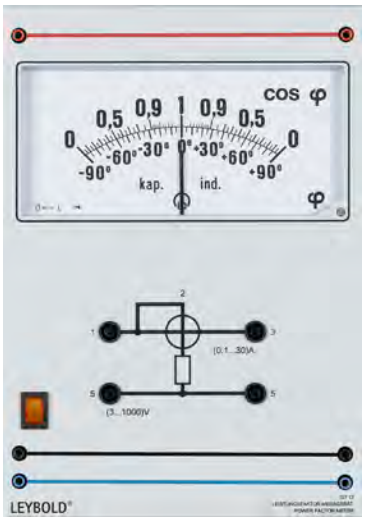
Demonstration meter for active power and capacitive and inductive reactive power, in the range 0.3 W (var) to 30 kW (kvar).

Technical data:

Measurement ranges:

- Voltage: 3/10/30/100/300/1000V
- R_i = 10 MΩ
- Current: 0.1/0.3/1/3/10/30 A
- R_i = 10 mΩ
- Frequency range:
  Active power: 0...20 kHz
  Reactive power: 50 Hz sin
- LED indication for:
  Active power consumption
  Active power output
  Capacitive reactive power
  Inductive reactive power
  Overload voltage
  Overload current
- Instrument:
  Moving coil
  Class 1.5
  192 x 96 mm (W x H)
  Scale division: 0...10 and 0...3
  Scale length: 119 mm
- Continuous overload protection in all measurement ranges up to 1000 V and 30 A
- Mains supply: 110/130/220/240 V, 50 Hz

727 11	Power meter



Power factor meter

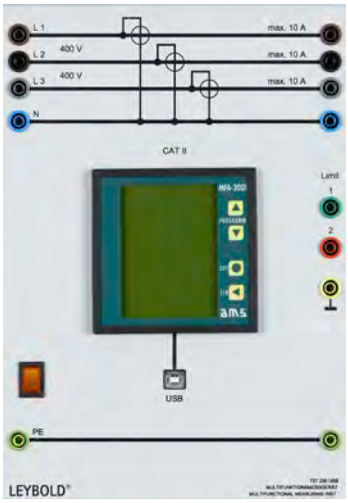
Demonstration meter for power factor (cos phi) and phase-angle.

Technical data:

Measurement ranges:

- Power factor: 0...1...0
- Phase angle: -90°(cap.)- 0 - +90°(ind.)
- Voltage range: 3...1000 V, R_i = 1 MΩ
- Current range: 0.1...30 A, R_i = 10 mΩ
- Frequency range: 20 Hz... 2 kHz
- No voltage range/current range switching
- Display instrument:
  Moving coil
  Class 1.5
  192 x 96 mm (W x H)
  Scale length: 119 mm
- Continuous overload protection in all measurement ranges up to 1000 V and 30 A- 192 x 96 mm (W x H)
- Mains supply: 110/130/220/240 V, 50 Hz

727 12	Power factor meter



Multi-functional meter

The multi-functional meter is an all-purpose electronic meter for the measurement and monitoring of all important parameters for three-phase mains. The LC display with background lighting allows for reliable readings with no glare to be made even from long distance. A clear user interface and direct display of the functions used for all measurements are characteristic of the instrument. With integrated active and reactive power meters.

Features:

- USB interface
- Compatible with CASSY Lab 524220 software for recording and evaluation of measured data
- Integrated kWh active power meter, kWh reactive energy meter and counter for operating time in hours
- Min/max memory for all relevant measured values
- Simultaneous display of 3 measuring values and energy operating hours
- Display of the mean current and of the mean maximum current (bimetallic/friction pointer function)
- Selectable integration time
- All measuring values with direct dimension display
- Two overload outputs or freely selectable
- One pulse output/one overload output
- Overload monitoring functions of all measuring values, freely selectable pulse output for active power
- Analogue output 0/4-20 mA or 0/2-10 V
- Direct input, 3 x 30 A AC
- Mains connection 230 V AC

Technical data:

Measurement quantities:

- Voltage: V, V_{min}, V_{L-N} ,V_{L-L} 3 x 23...475 V AC
- Current: I, I_{mean}, I_{max}, $I_{L1/IL2/IL3}$ up to 3 x 10 A AC
- Active power: P, P_{mean}, P_{max}, $P_S/P_{L1}/P_{L2}/P_{L3}$
- Reactive power: Q, Q_{mean}, Q_{max}, $Q_S/Q_{L1}/Q_{L2}/Q_{L3}$
  Power factor cos ϕ, cos ϕ_S/cos ϕ_S/cos $\phi_{S\,mean}$/cos ϕ_S
- Mains frequency: f_{mains},$f_{L1}/f_{L2}/f_{L3}$ 45...65 Hz
- Accuracy: 1% of maximum value in measuring range

727 230USB	Multi-functional meter

Moving iron meter, 2.5 A

Robust instrument for current monitoring in continuous use.

Technical data:

- Moving iron galvanometer
- Front frame: 144 x 144 mm
- Class: 1.5
- Measurement ranges: 0 - 2.5 A

727 32	Moving iron meter, 2.5 A

Complete equipment set DC/AC/EL

Optimised equipment set for carrying out experiments from the following topic groups:

- STE 2.2 DC Technology
- STE 2.3 AC Technology
- STE 6.1.1 Discrete Components and Basic Electronic Circuits

Scope of delivery:

- 1 Resistor, 0.1 Ω, 2 W
- 1 Resistor, 0.22 Ω, 2 W
- 1 Resistor, 1 Ω, 2 W
- 2 Resistors, 10 Ω, 2 W
- 1 Resistor, 47 Ω, 2 W
- 2 Resistors, 100 Ω, 2 W
- 1 Resistor, 150 Ω, 2 W
- 1 Resistor, 220 Ω, 2 W
- 1 Resistor, 330 Ω, 2 W
- 1 Resistor, 470 Ω, 2 W
- 1 Resistor, 1 kΩ, 2 W
- 1 Resistor, 1.5 kΩ, 2 W
- 1 Resistor, 2.2 kΩ, 2 W
- 1 Resistor, 3.3 kΩ, 2 W
- 1 Resistor, 10 kΩ, 0.5 W
- 1 Resistor, 47 kΩ, 0.5 W
- 1 Resistor, 100 kΩ, 0.5 W
- 1 Resistor, 330 kΩ, 0.5 W
- 1 Resistor, 1 MΩ, 0.5 W
- 1 Potentiometer, 220 Ω, 3 W
- 1 Potentiometer, 1 kΩ, 1 W
- 1 Potentiometer, 10 kΩ, 1 W
- 1 Potentiometer, 100 kΩ, 1 W
- 1 VDR resistor
- 1 Photoresistor, LDR 05
- 1 NTC thermistor, 150 Ω, 1 W
- 1 PTC thermistor, 150 Ω, 1 W
- 1 Capacitor, 100 pF, 160 V
- 1 Capacitor, 22 pF, 100 V
- 1 Capacitor, 0.1 µF, 100 V
- 1 Capacitor 1 µF, 100 V
- 1 Capacitor 2.2 µF, 63 V
- 2 Capacitors 4.7 µF, 63 V
- 1 Capacitor 10 µF, 35 V
- 1 Capacitor 47 µF, 40 V
- 1 Capacitor 100 µF, 35 V
- 2 Capacitors 470 µF, 16 V
- 1 LED, red, LED 2, light emitted from top
- 1 LED, infrared, light emitted laterally from side)
- 1 LED, green, LED1, from top
- 1 LED, red, from side
- 1 Ge diode, AA 118
- 4 Si diodes, 1N 4007
- 1 Zener diode, ZPD 6.2
- 1 Zener diode, ZPD 9.1
- 1 Diac, BR 100
- 1 Photo-diode, BPX 43
- 1 Transistor, BD 137 (NPN), emitter at bottom
- 1 FET, BF 244
- 2 Thyristors, TYN 1012
- 1 Triac, BT 137/800
- 1 Inductor, 33 mH
- 2 Screw lamp holders E10, point sideways
- 2 Screw lamp holders E10, pointing up
- 2 Push buttons, single-pole
- 2 Change-over switches, single-pole
- 1 Relay with single-pole change-over contact
- 1 Coil, 500 turns
- 1 Coil, 1000 turns
- 1 Transformer core, for assembly and disassembly
- 2 Plug-in battery holder
- 2 Monocell batteries, 1.5 V
- 1 Magnet with core
- 1 Set of 10 incandescent lamps, 4 V/0.16 W, E10
- 1 Set of 10 incandescent lamps 12 V/3 W, E10
- 1 Set of 10 incandescent lamps, 2.5 V/0.25 W, E10
- 1 Set of 10 incandescent, lamps 6 V/3 W, E10
- 1 Glow lamp 110 V, E10
- 2 Trays, STE

727 510N	Complete equipment set DC/AC/EL

Standard image, contents may differ

Basic set T 2.4.1, STE

Collection of STE components for „Three-Phase Transformers and Transformer Circuits".

Scope of delivery:

- 1 E-core assembly kit
- 1 Base for E-core
- 6 Coils, 250 turns
- 3 Coils, 500 turns
- 3 Resistors, 56 ohm, 11 W
- 1 Tray STE

727 514	Basic set T 2.4.1, STE

Basic set T 2.4.2, STE

Collection of STE components for „Three-Phase Circuits and Rectifiers". For experiments involving single/3-phase transformers, phase-shifts, transformer configurations and rectifier circuits: M1, M2, M3, M6, B2 and B6.

Scope of delivery:

- 6 Si-diodes, BY 255
- 1 Resistor, 1 Ω, 2 W
- 1 Resistor, 100 Ω, 2 W
- 1 Resistor, 1 kΩ, 2 W
- 1 Capacitor, 22 µF, 16 V
- 1 Capacitor, 100 µF, 35 V
- 1 Capacitor, 1000 µF, 40 V
- 1 Coil, 10 mH
- 1 Tray, STE

727 515	Basic set T 2.4.2, STE

Standard image, contents may differ

Basic set STE 6.1.1

Collection of STE components for „Discrete Components and Basic Electronic Circuits".

Scope of delivery:

- 1 Resistor, 10 Ω, 2 W
- 1 Resistor, 100 Ω, 2 W
- 1 Resistor, 330 Ω, 2 W
- 1 Resistor, 470 Ω, 2 W
- 1 Resistor, 1 kΩ, 2 W
- 1 Resistor, 1.5 kΩ, 2 W
- 1 Resistor, 2.2 kΩ, 2 W
- 1 Resistor, 3.3 kΩ, 2 W
- 1 Resistor, 10 kΩ, 0.5 W
- 1 Resistor, 47 kΩ, 0.5 W
- 1 Resistor, 100 kΩ, 0.5 W
- 1 Resistor, 1 MΩ, 0.5 W
- 1 Potentiometer, 1 kΩ, 1 W
- 1 Potentiometer, 10 kΩ, 1 W
- 1 Potentiometer, 100 kΩ, 1 W
- 1 Voltage dependent resistor
- 1 Capacitor, 100 pF, 160 V
- 1 Capacitor, 22 nF, 100 V
- 1 Capacitor, 0.1 µF, 100 V
- 1 Capacitor, 1 µF, 100 V
- 1 Capacitor, 2.2 µF, 63 V
- 2 Capacitors, 4.7 µF, 63 V
- 1 Capacitor, 10 µF, 35 V
- 1 Capacitor, 47 µF, 40 V
- 1 Capacitor, 100 µF, 35 V
- 1 Capacitor, 470 µF, 16 V
- 1 LED, infrared, sideways emission
- 1 Ge diode, AA 118
- 4 Si diodes, 1N 4007
- 1 Zener diode, ZPD 9.1
- 1 Zener diode, ZPD 6.2
- 1 LED, green, upwards emission, STE 2/19
- 1 LED, green, upwards emission, STE 2/50
- 1 LED, red, sideways emission

- 1 Diac, BR 100
- 1 Photo-diode, BPX 43
- 1 Transistor, BD 137 (NPN), emitter at bottom
- 1 FET, BF 244
- 2 Thyristors, TYN 1012
- 1 Triac, BT 137/800
- 1 Inductor, 33 mH
- 2 Lamp holders, E10, upwards facing
- 1 Push button, single-pole
- 1 Set of 10 incandescent lamps, 12 V/3 W, E10
- 1 Tray, STE

727 531N	Basic set STE 6.1.1

Standard image, contents may differ

Supplementary set T 6.1.18

Basic Power Electronics (Supplement to STE 6.1.1).

Scope of delivery:

- 1 Resistor, 10 Ω, 10 W
- 1 Resistor, 100 Ω, 2 W
- 1 Resistor, 220 Ω, 2 W
- 1 Resistor, 680 Ω, 2 W
- 1 Resistor, 1 kΩ, 2 W
- 1 Resistor, 3.3 kΩ, 2 W
- 1 Resistor, 4.7 kΩ, 2 W
- 1 Resistor, 10 kΩ, 0.5 W
- 1 Variable resistor, 47 kΩ, 1 W
- 1 Capacitor, 1 nF, 100 V
- 1 Capacitor, 10 nF, 100 V
- 1 Capacitor, 47 nF, 100 V
- 1 Capacitor, 0.1 µF, 100 V
- 1 Capacitor, 100 µF, bipolar
- 2 Zener diodes, ZPY 8.2
- 1 NPN transistor, BD 137, emitter at bottom
- 1 PNP transistor, BD 138, emitter at bottom
- 1 MOSFET, BSV 81
- 1 Diac, MBS 4991
- 1 Thyristor trigger unit, TCA 785
- 1 GTO thyristor, BTW 58
- 1 Pulse width generator
- 2 Pulse isolating transformers, 1:1, 400 mW
- 1 Ignition pulse generator, activated by touch surface
- 1 Push button, (NC), single-pole
- 1 Change-over switch, two-pole
- 1 Coil, 1000 turns
- 1 Incandescent lamp, 24 V/3 W, E10
- 1 Tray, STE

727 657N	Supplementary set T 6.1.18

Standard image, contents may differ

Basic machine unit

For mounting of electrical training machines in training panel frames.

Technical data:

- Dimensions: 200 mm x 297 mm
- Terminals: 4 mm sockets (5 x 2 sockets)
- Connector for rotor position sensor: 10-pin terminal strip
- Connector for three-phase generator: 6-pin DIN socket
- Rotor axle: 100 mm, 8 mm Ø

727 811	Basic machine unit

Rotor position pick-up

Electronic device to pick up the position of ELM magnetic rotor (563 19) and ELM 4-pole magnetic rotor (563 191) together with the three phase generator (725 721). The rotor position pick-up is mounted on the basic machine unit (727 811).

727 812	Rotor position pick-up

ELM set: Multipole stator and rotor

Set consisting of:

Stator

Multi-pole stator for attachment to basic machine unit 727811 or 72781. The stator block is fixed to the base by means of screws. Using 4-mm safety sockets, the three phase windings can be connected in either star or delta configuration. Each phase winding is divided into five strands. The phasewindings are easily distinguished by different coil colours.

Rotor

Rotor equipped with 30 surface mounted permanent magnets, 3 of which are combined to one pole. North and south poles are colour-coded. The rotor can be belt-driven using the drive unit 72788.

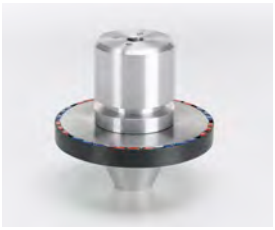
Technical data:

- Voltage: 12 V
- Current: I_{max} = 1 A
- Number of poles: 5
- Coil resistance: 2.5 Ω

Scope of delivery:

- Multi-pole stator
- Rotor with surface mounted magnets
- 4 fastening screws

727 815	ELM set: Multipole stator and rotor



ELM PM magnet rotor with inner magnets

Rotor with 20 inward facing magnets to be used with the stator 727815. Two magnets are combined into one pole, the north and south poles of which are marked with different colours. The rotor can be belt-driven using the drive unit 72788.

727 816	ELM PM magnet rotor with inner magnets

Basic terminal unit

For electrical connection of the assembled machine with meters and load units, with fastening bolts for the masks of the corresponding assembled machines.

727 82	Basic terminal unit

Set of masks

Contains a special mask for each motor or generator type which shows the terminal board with the standardised connections and the symbol of the machine. The mask is hung on the bolts of the basic connection unit.

727 83	Set of masks

Starter

Circular rheostat with scale from 22...0 Ω for starting DC motors.

Technical data:

- Resistance: 22 Ω

727 85	Starter

Field regulator

Circular rheostat with scale 47...0 Ω for setting the excitation of DC machines.

Technical data:

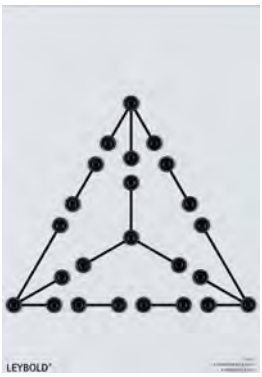
- Resistance: 47 Ω

727 86	Field regulator

Star-delta load

Plug-in board for assembly of loads for generators with STE plug-in units in star or delta connection.

727 87	Star-delta load



Drive unit

Universal motor with pulley and phase control for continuous speed adjustment from 0 to 3000 rpm. For assembly on the demonstration experiment frame (301 300) or panel frame (726 19).

Technical data:

- Supply voltage: 230 V AC
- Dimensions: 200 mm x 297 mm

727 88	Drive unit

Additionally required:

Count	Cat.-No.	Name
1	685 96	Driving belt, long for drive unit 72788

Linear motor basic unit

For use as a track for the linear motor with coil assembly (727 92).

Technical data:

- Length 1500 mm
- Diameter: 16 mm

Scope of delivery:

- 2 training panels with holder for track
- 1 track

727 91	Linear motor basic unit

Linear motor with coil assembly

Carriage with ball bearings and 3 coils, coil terminals with 4-mm safety sockets.

Technical data:

- Voltage: max. 24 V three-phase voltage
- Tractive force: max. 0.8 Nm

727 92	Linear motor with coil assembly

CBC 12.5 Servo technology

Disc with Windows program in German, English and French for the measurement of servo data via the serial interface from the block commutation, sine commutation control units or the digital position controller. The software is also used to control these devices. The program contains two different user interfaces, an extended block circuit diagram corresponding to the connected device with all the appropriate operating data and a time line plotter for the display of voltage, current, speed and position. With this software it is possible to record step responses of the servo drive and to investigate contour errors. Furthermore, four different position reference variables can be stored which are then moved to in sequence (to simulate a process).

Technical data:

System requirements:

- Equipment sets E2.6.2.1, E2.6.2.2 or E2.6.2.3
- Windows XP/Vista/7/8, two free USB-Ports

728 410	CBC 12.5 Servo technology

CBM10 MOMO/FCCP

The CD contains two Windows programs in German and English, one for the recording of characteristics of electrical machines (MOMO) and one (FCCP) for the control of the universal converter 735 297 via the control unit PWM 735 291. School licence.

MOMO: Program for recording the characteristics of DC, AC and three-phase machines in the four quadrants of the speed/torque planes. The measurement values for speed, torque, current, voltage, active power and frequency of the feeding system are transferred via the serial port from the control unit for the pendulum machine to the PC. The display of these measurement variables and the variables derived mathematically from them (apparent power, reactance and mechanical power as well as efficiency and slip), can be evaluated graphically or in tabular form. For three-phase machines the current locus curve can also be depicted and slip can be determined graphically. For this there is a wide range of tools at your disposal. The tables can also be processed further using MS-Excel®.

FCCP: Program for adjusting of the control unit PWM. The following parameters can be set:

- Nominal machine data
- Starting voltage, slip and I x R compensation
- Ramp time
- Magnetisation current
- Modulation type.

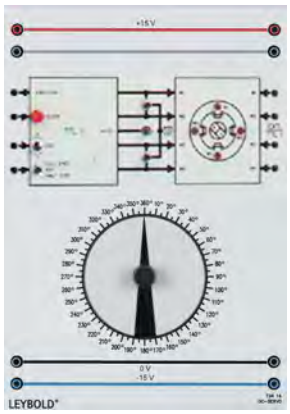
The current voltage/frequency characteristic is displayed in a graphic.

Technical data:

- Windows XP/Vista/7/8, two free USB ports

728 421	CBM10 MOMO/FCCP

The software is available for download at www.ld-didactic.com.



Stepper motor

Stepper motor on experiment panel with built-in control logic.

- Operating modes: single-step, half and full-step, clockwise and anti-clockwise rotation
- 64 steps per revolution in half-step mode
- Control: manually via a push button, by means of an external generator or microcomputer, each with TTL level

Technical data:

- Max. control frequency half-step: 800 Hz
- Max. control frequency full-step: 400 Hz
- Inputs and outputs via 4 mm-sockets
- Supply voltage: ±15 V DC

728 55	Stepper motor

Lamp sockets E14, set of three

3 built-in E14sockets for incandescent light bulbs, max. 60 W. With 19-mm bridging plugs which can be connected in parallel.

729 09	Lamp sockets E14, set of three

RS-232 cable, 9-pole

RS 232 cable (1:1) with a 9-pin sub-D connector and a 9-pin sub-D socket.

729 769	RS-232 cable, 9-pole

Coupling 0.3

Rubber coupling sleeve for mechanical connection of two electrical machines of the 0.1 kW or 0.3 kW series.

731 06	Coupling 0.3

Shaft end guard 0.3

Attachable guard for protection against contact with electrical machine rotating parts of the 0.1 kW or 0.3 kW series.

731 07	Shaft end guard 0.3

Gearbox 0.3

Two-stage planetary gearbox with free-moving motor shaft and drive shaft. Suitable for stepping down high servo speeds (e.g. 6000 rpm) to lower working speeds as well as for increasing the working torque.

Technical data:

- Gear ratio: 36:1
- Constant torque: max. 24 Nm
- Input speed: max. 6000 rpm with CDF (cyclic duration factor) = 10%

731 075	Gearbox 0.3

Coupling guard 0.3

Attachable guard for protection against contact with electrical machine rotating parts of the 0.1 kW or 0.3 kW series.

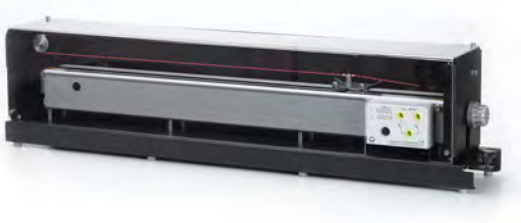
731 08	Coupling guard 0.3

Coupling guard 0.3 transparent

Attachable guard for protection against contact with electrical machine rotating parts of the 0.1 kW or 0.3 kW series.

731 081	Coupling guard 0.3 transparent

Linear unit 0.3



Linear guide rail with a ball-and-screw spindle for driving a sled. The sled moves a pointer with a vernier scale along a measuring tape with mm divisions and activates the integrated limit switches (NO contacts) at the left and right ends. The entire linear unit is equipped with a plexiglass hood which serves as protection against it being touched.

Technical data:

- Length: 900 mm
- Travel: 650 mm
- Pitch: 5 mm/rotation
- Reading accuracy: 0.1 mm
- Speed: 3000 rpm max.
- Limit switches: 2 NO contacts
- Contact load: 100 V, 0.1 A DC

731 085	Linear unit 0.3

Similar to illustration

Linear unit with position encoder 0.3

Linear guide rail with a ball-and-screw spindle for driving a sled. The sled moves a pointer with a vernier scale along a measuring tape with mm divisions and activates the integrated limit switches (NO contacts) at the left and right ends. A cord connects the slide to an incremental position encoder which supplies two square-wave signals (A, B) displaced by 90° and a reference pulse (REF). The entire linear unit is equipped with a plexiglass hood which serves as protection against it being touched.

Technical data:

- Length: 900 mm
- Travel: 650 mm
- Pitch: 5 mm/rotation
- Reading accuracy: 0.1 mm
- Speed: 3000 rpm max.
- Limit switches: 2 NO contacts
- Contact load: 100 V, 0.1 A DC
- Incremental position encoder, tracking (A, B): 5 pulses/mm
- Incremental position encoder, REF tracking: 1 pulses/100 mm

Scope of delivery:

- Connecting lead, 6-pole, L = 1.5 m

731 086	Linear unit with position encoder 0.3

Potentiometric angle transducer 0.3

Transducer used for measuring the actual angular position of a shaft for the precise positioning of a drive via position servo control. The transducer is equipped with a 360 degree scaled angle disc for visual display of the shaft position.

Technical data:

- Reading accuracy: 1°
- Speed: 200 rpm max.
- Potentiometer: 10 kΩ
- Extent of rotation, mechanical, 360° unlimited
- Extent of rotation, electric, 340°
- Resolution with respect to infinity
- Supply voltage: ±15 V DC

731 089	Potentiometric angle transducer 0.3

Tacho generator 0.3

For registering the speed of electrical machines in the 0.1 kW and 0.3 kW series.

Technical data:

- Output voltage: ±1 V/1000 rpm

731 09	Tacho generator 0.3

Incremental tacho 0.3

For registering the speed of electrical machines in the 0.1 kW and 0.3 kW power class, as well as for incremental positioning of a servo machine. The TTL-compatible signals, A, B and REF, are accessible via 4-mm sockets. 1024 pulses at A or B correspond to a mechanical angle of rotation of 360 degrees.
The signals A and B are phase-shifted by 90 degrees for the determination of the shaft's rotation direction. The REF pulse is generated once per shaft revolution. The universal speed indicator or the control unit block commutation is needed for the power supply and display.

Technical data:

- Connection: 6-pin DIN socket
- Speed: 10.000 rpm max.
- Increments: 1024 pulses/360°

Scope of delivery:

Contained in Scope of delivery: Connection cable, 6-pole, L = 1.5 m.

731 092	Incremental tacho 0.3

Resolver 0.3

Brushless hollow-shaft resolver for detecting the angular position of a shaft. The resolver serves as a detector for the sine commutation of a permanently excited brushless DC motor as well as for recording the speed and perform positioning in AC servo drives. In order to set the shaft position of the resolver in a definite position with respect to the AC servo motor, the resolver stator can be mechanically adjusted by ±45 degrees. The resolver is fed with a sinusoidal signal and supplies two signals of equal frequency, but different amplitudes to the output. The amplitudes are dependent on the angular position of the shaft. With one revolution of the shaft, the envelope curves of the amplitudes produce one sinusoidal and one cosine signal of 360° electrical each. From these signals the evaluating electronics in the sine commutation control unit (735 293) determines the absolute position of the shaft.

Technical data:

- Speed: 10.000 rpm max.
- Transformation ratio: 0.5
- Electrical error: ±0.25°
- The inputs and outputs are each accessible via 4-mm sockets or 6-pin DIN socket
- Supply voltage: 4 V/10 kHz supplied by the sine commutation control unit

Scope of delivery:

- Connection cable 6-pole, L = 1.5 m

731 094	Resolver 0.3

Commutation pick-up 0.3

For determining the rotor position of a permanently-excited brushless DC motor (AC servo). The pick-up contains three Hall-type switches and a 4-pole pick-up magnet mounted to the shaft. In order to set the shaft position of the commutation pick-up in a definite position with respect to the AC servo motor, the pick-up magnet can be mechanically adjusted by ± 45 degrees. The signals generated during the rotation of the shaft supply the evaluating criteria for the block signal type commutation of a 4-pole AC servo motor.

Technical data:

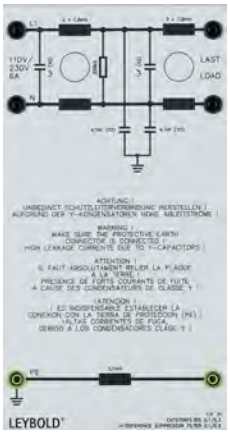
- Speed: 10.000 rpm max.
- Output voltage: TTL level
- Supply voltage: + 15 V DC supplied by block commutation control unit , cat. no. 735 292

Scope of delivery:

- Connection cable 6-pole, L = 1.5 m

731 096	Commutation pick-up 0.3

Interference suppressor filter 0.3



Two-stage interference suppressor filter with two current-compensated chokes each and two class X and Y capacitors each and one choke connected to the protective earth connector for the disturbance suppression of the universal motor 0.3 and repulsion motor 0.3. The filter is connected between the mains and machine and reduces the machine's output of line-bound disturbance signals in a low-voltage network in accordance with EN 5008-1.

Technical data:

- V = 110/230 V, 47...62 Hz
- I_N = 6 A

731 31	Interference suppressor filter 0.3

Squirrel cage fault simulator

The fault simulator, in conjunction with asynchronous squirrel-cage motors allows for simulation of typical malfunctions like shorts to ground, winding breaks, turn-to-turn faults, winding-to-frame shorts and tripping of the thermal circuit breaker. The faults are generated by 13 switches arranged behind a locked cover. The fault simulator is an adapter to be attached to the terminal panel of the squirrel cage motor.

731 391	Squirrel cage fault simulator

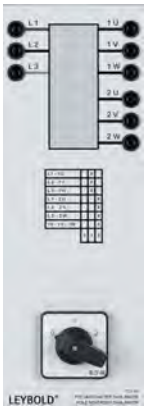
On/off switch, three-pole

For switching of three-phase units.

Technical data:

- Switch load: 20 A/500 V AC
- Switch positions: 0 - 1

731 42	On/off switch, three-pole



Star-delta switch

To start induction machines.

Technical data:

- Switch load: 20 A / 500 V AC
- Switch positions: 0 - Y - Δ

731 47	Star-delta switch

Star-delta reversing switch

To start and to change the direction of rotation of induction machines.

Technical data:

- Switch load: 20 A / 500 V AC
- Switch positions: Δ - Y - 0 - Y - Δ

731 48	Star-delta reversing switch

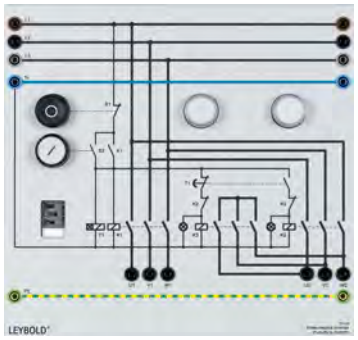
Reversing switch

To change the direction of rotation of three-phase motors.

Technical data:

- Switch load: 20 A / 500 V AC
- Switch positions: 1 - 0 - 2

731 49	Reversing switch



Star-delta starter

Contactor group with time relays for starting three-phase motors of up to approx. 1,5 kW. On/off switching is carried out via two pushbuttons I and 0. Automatic switchover from star to delta is carried out after the preset time elapses. The momentary operating status is displayed via two signal lamps.

Technical data:

- Switching capacity: 1.5 kW
- Switchover time delay: 0.3...30 s
- Supply voltage: 3 x 400 V AC

731 50	Star-delta starter

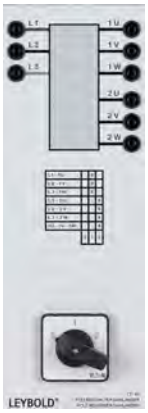
Soft starter 0.3 /1.0

3-phase soft control device for asynchronous machines with control input and the following setting options:

- Start ramp time
- Start voltage
- Stop ramp time

731 51	Soft starter 0.3 /1.0

Pole reverser, Dahlander



Switching over the stator windings of special asynchronous machines alters the number of pole pairs and therefore the synchronous speed of the rotating field.

Technical data:

- Switch load: 20 A/500 V AC
- Switch positions: 0 - 1 - 2

731 55	Pole reverser, Dahlander

Pole reverser SW

For switching over the stator windings of asynchronous machines with separate windings.

Technical data:

- Switch load: 20 A/500 V AC
- Switch positions: 0 - 1 - 2

731 57	Pole reverser SW

Blocking gear 0.3

Hand operated gear mechanism for setting the rotor of three-phase 0.3 kW asynchronous motors with slip ring rotor when used as a phase shifting transformer.

Technical data:

- $n_2 = 1$
- $n_1 = 20$

731 65	Blocking gear 0.3

DC compound machine 0.3

DC compound machine for motor and generator operation, can be used as shunt, series, or compound wound machine, series winding with tap for compounding and shunt winding. All windings are separately connected to 4 mm safety sockets.

Technical data:

- Power: 0.3 kW
- Voltage: 220 V
- Current: 1.8 A
- Excitation voltage: 220 V
- Excitation current: 0.25 A
- Speed: 2000 rpm

731 86	DC compound machine 0.3

Shunt wound machine 0.3

DC shunt wound machine for motor and generator operation. All windings are separately connected to 4 mm safety sockets.

Technical data:

- Class: 0.3
- Power: 0.3 kW
- Voltage: 220 V
- Current: 1.8 A
- Excitation voltage: 220 V
- Excitation current: 0.25 A
- Speed: 2000 rpm
- International protection code: IP 20
- Insulation system: B/F

731 91	Shunt wound machine 0.3

Series wound machine 0.3

DC series wound machine for motor and generator operation. All windings are separately connected to 4 mm safety sockets.

Technical data:

- Power: 0.3 kW
- Voltage: 220 V
- Current: 1.9 A
- Speed: 2000 rpm

731 92	Series wound machine 0.3

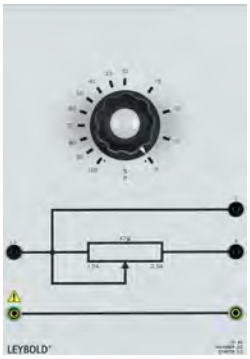
Double wound machine 0.3

DC double wound machine for motor and generator operation. All windings are separately connected to 4-mm safety sockets.

Technical data:

- Power: 0.3 kW
- Voltage: 220 V
- Current: 1.8 A
- Excitation voltage: 220 V
- Excitation current: 0.25 A
- Speed: 2000 rpm

731 93	Double wound machine 0.3



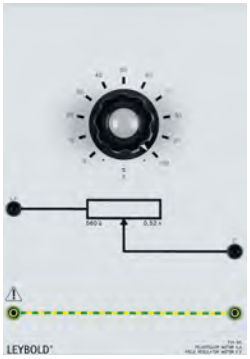
Starter 0.3

Circular rheostat (step winding) with scale (100 - 0%) for starting 0.3 kW DC motors.

Technical data:

- Resistance: 47 Ω
- Current: 2.5 A

731 94	Starter 0.3



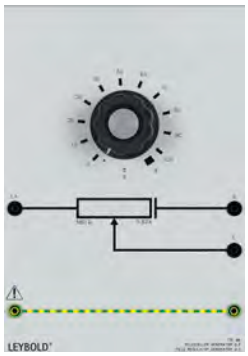
Field regulator, motor 0.3

Circular rheostat with scale (0 - 100%) for adjusting the excitation in 0.3 kW DC shunt and compound wound motors.

Technical data:

- Resistance: 560 Ω
- Current: 0.52 A

731 95	Field regulator, motor 0.3



Field regulator, generator 0.3

Circular rheostat with short-circuit contact and scale 0 - 100 % for adjusting the excitation in 0.3 kW DC shunt and compound wound generators.

Technical data:

- Resistance: 560 Ω
- Current: 0.52 A

731 96	Field regulator, generator 0.3

Machine test system 0.3

Equipment set for recording the characteristics of electrical machines of the 0.3 kW class in all four quadrants, consisting of:

- Cradle-type three-phase asynchronous machine
- Control unit

Cradle-type three-phase asynchronous machine
Squirrel-cage rotor on oscillating bearing with integrated torque pick-up for recording speed, plus stainless steel bending bar with strain gauge for measuring torque. This specially-designed machine can drive any of the machines contained in the electrical machine system 0.3 kW power class and brake any of them down to a standstill. Power is supplied from a control unit via a 7-pole connecting cable with round 7-pin connector, while signals are transmitted via a fixed cable with D-Sub plug connectors.

Control unit
Microcontroller equipped device with integrated frequency converter for the power supply and control of the cradle-type three-phase asynchronous machine. Display of speed and torque of the machine under test. Manual and automatic recording of the characteristics in all four quadrants of the speed/torque plane. Connection to the PC via USB port.

Technical data:

- Automatic digital speed control: ±5000 rpm
- Automatic digital torque control: ±9.9 Nm
- Automatic recording of run-up and load characteristics
- Load simulations: flywheel, freely adjustable fan drive ($M\sim kn^2$) freely adjustable winding drive ($M\sim k/n$), lift drive (constant torque)
- Characteristics recorded in accordance with user specifications (Mi=ni)
- External control: ±10 V
- Seven-segment display, 25 mm high
  Speed: 4 digits
  Torque: 3 digits
- Parallel operation is possible with the help of the software
- Temperature monitoring:
  Machine under test
  Cradle type three-phase asynchonous machine
  Control unit
- Shaft guard monitoring: system shut-down with protection for unintended system start
- Four quadrant display with LEDs for operating mode of the machine under test
- Adjustable torque limiting (overload protection) and stop speed (for automatic characteristic recording)
- RMS measurement: three inputs for voltage measurement (V_{max}=600 V AC/DC), one input for current measuring (I_{max}=10 A AC/DC), all suitable for frequency converter
- USB connection for transmission of measured values and remote control via software CBM 10
- Highest security standards: leakage current <5 mA
- Power supply: 230 V, 47 ... 62 Hz, 2 kW

Scope of delivery:

- Mains lead with earth-contact plug
- Demo version of software CBM 10
- USB cable, 3 m
- 25-pole connecting cable
- Supply cable for cradle-type machine
- Dynamometer
- Cylindrical bar

731 989USB	Machine test system 0.3

AC servo motor 0.3

Permanently-excited 4-pole brushless DC motor for use as a direct drive and for implementing highly dynamic positioning and automatic drives in 4-quadrant operation mode.

731 994	AC servo motor 0.3

Universal motor 0.3

For operation with AC or DC.

Technical data:

Ratings for connection to AC:

- Power: 0.2 kW
- Voltage: 230 V
- Current: 2.5 A
- Frequency: 50 Hz
- Speed: 3000 rpm

Ratings for connection to DC:

- Power: 0.2 kW
- Voltage: 140 V
- Current: 3 A
- Speed: 3000 rpm

732 00	Universal motor 0.3

Repulsion motor 0.3

With adjustable brushes for change of speed and direction.

Technical data:

- Setting range: -2100...0...+2100 rpm
- Power: 0.25 kW
- Voltage: 230 V
- Current: 2.9 A
- Frequency: 50 Hz
- Power factor: 0.69
- Speed: 2100 rpm

732 02	Repulsion motor 0.3

Auxiliary phase motor R 0.3

Single-phase AC motor with starting relay and bifilar starter winding.

Technical data:

- Power: 0.2 kW
- Voltage: 230 V
- Current: 2.6 A
- Frequency: 50 Hz
- Power factor: 0.7
- Design: 4-pole
- Speed: 1380 rpm

732 03	Auxiliary phase motor R 0.3

Capacitor motor R 0.3

Single-phase AC motor with starting relay, starting and operating capacitor. Industrial design with one shaft end.

Technical data:

- Power: 0.37 kW
- Voltage: 230 V
- Current: 2.6 A
- Frequency: 50 Hz
- Power factor: 0.93
- Starting capacitor C_A: 50-63 µF
- Operating capacitor C_B: 20 µF
- Design: 4-pole
- Speed: 1400 rpm

732 04	Capacitor motor R 0.3

Auxiliary phase motor F 0.3

Single-phase AC motor with centrifugal switch and bifilar starter winding.

Technical data:

- Power: 0.2 kW
- Voltage: 230 V
- Current: 2.6 A
- Frequency: 50 Hz
- Design: 4-pole
- Speed: 1380 rpm

732 05	Auxiliary phase motor F 0.3

Capacitor motor F 0.3

Single-phase AC motor with centrifugal switch, starting and operating capacitor.

Technical data:

- Power: 0.25 kW
- Voltage: 230 V
- Current: 2.2 A
- Frequency: 50 Hz
- Power factor: 0.85
- Design: 4-pole
- Speed: 1420 rpm

732 06	Capacitor motor F 0.3

Squirrel cage motor 230/400/0.3

Three-phase asynchronous motor with squirrel cage rotor, industrial design with one shaft end.

Technical data:

- Class: 0.3
- Power: 0.25 kW
- Voltage: 400 /230V, Y/ Δ
- Current: 0.76 /1.32 A
- Frequency: 50 Hz
- Power factor: 0.79
- Design: 4-pole
- Speed: 1350 rpm
- International protection code: IP 20
- Insulation system: F

732 104	Squirrel cage motor 230/400/0.3

Squirrel cage motor 400/690/0.3

Three-phase asynchronous motor with squirrel cage rotor and distinct pull-out torque. Industrial design with one shaft end.

Technical data:

- Class: 0.3
- Power: 0.27 kW
- Voltage: 400/690 V, Δ/Y
- Current: 1.0/0.58 A
- Frequency: 50 Hz
- Power factor: 0.7
- Design: 4-pole
- Speed: 1350 rpm

732 11	Squirrel cage motor 400/690/0.3

Squirrel cage motor basic 230/400/0.3

Industrial three-phase asynchronous motor with squirrel cage rotor.

Technical data:

- Power: 0.25 kW
- Voltage: 230/400 V, Δ/Y
- Current: 1.0/0.58 A
- Frequency: 50 Hz
- Design: 4-pole
- Speed: 1445 rpm

732 201	Squirrel cage motor basic 230/400/0.3

Squirrel cage motor basic 230/400, brake 0.3

Industrial three phase asynchronous motor with cage rotor, with one shaft extension. With electro-mechanical holding brake, controlled via a rectifier.

Technical data:

- Power: 0.25 kW
- Voltage: 230/400 V, Δ/Y
- Current: 1.0/0.58 A
- Frequency: 50 Hz
- Design: 4-pole
- Speed: 1445 rpm

732 202	Squirrel cage motor basic 230/400, brake 0.3

Similar to illustration

Squirrel cage motor basic 400/690/0.3

Industrial three-phase asynchronous motor with squirrel cage rotor, one shaft end.

Technical data:

- Class: 0.3
- Power: 0.25 kW
- Voltage: 400/692 V, Δ/Y
- Current: 1.0/0.58 A
- Frequency: 50 Hz
- Design: 4-pole
- Speed: 1445 rpm

732 203	Squirrel cage motor basic 400/690/0.3

Similar to illustration

Capacitor motor CS basic 0.3

Industrial single phase alternating current motor with centrifugal switch, start and operation condenser and one shaft extension end.

Technical data:

- Power: 0.25 kW
- Voltage: 230 V
- Current: 1.0/0.58 A
- Frequency: 50 Hz
- Design: 4-pole
- Speed: 1440 rpm

732 204	Capacitor motor CS basic 0.3

Motor protection switches

Cat.-No.	Designation
732 13	Motor protection switch, 0.6-1 A
732 14	Motor protection switch, 1-1.6 A
732 83	Motor protection switch, 1.6-2.4 A
732 84	Motor protection switch, 2.4-4 A
733 54	Motor protection switch, 6-10 A

Squirrel cage motor D 0.3

Three-phase asynchronous motor with squirrel cage rotor, Dahlander circuit, pole reversible. Industrial design with one shaft end.

Technical data:

- Power: 0.25/0.37 kW
- Voltage: 400 V, Δ/Y-Y
- Current: 1.0/1.1 A
- Frequency: 50 Hz
- Power factor: 0.62/0.75
- Design: 4/2-pole
- Speed: 1400/2800 rpm

732 24	Squirrel cage motor D 0.3

Squirrel cage motor SW 0.3

Three-phase asynchronous motor with squirrel cage rotor, 2 separate windings, pole reversible.

Technical data:

- Power: 0.11/0.20 kW
- Voltage: 400 V, Y/Y
- Current: 0.6/0.7 A
- Frequency: 50 Hz
- Power factor: 0.71/0.72
- Design: 6/2-pole
- Speed: 880/1390 rpm

732 26	Squirrel cage motor SW 0.3

Multi-function machine 0.3

Three-phase multi-function machine, can be used as slip ring motor or as synchronous machine for motor and generator operation.

Technical data:

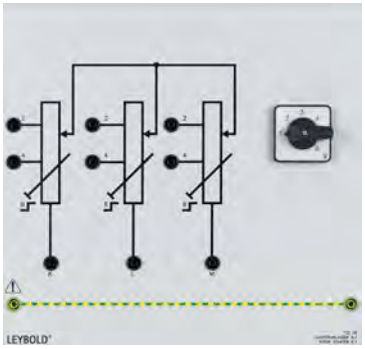
Operation as asynchronous motor

- Power: 0.27 kW
- Voltage: 230/400 V, Δ/Y
- Current: 1.44/0.83 A
- Frequency: 50 Hz
- Power factor: 0.7
- Design: 4-pole
- Speed: 1360 rpm

Operation as synchronous motor

- Power: 0.27 kW
- Voltage: 230/400 V, Δ/Y
- Current: 0./0.52 A
- Excitation voltage: 20 V
- Excitation current: 4 A
- Frequency: 50 Hz
- Power factor: 1
- Design: 4-pole
- Speed: 1500 rpm

732 28	Multi-function machine 0.3



Rotor starter 0.3

Three resistors, synchronously adjustable in 6 steps, for slip ring motors and 0.3 kW multi-function machines.

Technical data:

- Resistance values of switch steps: 20/10/5.5/2.5/1/0 Ω
- Additional fixed taps at: 10/2.5 Ω

732 29	Rotor starter 0.3

Slip-ring motor 0.3

Three-phase asynchronous motor with slip ring rotor.

Technical data:

- Power: 0.27 kW
- Voltage: 230/400 V, Δ/Y
- Current: 2/1.16 A
- Frequency: 50 Hz
- Power factor: 0.72
- Design: 4-pole
- Speed: 1340 rpm

732 33	Slip-ring motor 0.3

Synchronous machine SP 0.3

Three-phase synchronous machine with salient pole rotor and damper cage for motor and generator operation.

Technical data:

- Power: 0.3 kW
- Voltage: 400 V, Y
- Current: 0.43 A
- Excitation voltage: max.140 V
- Excitation current: max.0.55 A
- Frequency: 50 Hz
- Power factor: 1/0.8
- Design: 4 pole
- Speed: 1500 rpm

732 36	Synchronous machine SP 0.3

Synchronous machine SR 0.3

Three-phase synchronous machine with smooth-core rotor and damper cage for motor and generator operation.

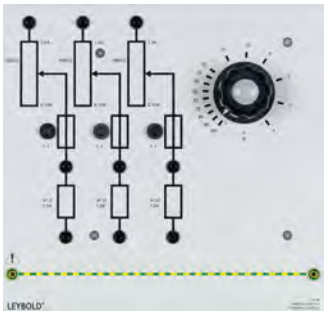
Technical data:

Motor operation

- Power: 0.3 kW
- Voltage: 230/400 V, Δ/Y
- Current: 0.66/1.14 A
- Excitation voltage: max.150 V
- Excitation current: max.0.95 A
- Frequency: 50 Hz
- Power factor: 0.97
- Design: 4-pole
- Speed: 1500 rpm

732 37	Synchronous machine SR 0.3

Resistive load 0.3



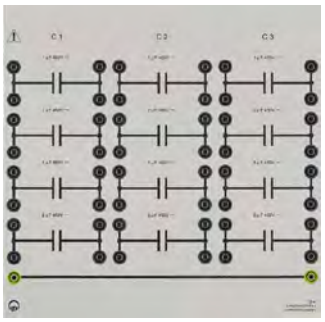
Three synchronously adjustable circular rheostats (step winding) with scale (100 - 0%), each with a series resistor and fuse in the sliding-contact connection, suitable for parallel, series, star and delta circuits.

Technical data:

- Resistance: 3 x 1800 Ω
- Series resistance: 3 x 47 Ω
- Current: 3 x 1 A

732 40	Resistive load 0.3

Capacitive load 0.3



Three groups of MP capacitors, each consisting of four capacitors, suitable for parallel, series, star and delta circuits.

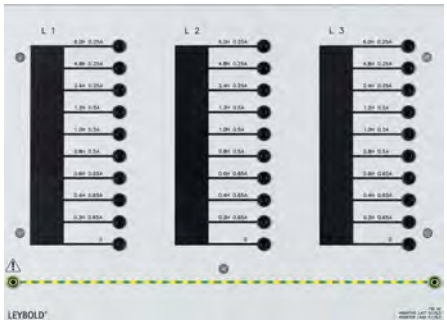
Technical data:

Capacitors:

- 3 x 1/2/4 µF, 450 V
- 3 x 8 µF, 400 V

732 41	Capacitive load 0.3

Inductive load 0.3/1.0



Three inductors with taps suitable for parallel, series, star and delta circuits.

Technical data:

Inductors:

- 0.2/0.4/0.6 H (0.65 A)
- 0.8/1.0/1.2 H (0.5 A)
- 2.4/4.8/6.0 H (0.25 A)

732 42	Inductive load 0.3/1.0

Flywheel 0.3

Suitable for determining friction losses in electrical machines with the aid of run-down experiments. In the case of electrical machines with exciter circuits, the iron and copper losses can also be determined. In the case of two and four quadrant drives, the energy recovery into the mains can be enlarged using the flywheel.

Technical data:

- Class: 0.3
- Speed: max. 3000 rpm
- Inertial torque: 0.006 kg m^2

732 44	Flywheel 0.3

Reluctance motor 0.3

Three-phase synchronous motor without separate excitation.

Technical data:

- Power: 0.25 kW
- Voltage: 380 V Δ
- Current: 1.5 A
- Frequency: 50 Hz
- Power factor: 0.45
- Design: 4-pole
- Speed: 1500 rpm

732 45	Reluctance motor 0.3

Motor with FCC 0.3

FCM 305 industrial frequency converter motor from the DANFOSS FCM 300 series, with 0.55 kW four-pole three-phase asynchronous motor and attached VLT® frequency converter. With optimum frequency converter and motor integration performed by the manufacturer. Standard start/stop and jog operating modes with variable speed carried out using the components already integrated into the motor cover.

Technical data:

- PROFIBUS DP/RS 485 compatible.
- Motor output power: 0.55 kW
- Mains voltage range: 3x 380...480 V ±10%
- Input current: 1.4 A (380 V), 1.1 A (480 V)
- Mains frequency: 50/60 Hz
- Power factor cos ϕ: 0.88/1.0 at nominal load
- Frequency range: 0...132 Hz
- Protection against: excess temperature, phase failure, under and over-voltage, voltage spikes

Socket assignment on the motor cover (4-mm safety sockets with PELV electrical isolation):

- START, JOG, RESET: with respect to internal +24 V, suitable for PLC programmable control.
- ANALOG 1 IN: with respect to internal +10 V, suitable for automatic control applications
- ANALOG 2 IN: 0...20 mA (with respect to the GND socket, measurement current loop input)
- ANA/DIG OUT: 0...20 mA/high-low level
- Mains connection: 4-mm safety sockets L1, L2, L3, PE
- PROFIBUS connection: 9-pin sub-D socket, contact assignment in conforming to EN 50170

Scope of delivery:

- Including technical documentation and software for setting parameters, observing and documenting the frequency converter.

732 46	Motor with FCC 0.3

Motor with FCC 1.0

FCM 311 industrial frequency converter motor from the DANFOSS FCM 300 series, with 1.1 kW four-pole three-phase asynchronous motor and attached VLT® frequency converter. With optimum frequency converter and motor integration performed by the manufacturer. Standard start/stop and jog operating modes with variable speed carried out using the components already integrated into the motor cover.

Technical data:

- PROFIBUS DP/RS 485 compatible.
- Motor output power: 1.1 kW
- Mains voltage range: 3x 380...480 V ±10%
- Input current: 2.5 A (380 V), 2.0 (480 V)
- Mains frequency: 50/60 Hz
- Power factor cos ϕ: 0.88/1.0 at nominal load
- Frequency range: 0...132 Hz
- Protection against: excess temperature, phase failure, under and over-voltage, voltage spikes

Socket assignment on the motor cover (4-mm safety sockets with PELV electrical isolation):

- START
- JOG
- RESET: with respect to internal +24 V, suitable for PLC programmable control.
- ANALOG 1 IN: with respect to internal +10 V, suitable for automatic control applications
- ANALOG 2 IN: 0...20 mA (with respect to the GND socket, measurement current loop input)
- ANA/DIG OUT: 0...20 mA/high-low level
- Mains connection: 4-mm safety sockets L1, L2, L3, PE
- PROFIBUS connection: 9-pin sub-D socket, contact assignment in conforming to EN 50170

732 49	Motor with FCC 1.0

Coupling 1.0

Rubber coupling sleeve for mechanical connection of two electrical machines of the 1.0 kW series.

732 56	Coupling 1.0

Shaft end guard 1.0

Attachable guard for protection against contact with electrical machine rotating parts of the 1.0 kW series.

732 57	Shaft end guard 1.0

Coupling guard 1.0

Attachable guard for protection against contact with electrical machine rotating parts of the 1.0 kW series.

732 58	Coupling guard 1.0

DC multi-function machine 1.0

DC multi-function machine for motor and generator operation, can be used as shunt, series, or compound wound machine, series and shunt winding with tap for compounding, with commutating winding and compensation winding. All windings are separately connected to 4 mm safety sockets.

Technical data:

Operation as compound wound motor

- Class: 1.0
- Power: 0.75 kW
- Voltage: 220/135 V
- Current: 4.8/5,8/5,4 A
- Excitation voltage: 220 V
- Excitation current: 0.24 A
- Speed: 2000/1700 rpm
- International protection code: IP 20
- Insulation system: B/F

732 60	DC multi-function machine 1.0

Similar to illustration

Shunt wound machine 1.0

DC shunt wound machine for motor and generator operation, with commutating winding and compensation winding. All windings are separately connected to 4-mm safety sockets.

Technical data:

Motor operation

- Class: 1,0
- Power: 1.0 kW
- Voltage: 220 V
- Current: 6.2 A
- Excitation voltage: 200 V
- Excitation current: 0.25 A
- Speed: 2100 rpm
- International protection code: IP 20
- Insulation system: B/F

732 61	Shunt wound machine 1.0

Similar to illustration

Series wound machine 1.0

DC series wound machine for motor and generator operation, with commutating winding and compensation winding. All windings are separately connected to 4-mm safety sockets.

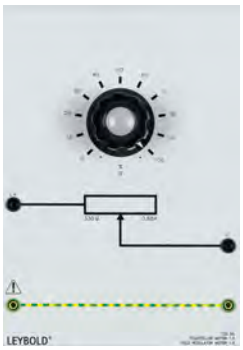
Technical data:

Motor operation

- Class: 1.0
- Power: 1.0 kW
- Voltage: 220 V
- Current: 6.5 A
- Speed: 2200 rpm
- International protection code: IP 20
- Insulation system: B/F

732 62	Series wound machine 1.0

Similar to illustration



Starter 1.0

Circular rheostat (step winding) with scale 100 - 0 % for starting DC motors 1.0 kW.

Technical data:

- Resistance: 13 Ohm
- Current: 8.5 A

732 64	Starter 1.0

Field regulator, motor 1.0

Circular rheostat with scale 0 - 100 % for adjusting the excitation in DC shunt and compound wound motors 1.0 kW.

Technical data:

- Resistance: 330 Ohm
- Current: 0.68 A

732 65	Field regulator, motor 1.0

Machine test system 1.0

Equipment set for recording the characteristics of electrical machines of the 1 kW class, consisting of:

- Cradle-type three-phase asynchronous machine
- Control unit

Cradle-type three-phase asynchronous machine
Squirrel-cage rotor on oscillating bearing with integrated torque pick-up for recording speed, plus stainless steel bending bar with strain gauge for measuring torque. This specially-designed machine can drive any of the machines contained in the electrical machine system 1.0 kW power class and brake any of them down to a standstill. Power is supplied from a control unit via a 7-pole connecting cable with round 7-pin connector, while signals are transmitted via a fixed cable with D-Sub plug connectors.

Control unit
Microcontroller equipped device with integrated frequency converter for the power supply and control of the cradle-type three-phase asynchronous machine. Display of speed and torque of the machine under test. Manual and automatic recording of the characteristics in all four quadrants of the speed/torque plane. Connection to the PC via USB port.

Technical data:

- Automatic digital speed control: ±5000 rpm
- Automatic digital torque control: ±19.9 Nm
- Automatic recording of run-up and load characteristics
- Load simulations: flywheel, freely adjustable fan drive (M~ kn^2) freely adjustable winding drive (M~ k/n), lift drive (constant torque)
- Characteristics recorded in accordance with user specifications (Mi=ni)
- External control: ±10 V
- Seven-segment display, 25 mm high
  Speed: 4 digits
  Torque: 3 digits
- Parallel operation is possible with the help of the software
- Temperature monitoring:
  Machine under test
  Cradle-type three-phase asynchonous machine
  Control unit
- Shaft guard monitoring: system shut-down with protection for unintended system start
- Four quadrant display with LEDs for operating mode of the machine under test
- Adjustable torque limiting (overload protection) and stop speed (for automatic characteristic recording)
- RMS measurement: three inputs for voltage measurement (V_{max}=600 V AC/DC), one input for current measuring (I_{max}=15 A AC/DC), all suitable for frequency converter
- USB connection for transmission of measured values and remote control via software CBM 10
- Highest security standards: leakage current <5 mA
- Power supply: 230 V, 47 ... 62 Hz, 2 kW

Scope of delivery:

- Mains lead with earth-contact plug
- Demo version of software CBM 10
- USB cable, 3 m
- 25-pole connecting cable
- Supply cable for cradle-type machine
- Dynamometer
- Cylindrical bar

732 689USB	Machine test system 1.0

Universal motor 1.0

For operation with 230 V AC or DC.

Technical data:

- Class: 1.0
- International protection code: IP 20
- Insulation system: B/F

Ratings for connection to AC:

- Power: 0.75 kW
- Voltage: 230 V
- Current: 5.2 A
- Frequency: 50 Hz
- Power factor: 0.78
- Speed: 2650 rpm

Ratings for connection to DC:

- Power: 0.8 kW
- Voltage: 220 V
- Current: 5.2 A
- Speed: 2650 rpm

732 70	Universal motor 1.0

Similar to illustration

Interference suppressor filter 1.0

Two-stage interference suppressor filter with two current-compensated chokes each and two class X and Y capacitors each for the disturbance suppression of the 1.0 kW universal motor and 1.0 kW repulsion motor. The filter is connected between the mains and machine and reduces the machine's output of line-bound disturbance signals in a low-voltage network in accordance with EN 5008-1.

Technical data:

- V = 110/250 V, 50/60 Hz
- I_N = 10 A

732 71	Interference suppressor filter 1.0

Repulsion motor 1.0

With adjustable brushes for change of speed and direction.

Technical data:

- Class: 1.0
- Setting range: -2900...0...+2900 rpm
- Power: 1.0 kW
- Voltage: 230 V
- Current: 10.2 A
- Frequency: 50 Hz
- Power factor: 0.65
- Speed: 2900 rpm
- International protection code: IP 20
- Insulation system: B/F

732 72	Repulsion motor 1.0

Similar to illustration

Auxiliary phase motor R 1.0

Single-phase AC motor with starting relay and bifilar starter winding.

Technical data:

- Power: 0.75 kW
- Voltage: 220 V
- Current: 5.8 A
- Frequency: 50 Hz
- Power factor: 0.81
- Design: 2-pole
- Speed: 2870 rpm

732 73	Auxiliary phase motor R 1.0

Similar to illustration

Capacitor motor R 1.0

Single-phase AC motor with starting relay, starting and operating capacitor.

Technical data:

- Power: 1.0 kW
- Voltage: 230 V
- Current: 6.4 A
- Frequency: 50 Hz
- Power factor: 0.99
- Design: 2-pole
- Speed: 2790 rpm

732 74	Capacitor motor R 1.0

Similar to illustration

Capacitor motor F 1.0

Single-phase AC motor with centrifugal switch, starting and operating capacitor. Industrial design with one shaft end.

Technical data:

- Class: 1.0
- Power: 1.1 kW
- Voltage: 230 V
- Current: 6.6 A
- Frequency: 50 Hz
- Power factor: 0.98
- Starting capacitor: C_A= 80 µF
- Operating capacitor C_B= 30 µF
- Design: 4-pole
- Speed: 1400 rpm
- International protection code: IP 20
- Insulation system: F

732 76	Capacitor motor F 1.0

Squirrel cage motor 230/400 1.0

Three-phase asynchronous motor with squirrel cage rotor, industrial design with one shaft end.

Technical data:

- Class: 1.0
- Power: 1.0 kW
- Voltage: 230/400 V, Δ/Y
- Current: 4.6/2.7 A
- Frequency: 50 Hz
- Power factor: 0.83
- Design: 4-pole
- Speed: 1410 rpm
- International protection code: IP 20
- Insulation system: F

732 804	Squirrel cage motor 230/400 1.0

Similar to illustration

Squirrel cage motor 400/690 1.0

Three-phase asynchronous motor with squirrel cage rotor and distinct pull-out torque.

Technical data:

- Class: 1.0
- Power: 1 kW
- Voltage: 400/690 V, Δ/Y
- Current: 2.5/1.44 A
- Frequency: 50 Hz
- Power factor: 0.79
- Design: 4-pole
- Speed: 1405 rpm
- International protection code: IP 20
- Insulation system: B

732 81	Squirrel cage motor 400/690 1.0

Similar to illustration

Squirrel cage motor D 1.0

Three-phase asynchronous motor with squirrel cage rotor, Dahlander circuit, pole reversible. Industrial design with one shaft end.

Technical data:

- Power: 0.75/1.1 kW
- Voltage: 400 V, Δ/Y-Y
- Current: 1.8/2.7 A
- Frequency: 50 Hz
- Power factor: 0.8/0.84
- Design: 4/2 pole
- Speed: 1425/2850rpm

732 94	Squirrel cage motor D 1.0

Similar to illustration

Squirrel cage motor SW 1.0

Three-phase asynchronous motor with squirrel cage rotor, 2 separate windings, pole reversible. Industrial design with one shaft end.

Technical data:

- Power: 0.4/1.0 kW
- Voltage: 400 V, Y/Y
- Current: 1.6/3.1 A
- Frequency: 50 Hz
- Power factor: 0.64/0.76
- Design: 6/2-pole
- Speed: 930/2870 rpm

732 96	Squirrel cage motor SW 1.0

Similar to illustration

Multi-function machine 1.0

Three-phase multi-function machine with slip ring rotor can be used as induction machine or as synchronous machine for motor and generator operation.

Technical data:

- Class: 1.0
- International protection code: IP 20
- Insulation system: B/F

Ratings for operation as slip ring motor:

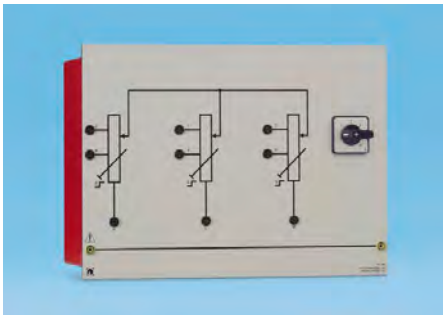
- Power: 0.8 kW
- Voltage: 230/400 V, Δ/Y
- Current: 3.5/2.0 A
- Frequency: 50 Hz
- Power factor: 0.75
- Design: 4-pole
- Speed: 1400 rpm

Ratings for operation as synchronous motor:

- Power: 0.8 kW
- Voltage: 230/400 V, Δ/Y
- Current: 2.6/1.5 A
- Excitation voltage: 24 V
- Excitation current: 11 A
- Frequency: 50 Hz
- Power factor: 1.0
- Design: 4-pole
- Speed: 1500 rpm

732 98	Multi-function machine 1.0

Similar to illustration



Rotor starter 1.0

Three resistors, synchronously adjustable in 6 steps, for slip ring motor and 1.0 kW multi-function machine.

Technical data:

- Resistance values of switch steps: 10/5/2.75/1.25/0.5/0 Ω
- Additional fixed taps at: 5/1.25 Ω

732 99	Rotor starter 1.0

Slip-ring motor 1.0

Three-phase asynchronous motor with slip ring rotor.

Technical data:

- Class: 1.0
- Power: 1.0 kW
- Voltage: 230/400 V, Δ/Y
- Current: 4.8/2.8 A
- Frequency: 50 Hz
- Power factor: 0.71
- Design: 4-pole
- Speed: 1420 rpm
- International protection code: IP 20
- Insulation system: B/F

733 03	Slip-ring motor 1.0

Similar to illustration

Synchronous machine SP 1.0

Three-phase synchronous machine with salient pole rotor and damper cage for motor and generator operation.

Technical data:

Ratings for motor operation

- Class: 1.0
- Power: 1.0 kVA / 0.8 kW
- Voltage: 400 V, Y
- Current: 1.52 A
- Excitation voltage: max. 220 V
- Excitation current: max. 0.6 A
- Frequency: 50 Hz
- Power factor: 0.8-1-0.8
- Design: 4-pole
- Speed: 1500 rpm
- International protection code: IP 20
- Insulation system: B/F

733 06	Synchronous machine SP 1.0

Similar to illustration

Synchronous machine SC 1.0

Three-phase synchronous machine with smooth core rotor and damper cage for motor and generator operation.

Technical data:

Ratings for motor operation

- Class: 1.0
- Power: 0.8 kVA / 0.8 kW
- Voltage: 230/400 V, Δ/Y
- Current: 2.66/1.52 A
- Excitation voltage: max.220 V
- Excitation current: max.1.6 A
- Frequency: 50 Hz
- Power factor: 0.8-1-0.8
- Design: 4-pole
- Speed: 1500 rpm
- International protection code: IP 20
- Insulation system: B/F

733 07	Synchronous machine SC 1.0

Similar to illustration

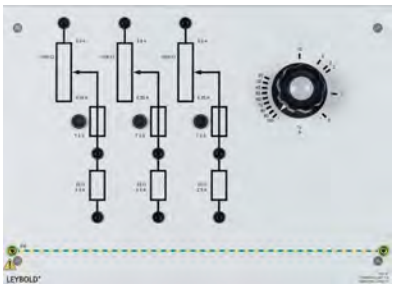
Resistive load 1.0

Three synchronously adjustable circular rheostats (step winding) with scale (100 - 0%), each with a series resistor and fuse in the sliding-contact connection, suitable for parallel, series, star and delta circuits.

Technical data:

- Resistance: 3 x 1000 Ω
- Series resistance: 3 x 22 Ω
- Current: 3 x 2.5 A

733 10	Resistive load 1.0



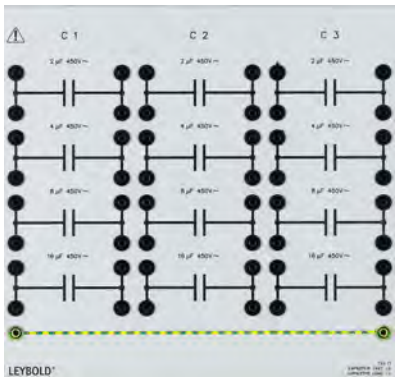
Capacitive load 1.0

Three groups of MP capacitors, each consisting of four capacitors, suitable for parallel, series, star and delta circuits.

Technical data:

- Capacitances:
  3 x 2/4 µF, 450 V
  3 x 8/16 µF, 400 V

733 11	Capacitive load 1.0



Flywheel 1.0

Suitable for determining friction losses in electrical machines with the aid of run-down experiments. In the case of electrical machines with exciter circuits, the iron and copper losses can also be determined. In the case of two and four quadrant drives, the energy regenerating into the mains can be prolonged using the flywheel.

Technical data:

- Class: 1.0
- Speed: max. 3000 rpm
- Inertial torque: 0.03 kg m²

733 14	Flywheel 1.0

Similar to illustration

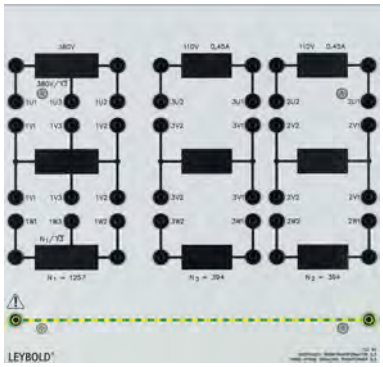
Three-phase transformer 0.3

Suitable for all circuit configurations. All connections via 4-mm safety sockets.

Technical data:

- Power: 300 VA
- Primary: 3 x 400/230 V, 50 Hz
- Secondary: 3 x 2 x 115 V

733 90	Three-phase transformer 0.3



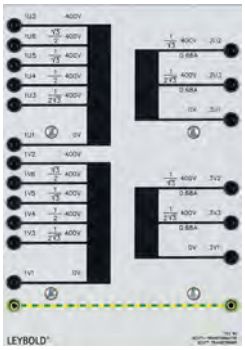
Three-phase transformer 1.0

Suitable for all circuit configurations. All connections via 4-mm safety sockets.

Technical data:

- Power: 1000 VA
- Primary: 3 x 400/230 V, 50 Hz
- Secondary: 3 x 2 x 115 V

733 91	Three-phase transformer 1.0



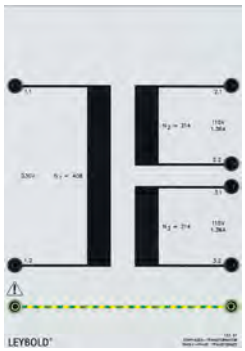
Scott transformer

For transforming from a two-phase to a three-phase mains and vice-versa using a Scott circuit. It can also be used as a three-phase isolating transformer for transformation of 3 x 115/230/400 V into 3 x 115/230 V and vice-versa.

Technical data:

- All connections via 4-mm safety sockets
- Power: 2 x 150 VA
- Primary: 2 x 115/200/230/346/400 V, 50 Hz
- Secondary: 2 x 115/230 V

733 93	Scott transformer



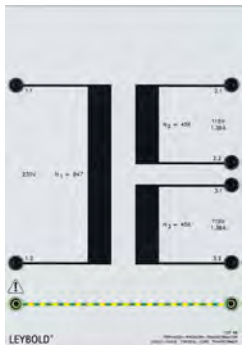
Single-phase transformer 0.3

All connections via 4-mm safety sockets.

Technical data:

- Power: 300 VA
- Primary: 230 V, 50/60 Hz
- Secondary: 2 x 115 V

733 97	Single-phase transformer 0.3



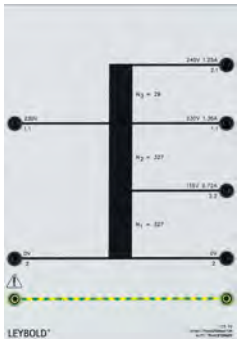
AC toroidal core transformer 0.3

All connections via 4-mm safety sockets.

Technical data:

- Power: 300 VA
- Primary: 230 V, 50 Hz
- Secondary: 2 x 115 V

733 98	AC toroidal core transformer 0.3



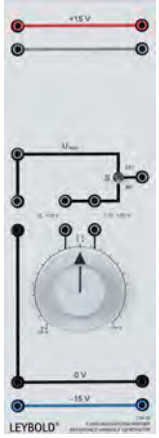
AC autotransformer 0.3

All connections via 4-mm safety sockets.

Technical data:

- Power: 300 VA
- Primary: 230 V, 50 Hz
- Secondary: 115/230/240 V

733 99	AC autotransformer 0.3



Reference variable generator

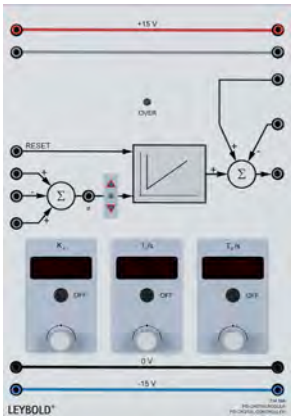
For the generation of a setpoint value, with linear division of the reference variable potentiometer.

Technical data:

- Output: 0...+10 V can be reconnected to -10...+10 V using bridging plug.
- Output can be switched over to an external reference voltage V_{REF} with the toggle switch or to 0 V using a bridging plug.
- Supply voltage: ±15 V DC

734 02	Reference variable generator

PID digital controller



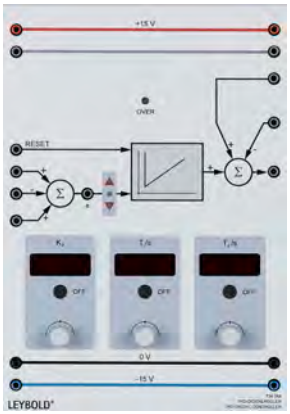
Standard industrial compact controller with fast microprocessor support for use as P, PI, PD or PID controller for continuous closed-loop control systems. With input summing point for two reference variables and one controlled variable, measurement point for error signal, tendency indication of the error signal with 3 LEDs, I and D elements can be switched off individually, I element can be reset via separate input (I_{OFF}). Including output summing point for adding or subtracting operations of disturbance variables. Manual selection of controller parameters with buttons and digital encoders. Representation of actual parameters on three four-digit 7-segment displays. Overload indication via three colour LED.

Technical data:

- Signal voltage range: -10 V...+10 V
- Sampling interval: 50 µs
- Proportional rate K_P: 0.1...100
- Correction time T_N: 0.1 s...100 s
- Rate time T_V: 0,1 s...100 s
- Selection of controller parameters with button s and digital encoder
- Representation of actual parameters on 7-segment displays
- Overload indication via three-colour LED
- Supply voltage: ±15 V DC

734 064	PID digital controller

PID digital controller Net



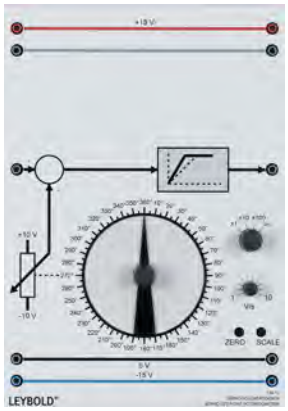
Standard industrial compact controller using 32-bit architecture for integration into the LeyLab network. The internal ARM microprocessor excels in a high sampling rate and a fast control response. The controller is used for continuous closed-loop systems e.g. in P, PI, PD or PID configuration. With input summing point for two reference variables and one controlled variable, measurement point for error signal, tendency indication of the error signal with three LEDs. P,I and D elements can be switched off individually. The I element can be reset via separate input (RESET). Including an output summing point for adding or subtracting of two external and one internal disturbance variables. The internal disturbance variable can be activated via the LAN. Manual selection of controller parameters with buttons and digital encoders. Representation of actual parameters on three four-digit 7-segment displays. Overload indication via three colour LED.
Equipped with a RJ45 socket for LAN operation. Internal control by the software *LEYLAB.control* 725006 or *LEYLAB. control Lite* 725007 to set and record the controller parameters from a central master PC and to generate disturbances. Suitable for use with patented „Learning networks" system

Technical data:

- Signal voltage range: -10 V...+10 V
- Sampling interval: 50 µs
- Proportional rate K_P: 0.1...100
- Correction time T_N: 0.1 s...100 s
- Rate time T_V: 0,1 s...100 s
- Selection of controller parameters with button s and digital encoder
- Representation of actual parameters on 7-segment displays
- Overload indication via three-colour LED
- Supply voltage: ±15 V DC

734 064N	PID digital controller Net

Servo setpoint generator

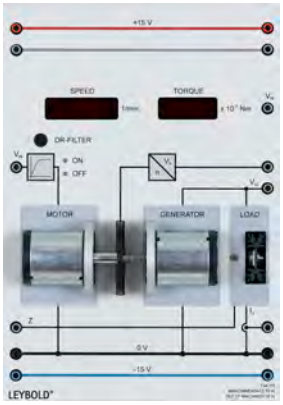


Position pick-up with rotating angular disc for application in servo systems. With input summing point for forward feeding of disturbance variables or for setpoint variable change and with connectable rate-of-change limiter with rise times of 1 V/s up to 1000 V/s.

Technical data:

- Signal voltage range: -10 V...+10 V
- Rotating angle:
  Mechanical 360° without limit stop
  Electrical 340° ±5°
- Fine setting of zero-point and scale factor
- Coarse setting with rotary switch
- Fine setting with potentiometer
- Supply voltage: ±15 V DC

734 10	Servo setpoint generator



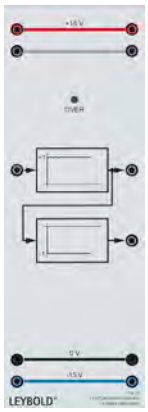
Set of machines 10 W

The set of 10 W machines is a technical controlled system for experiments on speed and voltage control. It consists of an electrical drive including digital speed sensing, a generator machine and an electronic load. Using the adjustable load, real generator operation can be investigated. The machine set makes it possible to measure the load characteristic of the generator and the dynamic behaviour of systems of higher order. A microprocessor controlled power module supplies the drive machine. Thus no external power amplifier is required. The set of machines comes with 7-segment displays for the measurement of speed and torque.

Technical data:

- Speed: 3000 rpm max.
- Control voltage: ±10 V
- Tachogenerator: ±10 V
- Switchable prefilter, time constant T = 800 ms
- Power consumption: 10 W max.
- Generator efficiency: 40%
- Supply voltage: ± 15 V DC

734 111	Set of machines 10 W



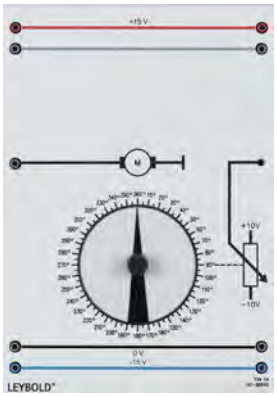
Power amplifier

Used for operating the simulated controlled system models. Two amplifier stages each with a voltage gain of +1 and -1, symmetrical operation possible with voltage gain of 2.

Technical data:

- Signal voltage range: -10 V...+10 V
- Output voltage range: -10 V...+10 V with respect to earth or symmetrical 0...± 20 V
- Output power: max. 30 W, short-circuit proof
- Supply voltage: ±15 V DC

734 13	Power amplifier



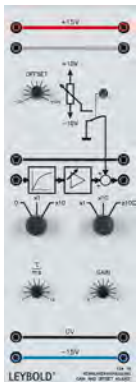
DC servo

Motor potentiometer with 360° mechanical rotation angle without limit, electrical rotation angle 340° ±5°, with DC motor and friction wheel drive, as model of an integral controlled system without compensation with negligible dead time, can also be used in a closed-loop positioning control system.

Technical data:

- Controlled system output signal (controlled variable): -10 V...+10 V
- Supply voltage: ±15 V DC

734 14	DC servo



Gain and offset adjust

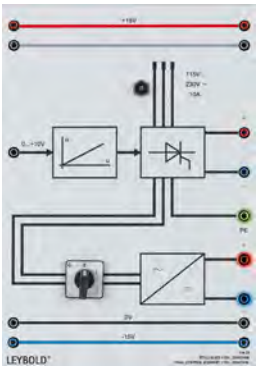
For the adjustment and matching of external signals to the normal voltage used in automatic control systems.

Technical data:

- Input voltage range: -50 V...+50 V
- Level matching via adjustable gain: 0...1, 0...10, 0...100
- Smoothing of pulsating signals:
  Time constants τ: 0.1...10 ms, 10...100 ms
- Offset voltage, switchable: -10 V...+10 V
- Coarse setting via rotary switch
- Fine setting via potentiometer
- Supply voltage: ±15 V DC

734 19	Gain and offset adjust

Actuator, 115...230 V/1 kW



For the connection of mains-operated DC motors 0.1 kW...1.0 kW. Electrical isolation between the control and the load side.

Technical data:

- Signal voltage range (manipulated variable): 0...+10 V
- Output voltage of the thyristor half-bridge: 0...V_{mains} with a max. load of 1.0 kW
- Built-in automatic circuit-breaker (T 10 A) triggered thermally and for overcurrent
- Output voltage for excitation: $V_{DC} = f(V_{mains})$, max. 10 A
- Outputs: 4-mm safety sockets
- Mains connection for thyristor half-bridge: 115...230 V, 48...62 Hz
- Supply voltage: ±15 V DC

Scope of delivery:

- Mains lead and earth-contact plug

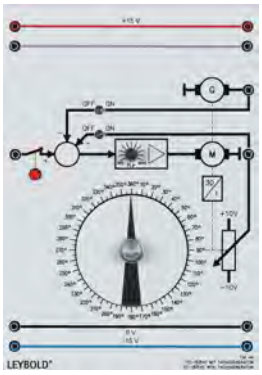
734 22	Actuator, 115...230 V/1 kW

Weight disc with hook

To increase the moment of inertia for cat. no. 73444.

734 36	Weight disc with hook

DC servo with tachogenerator



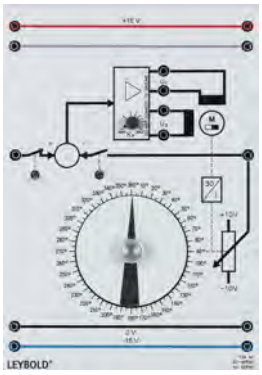
Motor-potentiometer combination with gear mechanism, control amplifier and angle code disc with toothed belt pinion.

Technical data:

- Control range: 270°
- Linearity: 1%
- Output voltage range: ±10 V
- Short-circuit proof

734 44	DC servo with tachogenerator

AC servo



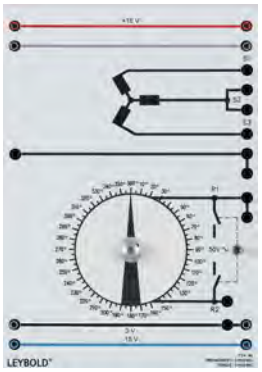
Motor-potentiometer combination with gear mechanism, control amplifier and angle code disk with toothed belt pinion.

Technical data:

- Control range: 270°
- Output voltage range: ±10 V
- Short-circuit proof

734 45	AC servo

Torque synchro



For use as rotating-field transmitter and receiver („electric waves").

Technical data:

- 360° system with three-phase output.
- Linearity: 1%
- Switchable 50 V (60 V) AC voltage rotor excitation via built-in mains supply (110 V - 240 V, 50 - 60 Hz)
- Angle code disc with pinion for coupling via toothed belt

734 46	Torque synchro

WinFACT COM3LAB/CASSY edition, german

WinFACT (Windows Fuzzy and Control Tools), German version, modularly designed software program for the analysis, synthesis and simulation of conventional automatic control systems. Single user licence. Allows integration of CASSY interfaces, cat. no. 524 013, 524 016 and COM3LAB master unit, cat. no. 700 00USB as processing interfaces.

Technical data:

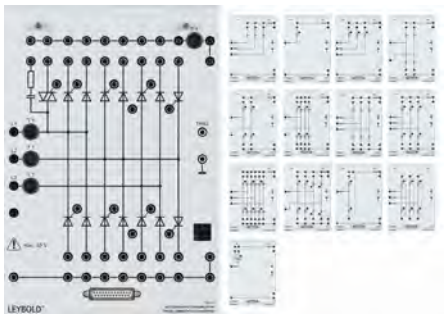
Contents

- **BORIS** (Block-oriented simulation, 15 blocks):
  Control-loop simulation, measurement data acquisition and processing, open-loop and closed-loop control. Endless, single-step and real-time simulation. Comprehensive system block library, exportable project documentation.
- **INGO** (Intelligent Graphic Interface):
  Graphic representation of the following WinFACT files:
  Simulation results (SIM extension)
  General value pairs (XY extension)
  Trajectory fields (MXY extension)
  Bode plot (BD extension)
  Locus curves (OK extension)
  3D family of characteristics or height lines (FWM extension)

System requirements

- Windows XP/Vista/7/8, two free USB ports

734 481	WinFACT COM3LAB/CASSY edition, german



Phase-commutated converter

Phase-commutated converter consisting of:

- 8 thyristors
- 6 diodes
- 1 triac with optional RC circuitry
- Compact universal converter for all conventional converter circuits, e.g. uncontrolled and controlled rectifiers, inverters, 4-quadrant operation

Control is effected via floating-potential signals transmitted along a 25-pole conductor cable from the converter control unit (735 112).

Technical data:

- Overload protection via fast-blow fuses
- Snubber circuit
- Mains connection: max. 230 V
- Output current: max. 1 A
- Trigger output
- Gate control signals accessible as floating potential signals

Scope of delivery:

Set of 13 overlay masks *phase-commutated converter*
Detection of the applied mask is automatic, thus establishing a preset base state in the converter controller unit (735 122) to prevent the destruction of components through incorrect control commands, thereby simplifying operation of the controller unit. The supplied overlay masks reduce considerable the effort for the experiment set up. Overlay masks do not physically cover necessary connections, they do graphically show the given circuit as a schematic:

- M1/M3, uncontrolled
- M1, controlled
- M3, controlled
- B2, uncontrolled
- B2, controlled
- B2, (un-)controlled for 3 half-waves
- B6, uncontrolled
- B6, controlled
- B6, (un-)controlled for 2 half-waves
- B2, doubled for polarity reversal (B2C)A(B2C
- W1, anti-parallel 1p
- W3, anti-parallel 3p
- Triac

735 012	Phase-commutated converter

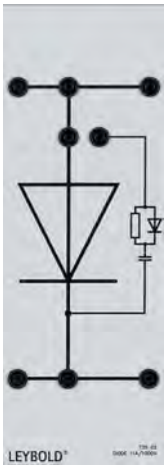
Diode, 1000 V/10 A

Fast-acting silicon rectifier diode with RCD suppressor circuit, which can be switched off, for the assembly of uncontrolled rectifier circuits or use as free-wheeling diode.

Technical data:

- Periodic repetitive peak reverse-bias voltage (V_{RRM}): max. 1000 V
- On-state current ($I_{F\,RMS}$): max. 10 A

735 02	Diode, 1000 V/10 A



Rectifier B6, 3X400 V/10 A

Uncontrolled mains rectifier in three-phase bridge circuit for the generation of a DC voltage from a three-phase mains. For the generation of link voltages with converters, switched-mode power supplies and in drive technology.

Technical data:

- Nominal voltage ($V_{N\,RMS}$): 3 x 400 V
- Nominal current (I_{NAV}): 10 A
- Surge forward current (I_{FSM}): 300 A
- I^2t-value: 450 A^2s
- Conducting state voltage (V_F): 1 V (per diode)

735 065	Rectifier B6, 3X400 V/10 A

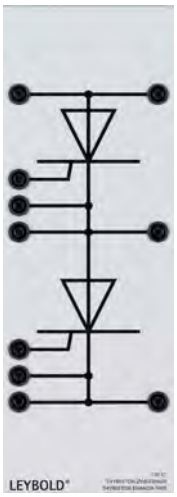
Thyristor branch pair, 1000 V/12 A

Two thyristors with high blocking capacity and RC suppressor circuit for the assembly of line-commutated rectifier and inverter circuits.

Technical data:

- Gate suppressor circuit
- Periodic repetitive peak reverse-bias voltage (V_{RRM}): max. 1000 V
- On-state current ($I_{F\,RMS}$): max. 12 A

735 07	Thyristor branch pair, 1000 V/12 A



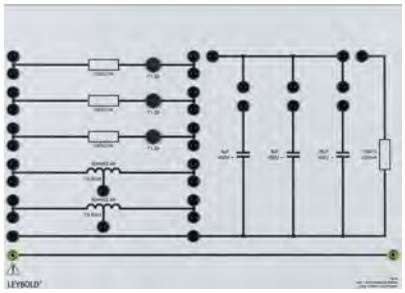
Load power electronics

Resistive, inductive and capacitive load for all single-phase and three-phase circuits in power electronics.

Technical data:

- 3 resistors 100 Ω, 1 A, with T 1.25 A fuse
- 1 resistor 1000 Ω, 220 mA
- 2 inductors 50 mH, 2.5 A, with tap at 12.5 mH
- 3 capacitors 4/8/16 µF, 450 V AC

735 09	Load power electronics



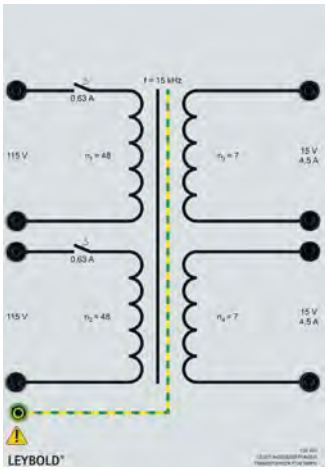
Capacitors 2x 1000 µF, 385 V

Two electrolytic capacitors which are short-circuit proof and switch-proof. For high performance in all application areas, especially for switched-mode and conventional power supplies or used to form DC voltage link. Built-in reverse voltage protection.

Technical data:

- Nominal capacitance: 2 x 1000 µF
- Nominal voltage: 385 V

735 095	Capacitors 2x 1000 µF, 385 V



Transformer for SMPS

Power transformer for primary switched-mode power supplies in a forward converter circuit. With the aid of four turn-off converter valves as well as two fast rectifiers, the following primary switched-mode power supplies can be implemented:

- Single-phase forward converter
- Push-pull converter with full-wave rectification
- Asymmetric half-bridge forward converter
- Full-bridge forward converter
- Owing to the shield winding the transformer is suitable for generating a reliable safety extra-low voltage in compliance with VDE 0100 (safety standards). The primary windings are equipped with thermal circuit breakers.

Technical data:

- Primary side:
  Input voltage (V_{in}): 2 x 115 V
  Winding: 2 x 48 turns
- Secondary side:
  Output voltage (V_{out}): 2 x 15 V/4.5 A
  Winding: 2 x 7 turns
- Nominal power (P_n): 135 VA
- Nominal frequency (f_n): > 15 kHz
- Protective-conductor terminal on the shield winding.

735 105	Transformer for SMPS

Converter controller unit

Microcontroller unit for line-commutated and self-commutated converters for setting up DC, AC and three-phase converters. Operation is performed manually via a selector and keys or via optional PC software.

Operational modes and operations for the line-commutated converter:

- Phase angle control for circuits: M1C, M3C, B2C, W1C, W3C, B6C, triac
- 4-quadrant mode: (B2C)A(B2C)
- Pulse group control (modulation packet control with zero-crossover switch)
- Control angle limitation
- 2 four-digit, 7-segment displays for control angle and three-phase indicator or duty cycle

Operational modes and operations for the self-commutated converter:

- Pulse width modulation
- Produces 3-phase alternating voltages with adjustable amplitude and frequency for the following types of commutation:
  block, trapezoidal, sine-wave, and VVC
- Single-phase high and low signal generator
- 2 four-digit, 7-segment displays for amplitude and frequency

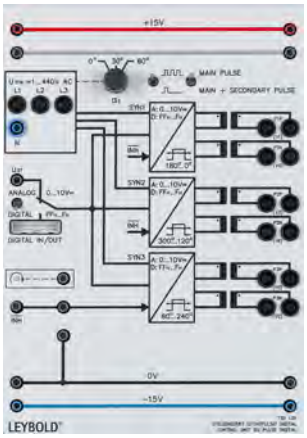
Technical data:

Connections:

- Analog input for external reference value (control angle, amplitude or frequency)
- USB port
- 25-pole male connector for attaching converter units (including connecting cable)
- Supply voltage via 12 V AC

735 122	Converter controller unit

Control unit six pulse, digital



Trigger pulse generator with analog and digital interface (8 bit) for connection to personal computer with CASSY interface in line-commutated, single-phase and three-phase rectifier and inverter circuits, as well as in AC and three-phase controllers.
The matching of the control unit to the converter circuit is carried out using several switches with the following options:

- Single pulse or pulse train operation possible
- Secondary pulse can be switched off (after 60°)
- Phase shift can be set for various natural commutating points: 0°, 30°, 60°

Reliable gate triggering of the valves is guaranteed for even small loads thanks to powerful gate trigger pulses and large voltage-time areas (500 µVs) of the trigger pulse. Rotating field monitoring:

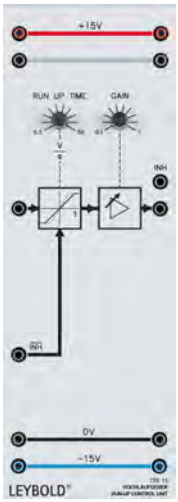
- Green LED when rotating field is clockwise
- Red LED when rotating field is anti-clockwise or for phase-failure

Technical data:

- Signal output for rotating field monitoring (can be OR-operated with the pulse inhibit input)
- 3 x 2 electrically isolated pulse outputs
- Pulse inhibit input
- Synchronising voltage: 1...440 V AC
- Input control voltage: 0...10 V DC for gate control angle 180°...0°
- Digital interface: TTL-level, 8-bit resolution for 180°
- Supply voltage: ±15 V DC

735 135	Control unit six pulse, digital

Run-up control unit



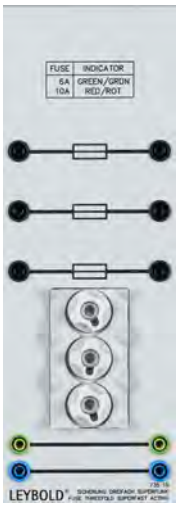
For generating a ramp voltage for a reference variable step change at the input.

Technical data:

- Voltage gain: 0.1...1
- Input voltage range: -10 V...+10 V
- Ramp integration time: 0.5...50 s
- Pulse inhibit input
- Supply voltage: ±15 V DC

735 17	Run-up control unit

Fuse threefold super-fast



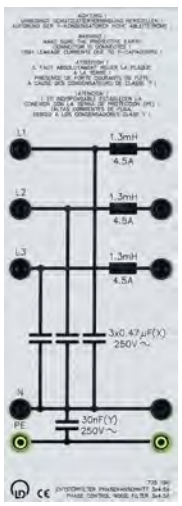
Set of 3 neozed fuses, ultra-rapid for protection of semiconductor valves.

Technical data:

- 3 x 10 A fuses
- 3 x 6 A fuses

735 18	Fuse threefold super-fast

Phase control noise filter 3 x 4.5 A

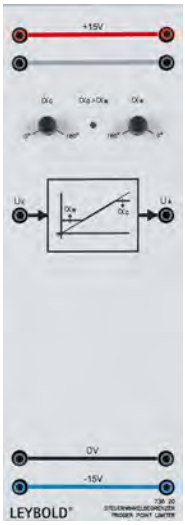


Single-stage, three-phase interference-suppression filter with high common-mode and normal-mode damping, particularly suitable for experiments in power electronics with self-commutated and line-commutated converter circuits. The filter is connected between the three-phase power supply and the experiment set-up and reduces the output of line-bound interference signals into the low-voltage network in accordance with EN 5008-1.

Technical data:

- 3 toroidal core chokes, 1.3 mH
- 3 X2-class capacitors, 0.47 µF
- 1 Y2-class capacitor, 30 nF
- V = 3 x 230/400 V, 47...63 Hz
- I_N = 3 x 4.5 A

735 190	Phase control noise filter 3 x 4.5 A



Trigger point limiter

For setting rectifier and inverter stability limits. LED indication for overlap.

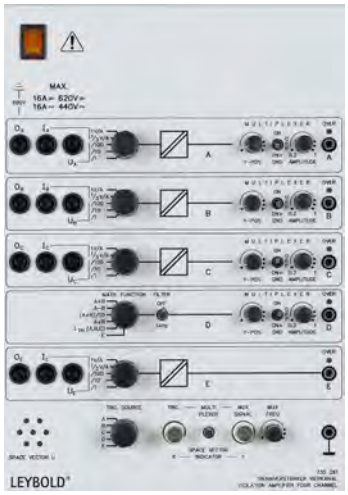
Technical data:

- Rectifier stability limit: 0°...180°
- Inverter stability limit: 180°...0°
- Supply voltage: ±15 V DC

735 20	Trigger point limiter

Isolation amplifier, four channel

Four highly linear, cross-talk and noise-immune isolating amplifiers for measurement recording on static converters, drives and frequency converters used in conjunction with an oscilloscope or the CASSY interface. Potential free measurements due to electrical floating inputs. Current measurement is enabled by built-in shunts. A multiplexer allows the four input signals to be displayed on one (storage) oscilloscope. All of the channels can be switched individually and the corresponding zero-line can be displayed on the screen. Position and amplitude can be set separately on the screen for each channel. A space vector indicator with LED display and oscilloscope output permits representation, measurement and evaluation of three-phase systems, particularly in connection with frequency converters and electrical machines. A mathematical module makes it possible to perform addition, subtraction and multiplication of two input signals. An internal filter permits optionally fundamental waves to be reconstructed out of PWM signals.



Technical data:

Isolation amplifier channels A, B, C, E:

- Frequency range: DC...80 kHz
- Voltage: max. 620 V DC/440 V AC
  Attenuator, 3-stage: x1, x0.1, x0.01
- Internal resistance: 1 MΩ
- Accuracy: 2%
- Current: max. 10 A AC/DC; 16 A for T < 15 min
- Ranges: 1 V/A and 1/3 V/A
- Internal resistance: 30 mΩ
- Accuracy: 5%
- Overdrive indication via LEDs
- Outputs: 4-mm sockets

Multiplexer:

- Multiplex frequency, adjustable: 50...500 kHz
- Amplitude attenuator: 0.2...1
- Y-position: -8 V...+8 V
- Trigger source: A, B, C, D or E
- Oscilloscope output: 2 BNC sockets

Mathematic module and filter:

- Operating modes for channel D:
  A+B, A-B, (AxB)/10, AxB, L_{IN}(A, B, C), E
- Low-pass filter, switchable: 1 kHz

Mains connection: 115/230 V, 47...63 Hz

735 261	Isolation amplifier, four channel

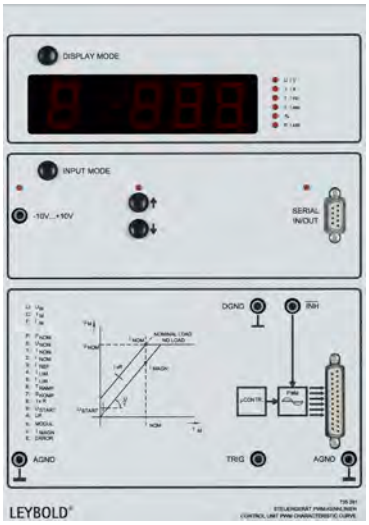
Connecting lead universal converter

25-pole sub-D connecting lead with two plugs, shielded, soft rubber and uncrossed design, length 2 m to connect the COM3LAB Power Electronics Board with the 3 x 230 V universal converter , cat. no 735 297.
For use in COM3LAB course PE II, cat. no. 700 22.

735 290	Connecting lead universal converter

Control unit PWM

Control unit with microcontroller for the assembly of a frequency converter in accordance with the PWM characteristic curve method, operated together with the universal converter. A three-phase pulse width modulator controls the six power transistors of the universal converter and thus generates a sinusoidally shaped motor current. The r.m.s. value of the motor voltage is set in accordance with a programmable, dynamically adapting V/f characteristic. The parameters are set via 14 menu items. Indication of the reference/actual value of the current, voltage, or frequency as well as all of the other parameters is handled via a four-digit LED display. Reference variable setting either via external analog interface (-10 V...+10 V) or internal manual input via up/down push-button. Serial interface (RS232) for the communication with a PC for the input of all parameters and the output of measured values. Additional output with 4-mm sockets for the triggering of an oscilloscope. Power supply from the universal converter (735 297) via 25-pin sub-D socket.



Technical data:

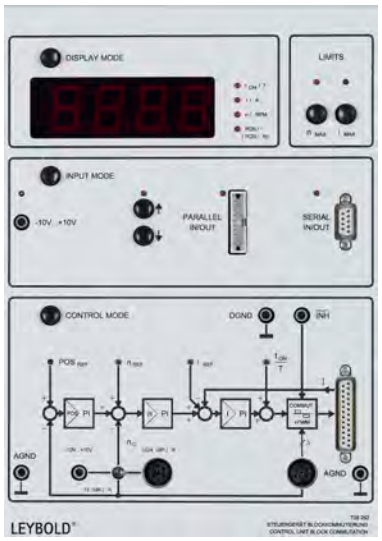
Parameters

- Nominal motor data:
  Power 0.1...1 kW
  Voltage 0...250 V
  Current 0...9.9 A
  Frequency 0...100 Hz
- Limiting data:
  Current 0...9.9 A
  Frequency 0...120 Hz
- Ramp time: 0.1...25 s
- Slip compensation: max. 200%
- IxR compensation: 0...99 V/A
- Starting voltage: 0...50 V
- Voltage/frequency ratio: 2...20 V/Hz
- Modulation types:
  PWM
  Vector modulation (VVC)
  Trapezoidal-shaped modulated motor voltage
  Block-shaped modulated motor voltage

735 291	Control unit PWM

Control unit block commutation

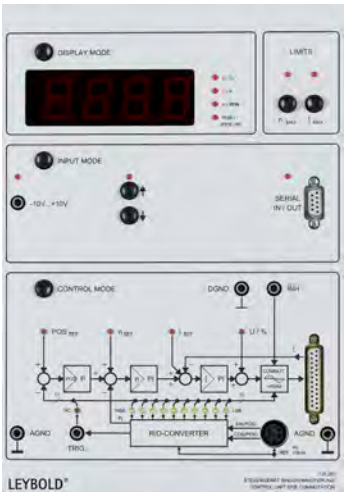
Control unit with microcontroller for the assembly of a highly-dynamic AC servo drive with block signal-shape commutation in operation together with the permanently excited brushless DC machine (AC servo), the universal converter and the commutation pick-up. Alternatively, a 0.3 kW synchronous or multi-function machine can be used. The pulse width modulation is selected so that block-shaped currents are generated in the motor windings. The digital controllers for current, speed and positioning are arranged in cascade configuration. The actual speed value is generated internally out of the commutation signals or measured with an analog or incremental tachogenerator. Commutation signals can also be used for positioning with low resolution (30 degrees). Higher resolution servo positioning is possible by connecting an external servo controller via the parallel interface and an external position pick-up.



Technical data:

- Adjustable limiting data:
  Current 0...9.9 A
  Speed 0...9990 rpm
- Indication of the mark-space ratio or the reference/actual value of the current, speed, or position is carried out via four-digit LED display.
- Reference variable setting either via external analog interface (-10 V...+10 V)
- Internal manual input via up/down push-button or parallel interface.
- Serial interface (RS232) for the communication with a PC for the input of desired values and the output of measured values.
- Power supply from the universal converter via 25-pin sub-D socket.

735 292	Control unit block commutation



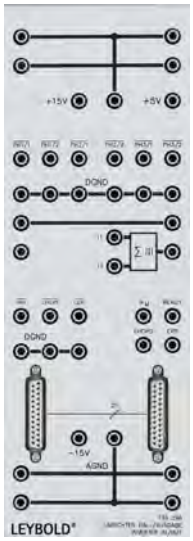
Control unit sine commutation

Control unit with microcontroller for the assembly of highly-dynamic AC servo drives with sinusoidal signal-shaped commutation in operation together with the permanently-excited brushless DC machine (AC servo), the universal converter and the resolver. Alternatively, a 0.3 kW synchronous or a multi-function machine can be used. The pulse width modulation is designed so that sinusoidally shaped currents are generated in the motor windings. The digital controllers for current, speed and positioning are arranged in cascade configuration. The actual speed value is generated internally out of the resolver signals. The resolver permits positioning with high resolution (10 bit/360 degrees, corresponding to 0.35 degrees).

Technical data:

- Adjustable limiting data:
  Current 0...9.9 A
  Speed 0...9990 rpm
- Indication of the amplitude factor or the reference/actual value of the current, speed, or position is carried out via four-digit LED display
- Reference variable setting via external analog interface (-10 V...+10 V) or internal manual input via up/down push-button.
- Serial interface (RS232) for the communication with a PC for the input of desired values and the output of measured values.
- Power supply from the universal converter via 25-pin sub-D socket.

735 293	Control unit sine commutation



Converter input/output

This connection panel enables the student to perform basic experiments with the universal converter, manual control of the power transistors and/or output of all status messages, control signals as well as galvanically isolated actual current values.

Technical data:

Input/outputs (TTL-level):

- PH1/1, PH1/2, PH2/1, PH2/2, PH3/1, PH3/2 for the control of the power transistors via the bridging plugs or TTL-signals, can also be used as measurement output for displaying the control signals on the oscilloscope
- Inhibit, chopper control input, clear
- Status outputs for:
  Motor temperature
  Brake chopper signal
  Converter faults
  Converter ready signal

Inputs/outputs (analog signals):

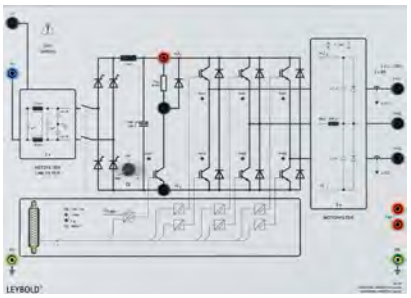
- 0...5 V corresponding to the trigger angle 180...0 degrees of the converter/rectifier
- Output for current of phases 1, 2 and 3
- Output current magnitude sum
- Power supply from the universal converter via 25-pin sub-D socket.

Scope of delivery:

- 25-pole connecting cable

735 296	Converter input/output

Universal converter 3 x 230 V



Transistor pulse converter with voltage link for the generation of a three-phase, frequency and amplitude-variable output voltage from an AC mains. This unit in conjunction with the corresponding control unit is used to assemble a frequency converter or servo amplifier.

Description:

- Single-phase mains connection
- Variable link voltage via fully controllable B2C rectifier bridge circuit
- Three-phase inverter built with IGBT (insulated gate bipolar transistor)
- Maximum operating frequency 20 kHz, resulting in good approximation of sinusoidal current as well as low noise build-up in the machine
- Output short-circuit proof, earth-fault proof and switch proof
- Interface for connection of the control unit (25-pole sub-D socket, TTL level)
- Each individual transistor can be switched on and off via the interface and is protected from damage with an interlocking device
- The respective activated IGBT's are displayed via LEDs
- Monitoring of the variable link voltage, machines and converter excess temperature, excess currents in the rectifier and inverter. Output of the switching status via interface and display via LEDs
- Integrated brake chopper
- Safe separated extra-low voltage (SELV) between the power component and the control unit
- Output currents are detected via Hall generators. Electrically separated output via interface
- 2 stage mains filter for the reduction of the line-bound interference
- 3-phase motor filter for the reduction of the edge steepness of the pulse voltages at the converter output to values < 250 V/µs

Technical data:

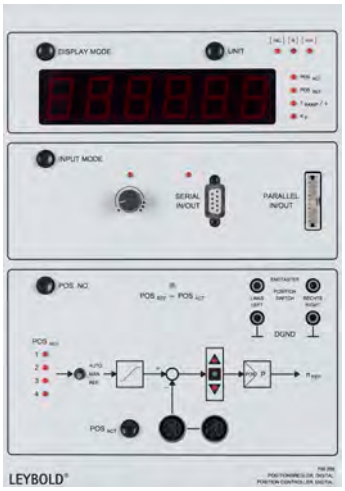
- Output voltage (V_{out}): 3 x 0...230 V
- Output current (I_A): max. 3 x 8 A
- Supply voltage: 200...240 V, 50/60 Hz via 4-mm safety sockets

Scope of delivery:

- 25-pole connecting cable

735 297	Universal converter 3 x 230 V

Position controller, digital



The microprocessor-controlled digital position controller, in conjunction with the AC servo drive with block commutation, is used to set up a high-precision single-axis positioning drive. Actual positions can be recorded either with the 0.3 kW incremental speed sensor (731 092), which supplies 1024 pulses per rotation or the 0.3 kW linear unit with a position encoder (731 086), which supplies 5 pulses per 1 mm of travel.

Technical data:

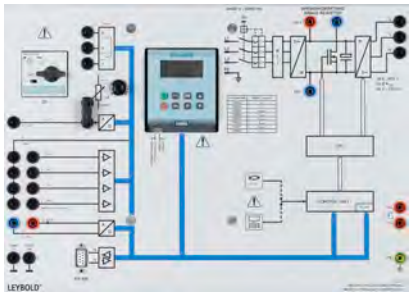
- Six-digit, seven-segment display to indicate positions in increments, rounds or mm.
- Integrated incremental rotary switch to set the position reference variable, controller parameters (K_p) and acceleration ramp.
- Convenient evaluation of the drive's operational data via serial interface (RS 232)
- Reference variables and parameters can then be set via the PC interface.

Scope of delivery:

- 20-pin cable for connection with the control unit block commutation (voltage supply and communication)
- 6-pin connecting lead.

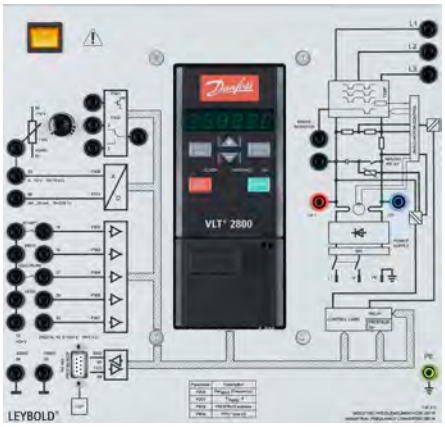
735 299	Position controller, digital

Industrial frequency converter 400 V



Industrial frequency converter for the production of a frequency-variable 3-phase source voltage of max. 400 V/120 Hz with a power rating of 1.5 kW. Operation via keypad or PC, for which a connecting set is included. In addition, an RS 485 port is provided.

735 3101	Industrial frequency converter 400 V



Industrial frequency converter 0.3

Industrial microprocessor-controlled transistor frequency converter, designed for educational purposes, with voltage link for the generation of three-phase, frequency and amplitude variable output voltage from a single-phase AC mains. This device can be used for open-loop and closed-loop control of all asynchronous machines of the power classes 0.3 kW. Front panel with printed block circuit diagram specially designed to illustrate the various applications/ program settings.

Features:

- Inverter control method in accordance with DANFOSS VVC procedure (voltage vector control)
- Programmable, V/f control characteristic capable of adapting dynamically to various different loads
- Programmable, PLC-compatible control inputs
- Analog inputs 0...10 V and 0/4...20 mA
- Programmable control and relay output, status indication via LEDs
- Inputs and outputs are short-circuit proof, earth-fault proof and switch-proof
- Electronic motor protection (with warning signal or automatic switch-off)
- Quality electrical isolation (SELV) between power circuit and control
- Programming and operation performed via key pad, serial interface (PROFIBUS DP) or potentiometer
- Display language can be set to English, German, French or Danish
- Display of all important operating states (e.g. frequency, motor current, voltage, torque) via LED 7 segment display
- Integratable speed controller

Technical data:

- Output current continuous: max. 3 x 2.2 A (3 x 3.5 A max. 60 s)
- Output power continuous: 0.9 kVA
- Output voltage: 3 x 0...133/230 V
- Output frequency: 0.2...132 Hz/1...1000 Hz
- Mains connection: 220...240 V, 50/60 Hz
- Input current: max. 5.9 A

Scope of delivery:

- Including mains connection cable and earth-contact plug
- Including technical documentation and software for setting parameters, observing and documenting the frequency converter.

735 312	Industrial frequency converter 0.3

LCP2 local control panel

Separate operating unit with display and keyboard (LCP2) for FCM 300, VLT 2800 and VLT 5000, With 1.80 m PROFIBUS DP connection cable.

Technical data:

- Copy function and data memory
- 4-digit display
- Simultaneous display of four current data values
- Attachable or detachable even during VLT operation

735 314	LCP2 local control panel

USB/RS 485 interface converter

For use with industrial frequency converter (735 312) and with the two frequency converter motors (732 46) and (732 49)

Technical data:

- Input: USB 1.1 and USB 2.0 compatible
- Output: 1 RS-485 serial port
- Genuine two-wire read/write operation
- Transfer rate 300 up to 115,200 bps
- Electronic isolation up to 3000 V
- Electricity supply: via USB port
- 9-pin sub-D plugs for RS 485

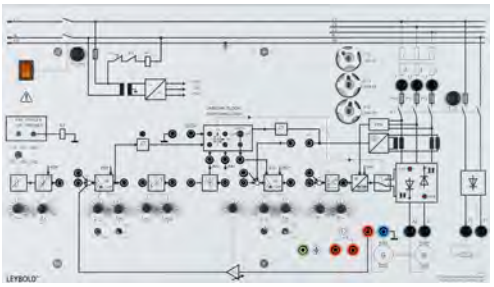
Scope of delivery:

- Drivers for Windows XP and LINUX

735 315USB	USB/RS 485 interface converter

Similar to illustration

Thyristor speed control unit



Compact static converter for setting and performing open and closed loop control of DC voltage and current. In addition to making a multitude of experiments possible, it can also be used to control the speed of a shunt wound machine from 0.1 kW to 2.6 kW with cascade current control in 4-quadrant operation.

Technical data:

Features:

- Mains switch and delayed response main contactor for armature and exciter voltages
- Separate fuses, which can be serviced externally, for excitation, the electronic components and three-phase current
- Exciter voltage output: 220 V, 1 A
- Thyristor power circuit with two fully controlled B6 bridges for circulating current-free 4-quadrant operation, nominal data (V_{L1N} = 90 V): 0...230 V, 12 A,
  Indication of the active static converter via 2 LEDs
- Complete electrical isolation between power circuit and control and regulating unit
- Extensive fault monitoring with signalling and switch-off.
- Activation for phase-failure, rotating field fault, machine or equipment overheating and time limit
- Control and regulating electronics with extensive indication, setting and measuring possibilities

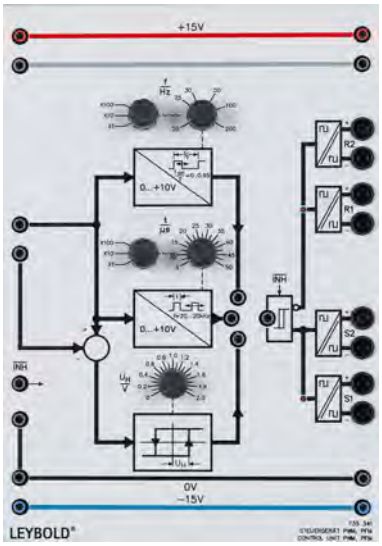
Open- and closed-loop control:

- Potentiometer for the setpoint with changeover switch for single quadrant and four quadrant operation
- Run-up integrator with potentiometer for the run-up time: 0.1...100 V/s
- Speed controller with summing point:
  2 inverting input and 1 non-inverting input
- Variable gain = 1...10 for actual speed value
  Coarse and fine adjustment of the proportional coefficient:
  K_{PN} = 0.5...5/5...50
- Coarse and fine adjustment of the reset time: T_{NN} = 0.1 s...1 s/1 s...10 s
- I controller can be switched off
- Overdrive indication via LED
- Both converters I and II have a potentiometer for current limitation
  $I_{max\ I}$ = 0...12 A
  $I_{max\ II}$ = 0...12 A
- Instantaneous comparator with adjustable hysteresis
- Absolute-value generator with measurement socket for control signal INVert
- Adaptive current controller with summing point:
  2 inverting inputs and 1 non-inverting input
  Recognition of intermittent current with LED display and measurement socket for the control signal STL (intermittent current)
  Reduction of the reset time to 1/10, when intermittent current is present, can be switched off
  Coarse and fine adjustment of the proportional coefficient:
  K_{PI} = 0.05...0.5/0.25...2.5
  Coarse and fine adjustment of the reset time:
  T_{NI} = 10 ms...100 ms/100 ms...1 s
  I controller can be switched off -overdrive indication with LED
- Trigger point limiter with the following setting options:
  Rectifier stability limit 0°...80°
  Inverter stability limit 180°...100°
- Switching logic with measurement sockets for the control signals and with a control input STOP
- 4-quadrant indication with 4 LEDs
- Current measurement with current converters
- The control set provides six double-pulse trains which are switched through to the thyristors of the rectifiers I or II via 12 gate pulse transformers

Supply voltage:

- Control unit: 230 V, 50 Hz
- Power circuit: via external three-phase transformer, 3 x 45/90 V, 50 Hz (735 32)

735 32	Thyristor speed control unit



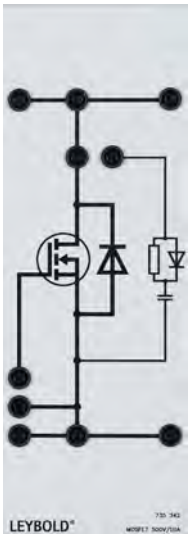
Control unit PWM / PFM

Universal control unit for the assembly of switching DC controllers, switched-mode power supplies and single-phase inverters. It is possible to control all the valves used in power electronics, such as thyristors, GTO thyristors, MOSFETs, Darlington transistors and IGBTs with an output amplifier having electrically isolated outputs for triggering and turn-off. Operation can be selected with the following control modes: pulse width modulation (PWM), pulse frequency modulation (PFM) or two-position control.

Technical data:

- Control voltage (all control modes): 0...10 V DC
- Pulse width modulator:
  Frequency ranges: 20...200 Hz/0.2...2 kHz/2...20 kHz
  Pulse duty cycle t_{ON}: 0...0.95
- Pulse frequency modulator:
  Pulse duration ranges: 5...50 µs/50...500 µs/0.5...5 ms
  Frequency: 20 Hz...20 kHz
- Two-position controller:
  Hysteresis: 0...2 V
- Output amplifier:
  Sustained short-circuit proof
- Indication of switching state via 2 LEDs
- 2 x 2 electrically isolated outputs (test voltage 3 kV)
- INHIBIT input
- Supply voltage: ±15 V DC

735 341	Control unit PWM / PFM



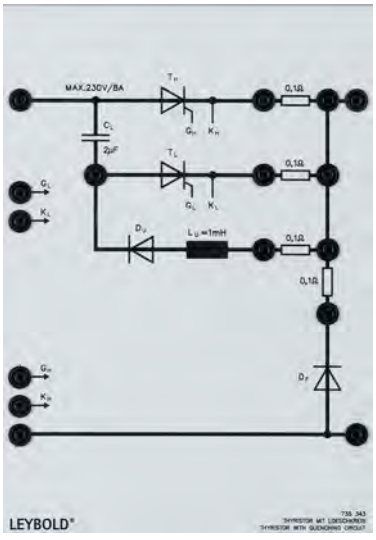
MOSFET 500 V/10 A

Enhancement-mode n-channel field effect transistor with fast-acting inverse diode (FREDFET) and with RCD protective circuit which can be switched off. For the assembly of DC controllers, switched-mode power supplies of high pulse frequency.

Technical data:

- Drain-source voltage (V_{DS}): 500 V
- Drain DC current (I_D): 10 A
- Drain-source closing resistor ($R_{DS(ON)}$): 0.6 Ω

735 342	MOSFET 500 V/10 A



Thyristor with turn-off circuit 230 V/8 A

Thyristor which can be turned off with capacitor turn-off and free-wheeling arm. The turn-off circuit consists of ring-around coil with blocking diode, a turn-off thyristor and turn-off capacitor. A DC controller can be implemented directly using the PWM/PFM control unit. Four integrated shunts enable problem-free measurement of the main current, turn-off current, ring-around current and the free-wheeling current. All the thyristors and diodes have a RCD protective circuit.

Technical data:

Main thyristor and turn-off thyristor

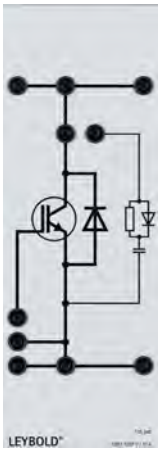
- Repetitive peak forward off-state voltage (V_{DRM}): max. 800 V
- On-state current, mean value ($I_{T\,AV}$): max. 13 A
- Circuit-commutated recovery time: (t_Q): 35 µs

Free-wheeling diode

- Repetitive peak forward off-state voltage (V_{DRM}): max. 1000 V
- On-state current, mean value ($I_{T\,AV}$): max. 8 A
- Shunts: 4 x 0.1 ohms, 1%
- Turn-off capacitor: 4 µF, 450 V
- Ring-around reactor: 1 mH

735 343	Thyristor with turn-off circuit 230 V/8 A

IGBT 1000 V/10 A



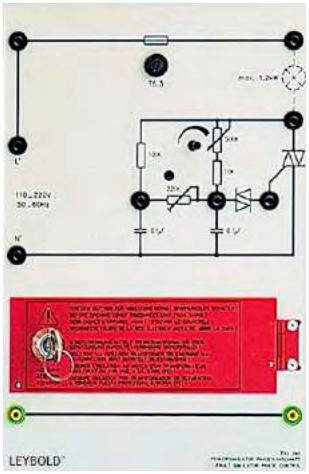
This IGBT (insulated gate bipolar transistor) demonstrates the behaviour of an enhancement-mode field-effect transistor (MOSFET) at the input and the behaviour of a bipolar power transistor at the output. With a fast acting inverse diode and an RCD protective circuit which can be switched off. For use in rapid switching applications with high voltages such as: DC controllers, switch-mode power supplies and inverters.

Technical data:

- Collector-emitter reverse-bias voltage (V_{CES}): max. 1000 V
- Collector current ($I_{C\,AV}$): max. 10 A
- Collector-emitter saturation voltage ($V_{CE\,SAT}$): 3.5 V
- Gate-emitter input capacitance (C_{GE}): 1.8 nF

735 346	IGBT 1000 V/10 A

Fault simulator for phase control



Standard dimmer circuit for resistive load (P = max. 1.2 kW) with preset minimum value, consisting of triac, diac, 2 potentiometers, resistors and capacitors. Various measurement points permit systematic trouble-shooting. A total of 20 faults from the following categories can be switched on:

- Line break
- Short-circuit
- Faulty assembly
- Faulty components

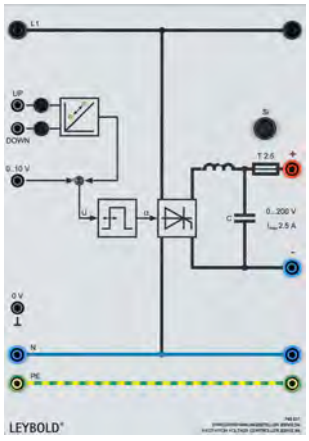
The faults are switched on using slide switches, which are located behind a lockable cover.

Technical data:

- Supply voltage: 110 V...230 V, 47 Hz...63 Hz

735 390	Fault simulator for phase control

Excitation voltage controller 200 V/2.5 A



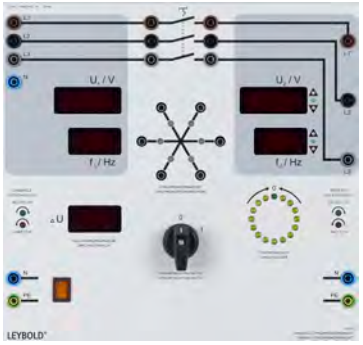
Adjustable power supply with smoothed current and voltage for supplying power to a synchronous machine in the power class 0.3 kW or 1.0 kW. Adjustment of the output voltage can be carried out internally using the UP/DOWN push-button or externally via 4-mm sockets using switching contacts, TTL-level or 24 V DC. The setting direction is indicated by two yellow LEDs. When the synchronous machine is run up asynchronously, it is not necessary to short circuit the excitation winding.

Technical data:

- Output voltage V: 0...200 V
- Output current I: max. 2.5 A
- The output is overload-proof and short-circuit-proof.
- Supply voltage: 230 V, 50/60 Hz

745 021	Excitation voltage controller 200 V/2.5 A

Manual synchronisation unit

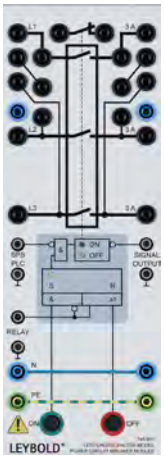


Synchronisation unit with manual switch to connect the generator to the mains.

Technical data:

- Two 7-segment voltage displays
- Two 7-segment frequency displays
- One 7-segment zero-volt display
- One optical synchronoscope
- Six synchronisation lamps
- One optical synchronisation indicator
- One rotating field indicator
- One manual three pole switch

745 05	Manual synchronisation unit



Power circuit breaker module

3-phase ON/OFF switch with auxiliary contact (NC) for 380 kV transmission line model. Can be controlled manually using ON/OFF push-button or externally via switching contact, TTL level or 24 V DC. The switching state is indicated by LED's and is additionally available as TTL level from 4-mm sockets. Control input (switching contact, TTL level, 24 V DC) for external switch-off command (tripping on faults).

Technical data:

- Contact load capacity: 400 V AC, 3 A
- Mains connection: 115/230 V, 50 Hz

745 561	Power circuit breaker module

3-phase stator

Stator for a three-phase machine in the form of a working model demonstrating function, built with drive-end shield and industrial terminal box, electrically functional, mounted on a base socket. The stator is designed to accommodate different rotors. Rotors are attached to the stator by means of star-grip bolts.

Technical data:

- Class: 0.3
- Colour:
  Machine body, light grey
  Base, black

747 720	3 phase stator

Squirrel cage rotor

Rotor for a three-phase asynchronous machine with pull-out torque in the form of a working model demonstrating function, with non-drive-end shield. The rotor is designed for use with the three-phase stator 747720.

Technical data:

- Class: 0.3
- Cage material: aluminium
- Colour: light grey

747 721	Squirrel cage rotor

Slip-ring rotor

Rotor for three-phase asynchronous motor with slip ring rotor in the form of a working model demonstrating function, with non-drive-end shield, fan and dust cover. The slip rings, brush holder as well as the brushes are visible through a perspex cover. The rotor is designed for use with the three-phase stator 747720.

Technical data:

- Class: 0.3
- Colour: light grey

747 722	Slip-ring rotor

Salient pole rotor

Rotor for three-phase synchronous machine with salient pole rotor in the form of a working model demonstrating function, with non-drive-end shield, fan and dust cover. The slip rings, brush holder as well as brushes are visible through a perspex cover. The rotor is designed for use with the three-phase stator 747720.

Technical data:

- Class: 0.3
- Colour: light grey

747 723	Salient pole rotor

Smooth core rotor

Rotor for three-phase synchronous machine with smooth-core rotor in the form of a working model demonstrating function, with non-drive-end shield, fan and dust cover. The slip rings, brush holder as well as brushes are visible through a perspex cover. The rotor is designed for use with the three-phase stator 747720.

Technical data:

- Class: 0.3
- Colour: light grey

747 724	Smooth core rotor

Reluctance rotor

Rotor for three-phase synchronous machine with reluctance rotor in the form of a working model demonstrating function, with non-drive-end shield, fan and dust cover. The slip rings, brush holder as well as brushes are visible through a perspex cover. The rotor is designed for use with the three-phase stator 747720.

Technical data:

- Class: 0.3
- Colour: light grey

747 725	Reluctance rotor

DC shunt stator

Stator for a DC shunt current machine in the form of a working model demonstrating function, featuring drive-end shield and industrial terminal boxes mounted on a base. The stator is designed to accommodate different rotors and equipped with star-grip bolts to attach them.

Technical data:

- Class: 0.3
- Colour:
  Machine body, light grey
  Base, black

747 726	DC shunt stator

Similar to illustration

DC rotor

Rotor for DC machine in the form of a working model demonstrating function, with non-drive-end shield, fan and dust cover. The collector, brush holder as well as the brushes are visible through a perspex cover. The rotor is designed for use with the DC stator (747 726).

Technical data:

- Class: 0.3
- Colour: light grey

747 728	DC rotor

Similar to illustration

Efficiency rotor

Rotor for a three-phase asynchronous machine with copper cage in the form of a working model demonstrating function, with non-drive-end shield. The rotor is designed for use with the three-phase stator 747720.

Technical data:

- Class: 0.3
- Cage material: copper
- Colour: light grey

747 729	Efficiency rotor

System: Electrical machines training system

Supplementary set for electrical machines training system (62-005-230) for recording characteristics of electrical machines in all four operating quadrants.

Technical data:

- Machine test system
- CBM10 software MOMO / FCCP
- 3-phase transformer
- 3-pole on-off switch
- EMT adapter kit (adapter base for machine test system)
- Coupling
- Set of safety experiment leads

762 101	System: Electrical machines training system

MPS set: Electrical machines training system

Electrical machines training system (62-005-230) with machine test system for recording characteristics of electrical machines in all four operating quadrants, consisting of:

- Electrical machines training system
- EMT storage frame
- EMT system frame
- Machine test system
- Softwarte CBM10 MOMO / FCCP
- 3-phase transformer
- 3-pole on-off switch
- EMT adapter kit (adapter base for machine test system)
- Coupling
- Set of safety experiment leads

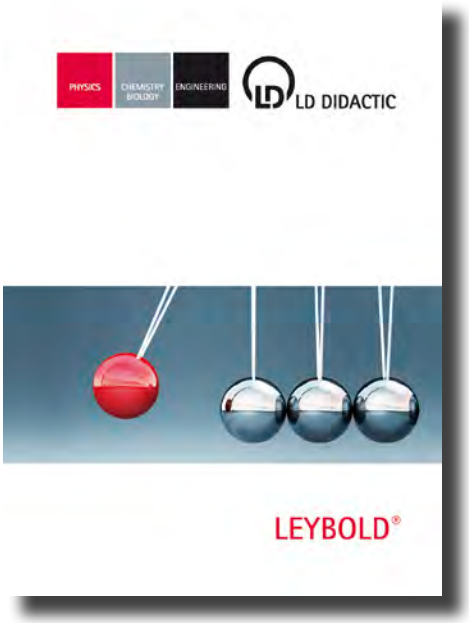
762 102*	MPS set: Electrical machines training system

*The MPS set *Electrical machines training* system (762 102) is not available in all countries. Please contact your local dealer.

Literature

Cat.-No.	Designation
775 685 EN	LIT: T8.2.1.6 Drive Control
565 642	LIT: Three-phase transformers and three-phase transformer circuits, T 2.4.1
565 652	LIT: Three-phase rectifier circuits, T 2.4.2
588 34EN	LIT: PS3.4 STM Electricity - Basic electric circuits
588 35EN	LIT: PS3.5 STM Electricity - Electromagnetism
588 36EN	LIT: PS3.6 STM Electricity - Motors
775 115EN	LIT: E2.1.3.3 Electrical Machines Teaching Models
775 175EN	LIT: E2.4.1.1 STE Power Electronics
775 185EN	LIT: E2.2.1.0 Transformers 0.3
775 190EN	LIT: E2.2.2.0 DC Machines 0.3
775 195EN	LIT: E2.2.3.0 AC Machines 0.3
775 200EN	LIT: E2.2.4.0 Induction Machines 0.3
775 205EN	LIT: E2.2.5.0 Synchronous Machines 0.3
775 220EN	LIT: E2.3.1.0 Transformers 1.0
775 225EN	LIT: E2.3.2.0 DC Machines 1.0
775 230EN	LIT: E2.3.3.0 AC Machines 1.0
775 235EN	LIT: E2.3.4.0 Induction Machines 1.0
775 240EN	LIT: E2.3.5.0 Synchronous Machines 1.0
775 250EN	LIT: E2.4.2.1 Static Converter Valves
775 255EN	LIT: E2.4.2.2 Fault Simulator Dimmer
775 260EN	LIT: E2.4.3.1 Switchable Valves and DC Choppers
775 265EN	LIT: E2.4.3.2 Switched-Mode Power Supplies
775 270EN	LIT: E2.4.3.3 Inverters
775 280EN	LIT: E2.5.2.1 Static Converter Drive with DC Machines
775 285EN	LIT: E2.5.3.1 Drives with Induction Machines
775 286EN	LIT: E2.5.3.2 Basics of Frequency Converters
775 290EN	LIT: E2.5.3.4 Drives with Industry Frequency Converter 0.3
775 295EN	LIT: E2.5.3.5 Drives with Industry Frequency Converter 1.0
775 300EN	LIT: E2.5.3.3 Drives with Educational Frequency Converter
775 305EN	LIT: E2.6.2.1 AC Servo with Block Commutation
775 310EN	LIT: E2.6.2.2 AC Servo with Sine Commutation
775 315EN	LIT: E2.5.2.3 Position Servo Control
775 320EN	LIT: E2.6.1.1. Basics of Servo Technology
775 325EN	LIT: E2.6.1.2 DC Servo
775 330EN	LIT: E2.6.1.3 AC Servo
775 345EN	LIT: E2.6.1.4 Stepper Motor
775 350EN	LIT: E2.2.6.1 Motor with Frequency Converter 0.3
775 355EN	LIT: E2.3.6.1 Motor with Frequency Converter 1.0

The literature is also available in other languages.



INDEX

IN ALPHABETICAL ORDER

On the following pages you will find the index for our equipment sets and individual components.

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TECHNICAL SERVICE AND CONSULTING

LEYBOLD DOES NOT ONLY PROVIDE THE HIGHEST POSSIBLE PRODUCT QUALITY, BUT ALSO INDIVIDUAL ADVICE AND TECHNICAL AFTER-SALES SERVICE.

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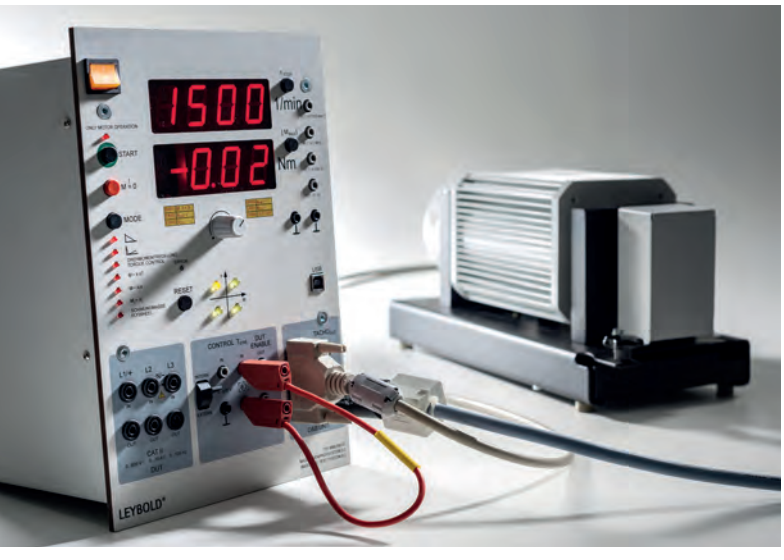

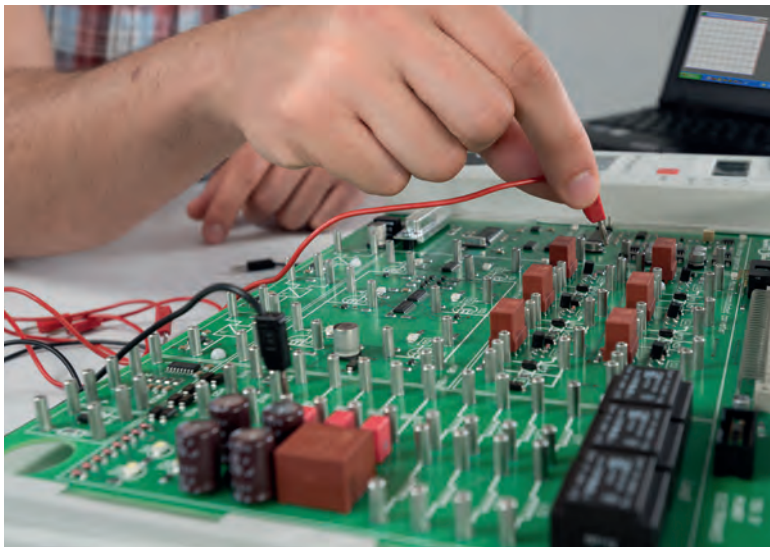

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