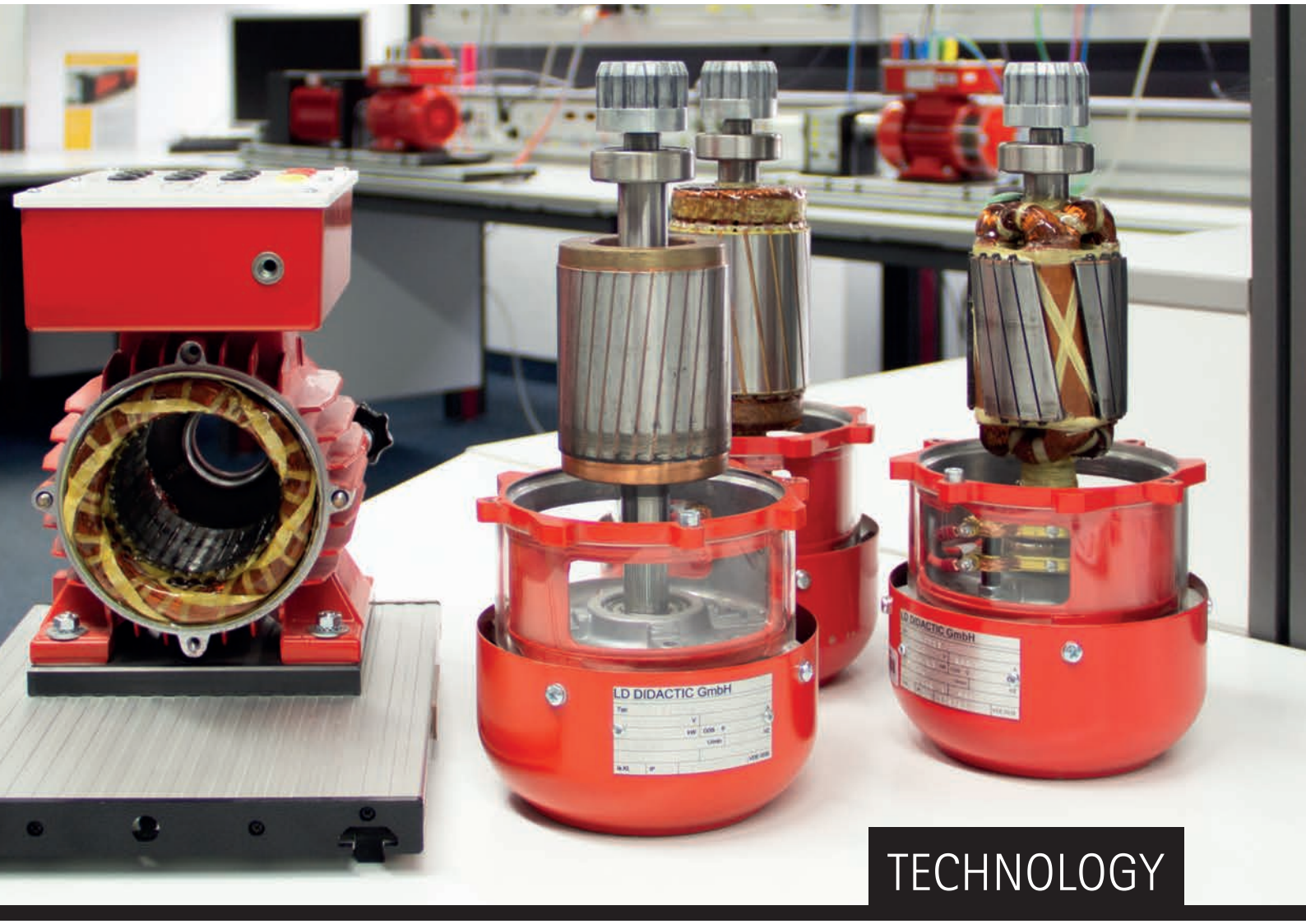
PHYSICS
CHEMISTRY
BIOLOGY
ENGINEERING

LD DIDACTIC

S.A.R.L.
SYSTEMES DIDACTIQUES

ELECTRICAL DRIVES



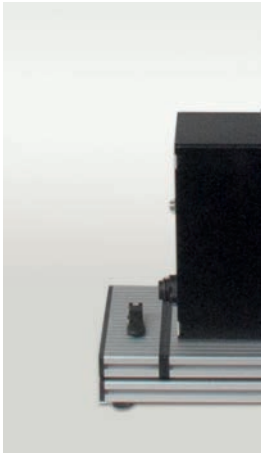
TECHNOLOGY

- EDUCATIONALLY DESIGNED MACHINES
- INDUSTRIAL MACHINES, 300 W
- INDUSTRIAL MACHINES, 1 KW
- POWER ELECTRONICS
- DRIVE TECHNOLOGY
- SERVO TECHNOLOGY

LEYBOLD®

CONTENT

LEYBOLD AT A GLANCE



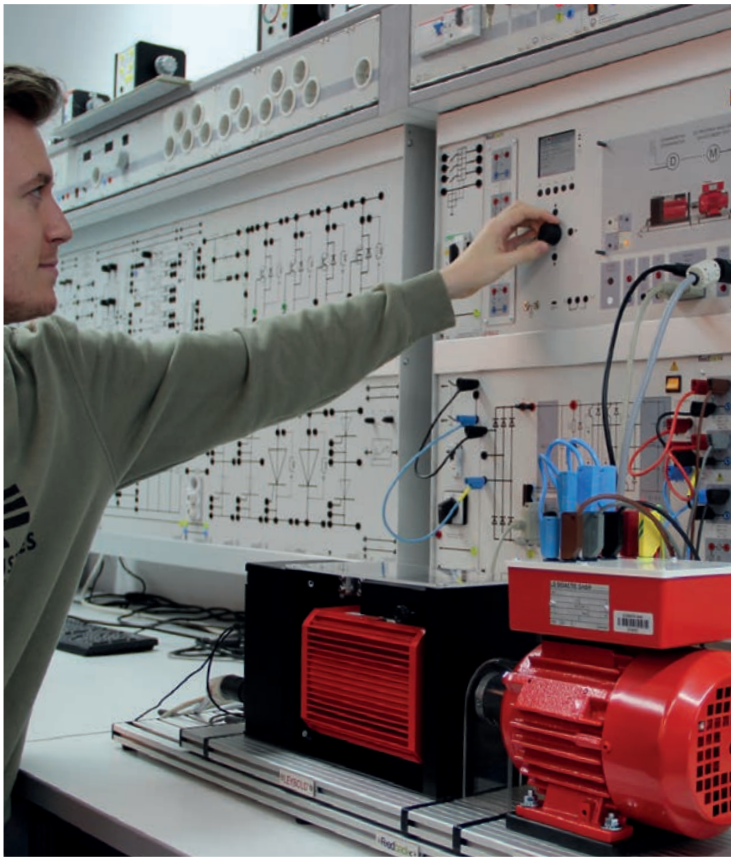
You can use LEYBOLD teaching systems to help your students learn about a variety of training topics in the automotive technology, electrical engineering and regenerative energy technology sectors. Our educational devices and teaching systems for vocational training perfectly combine theory and practice and are excellent for integrating into project work.

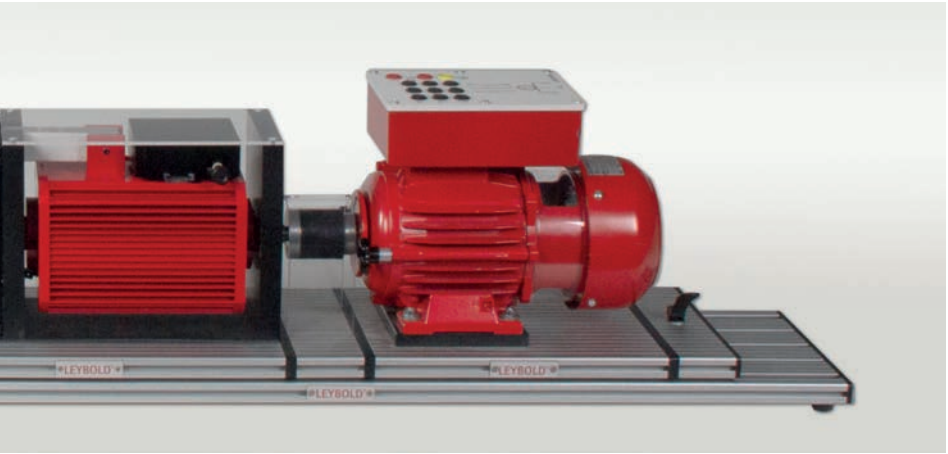
In this catalogue we will introduce you to our teaching systems from the drive technology sector. We will provide you with customised solutions for your technology and workshop laboratory that are designed to achieve individual learning objectives.

ELECTRICAL DRIVES

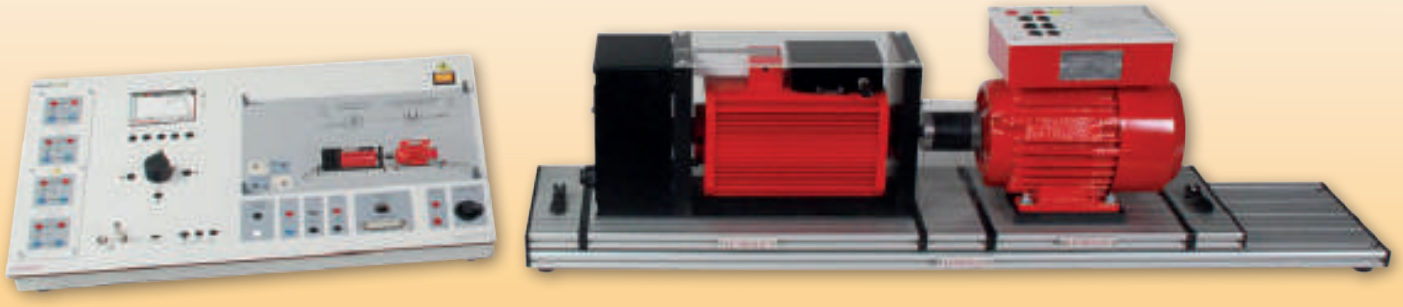
TEACHING SYSTEMS FOR TRAINING & DEVELOPMENT

EQUIPMENT BY TOPICS





PRODUCT HIGHLIGHTS

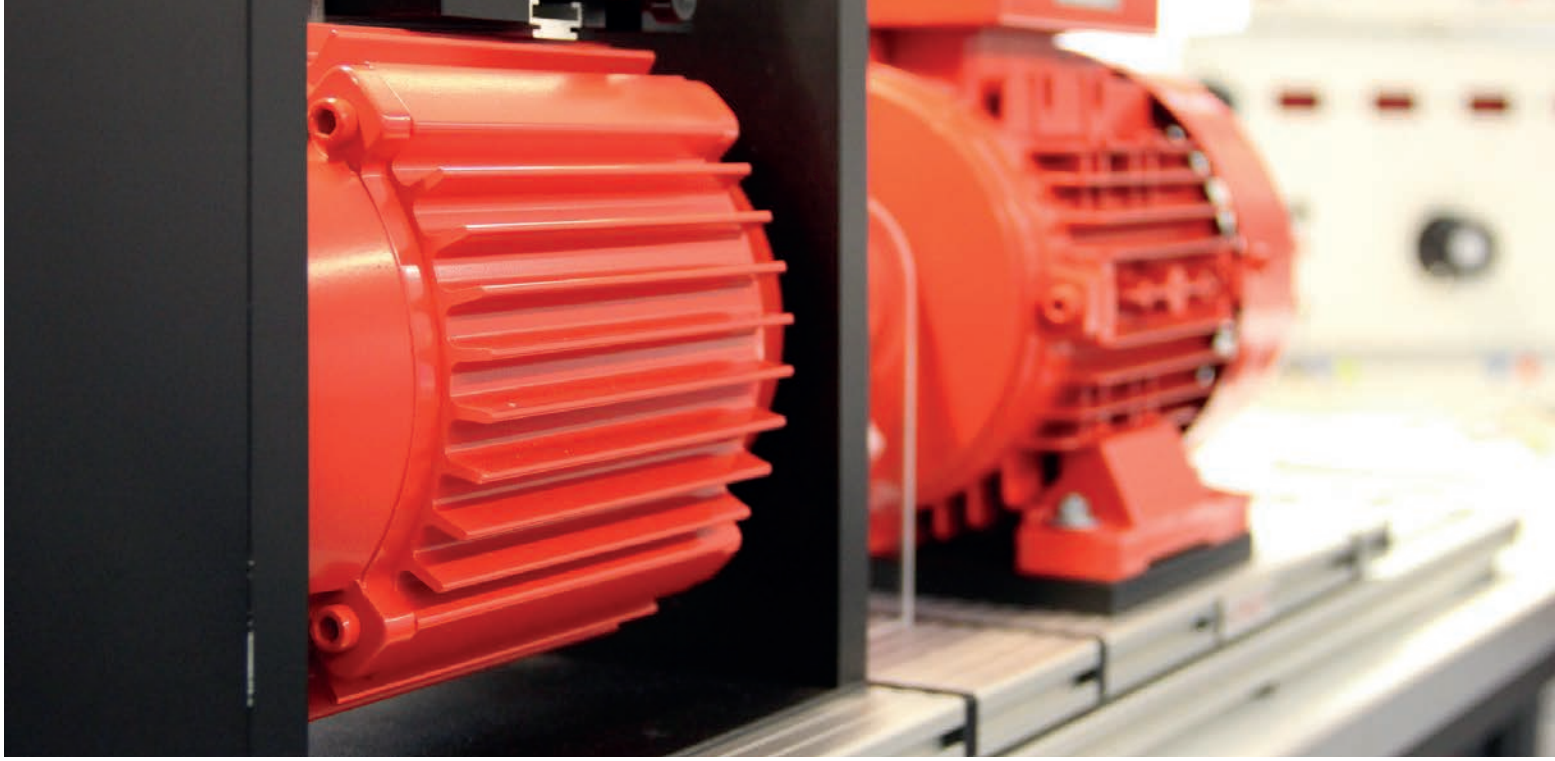


The innovative LEYBOLD machine test system enables DC, AC and three-phase electric machines of 300 W class and 1 kW machines to be analysed. The sophisticated, industrial design for educational purposes ensures that specimens can, amongst other things, be replaced quickly and easily. The safety requirements of the Machinery Directives are met at all times.

EDUCATIONAL CONTENTS

All of the systems are easy to operate via a tablet, PC or directly on the device.

- Genuine four quadrant system with actual mechanical and electric power measurement
- Testing machines
  - Motor testing
  - Generator testing
- Load simulation, e.g.
  - Start-up of asynchronous machines in the network
  - Speed operation with variable drives
- Generator control
  - Generator operated in isolation
  - Generator operated in the network
- Mechanics testing
  - Static analysis
  - Dynamic analysis
- Setup, behaviour and operating principles of various machine types
- Analysis, characteristic value calculation and inclusion of machine-typical characteristics in various load situations
- Impact on electric networks and the latest required switching devices



MACHINES WITH EXCHANGEABLE ROTORS

Prototype machines for main voltage consist of a stator and various interchangeable rotors. Once the stator and rotor have been assembled, this results in an operational electrical machine in the 300 W class.

The stator housing is mounted on a base and can be connected directly to machine test system. Star-grip tension bolts connect the stator and rotor, allowing the rapid exchange of the rotor. The rotors are equipped with a non-drive end cap, fan, cover and may also have slip rings, brushes and similar.

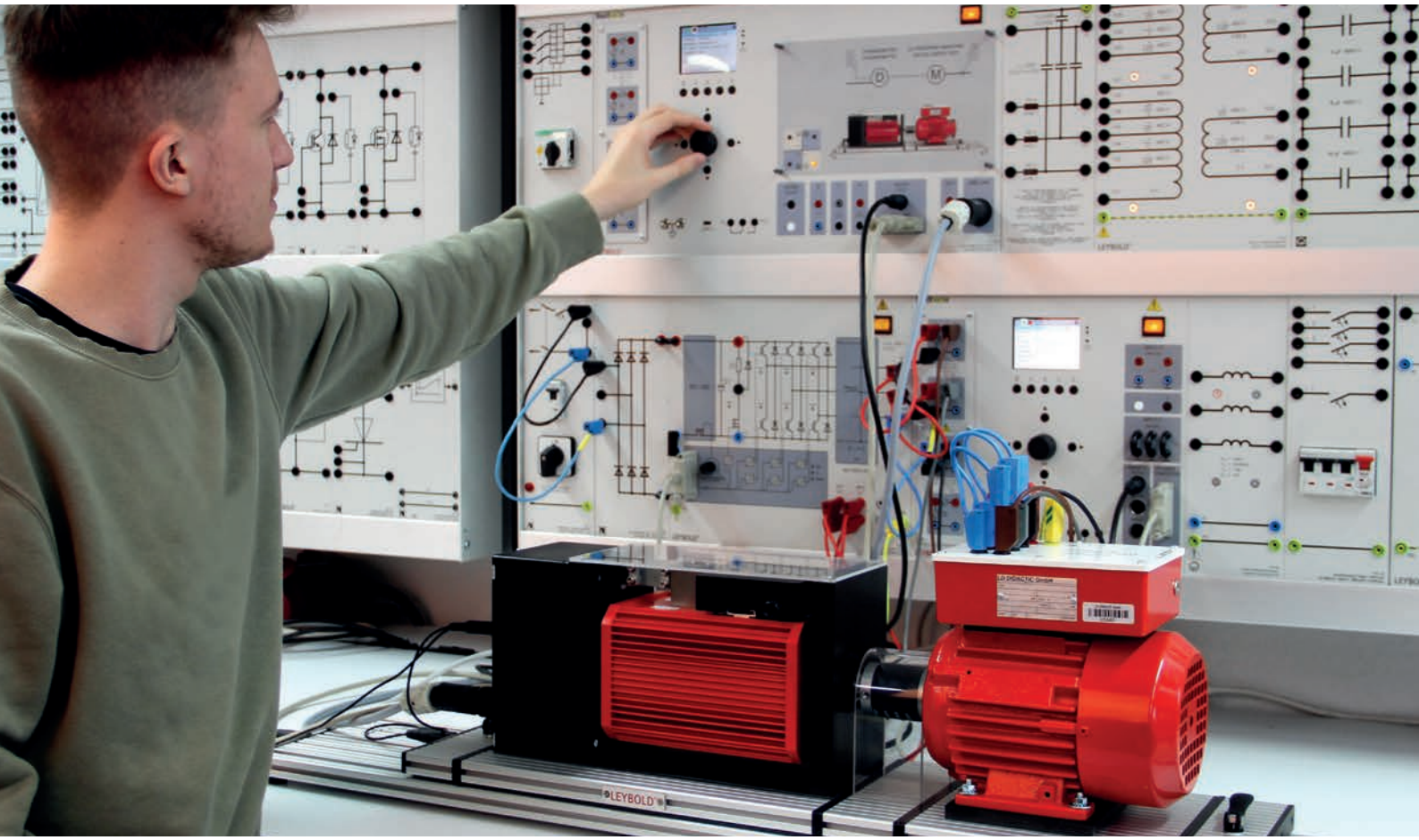
In combination with the machine test system, it is possible to attribute the characteristic curves of the machines to the properties of the specific rotor. Depending on the rotor used, the prototype machine then shows the typical properties of asynchronous and synchronous machines.

MACHINES WITH EXCHANGEABLE ROTORS

LINEAR MOTOR

The linear motor is designed to demonstrate the basic principles of a linear asynchronous motor. The stator of the linear motor is made up of three coils connected in series. An iron bar is used as the short circuit rotor and guide.

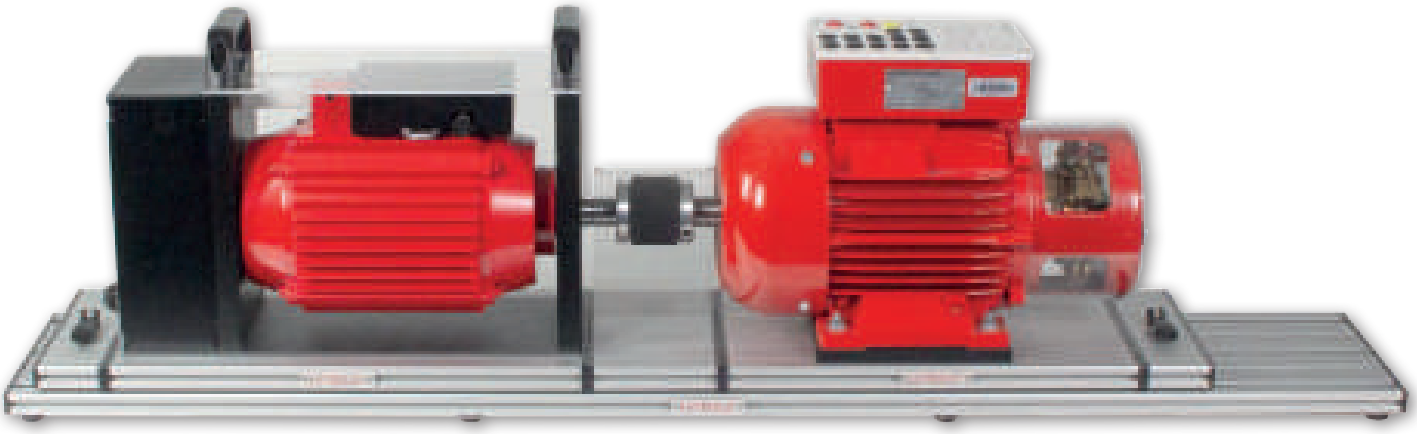
MACHINE TEST SYSTEM



The Machine Test CASSY can be used as a tabletop unit or in a frame.

BENEFITS AT A GLANCE

- Machine test system developed based on the latest safety requirements
- Compatible with existing drive technology equipment
- Integrated Power Analyser CASSY functions to analyse specimens in the control unit
- Part of the CASSY family compatible with all of the interfaces to CASSY Lab 2, digital experiment instructions "Lab Docs", MATLAB® and LabView™



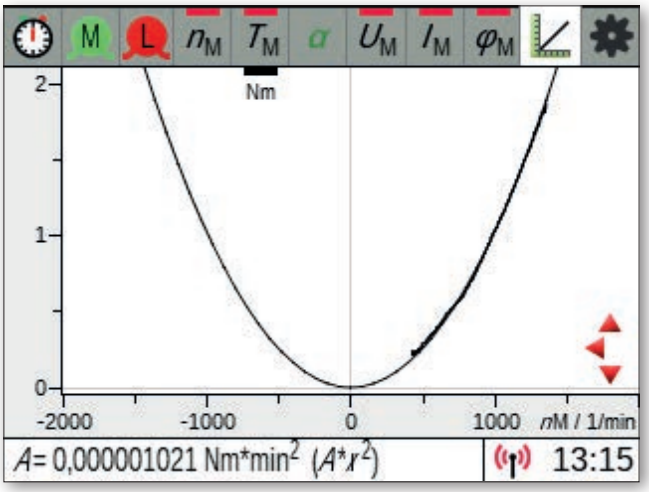
Suitable for 300 W and 1 kW machines

ELECTRICAL MACHINES SUITABLE FOR EVERY DAY USE

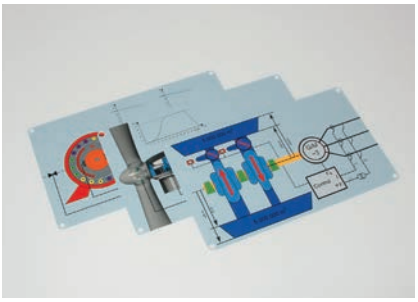
Although the fundamental principals of electric machines have been around for more than 150 years, continuous developments, such as Industry 4.0, have ensured that technological progress has been achieved in this field in recent decades. The specialists in this field are thus continually being required to broaden their knowledge.

As well as testing engines and generators, the new requirements for the machine test system also combine the load simulation of machines with direct start-up in the network or for speed-controlled drives.

The measurements can be recorded with a PC, analysed and distributed via WiFi. However, there is also the option of completing the measurements, including the analysis and distribution of data, without a PC directly on the device.



Load simulation mode of quadratic functions



Masks to visualise the generator types:

- *Synchronous generator*
- *Wind power plant*
- *Pumped storage power station*

LEARNING OBJECTIVES

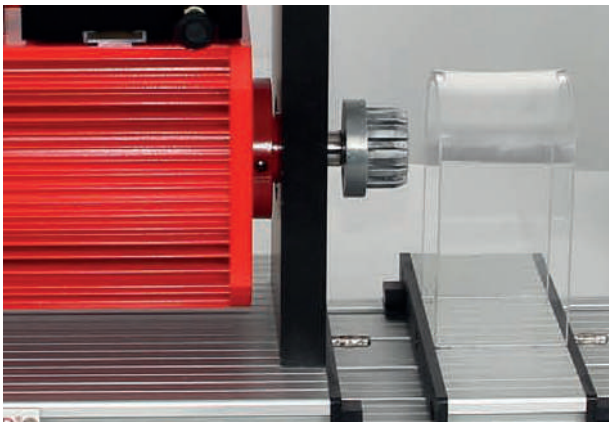
- Design and mode of operation of machines
- Behaviour of machines as motors
- Behaviour of machines as generators
- Speed setting options
- Efficiency
- Characteristic curves of motors
- Load simulation
- Speed and load setting options
- Starting and braking
- Characteristic curves of generators
- Idle and short circuit test

SAFETY CONCEPT OF MACHINE TEST SYSTEM

HEAVY-DUTY MACHINE BENCH & MECHANICAL LOCK

A heavy-duty aluminium machine bench serves to fix the machines in place. Mechanical impulses, which can occur when IPM motors, synchronous motors or high efficiency machines stall, are absorbed by the bench and the mechanical latches on both sides. The machines can be moved around on the machine bench at any time so that two machines can be operated against each other on the machine bench. The installation of digital and analogue tachometers can be installed easily.

PROTECTION AGAINST CONTACT WITH ROTATING PARTS

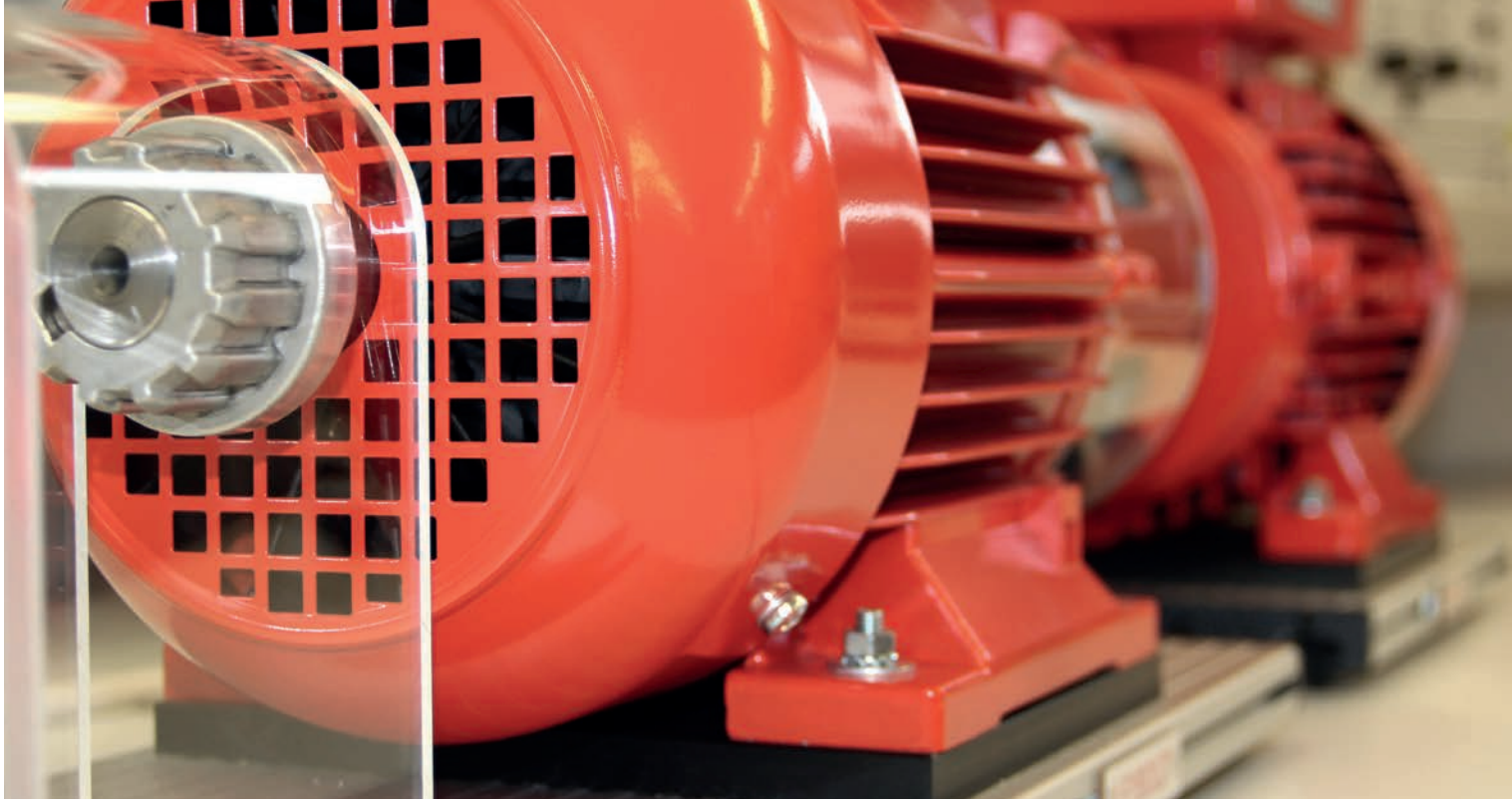


The shaft is connected to the bases of the machine and the pendulum machine by a hood on its own base. The drive shafts can only be accessed after disassembling the drive system. In addition, the base latches are electrically monitored, therefore the unit switches off as soon as the base is detached. Optical tachometers can still be used here.

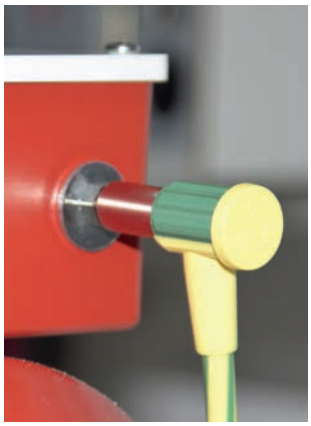
INSULATION FOR ELECTROMAGNETIC COMPATIBILITY

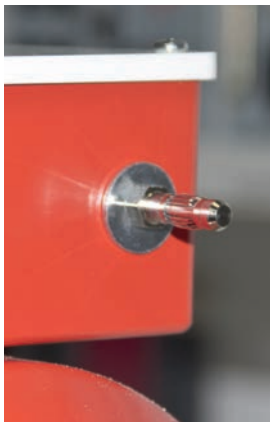
All motors are insulated against the base so that unnecessary current loops do not increase interference radiation and stray leakage currents do not influence the measuring sensors.

This is the requirement for Industry 4.0-compatible frequency converters and servo actuators as well as the associated speed rotation angles and position sensors.



ADDITIONAL POTENTIAL EQUALISATION





Additional potential equalisation is necessary to protect people and the unit. A break in the protective conductor would put the machine or even the entire unit under voltage, as leakage currents could be conducted directly to the motor and the unit via the stator.

An additional protective conductor (potential equalisation) can be created to teach the problem in lessons and labwork. A unit which is often used in medical technology with 6 mm connectors and 10 mm² wires (green/yellow) is used for this. This makes it possible to create an additional protective conductor or local potential equalisation quickly and as intended.

PREPARED FOR EDUCATIONAL PURPOSES TO IMPROVE COMPREHENSION

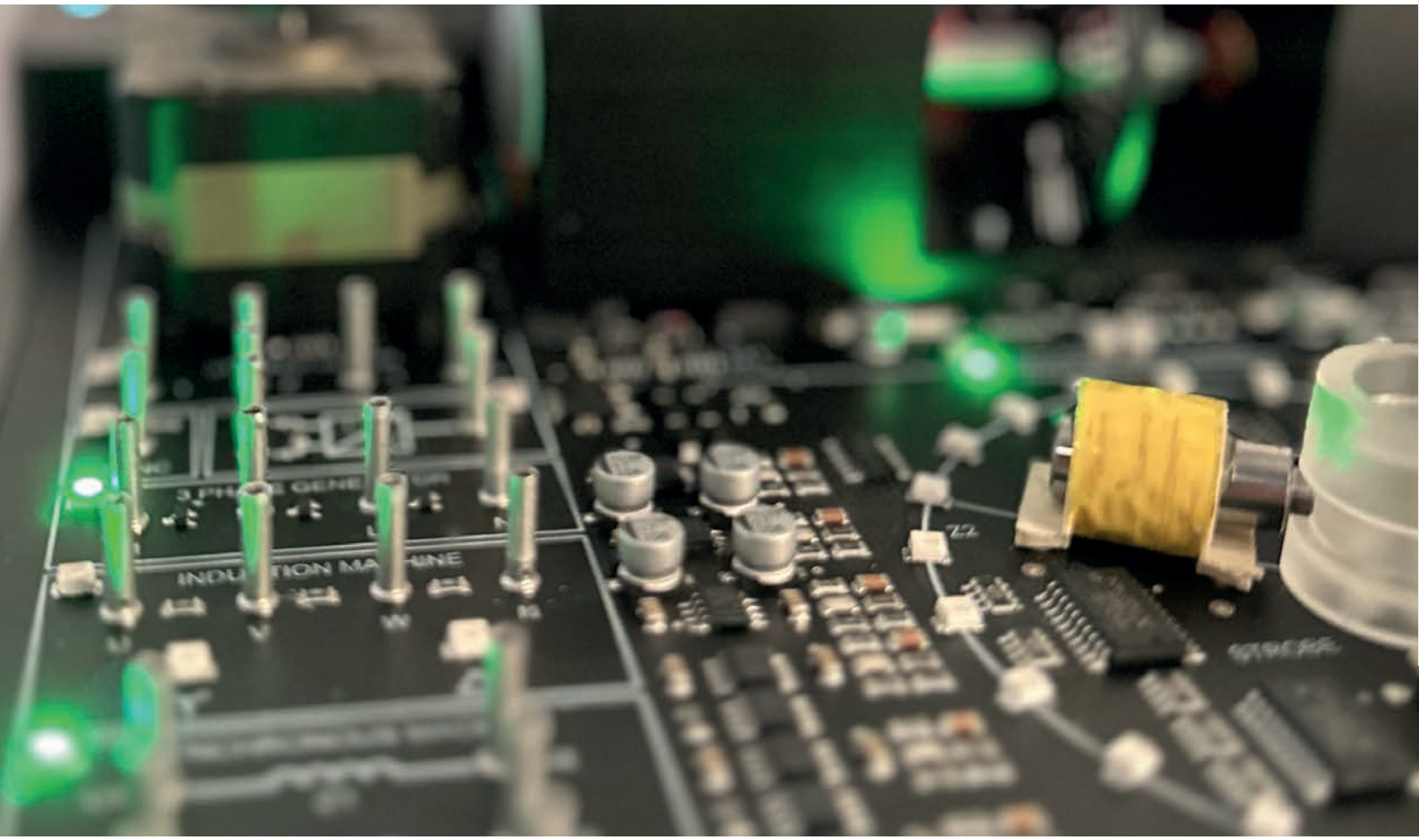
The machines are all industrially manufactured, designed for education and equipped with a shaft end. The terminal board is on the top for the flexible set-up of experiments. The machines are partially opened and covered so that important components are visible.

FURTHER SAFETY FEATURES

- Temperature switch to protect against overheating
- Automatic shutdown to protect against damage caused by an overload
- Coil ends are led out on the terminal board on 4 mm safety sockets
- All measurements are isolated

COM4LAB

THE NEXT GENERATION OF THE ELECTRICAL ENGINEERING LAB



BENEFITS AT A GLANCE

- Compact electrical engineering laboratory: quickly and easily ready for use
- Complete training system, including power supply, measuring instruments, function generator and experiment board
- Comprehensive curriculum with more than 25 cloud-based courses designed for educational purposes

1. MASTER UNIT

Base station with mains adapter and measuring instruments

2. EXPERIMENT BOARD

Experiment hardware for the course subject (physical experiment), safe and clearly structured with interactive course guidance

3. COURSES

Learning modules comprising all of the theoretical and practical content and knowledge-based checks

COM4LAB is a complete but compact electrical engineering laboratory and combines practical experiments with the benefits of interactive e-learning providing the best learning outcomes. **COM4LAB** enables modern, digital training using any type of smartphones, tablets and laptops – at the training centre, on site at the company or at home.

The **COM4LAB** courses stand out for including the latest, practical and high-quality educational content. Students are presented the educational content using animations, texts, images, interactive elements and videos. The students can actively perform the integrated experiments on the experiment board enabling them to directly and effectively learn the necessary skills. Assessments at regular intervals are used to automatically test the theoretical knowledge and practical skills. It can also be shared via learning management systems, like MS Teams, and the **COM4LAB** courses work on any end device regardless of the operating system and manufacturer.

COM4LAB is an efficient training system that already reduces the amount of preparation time for the instructor and enables lessons to be started on time thanks to the system being easy to set up and shut down. The combination of theoretical and practical self-study offers an efficient training method. The resilient and stable design guarantees a long service life and keeps subsequent costs at a minimum.

With its cloud-based system and independence from manufacturers and operating systems, **COM4LAB** is future-proof. The compact and yet complete laboratory replaces a laboratory workstation and does thus not require an expensive laboratory infrastructure. In contrast to large, complex training systems, **COM4LAB** guarantees a reduced amount of maintenance costs. The modular design also enables cost-efficient additions.

EDUCATIONAL SYSTEM DRIVES FOR MACHINES

CONVERTER CONTROLLER CASSY

POSSIBLE APPLICATIONS

DRIVE FOR
DC MACHINE:

- Influence of pulse width and frequency on the armature voltage
- Speed control using armature voltage

DRIVE FOR
ASYNCHRONOUS MACHINE:

- Parametrisation of a frequency converter with V/F control
- Control optimisation of a cascade control with PID controllers

DRIVE FOR
SYNCHRONOUS MACHINES:

- Difference between the commutation methods
- Setup:
  - Permanently activated as BLDC drive
  - Externally activated with incremental commutation

CONCISE INFORMATION ON POWER ELECTRONICS IN THE DRIVE TECHNOLOGY

LD DIDACTIC has developed a compact didactical control unit with a power element to meet the necessary requirements of the increasing importance of electrical machines controlled via power electronics in the technical and educational sector. This unit is used to introduce the basic principles of modern technology.

In conjunction with electrical machines, the control unit (Converter Control CASSY) controls both drive systems for DC machines, asynchronous machines and synchronous machines.

In DC operating mode (H-bridge), variable DC voltages can be generated using pulse width modulation. This forms the basis of the DC drive for four quadrant operating mode. It is also possible to provide an overview of the setup of a cascade control for angle-oriented speed and position control.

Frequency and voltage-variable three-phase voltages can be generated as frequency converters for 3-phase asynchronous machines. A V/F function is used to analyse the modulation methods and frequencies.

Various commutators, such as block, sinus and incremental commutators, can be used to operate 3-phase synchronous machines and examine the differences between the commutator processes. The generated rotational movement and torque can be used to set up a permanently activated synchronous machine as a BLDC drive and a separately excited synchronous machine as a servo drive.

The Converter Controller CASSY finally comprises an integrated measuring unit. It is easy to measure the voltage between the phases of a frequency converter using this measuring device. By connecting the integrated, digital filter, it is possible to measure pulse width modulation variables.

DRIVES OF THE DC MACHINE

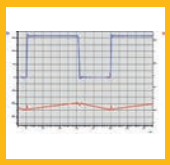
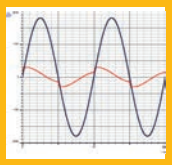
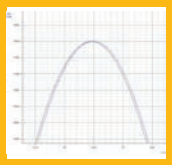





Fig. 1 *Fig. 2* *Fig. 3* *Fig. 4*

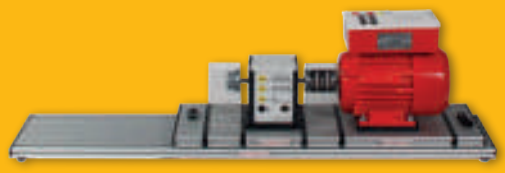
Fig. 1 *Pulse/width modulation*

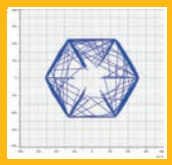
Fig. 2 *Dynamic speed control with sinusoidal reference variable*

Fig. 3 *Section from Figure 2*

Fig. 4 *Armature current over 4 quadrants*

DRIVES OF THE ASYNCHRONOUS MACHINE



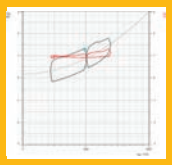


Fig. 1 *Fig. 2* *Fig. 3* *Fig. 4*

Fig. 1 *Current vector of a three-phase asynchronous machine without a filter*

Fig. 2 *Voltage vector of a three-phase asynchronous machine without a filter*

Fig. 3 *Torque characteristic curve during load simulation of a fan*

Fig. 4 *V/F characteristic curve during load simulation of a fan*

DRIVES OF THE SYNCHRONOUS MACHINE

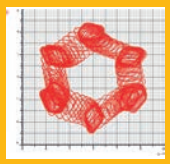
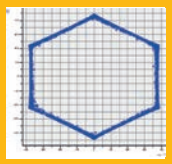
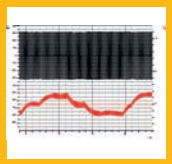




Fig. 1 *Fig. 2* *Fig. 3*

Fig. 1 *Current vector of a block commutation*

Fig. 2 *Voltage vector of a block commutation*

Fig. 3 *Voltage and current of a block commutated, permanently activated synchronous machine*

CASSY FAMILY
UNIVERSAL MEASURING SYSTEM

BENEFITS AT A GLANCE

- Simple, manual operation with all standard digital end devices
- Modern interfaces
  - USB-C
  - WiFi
  - Ethernet
- comprehensive software support
  - Lab Doc interactive instructions
  - Clear web interface
  - Integrated VNC server
  - CASSY Lab 2
  - LabView™ and MATLAB®
- Experiments can be conducted with and without a PC

CASSY LAB 2 SOFTWARE
FOR DRIVES & ENERGY SYSTEMS

- School licence enables use on any number of PCs at a school, college or a university
- Supports Power Analyser CASSY, Converter Controller CASSY and Machine Test CASSY
- Manual or automatic acquisition of measured values
- Different types of analysis available, including integrals, diagram labels, etc.
- Connection to integrated measured value server established in local network via QR code
- Measurement data and diagrams can easily be exported via clipboard
- Free updates and demo versions available on the internet
- System requirements:
  Windows 7/8/10/11 (32+64 bit),
  alternatively Linux or MacOS X (up to version 10.14) with Wine, free USB port, local network, supports multi-core processors

POWER ANALYSER CASSY

The Power Analyser CASSY combines isolated and differential oscilloscopes, multimeters, Watt metres, energy analysers and recording metres.

POWER ANALYSER CASSY PLUS

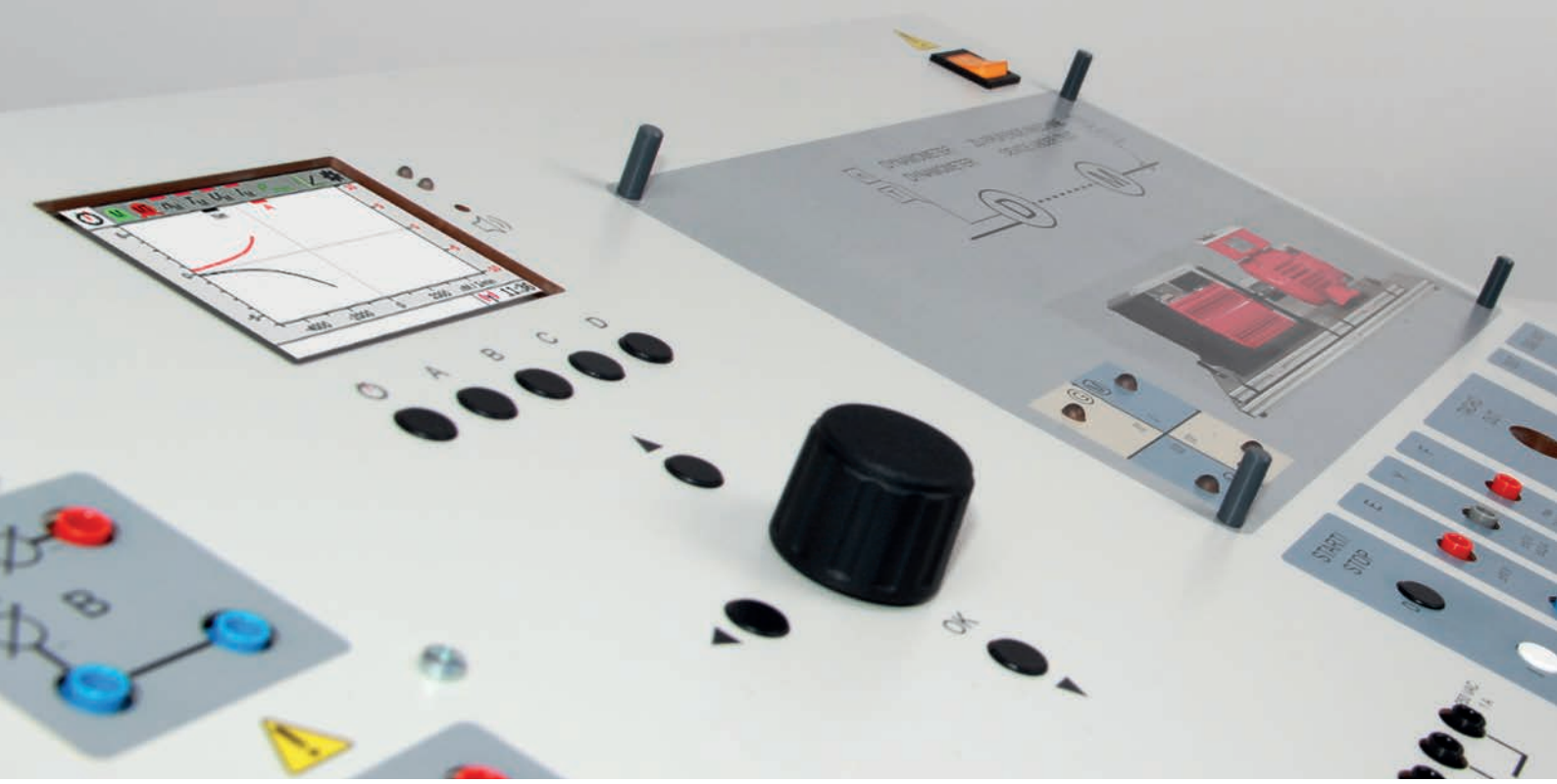
The Power Analyser CASSY Plus offers all the capabilities of the Power Analyser CASSY with the addition of a 4-channel isolation amplifier. The analogue outputs enable the connection of, for example, an oscilloscope. In addition, one output can be used as a function generator.

Additional functions of the Power Analyser CASSY Plus:

- Up to 4 safe and isolated analogue signal outputs for e.g. oscilloscopes and/or control equipment
- Real-time mathematical functions of signals
- Function generator and reference value generator

BOTH DEVICES ARE SUITED TO THE FOLLOWING AREAS OF APPLICATION:

- Energy networks
  - Voltage and frequency stability
  - Load behaviour of networks
  - Effect of harmonics
- Electrical machines
  - Inrush current from transformers and machines
  - Transformation ratio of transformers
  - Efficiency of machines
- Power electronics
  - Rectifier
  - DC/DC converter and DC/AC converter
  - Frequency converter
  - Filter
- Drive technology
  - Measurement in drive systems
  - Measurement of discharge current
  - Efficiency of drives
- Installation technology
  - RCD currents
  - Feedback from LED and gas discharge lamps
  - Automatic circuit breakers and fuses



MACHINE TEST CASSY 300 W I 1 KW

The Machine Test CASSY is part of the machine test system used to analyse electrical drives and simulate machine loads. It is a compact device that can be used in the panel frame or as a tabletop unit.

It also includes a high-performance measurement and analysis system with four insulated and isolated measurement channels to simultaneously measure the current and voltage.

- Analysis of machines as a motor and generator
- Behaviour of various load cases, e.g. flywheel mass, fan, etc.
- Behaviour of time-variable load conditions
- Analysis of the frequency converter with asynchronous and IMP machines
- Starting with star-delta circuit, soft starter and frequency converter
- Parametrisation of control units for a soft or heavy start with a slip ring starter

THE CASSY FAMILY

FOR VOCATIONAL TRAINING

The technical specifications apply to the following products from this range:

MEASURING FUNCTIONS & CONTROL

- 4 channel power analyser included
- 1 MSample per channel / 16 bit sampling
- 1000 VDC / 700 V AC max. voltage
- 24 A DC / 16 A AC / max. current
- φ, P, f, t, φU_A-U_X
- Integrated filter, connectable, 140 Hz - 560 Hz, -3 dB

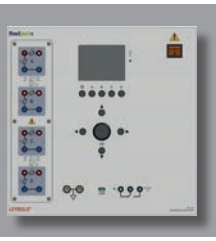
INTERFACES

- USB (type C socket)
- LAN (RJ45)
- WiFi (800.11ag)
- Supports WiFi Hotspot

SOFTWARE SUPPORT

- CASSY LAB 2
- Lab Docs (network, USB)
- LabView™ (network, USB)
- MatLab® (network, USB)
- WebAPP (internal web server)
- 16 GB internal memory
- Max. 4 connectable TCP clients

Power Analyser CASSY
Analysis and measurement of networks with several phases



- 4 channels ±1000 V / ±100 V / 1 MSamp. / 16 bit
- 4 channels ±24 A / ±2.4 A / 1 MSamp. / 16 bit

Power Analyser CASSY Plus
Network analysis and control of loads, relays, etc.

- 5 channels ±10 V/ 1 MS / 12 bit as analogue output

Machine Test CASSY 0.3
Testing and analysis of electrical machines and drives up to approx. 300 W

- Special measured variables integrated (T_M, n_M, α_M)
- Measured variables in real time (U_M, I_M, P_{el}, φ_M, P_{mec}, S_M, Q_M, s_M, η_M)
- 1 channel ±10 V/ 1 MS / 12 bit as analogue output
- 2 analogue channel inputs -±10 V
- 1 digital channel input 0- 5/24V
- Dynamometer, digital tachometer and temperature monitor

Machine Test CASSY 1.0
Testing and analysis of electrical machines and drives up to approx. 1000 W

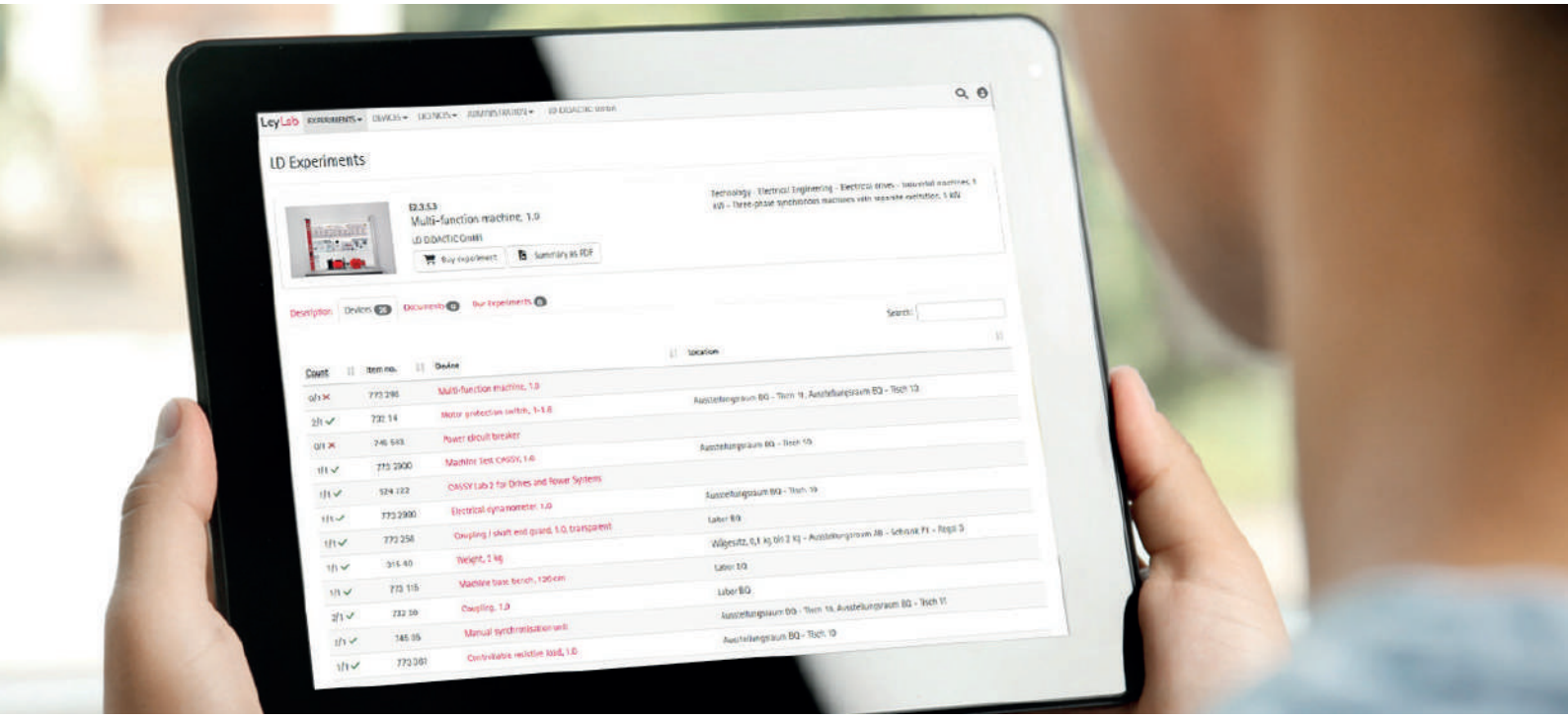
- Special measured variables integrated (T_M, n_M, α_M)
- Measured variables in real time (U_M, I_M, P_{el}, φ_M, P_{mec}, S_M, Q_M, s_M, η_M)
- 1 channel ±10 V/ 1 MS / 12 bit as analogue output
- 2 analogue channel inputs -±10 V
- 1 digital channel input 0- 5/24V
- Dynamometer, digital tachometer and temperature monitor

Converter Controller CASSY
Control of drives with different signal types with and without a control unit

- Special measured variables integrated (U_{DC}, I_{DC}, I_U, I_W, n_x, α_x, α_{Posx})
- 2 analogue channel inputs -±10 V
- 3 digital channel inputs 0- 5/24V
- Analogue & digital tachometer, frequency converter, resolver, block commutator & temperature monitor

LEYLAB –

ONLINE PORTAL FOR THE ORGANISATION & MANAGEMENT OF EXPERIMENTS, DEVICES & LITERATURE



The LeyLab online portal provides instructors with everything for time-saving lesson preparation. In addition to the appropriate equipment, the corresponding devices, including the digital experiment instructions and lots of information in the instructor version, are illustrated clearly and can be found quickly. With a single click, the instructor can thus share the instructions with all of the students on their smartphones, tablets and PCs.

- Complete online portal
- Centralised organisation & management of experiments and devices
- No installation required
- For all platforms, smartphones, tablets, laptops or PCs
- Including video tutorials
- Accessible at all times from anywhere

EXPERIMENT COLLECTION

ANY TIME & ANYWHERE

- Access to the entire LD experiment catalogue including all the relevant information for every experiment
- Find required experiment quickly and reliably
- Setup own collection of experiments
- Easily expand the LD experiments
- Simply create own new experiments
- Intelligently link devices
- Additional documents are available where required for the experiment
- Collection of all types of documents including PDFs, videos or links to websites

CENTRALLY AVAILABLE
LITERATURE

- Purchased LD literature saved with relevant experiment
- Easy to share with all of the students
- Personalised experiment instructions can be included

DEVICE COLLECTION

INVENTORY AT A GLANCE

- Direct overview of all available devices, including quantity and storage location
- Save time when searching for devices
- Detailed information about each device
- Easy inventory of the complete collection
  - LD devices and other manufacturers' devices
  - With bar code functionality
- Clear inventory management including loan and return function

EVERYTHING IN ONE PLACE
LICENCE MANAGEMENT

- All of the LD software and experiment literature
- Licence codes are saved securely in the cloud so that they are not lost and can be used to install software on new hardware

GUEST ACCESS & COLLABORATION

SHARING INFORMATION

- LeyLab can be accessed by third parties
- Collaboration with colleagues
- User management with access levels
- Exchange of information enables centralised organisation

EXPERIMENT INSTRUCTIONS
PERFECT SUPPORT FOR INSTRUCTORS & STUDENTS

The well-known paper experiment instructions are now not only digital but also interactive and can be edited. Students enter answers directly in Lab Docs on their tablet. Measured values are added to tables in real-time and can be analysed immediately. Images and videos can be integrated in addition to the well-known instructions, tasks and analysis. This is all combined into a complete digital report that can be saved and simply shared to be corrected.

Lab Docs can be opened on any of the students' tablets, smartphones or PCs – regardless of the manufacturer or software platform. Problems such as installations, updates, the age of the device or a mixture of manufacturers are a thing of the past. Once they have opened Lab Docs, students can work with it immediately.

STUDENTS' VERSION

Observation and measurement results

13. Release the Maschinen Test CASSY by pressing the **white button** once.
14. Now the machine is active and switched on.
15. Start the measurement with the Start/Stop button: if the measurement should be repeated then **Delete all measurements**

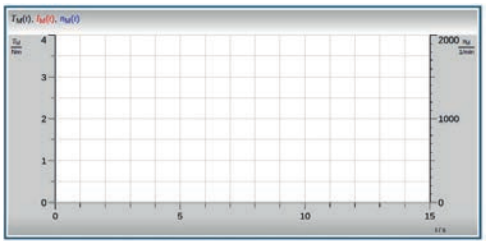


Fig. 4: Torque T_M(n_M1) T_{M1}, speed n_{M1} and machine current I_{M1} with an inertia of 0,05 kgm².

16. Using the sliders, determine the starting time of the motor with a flywheel mass of 0,050 kgm².

INSTRUCTORS' VERSION

Observation and measurement results

13. Release the Maschinen Test CASSY by pressing the **white button** once.
14. Now the machine is active and switched on.
15. Start the measurement with the Start/Stop button: if the measurement should be repeated then **Delete all measurements**

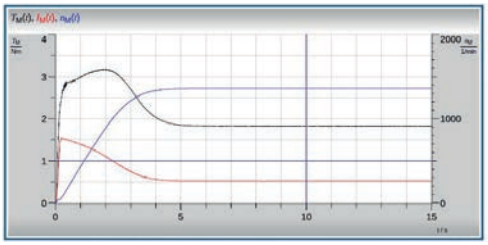


Fig. 4: Torque T_M(n_M1) T_{M1}, speed n_{M1} and machine current I_{M1} with an inertia of 0,05 kgm².

16. Using the sliders, determine the starting time of the motor with a flywheel mass of 0,050 kgm²,

n_M = 500 1/min
t = 10,0 s

PREPARATIONS
SAVING TIME

- LeyLab contains all of the acquired LD experiment instructions that can be accessed anywhere
- All of the information is available directly in the experiment – literature, required devices, storage location and additional information
- List of experiments that can be completed with existing devices
- Experiment instructions comprise detailed supporting information including experiment objectives, analysis and additional information
- Easy-to-transfer experiment instructions
- Free online updates of the experiment instructions in LeyLab

EXPERIMENTING
SIMPLE TO USE & FUNCTIONAL

- Clearly structured worksheets with information and images
- Step-by-step instructions for completing experiments and warnings to ensure they are completed safely
- Actual examples of measurement results and diagrams for students to check themselves

DISTRIBUTION

LITERATURE

- Sharing the experiment instructions in LeyLab with all of the students
- Via QR code on site or online lessons
- Link by e-mail, learning platform or online classes
- PDF file by e-mail, learning platforms or online classes

SUPPORT

ONLINE PLATFORMS

- Microsoft Teams for Education
- Other platforms

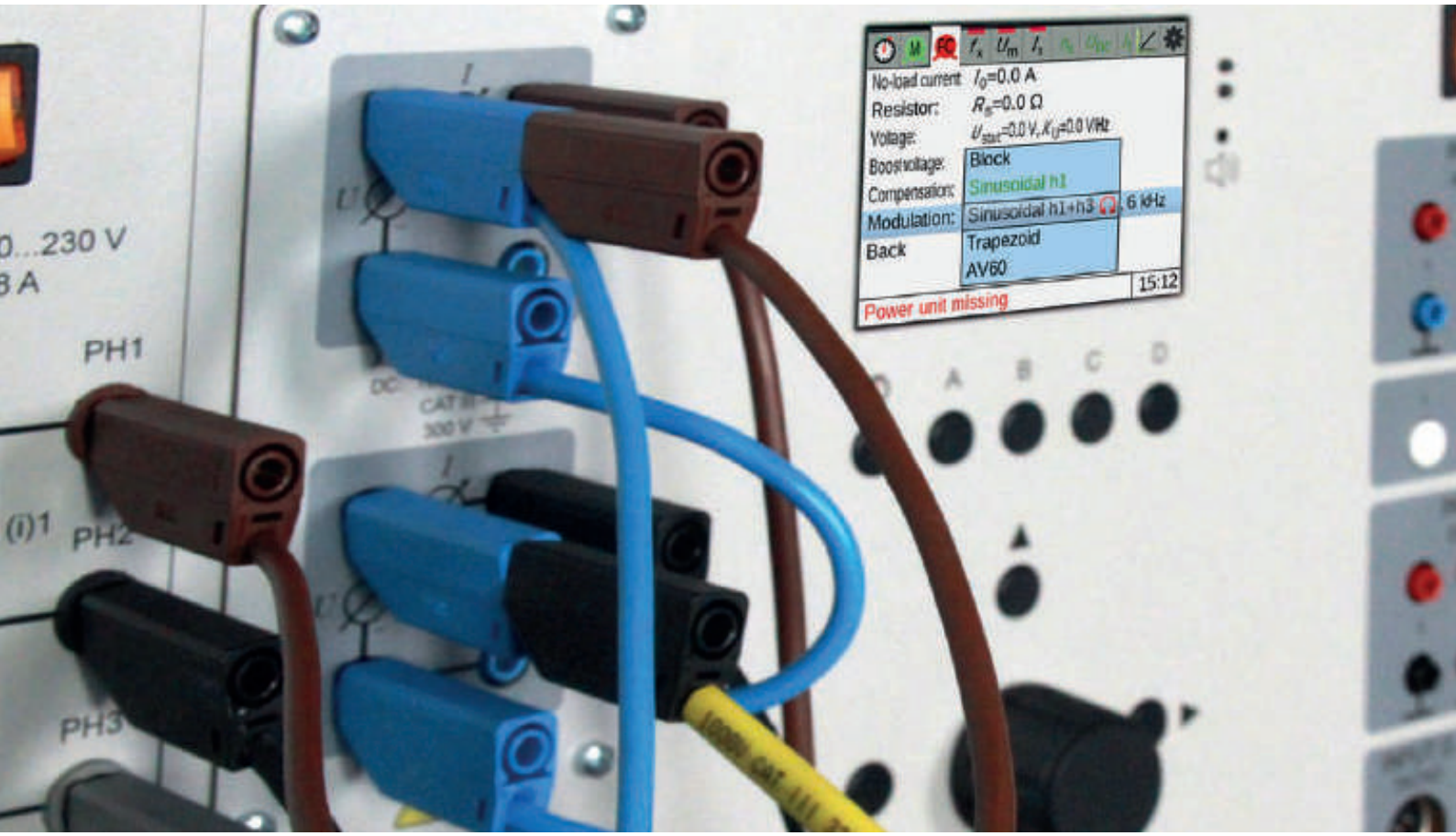
LAB DOCS EDITOR PRO

Create your own or simply edit the digital experiment instructions

To achieve the best results for students, digital experiment instructions can be adapted to the educational and methodological approaches with immediate effect. This is very easy to implement using the software Lab Docs Editor Pro. This can also be used to create completely new experiment instructions without any prior knowledge.

- Create instructions and tasks; integrate and edit interactive diagrams and tables; add text and answer fields
- Add images, vector graphics, hyperlinks, etc.
- Prepare and create material lists
- Create formulas in LaTeX-Syntax
- Integrate videos and websites e.g. GeoGebra

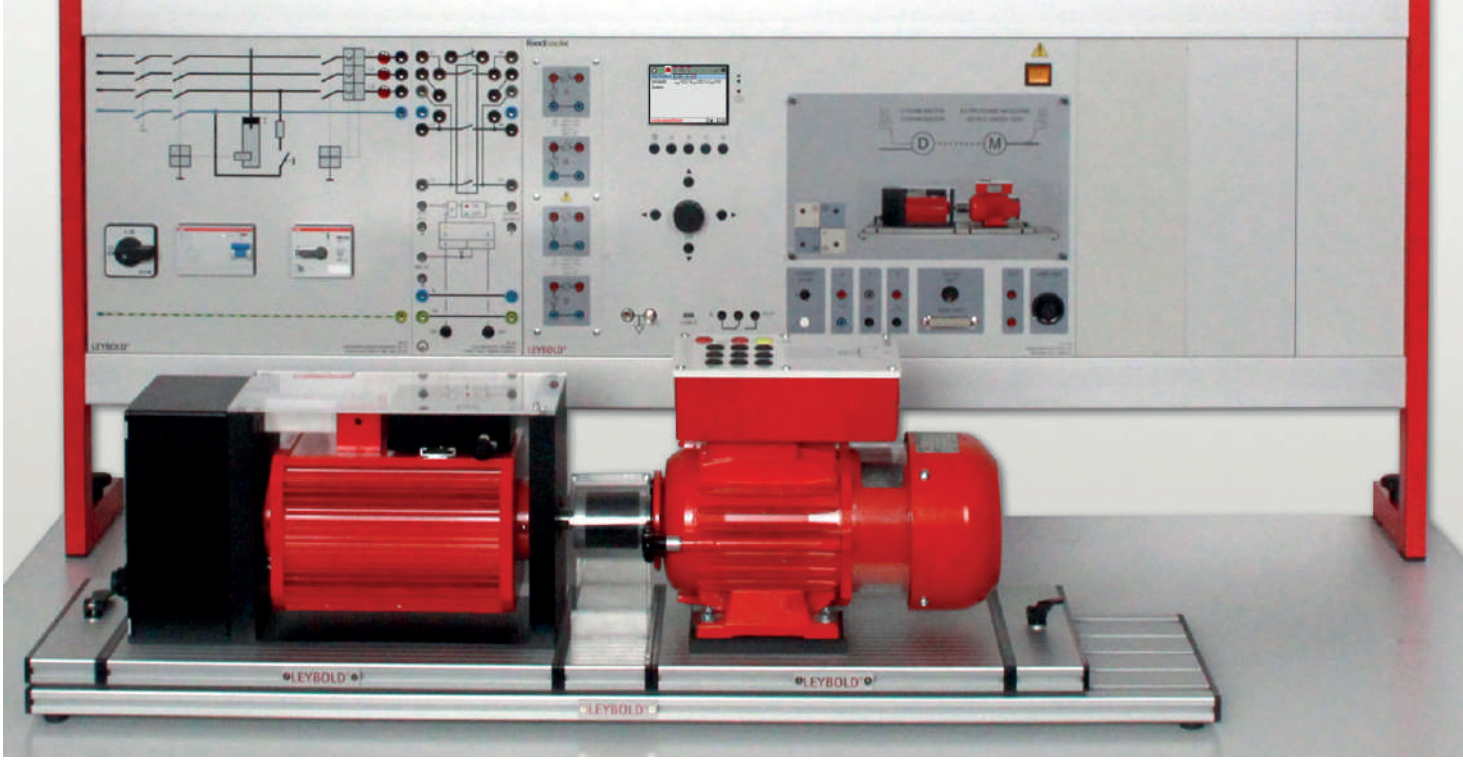
TRAINING PLATFORMS SYSTEM – TPS

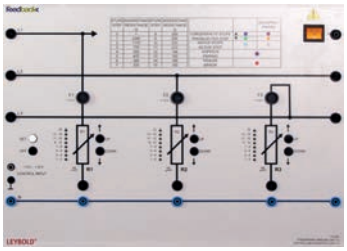


The LEYBOLD experiment platforms are the core of a successful learning system. The selected equipment stands out for being clearly structured. The TPS equipment ensures that all of the required curricula in the relevant topic can be developed.

THE MODULAR TRAINING PLATFORM SYSTEM FOR STUDENT & DEMONSTRATION EXPERIMENTS

- Use of original components
- Experiment literature to prepare lessons and complete experiments
- Clear front view





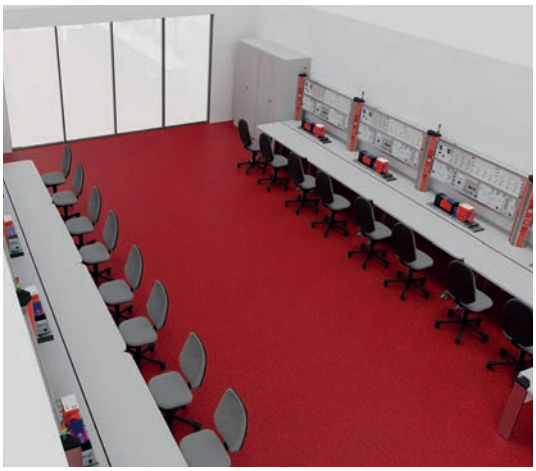
The consistent use of 4 mm safety bushes, cables and bridge plugs enables experiments to be completed safe. Supported by detailed experiment instructions, the students have a variety of opportunities to learn new knowledge and skills while simultaneously consolidating knowledge they have already acquired.

The reliable TPS experiment platform system is also perfectly suitable for the instructor to demonstrate complex experiments. Supporting technologies such as CASSY App, CASSY LAB 2 and Lab Docs additionally offer the possibility to perform all experiments on the PC. This closes the gap between traditional learning methods and new technologies.

The system can be easily expanded at any time through its flexible modules. This also ensures easy maintenance. Thanks to the stable metal housing devices can also be used as a desk housing.

The modular concept enables technology laboratories to be retrofitted and expanded quickly and easily with the TPS system.

LABORATORY ROOM PLANNING & SETUP



By collaborating with ELABO GmbH, LD DIDACTIC has gained a partner to provide equipment for learning laboratories. Customers can rely on the competence and knowledge from two experts with many years experience planning and realising new specialist rooms in automobile technology and electric engineering.

This collaboration means that LD DIDACTIC is working with a company that has been known for its innovations and the quality of the electric engineering laboratory equipment since 1972. ELABO is also known as a pioneer when it comes to considering ergonomic aspects as well as the integration of power supply and measurement devices into laboratory furnishings.

Overview of partner benefits:

- Two experts supply everything from a single source with one point of contact
- Combination of laboratory equipment and teaching system provide efficient lessons
- Professional planning and visualisation of the future laboratory
- Flexible functionality can be integrated into the furnishings
- Individual workplace solutions (e.g. custom-made storage space and creative side room solutions)
- Digital teaching using software for room and device control
- Creative solutions make the learning environment more modern
- Modular setup and teaching solutions offer flexibility for the challenges of future training tasks
- Different equipment lines for specific requirements
- Implementation with complete budget
- Modern design solutions provide optimum learning atmosphere

All equipments can be purchased with the mobile experiment stand, including experimental frame and profile for electrical installation.

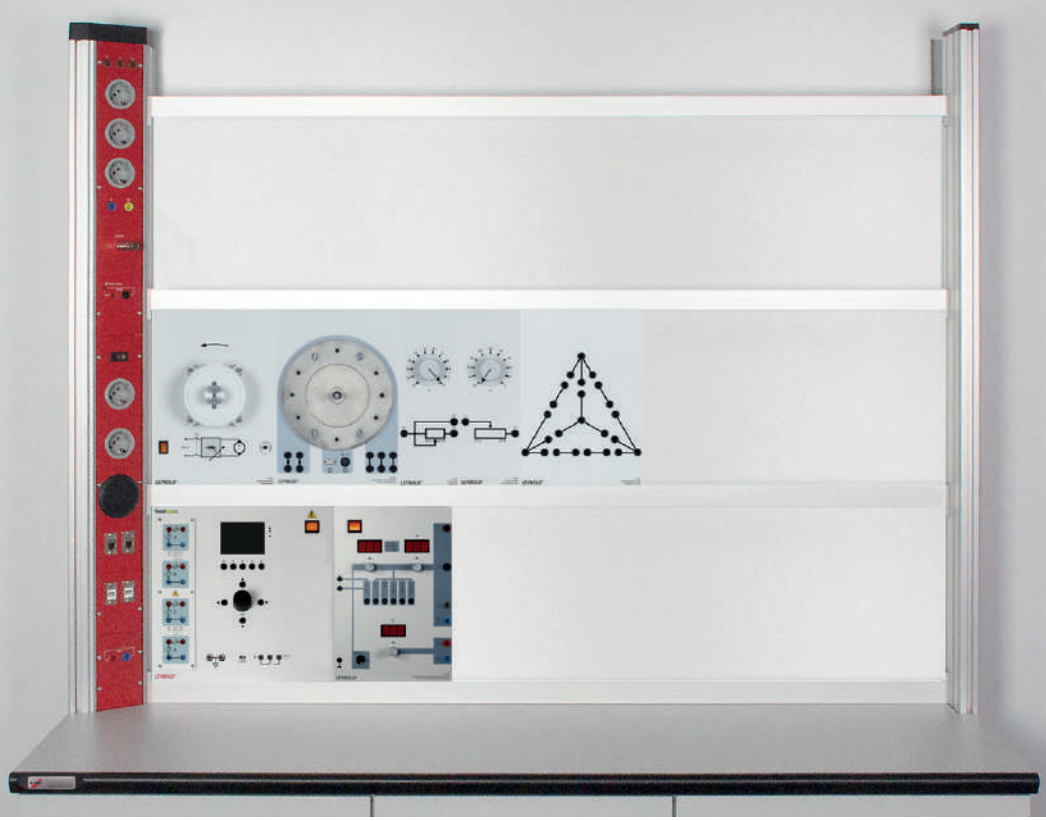
E2.1.5.2
Industrial induction machines with rotor kits

For more information, see page 35.

CHAPTER SUMMARY

Electrical machine teaching models ELM

E2.1.1.1
ELM Basic machines for extra-low voltage



ELM Basic machines for extra-low voltage (E2.1.1.1)

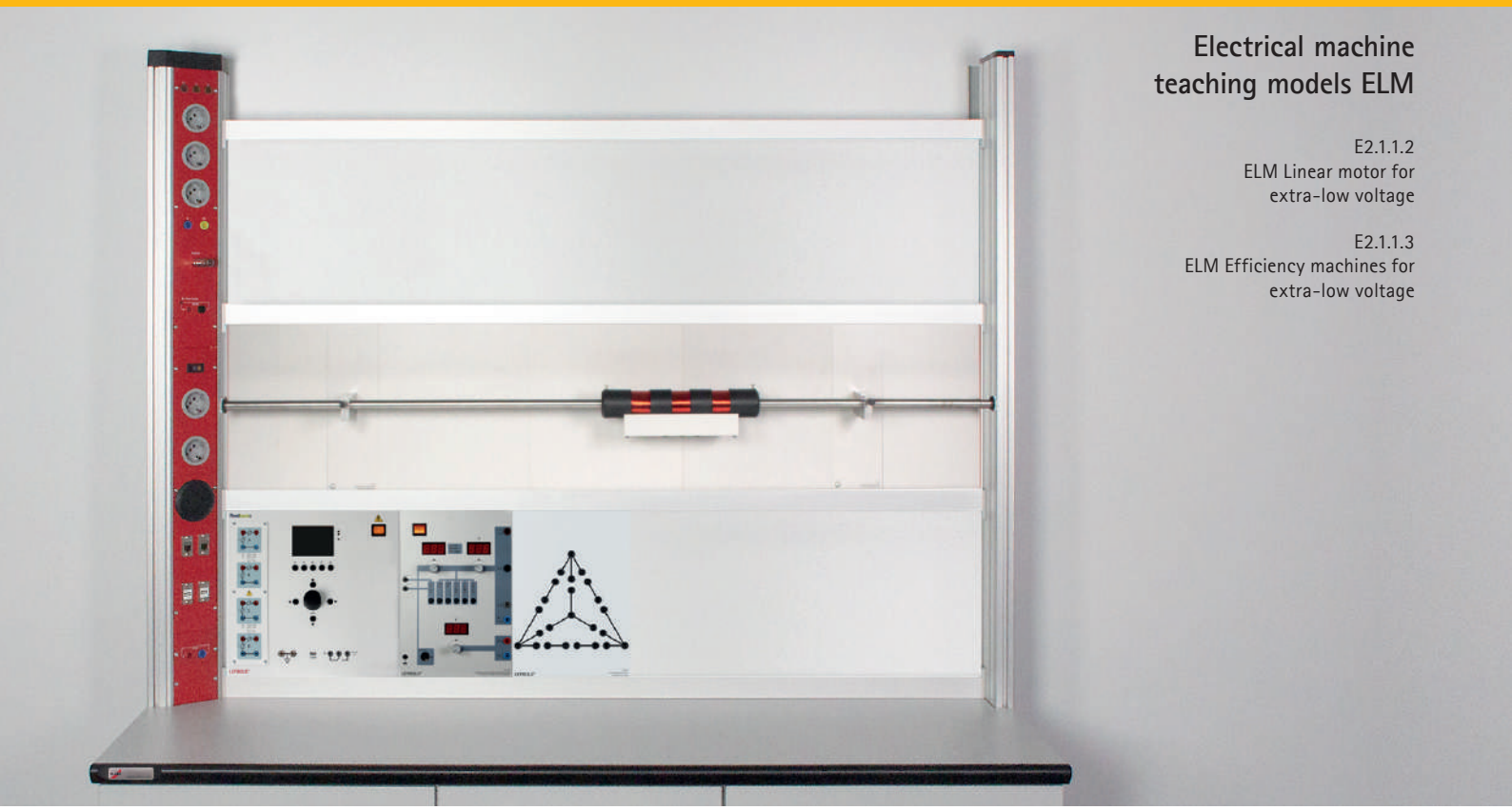
Cat. No.	Description	E2.1.1.1
563 11	ELM coil, 250 turns	6
563 12	ELM squirrel cage rotor	1
563 13	ELM brush	5
563 17	ELM centring disc	1
563 181	ELM brush holder rack	1
563 22	ELM two-pole rotor	1
563 23	ELM three-pole rotor	1
563 24	ELM drum rotor	1
563 25	ELM rotating field attachment and squirrel cage ring	1
563 28	ELM magnetic needle rotor	1
563 29	ELM aluminium ring with iron disc	1
563 091	ELM pole shoe for magnets	2
563 101	ELM wide pole shoe for coils	3
563 115	ELM coil, 500 turns	3
563 201	ELM narrow pole shoe for coils	6
563 211	ELM split pole shoe for coils	2
727 811	Basic machine unit	1
727 82	Basic terminal unit	1
727 83	Set of support film	1
727 85	Starter	1
727 86	Field rheostat	1
727 87	Star-delta load	1
727 88	Drive unit	1
685 96	Driving belt, long, for drive unit 72788	1
510 48	Magnets, 35 mm diam., pair	1
578 16	Capacitor, 4.7 µF, STE 2/19	3
579 06	Lamp holder, E10, top, STE 2/19	3
505 171	Bulbs, 6 V/1.1 W, E10, set of 10	3
505 191	Bulbs, 15 V/2 W, E10, set of 5	3

Cat. No.	Description	E2.1.1.1
579 10	Pushbutton (NO), STE 2/19	1
579 13	Toggle switch STE 2/19	1
563 04	Storage tray for ELM devices	2
727 100	Power Analyser CASSY	1
580 0136	Tachometer (handheld)	1*
725 722	Low Voltage Three Phase Inverter	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
563 16	Hex key	1
563 31	Oil, 100 ml, in dropping bottle	1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

With this equipment, direct current, alternating current, and three-phase current machines are assembled from a few manageable individual parts. The functional machines show the different combinations of the stators and rotors and allows for inspections of various snubber (circuit) types. Despite the example set by the electrical machine teaching model, physical processes and typical behaviours of large machines can be demonstrated. The machines are mounted on a connection base unit and with special support overlays. The open design of the machines allows the individual functional parts to be monitored during operation. All attempts are run only with non-hazardous protective extra-low voltage. As well as conventional machine types, the basic features of linear motors are also covered. Rotating field machines with permanently excited rotors from rare earth metals (high-efficiency rotors) are new.



Electrical machine teaching models ELM

E2.1.1.2
ELM Linear motor for extra-low voltage

E2.1.1.3
ELM Efficiency machines for extra-low voltage

ELM Linear motor for extra-low voltage (E2.1.1.2)

Cat. No.	Description	E2.1.1.2	E2.1.1.3
727 91	Linear motor basic unit	1	
727 92	Linear motor with coil body	1	
563 04	Storage tray for ELM devices	1	
564 172	LIT-print: Electrical Training Machines	1*	1*
727 100	Power Analyser CASSY	1	1
580 0136	Tachometer (handheld)	1*	1*
725 722	Low Voltage Three Phase Inverter	1	1
726 09	Panel frame T130, two-level	1	1
500 59	Safety bridging plugs, black, set of 10	1	1
500 592	Safety bridging plugs with tap, black, set of 10	1	1
500 855	Safety experiment cables, 32 A, set of 34	1	1
727 812	ELM rotor position sensor		1
727 815	ELM set of multipole stator and rotor		1
727 816	ELM PM rotor magnets, interior		1
727 811	Basic machine unit		1
727 82	Basic terminal unit		1
727 83	Set of support film		1
727 87	Star-delta load		1
727 88	Drive unit		1
685 96	Driving belt, long, for drive unit 72788		1
510 48	Magnets, 35 mm diam., pair		1
579 06	Lamp holder, E10, top, STE 2/19		3
505 171	Bulbs, 6 V/1.1 W, E10, set of 10		3
505 191	Bulbs, 15 V/2 W, E10, set of 5		3
727 800	Storage ELM		1
775 071EN	LIT-print: Electrical Equipment in Hybrid and Electric Vehicles		1*
563 16	Hex key		1
563 31	Oil, 100 ml, in dropping bottle		1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

E2.1.1.2 ELM Functional principles of linear motors

Linear motors of a linear force acting in a straight line. The various designs and operating principles are derived from the familiar rotating electrical machines. In practice, there are asynchronous linear motors and permanently excited synchronous linear motors. The simple and robust design of the asynchronous linear motor helps to understand the basic principles of these drives.

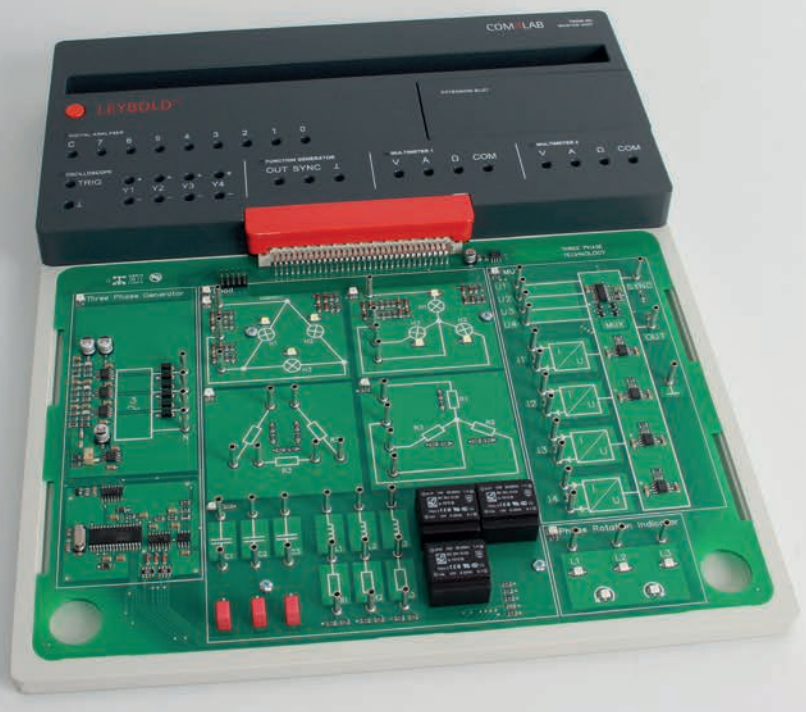
E2.1.1.3 Efficiency machines for extra-low voltage

Due to the lossless rotor excitation and the lower use of raw materials (Al, Fe, Cu), the energy efficiency increases compared to a classic synchronous motor. When used as a direct drive, an additional efficiency gain compared to geared motors can be identified for small motor outputs: permanent magnet motors are wear-free and require neither lubricants nor gears. Even as generators in micro power plants, efficiency machines achieve higher efficiencies than previous solutions allow. In conjunction with the three-phase power supply, block and sinusoidal modulation types can be investigated. The function of the rotor position sensor equipped with Hall elements is also the subject of the experiments. By simply connecting the windings using bridge plugs, star and delta connection can be quickly and clearly converted into each other. Two high-efficiency rotors are available: one rotor with glued-on outer magnets and one rotor with recessed inner magnets. The magnets are colour-coded for pole differentiation. The 10-pin stator windings are also coloured to clarify the assignment to the three phases.

Motors and Generators

ME2.1.2
COM4LAB:
Three-Phase Technology

ME2.1.3
COM4LAB:
Asynchronous Machines



COM4LAB: Three-Phase Technology (ME2.1.2)

Cat. No.	Description	ME2.1.2	ME2.1.3
700 2401	COM3LAB Course: Three-Phase Technology - COM4LAB ready	1	
70025-00	COM4LAB Board: Electrical Machines		1
70025-20	COM4LAB Course: Asynchronous Machines		1
70000-00	COM4LAB Master Unit	1	1
70000-11	USB-C Charger 45 W Europlug (Type C)	1	1
70000-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1	1

ME2.1.2 COM4LAB: Three-Phase Technology

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 analyzed 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.

ME2.1.3 COM4LAB: Asynchronous Machines

The COM4LAB course entitled "Asynchronous Machines" is the first course to the fascinating world of electrical machines. The performance of the asynchronous machines is explained on a physical-mechanical level as well as examined by recording characteristics using an integrated machine test system. Terminal connections, changing of rotational direction and speed control are practically devised using a number of experiments. The course comprises 10 chapters.

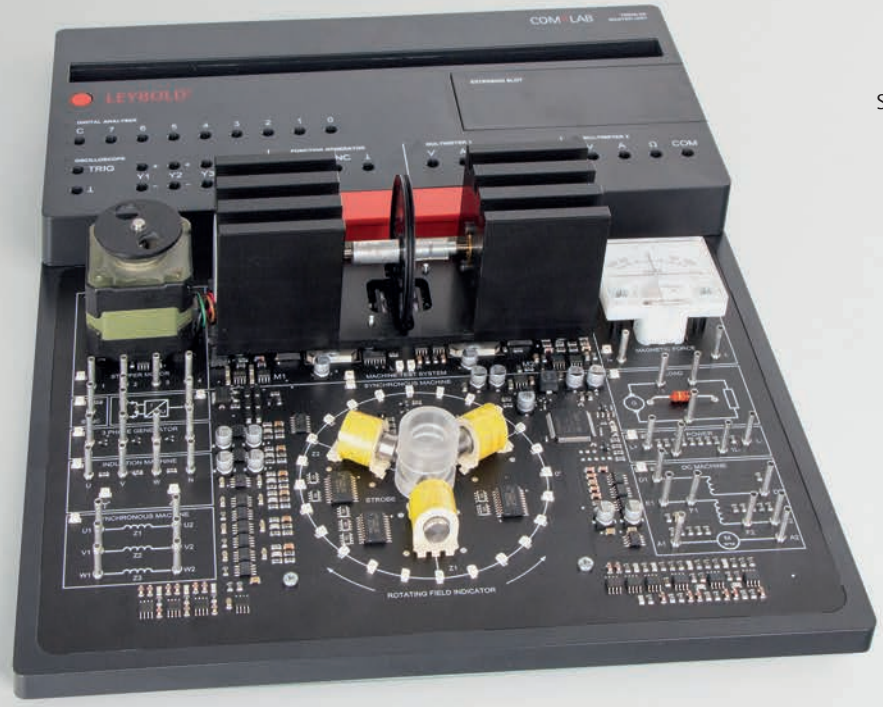
topics

- 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

Motors and Generators

ME2.1.4
COM4LAB:
Synchronous Machines

ME2.1.5
COM4LAB:
DC Machines



COM4LAB: Synchronous Machines (ME2.1.4)

Cat. No.	Description	ME2.1.4	ME2.1.5
70025-00	COM4LAB Board: Electrical Machines	1	1
70025-30	COM4LAB Course: Synchronous Machines	1	
70025-40	COM4LAB Course: DC Machines		1
70000-00	COM4LAB Master Unit	1	1
70000-11	USB-C Charger 45 W Europlug (Type C)	1	1
70000-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1	1

ME2.1.4 COM4LAB: Synchronous Machines

The COM4LAB course entitled "Synchronous Machines" is the second course to the fascinating world of electrical machines. The performance of the synchronous machines, the speed measurement and the speed adjustment are examined. The design, the principle of operation and the performance of the stepper motor are practically devised using a number of experiments. The course comprises 9 chapters.

ME2.1.5 COM4LAB: DC Machines

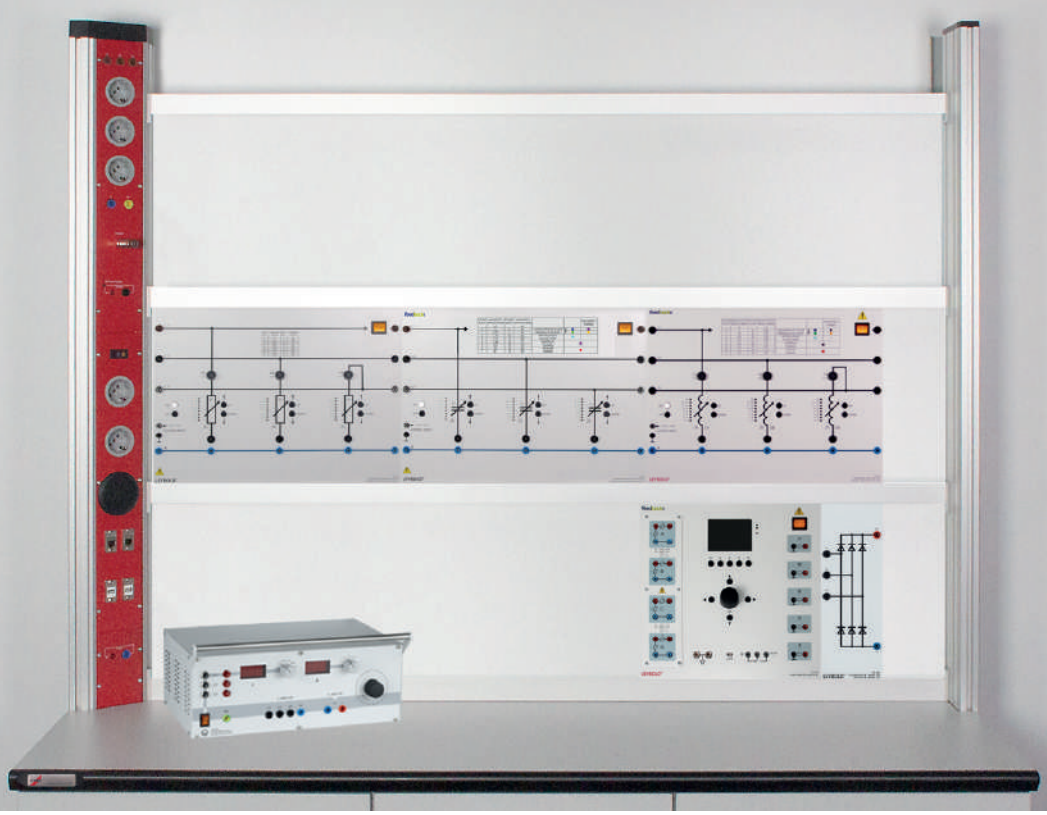
The COM4LAB course entitled "DC Machines" is the third course to the fascinating world of electrical machines. The performance of the DC machines for different connection types is explained and practically devised using a number of experiments. The course comprises 9 chapters.

topics

- design
- circuit diagrams
  block circuit diagram | eqivalent circuit diagram
- connection types
  external excitation | shunt winding | series winding | generator operation

Basics of single-phase and three-phase energy networks

E2.1.3.1
Load behaviour in DC, 1-phase and 3-phase networks



Load behaviour in DC, 1-phase and 3-phase networks (E2.1.3.1)

Cat. No.	Description	E2.1.3.1
773 360	Controllable resistive load, 0.3	1
773 362	Controllable capacitive load, 0.3	1
773 364	Controllable inductive load	1
735 065	Rectifier B6, 3 x 400 V / 10 A	1
735 095	Capacitors 2 x 1000 µF, 385 V	1
116 0-60070ECT	LIT: Loads in DC and AC grids	1
727 110	Power Analyser CASSY Plus	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
726 75	Three-phase terminal unit with RCD	1
733 91	3-phase transformer, 1.0	1
726 09	Panel frame T130, two-level	1
500 617	Safety cable, 25 cm, brown	3
500 614	Safety experiment cable, 25 cm, black	3
500 6181	Safety cable, 25 cm, grey	3
500 602	Safety experiment cable, 10 cm, blue	9
500 59	Safety bridging plugs, black, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The equipment enables the investigation of the properties of electrical energy in single-phase and three-phase systems. Special attention is focused on the measuring analysis of the physical parameters (voltage, current, phase, power). This makes it an excellent piece of equipment for entry into three-phase technology.

The measuring instrument Power Analyser CASSY was specially developed for this type of experiment. The vector display for the correlation of current, voltage and associated phase angle as a function of the loads is integrated in this instrument. This real-time representation illustrates the effects of different network loads in a particularly impressive way.

The equipment is equally suitable for pupil and student experiments in the laboratory with low voltage (DC, AC and three-phase current) and - with a mobile trainer - for teacher demonstrations in the classroom or lecture hall. The experiments are carried out according to the manual.

topics:

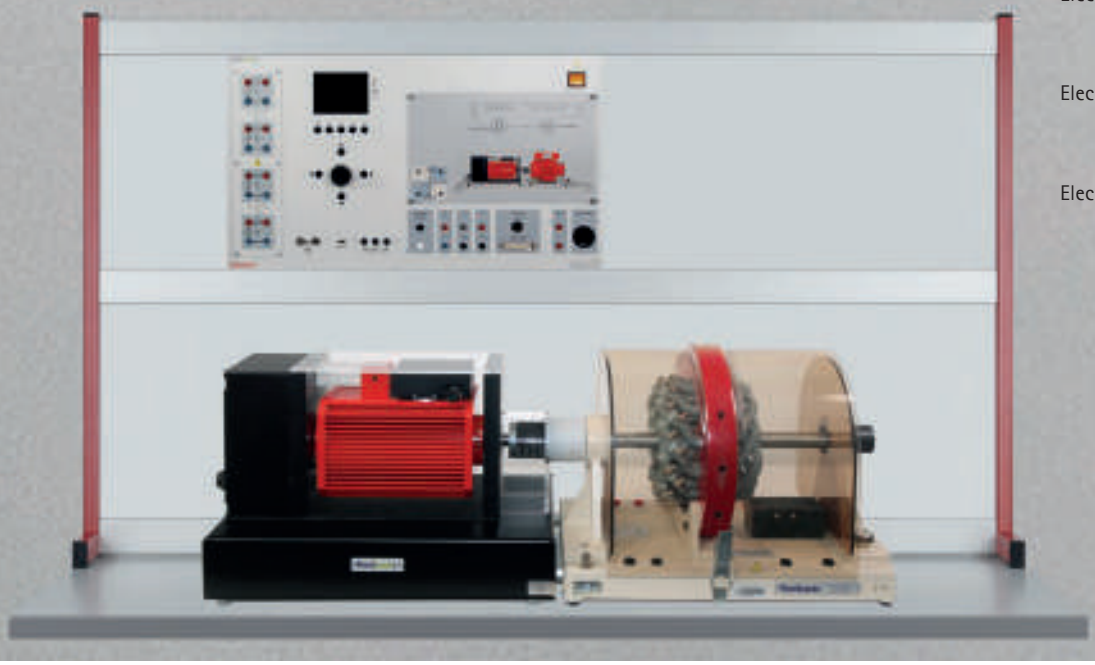
- single-phase system / three-phase system
- representation of phases and phase differences (oscilloscope representation and vector diagram)
- Ohmic load / Ohm's law
- star connection / delta connection
- influence of inductive and capacitive load
- active power, reactive power and apparent power
- basics of load compensation

Electrical machine training system

E2.1.4.1
Electrical machine training system, complete set

E2.1.4.2
Electrical machine training system, basic set

E2.1.4.3
Electrical machine training system, supplementary set



Electrical machine training system, complete set (E2.1.4.1)

Cat. No.	Description	E2.1.4.1	E2.1.4.2	E2.1.4.3
62- 100	Dissectible Machines Tutor, basic module	1	1	
67- 190	Resistor/Capacitor load	1		
62- 102	Rotatable Brush Gear	1		
67- 113	Variable Resistance 200 ohm 3A	1		
65- 130	Switching unit of Dissectible Machines Tutor	1		
67- 470	Friction brake	1		
731 62	Synchronisation indicator	1		
775 215EN	LIT-print: Dissectible Machines System	1	1	
773 1900	Machine Test CASSY, 0.3	1		1
773 1910	Dynamometer 0,3 DM	1		1
524 222	CASSY Lab 2 for Drives and Power Systems	1		1
731 06	Coupling, 0.3	1		1
745 561	Power circuit breaker module	1		1
580 0136	Tachometer (handheld)	1		
725 442DG	Three-phase voltage 400 V/2.5 A	1		
726 85	Adjustable transformer 0...260 V	1		
62- 101	Storage plate for Dissectible Machines Tutor	1	1	
738 01	Cable and plug box	4	4*	
726 287	Panel Frame FB T150, three level	2		
500 855	Safety experiment cables, 32 A, set of 34	1	1*	
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1*	
724 733	Mobile cable holder	1	1*	

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The Electric Machine Trainer equipment is based on a teaching system with dismountable didactic machines. The machines, assembled from individual components – from a kit according to instructions, can be fully metrologically examined and compared with each other.

objectives

- explanation of the components of an electric motor
- electromagnetic basics
- DC motors
- Generators
- series, shunt and compound motors.
- single-phase and three-phase AC motors and generators,
- series, universal, capacitor motors
- malfunctions in electric motors

E2.1.4.2 Dissectible Machines System, basic set

This equipment is a reduced equipment of the complete system in E2.1.4.1. All experiments are also carried out with the kit of dismountable didactic machines. Simple tools such as screwdrivers and pliers are necessary for this.

E2.1.4.3 Dissectible Training System, Supplementary Set

With this teaching system, electrical machines are constructed from individual elements and investigated. The topics are very diverse and range from the fundamentals of magnetic circuits to commutator machines and three-phase machines. All relevant components of the motors are visible and must be mechanically assembled and electrically connected.

Industrial machines with exchangeable rotors

E2.1.5.1
DC machine with
exchangeable rotors

DC machine with exchangeable rotors (E2.1.5.1)

Cat. No.	Description	E2.1.5.1
774 7726	DC stator NS, 0.3	1
774 7728	DC rotor, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
773 110	Machine base bench, 90 cm	1
315 39	Weight, 1 kg	1
731 06	Coupling, 0.3	1
775 190EN	LIT-print: DC machines 0.3	1
725 852DG	DC machine supply, 0.3	1
726 09	Panel frame T130, two-level	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1
774 7730	Assembly set exchangeable rotor base, 0.3	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

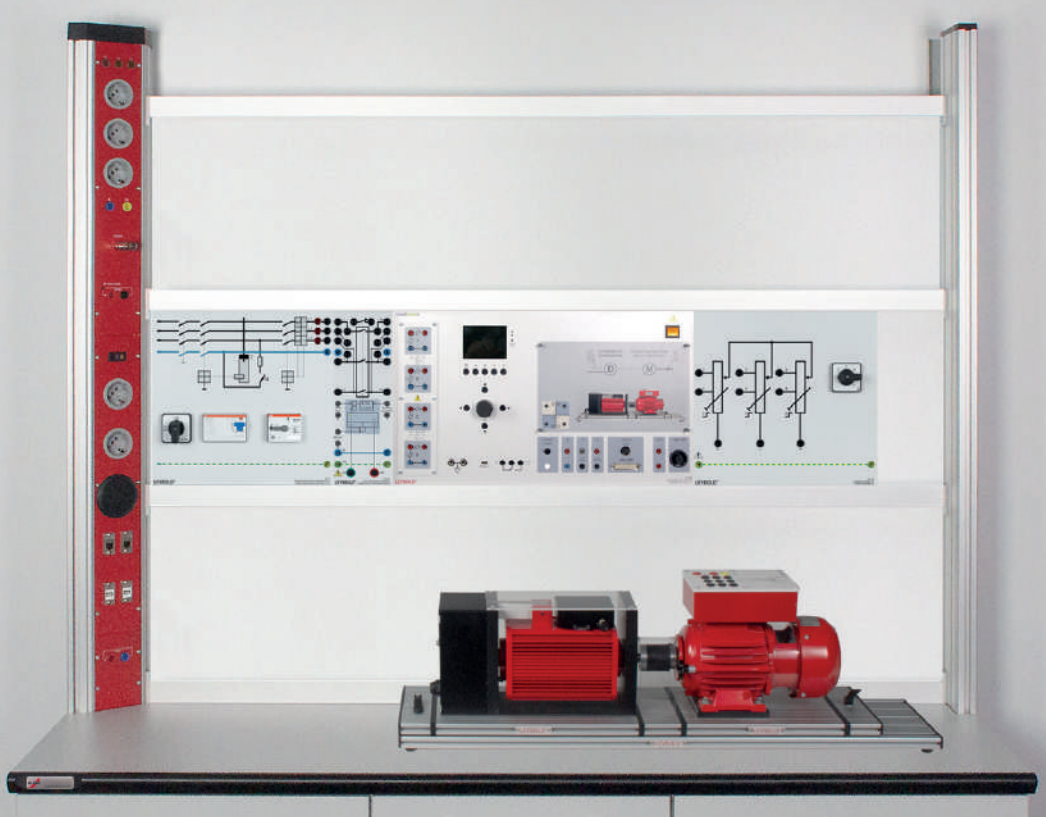
The DC machines with a changeable rotor consist of a rotor and two different stators. Only by assembling the stator and rotor does a ready-to-operate electrical machine of the 300 W class come into being. The stator contains a shunt winding or a series winding, the drive-end shield and the terminal box.

The stator housing is mounted on a base and can be connected directly to the machine test system 0.3. The stator and rotor are securely connected by star grip tension bolts, which allow the rotor to be changed quickly. No tools are required for this.

The rotors are equipped with non-drive-end shield, fan impeller, cover bonnet and commutator, brushes, etc. Together with the machine test system, the characteristic curves of the machines can be traced back to the properties of the respective stator. Depending on the stator used, the model machine then shows the typical characteristics of shunt-wound and series-wound machines.

topics

- recording the torque-speed characteristic
- determination of the nominal operating values of electrical machines as a motor or as a generator
- comparison of the efficiencies of different machines as motor or as generator
- load characteristic in generator operation
- no-load characteristic in generator operation



Asynchronous machines with exchangeable rotors

E2.1.5.2
Industrial induction machines
with rotor kits

Asynchronous machines with exchangeable rotors (E2.1.5.2)

Cat. No.	Description	E2.1.5.2
774 7720	Three-phase stator, 0.3	1
774 7721	Squirrel cage rotor, 0.3	1
774 7729	Squirrel cage rotor, high efficiency, 0.3	1
774 7722	Slip-ring rotor, 0.3	1
732 29	Rotor starter, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
773 110	Machine base bench, 90 cm	1
315 39	Weight, 1 kg	1
731 06	Coupling, 0.3	1
775 200EN	LIT-print: Induction Machines 0.3	1*
726 75	Three-phase terminal unit with RCD	1
726 09	Panel frame T130, two-level	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1
774 7730	Assembly set exchangeable rotor base, 0.3	1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The asynchronous machines with alternating rotor consist of a stator and three different rotors. Only by assembling the stator and rotor does a ready-to-operate electrical machine of the 300 W class come into being. The stator contains a three-phase winding, the drive-end shield and the terminal box.

The rotors are constructed as aluminium squirrel cage rotors, copper squirrel cage rotors and slip-ring rotors. The stator housing is mounted on a base and can be connected directly to the machine test system 0.3. The stator and rotor are securely connected by star grip tension bolts, which allow the rotor to be changed quickly. No tools are required for this.

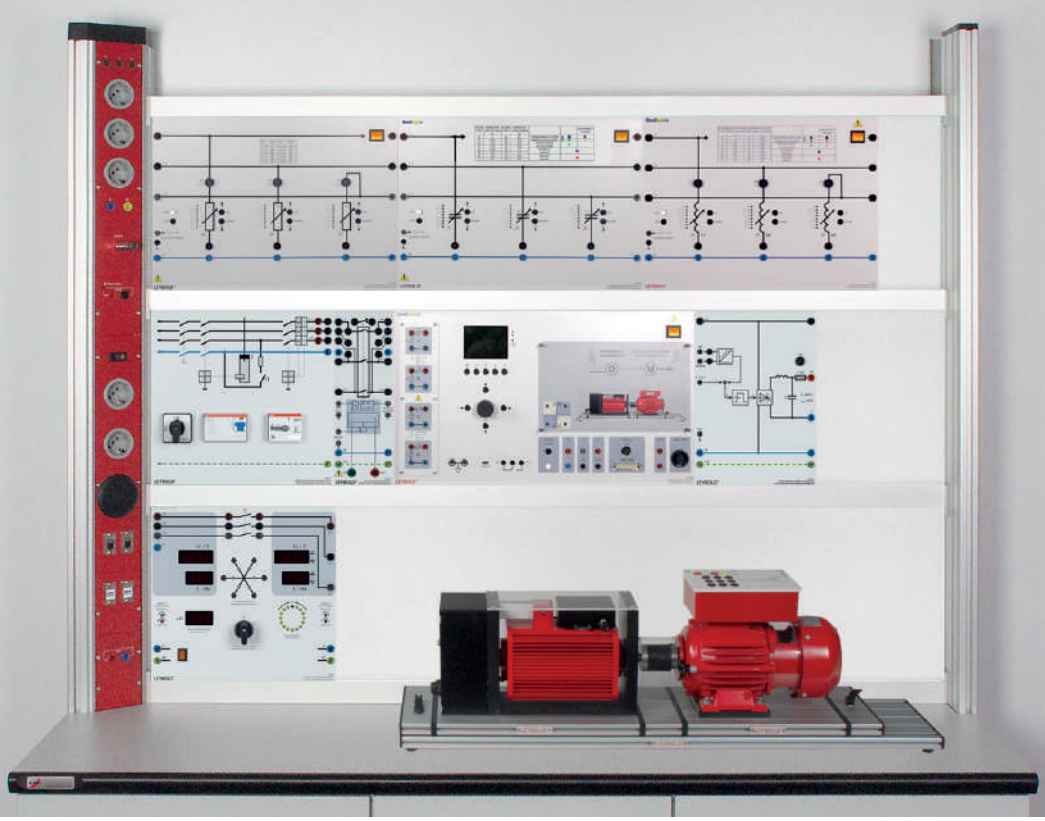
The rotors are equipped with non-drive-end shield, fan impeller, cover bonnet and commutator, brushes, etc. Together with the machine test system, the characteristic curves of the machines can be traced back to the properties of the respective stator. Depending on the rotor used, the model machine then shows the typical characteristics of squirrel cage and slip-ring machines.

topics

- recording the torque-speed characteristic
- determination of the nominal operating values of electrical machines as a motor
- comparison of the efficiencies of different machines as motor

Industrial machines with exchangeable rotors

E2.1.5.3
Synchronous machines with exchangeable rotors



Synchronous machines with exchangeable rotors (E2.1.5.3)

Cat. No.	Description	E2.1.5.3
774 7720	Three-phase stator, 0.3	1
774 7723	Salient pole rotor, 0.3	1
774 7724	Smooth core rotor, 0.3	1
774 7725	Reluctance rotor, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
315 39	Weight, 1 kg	1
773 110	Machine base bench, 90 cm	1
731 06	Coupling, 0.3	1
775 205EN	LIT-print: Synchronous Machine 0.3	1*
726 75	Three-phase terminal unit with RCD	1
745 021	Excitation voltage controller 200 V/2.5 A	1
726 09	Panel frame T130, two-level	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1
774 7730	Assembly set exchangeable rotor base, 0.3	1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The synchronous machines with rotor kits consist of a stator and three different rotors. Only by assembling the stator and rotor does a ready-to-operate electrical machine of the 300 W class come into being. The stator contains a three-phase winding, the drive-end shield and the terminal box.

The rotors are designed as solid pole rotor, salient pole rotor and reluctance rotor. The stator housing is mounted on a base and can be connected directly to the machine test system 0.3. The stator and rotor are securely connected by star grip tension bolts, which allow the rotor to be changed quickly. No tools are required for this.

The rotors are equipped with non-drive-end shield, fan impeller, cover and commutator, brushes, etc. Together with the machine test system, the characteristic curves of the machines can be traced back to the properties of the respective stator. Depending on the rotor used, the model machine then shows the typical characteristics of synchronous machines as a motor or generator.

CHAPTER SUMMARY

Transformers, 300 W

E2.2.1.1
Three-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 auto-transformer, 0.3

Three-phase transformer, 0.3 (E2.2.1.1)

Cat. No.	Description	E2.2.1.1	E2.2.1.2	E2.2.1.3	E2.2.1.4	E2.2.1.5
733 90	3-phase transformer, 0.3	1				
773 360	Controllable resistive load, 0.3	1	1	1	1	1
775 185EN	LIT-print: Transformers 0.3	1*				
727 110	Power Analyser CASSY Plus	1		1	1	1
524 222	CASSY Lab 2 for Drives and Power Systems	1	1	1*		1*
725 442DG	Three-phase voltage 400 V/2.5 A	1	1			
726 09	Panel frame T130, two-level	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
500 855	Safety experiment cables, 32 A, set of 34	1	1	1	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1	1	1	1
733 93	Scott transformer		1			
775 220EN	LIT-print: Transformers 1.0		1*	1*	1*	1*
733 97	1-phase transformer, 0.3			1		
773 362	Controllable capacitive load, 0.3			1	1	1
773 364	Controllable inductive load			1	1	1
726 85	Adjustable transformer 0...260 V			1	1	1
733 98	AC toroidal core transformer, 0.3				1	
733 99	AC auto-transformer, 0.3					1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

These practical exercises study exclusively transformers used in energy generation.

E2.2.1.1 3-Phase Transformers, 0.3

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.

E2.2.1.2 Scott-Transformer, 0.3

Scott transformers are made by connecting together two different transformers with special windings. They are designed for transformation to and from a two-phase network with a 90° phase-shift to a three-phase network with 120° phase-shift. Its main field of application is measurement and protection technology.

E2.2.1.3 AC-Transformers, 0.3

The AC transformer (single-phase transformer) is a standard module which can be used for many applications across the whole of electrical engineering. This transformer is suitable for the investigations of the equivalent circuit diagram with short-circuit, open-circuit and load test.

E2.2.1.4 AC Toroidal Core Transformer, 0.3

A toroidal transformer is ring-shaped. The material used for the core can be soft iron or ferrite material. The shape means that there is very little magnetic scattering. However, the manufacturing process of the windings is more complex than in conventional transformer types. The switch-on current for toroidal transformers can be very high and in practice needs to be limited by suitable means.

E2.2.1.5 AC-Autotransformer, 0.3

Auto-transformers are designed to save on materials. They are distinct from conventional transformers in that they have a common winding for the primary and secondary circuits which is tapped part way along. Auto-transformers therefore do not have any galvanic isolation between the primary and secondary. The auto-transformer has a complex equivalent circuit and can only be described to a limited extent by short-circuit, no-load and load tests.

DC machines, 300 W

E2.2.2.1
DC compound machine, 0.3

E2.2.2.2
Universal motor DC, 0.3

DC compound machine, 0.3 (E2.2.2.1)

Cat. No.	Description	E2.2.2.1	E2.2.2.2
773 186	Compound machine, 0.3	1	
732 83	Motor protection switch, 1.6-2.4 A	1	
745 561	Power circuit breaker module	1	1
773 1900	Machine Test CASSY, 0.3	1	1
524 222	CASSY Lab 2 for Drives and Power Systems	1	1
773 1991	Electrical dynamometer, 0.3	1	1
773 108	Coupling / shaft end guard 0.3, transparent	1	1
773 110	Machine base bench, 90 cm	1	1
315 39	Weight, 1 kg	1	1
731 06	Coupling, 0.3	1	1
731 94	Starter, 0.3	1	1
731 95	Field rheostat, motor, 0.3	1	
773 360	Controllable resistive load, 0.3	1	
731 96	Field rheostat, generator, 0.3	1	
775 190EN	LIT-print: DC machines 0.3	1*	1*
725 852DG	DC machine supply, 0.3	1	1
726 09	Panel frame T130, two-level	1	1
500 59	Safety bridging plugs, black, set of 10	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1
500 855	Safety experiment cables, 32 A, set of 34	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1
773 200	Universal motor, 0.3		1
732 84	Motor protection switch, 2.4-4 A		1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

DC machines have increasingly seen competition from asynchronous (induction) machines fed via frequency converters. They are, however, still preferred in many special applications for drive technology.

E2.2.2.1 DC compound machine, 0.3

Compound machines feature two separate field windings and can therefore be operated as series-wound, shunt-wound or compound-wound machines. The series-wound winding can also be tapped in order to investigate various types of compound winding.

E2.2.2.2 Universal motor DC, 0.3

Universal motors are a kind of commutator machine for both DC and AC operation. This is achieved by additional lamination of the iron in the stator. Universal motors can also be called single-phase series-wound motors. They are in widespread use, for example, in household appliances and machine tools.

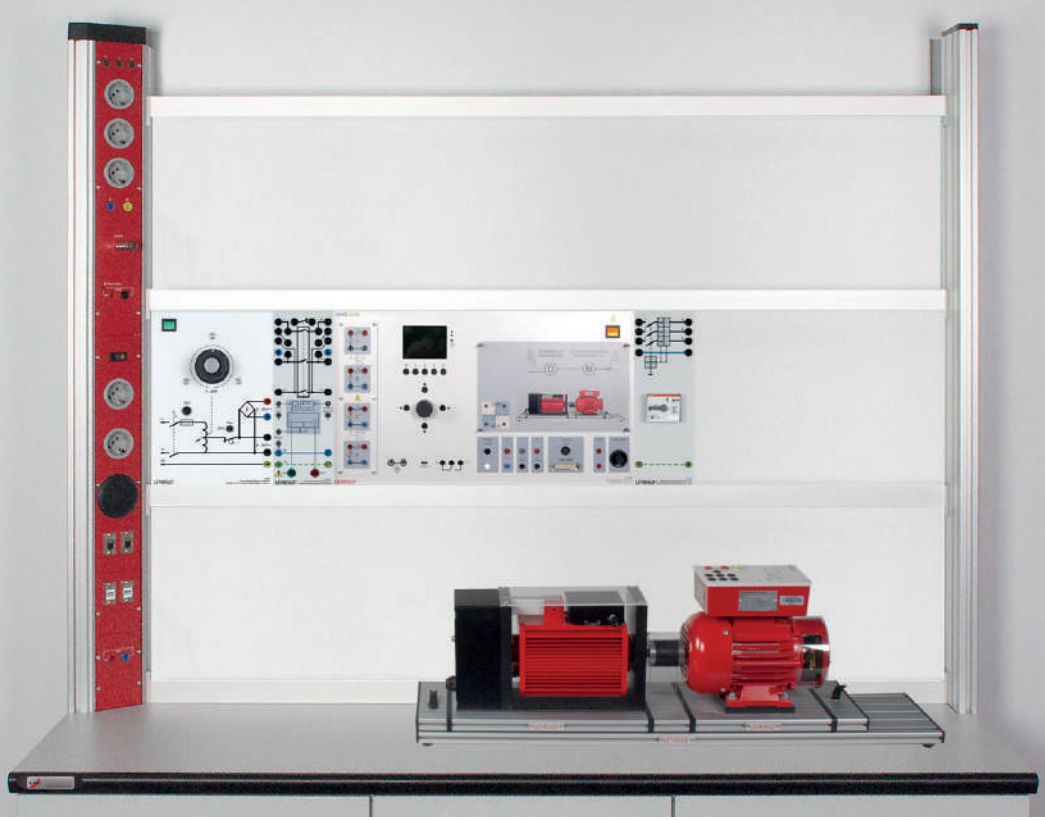
Objectives

- Protective measures and electrical safety
- Setting up DC machines and putting them into operation
- Use of starting circuits
- Assessment of DC machine characteristics

AC machines, 300 W

E2.2.3.1
Universal motor AC, 0.3

E2.2.3.2
Capacitor motor, 0.3



Universal motor AC, 0.3 (E2.2.3.1)

Cat. No.	Description	E2.2.3.1	E2.2.3.2
773 200	Universal motor, 0.3	1	
732 84	Motor protection switch, 2.4-4 A	1	1
745 561	Power circuit breaker module	1	1
773 1900	Machine Test CASSY, 0.3	1	1
524 222	CASSY Lab 2 for Drives and Power Systems	1	1
773 1991	Electrical dynamometer, 0.3	1	1
773 108	Coupling / shaft end guard 0.3, transparent	1	1
315 39	Weight, 1 kg	1	1
773 110	Machine base bench, 90 cm	1	1
731 06	Coupling, 0.3	1	1
775 195EN	LIT-print: AC Machines 0.3	1*	1*
726 85	Adjustable transformer 0...260 V	1	
726 09	Panel frame T130, two-level	1	1
500 59	Safety bridging plugs, black, set of 10	2	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1
500 855	Safety experiment cables, 32 A, set of 34	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1
773 2041	Capacitor motor, 0.3		1
727 115	4 Relays 230 V / 5 A		1
726 71	Single-phase terminal unit		1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

LD DIDACTIC offers a versatile range of products for AC motors, whereby their design, connection to an AC power supply network, as well as their starting and operating behaviour, are described in detailed experiments.

E2.2.3.1 Universal motor AC, 0.3

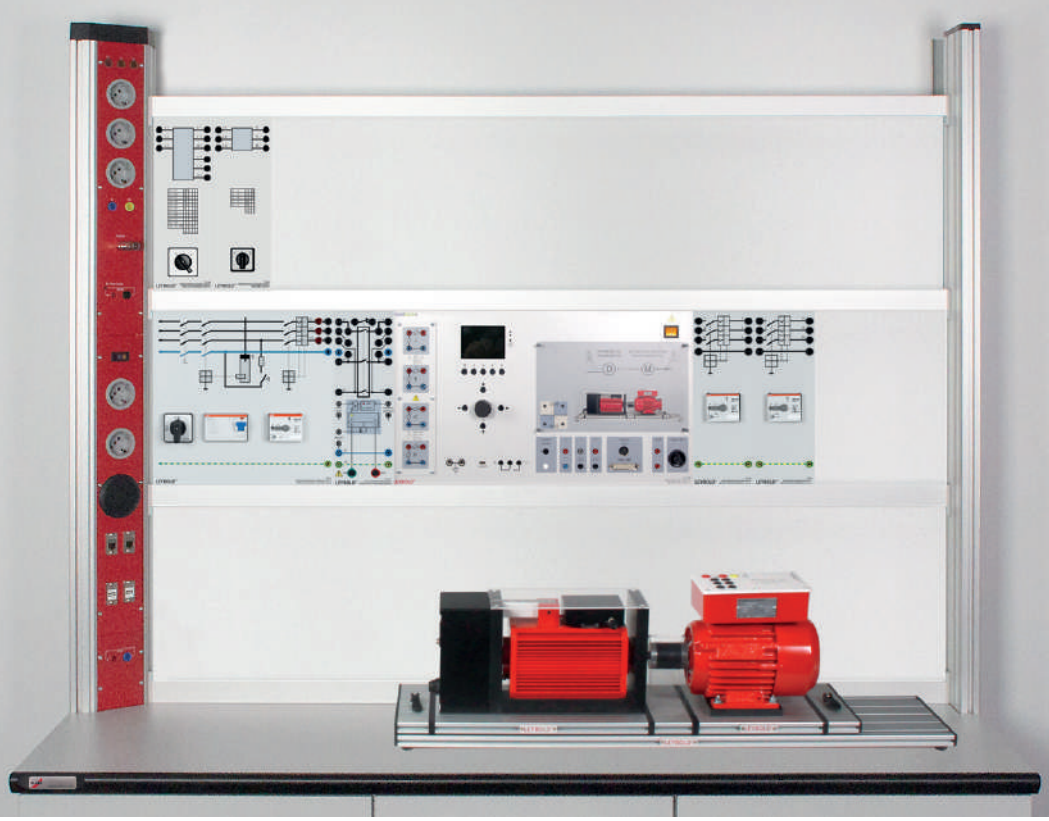
Universal motors are a kind of commutator machine for both DC and AC operation. This is achieved by additional lamination of the iron in the stator. Universal motors can also be called single-phase series-wound motors. They are in widespread use, for example, in household appliances and machine tools.

E2.2.3.2 Capacitor motor, 0.3

Capacitor motors are rotating field machines with squirrel cage rotors which operate on single-phase AC. The rotating field is elliptical and is generated by a 2-core stator winding. The main winding of the stator is connected directly to the power supply, while the auxiliary winding, which is displaced with respect to the main winding, is supplied via a capacitor connected in series. In order to increase the starting torque, a starting capacitor is connected in parallel with the operational capacitor via a relay.

Objectives

- Protective measures and electrical safety
- Setting up electrical machines and putting them into operation
- Use of starting circuits
- Assessment of electrical machine characteristics



Three-phase asynchronous machines, 300 W

E2.2.4.1
Squirrel cage rotor, 400/690, 0.3

E2.2.4.2
Squirrel cage rotor, 230/400, 0.3

E2.2.4.3
Squirrel cage rotor, 230/400 0.4, IE3

Squirrel cage rotor, 400/690, 0.3 (E2.2.4.1)

Cat. No.	Description	E2.2.4.1	E2.2.4.2	E2.2.4.3
773 212	Squirrel cage motor 400/690, 0.3	1		
732 13	Motor protection switch, 0.6-1	1	1	1
731 44	Motor protection switch, 0.4-0.6	1		
745 561	Power circuit breaker module	1	1	1
773 1900	Machine Test CASSY, 0.3	1	1	1
524 222	CASSY Lab 2 for Drives and Power Systems	1	1	1
773 1991	Electrical dynamometer, 0.3	1	1	1
773 108	Coupling / shaft end guard 0.3, transparent	1	1	1
315 39	Weight, 1 kg	1	1	1
773 110	Machine base bench, 90 cm	1	1	1
731 06	Coupling, 0.3	1	1	1
731 49	Reversing switch	1	1	1*
731 47	Star-delta switch	1		
731 51	Soft starter, 0.3 /1.0	1*	1*	1*
732 41	Capacitive load 0.3	1*	1*	
773 1391	Squirrel cage fault simulator	1*	1*	1*
727 293	Digital insulation tester	1*	1*	1*
739 836	Milliohm meter	1*	1*	1*
775 200EN	LIT-print: Induction Machines 0.3	1*	1*	1*
726 75	Three-phase terminal unit with RCD	1	1	1
726 09	Panel frame T130, two-level	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
500 855	Safety experiment cables, 32 A, set of 34	1	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1	1
773 2104	Squirrel cage motor 230/400, 0.3		1	
773 2108	Squirrel cage motor 230/400, 0.3 IE3			1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

E2.2.4.1 Squirrel cage rotor, 400/690, 0.3

Asynchronous machines as squirrel cage rotors are widely used. These are particularly low-maintenance motors. With the supply by frequency converters, these are increasingly replacing DC machines. Squirrel cage asynchronous machines are used as motors and rarely as generators. The asynchronous motor in this configuration has the suffix 400 / 690 V, which corresponds to the rated voltage specification of the motor. Only with this voltage does the motor have to be operated in a 230 V / 400 V in delta and therefore starting can also take place in star delta.

E2.2.4.2 Squirrel cage rotor, 230/400, 0.3

Asynchronous machines as squirrel cage rotors are widely used. These are particularly low-maintenance motors. With the supply by frequency converters, these are increasingly replacing DC machines. Squirrel cage asynchronous machines are used as motors and rarely as generators. The asynchronous motor in this configuration has the suffix 230 / 400 V, which corresponds to the rated voltage specification of the motor. Only with this voltage must the motor be operated in a 230 / 400 V in the star and therefore no start-up can take place in the star delta.

E2.2.4.3 Squirrel cage rotor, 230/400 0.4, IE3

The EU regulations for energy-using products only apply to motors above 0.75 kW, but it still makes sense to take a look at the efficiency of motors with 0.3 kW that operate continuously. Machines that drive pumps or fans that run 24 hours a day are equipped with such motors. The higher purchase price is recouped by the energy savings. It makes sense to compare the Squirrel cage motor 7732104 with the asynchronous machine 7732108.

Objectives

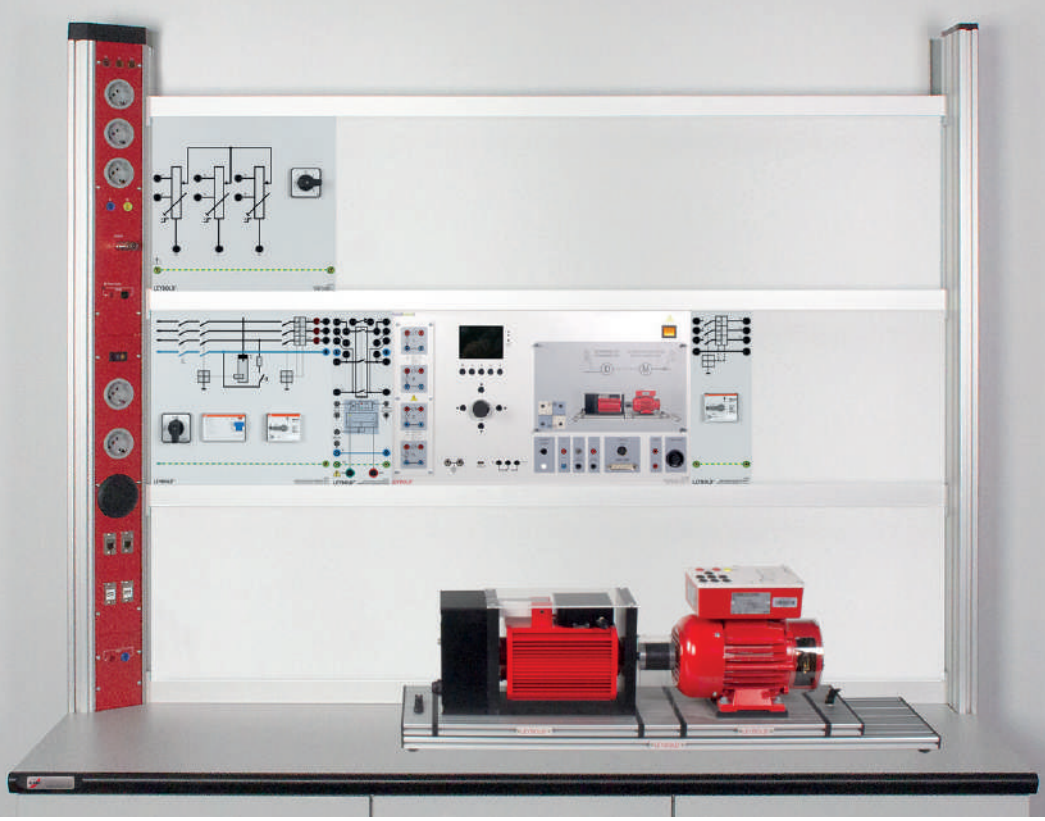
- Protective measures and electrical safety
- Construction and commissioning of electrical machines
- Use of starting circuits
- Efficiency of the machine
- Assessment of characteristic curves of electrical machines

Three-phase asynchronous machines, 300 W

E2.2.4.4
Slip-ring rotor, 0.3

E2.2.4.5
Squirrel cage rotor D, 0.3

E2.2.4.6
Multi-function machine, 0.3



Slip-ring rotor, 0.3 (E2.2.4.4)

Cat. No.	Description	E2.2.4.4	E2.2.4.5	E2.2.4.6
773 233	Slip-ring motor, 0.3	1		
732 13	Motor protection switch, 0.6-1	1		1
745 561	Power circuit breaker module	1	1	1
773 1900	Machine Test CASSY, 0.3	1	1	1
524 222	CASSY Lab 2 for Drives and Power Systems	1	1	1
773 1991	Electrical dynamometer, 0.3	1	1	1
773 108	Coupling / shaft end guard 0.3, transparent	1	1	1
315 39	Weight, 1 kg	1	1	1
773 110	Machine base bench, 90 cm	1	1	1
731 06	Coupling, 0.3	1	1	1
732 29	Rotor starter, 0.3	1		1
775 200EN	LIT-print: Induction Machines 0.3	1*	1*	1*
726 75	Three-phase terminal unit with RCD	1	1	1
726 09	Panel frame T130, two-level	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
500 855	Safety experiment cables, 32 A, set of 34	1	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1	1
773 224	Squirrel cage motor D, 0.3		1	
732 14	Motor protection switch, 1-1.6		1	
731 55	Pole reverser, Dahlander		1	
773 228	Multi-function machine, 0.3			1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

E2.2.4.4 Slip-ring rotor, 0.3

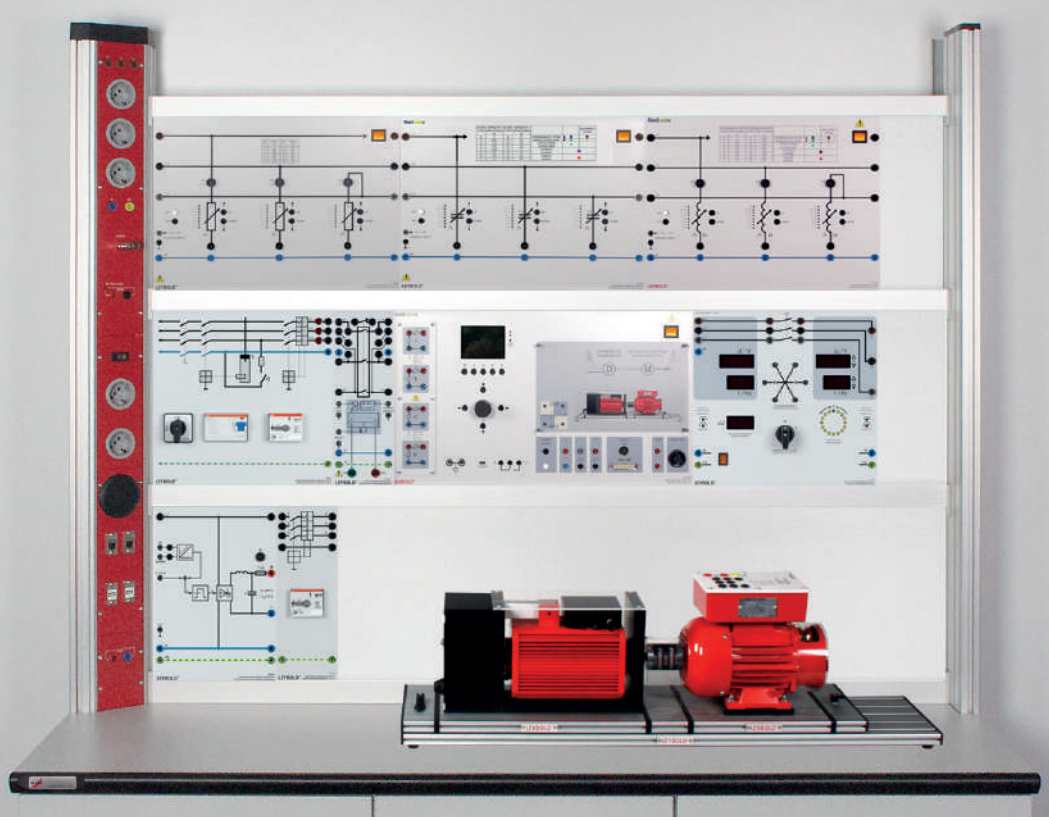
The tests are carried out with industrially manufactured machines. All test machines have a special base for connection to the Machine Test System 0.3. With the Machine Test CASSY all measured values of the AC machines are recorded. The measured values can be shown directly on the built-in display as a single value, table of a measurement series or diagram. The measurements can be made without additional software, and the measured data can be stored locally on the unit. The Machine Test CASSY is used to record the characteristic curves of the test machines. The power supply for the test machines is partly taken directly from the public supply network.

E2.2.4.5 Squirrel cage rotor D, 0.3

Squirrel cage rotor D is a special design for asynchronous machines (Dahlander motors). In Dahlander circuits, the three-phase windings of the stator are equipped with a central tap. This allows the number of pole pairs and therefore the speed of the rotor to be switched in the ratio of 1:2

E2.2.4.6 Multi-function machine, 0.3

Unlike squirrel cage rotor machines, a slip-ring rotor is in the form of a three-phase winding attached to a slip-ring and accessible from the outside via brushes. Wound rotor motors are preferred for use in drives which require high torque but low starting current. Asynchronous machines with slip-ring rotors are increasingly being replaced with conventional machines featuring squirrel cage rotors fed via a frequency converter. Such drives achieve similar operating behaviour to slip-ring motors but they are easier to manufacture and avoid wear to the slip contacts, which undergo both mechanical and electrical wear and tear.



Three-phase synchronous machines, 300 W

E2.2.5.1
Salient pole rotor, 0.3

E2.2.5.2
Smooth pole rotor, 0.3

E2.2.5.3
Multi-function machine, 0.3

Salient pole rotor, 0.3 (E2.2.5.1)

Cat. No.	Description	E2.2.5.1	E2.2.5.2	E2.2.5.3
773 236	Synchronous machine SP, 0.3	1		
732 13	Motor protection switch, 0.6-1	1	1	1
745 561	Power circuit breaker module	1	1	1
773 1900	Machine Test CASSY, 0.3	1	1	1
524 222	CASSY Lab 2 for Drives and Power Systems	1	1	1
773 1991	Electrical dynamometer, 0.3	1	1	1
773 108	Coupling / shaft end guard 0.3, transparent	1	1	1
315 39	Weight, 1 kg	1	1	1
773 110	Machine base bench, 90 cm	1	1	1
731 06	Coupling, 0.3	1	1	1
745 05	Manual synchronisation unit	1	1	1
773 360	Controllable resistive load, 0.3	1	1	1
773 362	Controllable capacitive load, 0.3	1	1	1
773 364	Controllable inductive load	1	1	1
775 205EN	LIT-print: Synchronous Machine 0.3	1*	1*	1*
726 75	Three-phase terminal unit with RCD	1	1	1
745 021	Excitation voltage controller 200 V/2.5 A	1	1	
726 09	Panel frame T130, two-level	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
500 855	Safety experiment cables, 32 A, set of 34	1	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1	1
773 237	Synchronous machine VP, 0.3		1	
773 228	Multi-function machine, 0.3			1
726 890	DC power supply unit 1...32 V/0...20 A			1
500 990	Adapter sockets, set of 2			1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The main field of application of the synchronous machine is power generation. It is also used as commutated synchronous machines in drive control. In recent years, the commutated synchronous machine has been used in e-mobility, where field control is used in addition to speed control.

E2.2.5.1 Salient Pole Rotor, 0.3

The field of application of the synchronous generator is very wide and ranges from car alternators to a ship's shaft generator and large power plant generators. Start-up, excitation and efficiency are investigated, as are different forms of load. In this context, the topic of power plant control is also interesting, which is dealt with in more detail in the subject area of Electrical Power Engineering. The field of application for salient pole generators is hydroelectric power stations and diesel generators, which require a high number of pole pairs at low speed.

E2.2.5.2 Smooth Pole Rotor, 0.3

The main field of application of the synchronous machine is power generation. It is also used as commutated synchronous machines in drive control. In recent years, the commutated synchronous machine has been used in e-mobility, where field control is used in addition to speed control. The field of application of the synchronous generator is very wide and ranges from car alternators to a ship's shaft generator and large power plant generators.

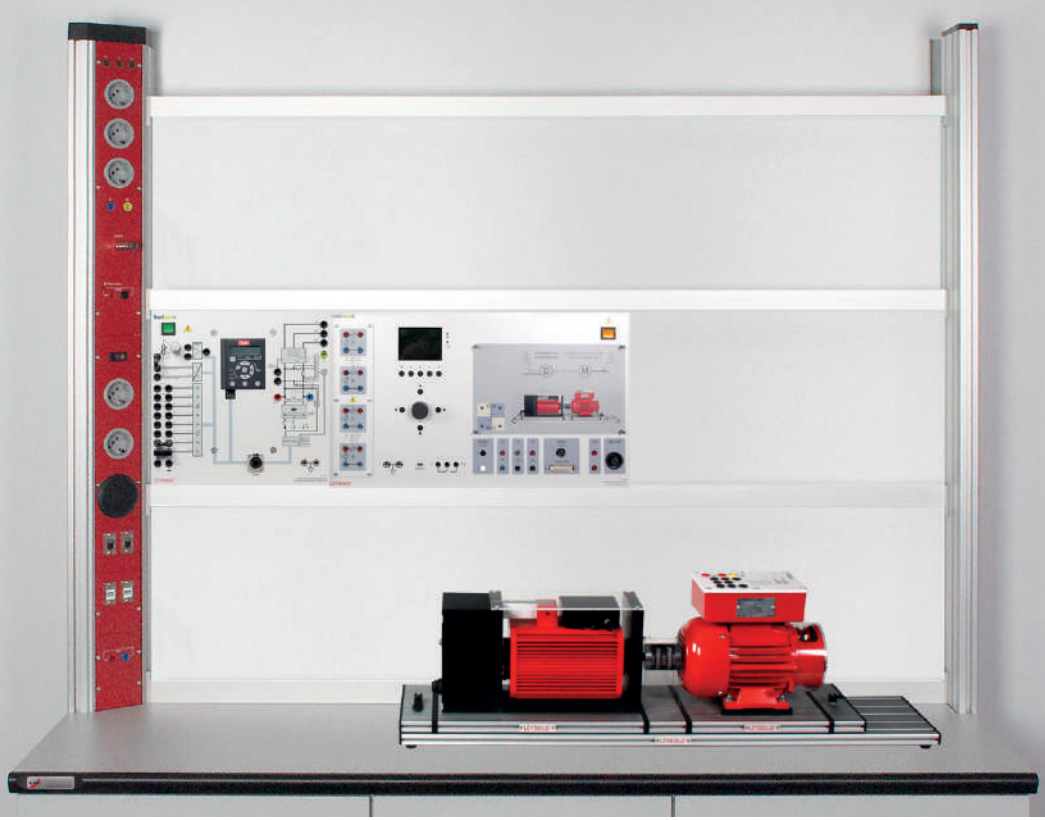
E2.2.5.3 Multi-function machine, 0.3

The multifunction machine is a full-pole rotor that is excited by an extra-low voltage source. The function of the full-pole rotor is also visible with this machine in the experiments.

Mechatronic motors, 300 W

E2.2.6.1
Synchronous machine, permanently excited with embedded magnets, EPM, 0.3

E2.2.6.2
Synchronous machine, permanently excited with surface magnets, BLDC, 0.3



Synchronous machine, permanently excited with embedded magnets, EPM, 0.3 (E2.2.6.1)

Cat. No.	Description	E2.2.6.1	E2.2.6.2
773 340	Synchronous machine, permanently excited with embedded magnets EPM, 0.3	1	
773 5313	Industrial frequency converter	1	
773 1900	Machine Test CASSY, 0.3	1	1
773 1991	Electrical dynamometer, 0.3	1	1
773 110	Machine base bench, 90 cm	1	
524 222	CASSY Lab 2 for Drives and Power Systems	1	1
731 06	Coupling, 0.3	2*	1
773 108	Coupling / shaft end guard 0.3, transparent	1*	1
315 39	Weight, 1 kg	1	1
773 109	Tacho generator, 0.3	1*	
726 09	Panel frame T130, two-level	1	1
689 3001	Set for equipotential bonding	1	
500 59	Safety bridging plugs, black, set of 10	1	1
500 591	Safety bridging plugs, yellow/green, set of 10	1	1
500 855	Safety experiment cables, 32 A, set of 34	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1
773 350	Synchronous machine, permanently excited with surface magnets BLDC, 0.3		1
773 5290	Converter Controller CASSY		1
773 5297	Universal converter		1
773 5295	DC power supply 390 V, 6 A, (PFC)		1
735 290	Connecting cable universal converter		1
773 1096	Commutating encoder, 0.3		1
773 115	Machine base bench, 120 cm		1
726 71	Single-phase terminal unit		1
500 602	Safety experiment cable, 10 cm, blue		3

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

Permanent magnet synchronous machines with buried magnets or surface magnets are usually used as motors. Due to their high efficiency, they often do not require their own cooling.

E2.2.6.1 Synchronous machine, permanently excited with embedded magnets, EPM, 0.3

Synchronous machines with buried magnets do not necessarily require a commutator. These machines are often used for high duty cycles. For example, in pumping stations of waterworks. This equipment uses an industrial frequency converter for speed control.

E2.2.6.2 Synchronous machine Permanently excited with surface magnets, BLDC, 0.3

Synchronous machines with surface magnets require a commutator. These machines are often used in positioning but also in the field of e-mobility. This equipment uses a LD DIDACTIC didactic frequency converter.

CHAPTER SUMMARY

Transformers, 1 kW

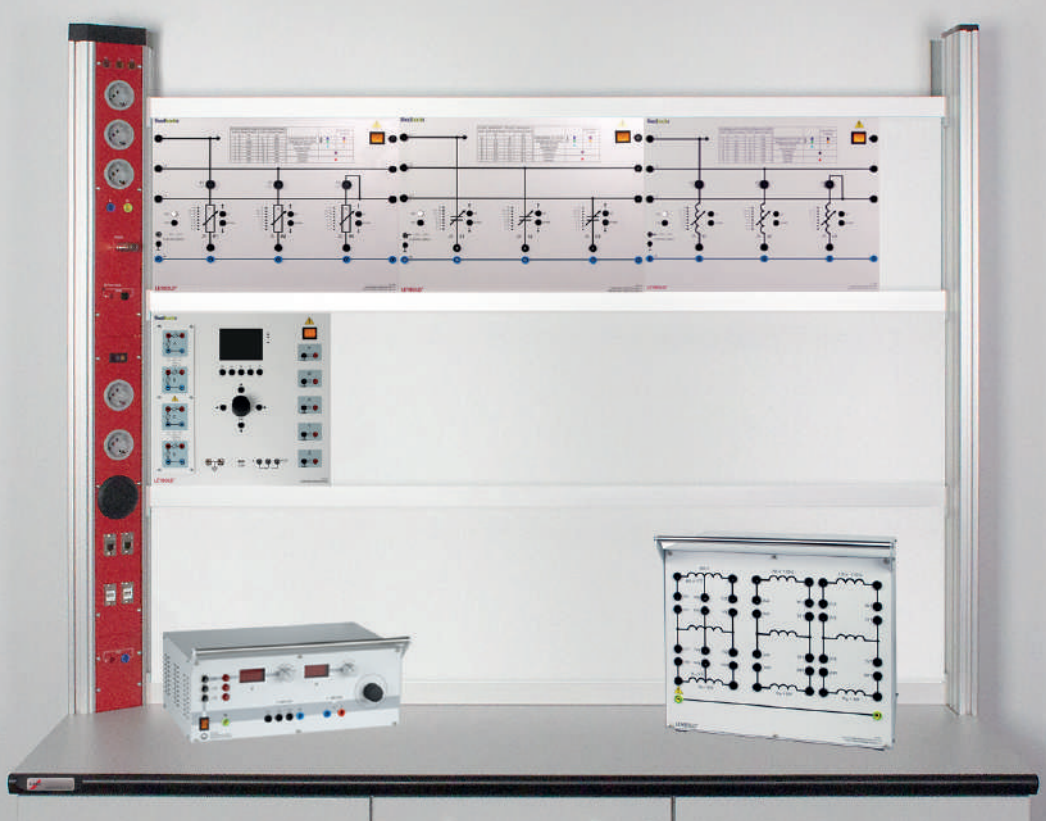
E2.3.1.1
Three-phase transformer, 1.0

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 auto-transformer, 0.3



Three-phase transformer, 1.0 (E2.3.1.1)

Cat. No.	Description	E2.3.1.1	E2.3.1.2	E2.3.1.3	E2.3.1.4	E2.3.1.5
733 91	3-phase transformer, 1.0	1				
773 361	Controllable resistive load, 1.0	1	1	1	1	1
775 220EN	LIT-print: Transformers 1.0	1*	1*	1*	1*	1*
727 110	Power Analyser CASSY Plus	1	1	1	1	1
524 222	CASSY Lab 2 for Drives and Power Systems	1	1	1*		1*
725 442DG	Three-phase voltage 400 V/2.5 A	1	1			
726 09	Panel frame T130, two-level	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
500 855	Safety experiment cables, 32 A, set of 34	1	1	1	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1	1	1	1
733 93	Scott transformer		1			
733 97	1-phase transformer, 0.3			1		
726 85	Adjustable transformer 0...260 V			1	1	1
733 98	AC toroidal core transformer, 0.3				1	
773 363	Controllable capacitive load, 1.0				1	
773 364	Controllable inductive load				1	
733 99	AC auto-transformer, 0.3					1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

In this practical course, only power engineering transformers are examined.

E2.3.1.1 Three-phase transformer, 1.0

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.

E2.3.1.2 Scott Transformer 0.3

Scott transformers are made by connecting together two different transformers with special windings. They are designed for transformation to and from a two-phase network with a 90° phase-shift to a three-phase network with 120° phase-shift. Its main field of application is measurement and protection technology.

E2.3.1.3 AC transformer, 0.3

The AC transformer (single-phase transformer) is a standard module which can be used for many applications across the whole of electrical engineering. This transformer is suitable for the investigations of the equivalent circuit diagram with short-circuit, open-circuit and load test.

E2.3.1.4 AC Toroidal Core Transformer, 0.3

A toroidal transformer is ring-shaped. The material used for the core can be soft iron or ferrite material. The shape means that there is very little magnetic scattering. However, the manufacturing process of the windings is more complex than in conventional transformer types. The switch-on current for toroidal transformers can be very high and in practice needs to be limited by suitable means.

E2.3.1.5 AC Autotransformer 0.3 kW

Auto-transformers are designed to save on materials. They are distinct from conventional transformers in that they have a common winding for the primary and secondary circuits which is tapped part way along. Auto-transformers therefore do not have any galvanic isolation between the primary and secondary. The auto-transformer has a complex equivalent circuit and can only be described to a limited extent by short-circuit, no-load and load tests.

DC machines, 1 kW

E2.3.2.1
Compound machine, 1.0

E2.3.2.2
Universal motor, DC, 1.0

Compound machine, 1.0 (E2.3.2.1)

Cat. No.	Description	E2.3.2.1	E2.3.2.2
773 260	Compound machine, 1.0	1	
733 53	Motor protection switch, 4-6	1	1
745 561	Power circuit breaker module	1	1
773 2900	Machine Test CASSY, 1.0	1	1
524 222	CASSY Lab 2 for Drives and Power Systems	1	1
773 2990	Electrical dynamometer, 1.0	1	1
773 258	Coupling / shaft end guard, 1.0, transparent	1	1
315 40	Weight, 2 kg	1	1
773 115	Machine base bench, 120 cm	1	1
732 56	Coupling, 1.0	1	1
732 64	Starter, 1.0	1	1
732 65	Field rheostat, motor, 1.0	1	
732 66	Field rheostat, generator, 1.0	1	
773 361	Controllable resistive load, 1.0	1	
775 225EN	LIT-print: DC Machines 1.0	1*	1*
725 862DG	DC machine supply, 1.0	1	1
726 09	Panel frame T130, two-level	1	1
500 59	Safety bridging plugs, black, set of 10	1	1
500 591	Safety bridging plugs, yellow/green, set of 10	1	1
500 855	Safety experiment cables, 32 A, set of 34	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1
773 270	Universal motor, 1.0		1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

When starting up under heavy load, in the rock breaking or cement industries or in iron smelting plants, DC motors are considered essential. Their ability to cope with high peaks of torque and their linear speed response over a large range constitute their distinctive features. DC machines are also widely used in small sizes, e.g. in motor vehicles, when a purely DC supply is all that is available.

E2.3.2.1 Compound machine, 1.0

Compound machines feature two separate field windings and can therefore be operated as series-wound, shunt-wound or compound-wound machines. The series-wound winding can also be tapped in order to investigate various types of compound winding.

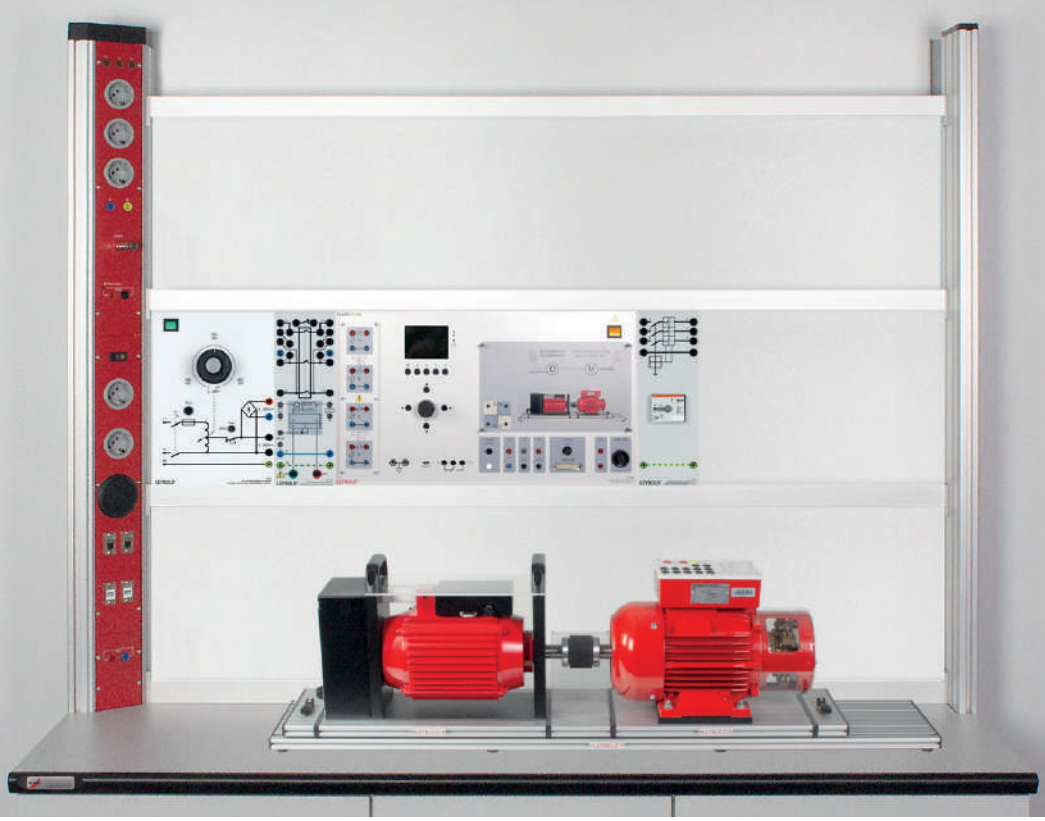
E2.3.2.2 Universal motor, DC, 1.0

Universal motors are a kind of commutator machine for both DC and AC operation. This is achieved by additional lamination of the iron in the stator. Universal motors can also be called single-phase series-wound motors. They are in widespread use, for example, in household appliances and machine tools.

AC machines, 1 kW

E2.3.3.1
Universal motor,
AC, 1.0

E2.3.3.2
Capacitor motor, 1.0



Universal motor, AC, 1.0 (E2.3.3.1)

Cat. No.	Description	E2.3.3.1	E2.3.3.2
773 270	Universal motor, 1.0	1	
733 53	Motor protection switch, 4-6	1	1
745 561	Power circuit breaker module	1	1
773 2900	Machine Test CASSY, 1.0	1	1
524 222	CASSY Lab 2 for Drives and Power Systems	1	1
773 2990	Electrical dynamometer, 1.0	1	1
773 258	Coupling / shaft end guard, 1.0, transparent	1	1
315 40	Weight, 2 kg	1	1
773 115	Machine base bench, 120 cm	1	1
732 56	Coupling, 1.0	1	1
775 230EN	LIT-print: AC Machines 1.0	1*	1*
726 85	Adjustable transformer 0...260 V	1	
726 090	Panel frame KH 160, two level	1	
500 59	Safety bridging plugs, black, set of 10	1	2
500 591	Safety bridging plugs, yellow/green, set of 10	1	1
500 855	Safety experiment cables, 32 A, set of 34	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	2
773 2741	Capacitor Motor 1.0		1
727 115	4 Relays 230 V / 5 A		1
726 71	Single-phase terminal unit		1
726 09	Panel frame T130, two-level		1

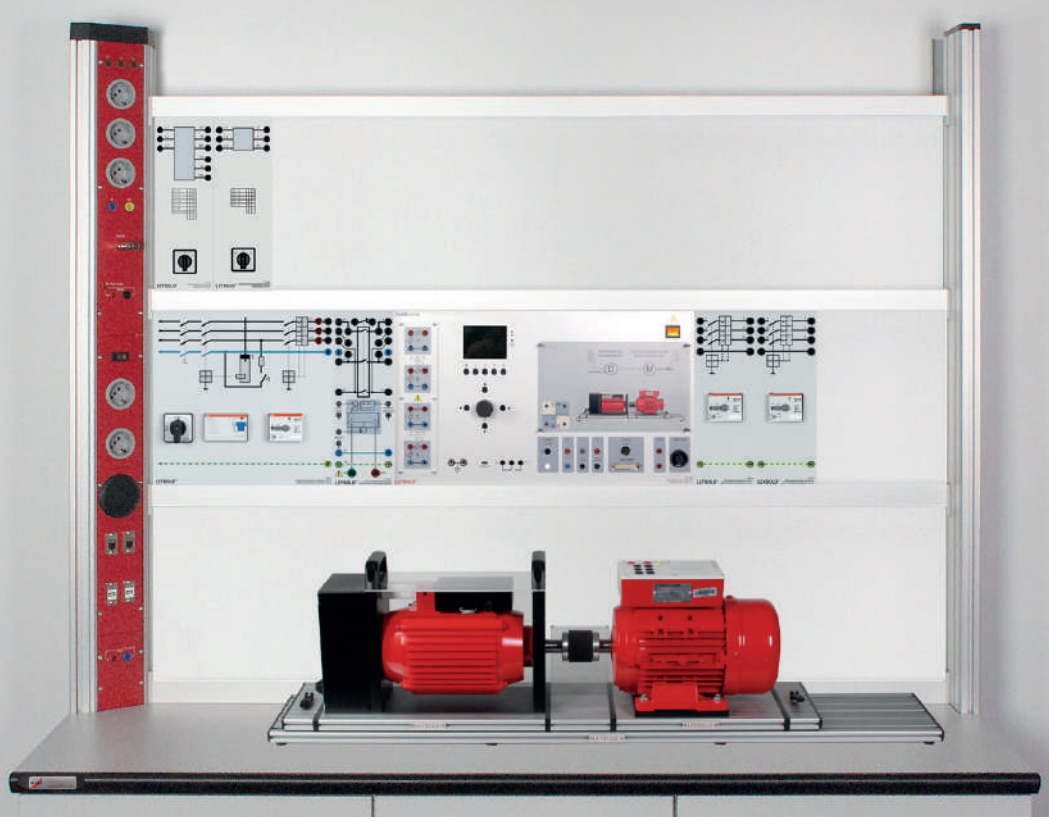
* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

LD DIDACTIC offers a versatile range of products for AC motors, whereby their design, connection to an AC power supply network, as well as their starting and operating behaviour, are described in detailed experiments.

E2.3.3.1 Universal motor, AC, 1.0
Universal motors are a kind of commutator machine for both DC and AC operation. This is achieved by additional lamination of the iron in the stator. Universal motors can also be called single-phase series-wound motors. They are in widespread use, for example, in household appliances and machine tools.

E2.3.3.2 Capacitor motor, 1.0
Capacitor motors are rotating field machines with squirrel cage rotors which operate on single-phase AC. The rotating field is elliptical and is generated by a 2-core stator winding. The main winding of the stator is connected directly to the power supply, while the auxiliary winding, which is displaced with respect to the main winding, is supplied via a capacitor connected in series. In order to increase the starting torque, a starting capacitor is connected in parallel with the operational capacitor via a relay.



Three-phase asynchronous machines, 1 kW

E2.3.4.1
Squirrel cage rotor, 400/690, 1.0

E2.3.4.2
Squirrel cage rotor, 230/400, 1.0

E2.3.4.3
Slip-ring rotor, 1.0

E2.3.4.4
Squirrel cage rotor D, 1.0

E2.3.4.5
Multi-function machine, 1.0

Squirrel cage rotor, 400/690, 1.0 (E2.3.4.1)

Cat. No.	Description	E2.3.4.1	E2.3.4.2	E2.3.4.3	E2.3.4.4	E2.3.4.5
773 281	Squirrel cage motor 400/690, 1.0	1				
732 84	Motor protection switch, 2.4-4 A	1	1	1	1	
732 14	Motor protection switch, 1-1.6	1				
745 561	Power circuit breaker module	1	1	1	1	1
773 2900	Machine Test CASSY, 1.0	1	1	1	1	1
524 222	CASSY Lab 2 for Drives and Power Systems	1	1	1	1	1
773 2990	Electrical dynamometer, 1.0	1	1	1	1	1
773 258	Coupling / shaft end guard, 1.0, transparent	1	1	1	1	1
315 40	Weight, 2 kg	1	1	1	1	1
773 115	Machine base bench, 120 cm	1	1	1	1	1
732 56	Coupling, 1.0	1	1	1	1	1
731 49	Reversing switch	1	1			
731 47	Star-delta switch	1				
773 1391	Squirrel cage fault simulator	1*	1*			
727 293	Digital insulation tester	1*	1*			
739 836	Milliohm meter	1*	1*			
775 235EN	LIT-print: Induction Machines 1.0	1*	1*	1*		
726 75	Three-phase terminal unit with RCD	1	1	1	1	1
726 09	Panel frame T130, two-level	1	1	1	1	1
500 59	Safety bridging plugs, black, set of 10	1	1	1	1	1
500 591	Safety bridging plugs, yellow/green, set of 10	1	1	1	1	1
500 855	Safety experiment cables, 32 A, set of 34	1	1	1	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1	1	1	1
773 256	Assembly set el. machine base 1.0 short	1*	1*			
773 257	Assembly set el. machine base 1:0 long	1*	1*			
773 2804	Squirrel cage motor 230/400 IE3 1.0		1			
731 51	Soft starter, 0.3 /1.0		1*			
773 303	Slip-ring motor, 1.0			1		
732 99	Rotor starter, 1.0			1		1

Cat. No.	Description	E2.3.4.1	E2.3.4.2	E2.3.4.3	E2.3.4.4	E2.3.4.5
773 294	Squirrel cage motor D, 1.0				1	
732 83	Motor protection switch, 1.6-2.4 A				1	1
731 55	Pole reverser, Dahlander				1	
773 298	Multi-function machine, 1.0					1*

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

E2.3.4.1 Squirrel cage rotor, 400/690, 1.0

Asynchronous machines as squirrel cage rotors are widely used and are particularly low-maintenance motors. The asynchronous motor in this configuration has the suffix 400 / 690 V, which corresponds to the rated voltage specification of the motor.

E2.3.4.2 Squirrel cage rotor, 230/400, 1.0

This machine is particularly suitable for the industrial frequency inverter and the didactic frequency inverter.

E2.3.4.3 Slip-ring rotor, 1.0

The tests are carried out with industrially manufactured machines. With the CMachine Test CASSY all measured values of the AC machines are recorded. The measured values can be shown directly on the built-in display as a single value, table of a measurement series or diagram. The measurements can be made without additional software, and the measurement data can be stored locally on the unit.

E2.3.4.4 Squirrel cage rotor D, 1.0

Squirrel cage rotor D is a special design for asynchronous machines (Dahlander motors). In Dahlander circuits, the three-phase windings of the stator are equipped with a central tap. This allows the number of pole pairs and therefore the speed of the rotor to be switched in the ratio of 1:2

E2.3.4.5 Multi-function machine, 1.0

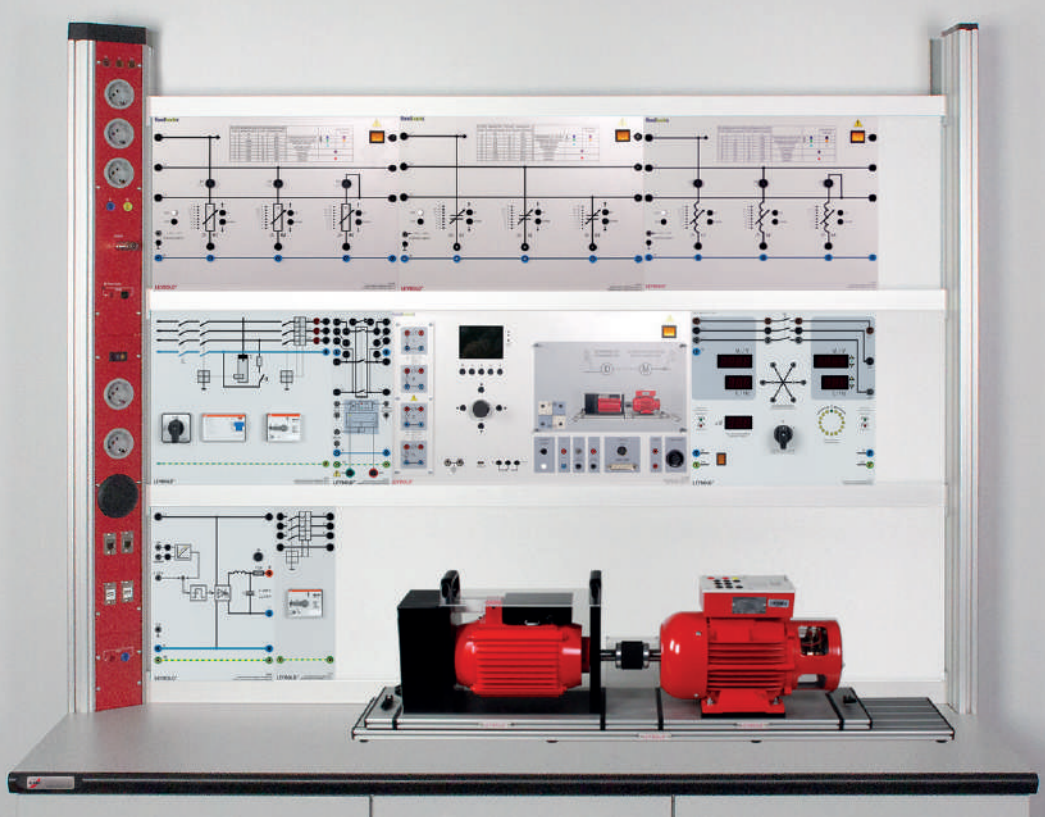
The multifunction machine is a slip-ring motor with the option of operating it as a synchronous machine with a suitable DC power source.

Three-phase synchronous machines with separate excitation, 1 kW

E2.3.5.1
Salient pole rotor, 1.0

E2.3.5.2
Smooth pole rotor, 1.0

E2.3.5.3
Multi-function machine, 1.0



Salient pole rotor, 1.0 (E2.3.5.1)

Cat. No.	Description	E2.3.5.1	E2.3.5.2	E2.3.5.3
773 306	Synchronous machine SP, 1.0	1		
732 14	Motor protection switch, 1-1.6	1	1	1
745 561	Power circuit breaker module	1	1	1
773 2900	Machine Test CASSY, 1.0	1	1	1
524 222	CASSY Lab 2 for Drives and Power Systems	1	1	1
773 2990	Electrical dynamometer, 1.0	1	1	1
773 258	Coupling / shaft end guard, 1.0, transparent	1	1	1
315 40	Weight, 2 kg	1	1	1
773 115	Machine base bench, 120 cm	1	1	1
732 56	Coupling, 1.0	1	1	1
745 05	Manual synchronisation unit	1	1	1
773 361	Controllable resistive load, 1.0	1	1	1
773 363	Controllable capacitive load, 1.0	1	1	1
773 364	Controllable inductive load	1	1	1
726 75	Three-phase terminal unit with RCD	1	1	1
745 021	Excitation voltage controller 200 V/2.5 A	1	1	
726 09	Panel frame T130, two-level	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
500 855	Safety experiment cables, 32 A, set of 34	1	1	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1	1	1
773 307	Synchronous machine VP, 1.0		1	
773 298	Multi-function machine, 1.0			1
726 890	DC power supply unit 1...32 V/0...20 A			1
500 990	Adapter sockets, set of 2			1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The main field of application of the synchronous machine is power generation. It is also used as commutated synchronous machines in drive control. In recent years, the commutated synchronous machine has been used in e-mobility, where field control is used in addition to speed control.

E2.3.5.1 Salient pole rotor, 1.0

The field of application for salient pole generators is hydroelectric power stations and diesel generators, which require a high number of pole pairs at low speed.

E2.3.5.2 Smooth pole rotor, 1.0

Full-pole generators are used in gas and steam power plants that require a low number of pole pairs at high speed. This rotor can better withstand the centrifugal forces that arise. The application area of the full-pole rotor generator is the choice for large thermodynamic power plants.

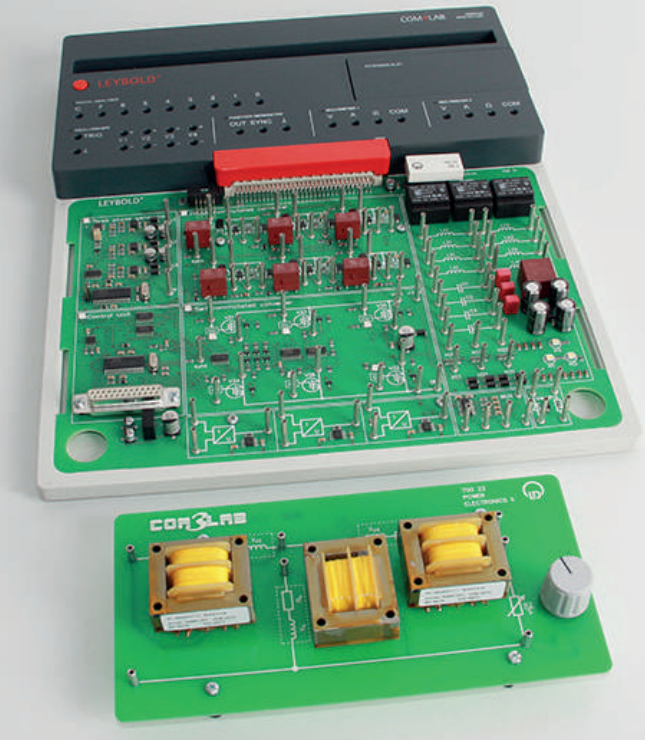
E2.3.5.3 Multi-function machine, 1.0

The multifunction machine is a full-pole rotor that is excited by an extra-low voltage source. The function of the full-pole rotor is also visible with this machine in the experiments.

CHAPTER SUMMARY

Power Electronics

ME2.2.1
COM4LAB: Power Electronics



COM4LAB: Power Electronics (ME2.2.1)

Kat.-Nr.	Bezeichnung	ME2.2.1
700 2101	COM4LAB Kurs: Leistungselektronik I - COM4LAB ready	1
700 22	COM4LAB: Leistungselektronik II - COM4LAB ready	1
70000-00	COM4LAB Master Unit	1
70000-11	USB-C Ladegerät 45 W Eurostecker (Typ C)	1
70000-22	COM4LAB Satz Sicherheitskabel, 2 mm, 24 St	1

The 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.

Learning objectives

- Basic physical principles of power semiconductors
- Design of key basic circuits for power electronics
- Assessment of properties of rectifiers and converters

Line-commutated converters

E2.4.2.1
Static / Controlled converter valves

Static / Controlled converter valves (E2.4.2.1)

Cat. No.	Description	E2.4.2.1
735 012	Line-commutated converters	1
735 122	Converter controller unit	1
735 190	Phase control noise filter 3 x 4.5 A	1
735 09	Load power electronics	1
773 186	Compound machine, 0.3	1*
773 110	Machine base bench, 90 cm	1*
773 108	Coupling / shaft end guard 0.3, transparent	1*
727 110	Power Analyser CASSY Plus	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
726 80	Transformer, 45/90, 3N	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	2
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

* additionally recommended

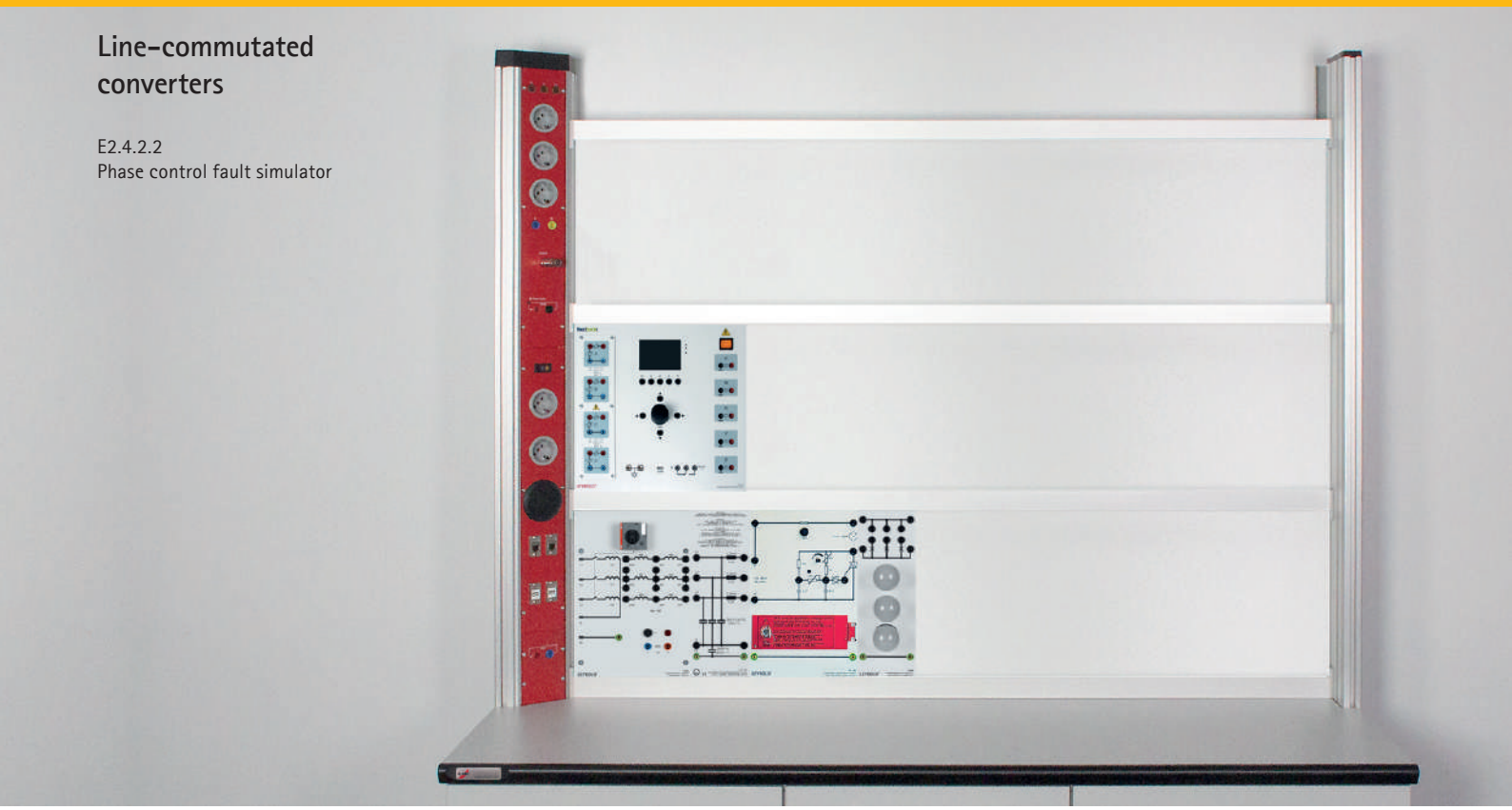
The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

Power electronics has developed from power converter technology into an important, comprehensive sub-field of electrical engineering. The tasks of power electronics are switching, controlling and converting electrical energy with power semiconductors at the most favourable efficiency possible. One of the main applications of power electronics is drive technology.

With the help of modern power electronics, variable-speed drives for 4-quadrants can be realised in DC and three-phase technology. Today, thyristor speed controllers, soft start circuits, frequency converters, servo drives, etc. are indispensable in industry, trade and households.

Line-commutated converters

E2.4.2.2
Phase control fault simulator



Phase control fault simulator (E2.4.2.2)

Cat. No.	Description	E2.4.2.2
735 390	Fault simulator for phase control	1
735 190	Phase control noise filter 3 x 4.5 A	1
505 272	Bulbs, 230 V/40 W, E14, set of 2	2
729 09	Lamp sockets E14, set of three	1
727 110	Power Analyser CASSY Plus	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
726 80	Transformer, 45/90, 3N	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

With this equipment, the operating behaviour of a phase-angle control can be taught and troubleshooting can be systematically trained on the basis of 20 adjustable faults without endangering components or persons.

The fault simulator is a standard dimmer for a resistive load (Pmax. = 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.

Self-commutated converters

E2.4.3.1
Switchable valves and DC controllers

Switchable valves and DC controllers (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 power electronics	1
735 18	Fuse, threefold, super-fast	1
735 065	Rectifier B6, 3 x 400 V / 10 A	1
735 095	Capacitors 2 x 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
537 34	Rheostat, 100 ohms	1
537 35	Rheostat, 330 ohms	1
773 186	Compound machine, 0.3	1*
773 108	Coupling / shaft end guard 0.3, transparent	1*
773 110	Machine base bench, 90 cm	1*
727 110	Power Analyser CASSY Plus	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
726 86	Stabilised power supply unit ±15 V / 3 A	1
726 80	Transformer, 45/90, 3N	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	2
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

* additionally recommended* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

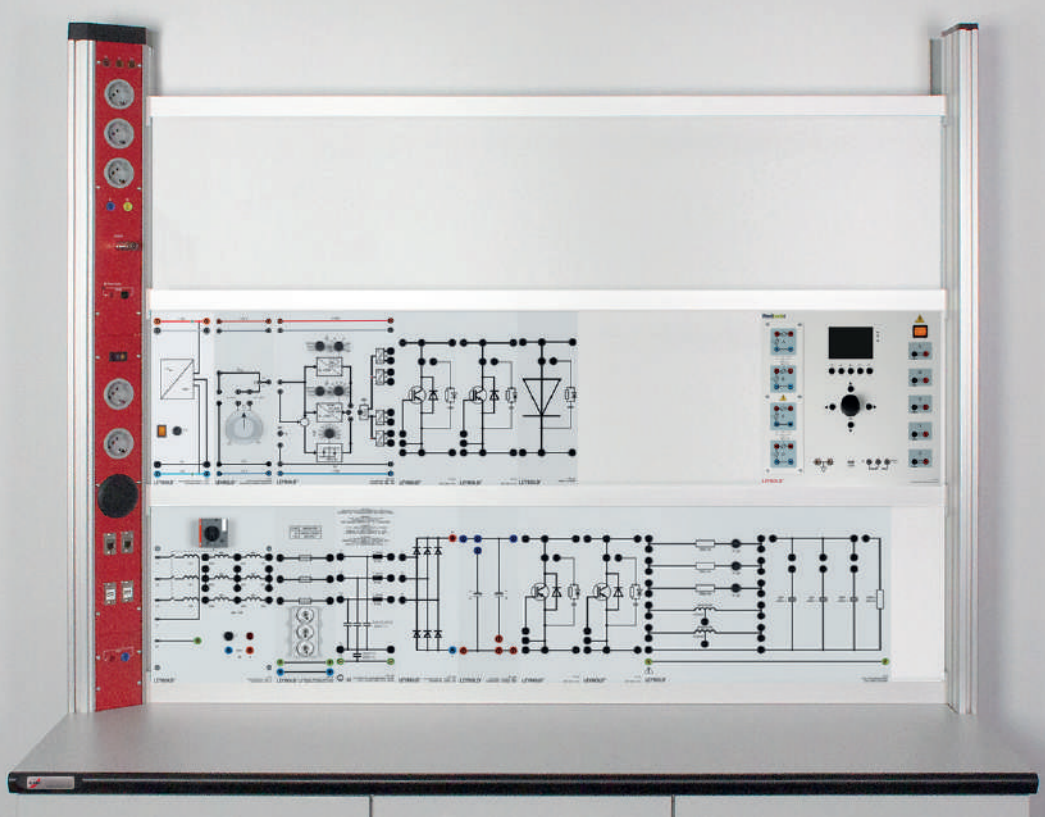
This equipment is equipped with DC choppers and deals with the valves that can be used for this purpose. DC choppers convert direct current of a given voltage and polarity into direct current of a different voltage and/or polarity. In contrast to other methods of voltage adjustment, they operate in principle without loss, practically with high efficiency, since the electronic valves are used in periodic switching operation. Today, DC choppers are used in a wide range of voltage, current and power applications, from power supply units for electronic circuits to the supply of trams, light railways and underground railways from DC networks.

Static converter valves with gate turn-off can be used to assemble a variety of DC controllers (DC/DC converters). Three different control methods are used for this:

- Pulse width modulation
- Pulse sequence modulation
- Two position control

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	1
735 09	Load power electronics	1
735 18	Fuse, threefold, super-fast	1
735 065	Rectifier B6, 3 x 400 V / 10 A	1
735 095	Capacitors 2 x 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	1
727 110	Power Analyser CASSY Plus	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
726 86	Stabilised power supply unit ±15 V / 3 A	1
726 80	Transformer, 45/90, 3N	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	2
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

Power electronics enables the construction of power supplies that are characterised by high efficiency and small size. This is achieved with switching components and at the highest possible switching frequencies. The following experiments on primary switched-mode power supplies can be set up and examined with regard to their properties:

Buck converter

- With different loads,
- Control of the voltage and current average by means of pulse width modulation,
- Function of a free-wheeling diode with ohmic inductive load,
- Function of a smoothing capacitor with ohmic inductive load,
- Efficiency of the buck converter

Inverting boost and buck converter

- With different loads,
- Control of the voltage and current average using pulse width modulation,
- Function of choke with gap current

Self-commutated converters

E2.4.3.3
Flyback converters,
flow converters and inverters

Flyback converters, flow converters and inverters (E2.4.3.3)

Cat. No.	Description	E2.4.3.3
734 02	Reference variable generator	1
735 09	Load power electronics	1
735 18	Fuse, threefold, super-fast	1
734 19	Gain and offset adjustment	1
735 02	Diode, 1000 V/10 A	4
735 065	Rectifier B6, 3 x 400 V / 10 A	1
735 095	Capacitors 2 x 1000 µF, 385 V	1
735 190	Phase control noise filter 3 x 4.5 A	1
735 341	Control unit PWM/PFM	1
735 105	Power transformer	1
735 346	IGBT 1000 V/10 A	4
727 110	Power Analyser CASSY Plus	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
726 86	Stabilised power supply unit ±15 V / 3 A	1
726 80	Transformer, 45/90, 3N	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	2
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

Primary switched-mode power supplies have a converter, there are two different converter principles:

Flyback converter

- Circuit design and function
- Control of the voltage and current average
- Influence of the RCD protective circuit.

Flow converter

- Single-ended flow transformer
- Asymmetrical half-bridge flow converter.

Inverter

- H-bridge
- Voltage reversal
- Current reversal
- Generation of a frequency and amplitude variable alternating voltage

E2.5.4.3
Starting of large flywheel masses with slip ring motor

For more information, see page 69.

CHAPTER SUMMARY

E2.5 DRIVE TECHNOLOGY

E2.5.2 INDUSTRIAL DC DRIVES

E2.5.2.1 Four-quadrant operation of a DC machine with controlled rectifiers

E2.5.2.2 Four-quadrant drive of a DC machine with an IGBT H-bridge circuit

E2.5.3 INDUSTRIAL THREE-PHASE DRIVES

E2.5.3.1 Static converter drives with asynchronous machines

E2.5.3.2 Fundamentals of frequency converters and rotating field technology

E2.5.3.3 Drives with educational frequency converter

E2.5.3.4 Drives with industrial frequency converter, 0.3

E2.5.3.5 Drives with industrial frequency converter, 1.0

E2.5.4 LOAD BEHAVIOUR OF DRIVES

E2.5.4.1 Direct starting and star-delta starting of an asynchronous motor under load

E2.5.4.2 Direct starting or starting with a soft starter of an asynchronous motor under load

E2.5.4.3 Starting of large flywheel masses with slip-ring motor

E2.5.4.4 Operating behaviour of speed-variable asynchronous motors under load

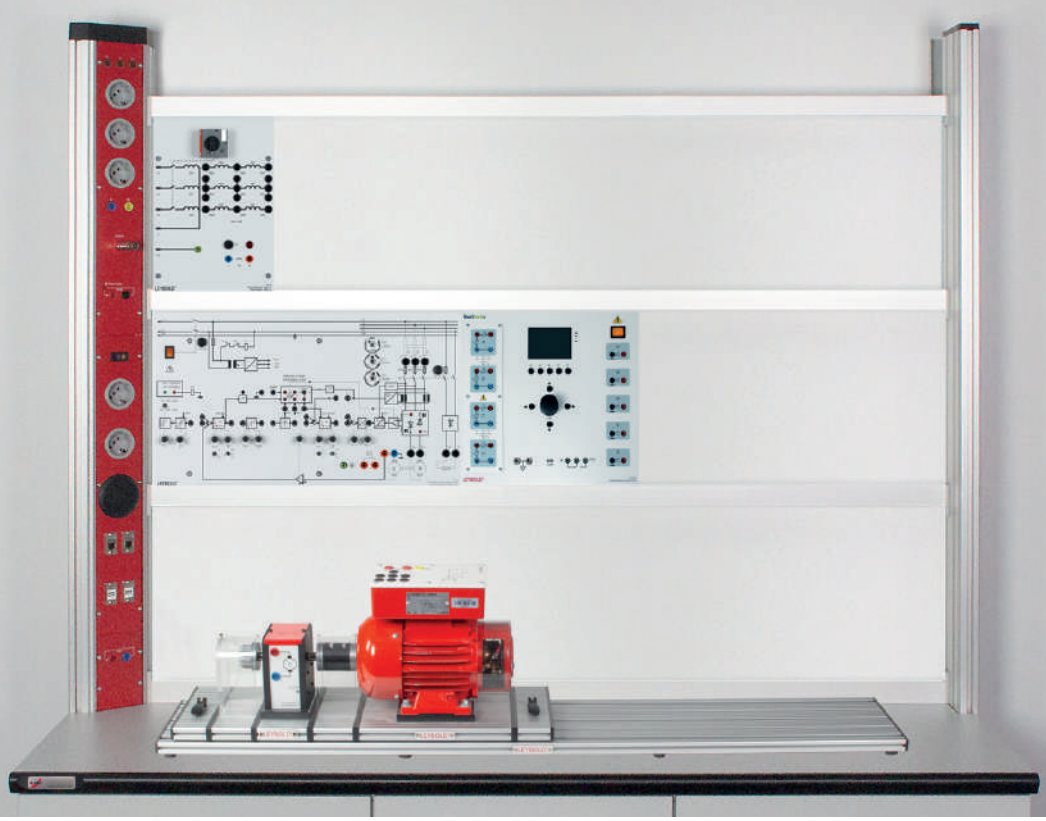
E2.5.4.5 Operating behaviour of speed variable DC machines under load

E2.5.4.6 Operating behaviour of speed-variable BLDC motors under load

E2.5.4.7 Determining the mechanical data of a machine

Industrial DC drives

E2.5.2.1
Four-quadrant operation
of a DC machine with
controlled rectifiers



Four-quadrant operation of a DC machine with controlled rectifiers (E2.5.2.1)

Cat. No.	Description	E2.5.2.1
735 32	Thyristor speed control unit	1
773 109	Tacho generator, 0.3	1
773 186	Compound machine, 0.3	1
773 115	Machine base bench, 120 cm	1
773 108	Coupling / shaft end guard 0.3, transparent	2
731 06	Coupling, 0.3	1
727 110	Power Analyser CASSY Plus	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
726 80	Transformer, 45/90, 3N	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

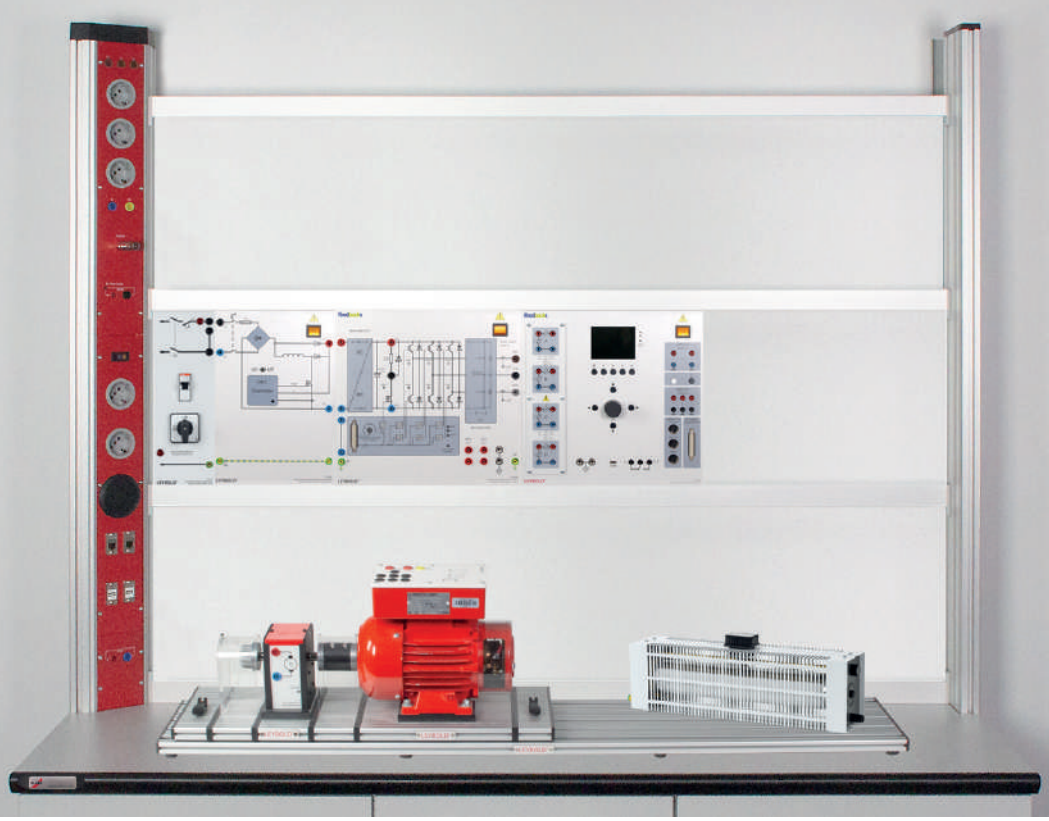
Traditionally, DC machines were used for variable speed drives. By adjusting the armature voltage or by armature field weakening, the speed can be altered and by changing the polarity of the armature or the excitation voltage, it is possible to reverse the direction of rotation. Whereas in times past 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.

Topics

- Automatic control of multi-quadrant drive
- Analysis of controlled systems
- Optimisation of the current control loop
- Recording of armature circuit constants
- Optimisation of speed control loop
- Setting of DC chopper and inverter stability limits
- Recording of the transient function of the controlled variable, armature current
- Switchover of static converter
- Setting current limiting

Industrial DC drives

E2.5.2.2
Four-quadrant drive
of a DC machine with
an IGBT H-bridge circuit



Four-quadrant drive of a DC machine with an IGBT H-bridge circuit (E2.5.2.2)

Cat. No.	Description	E2.5.2.2
773 186	Compound machine, 0.3	1
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
537 34	Rheostat, 100 ohms	1
773 109	Tacho generator, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	2
731 06	Coupling, 0.3	1
773 115	Machine base bench, 120 cm	1
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

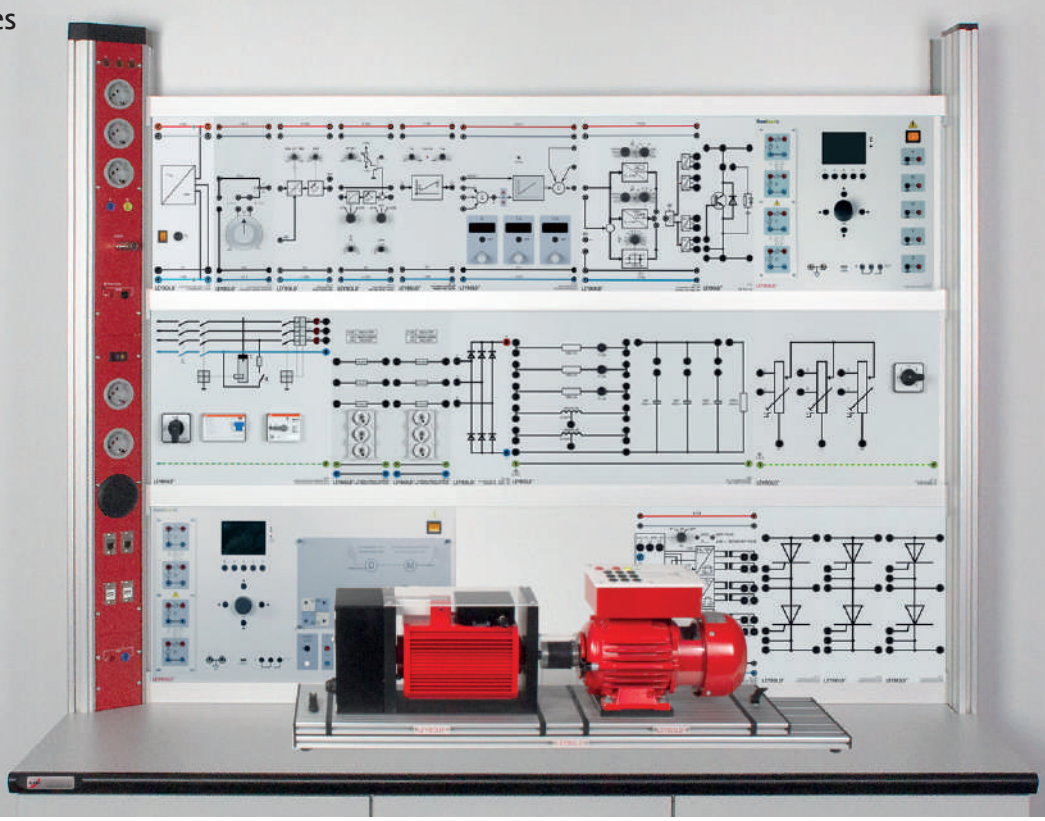
With this equipment, you can set up a modern DC drive system to control the speed across four quadrants. The power electronics are realised in the form of a universal converter, which is controlled by the Converter Controller CASSY. A DC shunt machine with an analogue tachometer is used for the drive. The H-bridge circuit enables the speed and direction of rotation to be adjusted.

Topics

- Set-up of an H-bridge
- Pulse width control
- Reversing the direction of rotation
- Speed adjustment of DC machines
- Current limit control

Industrial three-phase drives

E2.5.3.1
Static converter drives with asynchronous machines

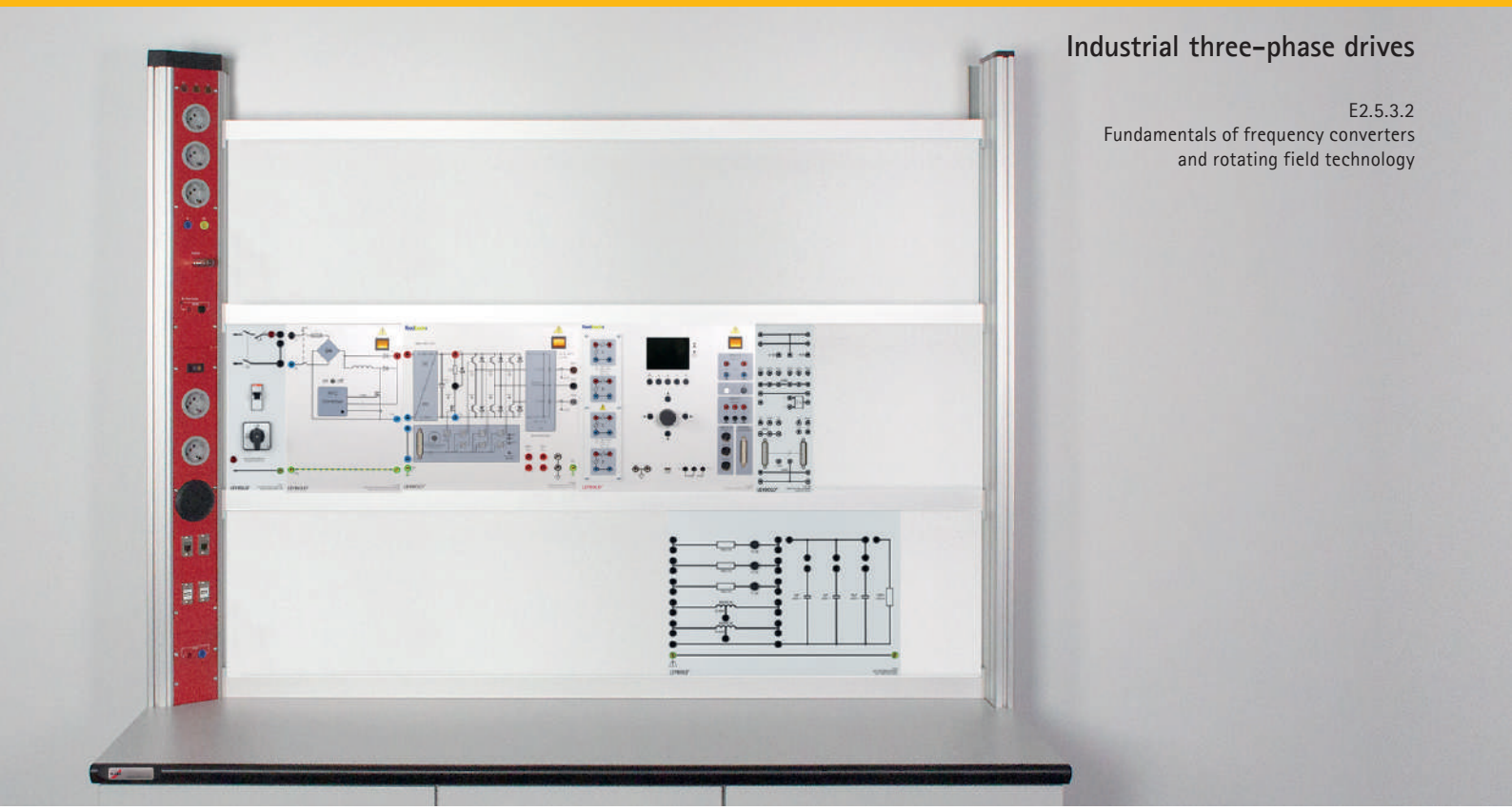


Static converter drives with asynchronous machines (E2.5.3.1)

Cat. No.	Description	E2.5.3.1
734 02	Reference variable generator	1
734 19	Gain and offset adjustment	1
735 07	Thyristor pair of arms, 1000 V / 12 A	3
735 09	Load power electronics	1
735 17	Ramp generator	1
735 18	Fuse, threefold, super-fast	2
735 20	Trigger point limiter	1
734 064N	PID digital controller net	1
735 065	Rectifier B6, 3 x 400 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 29	Rotor starter, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
773 1991	Electrical dynamometer, 0.3	1
773 115	Machine base bench, 120 cm	1
773 228	Multi-function machine, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	2
773 109	Tacho generator, 0.3	1
731 06	Coupling, 0.3	2
524 222	CASSY Lab 2 for Drives and Power Systems	1
726 86	Stabilised power supply unit ±15 V / 3 A	1
726 75	Three-phase terminal unit with RCD	1
725 442DG	Three-phase voltage 400 V/2.5 A	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	2
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The equipment is used to carry out experiments on influencing the speed of asynchronous machines (IM) as slip-ring rotors with line-operated power converters. The speed of the IM depends on the stator voltage and the rotor resistance and can be influenced in the experiment via these two variables. In addition to commissioning and parameter setting, the changed behaviour of the machine is examined. For this purpose, load characteristics are recorded and characteristic values determined. With a PID controller, the experimental set-ups can be extended to speed-controlled drives.



Industrial three-phase drives

E2.5.3.2
Fundamentals of frequency converters
and rotating field technology

Fundamentals of frequency converters and rotating field technology (E2.5.3.2)

Cat. No.	Description	E2.5.3.2
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
735 09	Load power electronics	1
735 296	Converter input/output	1
565 432	LIT-print: Fundamentals of Frequency Converter Technology	1*
524 222	CASSY Lab 2 for Drives and Power Systems	1
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

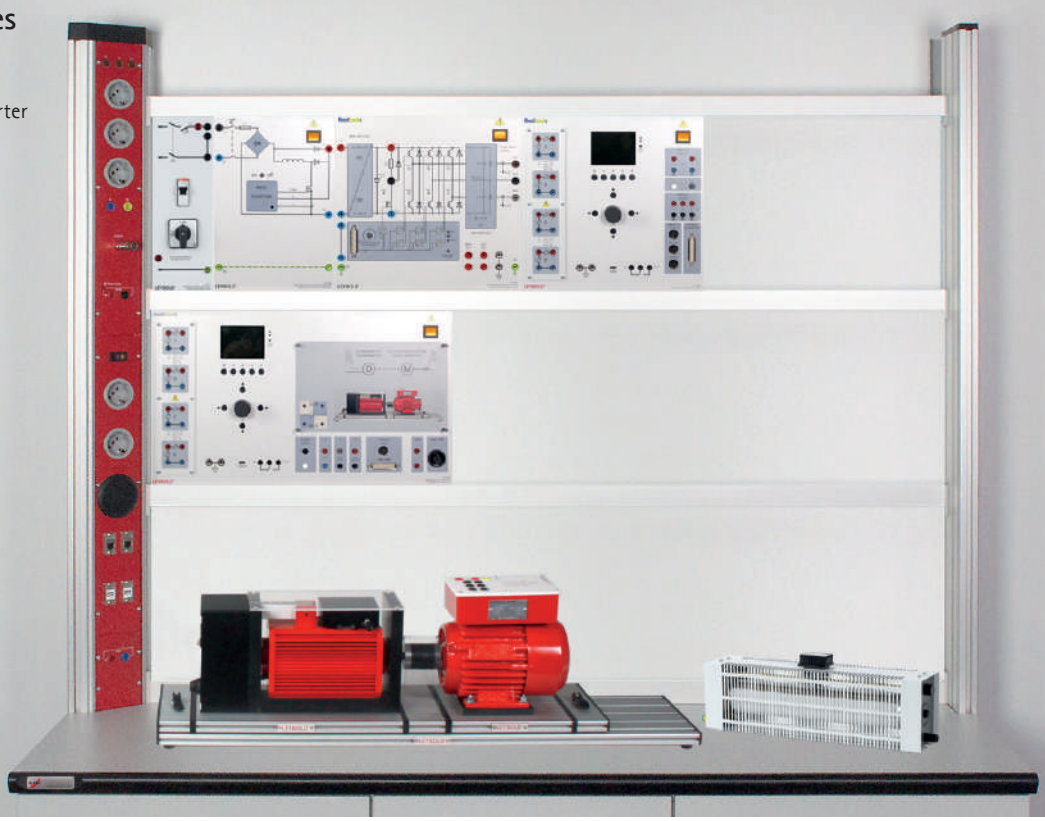
This equipment set offers an insight into the circuitry of frequency converters with variable voltage link. Measurements are made on the components of a frequency converter especially designed for educational purposes. The experiments use a static electronic load, which facilitates the evaluation of current and voltage curves. A rotating field with variable frequency is also investigated.

The following components can be accessed:

- DC link
- IGBT H-bridge
- Brake chopper
- 3-phase inverter

Industrial three-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
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 2104	Squirrel cage motor 230/400, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
315 39	Weight, 1 kg	1
773 110	Machine base bench, 90 cm	1
731 06	Coupling, 0.3	1
537 34	Rheostat, 100 ohms	1
565 442	LIT-print: Frequency Converter Technology - Drives	1*
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The importance of frequency converters for manufacturing and operating concepts has never been greater. A frequency converter optimises not only the motor operation, but often the entire driven machine.

Frequency converters are used with the following objectives:

- Optimisation of energy efficiency
- Efficient factory automation
- Process control and optimisation

This configuration deals with the optimal adaptation of frequency converters and machines without controlling the speed.

Industrial three-phase drives

E2.5.3.4
Drives with industrial frequency converter, 0.3

Drives with industrial frequency converter, 0.3 (E2.5.3.4)

Cat. No.	Description	E2.5.3.4
773 5313	Industrial frequency converter	1
773 2104	Squirrel cage motor 230/400, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
315 39	Weight, 1 kg	1
773 110	Machine base bench, 90 cm	1
731 06	Coupling, 0.3	1
537 34	Rheostat, 100 ohms	1
775 290EN	LIT-print: Drives with industrial frequency converter 0.3	1*
726 09	Panel frame T130, two-level	1
689 3001	Set for equipotential bonding	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
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1
500 602	Safety experiment cable, 10 cm, blue	2

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

Industrial frequency converters are used for machine optimisation and automation. The equipment includes an industrial, compact frequency converter. The focus of the experiments is on commissioning and parametrising the converter and investigating the machine behaviour.

The manufacturer's software is used for parametrisation; programming by hand is possible but not didactically useful given the large number of parameters

Topics

- Design of drives with asynchronous motors
- Torque, efficiency and optimal magnetisation
- Setting the parameters of the frequency converter
- Measurements of the converter output voltage
- Voltage and current vector
- Starting a drive with a frequency converter
- Influence of slip compensation
- Influence of load compensation
- Recording the V/f characteristic at different load conditions

Industrial three-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 3102	Industrial frequency Converter 400 V	1
773 2804	Squirrel cage motor 230/400 IE3 1.0	1
773 2900	Machine Test CASSY, 1.0	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 2990	Electrical dynamometer, 1.0	1
773 258	Coupling / shaft end guard, 1.0, transparent	1
315 40	Weight, 2 kg	1
773 115	Machine base bench, 120 cm	1
732 56	Coupling, 1.0	1
537 34	Rheostat, 100 ohms	2
726 09	Panel frame T130, two-level	1
689 3001	Set for equipotential bonding	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
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

* additionally recommended

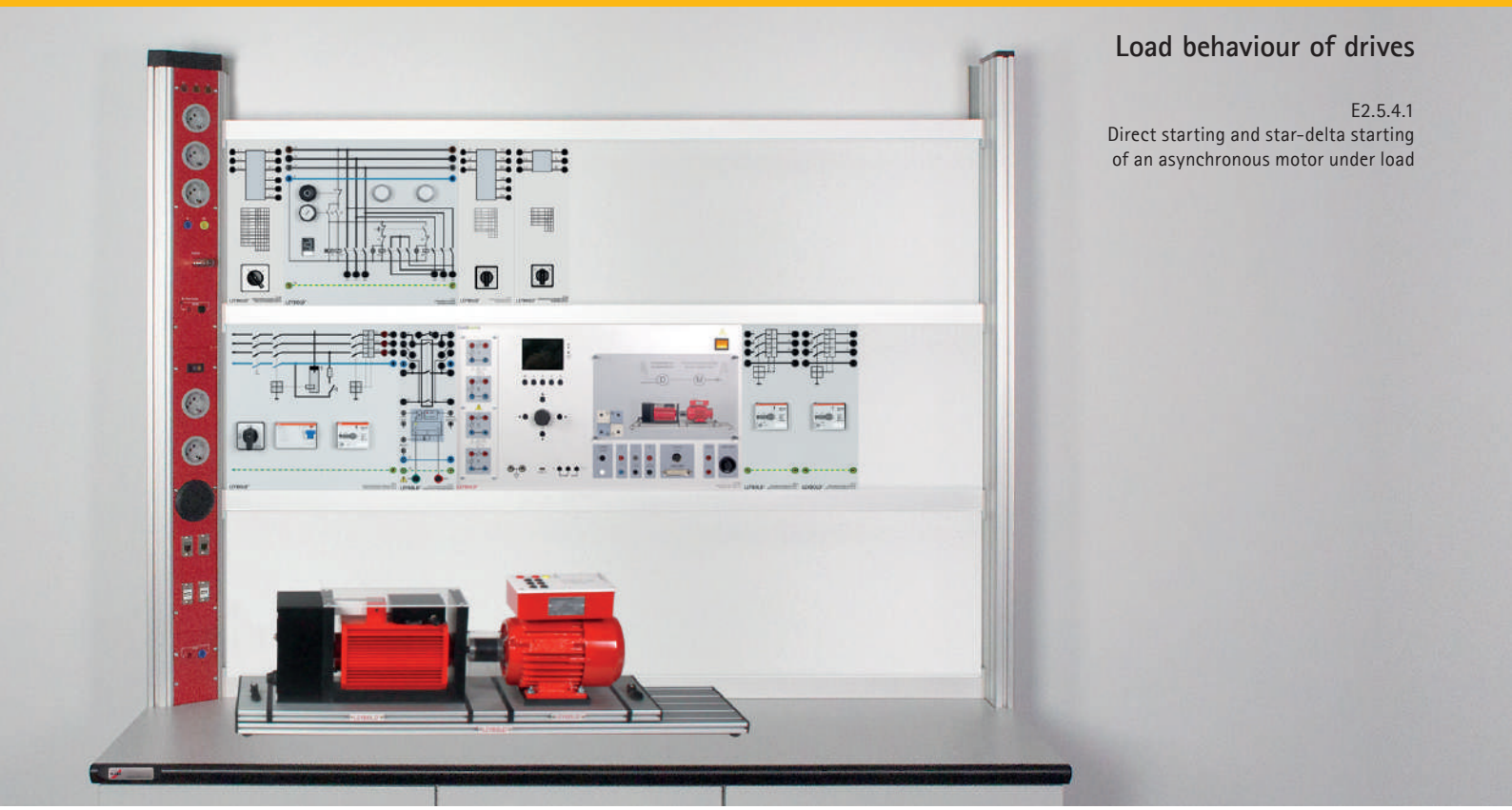
The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

Industrial frequency converters are used for machine optimisation and automation. The equipment includes an industrial, compact frequency converter class 1 kW. The focus of the experiments is on commissioning and parametrising the converter and investigating the machine behaviour.

The manufacturer's software is used for parametrisation; programming by hand is possible but not didactically useful given the large number of parameters.

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
- Measurements are carried out by the Machine Test CASSY



Load behaviour of drives

E2.5.4.1
Direct starting and star-delta starting of an asynchronous motor under load

Direct starting and star-delta starting of an asynchronous motor under load (E2.5.4.1)

Cat. No.	Description	E2.5.4.1
773 212	Squirrel cage motor 400/690, 0.3	1
731 48	Star-delta reversing switch	1
731 50	Star-delta starter	1
732 13	Motor protection switch, 0.6-1	1
731 44	Motor protection switch, 0.4-0.6	1
745 561	Power circuit breaker module	1
773 1900	Machine Test CASSY, 0.3	1
524 222	CASSY Lab 2 for Drives and Power Systems	1*
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
315 39	Weight, 1 kg	1
773 110	Machine base bench, 90 cm	1
731 06	Coupling, 0.3	1
731 47	Star-delta switch	1*
731 49	Reversing switch	1*
726 75	Three-phase terminal unit with RCD	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	2
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

In these experiments, the behaviour of an asynchronous motor is investigated upon direct start-up and star-delta start in the network.

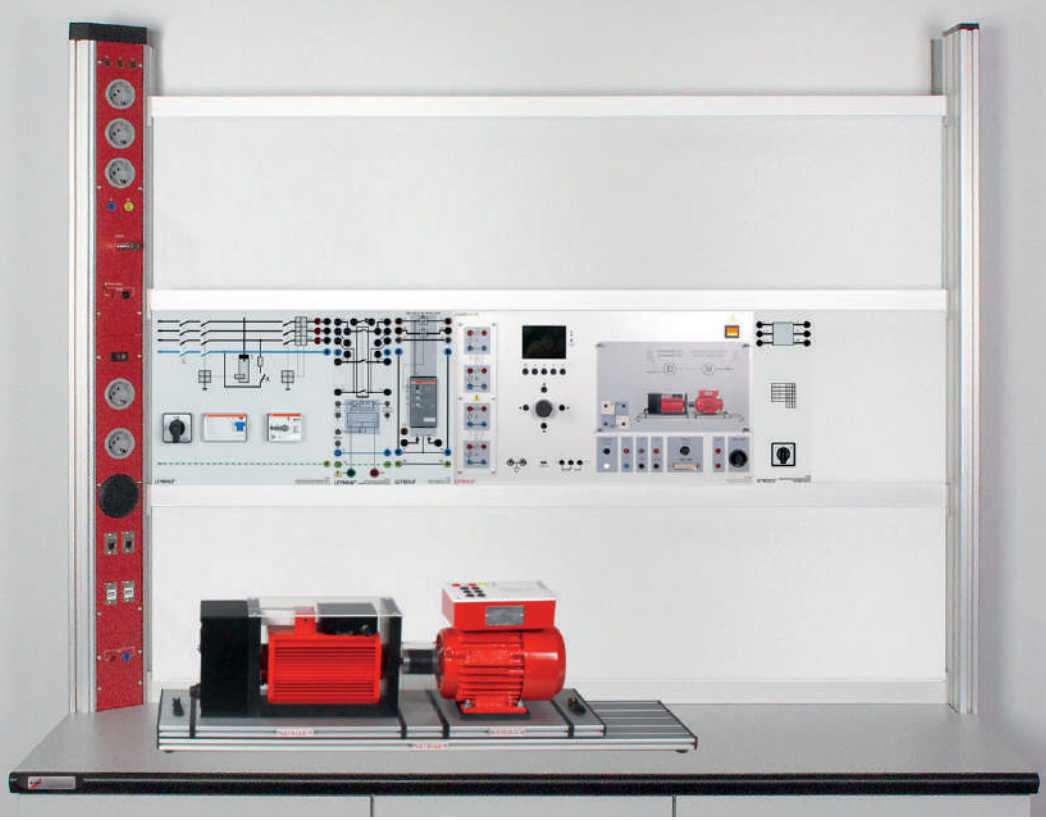
The experiments are performed with an asynchronous machine 400/692 V. These can only be operated with the star-delta start directly on a supply network. In Germany, the direct start is only allowed with machines up to 4 kW. The high-efficiency machines and their high switch-on currents of up to 8 times the nominal current put a strain on the supply networks.

Objectives

- Mains feedback with direct start with and without load
- Mechanical load of the driven working machine
- Optimisation of the star-delta start
- Determining the switching time of an automatic star-delta circuit
- Measurements are performed by the Machine Test CASSY

Load behaviour of drives

E2.5.4.2
Direct starting or starting with a soft starter of an asynchronous motor under load



Direct starting or starting with a soft starter of an asynchronous motor under load (E2.5.4.2)

Cat. No.	Description	E2.5.4.2
773 2108	Squirrel cage motor 230/400, 0.3 IE3	1
732 13	Motor protection switch, 0.6-1	1
731 49	Reversing switch	1
731 51	Soft starter, 0.3 /1.0	1
745 561	Power circuit breaker module	1
773 1900	Machine Test CASSY, 0.3	1
524 222	CASSY Lab 2 for Drives and Power Systems	1*
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
315 39	Weight, 1 kg	1
773 110	Machine base bench, 90 cm	1
731 06	Coupling, 0.3	1
726 75	Three-phase terminal unit with RCD	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	2
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The first experiments perform investigations of the behaviour of an asynchronous motor 230/400 V with direct start and direct rotation in the network. Starting the resistors contradicts the current efficiency guidelines. Thyristor-controlled soft starters have been developed for these motors, which can reduce motor voltage without a loss of power.

Objectives

- Mains feedback with direct start with and without load
- Mains feedback with direct rotation with and without load
- Mechanical load of the driven working machine
- Start with soft starters
- Optimisation of the soft starter
- Measurements are performed by the Machine Test CASSY

Load behaviour of drives

E2.5.4.3
Starting of large flywheel masses
with slip-ring motor

Starting of large flywheel masses with slip-ring motor (E2.5.4.3)

Cat. No.	Description	E2.5.4.3
773 233	Slip-ring motor, 0.3	1
732 13	Motor protection switch, 0.6-1	1
732 29	Rotor starter, 0.3	1
745 561	Power circuit breaker module	1
773 1900	Machine Test CASSY, 0.3	1
524 222	CASSY Lab 2 for Drives and Power Systems	1*
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
315 39	Weight, 1 kg	1
773 110	Machine base bench, 90 cm	1
731 06	Coupling, 0.3	1
726 75	Three-phase terminal unit with RCD	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	2
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 851	Safety experiment cables, 32 A, set of 32	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

* additionally recommended

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The heavy start is left to the slip-ring rotors. The starting current can be reduced to the nominal current by switching through the resistors in the rotor circuit.

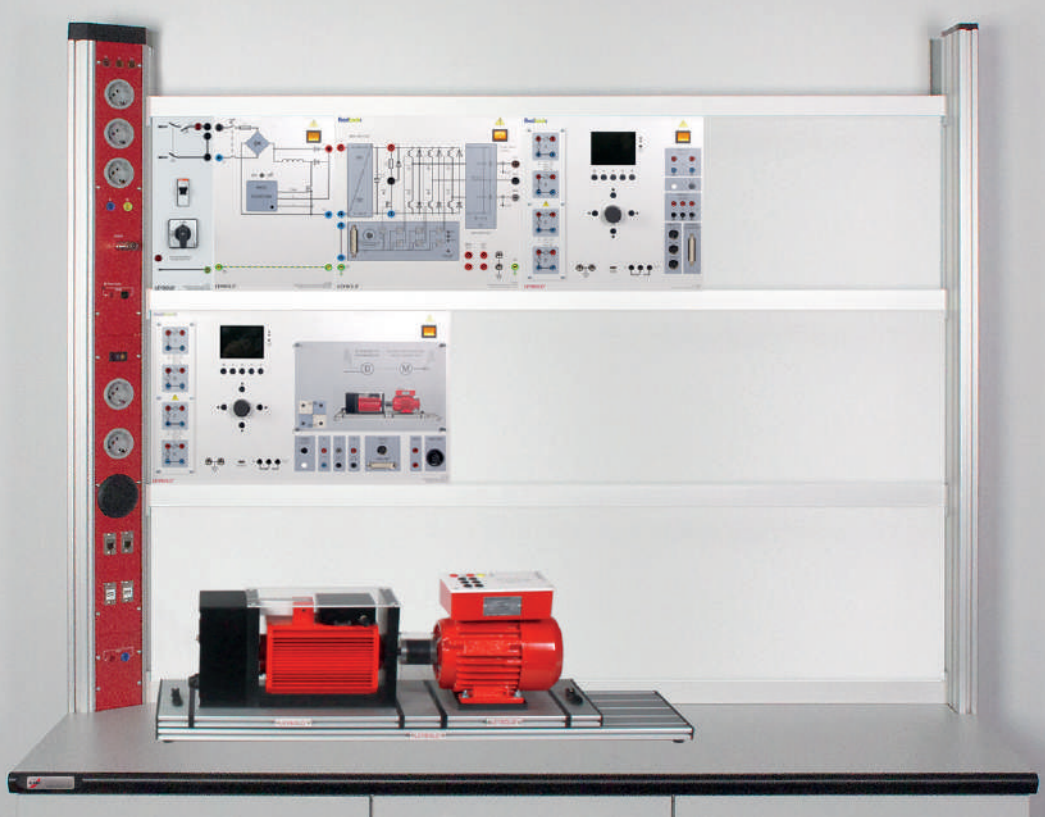
In this experiment, the manual rotor starter is available for the heavy start.

Objectives

- Mains feedback with heavy start
- Mechanical load of the driven working machine
- Optimisation of a start control
- Energy requirement for direct start of an asynchronous motor
- Energy requirement for soft start of an asynchronous motor

Load behaviour of drives

E2.5.4.4
Operating behaviour of speed-variable asynchronous motors under load



Operating behaviour of speed-variable asynchronous motors under load (E2.5.4.4)

Cat. No.	Description	E2.5.4.4
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 2104	Squirrel cage motor 230/400, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
315 39	Weight, 1 kg	1
773 110	Machine base bench, 90 cm	1
731 06	Coupling, 0.3	1
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 602	Safety experiment cable, 10 cm, blue	3
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The learner will get to know the behaviour of working machines on a drive with asynchronous motor.

In later experiments, the different behaviours of working machines are presented.

Characteristics diagrams and time diagrams are recorded and analysed for evaluation purposes.

Objectives

- Energy requirement for starting under load
- Energy requirement for change of direction of rotation
- Behaviour of working machines
- Torque is constant as with lifts; cranes (T_L = const.)
- Torque rises lineally with speed; extruder, flexing work ($T_L \sim n$)
- Torque rises quadratically with speed; turbo machines, fans, pumps ($T_L \sim n^2$)
- Torque decreases inversely proportional to speed; lathes and milling machines, winding machines ($T_L = 1/n$)
- Flywheel mass

Load behaviour of drives

E2.5.4.5
Operating behaviour of speed variable DC machines under load

Operating behaviour of speed variable DC machines under load (E2.5.4.5)

Cat. No.	Description	E2.5.4.5
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 186	Compound machine, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
315 39	Weight, 1 kg	1
773 110	Machine base bench, 90 cm	1
731 06	Coupling, 0.3	1
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 602	Safety experiment cable, 10 cm, blue	3
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

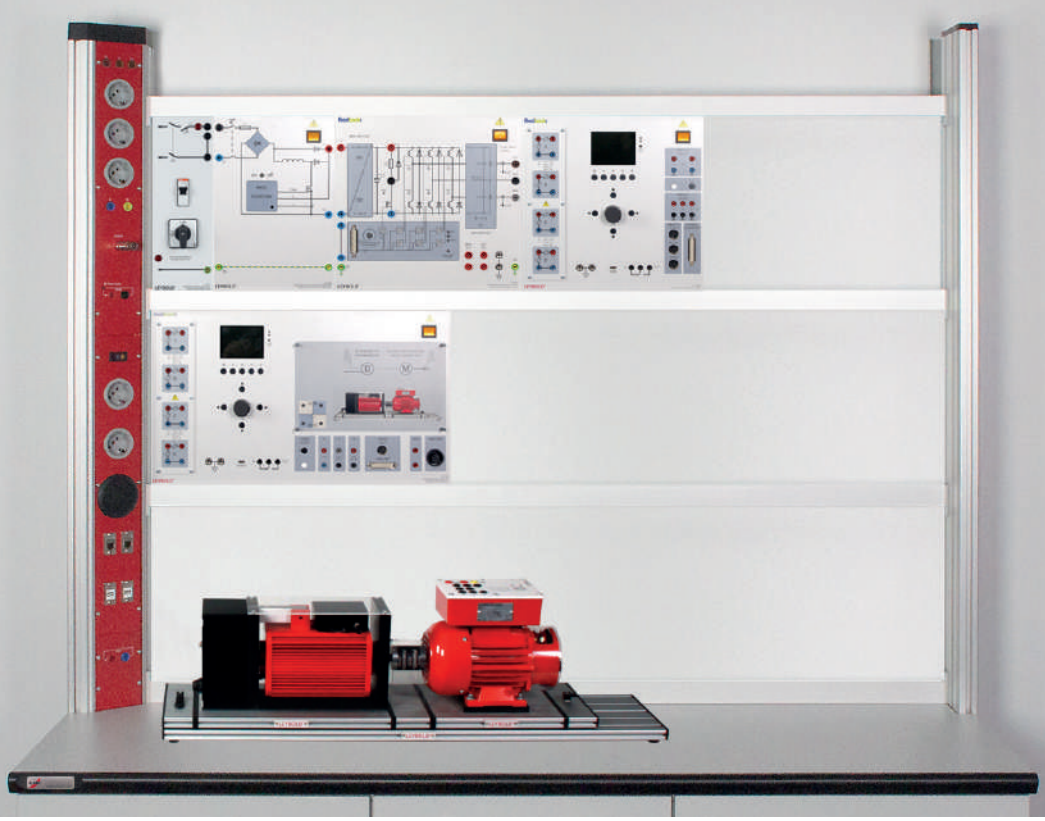
Direct current machines are no longer so popular among controlled and regulated drives. The high purchase price and maintenance costs arising due to the brushes mean these have largely been replaced by BLDC machines.

Despite the aforementioned disadvantages, this drive is still used in drive technology because of its highly dynamic control behaviour.

The learner will get to know the behaviour of working machines on a drive with direct current motor. In the first few experiments, the efficiency of a speed-variable drive is investigated. In later experiments, the different behaviours of working machines are presented.

Load behaviour of drives

E2.5.4.6
Operating behaviour of speed-variable BLDC motors under load



Operating behaviour of speed-variable BLDC motors under load (E2.5.4.6)

Cat. No.	Description	E2.5.4.6
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 350	Synchronous machine, permanently excited with surface magnets BLDC, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
315 39	Weight, 1 kg	1
773 110	Machine base bench, 90 cm	1
731 06	Coupling, 0.3	1
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 602	Safety experiment cable, 10 cm, blue	3
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

Due to their high efficiency and the excellent dynamic properties, BLDC machines have replaced direct current machines in many speed and position control systems. Permanently excited synchronous machines which behave like a direct current machine with a commutated drive are BLDC machines.

The high efficiency is achieved thanks to the permanent excitation. The rotors can be produced with a very low moment of inertia, which allows for highly dynamic behaviour.

Load behaviour of drives

E2.5.4.7
Determining the mechanical data of a machine

Determining the mechanical data of a machine (E2.5.4.7)

Cat. No.	Description	E2.5.4.7
773 2104	Squirrel cage motor 230/400, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 1991	Electrical dynamometer, 0.3	1
773 108	Coupling / shaft end guard 0.3, transparent	1
315 39	Weight, 1 kg	1
773 110	Machine base bench, 90 cm	1
731 06	Coupling, 0.3	1
726 09	Panel frame T130, two-level	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The learner will get to know the fundamentals of mechanical losses and the moment of inertia with an asynchronous machine. These properties are investigated in several experiments. Another group of experiments with the behaviour of different work machines.

The mechanical losses can be determined with a static measurement, i.e. with a constant speed. For this measurement, the moment of inertia is not effective. The mechanical losses consist of the bearing friction and the energy required for cooling.

For a dynamic measurement with constant acceleration, the moment of inertia as well as the mechanical forces from friction and cooling are also effective. The moment of inertia can then be determined.

Objectives

- Mechanical losses
- Fan losses
- Moment of inertia

E2.6.1.1
Fundamentals of commutator technology

For more information, see page 76.

CHAPTER SUMMARY

E2.6 SERVO TECHNOLOGY

E2.6.1 ELECTRONICALLY COMMUTATED MACHINES

E2.6.1.1 Fundamentals of commutator technology

E2.6.1.2 Block commutated synchronous machine

E2.6.1.3 Sine commutated synchronous machine

E2.6.1.4 Incrementally commutated permanently excited synchronous machine with embedded magnets

E2.6.2 INDUSTRIAL SERVOS 300 W

E2.6.2.1 DC servo with industrial DC machine

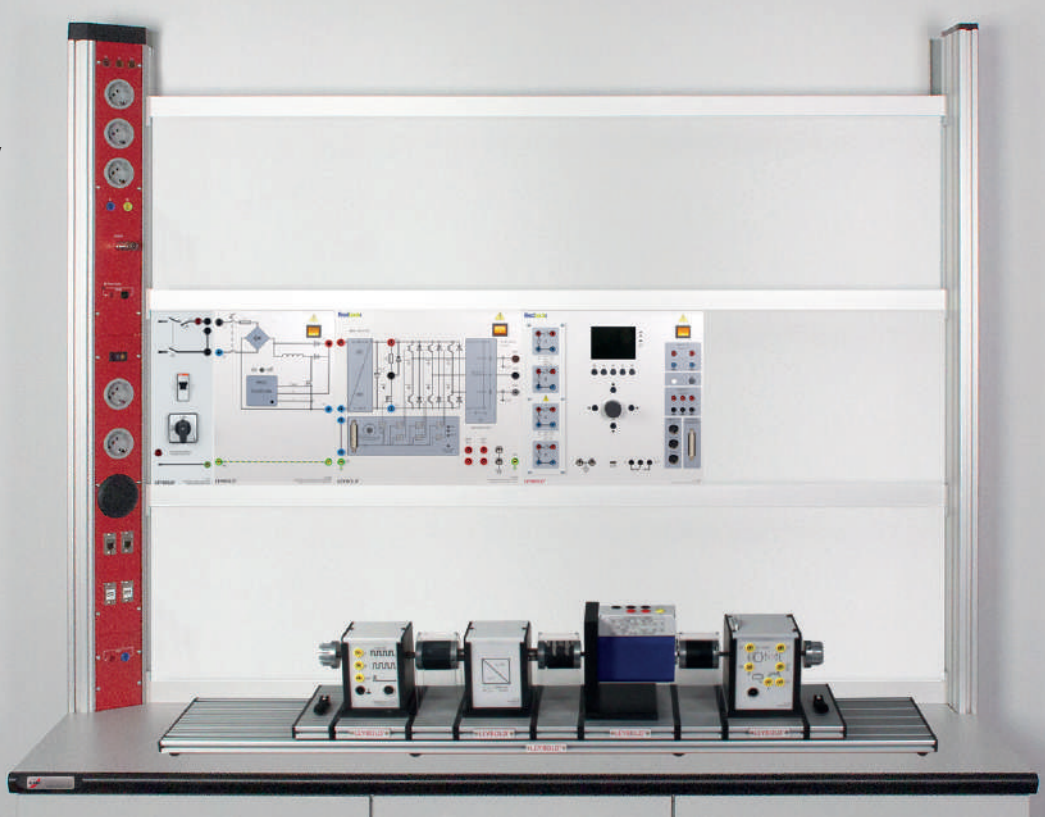
E2.6.2.2 AC servo with industrial asynchronous machine

E2.6.2.3 AC servo with industrial permanent magnet synchronous machine

E2.6.2.4 AC servo with industrial separately excited synchronous machine

Electronically commutated machines

E2.6.1.1
Fundamentals of commutator technology



Fundamentals of commutator technology (E2.6.1.1)

Cat. No.	Description	E2.6.1.1
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
735 296	Converter input/output	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 1994	AC Servo motor, 0.3	1
773 1096	Commutating encoder, 0.3	1
773 1094	Resolver, 0.3	1
773 1092	Incremental tacho, 0.3	1
773 115	Machine base bench, 120 cm	1
773 108	Coupling / shaft end guard 0.3, transparent	3
731 06	Coupling, 0.3	2
773 1075	Gear, 0.3	1
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

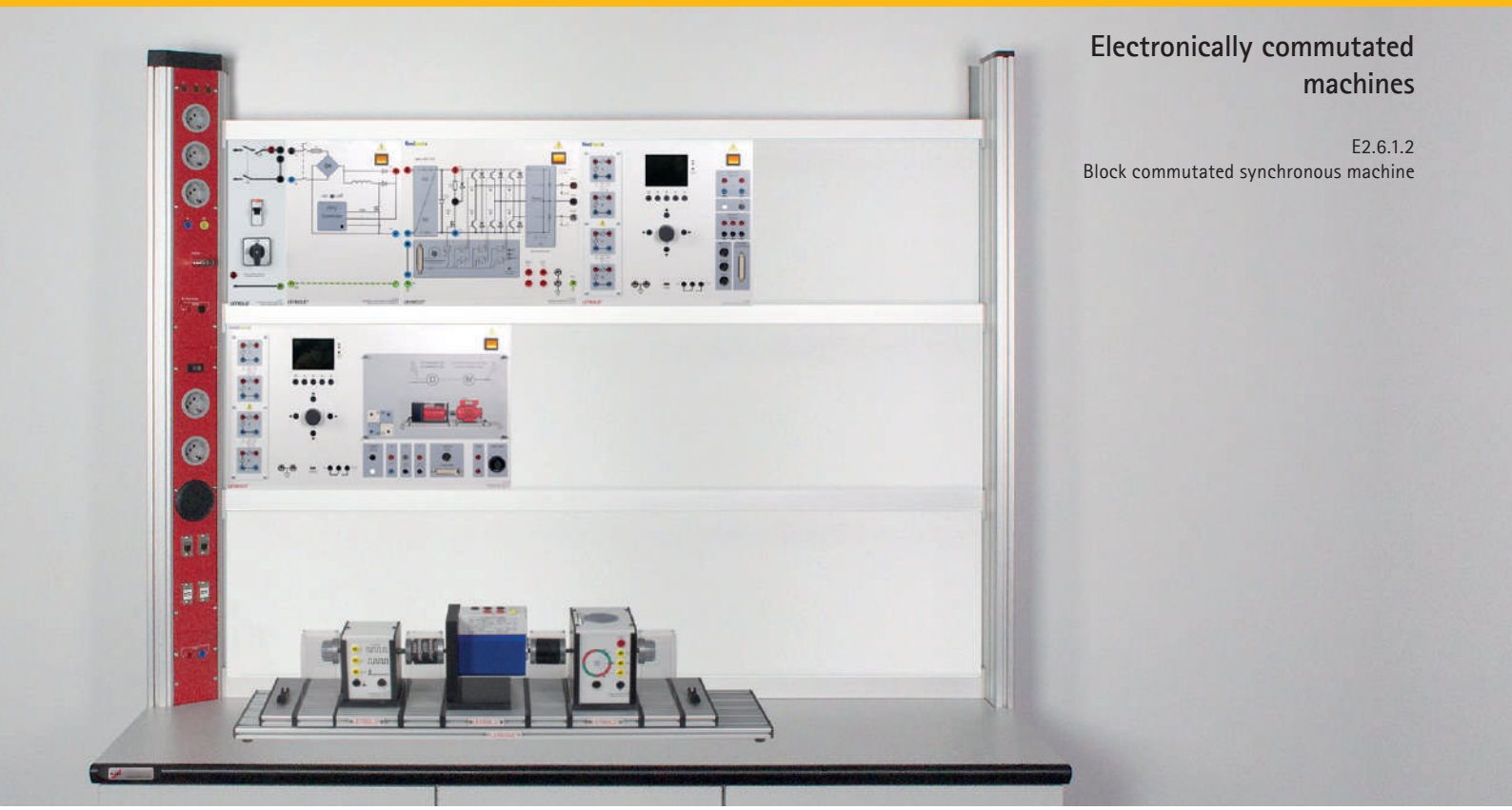
The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

Permanently excited or separately excited synchronous machines cannot be operated safely without commutation. In this equipment, the learner deals with the basics of commutation. They can choose between block, sinus and digital commutation. Data is identified and recorded and analysed in characteristics diagrams for evaluation purposes.

With this equipment, the learner should recognise the necessity and function of commutation.

Objectives

- Mechanical alignment of the rotor
- Block commutation,
- Rotation of the rotor
- Field control via converter control
- Field-oriented control
- Sine commutation with resolver
- Digital commutation
- Measures are made with the Converter Controller CASSY



Electronically commutated machines

E2.6.1.2
Block commutated synchronous machine

Block commutated synchronous machine (E2.6.1.2)

Cat. No.	Description	E2.6.1.2
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 1994	AC Servo motor, 0.3	1
773 1096	Commutating encoder, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
773 1991	Electrical dynamometer, 0.3	1
773 115	Machine base bench, 120 cm	1
773 108	Coupling / shaft end guard 0.3, transparent	3
731 06	Coupling, 0.3	2
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The equipment makes it possible to reproduce the functions of a BLDC machine The BLDC machines have block commutation, the behaviour is dictated by the electronic control.

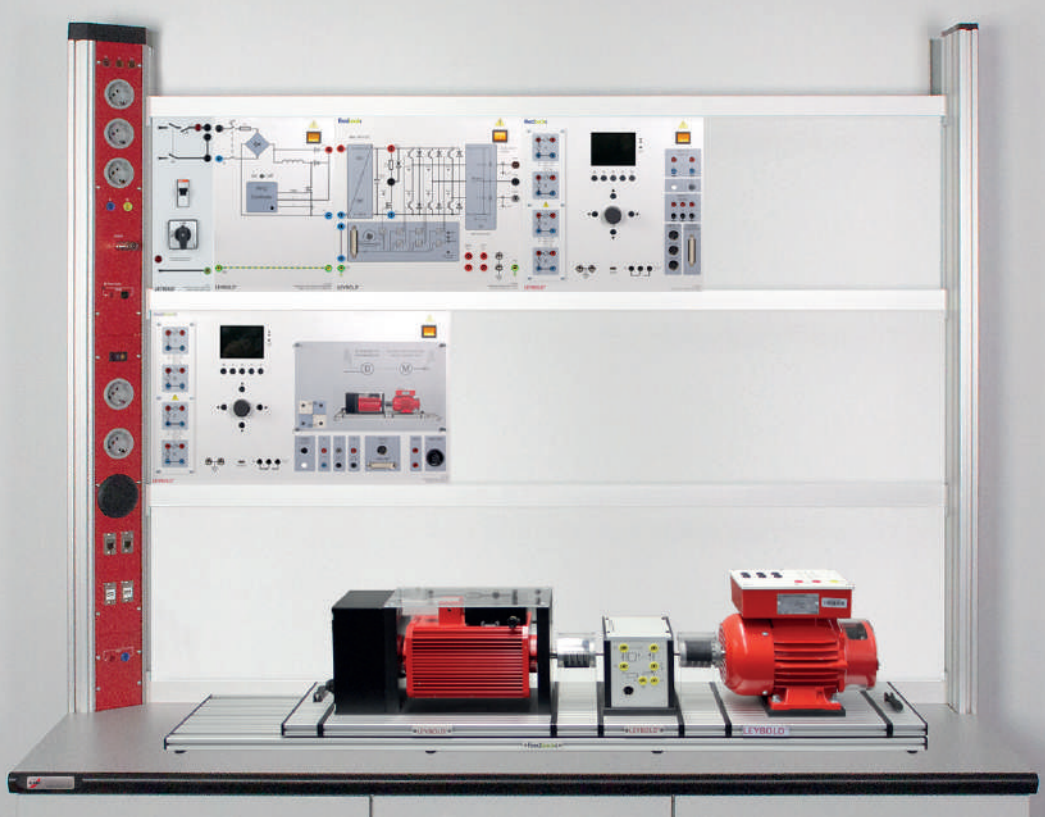
The learner will perform an analysis of the behaviour of a BLDC machine on a permanently excited synchronous machine. Measuring machine parameters, analysing machine characteristics with varying loads. Determining controller properties using the step response of the BLDC machine

Objectives

- Control of the direction of rotation
- Speed control
- Load behaviour
- Step response

Electronically commutated machines

E2.6.1.3
Sine commutated synchronous machine



Sine commutated synchronous machine (E2.6.1.3)

Cat. No.	Description	E2.6.1.3
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 350	Synchronous machine, permanently excited with surface magnets BLDC, 0.3	1
773 1094	Resolver, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
773 1991	Electrical dynamometer, 0.3	1
773 115	Machine base bench, 120 cm	1
773 108	Coupling / shaft end guard 0.3, transparent	3
731 06	Coupling, 0.3	2
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

Here, the following focal points are worked out on a permanently excited synchronous machine (PMSM) with surface magnets as a BLDC motor and generator: measurement of machine parameters and analysis of the machine characteristic curve at different loads. Determining the controller properties through the step response of the PMSM machine is also a focal point.

Objectives

- Function as generator
- Function as motor
- Control of the direction of rotation
- Speed control
- Load behaviour
- Step response

Electronically commutated machines

E2.6.1.4
Incrementally commutated permanently excited synchronous machine with embedded magnets

Incrementally commutated permanently excited synchronous machine with embedded magnets (E2.6.1.4)

Cat. No.	Description	E2.6.1.4
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 340	Synchronous machine, permanently excited with embedded magnets EPM, 0.3	1
773 1092	Incremental tacho, 0.3	1
773 1900	Machine Test CASSY, 0.3	1
773 1991	Electrical dynamometer, 0.3	1
773 115	Machine base bench, 120 cm	1
773 108	Coupling / shaft end guard 0.3, transparent	2
731 06	Coupling, 0.3	2
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

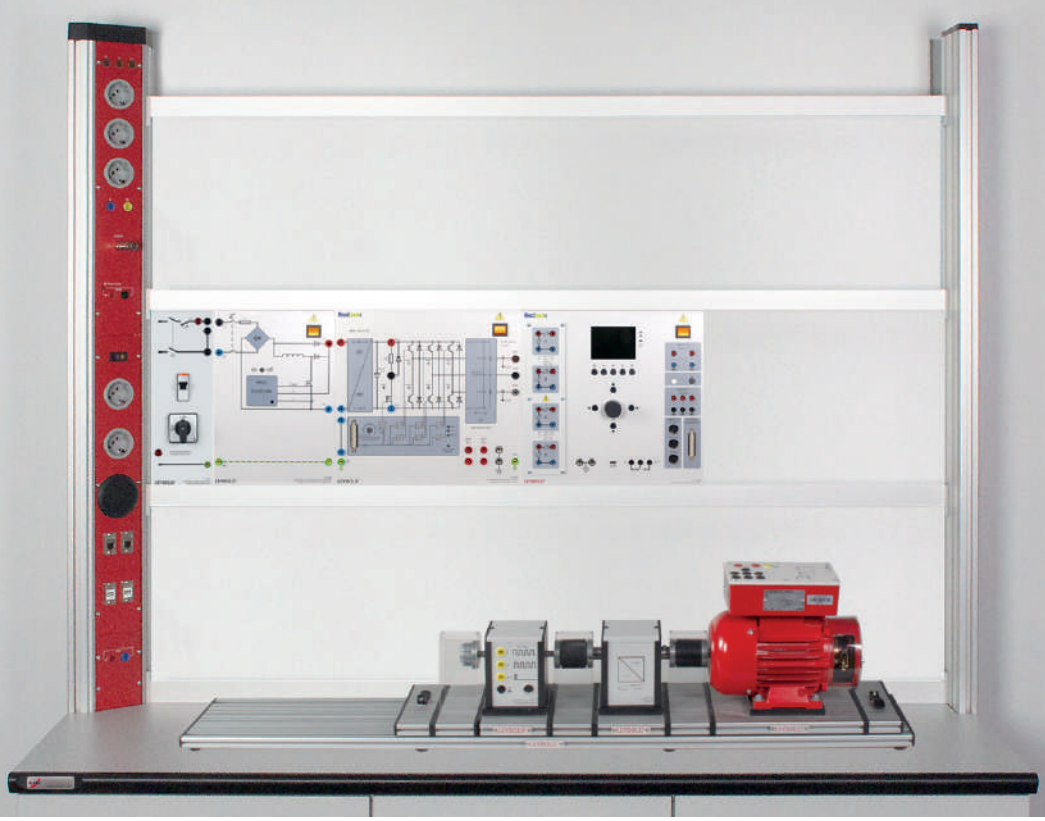
The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

The equipment facilitates the analysis of a sinus-commutated permanently excited synchronous machine (PMSM) with embedded magnets.

The learner analyses a permanently excited synchronous machine (PMSM) with embedded magnets as motor and generator. Measuring machine parameters, analysing machine characteristics with varying loads. Determining controller properties using the step response of the PMSM machine.

Industrial servos, 300 W

E2.6.2.1
DC servo with industrial DC machine



DC servo with industrial DC machine (E2.6.2.1)

Cat. No.	Description	E2.6.2.1
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 186	Compound machine, 0.3	1
773 1092	Incremental tacho, 0.3	1
773 110	Machine base bench, 90 cm	1
773 108	Coupling / shaft end guard 0.3, transparent	1
731 06	Coupling, 0.3	1
773 1075	Gear, 0.3	1
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

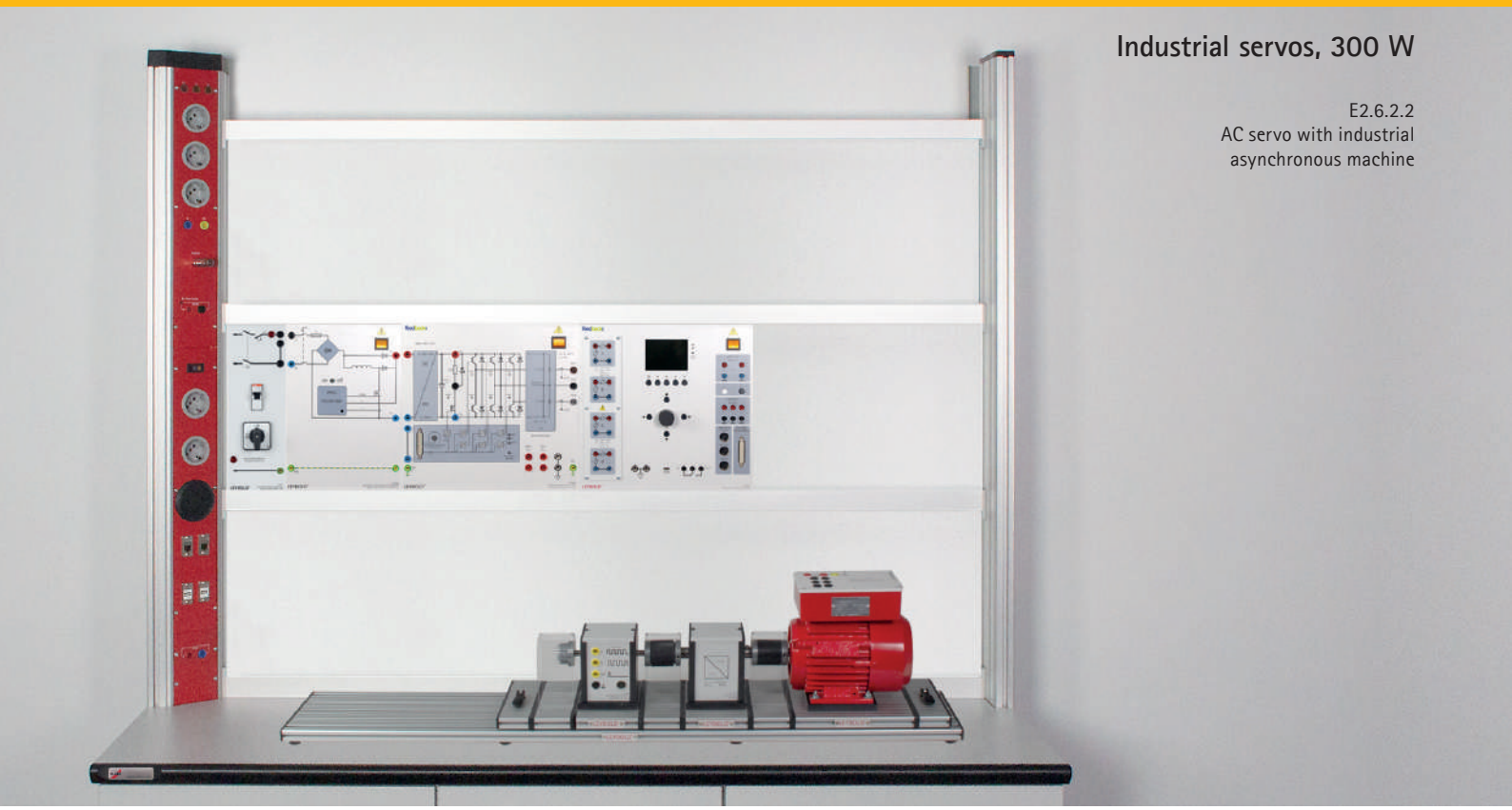
The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

DC servos have a wide range of applications, highly dynamic control was only possible with them for a long time. In many applications, they have been replaced by permanently excited synchronous machines. This is because of the higher maintenance cost and lower efficiency of direct current machines. A modern, angle-oriented speed control requires an incremental recording of the rotation angle.

The learner analyses the set-up and function of a DC servo drive on the DC drive. Measurements and calculations are used to attempt to optimise the drive for its applications.

Objectives

- Optimising control loops
- 2 and 4 quadrants control
- Static speed control
- Dynamic speed control
- Highly dynamic speed control
- Position control
- Step response



Industrial servos, 300 W

E2.6.2.2
AC servo with industrial asynchronous machine

AC servo with industrial asynchronous machine (E2.6.2.2)

Cat. No.	Description	E2.6.2.2
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 2104	Squirrel cage motor 230/400, 0.3	1
773 1092	Incremental tacho, 0.3	1
773 110	Machine base bench, 90 cm	1
773 108	Coupling / shaft end guard 0.3, transparent	1
731 06	Coupling, 0.3	1
773 1075	Gear, 0.3	1
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 602	Safety experiment cable, 10 cm, blue	3
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

AC servos with asynchronous machines are the cheapest solution for speed-controlled drives. They are, however, not as dynamic as direct current machines or permanently excited synchronous machines. One cause for this is the electric time constant from the stator-rotor constant. Another is the dependence of the torque on the slippage, which has a dampening effect on acceleration.

The set-up of an AC servo with an asynchronous machine is analysed. Measurements and calculations are used to attempt to optimise the drive for its applications

- Calculating the control difference
- Analysing loads with step of reference variable
- Approaching stability limits

Industrial servos, 300 W

E2.6.2.3
AC servo with industrial permanent magnet synchronous machine

AC servo with industrial permanent magnet synchronous machine (E2.6.2.3)

Cat. No.	Description	E2.6.2.3
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 1994	AC Servo motor, 0.3	1
773 1092	Incremental tacho, 0.3	1
773 115	Machine base bench, 120 cm	1
773 108	Coupling / shaft end guard 0.3, transparent	1
731 06	Coupling, 0.3	1
773 1075	Gear, 0.3	1
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 602	Safety experiment cable, 10 cm, blue	3
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

AC servos with permanently excited synchronous machines are highly valued due to their high dynamics and are the most widely used drives in CNC technology. This type of machine has reached almost all areas of drive technology, e.g. PC fans, quadrocopters and electric vehicles. In the field of power drives, high efficiency and freedom of maintenance are critical. For small drives, the variety of designs is often decisive. This equipment allows the learner to investigate the properties of this variable drive.

Industrial servos, 300 W

E2.6.2.4
AC servo with industrial separately excited synchronous machine

AC servo with industrial separately excited synchronous machine (E2.6.2.4)

Cat. No.	Description	E2.6.2.4
773 5290	Converter Controller CASSY	1
735 290	Connecting cable universal converter	1
773 5297	Universal converter	1
773 5295	DC power supply 390 V, 6 A, (PFC)	1
524 222	CASSY Lab 2 for Drives and Power Systems	1
773 237	Synchronous machine VP, 0.3	1
773 1092	Incremental tacho, 0.3	1
773 115	Machine base bench, 120 cm	1
773 108	Coupling / shaft end guard 0.3, transparent	1
731 06	Coupling, 0.3	1
773 1075	Gear, 0.3	1
745 021	Excitation voltage controller 200 V/2.5 A	1
726 71	Single-phase terminal unit	1
726 09	Panel frame T130, two-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 602	Safety experiment cable, 10 cm, blue	3
500 855	Safety experiment cables, 32 A, set of 34	1
500 856	Safety experiment cables, 32 A, yellow/green, set of 5	1

The pictured experiment stand is not included in this equipment. It can be added on request for an extra charge.

AC servos with separately excited synchronous machines are able to adapt the property of the motor, especially in production machines, by changing the field. This type of machine is also used with electric vehicles. This equipment allows the learner to investigate the properties of this variable drive.

The equipment is equally suitable for pupil and student experiments in the laboratory with low voltage (DC, AC and three-phase current) and - with a mobile trainer - for teacher demonstrations in the classroom or lecture hall. The experiments are carried out according to the manual.

KEYWORD INDEX

CHAPTER INDEX

- Directly informations about new products and trends
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- Exquisite selection of experiments
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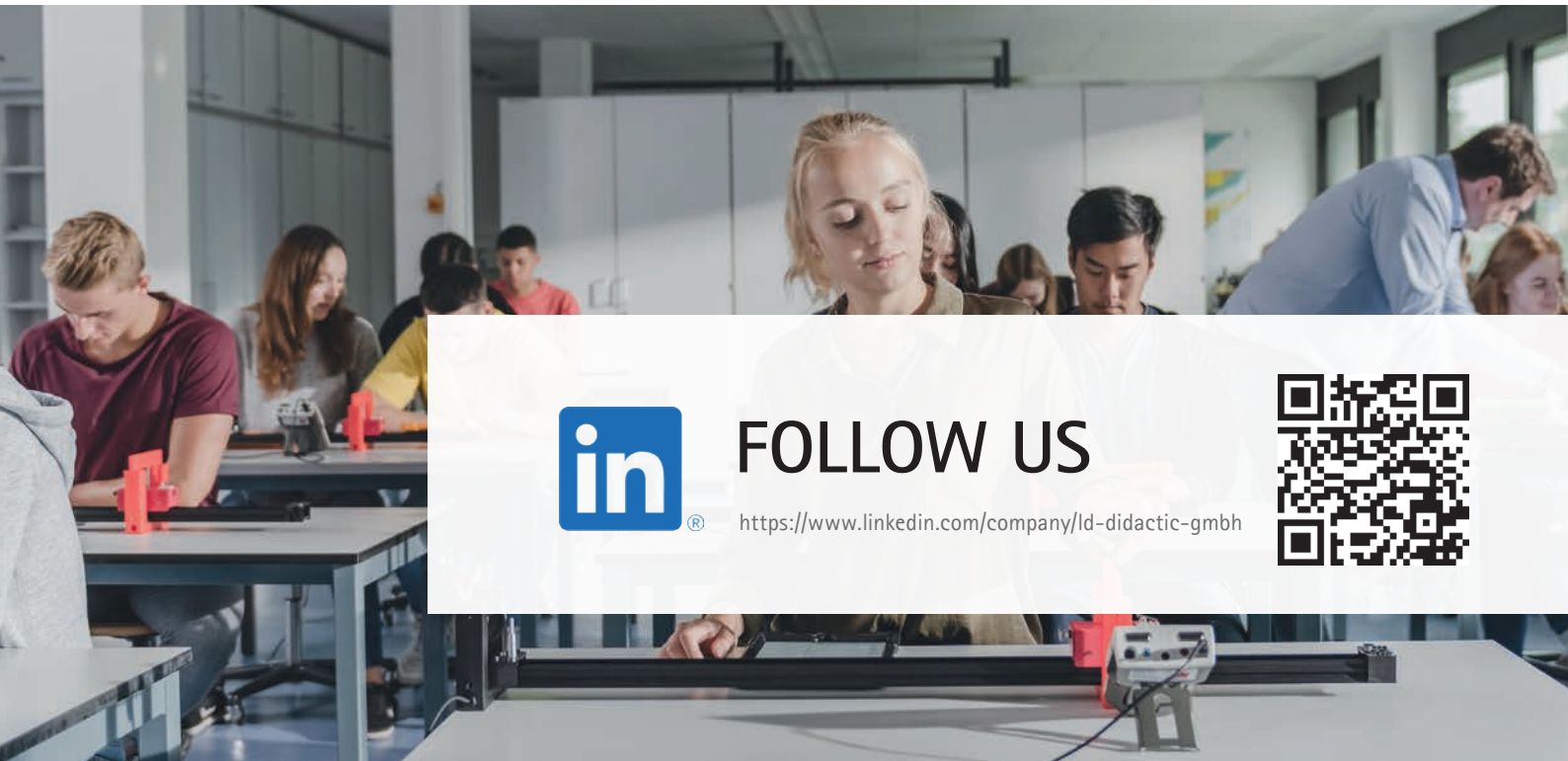

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