LUCAS-NÜLLE

TRAINING SYSTEMS FOR DRIVE TECHNOLOGY

Acquiring Hands-On, Project-Oriented Technical Competence

4th Edition

Contents

Obtaining Technical Skills and Qualifications through Quality Training
Training Systems for Drive Technology 4

Different Systems for Different Needs
Our objective: to satisfy Everyone's Expectations 6
Training Panel System 8
Assembly Exercise System 9

Breathing Life into the Presentation of Complex Training Content
Project-Oriented Learning Media – Tailored to fit all Training Systems 10

The Entire Program at a Glance 12

More than just a Training System
The Full Solution - A Laboratory for Electrical Machines, Power Electronics and Modern Drives 14

One Drive Program, Two Power Classes 16
Perfect Support – PC-controlled Operation and Measurement Value Recording 20
Analogue/Digital Multimeter 22

Contents

Electrical Machines
The Foundation for Drive Technology 26
DC Machines (UniTrain) 28
Asynchronous Machines 29
Synchronous Machines (UniTrain) 30
Stepping Motors (UniTrain) 31
BLDC/Servo Motors (UniTrain) 32
Linear Motors (UniTrain) 33
Single & Three-phase Transformers (UniTrain) 34
Electromagnetic Compatibility (UniTrain) 35
Winding Transformer Coils 36
Winding Electrical Machine Coils 37
DC Machines 38
AC Machines 39
Asynchronous Machines 43
Synchronous/Reluctance Machines 51
Three-phase Machines 53
Transformer Trainer 55

Power Electronics and Didactically Designed Drives
Loss-free Control of Electrical Machines 58
Line-Commutated Power Converters (UniTrain) 60
Self-Commutated Power Converters (UniTrain) 61
Frequency Converter Drives (UniTrain) 62
Active Power Factor Correction PFC (UniTrain) 63
Line-Commutated Converter Circuits 64
Converter Drives with DC Motors 65
Self-Commutated Converter Circuits 66
Frequency Converter Drives 67
Servo Drives 68
Converter Drives with a DC Motor 69

Model-Based Development of Drives with Matlab®/Simulink®
Expand the Training System to a Programmable, Rapid Prototyping System for Drive Technology 72
Field-Oriented Control of Asynchronous Motors with Matlab®/Simulink® 74
Variable-Speed Permanent-Magnet Servo Drives with Matlab®/Simulink® 76
DC Drives with Cascade Control Using Matlab®/Simulink® 78

Industrial Drives
Parameterization of Industrial Components 82
Smooth starting Three-phase Machines 84
Frequency Converter Drives 85
Project Work: Industrial Wiring of Frequency-converter Drives 86
PLC controlled Drive Systems 87
Positioning with Synchronous Servo Drives 88
Motor Management Relays 89

Obtaining Technical Skills and Qualifications through Quality Training

Training Systems for Drive Technology

Technical progress …

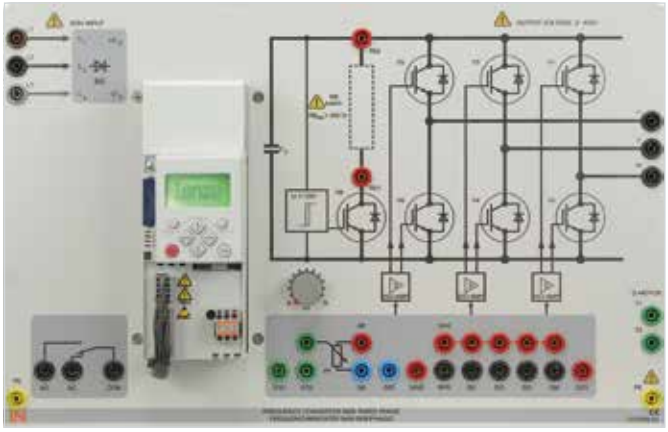
Drive technology is becoming more and more of a force as automation transforms industry. This field is closely intertwined with other areas of technology like process automation, automatic control technology or computer technology. Due to the rapid pace of developments here, drive technology has become one of the most innovative areas of electrical engineering.

… is having an enormous impact on training and education

New industrial drive technologies are necessitating new training systems. New developments like the proliferation of frequency converters and servo drives as well as their integration in process automation systems are only a few examples of how fields in vocational studies are being transformed. This increases the demands on today's drive technicians which leads in turn to a need for modern, practice-oriented training systems that are capable of training students on the latest state-of-the-art technology and how to competently handle such equipment.

A strong partner in industry …

… is the guarantee that our systems are closely modelled to actual practice. Lucas-Nülle has found this strong partner in the highly rated drive technology producer Lenze AG. First, we take the most state-of-the-art drive technology products manufactured by Lenze and modify them for teaching purposes by precisely adapting them to the needs of training schools and educational institutions. All power stages are covered, ranging from simple motor controls to frequency converters up to and including servo converters with field-bus interfaces for integration into process automation.



The modularity and scalability of these teaching and training systems form the innovative and cutting-edge foundation for a solid grounding in drive technology.

Source: Lenze AG

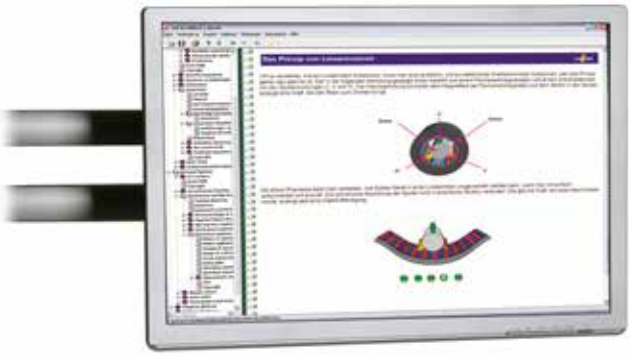
Different Systems for Different Needs

Our Objective: to Satisfy Everyone's Expectations

UniTrain Multimedia Lab with 100 courses

With our UniTrain multimedia experiment and training system, the student is guided through theory and well-conceived experiments in clearly structured course software comprising texts, graphics, animations and tests.

In addition to the training software, each course consists of an experiment card on which the practical exercises and operations are carried out. The program offers course instruction on such topics as "electrical machines", "power electronics" and "drives" covering all of the required know-how and skill needed for understanding, connecting, controlling and operating modern drives. Supported by an array of animations as well as numerous experiments on real systems, these courses explore and elaborate on the fundamentals, principles and properties of components found in electrical motors, power electronics and drive systems.



Your benefits

- Theory and practice at the same time and the same place
- High student motivation induced by PC support and new media
- Rapid learning success thanks to well-structured course design
- Rapid comprehension of theory thanks to animation and graphics
- Technical skills trained with autonomous experimenting
- Constant feedback provided by comprehension questions and tests
- Guided trouble-shooting using integrated fault simulator
- Guaranteed safety thanks to extra-low safety voltage
- Huge selection of courses (courses on more than 100 topics available)
- Sample solutions for trainers

UniTrain-system

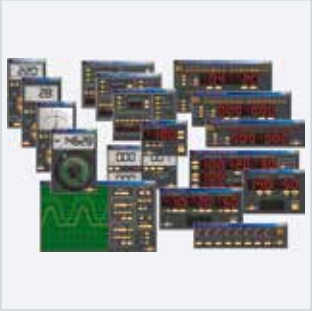
- Complete, portable lab
- Multimedia courses
- High-tech measurement and control interface
- Theory and practice at the same time

UniTrain interface with USB

- Oscilloscope with 2 analogue differential inputs
- Sampling rate 40 MSamples
- 9 measurement ranges 100 mV - 50 V
- 22 time ranges 1 µs - 10 s
- 16 digital inputs and outputs
- Function generator up to 1 MHz
- 8 relays for fault simulation

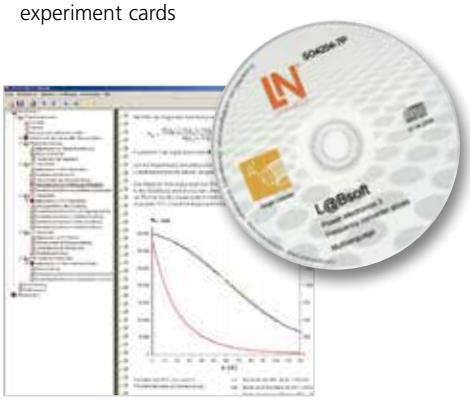
UniTrain experimenter

- Accommodates experiment cards
- Experimenting voltage ± 15 V, 400 mA
- Experimenting voltage 5 V, 1 A
- Variable DC or three-phase power source 0 ... 20 V, 1 A
- IrDa interface for multimeter
- Additional serial interface for experiment cards



Integrated measuring instruments and power supplies

- Multimeter, ammeter, voltmeter
- Dual-channel storage oscilloscope
- Function and waveform generator
- Three-fold power supply for AC and DC
- Three-phase power supply
- ... and much more



Training and experiment software LabSoft

- Huge selection of courses
- Comprehensive theory
- Animations
- Interactive experiments with operating instructions
- Free navigation
- Documentation of measurement results
- Tests

Different Software for Different Needs

Training Panel System

Whether it is for traditional frontal classroom instruction or for hands-on training in student experiments, with the training panel system you can implement any kind of instruction or training method. The training panels consist of laminated panels coated with melamine resin on both sides. The panel height is standard DIN A4 so that it can easily be inserted into the experiment stands.

Training panel system

Your benefits

- Multifaceted and flexible thanks to modular design
- Suitable for student exercises and demonstration
- Safe thanks to double insulation (safety sockets and safety cables)
- Integration of industrial components makes systems similar to industrial use
- Clear and legible front panel thanks to high contrast and scratch-proof printing process
- Modern instrumentation with PC connection
- Colourful experiment and technical training handbooks
- Student worksheets and sample solutions

Assembly Exercise System

Perfect complement for project-oriented instruction:
In the assembly exercises, emphasis is on the handling of tools and developing manual skill. All of the exercises are of a practical hands-on nature. The electrical connections are carried out with industrial wiring materials such as mounting rails, comb plates as well as screws and a variety of wiring methods. All parts and components are reusable except for the consumables (cables).

Assembly exercise system

Your benefits

- Plan and implement projects
- Learn connection techniques
- High degree of practical experience using industrial-type technical documentation and software
- Combinable with the LN training panel system
- Circuitry is implemented using industrial components
- Complete project documentation

Animated Presentation of Complex Training Contents

Interactive Lab Assistant (ILA)

Interactive Lab Assistant (ILA) gives you all the support you need for carrying out experiments. It not only provides instructions, it also supplies valuable theoretical information, records measurements and automatically creates the necessary laboratory documentation in the background in the form of a printable document or a PDF file. If you want to change the experiment instructions, you can simply use Labsoft Classroom Manager to modify or add content.

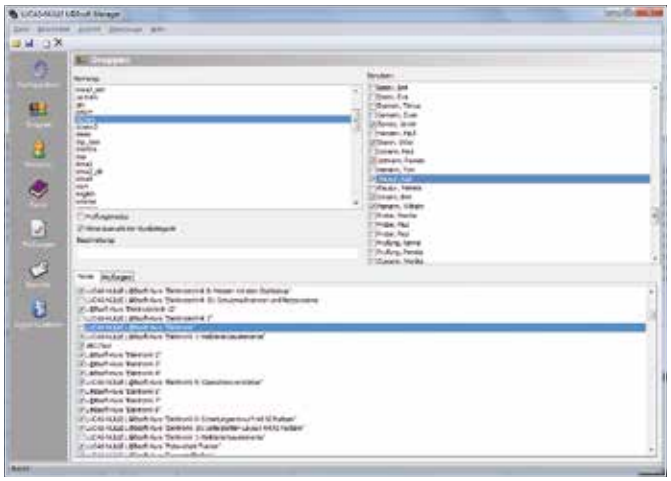
Interactive Lab Assistant (ILA) "energy efficient drives"

Your benefits

- Theory conveyed using easily understood animations
- Support whilst carrying out experiments
- Interactive display of experiment set-ups
- Access to actual measuring instruments and testers with extensive evaluation capabilities
- Practically oriented project exercises to perfect successful learning
- Integrated operating instructions
- Documentation of experiment results (creation of an experiment report)
- Knowledge tests including feedback function

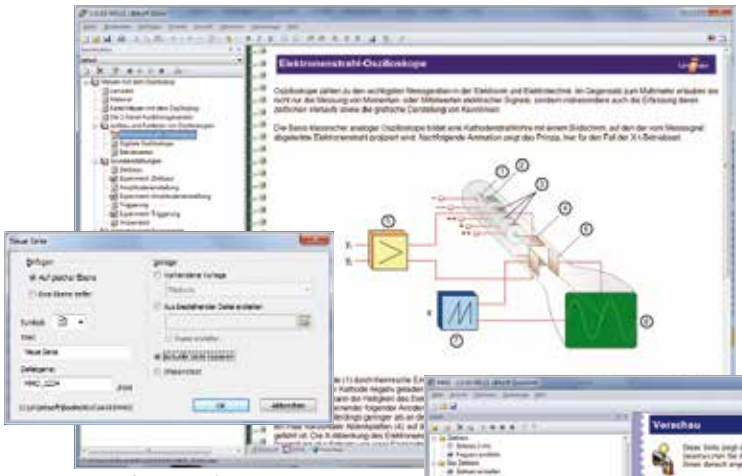
LabSoft Classroom Manager

LabSoft Classroom Manager is an administration software package with extensive functionality. It allows practically oriented training and learning processes to be organised and managed in comfort. Classroom Manager is suitable for all LabSoft-based training programs, such as ILA, UniTrain, InsTrain and CarTrain. It consists of the following sub-programs:

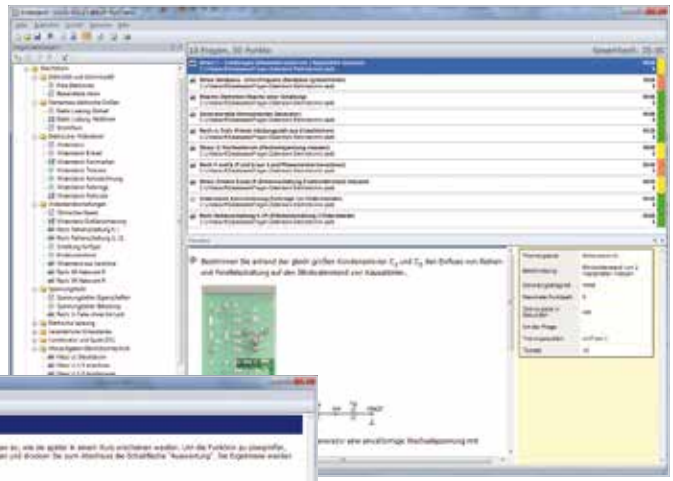


Labsoft Manager: *Administer your LabSoft courses, students and student groups with LabSoft Manager. Then you can provide students with the right exercises for their needs at all times.*

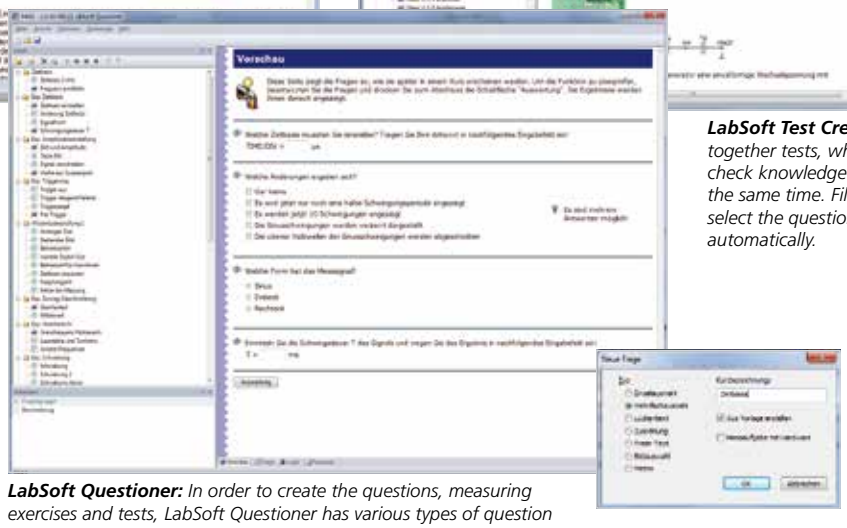
LabSoft Reporter: *Progress and test results can be displayed using LabSoft Reporter. This provides multiple ways of assessing results of courses and tests for individuals or groups allowing you to quickly and specifically monitor progress.*



LabSoft Editor: *features several wizards to help you devise your own new courses and guide trainees step by step through the necessary tests.*



LabSoft Test Creator: *is used to put together tests, which can be used to check knowledge and practical skills at the same time. Filter functions help to select the questions either manually or automatically.*



LabSoft Questioner: *In order to create the questions, measuring exercises and tests, LabSoft Questioner has various types of question available. Exercises and questions can then be inserted into courses and tests.*

The Entire Program at a Glance

Industrial drives

- Putting into operation
- Setting and optimising parameters
- Operating with industrial loads
- Networking with PLC controls
- Project work

EDT 17
Smooth starting three-phase machines

Didactically designed drives

- Operation
- Optimisation
- Operating response

Power electronics

- Circuitry
- Power semiconductors
- Identifying operational and technical context

EPE31
Converter drives with DC motors

EPE41
Frequency converter drives

EPE 42
Servo drives

EPE 43
Converter drives with DC motor

EPE30
Line-commutated converter circuits

EPE40
Self-commutated converter circuits

Electrical machines

- Connection
- Starting
- Motor response
- Measuring speed and torque
- Characteristics
- Project work

EEM 4.5
Fault simulation on electrical machines

EEM 4.6
Protection for electrical machines

EST 1
Manual switching in three-phase circuits

EST 2
Contractor circuits in three-phase circuits

EEM 2
DC machines

EEM 3
AC machines

UniTrain

- Basic training
- Fundamentals
- Understanding function and operation

Course
DC machines

Course
Asynchronous machines

Course
Synchronous and slip-ring machines

Course
Stepping motor

Course
BLDC / servo motor

CLP 20
PLC controlled drive systems

EDT 25
Frequency converter drives

ELP 25
Project work: industrial wiring of frequency-converter drives

EDT 32
Positioning with synchronous servo drives

EDT 51
Motor management relays

Designing drive controllers with Matlab®/ Simulink®

- Rapid implementation of user-defined and reconfigurable processor/hardware-in-the-loop systems using automatic generation of code
- Algorithm engineering to bridge the gap between theory and practice

EPE 51
Field-oriented control with Matlab®/Simulink®

EPE 52
Variable-speed servo drives with Matlab®/Simulink®

EPE 53
Variable-speed DC drives with Matlab®/Simulink®

EEM 5.2
Mains synchronisation

EEM 5.3
Three-phase reluctance machine

EEM 5.1
Synchronous machines

EEM 10
Dismountable three-phase machine set

ENT 5
Transformer trainer

EMW 10
Winding transformer coils

EMW 20
Winding electrical machine coils

Course
Linear motor

Course
Single & Three-phase transformers

Course
Electromagnetic compatibility (EMC)

Course
Line-commutated power converters

Course
Self-commutated power converters

Course
Frequency converter drives

Course
Active power factor correction PFC

More than just a Training System

The Full Solution - A Laboratory for Electrical Machines, Power Electronics and Modern Drives

Using modern educational media to put life into complex training content

Total solutions for modern drives: frequency converters, servo drives, positioning, smooth starting, motor management relays

Connection, starting and testing of DC, AC, three-phase and synchronous machines

Blended learning: multimedia-based instruction using UniTrain

One Drive Program, Two Power Classes

300 W and 1 kW

The complexity inherent in industrial drive technology poses a special challenge for the training and education of electronics and mechatronics specialists. Understanding and mastering electrical machines, their construction design, operation, connection techniques, characteristics and especially their operating response in conjunction with different loads; all of this constitutes the core competencies of skilled workers, technicians and engineers. To live up to the various requirements in this field, Lucas-Nülle offers drives in two different power classes – 300 W and 1 kW.

Two power classes – targeting two different user groups

Benefits

- Record typical machine characteristics
- Response equivalent to that of machines of considerably higher power classes
- 300 W – standard equipment for drive technology and mechatronics
- 1 kW – high-end equipment set for drive technology, mechatronics and power engineering
- Machines and other equipment available for various mains voltages and system configurations

Safe operation and handling

All connections are carried out using safety connecting cables and sockets.

Benefits

- Highly safe circuitry
- Clearly labelled connections and terminals
- Labelling corresponding to DIN/IEC standards
- All moving parts protected with safety guards
- Temperature sensors to protect the machine against thermal overload

Optimum handling

All machines of the same power class are outfitted with shafts of the same height and come with a vibration-attenuating base frame.

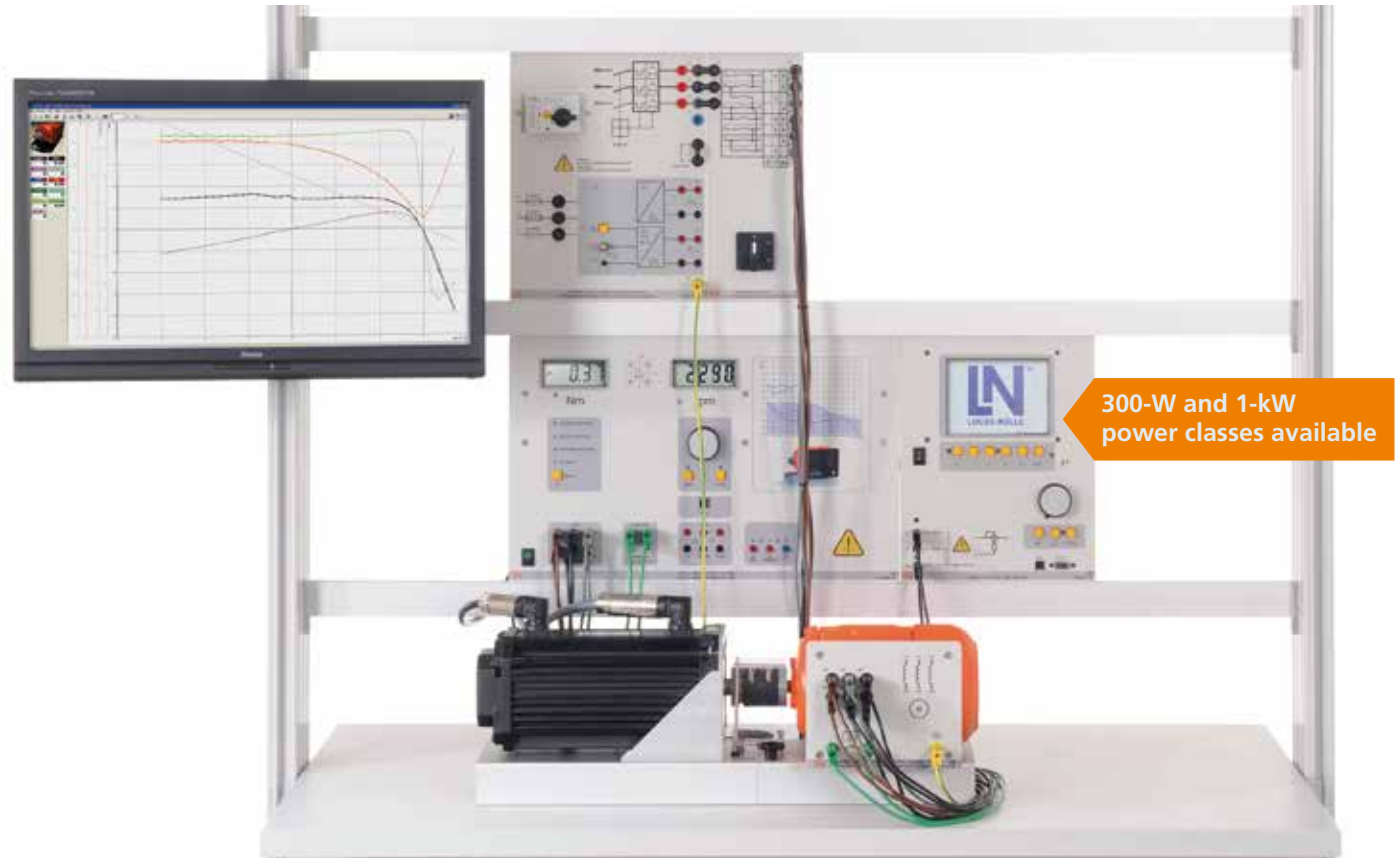
Benefits

- Permits simple, stable coupling of machines and attachments
- Tightly fitting, elastic coupling sleeves
- High-traction and disturbance-free operation

Machine Test Stand

Complete and all-encompassing – Servo Machine Test Stand

The servo machine test stand is a complete testing system designed for the investigation of electrical machines and drives. It consists of the digital control unit, a servo drive and the ActiveServo software. The system combines the latest technology with simple, easy-to-use handling. Besides the drive and brakes, it is also possible to realistically emulate working machine models. This is how machines, generators and drives can be studied in the laboratory under industrial conditions. The system contains ten different operating modes/working machine models. There is a system specially adapted for both power classes.



NATIONAL INSTRUMENTS
LabVIEW

Control unit

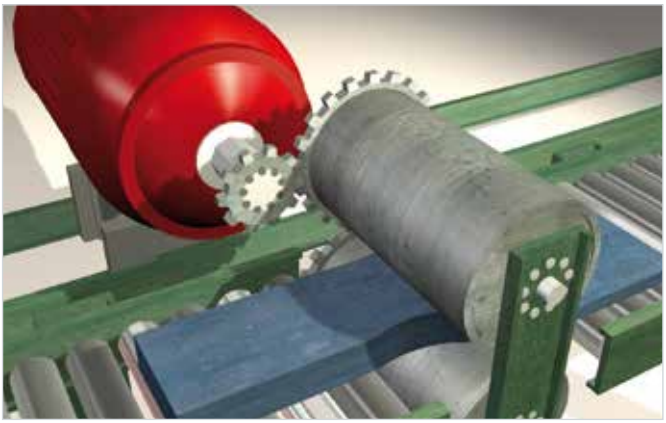
- Drives and brakes operate four quadrants
- Dynamic and static operating modes
- USB interface
- Determining speed and torque
- Integrated electrically isolated measurement amplifier for current and voltage measurement
- Thermal monitoring of machine under test
- Safety disabling when operated without shaft guard

Drive unit

- Self-cooling servo
- Integrated speed and rotor position detection using a resolver
- Temperature monitoring with built-in temperature sensor
- Drift- and calibration-free system
- Connection utilising plug-in connector protected against polarity reversal
- High power reserves for detailed and precise emulation of loads

10 operating modes

- Automatic torque control
- Automatic speed control
- Manual and automatic mains synchronisation
- Flywheel drive
- Lift drive
- Roller/calender
- Ventilator
- Compressor
- Winding drive
- Freely definable time-dependent load

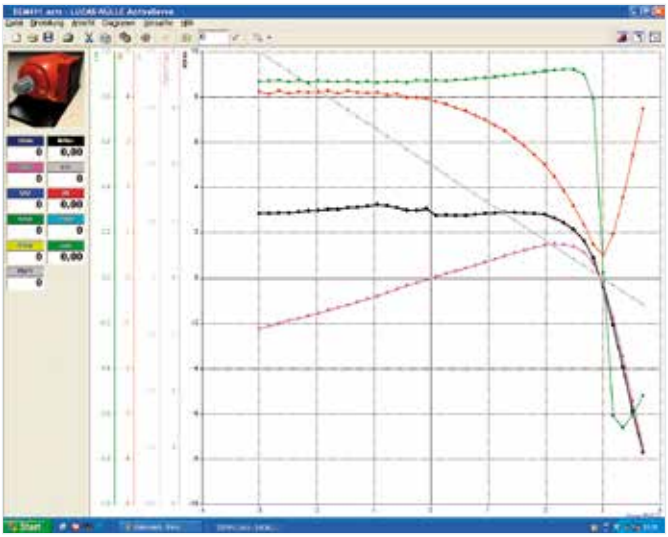


Perfect Support – PC-Controlled Operation and Measurement Value Recording

… doing what ActiveServo and ActiveDrive were designed for.

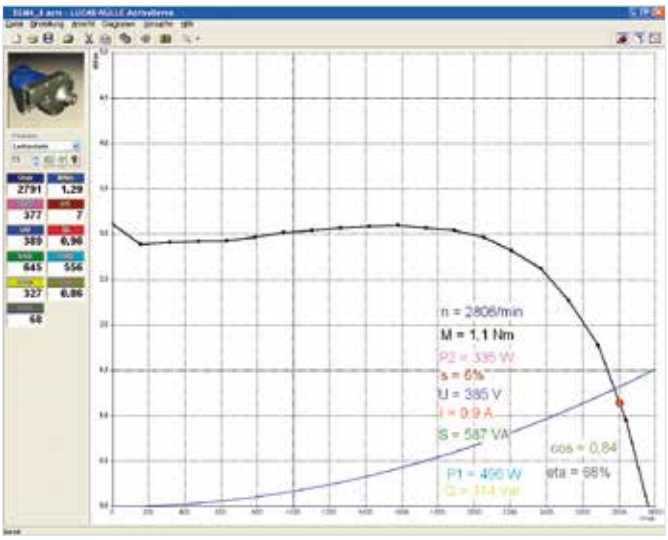
Recording motor characteristics

- Measurement across all four quadrants
- Recording measured values in speed- and torque-controlled operation
- Measurement, calculation and graphic display of measured and calculated mechanical and electrical variables
- Freely definable ramp functions for performing PC-controlled load experiments



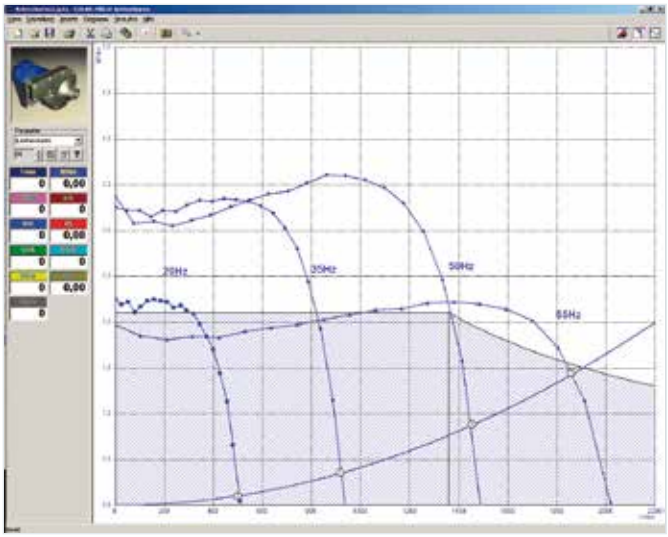
Determining operating points with adjustable, emulated working machines

- Superpositioning of curves from drive and working machines
- Realistic and precisely detailed emulation
- Determination of stable and unstable operating points
- Determination of the working and overload range



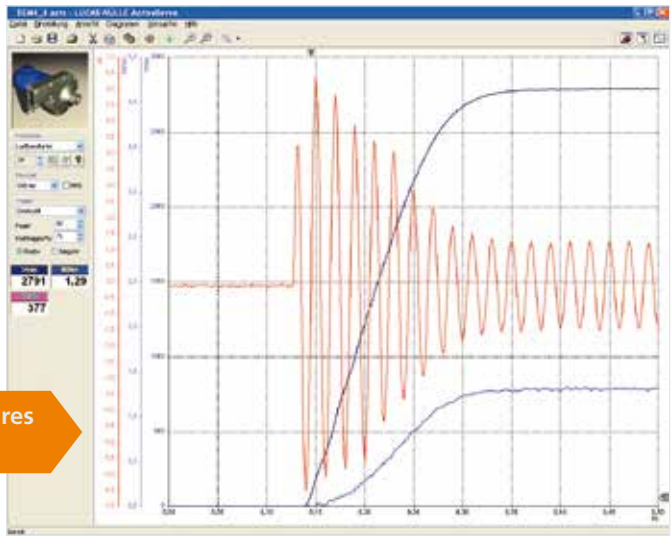
Integrated evaluation of measurement results

- Simultaneous display of the characteristics of different measurement sequences to illustrate changes (here, changes to parameters on a frequency converter)
- Plotting permissible operating range and the nominal values in a graph
- Labelling measurements in a graph
- Comfortable export of measurements into a spreadsheet program for further processing



Dynamic measurements in the time domain using the servo machine test stand

- Determination of starting currents under different loads
- Dynamic examination of controlled drives
- Realistic emulation of working machines even under dynamic conditions
- Depicts electrical variables as momentary values or as rms values



Additional features of ActiveServo

Analogue/Digital Multimeter

Four different meters in one instrument

The areas of electrical machines, power electronics and drive technology place particular demands on measuring instruments. Besides very high overload protection, the registering of the measured values must be carried out independently of the recording of the curve. The analogue/digital multimeter was designed especially for this. It simultaneously replaces up to four different measuring instruments – being an ammeter/voltmeter, power meter and phase angle meter all in one. The graphic display allows the instrument to be used both for student experiments as well as for demonstration purposes.

Equipment

- Simultaneous measurement of both voltage and current independent of the curve shape (measurement of clocked voltages)
- Calculation of active, apparent and reactive power and power factor
- Electrically damage-proof up to 20 A/600 V
- Large, high contrast, background-illuminated graphic display
- Large or standard display of up to 4 measured values

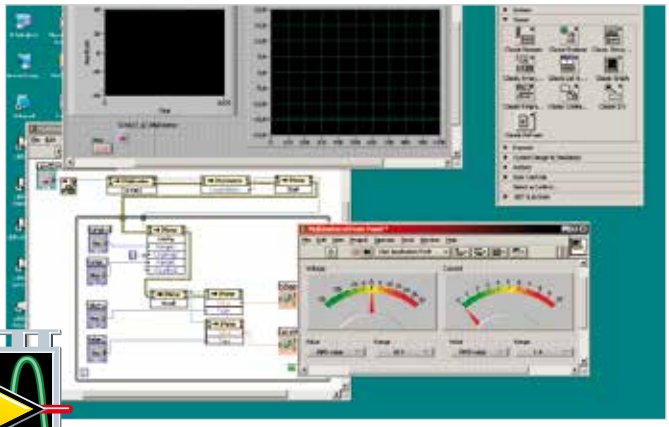
PC connection

Using the USB interface, all of the measured values can be displayed on the PC. The following instruments are available:

- Voltmeter, ammeter, power indicator
- Watt meter for motor and generator operating modes
- Oscilloscope for the display of current, voltage and power
- Data logger for recording the values of up to 14 different measurement variables

LabVIEW compatible

LabVIEW drivers as well as various functional examples permit analogue and digital multimeters to be integrated into the LabVIEW environment.



NATIONAL INSTRUMENTS
LabVIEW

Electrical Machines

26 The Foundation for Drive Technology

28 DC Machines (UniTrain)

29 Asynchronous Machines (UniTrain)

30 Synchronous Machines (UniTrain)

31 Stepping Motors (UniTrain)

32 BLDC/ Servo Motors(UniTrain)

33 Linear Motor (UniTrain)

34 Single & Three-Phase Transformers (UniTrain)

35 Electromagnetic Compatibility (UniTrain)

36 Winding Transformer Coils

37 Winding Electrical Machine Coils

38 DC Machines

39 AC Machines

43 Asynchronous Machines

51 Synchronous/Reluctance Machines

54 Three-Phase Machines

55 Transformer Trainer

Electrical Machines

The Foundation for Drive Technology

Electrical machines form the very basis of modern drives. New training and educational priorities have necessitated new training qualifications for the commissioning and operation of electrical machines. One area of particular importance is the operation of various working machines such as ventilators, lifting equipment and flywheels. The fundamentals of electrical machines are graphically presented using many examples, explanatory texts, exercises and practical assignments.

Multidisciplinary nature
Electrical machines are a central component of modern processing systems, plants and equipment. They are deployed in such areas as mechanical engineering, conveyor and transport technology, process engineering and production lines. Processes continue to become more and more automated through modern power electronic controls and the use of programmable logic controls.

Practice-oriented deployment
Using the "Electrical Machines" training panel system, students explore the practical side of connecting up and operating electrical machines. The accumulated experience is then made more concrete by means of a host of practical exercises and projects.

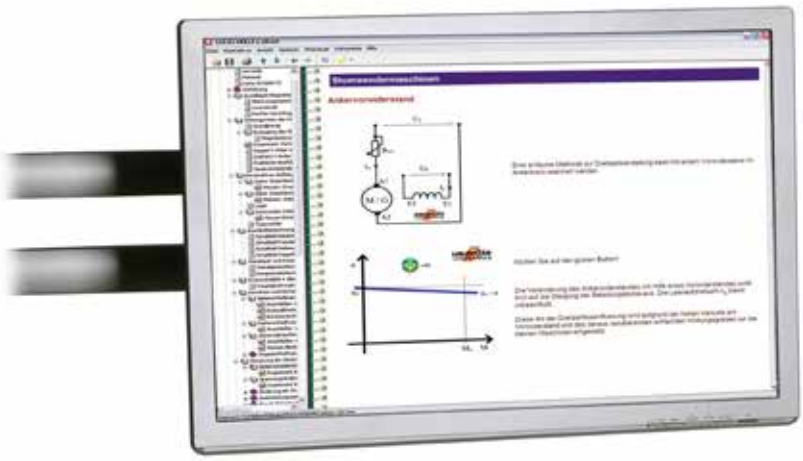
Training systems
The training systems are designed to convey the basic knowledge of electrical machines, demonstrating how they work and displaying their characteristics. The fundamentals of electrical machines are graphically presented using many examples, explanations, exercises and practical assignments.

- UniTrain "Electrical Machines"
- Training panel system "Electrical Machines"

DC Machines

Shunt-Wound Machines – Series-Wound Machines – Compound-Wound Machines – Universal Machines

The DC machines continue to serve as an introduction to the entire field. In actual industrial applications, these motors nowadays tend only to be deployed as small drives with permanent excitation.



UNITRAIN SYSTEM

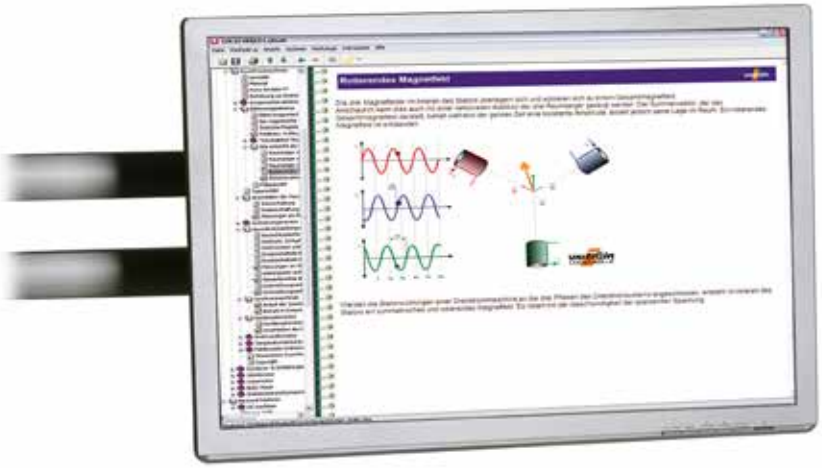
Training content

- Shunt-wound, series-wound, compound-wound, universal machines
- Connection of DC machines
- Initiating experiments on starting
- Setting the neutral zone
- Investigating operating response under field-weakening conditions
- Familiarisation with open-loop speed control
- Carrying out experiments on generator and braking operation

Asynchronous Machines

Squirrel-Cage Motors – Permanent Magnet Motors – Capacitor Motors – Short-Circuit Rotors – Voltage Regulating Transformers

Thanks to their enormous popularity, asynchronous machines are of supreme importance – all the more so in training and education.



UNITRAIN SYSTEM

Training content

- How static and rotating magnetic fields arise
- Stator voltage and current measurements on the stator
- Connection of the stator in star or delta circuit configuration
- Different operating responses for different rotors
- Different response for start-up as well as in the field-weakening range
- Trouble-shooting

Synchronous and Slip-Ring Machines

Slip-Ring Rotor Machines – Synchronous Machines – Reluctance Machines

Synchronous machines are primarily used as generators in power generation and as highly dynamic drives (servos).

UNITRAIN SYSTEM

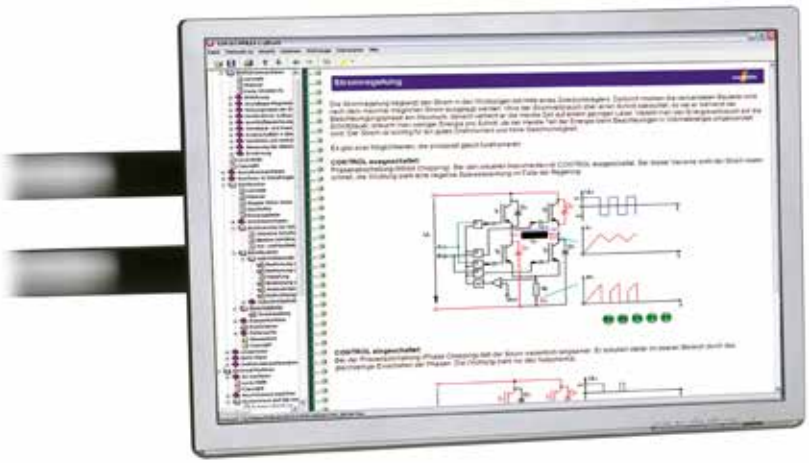
Training content

- Explaining through actual practice how the technology works including its applications
- Exploring the physics needed to understand the technology
- Starting machines with starting resistors and at variable frequency
- Open-loop speed control
- Influence of open and connected rotor windings
- Effects of different exciter voltages

Stepping Motor

Design – Operating Principle – Positioning

Stepper motors allow for a cost-effective solution to your positioning needs. For that reason, they are produced in large volumes for a variety of industrial applications.



UNITRAIN SYSTEM

Training content

- Illustrate stepper motor technology using animations, theory and experiments
- Control operation principles
- Demonstrate differences between two current-limiting methods
- Limits of the stepper motor
- Complex positioning assignments

BLDC / Servo Motor

Operation – Position Detection – Closed-Loop Control

Brushless DC motors (BLDC) are being used in the most diverse areas and applications. BLDC motors have a high degree of efficiency and operate like permanently excited synchronous motors.

UNITRAIN SYSTEM

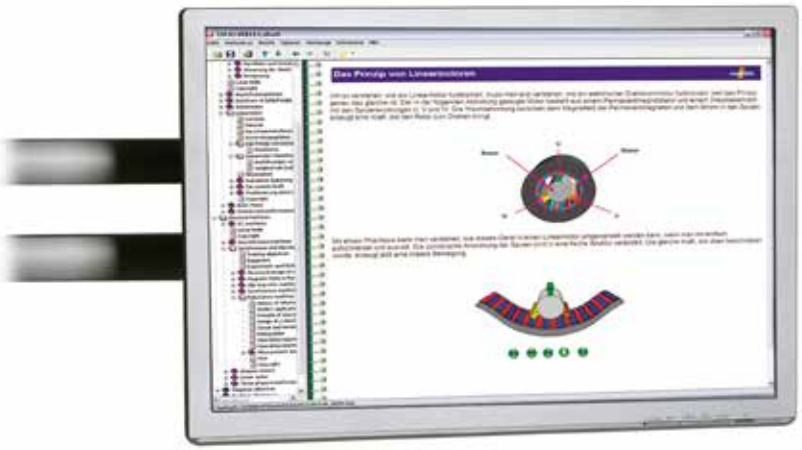
Training content

- Design and operation of the motor and the control electronics
- Examining the pick-up system
- Investigating the power supply of the motor
- Design of a torque- and speed-controlled drive

Linear Motor

Operation – Applications – Positioning Tasks

Linear motors are very effective in just about any application requiring linear motion. Even in modern automation applications there is no way to get around linear motors.



UNITRAIN SYSTEM

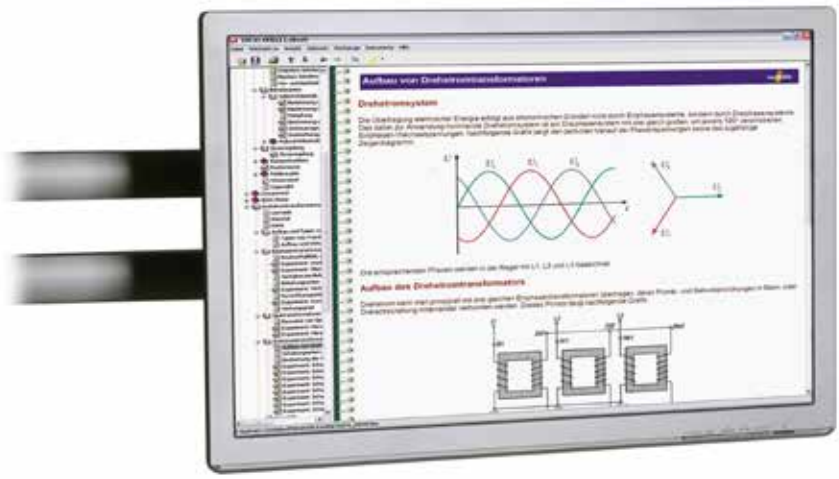
Training content

- Design, operation and operating responses of linear motors
- Meaning of the terms "Lorentz force" and "induced voltage"
- Applications for linear motors
- Different designs of linear motors
- Determining the motor constants
- Positioning operations with the linear motor
- Methods of detecting position (encoder, Hall-type sensors)
- Determining position with the aid of analogue Hall sensors

Single & Three-Phase Transformers

Design – Connection Types – Load Response

Transformers are electrical machines designed to convert alternating or three-phase currents into higher or lower voltages. Three-phase transformers are particularly important in transmitting electrical power.



UNITRAIN SYSTEM

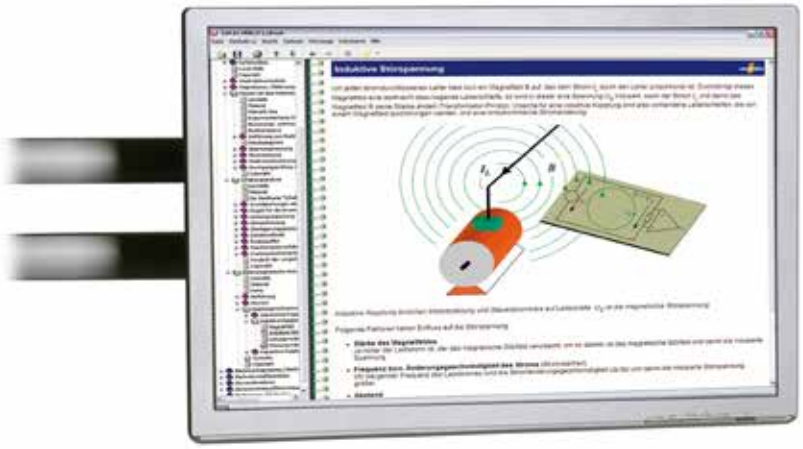
Training content

- Become familiar with the transformer principle and the equivalent circuit diagram
- Record current and voltage with and without load
- Investigate the transmission ratio
- Investigate how various loads respond to various vector groups
- Investigate asymmetrical loads connected to different vector groups
- Determine short-circuit voltage

Electromagnetic Compatibility (EMC)

Coupling Effect – Interference Immunity – Standards

Aspects of a circuit's electromagnetic compatibility play an important role during development and fault finding. Here, coupling effects within the circuit as well as interference are of importance.



UNITRAIN SYSTEM

Training content

- The meaning of the term "electromagnetic compatibility" (EMC)
- Describing electromagnetic coupling effects
- Investigation of galvanic, inductive and capacitive coupling between conductor paths
- Measures taken to improve a circuit's EMC properties
- Measures taken to enhance a circuit's immunity to interference

Winding Transformer Coils

Assembling Single-Phase and Three-Phase Transformers

The manufacture of transformers is at the core of this training system. Everything about transformers is learned in the course of hands-on assembly and operation. The training system contains all of the components and tools needed to manufacture transformers. And most of these components are recyclable, so once you've completed the experiment, you can disassemble the transformer again. Additional experiments enable you to investigate the transformer's operating response in conjunction with different loads.

Wound transformers under test

Experiment example: "Winding transformer coils EMW 10"

Training content

- Design and operation of single-phase and three-phase transformers
- Calculating winding data
- Producing windings
- Testing transformer operation according to standards
- Investigating different operating responses under different loads and vector groups

Winding Electrical Machine Coils

Assembly of a Three-Phase Motor with Squirrel-Cage Rotor

The training system provides instruction on the coil windings of a three-phase motor with squirrel-cage rotor. In the process, windings are wound into a coil and the coil is inserted into the stator and connected up. A completely functional motor is assembled. This allows the design and operation of a motor to be learned through actual hands-on practice. The training system contains all of the components and tools required for the manufacture of a three-phase asynchronous motor. Most of the components can be reused after the experiment has been performed. In additional experiments, the various operating modes are investigated using the machine test stand.

Wound motor under test

Experiment example: "Winding electrical machine coils EMW 20"

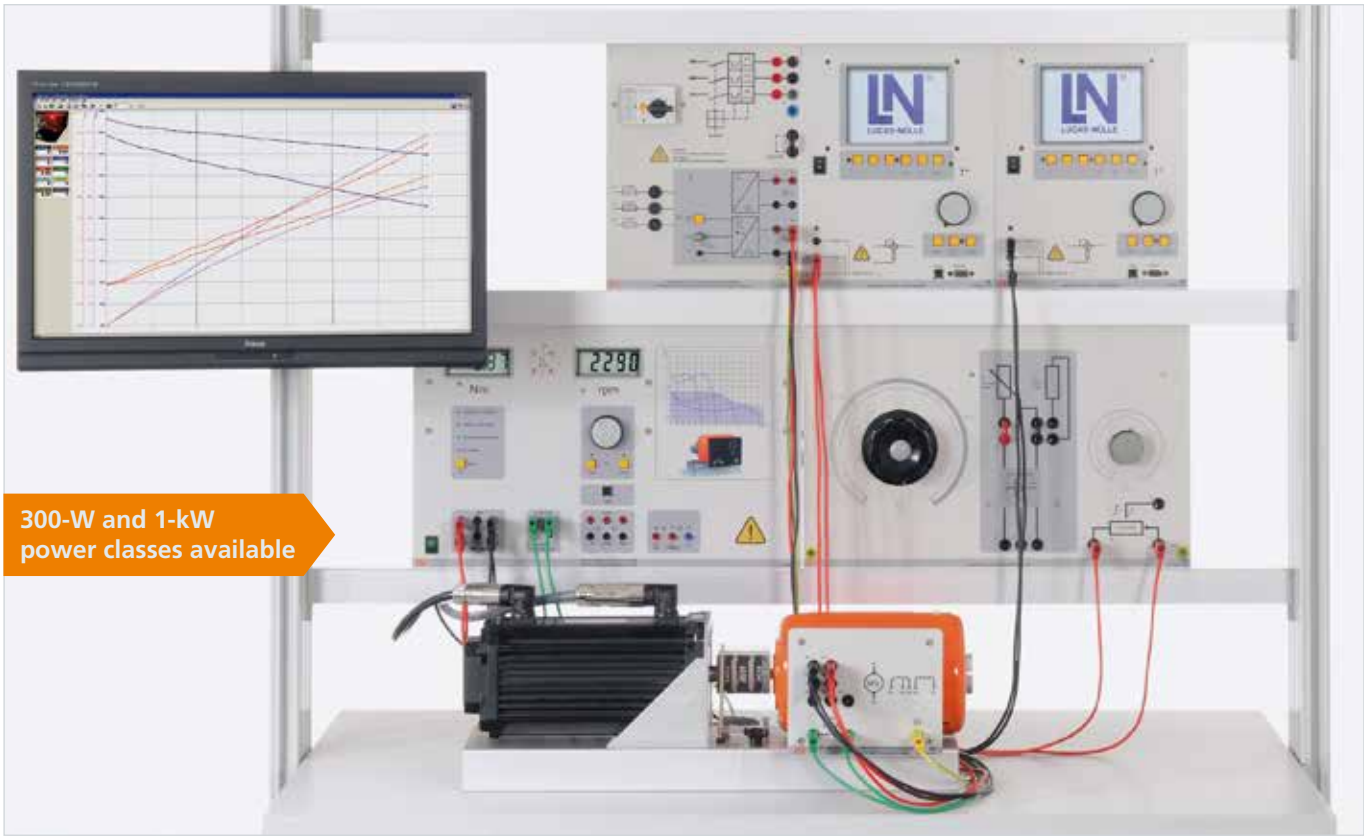
Training content

- Electrical and mechanical design motors
- Determining the winding data
- Producing windings
- Inserting and wiring coil windings
- Testing motor operation according to standards
- Connection, wiring and putting into operation
- Recording the speed and torque response

DC Machines

Shunt-Wound Machine – Series-Wound Machine – Compound-Wound Machine

DC machines continue to form the foundation for training in the area of electrical machines. They are used to clearly and concisely demonstrate the potential of open-loop and closed-loop control techniques.



300-W and 1-kW power classes available

Experiment example: "DC machines EEM 2"

Training content

Motor operation:

- Motor connection
- Comparing various machine types
- Typical machine ratings and characteristics
- Speed control with starter and field regulator
- Reversing rotation direction

Generator operation:

- Generator connection
- Armature voltage as a function of exciter current
- Function and use of the field regulator
- Self-excited and separately excited voltage control
- Load diagrams of the generator

AC Machines

Universal Motors

Universal motors are static converter machines and principally serve as drives for electric tools and household appliances. They are found with power ratings of up to around 2 kW. Thanks to their simple speed control, universal motors make up a considerable percentage of all AC machines.

Experiment example: "AC machines EEM 3.1"

Training content

- Connection, wiring and putting into operation
- Reversal of rotation direction
- AC- and DC-voltage operation
- Recording the speed and torque response
- Operation with different load machines such as ventilators

AC Machines

Single-Phase Motor with Bifilar Starter Winding

The single-phase motor with bifilar starter winding is one of the asynchronous machines. In addition to the main winding, there is a starter winding which has a high internal resistance which is partially bifilar and thus magnetically ineffective. This is disconnected after starting is achieved. The motors do not contain any parts which would be subject to wear and tear like a collector or slip-rings, and operate at a fixed, virtually synchronous speed. The power range reaches up to approx. 2 kW.

Experiment example: "Single-phase motor with bifilar starter winding EEM 3.3"

Training content

- Connecting, wiring and putting into operation
- Reversal of rotation direction
- Recording the speed and torque response
- Operation with different load machines, like ventilators

Single-Phase Motor with Operating and Starting Capacitor

Single-phase motors with operating and starting capacitors belong to the cadre of asynchronous machines. Besides the main winding, these motors are equipped with an auxiliary winding with a series-connected capacitor. The motors do not contain any components which are subject to wear and tear like collectors and slip-rings and operate at a fixed and virtually synchronous rotation speed. The power range reaches up to approximately 2 kW. Capacitor motors are used to drive household appliances, refrigerators as well as small-scale drives used in manufacturing machinery.

Experiment example: "Single-phase motor with operating and auxiliary capacitor EEM 3.4"

Training content

- Connecting, wiring and putting into operation
- Reversing the rotation direction
- Operating with and without starting capacitor
- Recording the speed and torque response
- Start-up and starting capacitor
- Investigating the current relay

AC Machines

Split-Pole Motors

Split-pole motors excel due to the fact that they are cost-efficient to produce and practically maintenance-free. Split-pole motors are constructed especially for deployment in mass-produced devices like ventilator motors or discharge pumps. The power range stretches from a few watts up to a power level of approx. 150 W.

Experiment example: "Split-pole motor EEM 3.5"

Training content

- Connecting, wiring and putting into operation
- Recording the speed and torque characteristics
- Operating with different load machines such as ventilators

Asynchronous Machines

Three-Phase Motors with Spuirrel-Cage Rotor

Three-phase motors with squirrel-cage rotors are the most frequently used motors in industry. These motors are not only both robust as well as maintenance-free but are also inexpensive to produce. The motors can be found in low-power versions in the watt ranges up to and including power levels of several megawatts. Thanks to the use of modern frequency converters, these motors can operate virtually loss-free at varied speeds enabling evermore application areas to be found for them.

Experiment example: "Three-phase motor with squirrel-cage rotor EEM 4.1"

Training content

- Connecting, wiring and putting into operation
- Operation in star and delta connection configuration
- Deployment of a star-delta switch
- Recording speed and torque characteristics
- Operation with various load machines such as ventilators, hoisting machinery

Asynchronous Machines

Three-Phase, Pole-Switchable Motor According to Dahlander

Due to the special winding, the three-phase motor with a Dahlander circuit enables the three-phase motor to be operated at two different speeds. The ratio of the speeds for this circuit is 2:1. With this type of motor simple drives can be assembled that are capable of two speeds, for example, a two-staged ventilator drive.

Experiment example: "Three-phase, pole-switchable motor according to Dahlander EEM 4.2"

Training content

- Connecting, wiring and putting into operation
- Operation with high- and low-speed stages
- Using a pole-reversing switch
- Recording speed and torque characteristics
- Operation with different load machines such as ventilators, hoisting equipment

Three-Phase Pole-Changing Motor – Two Separate Windings

The system consists of two three-phase motors in a single housing with separate windings. Since both windings operate separately from each other, different integer ratios can be produced between the speeds. These motors are always used for simple applications wherever the speed ratio between slower and faster speed is greater than two, for example, in crane applications where you have inching mode and higher speed.

Experiment example: "Three-phase pole-switchable motor with two separate windings EEM 4.3"

Training content

- Connecting, wiring and putting into operation
- Operation at higher and lower rotation speeds
- Using a pole-reversing switch
- Recording speed and torque characteristics
- Operation with different load machines such as ventilators, hoisting equipment

Asynchronous Machines

Three-Phase Motor with Slip-Rings

In contrast to motors with squirrel-cages, slip-ring motors are equipped with a rotor outfitted with wound coils. These rotors can be connected to resistors or static converters. This makes speed adjustment possible.

Experiment example: "Three-phase motor with slip-rings EEM 4.4"

Training content

- Connecting, wiring and putting into operation
- Adjusting the speed by altering resistance across the rotor
- Recording speed and torque characteristics
- Operation with various load machines such as ventilators, hoisting equipment

Fault Simulation on Electrical Machines

Simply plug the fault simulator into a three-phase asynchronous motor. The widest range of realistic faults can be activated using lockable fault switches. These faults can be detected and analysed using industrial-type measuring instruments. Repair measures can be worked out on the basis of the measuring results. All measurements are performed with the power switched off.

Experiment example: "Fault simulation on electrical machines EEM 4.5"

Open fault simulator

Training content

- Winding breaks in coils
- Winding-to-winding insulation faults
- Winding-to-housing insulation faults
- Combination of various faults
- Fault assessment and practical repair measures
- How to handle insulation meters

Asynchronous Machines

Protection for Electrical Machines

Squirrel-cage motors were designed to operate with constant loads. Load changes as well as high start-up currents lead to excessive overheating of the motor. Sensors are used to monitor the temperature and the motor's current consumption. These activate protective devices such as motor circuit-breakers, protective relays or thermistor relays.

Experiment example: "Protection for electrical machines EEM 4.6"

Training content

- Selection, installation and adjustment of various motor protection systems
- Motor circuit-breaker
- Motor protection relay
- Thermistor protection
- Influence of various operating modes on the heat build-up of the motor
- Tripping characteristics of the protective systems
- Protection against impermissible loads

Manual Switching in Three-Phase Circuits

The development of circuits as well as the correct choice of circuit elements and equipment is at the focal point of this training system segment. Multi-poled motors up to a certain power class can be switched directly into the three-phase circuit. To do this, appropriate switching equipment is provided for each application.

Experiment example: "Manual switching in three-phase circuits EST 1"

Training content

- Manual switching in the three-phase circuit
- Star-delta circuit of a three-phase induction motor with squirrel-cage rotor
- Star-delta reversing circuit of a three-phase induction motor with squirrel-cage rotor
- Pole reversing with three-phase induction motor according to Dahlander
- Pole reversing with three-phase induction motor with two separate windings

Asynchronous Machines

Contactor Circuits in Three-Phase Circuits

Starting at a certain power class, it is no longer possible to switch three-phase machines directly. This is why indirect switching is performed on these machines using contactor circuits of various kinds. The training here features the development of control circuitry and how operational control is designed. Using the extension equipment sets, it is possible to explore even more complex control operations and tasks. The machine equipment set contains all of the motors and equipment required to test direct and indirect control of motors in the three-phase circuit.

Experiment example: "Contactor circuits in three-phase EST 2"

Industrial contactor circuits

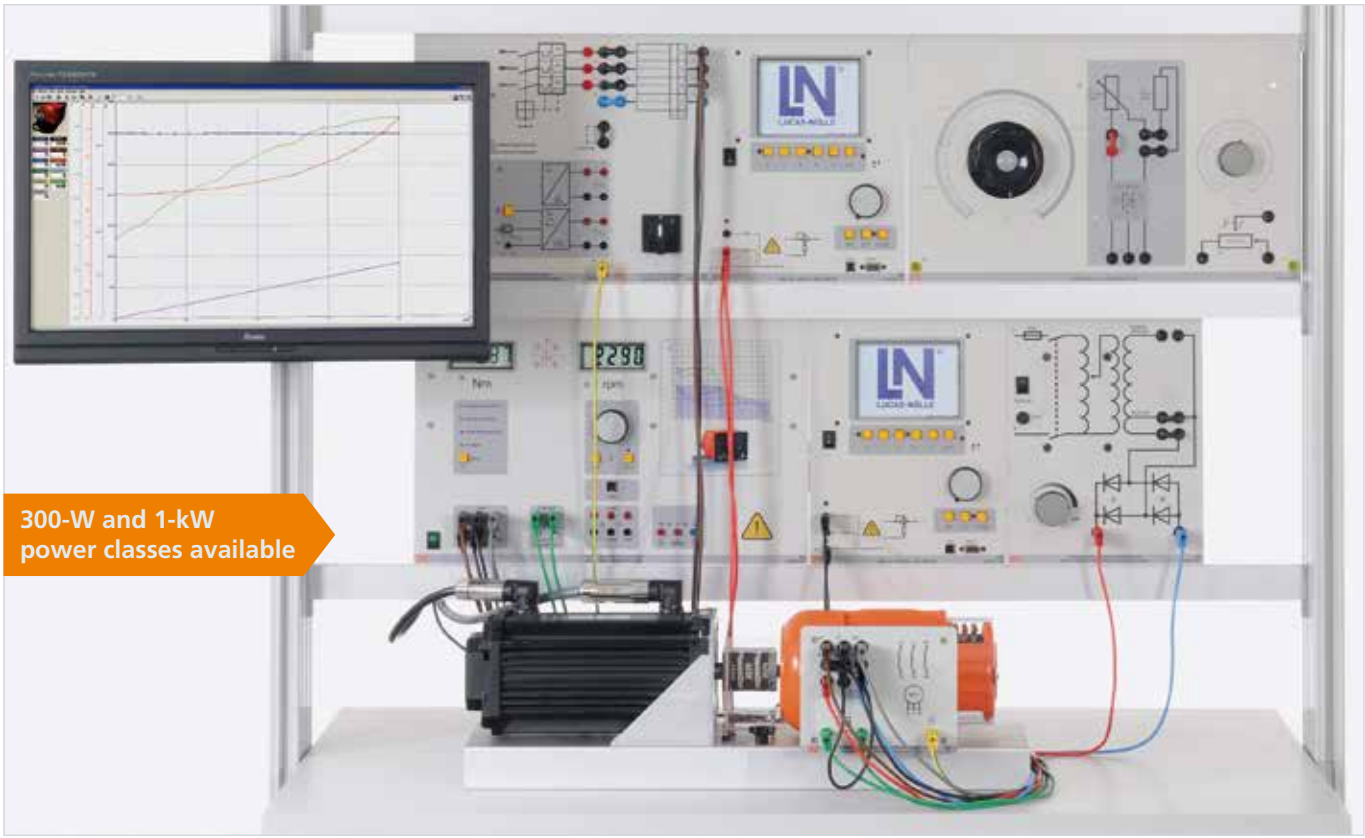
Training content

- Setting the motor protection relay in accordance with the motor's rating plate
- Protection, safety and disconnection functions
- Project planning, construction and putting complex controls into operation
- Operational testing and trouble-shooting
- Compact programmable control
- Star-delta circuits
- Reversing contactor control with safety interlocking
- Connection of three-phase motors
- Drafting circuit diagrams

Synchronous / Reluctance Machines

Synchronous Motors and Generators

Synchronous machines are primarily used as generators in power supply networks. Power levels in this area can reach up to around 2,000 MVA. Other additional areas of application are large-scale drives for cement mills and conveyor belt systems with power levels in the megawatt range. Highly dynamic servos with permanently excited rotors complete the spectrum of synchronous machines. In contrast to asynchronous machines, here the rotor operates in sync with the rotating magnetic field.



Experiment example: "Synchronous machines EEM 5.1"

Training content

Motor operation:

- Motor connection
- Starting
- Phase-shift operation
- Load characteristics in motor operation
- V characteristics
- Stability limits
- Under-excitation and over-excitation

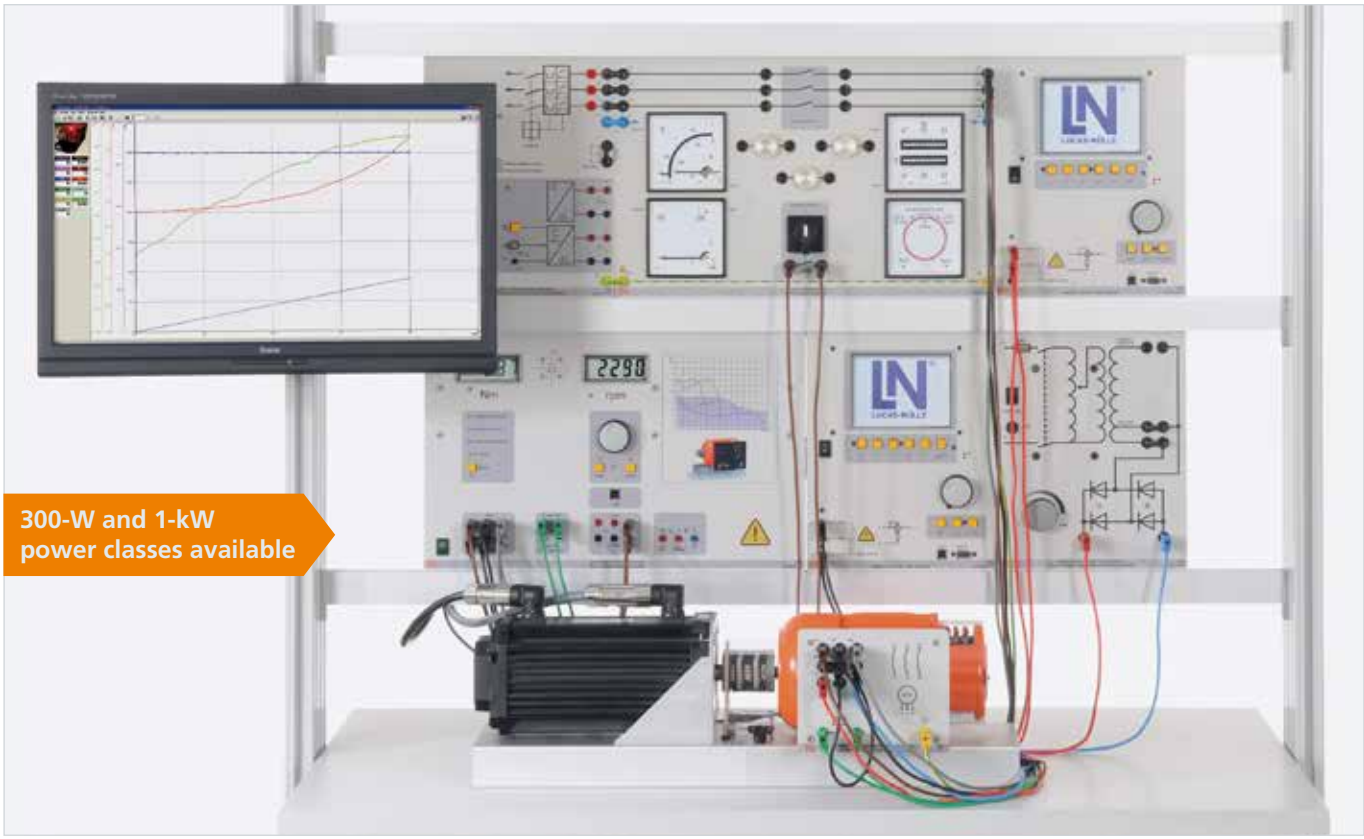
Generator operation:

- Generator connection
- Voltage adjustment via the exciter current
- Load characteristics in generator operation

Synchronous/Reluctance Machines

Mains Synchronisation

In the case of mains synchronisation, the unloaded generator is switched to the mains. Voltage, frequency and phase angle have to coincide with the corresponding variables on the mains. Different measuring instruments are used to measure these variables. The variables are set by means of the generator speed and excitation.



Experiment example: "Mains synchronisation EEM 5.2"

Training content

- Manual mains synchronisation with the aid of synchronising bright-method, dark-method and three-lamp synchronisation circuits
- Mains synchronisation using two-range frequency, two-range voltmeter, synchronoscope and zero-voltage meter
- Influence of the generator speed
- Influence of generator excitation
- Adjusting power flow by means of the drive

Three-Phase Reluctance Machine

Reluctance motors constitute a cross between asynchronous and synchronous motors. Due to the special design of the rotor with salient pole construction, the motor is able to operate like an asynchronous motor. Starting at a certain speed, it then locks into synchronous speed with the stator field. Reluctance machines are used, for example, in the textile industry for synchronous despooling of yarn. This involves several motors operating under the control of a frequency converter.

Experiment example: "Three-phase reluctance machine EEM 5.3"

Training content

- Connecting, wiring and putting into operation
- Reversing the rotation direction
- Recording the speed and torque characteristics

Three-Phase Machines

Dismountable Three-Phase Machine Set

This training system consists of a standard stator for all machine types and a set of interchangeable rotors. Thanks to its dismountable design, the set is particularly suitable for teaching the basics since it delves into the various machine construction designs and their differences. Unlike conventional cut-out models, these machines are fully operational and can be coupled to the machine test system.

Equipment example: "Dismountable three-phase machine set EEM 10"

Training content

Design and construction differences of three-phase machines as well as connection, putting into operation and recording characteristics of:

- Short-circuit rotors
- Synchronous machines
- Slip-ring rotors
- Reluctance machines

Transformer Trainer

Single-Phase and Three-Phase Transformers

Transformers are made to convert currents and voltages. These so-called passive electrical machines are designed to adapt designated equipment to the different voltage levels made available by the power industry. The power levels range beyond 1,000 MVA. Small transformers can be found everywhere in industry and in the consumer goods sector. The power classes can range from the smallest version up to the large-scale transformers that supply entire production plants.

Experiment example: "Transformer trainer ENT 5"

Training content

- Isolation and autotransformers
- Equivalent circuit diagrams
- Transformation ratios
- No-load and short-circuit experiments
- Vector groups in three-phase transformers
- Design and operation of transformers
- Single-phase transformer
- Three-phase transformer

Lenze
Lenze
Lenze
Diagnostic
Device Command
Command Status
Diagnostic
Diagnostic
Device Command
Command Status
Diagnostic

Power Electronics and Didactically Designed Drives

58 Loss-Free Control of Electrical Machines

60 Line-Commutated Power Converters (UniTrain)

61 Self-Commutated Power Converters (UniTrain)

62 Frequency Converter Drives (UniTrain)

63 Active Power Factor Correction PFC (UniTrain)

64 Line-Commutated Converter Circuits

65 Converter Drives with DC Motors

66 Self-Commutated Converter Circuits

67 Frequency Converter Drives

68 Servo Drives

69 Converter Drives with DC Motor

Power Electronics and Didactically Designed Drives

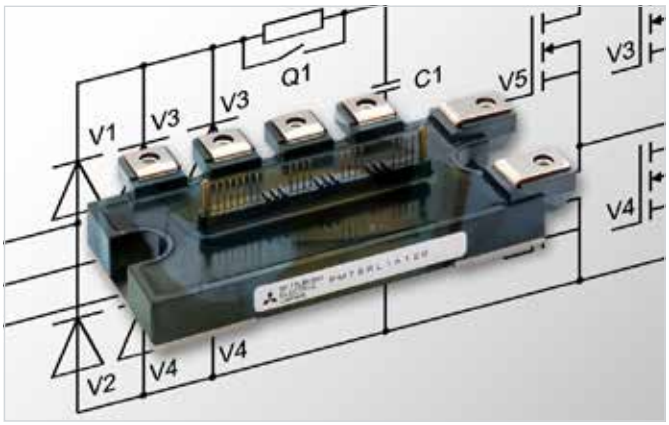
Loss-Free Control of Electrical Machines

Power electronics is the technology of switching and converting electrical power to greater power levels. Nowadays we use power semiconductors like diodes, thyristors and IGBTs to perform these operations. The main application area for power electronics is drive technology.
The training systems in this area are designed to explore technical relationships beginning with static converter technology and even include automatically controlled drives. The software is well-conceived and provides the consistent support crucial for both quick and clear experiment set-up and rapid learning success.

Power semiconductors

The rapid developments being made in power semiconductors continue to forge ever-newer applications and improvements in electrical drives. Innovations include the following: shrinking power loss, work with higher frequencies and operation with "intelligent power modules".

These modules contain, in addition to power semiconductors, the control unit and safety circuitry needed to protect against impermissibly high currents and excess temperatures.



Source: Mitsubishi Electric B.V.

Automatic control of machines

Many manufacturing processes employ automatic speed-controlled drives or positioning drives. Besides the machine and its associated power electronics, it is the automatic control system which exerts a great deal of influence on the drive's response. It is the technician's job to make sure that control operation is suited to the manufacturing process.

Training systems

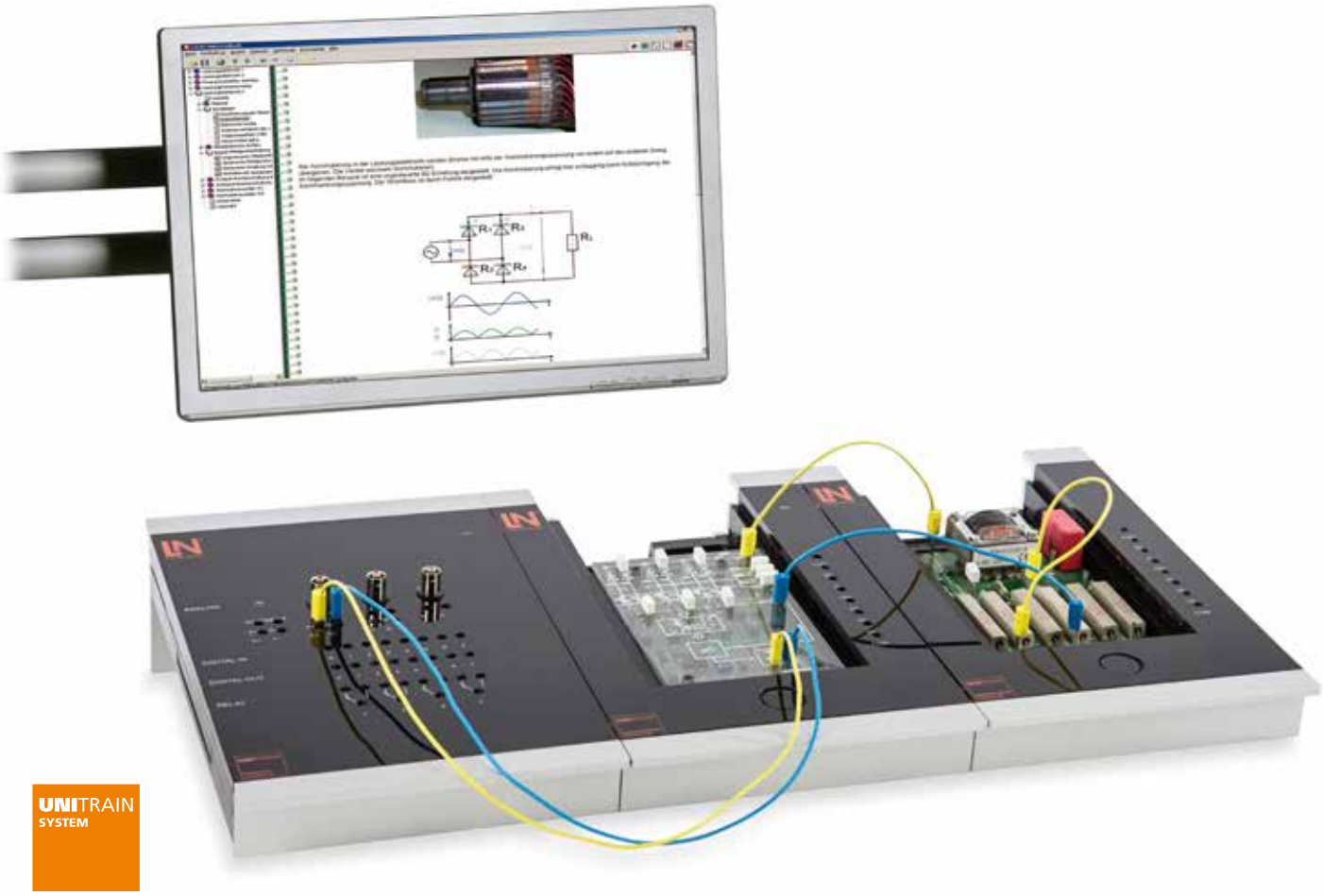
Our training systems cover the following topics:

- Line-commutated static converters
- Self-commutated static converters
- Automatically controlled DC drives
- Frequency converter drives

Line-Commutated Power Converters

Uncontrolled Rectifiers – Controlled Rectifiers – AC and Three-Phase AC Power Controllers

Power electronics is firmly anchored in modern life. Without it such things as dimmable halogen lighting, speed-variable drills or electric heating would be impossible. Power semiconductors such as diodes, thyristors and power transistors make all this possible.



UNITRAIN SYSTEM

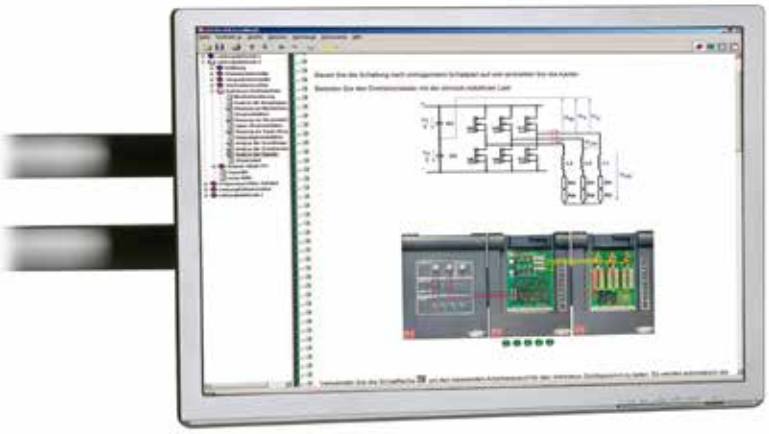
Training content

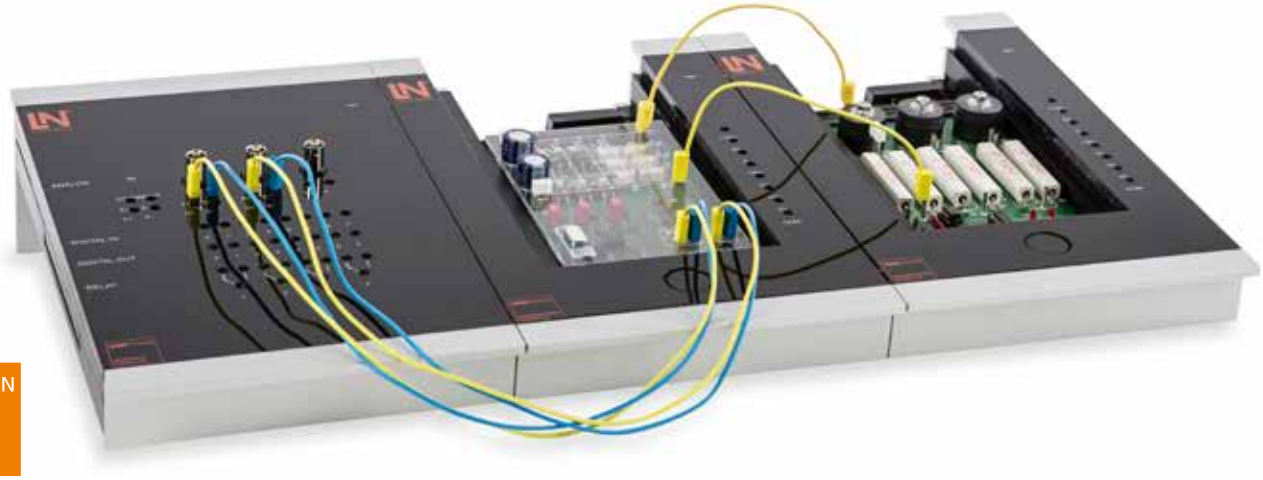
- Design and operation of single-phase and three-phase rectifiers
- Operating characteristics of uncontrolled, semi-controlled and fully controlled static converter circuits
- Power semiconductors and their control
- Power electronics measurement variables
- Measurement and analysis of static converter circuit power
- Analysis of current, voltage and power using fast Fourier transform analysis (FFT)

Self-Commutated Power Converters

PWM – Four-Quadrant Power Controller – Power Inverter

The number of speed-variable drives to be found in modern machines is constantly increasing. The reasons for this are the growing expectations and the advent of modern competitively priced power inverters. Today these power inverters work with PWM technology.





UNITRAIN SYSTEM

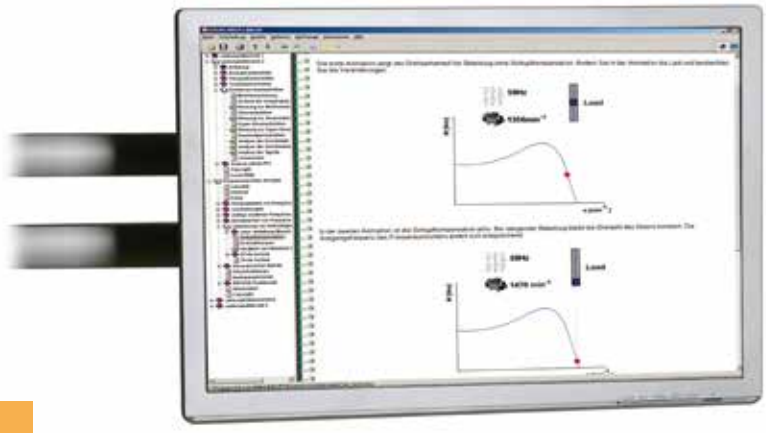
Training content

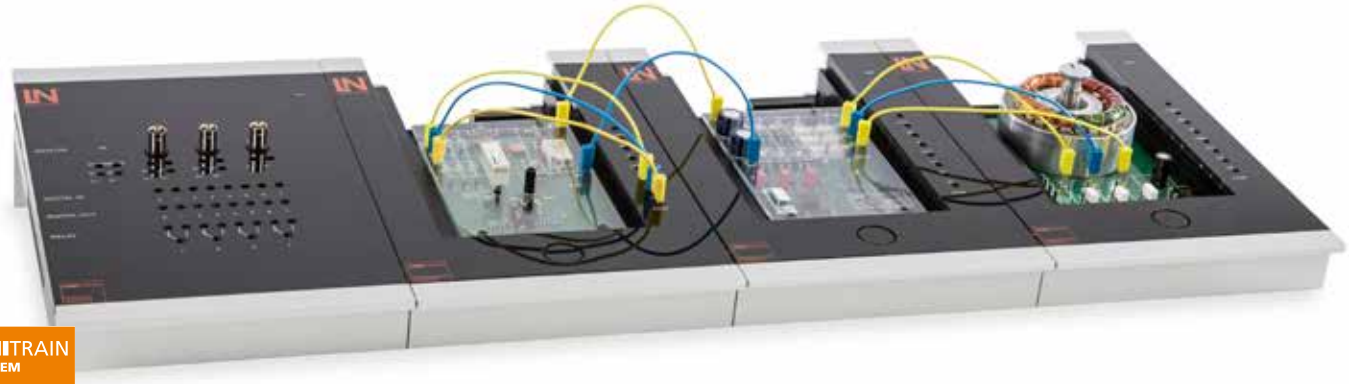
- PWM for generating variable DC and AC voltages
- Recording control and operating characteristics
- Design and operation of three-phase AC inverters
- Block commutation, sinusoidal, super-sine and space vector modulation for the generation of voltage- and frequency-variable voltages
- Instrumentation-based analysis of various modulation methods based on signal characteristic measurements and fast Fourier transform analysis (FFT)

Frequency Converter Drives

Feed-in – DC link – Power Inverter – Speed Adjustment

Frequency converters are responsible for making the low-loss, continuous speed adjustment of three-phase asynchronous motors possible. In addition to pure motor control and motor protection functions, modern frequency converters today are also assuming some process automation tasks.





UNITRAIN SYSTEM

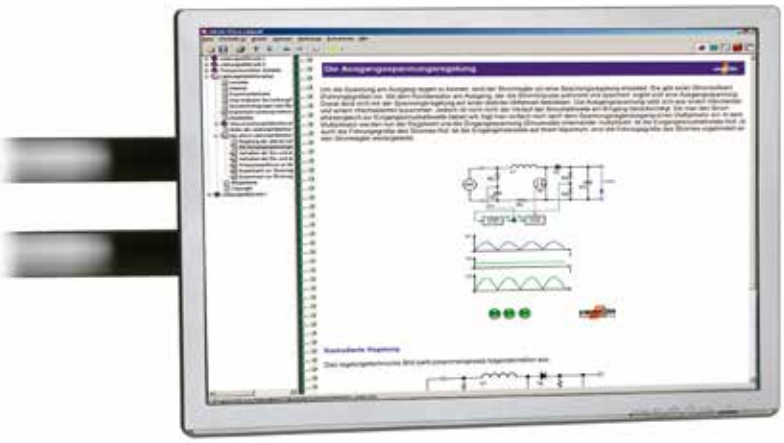
Training content

- Design of modern frequency converters
- Generation of DC link voltages
- Recording U/f-characteristics
- Design and operation of brake choppers
- Optimisation of speed-controlled drives
- Learning about "87-Hz technology"
- Recording and analysing currents, voltages and power levels

Active Power Factor Correction PFC

Active PFC Control – Harmonic Analysis

Today, every mains power supply built into a computer is equipped with PFC (PFC – Power Factor Correction). The reason for this popularity is a European-wide norm that stipulates that, as of a particular power level, loads have to draw their current from the mains in a linear relationship to their voltage characteristic.



UNITRAIN SYSTEM

Training content

- Active and passive power factor correction
- Design and operation of an active power factor correction circuit
- Application areas for power factor correction
- Comparison to conventional bridge rectifier circuits
- Recording and analysing currents, voltage and power levels (also using FFT)

Line-Commutated Converter Circuits

Diodes – Thyristors – Triacs

Line-commutated static converters permit power to be fed from an AC or three-phase mains into a DC circuit. They can be designed for operation in controlled mode using thyristors and triacs or non-controlled mode with diodes.

Experiment example: "Line commutated converter circuits EPE 30"

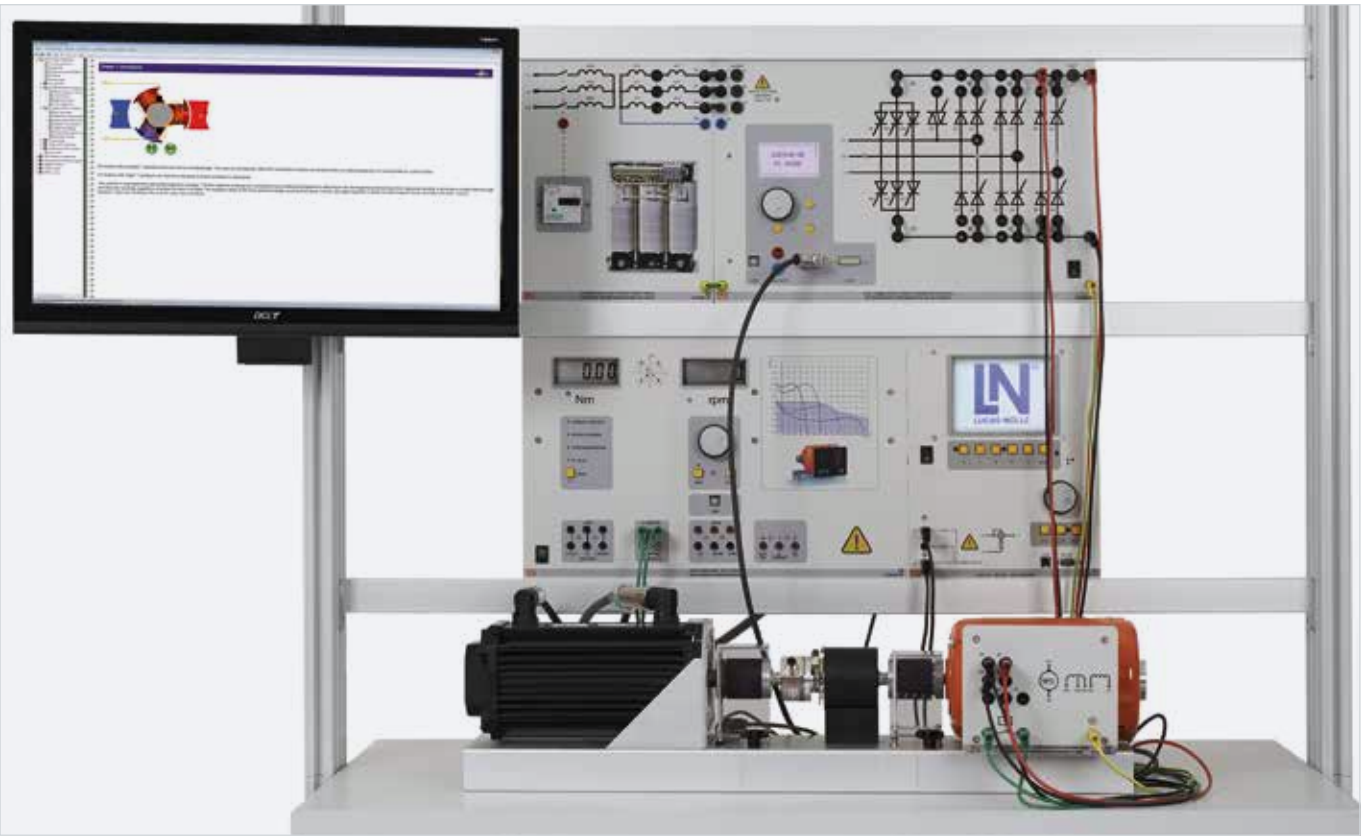
Training content

- Fundamentals of the diode, thyristor, triac
- Rectification
- Control principles: phase-control, full-wave control, burst firing control, pulse pattern control, rectifier operation, inverter operation
- Circuits:
  M1, M2, M3, B2, B6, M1C, M2C, M3C, B2C, B6C, B2HA, B2HK, B2HZ, B6C, B6HA, B6HK, W1C, W3C
- Resistive, capacitive and inductive loads
- Control characteristics and operating graphs
- Suppressor circuit
- Computer-assisted data acquisition
- Frequency analysis and examination of harmonics

Converter Drives with DC Motors

Motors – Power Electronics – Automatic Control

Automatically controlled DC drives excel due to their excellent speed and torque controllability and highly dynamic response. When it comes to power semiconductors for large-scale, high-powered drives, engineers turn to line-commutated converters with thyristors. These components stand out on account of their overload capacity and tendency to low power loss.



Training system: "Converter drives with DC motors and servo machine test stand"

Training content

- Closed-loop speed control in 1- to 4-quadrant operation with and without cascade current control
- Open-loop speed control with one-way converter
- Open-loop control with two-way converter
- Four-quadrant operation, energy feedback
- Closed-loop speed control, current control, cascade control, adaptive control
- Computer-assisted controlled-system and controller analysis, setting parameters
- P-, PI-control
- Optimisation of the controller

Self-Commutated Converter Circuits

IGBT – PWM Control – Inverter Control

The widespread proliferation of power electronic equipment requires electronics specialists and engineers alike to command in-depth knowledge enabling them as users to handle such devices competently and in a resource-saving manner or to put them in a position to systematically explore the subject in research and development.

For that reason power converters are a fundamental constituent in curricula for students studying electronics and electrical engineering. The "Self-commutated converter circuits" training system comprises sophisticated experiments to convey the basics in hands-on exercises and project-oriented work. Circuitry, modulation and rotary-field generation are the key topics rendered easily comprehensible thanks to theoretical sections and, especially, graphic animations, thus rapidly leading to the next level of competence.

Training system: "Self-commutated power converter with a passive R-L load"

Training objectives

- Pulse-width modulation
- DC chopper in single- and 4-quadrant operation
- AC power switch
- Three-phase converter with block/sine commutation and space-vector modulation
- Resistive and inductive loads
- Suppressor circuits, link circuits, free-wheeling
- Control characteristics and operating graphs
- Interpolation, clock frequency, ripple
- Frequency analysis and examination of harmonics

Frequency Converter Drives

Mains Rectifier – DC Link – Inverter – Motor

A modern frequency converter can transform any standard three-phase motor into a variable-speed drive. The standard three-phase motor's robustness and widespread use have significantly contributed to the tremendous success of electronic drive technology incorporating frequency converters. Today, frequency converters are found in numerous applications in the textile industry and in packaging machinery, lifting equipment and even washing machines. The interplay between power electronics and motor operation can be studied and learned with the "Frequency converter drives" training system.

Training system: "Frequency converter drive with servo machine test stand"

Training objectives

- Differentiating between various converter types
- Design of modern frequency converters
- Link circuits
- Brake choppers
- Control methods (U/f-characteristic, U/f2-characteristic, vector control)
- Speed adjustment and ramps
- Optimization methods
- Analysis of voltage and frequency relationships

Servo Drives

Encoder – Commutation – Control

Servo drives are variable-speed units designed to meet high dynamic response and overload demands. They are often used in automation solutions involving significant changes in speed and torque, such as in machine tools or robot systems. The training system for servo drives clearly demonstrates the functionality of a variable-speed servo system with a permanent magnet.

Training system: "Servo drives with a servo machine test stand"

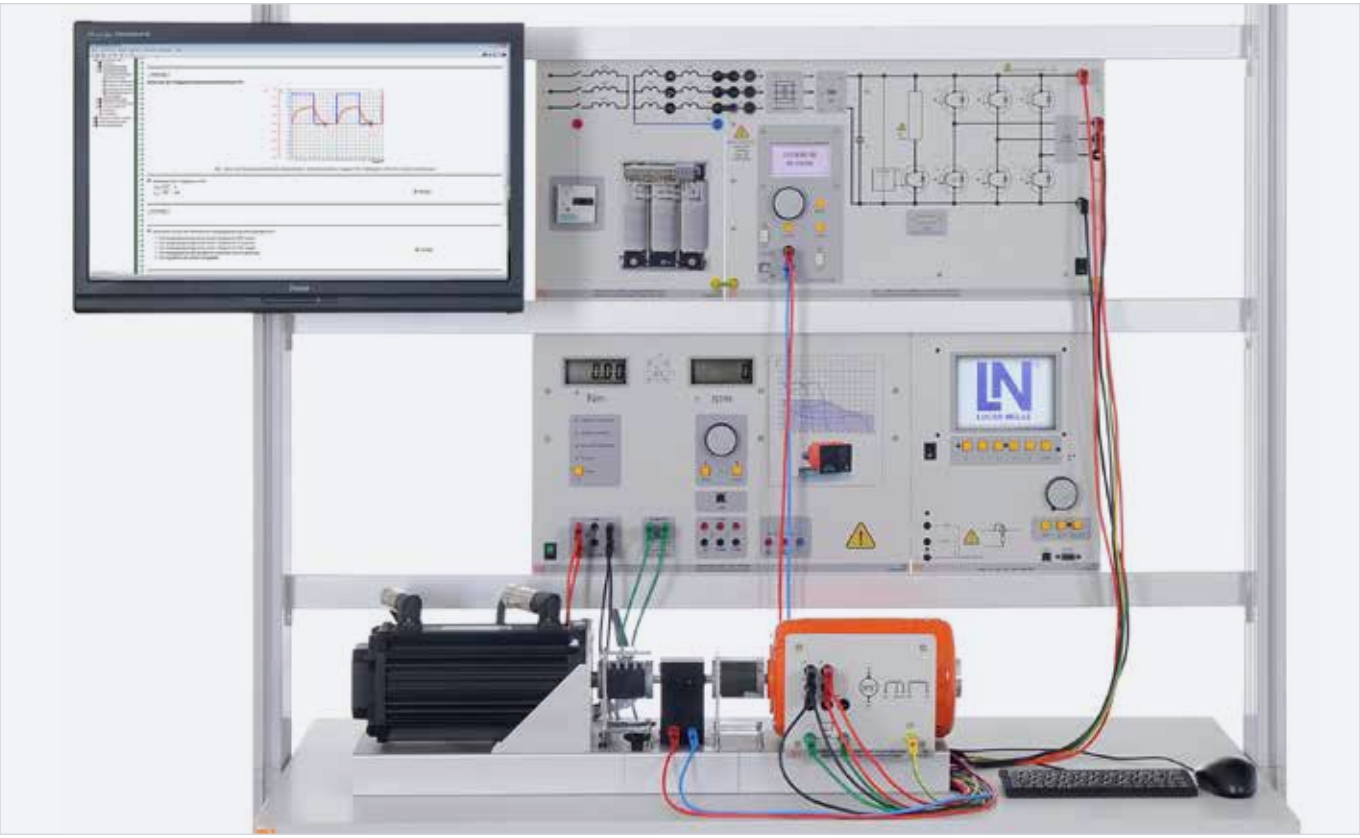
Training objectives

- Design of a servo drive
- Investigation of coordinate and encoder systems
- Operating principle of a servo motor with electronic commutation
- Analysis of modulation
- Design of control loop structures
- Analyses of variable-speed drives

Converter Drives with DC Motor

DC Motor – Power Electronics – Speed Control

Thanks to their simple control structure, converter drives with a DC motor are particularly suitable for an introduction to the subject of variable-speed drives. A separate consideration of closed-loop current and speed control enables the student to put the controller parameters into initial operation and then to optimise them step-by-step. The training system, in effect, provides a vivid and graphic demonstration of how a variable-speed drive system operates.



Training system: "Converter drives with a DC motor and servo machine test stand"

Training objectives

- Open-loop speed control in single-quadrant operation
- Open-loop speed control in 4-quadrant operation
- Closed-loop speed control in general
- Closed-loop current control
- Cascade control
- Computer-aided analyses of controlled systems and their controllers
- P-, PI-controller parameterization
- Controller optimization

VL
DYNOLUTION
+CS
+PDU

Model-Based Development of Drives with Matlab®/Simulink®

72 Model-Based Development of Drives with Matlab®/Simulink®

74 Field-Oriented Control of Asynchronous Motors with Matlab®/Simulink®

76 Variable-Speed Permanent-Magnet Servo Drives with Matlab®/Simulink®

78 DC Drives with Cascade Control Using Matlab®/Simulink®

Model-Based Development of Drives with Matlab®/Simulink®

Expand the Training System to a Programmable, Rapid Prototyping System for Drive Technology

Nearly all electrical drives such as those used in industrial plants and electric vehicles incorporate three-phase technology. The automatic control of such drives, for instance, to ensure smooth start-up or measured acceleration, entails mathematically complex and elaborate programming. Implementation is therefore often characterized by very long development times.

A newly created toolbox will in future make it possible to simulate complex controller structures for three-phase drives with Matlab®/Simulink® in advance, and subsequently test them on a real converter with a motor and load by means of automatically generated code.

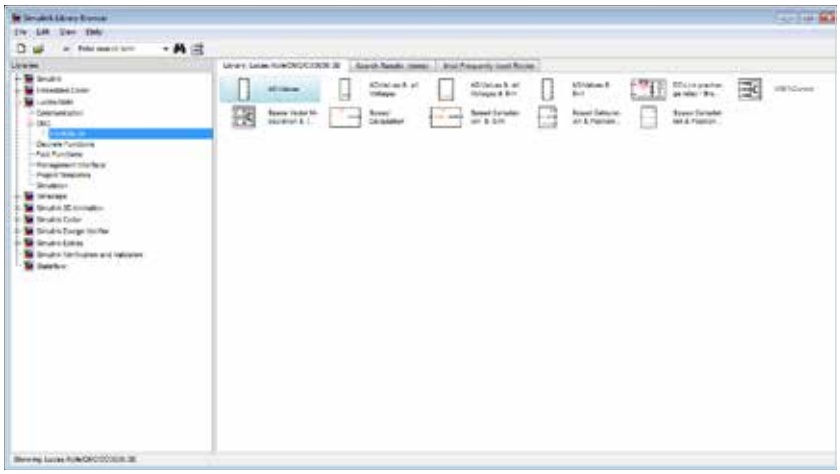
Training system: "Field-oriented control of asynchronous motors with Matlab®/Simulink®"

Your benefits

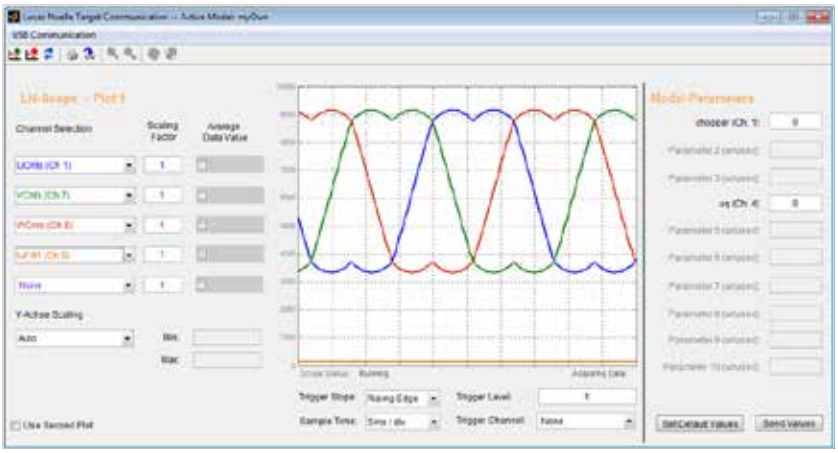
- Safe handling thanks to intrinsically safe hardware (all protective functions are implemented independently of software)
- Promotion of a deeper understanding of a complex subject, e.g. in education and training, or through use of the toolbox in laboratory programs accompanying theory
- Very rapid, model-based, parameterizable software generation for own controllers in conjunction with industrial applications
- Pursuit of new methods of research on rotary-field drives, e.g. control using state-space methods, condition monitoring for errors, sensorless automatic speed control using new observational techniques
- Impressive design possibilities for closed-loop control of three-phase drives
- Creation of complex algorithms using fast control cycles of 125 µs
- P-, PI-controller parameterization
- Controller optimization

Quicker results with the Matlab® toolbox

A toolbox adapted to the power electronics hardware enables rapid implementation of one's own applications. Special templates allow simple introduction by configuring the system so that only a few adjustments still need to be made by the user. The toolbox provides users with all the necessary modules for controlling hardware-related functions, as well as blocks for fast transformations and controllers. The system can be extended at will by adding one's own library elements to those of the Matlab®/ Simulink®.



Special toolbox for the training system



Graphic user interface in the Matlab® environment

Hardware connection via Matlab® Scope

A special graphic dialog serves to establish the connection between Matlab® and hardware via a USB interface. The time characteristics of all internal variables can be visualized during runtime. A number of different time resolutions and trigger options are available here. The signals can be displayed in the time domain as well as the frequency domain. The display can be divided into two units, making it possible to visualize up to ten signals simultaneously. Parameters such as those related to the controller can be uploaded conveniently from the PC to the hardware during runtime.

Field-Oriented Control of Asynchronous Motors with Matlab®/Simulink®

Training System

Three-phase drives are used in almost all electrical drives today. The automatic control of such drives is a mathematically complex and costly undertaking. With the help of a special toolbox for Matlab®/Simulink®, the training system makes it possible to simulate complex control algorithms, and subsequently test them by means of automatically generated code on authentic, intrinsically safe hardware incorporating a motor and load.

Training system: "Field-oriented control of asynchronous motors with Matlab®/Simulink® and a servo machine test stand"

Training objectives

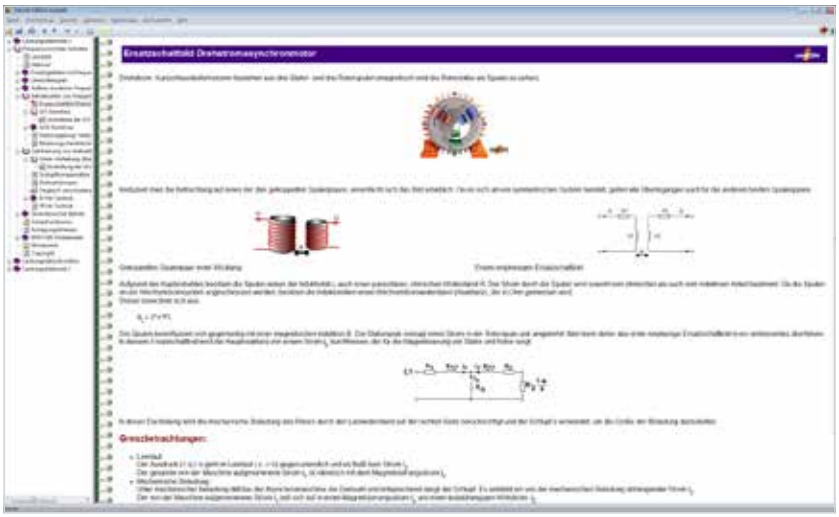
- Creation of an HIL system (hardware in the loop) under real-time conditions
- Modeling and design of field-oriented control on a continuous design level
- Discretization of control for operation on a DSP (digital signal processor)
- Creation and optimization of current and speed controllers
- Park and Clarke transformation
- Integration of space-vector modulation for optimal control of IGBTs
- Decoupling of field-oriented currents and voltages
- Speed detection via an incremental encoder
- Comparison of simulation results with real measurements

Interactive Learning Environment

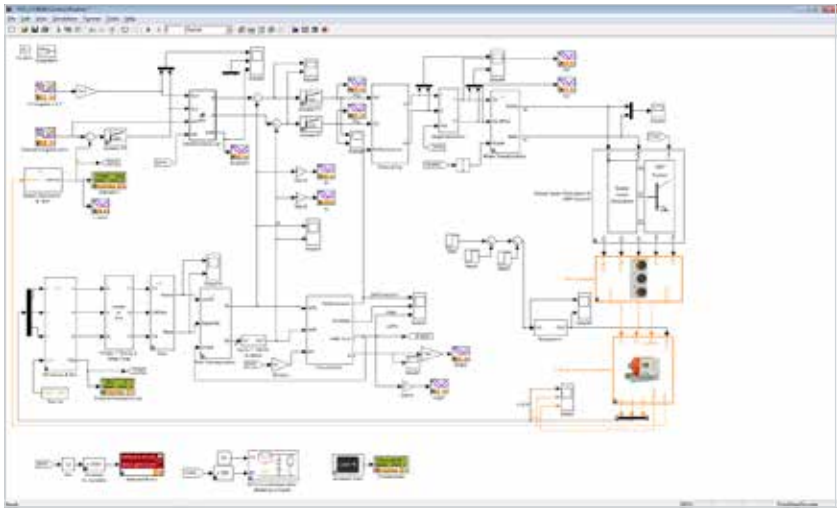
How does field-oriented control work?

Drives with field-oriented control are today found in many machines. The high dynamics and ample torque reserves characterize these drive systems.

This ILA course guides you step by step through the topic of field-oriented control. In addition to the creation of the process control models, the course also covers the testing and optimization of the control loop.



ILA course: "Field-oriented control of asynchronous motors"



Field-oriented control of a three-phase motor

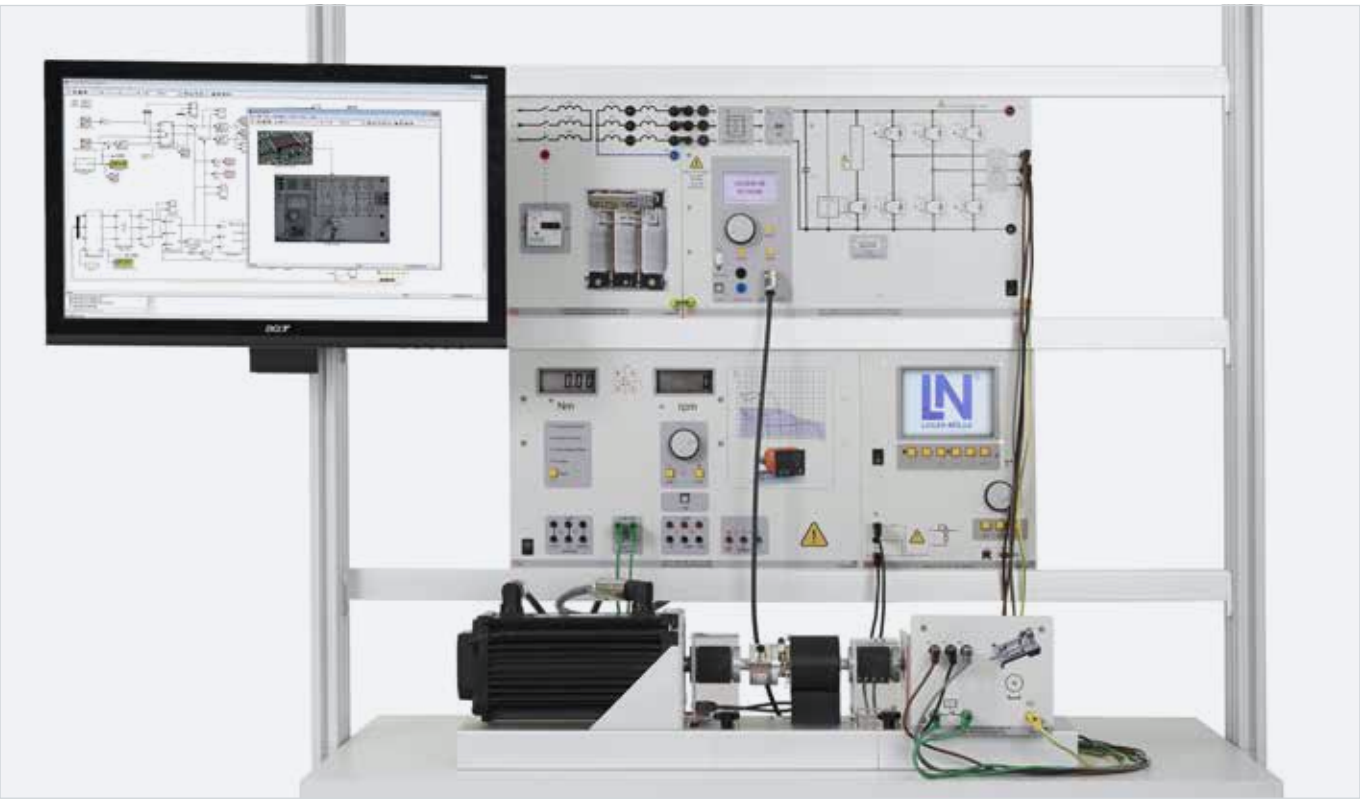
Simulation or real control?
Decide for yourself.

A single Simulink® model forms the foundation for simulation or functions as the program for the actual hardware. It is only after completion that the user chooses between simulation or application in the real system. Accordingly, it is possible during simulation to test and optimize the control loop and then use the model to put the actual hardware into operation. This procedure guarantees rapid learning success. At the same time the distinction between simulation and real systems is clearly recognised.

Variable-Speed Permanent-Magnet Servo Drives with Matlab®/Simulink®

Training System

Synchronous servo motors are now used in many modern drives. In addition to dynamic response, energy efficiency is also playing a major role. The training system permits in-depth investigations of existing control loop concepts thanks to the open programming feature Matlab®/Simulink® and permits new approaches to be safely tested. For instance, the system can be used to create drives typically employed in industry and the automotive sector.



Training system: "Variable-speed permanent-magnet servo drives with Matlab®/Simulink® and the servo machine test stand"

Training objectives

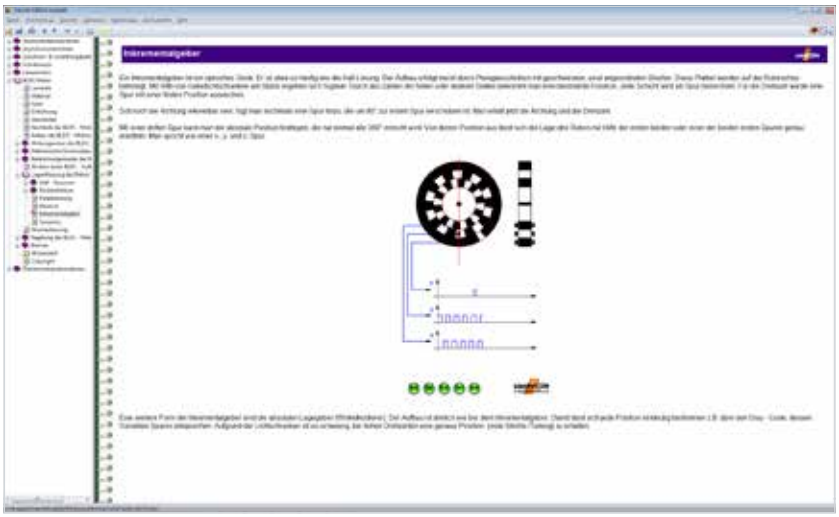
- Creation of a HIL system under real-time conditions
- Modelling and design of an automatic servo control on a continuous design level
- Discretization of a closed-loop control for operation on a DSP
- Creation and optimization of current and speed controllers
- Park and Clarke transformation
- Integration of space-vector modulation for optimal control of IGBTs
- Decoupling of field-oriented currents and voltages
- Speed and position detection via an incremental encoder
- Comparison of simulation results with real measurements

Interactive Learning Environment

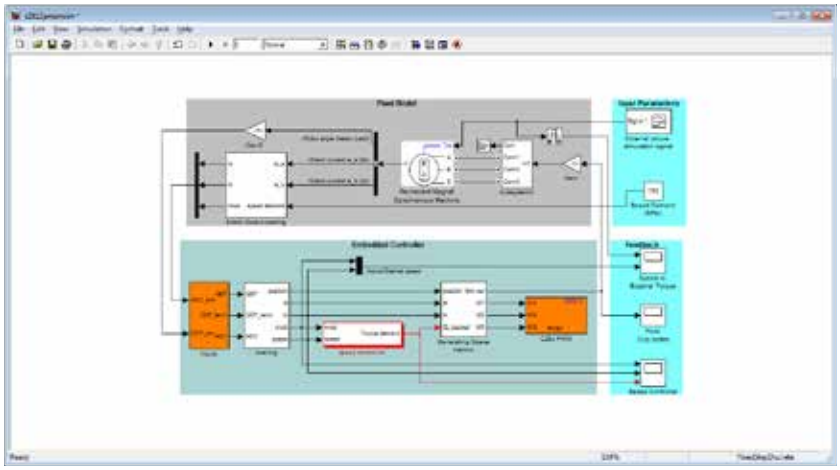
How does a drive with a synchronous servo motor operate?

Permanently-excited synchronous motors do not work without corresponding control electronics. Create a synchronous servo drive and work your way through this topic, starting with open-loop control all the way to closed-loop control.

The ILA course guides you step by step, the open system making it easy to implement progressive concepts so that the drive can be expanded according to your own ideas.



Function of the feedback system in the ILA course



Model-based design of a serv drive system

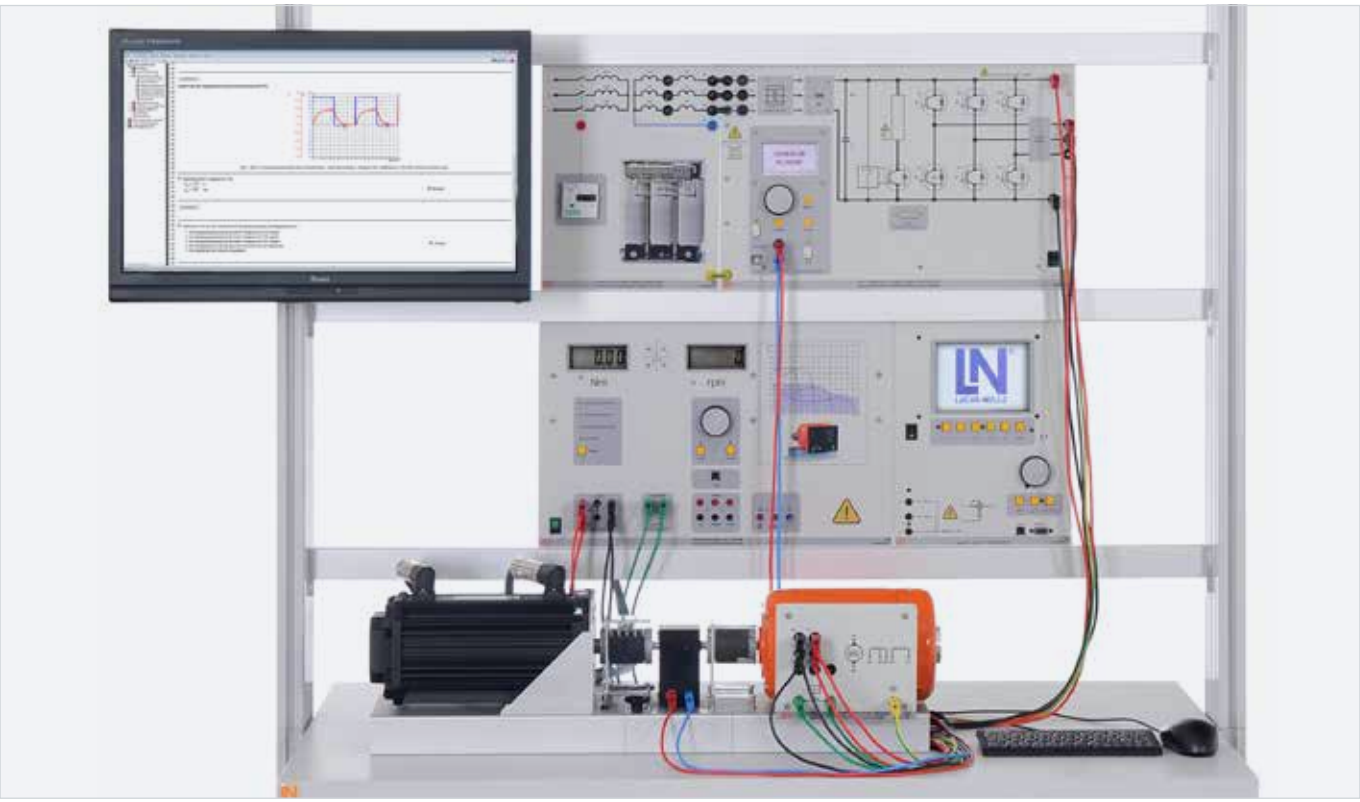
What is my drive's dynamic response?

Use the servo machine test stand to examine the drive. Different load emulations such as use of a variable flywheel make it possible to investigate the drive's control response under real-life conditions. Optimize controller parameters and make independent decisions on the performance of your drive.

DC Drives with Cascade Control using Matlab®/Simulink®

Training System

Thanks to their clearly arranged control structure, power converters with DC motors are particularly suitable for programming one's own initial, own control algorithms. This training system permits implementation, optimization and operation of the student's own control configurations. Not only conventional approaches, but also new ideas and extensions can be tried out safely in the open system.



Training system: "DC drives with cascaded control using Matlab®/Simulink® and a servo machine test stand"

Training objectives

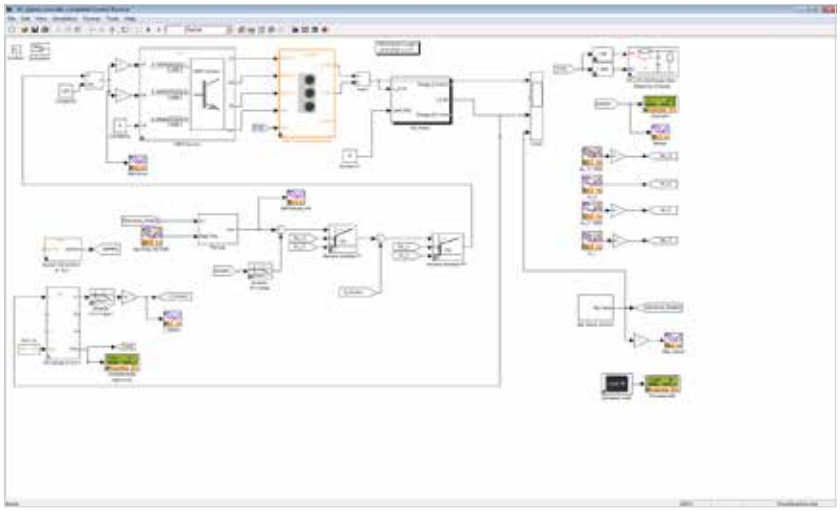
- Creation of a HIL system under real-time conditions
- Modelling and design of cascade control loop for DC motors at the continuous design level
- Discretization of the control loop for operation on a DSP
- Creation and optimization of current and speed controllers
- Speed detection via an incremental encoder
- Comparison of simulation results with real measurements

Interactive Learning Environment

How does a variable-speed DC drive work?

This ILA course provides practical examples to demonstrate the design, configuration and commissioning of DC drives. Current and speed controllers are implemented and optimized step by step. Direct application in control engineering models and work with real systems ensure successful learning on a lasting basis.

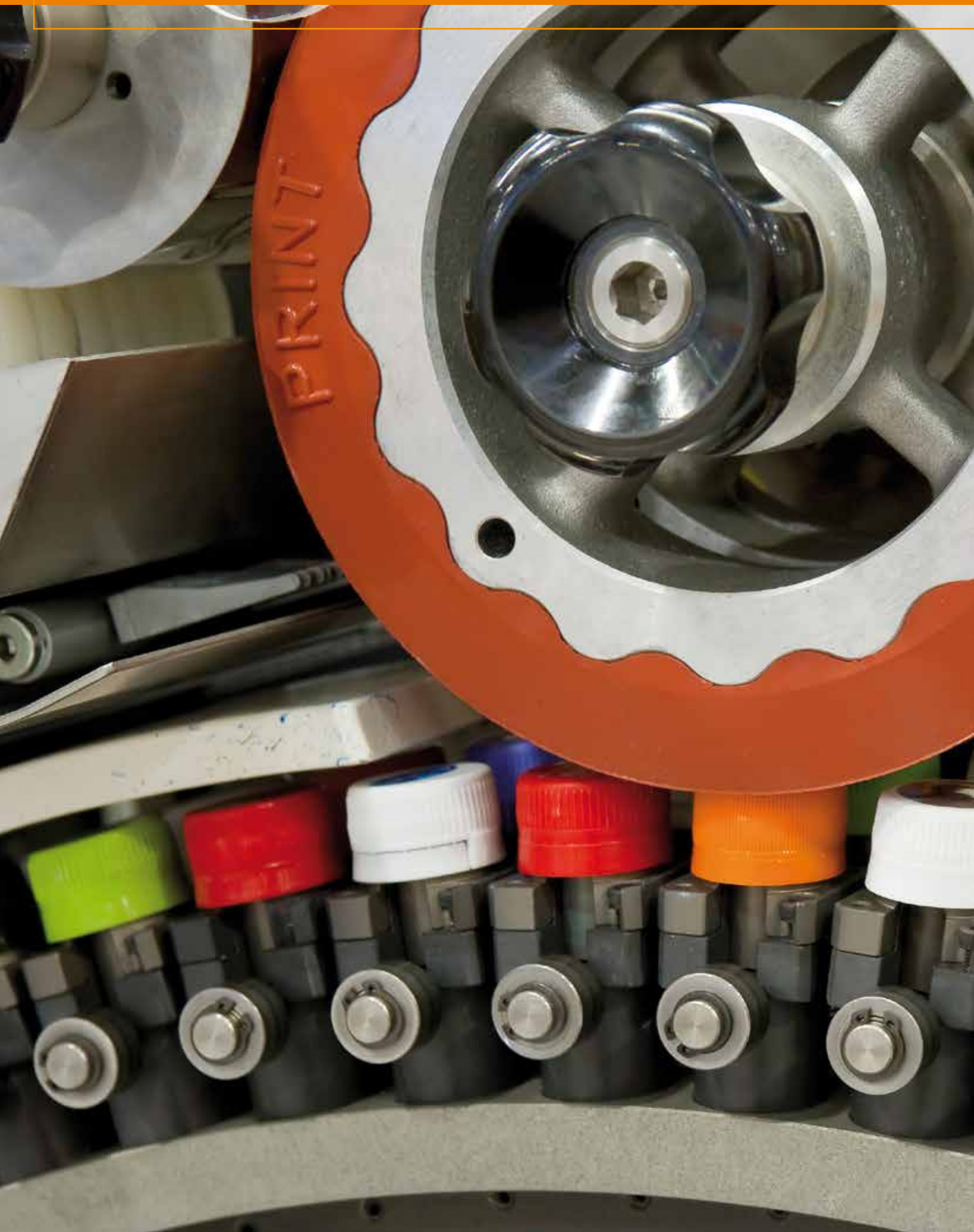
Fundamentals of DC motors in the ILA course



Optimization of controller settings

How are controllers designed?

The training system can be used to test controller design as part of simulations as well as real environments. A graphic user interface optimizes access to the control variables' dynamic signals and thus permits rapid adjustments to settings as well as their testing.


PRINT

Industrial Drives

82 Parameterization of Industrial Components

84 Smooth Starting Three-Phase Machines

85 Frequency Converter Drives

86 Project Work: Industrial Wiring of Frequency-Converter Drives

87 PLC Controlled Drive Systems

88 Positioning with Synchronous Servo Drives

89 Motor Management Relays

Industrial Drives

Parameterization of Industrial Components

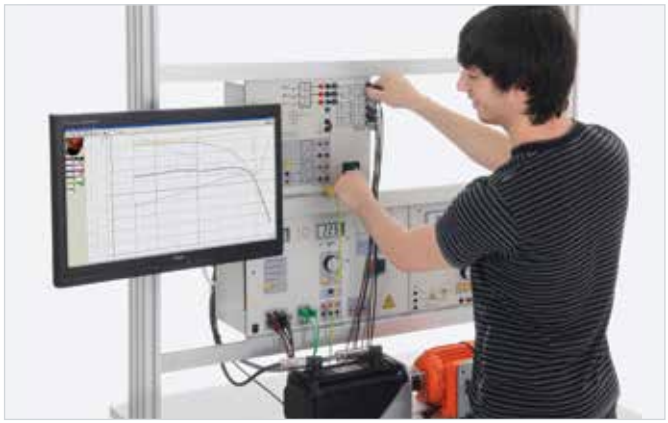
Today, the idea of a modern industrial world without controllable electrical drives is totally unthinkable. Their area of application ranges from high power performance to traction drives, machine tools and production machines up to and including applications in the automotive sector. As opposed to didactically designed drives, these training systems are equipped with industrial equipment. The training here focuses on how to handle and set the parameters of real industrial drive equipment.

Industrial components
The use of industrial components made by well-known manufacturers such as Lenze AG or Siemens puts us in a position to convey practical industrial know-how directly to the student. The designations of all of the terminals and connections correspond exactly to equipment used in industry. Standard industrial operating instructions and software are used in the projects and exercises.

Multi-disciplinary
Field-bus interfaces in connection with frequency converters, servo drives and motor management relays provide the basis for interdisciplinary applications together with automation technology. The drives can be controlled via PLC and operated using HMIs. This permits the visualisation of typical process control variables, disturbance variables and operating modules.

Training systems
Our training systems cover the following topics:

- Smooth starters
- Frequency converter drives
- Servo drives
- Motor management relays



Smooth starting Three-Phase Machines

Cutting High Switch-On Currents

Smooth starters use phase-angle control to reduce the motor's voltage during switch-on. The starting current drops proportionally to the terminal voltage. The power section of a smooth starter normally consists of two thyristors switched anti-parallel per phase. In order to be able to keep the power losses and the associated heat build-up as low as possible, the power semiconductors are shunted by a power circuit-breaker subsequent to the starting phase.

Experiment example: "Smooth starting three-phase machines EDT 17"

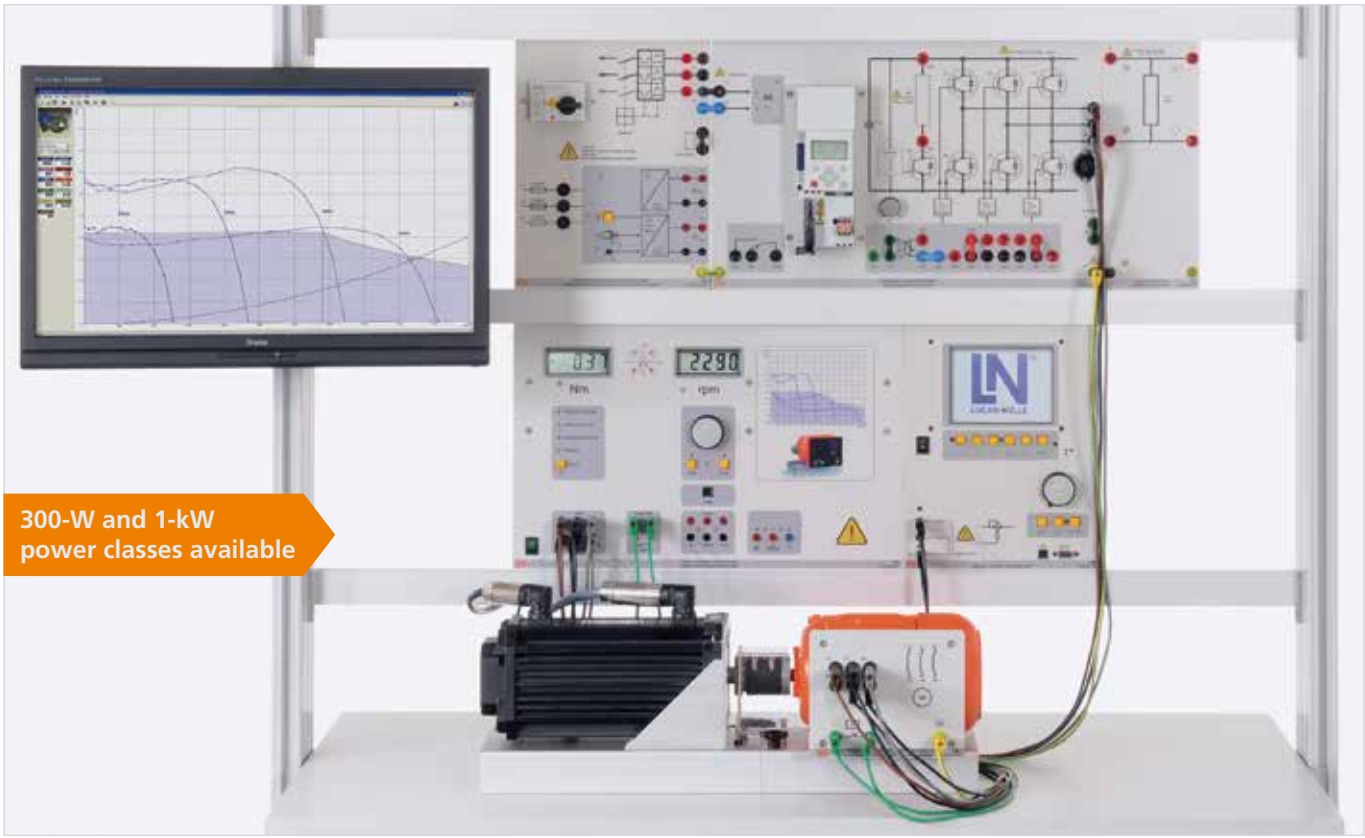
Training content

- Putting the circuit into operation
- Setting the parameters for run-up, run-down and starting voltage
- Examining the current and voltage levels during starting
- Starting under different load scenarios
- Comparing star and delta start-up

Frequency Converter Drives

The Variable Speed Drive

Modern frequency converters transform any given three-phase standard motor into a drive with variable speed. The robust nature and popularity of three-phase standard motors have made a significant contribution to the huge success that electronic drive technology with frequency converters enjoys. The higher demands placed on drives due to developments in process automation means that more and more motors are being controlled by frequency converters. Thanks to customised open-loop speed control, today pumps and air-conditioning units are able to save a substantial amount of energy.



300-W and 1-kW power classes available

Experiment example: "Frequency converter drives EDT 25"

Training content

- Computer-assisted set-up and operation
- Parameterization of setpoint variables, rotation direction, starting operation, operating frequency, limiting values, nominal voltage, nominal current, rated frequency, power factor etc.
- Investigating the operating response under working machine loads
- Recording the speed and torque characteristics across all four quadrants
- Drive optimization
- Operation with a brake chopper
- Operation with vector control

Project Work: Industrial Wiring of Frequency-Converter Drives

Design – Industrial Wiring – Putting into Operation

Using the training system titled "Frequency Converter Project Work", trainees learn hands-on how to set up and wire the industrial components found in a control cabinet. By using frequency converters with compact controls, the ideal combination between drive and process control technology is found. The result is a system that allows different industrial projects to be designed, set up, parameterized and tested. By integrating servo and machine test stands, it is possible to subject the final projects to testing under realistic conditions.

Experiment example: "Project work: industrial wiring of frequency-converter drives EPL 25"

Operating elements

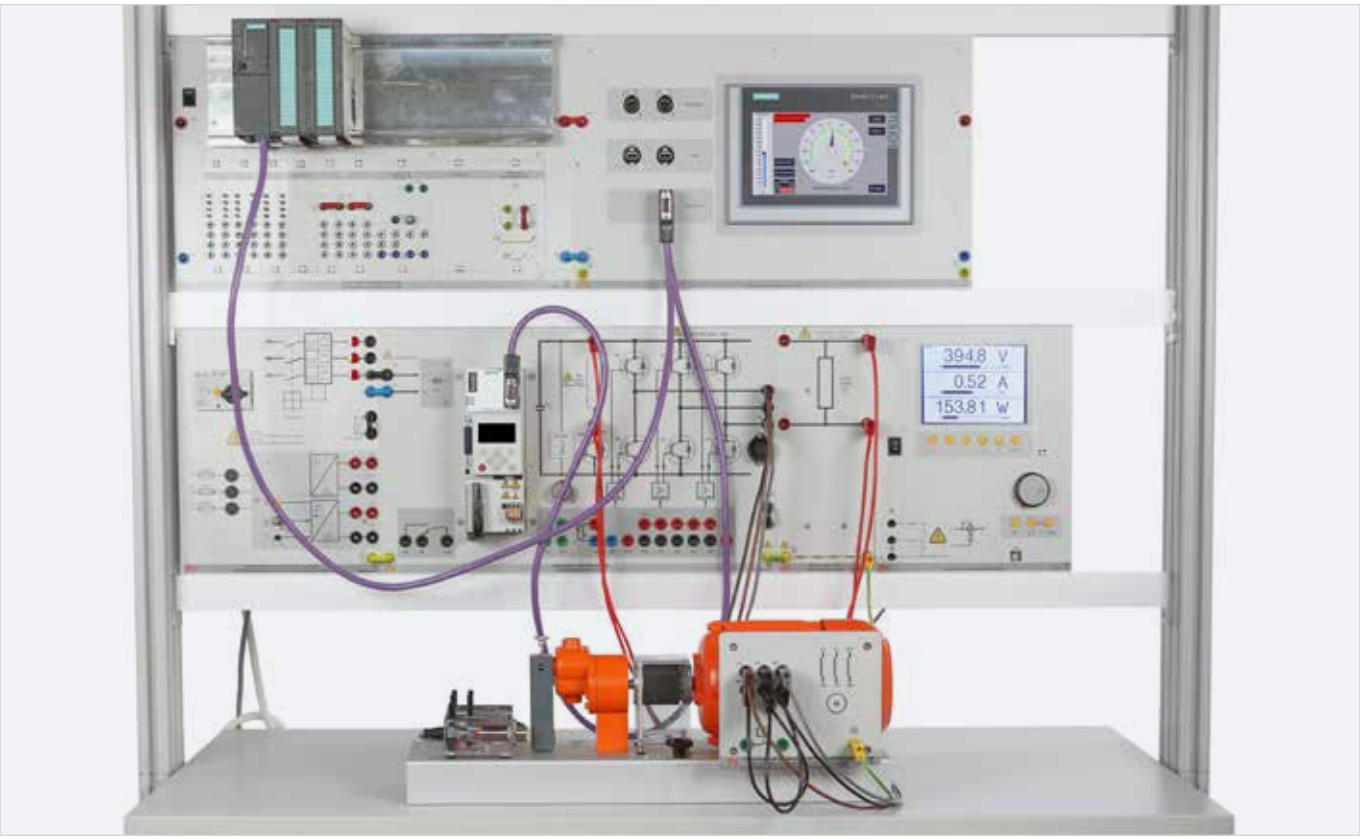
Training content

- Drafting, implementing and analysing circuit diagrams
- EMC-approved set-up and wiring of the control cabinet equipped with industrial components
- Putting the system into operation
- Approval and acceptance according to DIN EN
- Protective conductor measurement
- Insulation measurement
- Parameterization of the frequency converter
- Programming the LOGO!® compact control unit

PLC Controlled Drive Systems

Link between Drive and Automation Engineering

This training system features project planning and programming of the PLC unit and the operator panel. It also covers putting the frequency converter into operation and setting its parameters using PROFIBUS-DP. The training system uses a servo brake in order to put the frequency converter-controlled drive machine under load. Overall an array of controllable working machines like ventilators, winding drives, calanders, compressors or flywheels can be simulated in this system.



Experiment example: "PLC controlled drive systems CLP 20"

Training content

- Parameterization, programming and putting into operation of a programmable logic controller
- Project planning and putting into operation of an operator panel
- Parameterization and putting into operation of a frequency converter
- Project planning and putting into operation of a field-bus system
- Parameter optimization on different adjustable working machines

Positioning with Synchronous Servo Drives

Always the Right Position

When people talk about servo drives today, they generally mean highly dynamic three-phase drives. Servo drives primarily perform positioning tasks in tooling machines, manipulators or robots. But these devices are increasingly finding their way into printing machines, conveyor belts and cutting machinery where precise positioning or angular synchronism are required.
Here, servo converters, motors with sensor technology and mechanical transfer elements form an extremely integrated system whose components have to be seen as a single entity.

Experiment example: "Positioning with synchronous servo drives EDT 32"

Training content

- Computer-assisted set-up, putting into operation and parameterization of a servo drive with linear axis
- Positioning and sequential control
- Parameterization of position and speed controller using a simple industrial parameter-setting software
- Reference travel function
- Investigating the effects of different controller settings on different loads

Motor Management Relays

Effective Motor Protection – Preventive Maintenance

Motor management systems are put into action in modern automation systems and make it possible to provide drives and processing systems with the optimum protection, control and monitoring system. These systems permit the detection of, for example, the motor temperature, voltage or current. The transparency of the motor and its functions is enhanced thanks to the field-bus system (e.g. PROFIBUS) that connects it to the primary process automation system. Consequently, the motor's operating capacity and energy consumption can be determined without having to perform measurements on site.

Experiment example: "Motor management relays EDT 51"

Training content

- Computer-assisted set-up and putting into operation
- Programming such operations as direct start-up, star and delta starting, starting pole-switchable motors, motor protection
- Parameterization of the overload variables and switch-off response under different loads
- Measuring dynamic processes during start-up
- Preventive maintenance

Decisive Product Benefits

… provide Costumers with Long-Term Satisfaction

Mr Georg Greshake, Teacher at Heinz-Nixdorf-Berufskolleg (Vocational College) in Essen:

"As always, the Lucas-Nülle training systems for drive technology just thrill me", says Georg Greshake, a teacher at Heinz-Nixdorf-Berufskolleg in Essen, "I have been using the servo machine test stand for many years now in mechatronics studies and I'm always completely satisfied with how the equipment performs during instruction.

Only just recently we upgraded and refurbished our vocational college laboratories and workshops with training equipment from Lucas-Nülle. We were impressed by the systems' high quality, didactically sound design and practice-tested conceptualisation.

By implementing the entire program, I can systematically plan out the entire training program, including the deliberate and careful introduction of industrial applications. The modular design of the system is one proven and integral feature.

The UniTrain system is used by the students to explore the important fundamentals. After this, they move on to the training panel system. The servo and machine test stand provides for impressive and realistic simulation of the industrial standard for instructional purposes.

It provides a true-to-life simulation of a wide range of different load machines. Even motor run-up experiments can be performed independently by the students. This enables them to reach a very high level of learning in a very short time and makes experimenting on one's own easier.

Ultimately our students are able to take the experience they gain during instruction and transfer it wholesale into hands-on work performed in true-to-life conditions in the training centre."

The Whole is Greater than the Sum of its Parts

Individual consultation with Lucas-Nülle

Do you require comprehensive advice or a firm offer?

Please contact us using any of the following means:

Tel.: +49 2273 567-0

Fax: +49 2273 567-39

E-Mail: export@lucas-nuelle.com

Lucas-Nülle is a byword for custom occupational training courses in all of the following areas:

- Building management systems
- Fundamentals of electrical engineering & electronics
- Machinery and systems engineering
- Electrical power engineering
- Telecommunications
- Refrigeration and air-conditioning technology
- Renewable energies
- Process control
- Microcontrollers
- Power electronics, electrical machines, drive technology
- Electropneumatics, hydraulics
- Automation technology
- UniTrain
- Instrumentation
- Automotive
- Lab systems

Ask us for detailed information.

Our employees will be happy to advise you.

Further information on our products can be found at the following web addresses:

www.lucas-nuelle.com

LUCAS-NÜLLE GMBH

Siemensstraße 2
50170 Kerpen, Germany

Tel.: +49 2273 567-0
Fax: +49 2273 567-69

www.lucas-nuelle.com
export@lucas-nuelle.com

Ref.-No.: K-E3-1111-GB
Drive Technology

12/16-GB (Printed in Germany)
Subject to technical alterations.