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Power Electronics and Didactically Designed Drives

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Loss-free Control of Electrical Machines

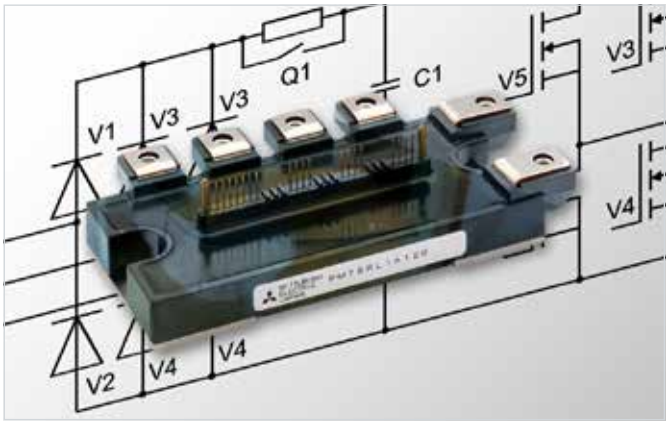
Power electronics is the technology of switching and converting electrical power to greater power levels. Nowadays we use power semiconductors like diodes, thyristors and IGBTs to perform these operations. The main application area for power electronics is drive technology.
The training systems in this 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.

Lucas-Nuelle

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

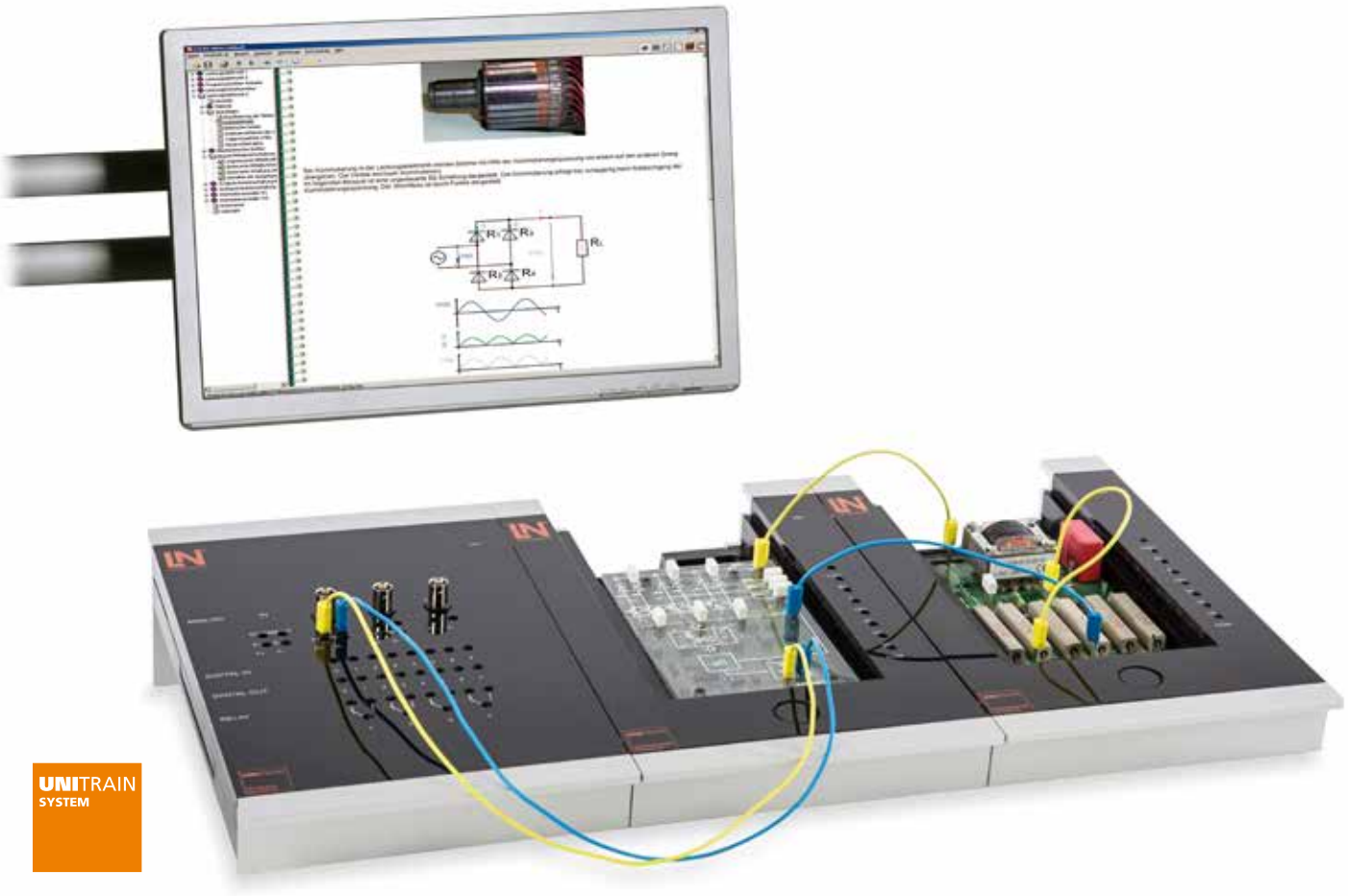
Our training systems cover the following topics:

- 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

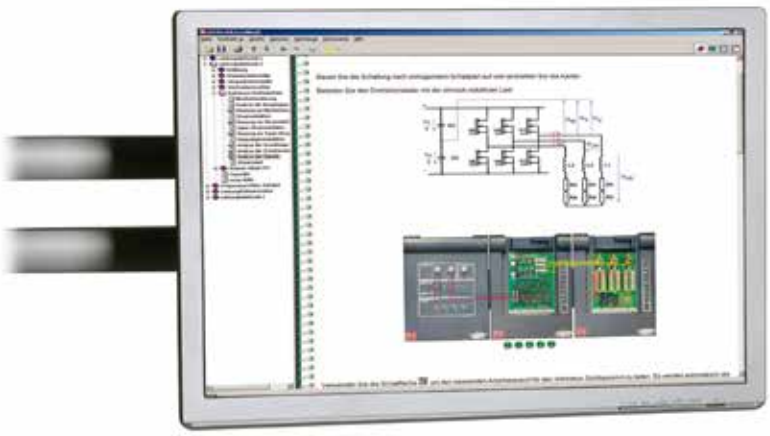
Training content

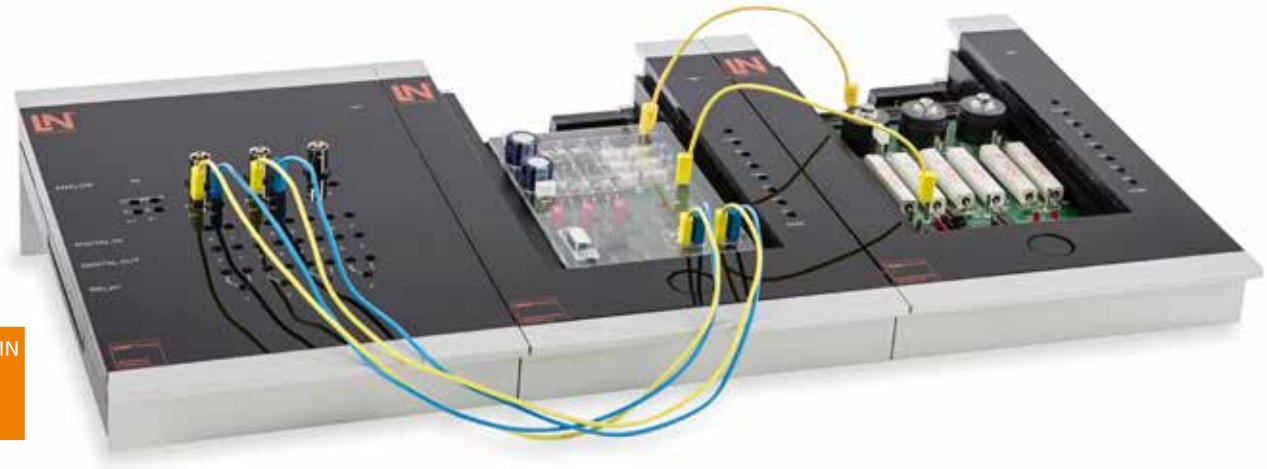
- Design and operation of single-phase and three-phase rectifiers
- Operating characteristics of uncontrolled, semi-controlled and fully controlled static converter circuits
- Power semiconductors and their control
- Power electronics measurement variables
- Measurement and analysis of static converter 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

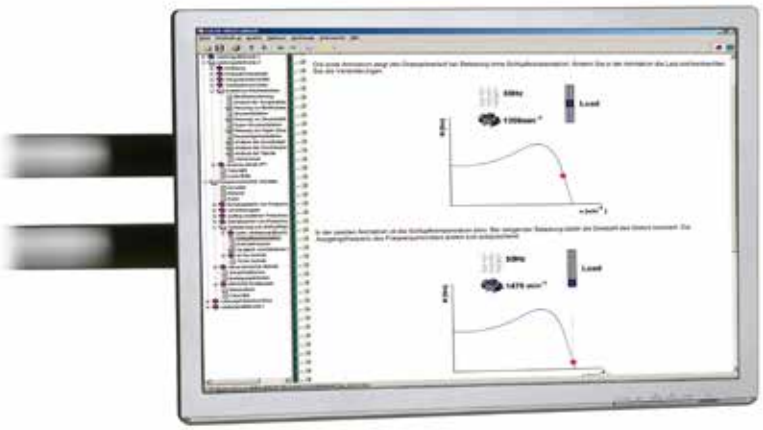
Training content

- 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

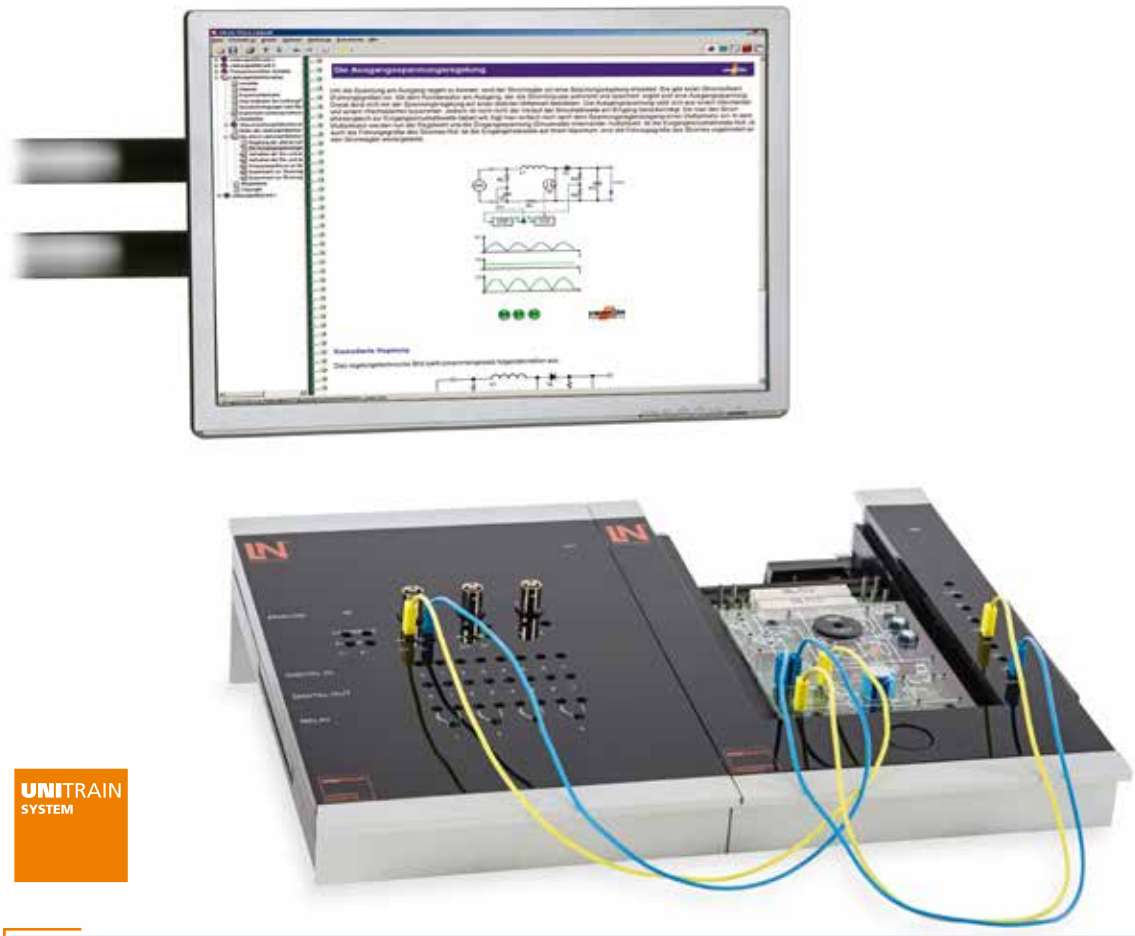
Training content

- 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"

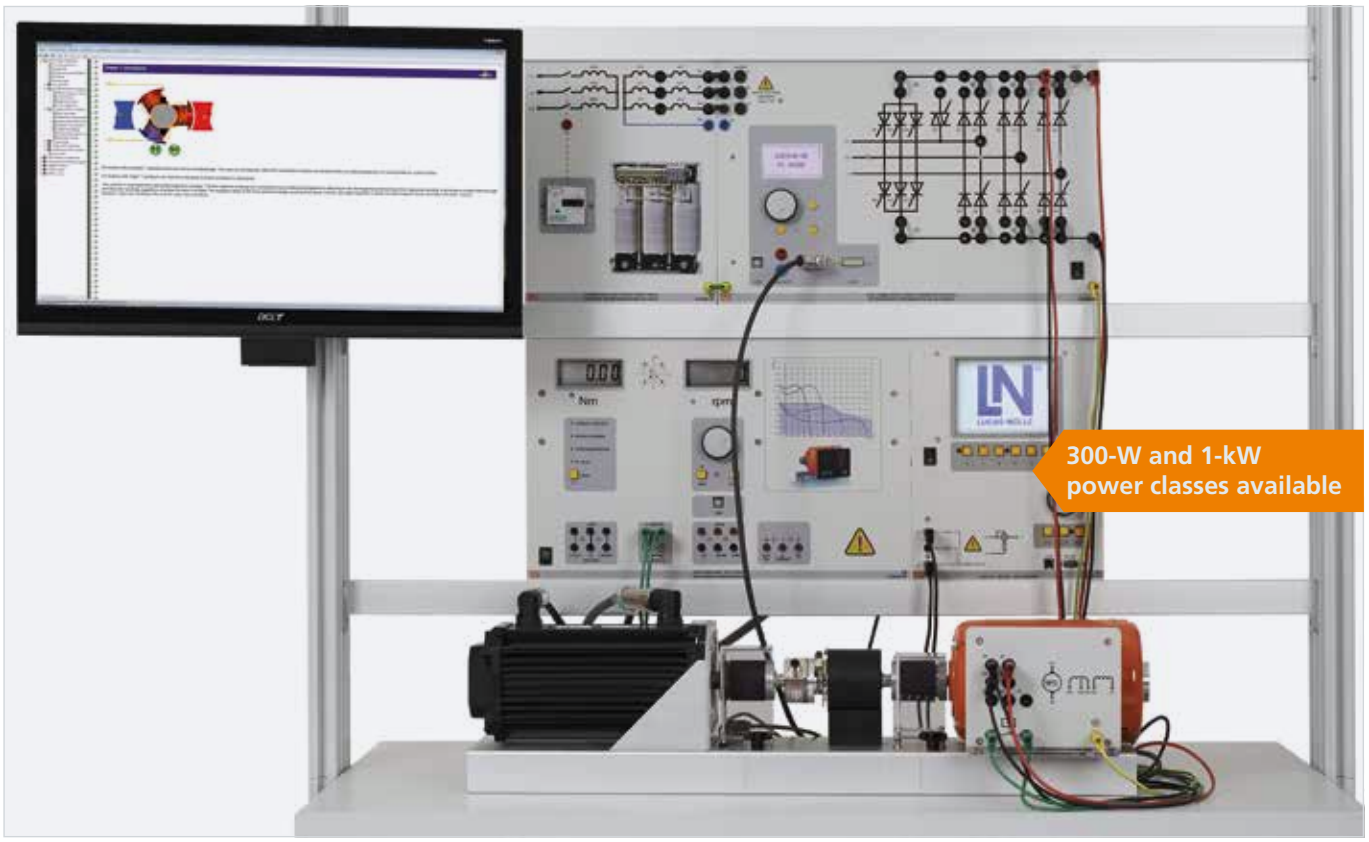
Training content

- 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

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"

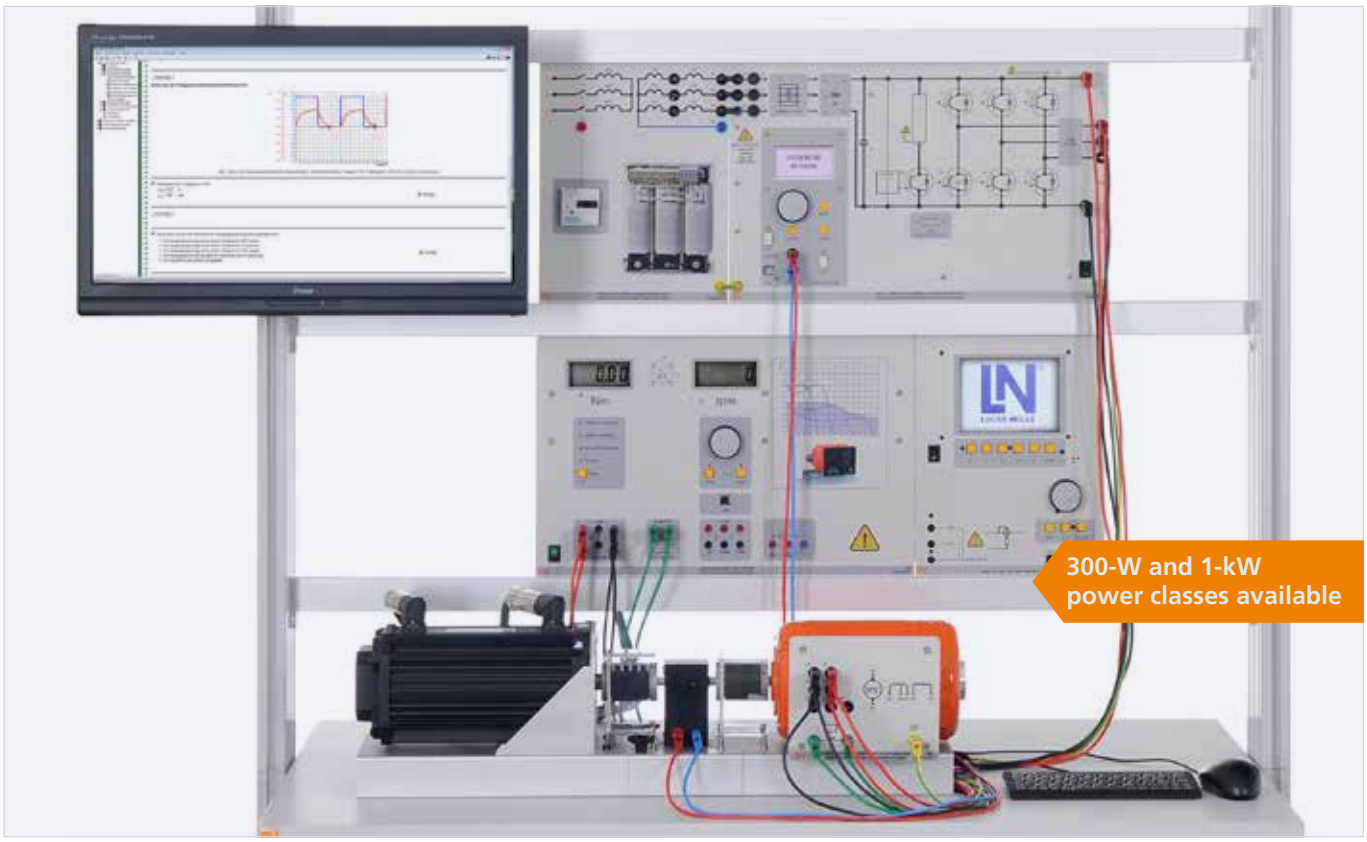
Training objectives

- 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