LEYBOLD®

ELECTRICAL DRIVE TECHNOLOGY

E2

- INNOVATIVE MACHINE SYSTEM 4.0
- HIGHLY EFFICIENT & SAFE
- NEW PENDULUM MACHINE FOR FORCE MEASUREMENT
Electrical machines and drives are present everywhere in daily life – whether in vacuum cleaners, drills, as the drive for conveyor belts or in cars. In fact, the fundamental principals of electrical machines have been known for more than 150 years and in recent years there has been technological progress in this field through further developments, such as Industry 4.0. The knowledge required by specialists in this field is becoming ever broader.

With our machine system 4.0 we have developed a new, safe and highly efficient teaching system for electrical drives. This means your trainees and students are prepared for the latest developments and requirements in practice:

- High efficiency machines as standard for better energy efficiency
- Higher dynamics at high torque
- Less workspace needed
- Modular set-up for all types of drive systems from fundamentals to advanced automation
- Safeguarding of the energy supply
- New industrial sectors, e.g. electric and hybrid cars, wind turbines

The trainees get to know not only the design but also the behaviour and mode of operation of various machine types – from well-established to the most modern and highly efficient machines. They are also in the position to analyse the behaviour under various load conditions, calculate the characteristic values and record machine-typical characteristic curves. The effects in electrical networks and the most modern switching devices are also acquired.

OVERVIEW OF THE SUBJECT AREAS

- Construction and operation of machines
- Behaviour of machines as motors
- Behaviour of machines as generators
- Speed setting options
- Efficiency
- Load simulation
- Load setting options
- Activation and braking
- Characteristics of the modes as motor as well as generator
- No-load operations and short circuit tests
MACHINE-SYSTEM 4.0 – ADVANTAGES

- Easy to handle and to operate all kind of machine types
- Manual and computer-assisted measuring supported
- Experiments are carried out with industrially manufactured machines designed for teaching
- High safety standards for the experimental set-ups
- All requirements from the German machine guidelines are met
- Improved torque measurement due to mechanical zero-point adjustment and the option to check and calibrate the measurements with weights
- Visibility of the measuring principle of torque measurement with strain gauges
- Machine test system control unit with integrated display for speed and torque
- System can be operated with or without PC

THE APPROPRIATE MACHINE FOR EVERY TEACHING REQUIREMENT

The machine system 4.0 distinguishes itself with simple handling and fulfils the most recent safety requirements for experiments carried out by trainees and students. Moreover, the machines comply with the latest regulations and standards for modern training in the field of electrical machines and drive technology.

TEACHING MACHINES
- For the precise analysis of the design and the functioning of electrical machines

EDUCATIONAL MACHINES
- Specially developed for teaching
- Clearly visible design of an electrical machine
- Can be disassembled
- Designed for electrical connections

INDUSTRIAL MACHINE
- Conforms to industrial standards
- 2 power ratings (300 W and 1,000 W)

Machines can also be used as motors or generators.
SAFETY REQUIREMENTS ARE THE TOP PRIORITY FOR EXPERIMENTS

An extremely secure design is required due to modern drive systems and especially to experiments with high efficiency machines. For this reason many norms have been created or supplemented in recent years. The new machine system 4.0 fulfils all safety requirements for student experiments.

A new, heavy-duty aluminium machine bench serves to fix the machines in place. Mechanical impulses, which can occur when IPM motors, synchronous motors or high efficiency machines stall, are absorbed by the bench and the mechanical latches on both sides. The machines can be moved around on the machine bench at any time so that two machines can be operated against each other on the machine bench. The installation of digital and analogue tachometers is possible without much effort.

The connection of the machine and the test system is protected by a transparent cover, which is also mounted at the bench. The drive shafts can only be accessed after disassembling the drive system. In addition, the base latches are electrically monitored, therefore the unit switches off as soon as the base is detached. An optical tachometer can still be used here.

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

This is the requirement for Industry 4.0-compatible frequency converters and servo actuators as well as the associated speed rotation angles and position sensors.
Do you want to combine your old machines with the new electrical machine test system and its new machine bench?

With our retrofitting service, old machines can be modified to fit the new machine bench. Let us know which machines you want to be retrofitted and how you want your new system to look in the future. We are happy to consult with you and provide an individual offer to suit your needs:

sales@ld-didactic.de
A NEW LOOK AT FORCE MEASUREMENT: THE PENDULUM MACHINE

With the new pendulum machine students can work out the correlation between force – torque – power based on their own experiences. As part of the complete education redesign, the measurement equipment on the pendulum machine can now be directly observed. With the visible force sensor, students can better understand how the torque of a machine is measured. The possibility of calibration by the students themselves makes the understanding of these correlations even deeper.

The characteristics can be recorded automatically using a PC or an electrical machine can be also manually put under load. In both ways not only the electrical energy is determined but also the mechanical energy through a direct measurement of torque and speed. This makes it easy to calculate the efficiency from the electrical and mechanical measurements. Dynamic measurement is done at least every 100 ms, resulting in an exact continues characteristic curve of the tested machine. You can record curves for load, run up characteristics and torque. The system provides load characteristics as for winder or blower. Additionally you can design your own load characteristics and use it for measurement with the different machines.

Measurement ranges:
- Torque: ±9.99 Nm (300 W); ±30 Nm (1 kW)
- Torque offset adjustment up to ±0.3 Nm
- Current up to ±16 A
- Voltage up to ±500 V AC-DC
Optimised drive units are in increasing demand by Industry 4.0. Therefore it is necessary in school and at university to investigate not just a machine but the complete drive system.

Our machine system 4.0 includes DC, AC and three-phase machines. These are subdivided into synchronous and asynchronous machines. This enables students to deal with the different machine types and their behaviour as well as losses in performance. The equipment for student experiments and demonstrations corresponds to technical developments and the new expectations for energy efficiency.

This equipment is a complete drive and braking system for students, vocational training centres and universities:

**E2.2.6.1 Synchronous machine with permanent excitation IPM with frequency converter 0.3**

The characteristic curves of the test machine are recorded with the machine test system. This is an industrial frequency converter motor consisting of a four-pole 0.55 kW three-phase asynchronous motor with attached frequency converter. The motor and frequency converter are optimally harmonised with one another. In the experiment the machine characteristics in comparison to corresponding machine types without integrated power electronics is investigated.

**OVERVIEW OF TOPICS**

- Design and mode of operation of an IPM motor
- Converter operation
- Motor characteristic curve
- Synchronous behaviour of the motor
- Determination of efficiency

**OVERVIEW OF THE LEARNING OBJECTIVES**

- Safety measures and electrical safety
- Design and commissioning of IPM machines
- Behaviour of IPM machine on start-up
- Behaviour of IPM machines under load
- Vector control of IPM machines

**HIGHLY EFFICIENT IS THE STANDARD NOWADAYS**

Our innovative electrical machines have been updated according to the latest energy guidelines. In many industrialised countries; it is not only the legal definitions for minimum requirements for efficiency that have led to highly efficient machines becoming the standard in industry. Environmental protection and holistic cost reductions have also contributed to this. By dealing with the greater performance of our high-efficiency machines and understanding the modes of operation, the basis for entering the professional world is already laid during training. Even if the 300 W class is not subject to the regulations, we are able to show the enormous difference in the exchange rotors with an aluminium rotor and a copper rotor.

When power counts – this is what the new electrical machines can do:

- Higher energy efficiency of ~13 %, 1.1 kW
- Ca. 15 % increased efficiency
- Up to 27 Nm (aluminium – copper rotor efficiency +10 %, +48 % for the same size)
ELECTRICAL DRIVE TECHNOLOGY
OVERVIEW

**DC COMPOUND MACHINE 0.3**
773 186

- Direct current compound machine
- Can be used as a shunt machine, series machine or as a compound machine
- Series winding with tap for compounding and shunt winding

**UNIVERSAL MOTOR 0.3**
773 200

- Universal motor as series machine
- Operation with alternating or direct current

**CAPACITOR MOTOR R 0.3**
773 204

- Single-phase alternating motor
- Includes a starting relay, a starting capacitor and an operating capacitor

**SQUIRREL CAGE MOTOR 400/690 0.3**
773 211

- Three-phase asynchronous motor with cage rotor
- 400/690 V Δ/Y

**SQUIRREL CAGE MOTOR D 0.3**
773 224

- Three-phase asynchronous motor with cage rotor
- Dahlander pole changing

**SQUIRREL CAGE MOTOR SW 0.3**
773 226

- Three-phase asynchronous motor with cage rotor
- Two separated coils

**MULTI-FUNCTION MACHINE 0.3**
773 228

- Three-phase multifunction machine with slip ring rotor
- Can be used as an asynchronous or synchronous machine
- For motor and generator operation

**SLIP RING MOTOR 0.3**
773 233

- Three-phase multifunction machine with slip ring rotor
- Visibility of the slip rings

**SQUIRREL CAGE MOTOR 230/400 0.3**
773 2104

- Three-phase asynchronous motor with cage rotor
- 230/400 V Δ/Y

All shown electrical machines are also available in the 1.0 kW power class.
ELECTRICAL DRIVE TECHNOLOGY
OVERVIEW

SYNCHRONOUS MACHINE SP 0.3
773 236
- Three-phase synchronous machine
- Salient pole rotor and damper cage
- Visibility of the slip rings

SYNCHRONOUS MACHINE SR 0.3
773 237
- Three-phase synchronous machine
- Non-salient pole rotor
- Visibility of the slip rings

SYNCHRONOUS MACHINE PERMANENT EXCITATION IPM 0.3
773 340
- Three-phase synchronous machine with interior permanent magnets (IPM) in the rotor
- Visibility of the magnets

SQUIRREL CAGE MOTOR BASIC
230/400 0.3
773 2201
- Three-phase asynchronous motor with cage rotor
- Connections on the top in the original terminal box
- Without educational terminal board

SQUIRREL CAGE MOTOR 230/400 BRAKE BASIC 0.3
773 2202
- Industrial three-phase asynchronous motor with cage rotor with electromechanical holding brake
- Without educational terminal board

SQUIRREL CAGE MOTOR BASIC 400/690 0.3
773 2203
- Three-phase asynchronous motor with cage rotor
- Connections on the top in the original terminal box
- Without educational terminal board

E2.1 EDUCATIONALLY DESIGNED MACHINES
E2.1.1 Machine Labs with the Plug-In System
E2.1.2 COM3LAB Multimedia: Motors & Generators
E2.1.3 Machine Assembly Kits

E2.2 INDUSTRIAL MACHINES 300 W
E2.2.1 Transformers
E2.2.2 DC Machines
E2.2.3 AC Machines
E2.2.4 Three-Phase Induction Machines
E2.2.5 Three-Phase Synchronous Machines
E2.2.6 Synchronmaschine Permanent Excitation
E2.2.7 Feedback Electrical Machines

E2.3 INDUSTRIAL MACHINES 1 KW
E2.3.1 Transformers
E2.3.2 DC Machines
E2.3.3 AC Machines
E2.3.4 Three-phase asynchronous machines
E2.3.5 Three-phase synchronous machines

E2.4 POWER ELECTRONICS
E2.4.1 Compact systems for power electronics
E2.4.2 Line-commutated converters
E2.4.3 Self-commutated static converters

E2.5 DRIVE TECHNOLOGY
E2.5.1 Compact systems for drive technology
E2.5.2 Industrial DC drives
E2.5.3 Industrial three-phase drives

E2.6 SERVO TECHNOLOGY
E2.6.1 Educationally designed servos

We also offering our electrical machines as part of a complete set for training.
With our new Danfoss converter we have a proven partnership at the cutting edge of technology:

- Can be used on a 230 V network (connection to a plug socket)
- Output 3-phase alternating current 132 V / 230 V
- The direct current link voltage can be measured
- Display for observation
- All inputs and outputs via 4 mm safety sockets
- Potentiometer for quick frequency adjustment
- Digital and analogue inputs
- Integrated two-channel “Safe Torque Off” (STO)
- Profi-Net connection removing
- USB connection
- Transfer of the drive parameters and data via Danfoss software (MCT 10)
- Potential equalisation sockets
- Operating mode V V C + or U/f

With the new Danfoss frequency converter you are perfectly positioned and connected both in terms of drive technology and in the world of automation technology.

Technical features, such as an additional EMC filter for reduction of leakage currents and potential equalisation sockets for the required integration into the potential equalisation system, complete the product.

Use our frequency converter together with:

- our asynchronous machines 230/400 V Δ/Y (773 2104) and permanent excitation synchronous machines (773 340)
- in conjunction with our PLC control system S7-1512C-1 PN TP (773 072) and S7-1516 PN/DP TP (773 077)
CONVERTER CONTROL CASSY
773 5290

Experience innovative ideas in power electronics and converter technology with the new Converter Control CASSY

The Converter Control CASSY supports our universal converter power unit (735 297) as well as the commutation pick-up (773 1096), the incremental tacho (773 1092) and the resolver (773 1094).

With the Converter Control CASSY you will get an introduction to modern converter technology. The following fundamental experiments, among other, can be carried out:

- Input bridge rectifier with DC link capacitor and the resulting behaviour on the network;
- Brake chopper for protecting the DC link capacitor and compensation of the braking energy;
- Alternating-current converter, in particular the rotating field generation on the voltage source inverter. Space vector and d – q components can be proven.

Further experiments on the topics:

- Typical industrial frequency converter with PWM characteristic curve method
- Rotation speed control
- Characteristic curve for control methods, such as block modulation and vector modulation
- IxR compensation, start voltage and slip compensation
- Investigation into the machine behaviour under different parametrisation
- Determining the optimal parameters for a frequency converter

- AC servo with block commutation
- Electronic motor
- Electrically commutated direct current machine
- Brushless three-phase motor
- AC servo
- AC servo with sine commutation
  - With the resolver encoder system, not only can the exact rotor position be measured, but also the tachometer voltage.
  - Evaluation of the path and angle information, which is directly used for positioning.

Alongside the control functions, all evaluations can be carried out simultaneously with the Converter Control CASSY. For this purpose, a Power Analyser CASSY is already integrated.

Diagram “Current and voltage of a frequency converter”

Detailed Information on
POWER ANALYSER CASSY &
POWER ANALYSER CASSY PLUS
can be found in the brochure „POWER ANALYSER CASSY“. 
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