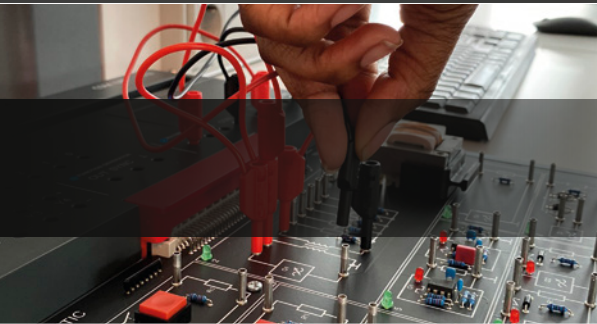


COM4LAB

NEXT GENERATION LAB



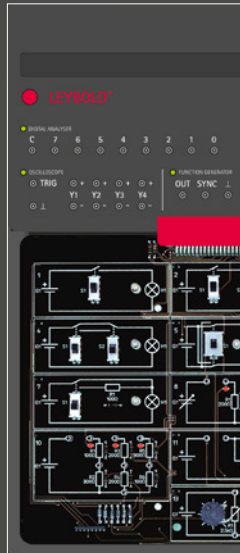
- — COMPACT ELECTRICAL ENGINEERING LAB
- — COMPREHENSIVE CURRICULUM
- — CLOUD-BASED COURSES
- — COST EFFICIENT EDUCATION



LEYBOLD®

COM4LAB

NEXT GENERATION LAB



COMPACT ELECTRICAL ENGINEERING LAB

COM4LAB is a complete electrical engineering lab in a compact form. The system consists of a Master Unit, various experiment boards and interactive courses. **COM4LAB** combines hands-on experiments with the benefits of interactive e-learning for the best possible training outcomes.

The compact hardware design allows for flexible and mobile learning.

COM4LAB enables modern digital training using smartphones, tablets and laptops of any kind - on-site at school, in the company or even at home.

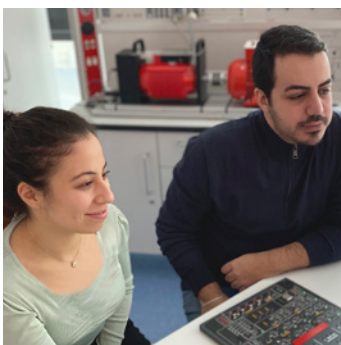


COMPREHENSIVE CURRICULUM

More than 25 different courses from the fields of electrical and automotive engineering cover the entire curriculum of the German dual training system - from circuit technology and control engineering to sensor technology.

The **COM4LAB** courses prove their worth with topicality, realism and quality of the learning content. These are didactically presented to the students via animations, text, images, interactive elements and videos. The students actively perform integrated experiments on the experiment board and learn the necessary skills directly and sustainably. The theoretical and practically-acquired knowledge is automatically checked with regular learning assessments.

With the **COM4LAB** editor, courses can be quickly and easily adapted as needed, extended and translated, and exams and questions can be created.





COM4LAB

GAIN KNOWLEDGE & UNDERSTAND TECHNOLOGY

CLOUD-BASED COURSES

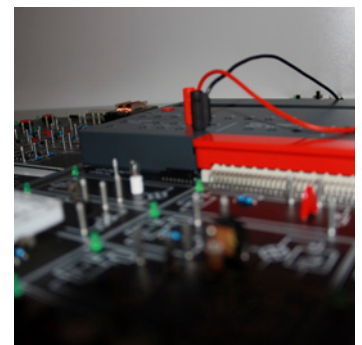
The **COM4LAB** courses are available at any time and from anywhere via the cloud. Sharing with learning management systems, such as Moodle or MS Teams, is also possible. In digital lessons, up to four students can connect their device to a **COM4LAB** workstation via the network. **COM4LAB** courses work on any device regardless of operating system and manufacturer. No software needs to be installed or maintained. Not only is a Bring-Your-Own-Device concept easily implemented, but teamwork is also promoted through group work. Students can save courses at any time and continue working on them from any location.

COM4LAB courses can also be used to prepare for lessons or for homework without the need for hardware thanks to its safe operation and uncomplicated handling.

COST-EFFICIENT EDUCATION

COM4LAB is an efficient training system that already minimises teacher preparation time and allows for a quick start in the classroom due to its rapid set-up and stowing away. The robust and stable design ensures a long service life and low secondary costs.

COM4LAB also offers a high degree of future-proofing thanks to its cloud-based system and independence from operating systems and manufacturers. The compact yet complete lab has an enormously reduced maintenance effort compared to large, complex training facilities. Furthermore, the modular design enables cost-efficient additions and replacement.



COM4LAB

THE SYSTEM AT A GLANCE

COM4LAB



1. MASTER UNIT

Base station with all connections and measuring instruments

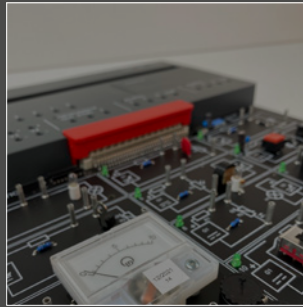
2. EXPERIMENT BOARD

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

3. COURSE

Learning module with all learning content (theory and experiments) as well as the knowledge checks, organised into chapters



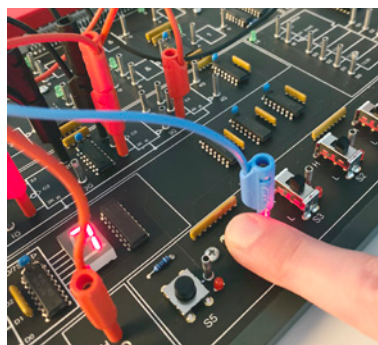


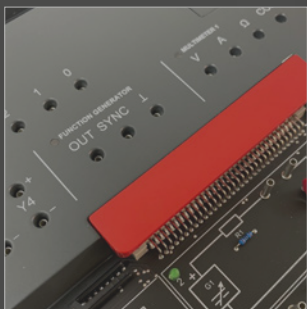
SIMPLY COMFORTABLE

- Perfect interaction between hardware and software based on German engineering standards
- No additional accessories such as measuring instruments, function generators or power supply unit required
- Quick and easy to use, setting up and stowing away in just a few steps
- Robust and stable, suitable for students to handle safely
- Space-saving thanks to compact design
- Simple and intuitive operation of all features
- Designed for perfect learning ergonomics
- Interactive guidance within the course, including experiments and measurements via the experiment board and Master Unit
- Compatible with all previous COM3LAB experiment boards
- Can be used in any location, even without electrical socket
- Work in safety extra low voltage range



THE SECRET OF SUCCESS IS
THE MIX OF THEORY & PRACTICE





COM4LAB

SUPPORTING TEACHING AND LEARNING

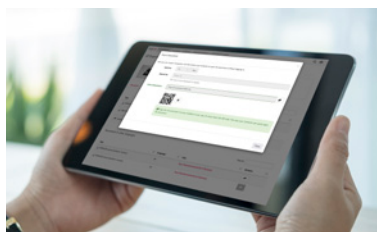


**MORE MOTIVATION
MORE LEARNING
SUCCESS**

EXTRA COM4:

INDIVIDUAL LEARNING LOCATION

- Course is always available for the student, anywhere
- Deepening knowledge at individual learning locations, from the café to the park
- Suitable for remote learning (e.g. in rural areas) due to compact size and independent power supply



COM4LAB DIGITAL DISTRIBUTION

- Courses are made available to all students via QR code or link
- Courses can be shared via learning management systems (LMS, e.g. Microsoft Teams, Moodle)

COM4LAB DIGITAL PREPARATION & FOLLOW-UP

- Access to COM4LAB courses in the online portal LeyLab at any time and from anywhere
- Teacher version with theory, example measurements and solutions saves preparation time



COM4LAB DIGITAL CHECKING

- Knowledge check with automatic answer confirmation
- Returning of course to teacher by e-mail or via LMS
- Collection of all digital course protocols
- Central overview of course status possible via LMS
- Simple check of results



COM4LAB

FROM START TO END



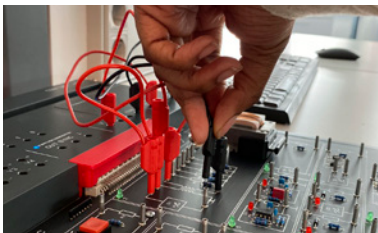
COM4LAB DIGITAL COURSE WORK

- Courses can be called up on the students' tablets, laptops
- Interactive learning content independently worked through individually or in a group (up to 4 students)



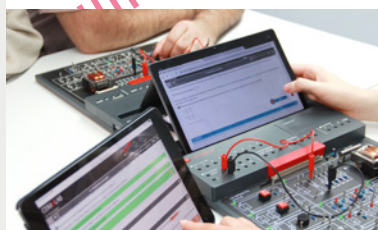
COM4LAB DIGITAL EXPERIMENTATION

- Joint experimentation via course and on the experiment board in teamwork
- Automatic, digital transmission of the measured values (virtual displays, tables and diagrams) to all devices in the work group



COM4LAB DIGITAL COURSE PROTOCOL

- Individual evaluation of the cooperative measurement results
- Individual processing of course
- Course protocol usable as digital documentation for deepening learning content/ further processing



EXTRA COM4:

INDIVIDUAL LEARNING SUPPORT

- Teacher can give students tips, offer immediate help during the class or present to the class
- Focus on teaching through self-study

EXTRA COM4:

INDIVIDUAL LEARNING SPEED

- Courses can be worked through at individual speed
- Courses can be saved at any time and then restarted
- Chapters can be printed out
- Courses can be continued with or without hardware

COM4LAB

THE PERFECT SOLUTION

COM4LAB AT VOCATIONAL COLLEGE

- Broad coverage of the curriculum topics
- Quick set-up and simple, safe operation
- Support for individual and group work
- Time-saving preparation and follow-up of lessons
- Promotion of teamwork and social skills
- Students learn from and with each other
- Independent learning with students' own equipment (up to 4 devices) and at their individual speed
- Simple learning checks and securing the learning level of the entire class
- Enhancing digital competence
- Ensuring high learning level and learning quality independent of the teacher
- Course can be edited for adaptation to the respective learning level



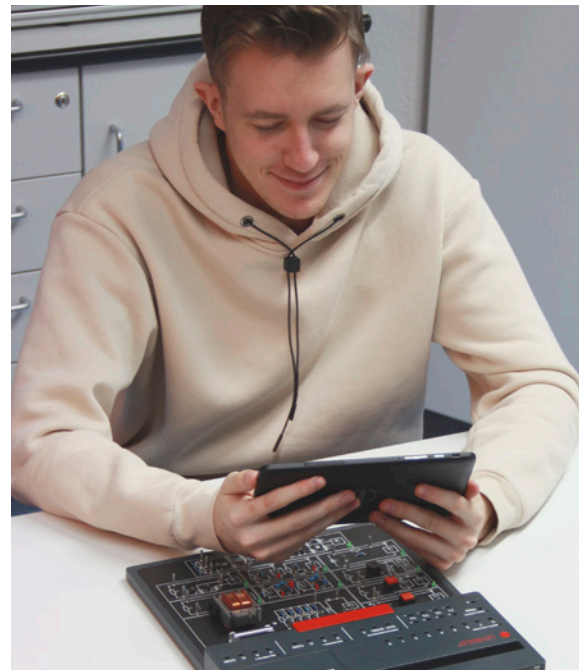
With all possible uses, individual preparation or following up on the course can be done with or without hardware at home.

COM4LAB

FOR VARIOUS LEARNING LOCATIONS

COM4LAB IN COMPANIES TRAINING ON THE JOB

- Optimal training and high motivation of own employees
- Additional staff for support is unnecessary, as **COM4LAB** can be set up and worked with independently
- For use at work or at home
- Learning or deeper exploration of topics relevant to the exam, in addition to in-house training
- Courses with focus on the company's main areas of business
- Low investment with high outcome
- **COM4LAB** as a convincing argument in the trainee recruiting process



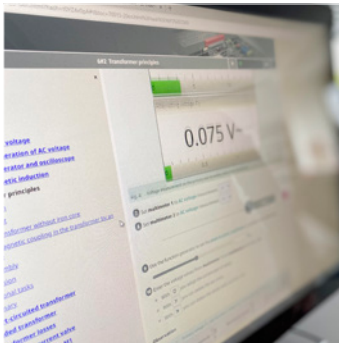
COM4LAB AT UNIVERSITY

- A **COM4LAB** workstation for a specific curriculum topic in the lab
- Independent work on and performing of experiments
- Option of free experimentation thanks to customisable courses and openness to other systems
- Preparation for lab work and immersion in teaching systems and theory
- Promotion of technical, social and digital competences
- Transparency about learning status and ensuring consistent quality



COM4LAB

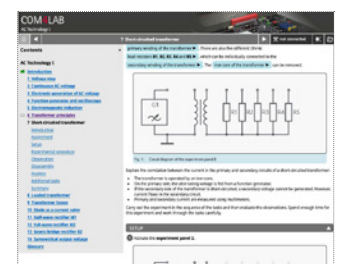
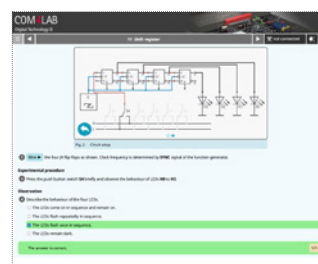
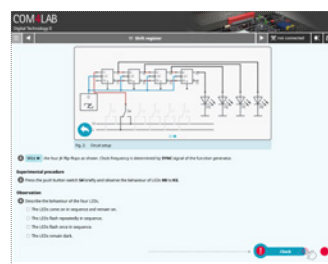
INTERACTIVE COURSES FOR INDEPENDENT LEARNING

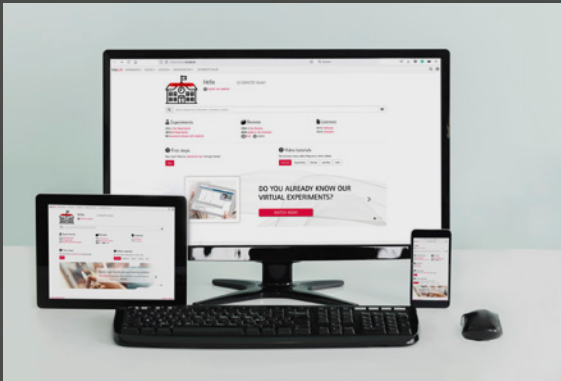


INTUITIVE DESIGN AND INTERACTIVE LEARNING CONTENT

The clear preparation of learning content combined with the awesome, intuitive course design ensures that learning is fun. The students are more motivated and achieve a higher efficiency and sustainability for their learning.

- Didactically prepared, curriculum-compliant learning content with theoretical and practical elements for long-lasting success in learning
- Interesting and comprehensible imparting of the learning content via interactive graphics, animations, videos and tutorials
- Practical experiments for a quick start in professional life
- Student version and teacher version (with all results) available in the cloud
- Immediately available in national languages due to online translation feature
- Audio and help functions ensure ease of use
- Direct feedback thanks to the knowledge checks (e.g. multiple choice, fill-in-the-blanks, yes/no questions) with automatic answer review
- Course can be saved and worked on later at any time





- For all software platforms
- Any tablet, smartphone, laptop or PC
- Solution for any IT infrastructure
- Allows for „Bring Your Own Device“ (BYOD)
- No installation necessary

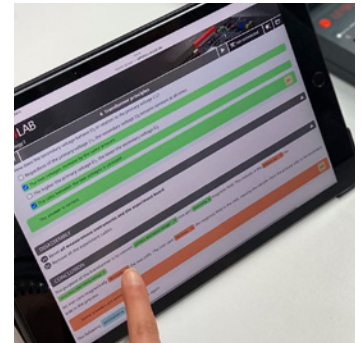


QUICKLY AND EASILY EDIT AND CREATE COURSES

All **COM4LAB** course content can be edited and adapted to your own needs. This way, different learning levels or teaching scenarios can be addressed. The **COM4LAB** editor has an impressive ease of use and comprehensive options, such as:

- Editing or deleting assignments
- Adding questions and explanations
- Inserting images or videos
- Creating text tasks (e.g. multiple choice) for exams
- Integrating new experiments, including measurements

Even completely new, interactive **COM4LAB** courses can be created with the editor.



INTERACTIVE MEASUREMENTS AND VIRTUAL 3D MEASURING INSTRUMENTS

Each course includes real experiments performed with the help of the experiment board. In addition to plugging circuits in using circuit diagrams, this also includes live measurements.

- Controlling measuring instruments directly from the course
- Measurements are transferred to the courses in real time - from virtual display to tables and diagrams
- Virtual 3D measuring instruments (oscilloscope and multimeter)
 - Modelled on professional life
 - Realistically operated for a high level of practical relevance

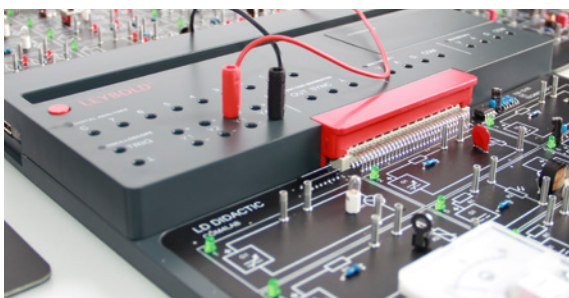
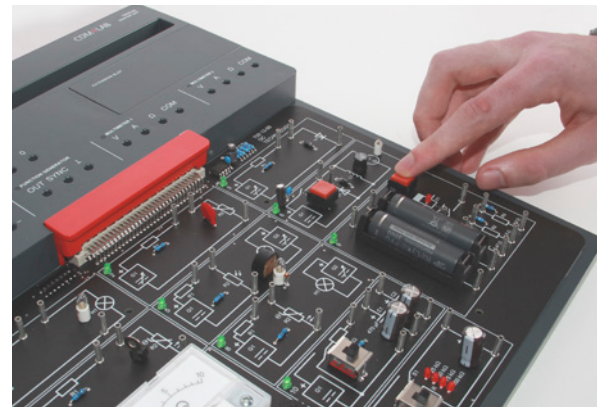


COM4LAB

REAL EXPERIMENTS FOR SUSTAINABLE LEARNING

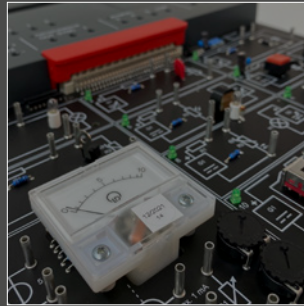
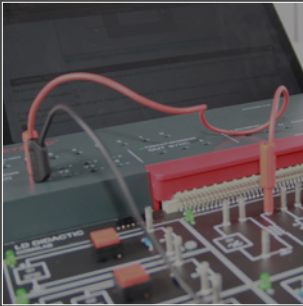
MASTER UNIT

- Clearly labelled and designed
- Includes all connections (WiFi, USB, Ethernet)
- Includes all precise and fast measuring instruments and signal generators in mini format
- Activity indicators for measuring instruments
- Tablet housing slot
- Connection with up to 4 digital devices
- Compatible with all existing COM3LAB experiment boards
- Luminous strip for optical status control



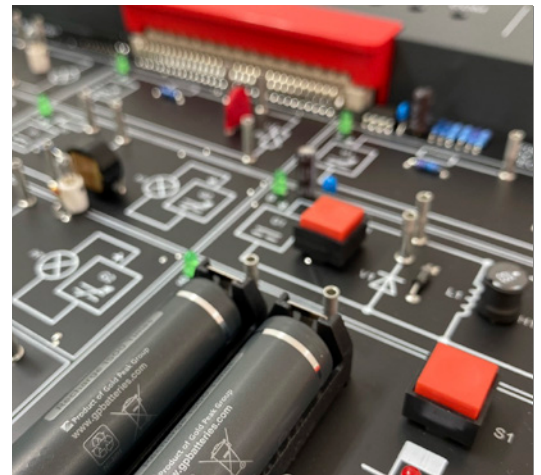
INTEGRATED MEASURING INSTRUMENTS

- 4-Channel-Oscilloscope with 4 differential inputs
- 8-Bit Digital Analyser
- Function Generator up to 100 KHz (square-wave, triangular, sinusoidal, DC)
- 2 x Multimeter (9 measurement ranges for current, voltage and resistance management)



EXPERIMENT BOARD

- Equipped with everything you need to perform all experiments within an entire topic
- Explanation of the experiment board and the corresponding course elements with interactive circuit diagrams
- Visible modules and use of original components for a high degree of realism
- Clearly recognisable experiment panels with circuits and corresponding standardised circuit symbols (DIN standard 60617)
- Interactive course guidance using LED lights on the experiment board
- Robust even with faulty connections



SAFETY

- COM4LAB only uses non-hazardous voltages and low currents
- 2 mm safety sockets and leads
- Kensington lock serves as theft protection for permanent workstation set-ups
- Courses are mechanically locked during assembly
- Security lock automatically switches off the board when opened



COM4LAB

COMPREHENSIVE CURRICULUM

QUICK AND SIMPLE TOPIC CHANGES



The compact experiment boards can be efficiently stored in cabinets thanks to a special holder.

When students are working on a new topic, the Master Unit is quickly and easily slid onto the new experiment board and the new course is instantly ready for use.

With your Master Unit you cover the following topics:

- DC technology
- AC technology
- Electronic components
- Digital technology
- Power electronics
- Three-phase technology
- Electrical machines
- Automation and bus technology
- Electro-pneumatics
- Photovoltaics
- Digital communication technology
- Modem technology
- Telecommunication lines
- Operational amplifiers
- Control engineering
- Sensor technology
- Protoboard for free experimentation
- Automotive electrics
- Automotive sensors
- Automotive digital technology
- Automotive data buses

COM4LAB

OVERVIEW OF COURSES

OVERVIEW OF COM4LAB SET-UPS

PAGE

ELECTROTECHNOLOGY

ME1.1.1	DC Technology I	16-17
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ME1.2.2	AC Technology II	18-19
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ME1.3.2	Electrical Components II	20-21
ME1.4.1	Digital Technology I	22-23
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ME6.1.1	Measurement Technology & Sensors - Operational Amplifier	30
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ME6.2.3	Control Engineering - Control loops and Stability	33
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AUTOMOTIVE TECHNOLOGY

MA3.1	Automotive Digital Technology I	36-37
MA3.2	Automotive Digital Technology II	36-37

Additional courses can be found on our homepage under www.leybold-shop.com

COM4LAB READY

COM4LAB is compatible with the existing COM3LAB generation.

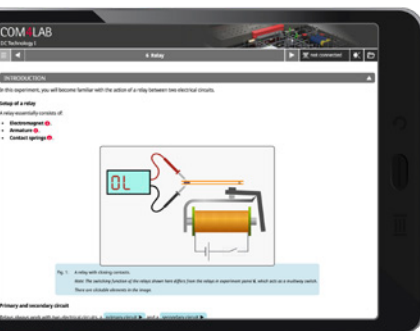
Use the wide range of COM3LAB experiment boards with the new COM4LAB Master Unit and secure the COM4LAB benefits for the future.



COM4LAB

DC TECHNOLOGY

In the area of direct current technology, we offer the **COM4LAB** set-ups **DC Technology I** and **DC Technology II**. Step by step, the laws of electrical engineering are explained and worked out with experiments and animations.



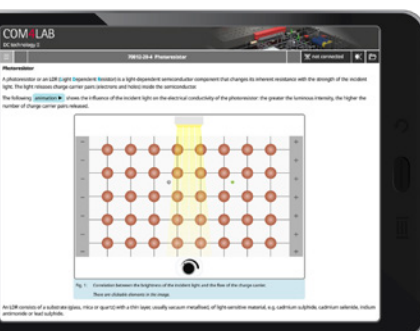
ME1.1.1 - 6. Relay

DC TECHNOLOGY I

The fundamental concepts and laws of electrical engineering are explained and worked out in a practical environment using a variety of experiments. The course comprises 14 chapters.

LEARNING OBJECTIVES

- Setup and effect of basic circuits
- Understand and apply the fundamental laws of electrical engineering



ME1.1.2 - 4. Photoresistor

DC TECHNOLOGY II

Characteristics of various passive electrical components are recorded and the basic circuit types in electrical engineering are practically devised using a number of experiments. The course comprises 15 chapters.

LEARNING OBJECTIVES

- Record the characteristics of passive electrical components
- Behaviour of passive electrical components such as capacitors, coils and batteries

Directly to the COM4LAB courses on DC Technology I & II





ME1.1.1 DC Technology I



ME1.1.2 DC Technology II

COM4LAB DC TECHNOLOGY I

TOPICS

- (Simple) electrical circuit with switch(es)
 - Series circuit
 - Multiway switching
 - Polarity reversing circuit
 - Relay
- Conductivity and electrical resistance
- Ohm's law
- Kirchhoff's circuit laws
- Analysis of resistive circuits
 - Series circuits
 - Parallel circuits
 - Unloaded/loaded voltage dividers
 - Wheatstone bridge



ME1.1.1 - 8. Ohm's law

COM4LAB DC TECHNOLOGY II

TOPICS

- Characteristics of the following passive electrical components:
 - Incandescent light bulb
 - VDR
 - Diode
 - LDR
 - NTC
 - PTC
- Capacitor
 - Series circuits
 - Parallel circuits
 - RC circuits
- Coil
 - Inductance
 - Moving coil instrument
- Battery
 - Series circuits
 - Parallel circuits



ME1.1.2 - 12. Moving coil instrument

SCOPE OF DELIVERY:

Cat. No.	Name	ME1.1.1
700 11-00	COM4LAB Board: DC Technology I	1
700 11-20	COM4LAB Course: DC Technology I	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug (Type C)*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

Cat. No.	Name	ME1.1.2
700 12-00	COM4LAB Board: DC Technology II	1
700 12-20	COM4LAB Course: DC Technology II	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug (Type C)*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

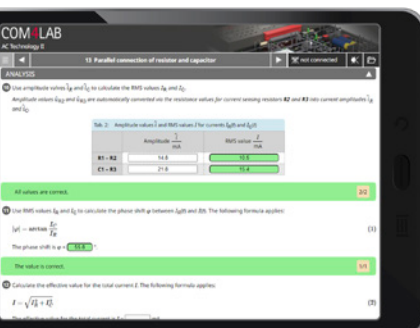
COM4LAB

AC TECHNOLOGY

For alternating current technology, the two **COM4LAB** set-ups **AC Technology I** and **AC Technology II** cover the effects of alternating currents and voltages.



ME1.2.1 – 9. Transformer losses



ME1.2.2 – 13. Parallel connection of resistor and capacitor

AC TECHNOLOGY I

It addresses the generation of AC voltage and the functions of a transformer. Various rectifier circuits are practically devised using a number of experiments. In addition, the handling of a function generator, oscilloscope and multimeters are trained. The course comprises 14 chapters.

LEARNING OBJECTIVES

- Handling and usage of the function generator and the oscilloscope
- Principle and function of a transformer
- Effects of various rectifier circuits

AC TECHNOLOGY II

Students work out the behaviour of passive components in various circuits. Various combinations of coil, capacitor and resistance are analysed and calculated. Also the students are instructed on how to use the function generator, oscilloscope and multimeters. The course comprises 20 chapters.

LEARNING OBJECTIVES

- Characteristics and connections in AC current circuits
- Handling and usage of the function generator and the oscilloscope

Directly to the COM4LAB courses on AC Technology I & II





ME1.2.1 AC Technology I

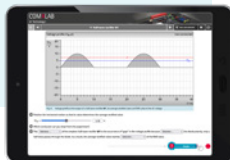


ME1.2.2 AC Technology II

COM4LAB AC TECHNOLOGY I

TOPICS

- Generation of alternating voltage
 - Step voltage
 - Continuous alternating voltage
 - Electronic generation of alternating voltage
- Function generator and oscilloscope
- Transformer
 - Induction
 - Principle of the transformer
 - Short-circuited transformer
 - Loaded transformer
 - Transformer losses
- Rectifier circuits
 - Diode as a current valve
 - Half-wave rectifier M1
 - Full-wave rectifier M2
 - Graetz bridge rectifier B2
 - Symmetrical output voltage



ME1.2.1 - 11. Half-wave rectifier M1

COM4LAB AC TECHNOLOGY II

TOPICS

- Generation of AC voltage
- Characteristic variables in AC technology
- Ohmic resistance in an AC circuit
- Coil in an AC circuit
 - Inductive resistance
 - Series connection and parallel connection of resistor and coil
- Capacitor in an AC circuits
 - Capacitive resistance
 - Series connection and parallel connection of resistor and capacitor
- Series connection and parallel connection of resistor, coil and capacitor
- Series compensation
- Parallel compensation
- Series resonance
- Parallel resonance



ME1.2.2 - 19. Series resonance

SCOPE OF DELIVERY:

Cat. No.	Name	ME1.2.1
700 13-00	COM4LAB Board: AC Technology I	1
700 13-20	COM4LAB Course: AC Technology I	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug (Type C)*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

Cat. No.	Name	ME1.2.2
700 14-00	COM4LAB Board: AC Technology II	1
700 14-20	COM4LAB Course: AC Technology II	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug (Type C)*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

COM4LAB

ELECTRONIC COMPONENTS

The topic Electronic Components comprises the **COM4LAB** set-ups **Electronic Components I** and **Electronic Components II**. A wide variety of components are needed for electrotechnical and electronic circuits. Both set-ups focus on active electronic components that have an amplifying effect or permit control.

ELECTRONIC COMPONENTS I

The most important diode types and their behaviour are presented. The functions, circuits and characteristics of the npn and pnp transistors are explored. The students are instructed on how to use the function generator, oscilloscope and multimeters. The course comprises 19 chapters.

LEARNING OBJECTIVES

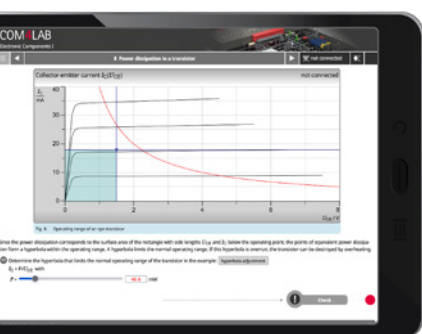
- Setup, function and use of diodes and transistors
- Record characteristics of diodes and transistors using an oscilloscope
- Standard circuits and their applications

ELECTRONIC COMPONENTS II

Special transistor types and semiconductors from the power electronics sector are used. One of their main applications, phase angle control, is examined taking the thyristor and the TRIAC as examples. The students are also instructed on how to use the function generator, oscilloscope and multimeters. The course comprises 14 chapters.

LEARNING OBJECTIVES

- Setup, function and use of field-effect transistors, MOSFETs, IGBTs, DIACS, Thyristors and TRIACS
- Record characteristics of these active components with an oscilloscope



ME1.3.1 - 8. Power dissipation in a transistor



ME1.3.2 - 5. Characteristics of a MOSFET



Directly to the COM4LAB courses on Electronic Components I & II



COM4LAB ELECTRONIC COMPONENTS I

TOPICS

- Diode characteristics
- Characteristic of a Zener diode
- Characteristic of a light-emitting diode
- Diode branches in a transistor
- Characteristics of a transistor
 - Input characteristic
 - Output characteristic
 - Control characteristic
- Power dissipation in a transistor
- Characteristic of a phototransistor
- Darlington configuration
- Operating point of a transistor
- Transistor in a common emitter circuit
- Transistor in a common collector circuit
- Transistor in a common base circuit
- Transistor in timer circuits



ME1.3.1 - 19. Transistors in timer circuits

COM4LAB ELECTRONIC COMPONENTS II

TOPICS

- Field-effect transistors (FET)
 - Transfer characteristic of the JFET
 - Output characteristic family of the JFET
 - JFET as switch
- MOSFET
 - Characteristics
 - MOSFET as switch
- IGBT
 - Characteristics
 - IGBT as switch
- DIAC
- Thyristor
 - Characteristic
 - Thyristor in a DC circuit
 - Phase angle control with a thyristor
- TRIAC
 - Characteristic
 - Phase angle control with a TRIAC



ME1.3.2 - 8. IGBT as a switch

SCOPE OF DELIVERY:

Cat. No.	Name	ME1.3.1
700 15-00	COM4LAB Board: Electronic Components I	1
700 15-20	COM4LAB Course: Electronic Components I	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug (Type C)*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

Cat. No.	Name	ME1.3.2
700 16-00	COM4LAB Board: Electronic Components II	1
700 16-20	COM4LAB Course: Electronic Components II	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug (Type C)*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

COM4LAB

DIGITAL TECHNOLOGY

With the two COM4LAB set-ups *Digital Technology I* and *Digital Technology II* students learn the fundamentals of digital technology. Both set-ups examine the troubleshooting procedure in detail.

DIGITAL TECHNOLOGY I

The fundamentals and laws of Boolean algebra are described using logic operations. The focus of the course is also on troubleshooting. The course comprises 16 chapters.

LEARNING OBJECTIVES

- Setup, function and functional principle of the individual gates and other logic components
- Learning important laws of propositional logic
- Perform troubleshooting procedures on the logic components

DIGITAL TECHNOLOGY II

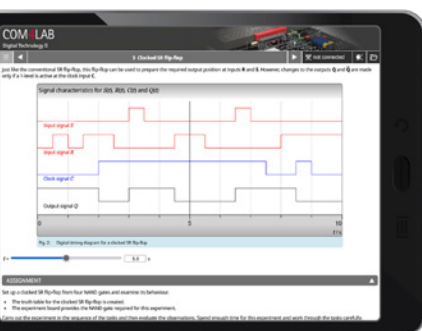
This course explores several flip-flop types and various applications such as counters, shift registers and parallel-serial converters. The course, comprising 12 chapters, also examines the troubleshooting procedure in detail.

LEARNING OBJECTIVES

- Setup, function and functional principle of the individual flip-flops
- Usage of flip-flops and other multivibrators
- Perform troubleshooting procedures on the logic components



ME1.4.1 – 15. Multiplexer and demultiplexer



ME1.4.2 – 3. Clocked RS flip-flop

Directly to the COM4LAB courses on Digital Technology I & II





ME1.4.1 Digital Technology I



ME1.4.2 Digital Technology II

COM4LAB DIGITAL TECHNOLOGY I

TOPICS

- TTL modules
 - AND gate
 - OR gate
 - NOT gate
 - XOR gate
 - NAND gate
- Operation with binary inputs
- Basic laws
 - De Morgan's laws
 - Associative law
 - Distributive law
- Karnaugh map
- Binary code
- Seven-segment display
- Half adder
- Full adder
- Multiplexer and demultiplexer
- Fault simulation



ME1.4.1 - 10. Karnaugh map

COM4LAB DIGITAL TECHNOLOGY II

TOPICS

- Bistable multivibrators
 - SR flip-flop
 - Clocked SR flip-flop
 - D flip-flop
 - JK flip-flop
 - JK master-slave flip-flop
- Monostable and astable multivibrator
- Schmitt trigger
- Flip-flop applications
 - Frequency divider
 - Counter
 - Shift register
 - Parallel-serial converter



ME1.4.2 - 10. Counter

SCOPE OF DELIVERY:

Cat. No.	Name	M1.4.1
700 17-00	COM4LAB Board: Digital Technology I	1
700 17-20	COM4LAB Course: Digital Technology I	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug (Type C)*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

Cat. No.	Name	M1.4.2
700 18-00	COM4LAB Board: Digital Technology II	1
700 18-20	COM4LAB Course: Digital Technology II	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug (Type C)*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

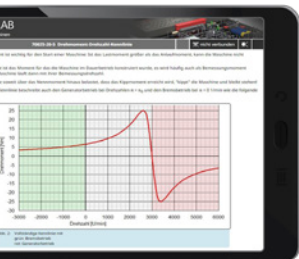
*Alternatively USB-C charger with UK-plug or US-plug

COM4LAB

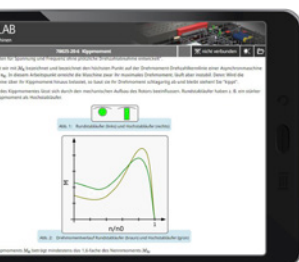
ELECTRICAL DRIVES



ME2.1.3 Asynchronous Machines



ME2.1.3 - 5. Torque-speed characteristic



ME2.1.3 - 6. Breakdown torque

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

TARGET AUDIENCE

Among others, the course can be used to support the training process for the following professions:

- Electrical system fitter
- Electronics technician for machine and drive technology

LEARNING OBJECTIVES

The students are to be able to:

- Recognise the basic physical principles of asynchronous machines and
- Record the characteristics of asynchronous machines

TOPICS

- Design
- Function
- Slip
- Star-Delta Start
- Rotational direction
- Torque-Speed characteristic
- Breakdown torque
- Power characteristic
- Speed control
- Control characteristic

SCOPE OF DELIVERY:

Cat. No.	Name	ME2.1.3
700 25-00	COM4LAB Board: Electrical Drives	1
700 25-20	COM4LAB Course: Asynchronous Machines	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug, Type C*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

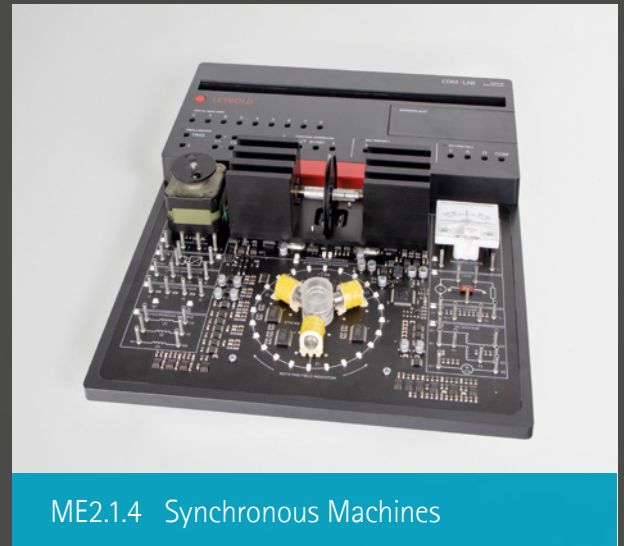
Directly to the COM4LAB Course



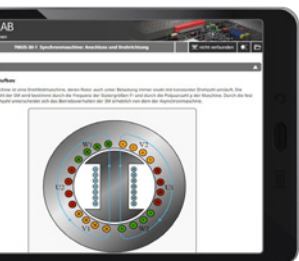
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COM4LAB

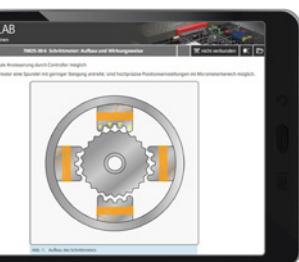
ELECTRICAL DRIVES



ME2.1.4 Synchronous Machines



ME2.1.4 - 1. Synchronous machine - Connection and direction of rotation



ME2.1.4 - 6. Stepping motor - Operation principle

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

TARGET AUDIENCE

Among others, the course can be used to support the training process for the following professions:

- Electrical system fitter
- Electronics technician for machine and drive technology

LEARNING OBJECTIVES

The students are to be able to:

- Recognise the basic physical principles of synchronous machines and
- Recognise the design, the principle of operation and different operating modes of the stepper motors

TOPICS

Synchronous machines

- Terminal
- Rotational direction
- Stepper mode
 - Star connection – Delta connection
- Speed measurement
- Speed adjustment with frequency converter

Stepper motor

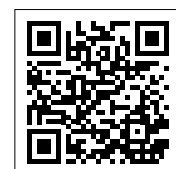
- Design
- Principle of operation
- Rotational direction
- Stepper mode
 - Full-step mode – half-step mode

SCOPE OF DELIVERY:

Cat. No.	Name	ME2.1.4
700 25-00	COM4LAB Board: Electrical Drives	1
700 25-30	COM4LAB Course: Synchronous Machines	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug, Type C*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

Directly to the COM4LAB Course



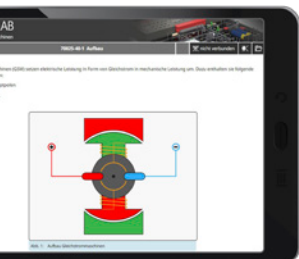
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COM4LAB

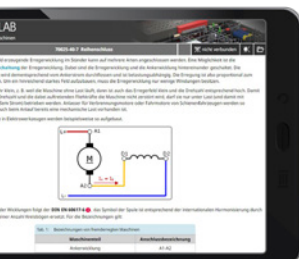
ELECTRICAL DRIVES



ME2.1.5 DC Machines



ME2.1.5 - 1. Setup



ME2.1.5 - 7. Series winding

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

TARGET AUDIENCE

Among others, the course can be used to support the training process for the following professions:

- Electrical system fitter
- Electronics technician for machine and drive technology

LEARNING OBJECTIVES

The students are to be able to:

- Recognise the basic physical principles of DC machines and
- Master different connection types for DC machines

TOPICS

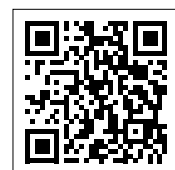
- Design
- Circuit diagrams
 - Block circuit diagram
 - Equivalent circuit diagram
- Connection types
 - External excitation
 - Shunt winding
 - Series winding
 - Generator operation

SCOPE OF DELIVERY:

Cat. No.	Name	ME2.1.5
700 25-00	COM4LAB Board: Electrical Drives	1
700 25-40	COM4LAB Course: DC Machines	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug, Type C*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

Directly to the COM4LAB Course



<https://www.leybold-shop.com/me2-1-5.html>

COM4LAB

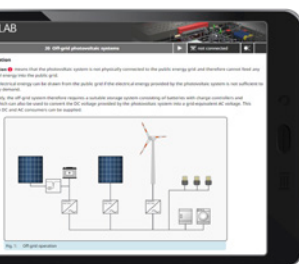
RENEWABLE ENERGY



ME3.1.1 Photovoltaics



ME3.1.1 - 1. Solar energy and its utilisation



ME3.1.1 - 20. Off-grid photovoltaic systems

The COM4LAB course **Photovoltaics** gives an insight into the world of modern photovoltaic systems, providing basic knowledge about the utilisation of the sun's energy with photovoltaic systems. All important topics are covered, from the study of the setup and operation of individual solar cells, solar modules and photovoltaic systems. The course also provides an insight into the components that are important for photovoltaic systems, such as accumulators, charge controllers, boost converters and inverters. The course consists of 21 chapters.

TARGET AUDIENCE

The course can be used to support the training process for the following professions, among others:

- Electronics technician for energy and building technology
- Electronics technician for devices and systems

It can also be used in secondary schools.

LEARNING OBJECTIVES

- Know the setup and operation of solar cells, solar modules and photovoltaic systems
- Know the setup and operation of necessary components such as accumulators, charge controllers, boost converters and inverters
- Know modern applications for photovoltaic systems

TOPICS

- Solar energy & its utilisation
- Solar cell
 - Setup
 - Mode of operation
 - Spectral sensitivity
 - Polarity
 - Energy conversion
- Solar module
 - Characteristics
 - Solar characteristic curve
- Wiring of solar modules
 - Series connection
 - Parallel connection
 - Series & parallel connection
- External influences
 - Shading
 - Tilt angle
 - Temperature
- Important components of a photovoltaic system
 - Accumulator
 - Charge controller
 - Boost converter
 - Inverter
- Applications
 - Solar-powered lighting systems
 - Off-grid/grid-connected photovoltaic systems

SCOPE OF DELIVERY:

Cat. No.	Name	ME3.1.1
700 53-00	COM4LAB Board: Photovoltaics*	1
700 53-20	COM4LAB Course: Photovoltaics	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug, Typ C**	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively, Photovoltaics Accessories for 115 V mains voltage

**Alternatively, USB-C charger with UK-plug or US-plug

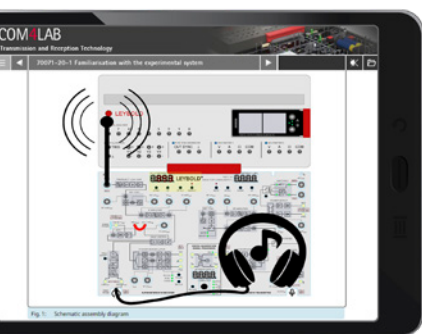
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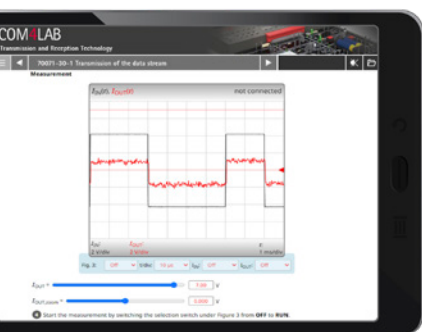
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COM4LAB

TRANSMISSION AND RECEPTION TECHNOLOGY



ME5.1.1 - 1. Familiarisation with the experimental system



ME5.1.2 - 1. Transmission of the data stream

In the field of transmission and reception technology, we offer the COM4LAB courses **RxTx 1 - Analogue Transmission Techniques AM, FM & PSK** and **RxTx 2 - Digital Modulations QPSK & QAM**. The setup of both classical and modern radio systems as well as the modulation of signals is explained step by step.

RXTX 1 - ANALOGUE TRANSMISSION TECHNIQUES AM, FM & PSK

The superheterodyne architecture as well as the basic analog modulations AM, FM, and PSK are covered.

LEARNING OBJECTIVES

- Identify components of a transmission and reception system
- Learn how to measure signals in various frequency ranges
- Recognise parameters influencing radio link quality
- Practise and analyse analogue modulations (AM, FM, PSK)

RXTX 2 - DIGITAL MODULATIONS QPSK & QAM

Different digital modulations, such as QPSK and QAM, are compared and characterised using digital measurement techniques.

LEARNING OBJECTIVES

- Modulation and demodulation of digital signals using shift keying
- Representation in the IQ constellation diagram and in the spectrum
- Utilised and signal bandwidths
- Quality of Service: data rates, bit error rates

TARGET AUDIENCE

The course can be used to support the training process for the following professions, among others:

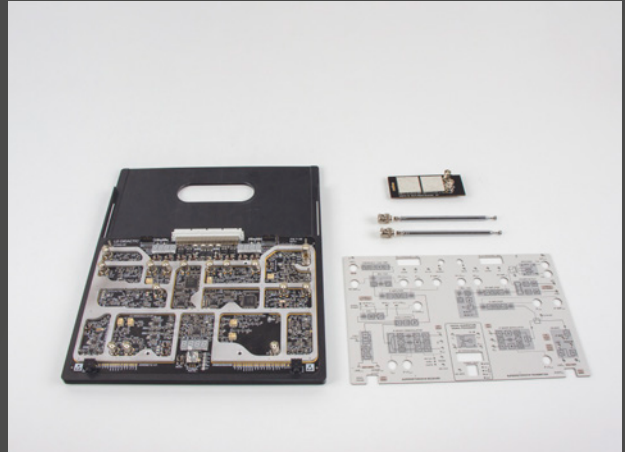
- Electronics technician for devices and systems
- Electronics technician for information and systems technology
- Aircraft electronics technician
- Industrial technologist in communications engineering
- System electronics technician
- Communications engineering (Bachelor)

Directly to the COM4LAB courses
on Transmission & Reception Technology





ME5.1.1 RxTx 1 - Analogue Transmission Techniques AM, FM & PSK



ME5.1.2 RxTx 2 - Digital modulations QPSK and QAM

COM4LAB RXTX 1 - ANALOGUE TRANSMISSION TECHNIQUES AM, FM UND PSK

TOPICS

- How the mixer works in communications engineering (local oscillator-mixer-filter structures)
- Characteristics of single-side and double-sideband signals, high-side and low-side mixers, etc.
- Gain and filter functions
- Functionality of a spectrum analyser (sweep mode)
- Comparison and analysis of modulations, such as amplitude modulation, frequency modulation and phase modulation
- Transmission of analogue audio signals and digital signals
- Recovery of the carrier frequency

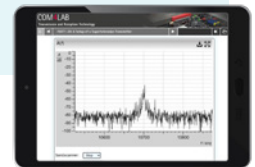


ME5.1.1 - 6. Setup of a Super-heterodyne transmitter

COM4LAB RXTX 2 - DIGITAL MODULATIONS QPSK AND QAM

TOPICS

- PSK Modulation
 - Transmission of data stream
 - Constellation diagram
 - Signal bandwidth
- QPSK Modulation
 - Orthogonality
 - Recovery of data stream
 - Synchronisation
 - Costas Loop
 - Signal bandwidth
- QAM Modulation
 - Signal form
 - Signal bandwidth
- Quality of Services
 - Symbols, bits and signal-to-noise ratio
 - Rotation of state field
 - Signal noise, crest factor and PAPR
- FSK Modulation
 - Signal in frequency range
 - Data transmission



ME5.1.2 - 5. QPSK-Modulation - Synchronisation

SCOPE OF DELIVERY:

Cat. No.	Name	ME5.1.1
700 71-00	COM4LAB Board: Transmission & Reception Technology	1
700 71-20	COM4LAB Course: RxTx 1 - Analogue transmission techniques AM, FM and PSK	1
700 72-00	COM4LAB Extension Board: Band-Scanner	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug, Type C*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

Cat. No.	Name	ME5.1.2
700 71-00	COM4LAB Board: Transmission & Reception Technology	1
700 71-30	COM4LAB Course: RxTx 2 - Digital Modulations QPSK and QAM	1
700 72-00	COM4LAB Extension Board: Band-Scanner	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug, Type C*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

COM4LAB

MEASUREMENT TECHNOLOGY & SENSORS



ME6.1.1 Operational Amplifier



ME6.1.1 - 1. Operational Amplifier



ME6.1.1 - 11. Integrator

The COM4LAB course entitled **Operational Amplifier** gives an insight into the world of operational amplifiers. From the standard circuit to the realisation of a function generator, all important topics are dealt with. The course comprises 20 chapters.

TARGET AUDIENCE

Among others, the course can be used to support the training process for the following professions:

- Electrical system fitter
- Electronics technician for: automation technology, energy and building technology, devices and systems, information and system technology, machine and drive technology or aircraft

LEARNING OBJECTIVES

The students are to be able to:

- Understand the characteristics and operation of the operational amplifier and
- Use and apply operational amplifiers correctly

TOPICS

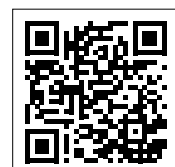
- Characteristics of an operational amplifier
- Inverting and non-inverting operational amplifier
- Switches
 - Comparator
 - Schmitt trigger
- Analogue arithmetic circuits
 - Adder
 - Subtractor
 - Integrator
 - Differentiator
- Filter circuits
 - Active RC filter
 - Passive RC filter
- Stabilisation circuits
 - Constant voltage source
 - Constant current source
- Oscillating circuits
 - Astable multivibrator
 - Wien bridge oscillator
- Function generator

SCOPE OF DELIVERY:

Cat. No.	Name	ME6.1.1
700 81-00	COM4LAB Board: Operational Amplifier	1
700 81-20	COM4LAB Course: Operational Amplifier	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug, Type C*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

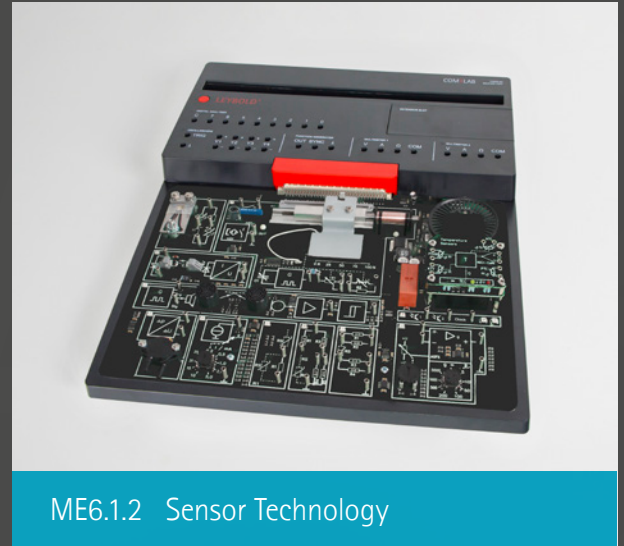
Directly to the COM4LAB Course



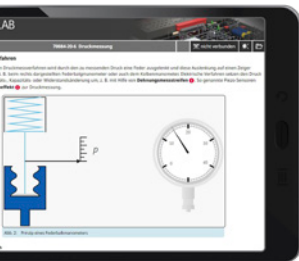
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COM4LAB

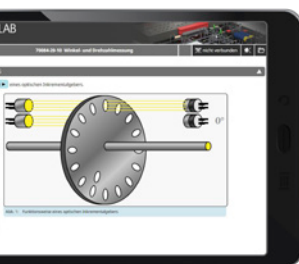
MEASUREMENT TECHNOLOGY & SENSORS



ME6.1.2 Sensor Technology



ME6.1.2 - 6. Pressure measurement



ME6.1.2 - 10. Angle and speed measurement

The **COM4LAB** course entitled **Sensor Technology** covers the fundamentals and basic terms of sensors. Typical sensors are explained and practically devised using a number of experiments. The course comprises 10 chapters.

TARGET AUDIENCE

Among others, the course can be used to support the training process for the following professions and subjects of study:

- Electronics technician for: automation technology, energy and building technology, devices and systems, information and system technology, machine and drive technology or aircraft
- Microtechnologist
- Measuring technology (bachelor's studies)
- Sensor technology (bachelor's studies)

LEARNING OBJECTIVES

The students are to be able to:

- Understand the basic principles of various typical sensors
- Understand the measurement of basic physical quantities

TOPICS

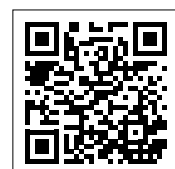
- Temperature measurement
 - Electronic circuits
 - Temperature sensors: Pt100, NTC, KTY and thermocouple
- Pressure measurement
- Light measurement
- Force measurement
 - With strain gauges
 - With bending bar
- Torque measurement
 - With torsion bar
- Angle and speed measurement
 - With optical encoder
- Displacement measurement
 - Resistive
 - Capacitive
 - Inductive
 - With ultrasonic sensor
 - With Hall sensor
 - With reed sensor

SCOPE OF DELIVERY:

Cat. No.	Name	ME6.1.2
700 84-00	COM4LAB Board: Sensor Technology	1
700 84-20	COM4LAB Course: Sensor Technology	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug, Type C*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

Directly to the COM4LAB Course



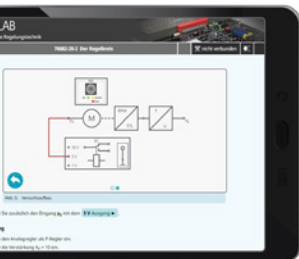
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COM4LAB

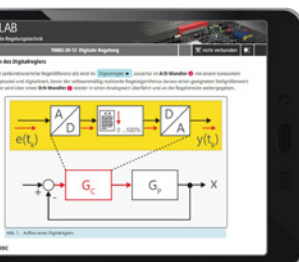
CONTROL ENGINEERING



ME6.2.2 Introduction to Control Engineering



ME6.2.2 - 2. Control loop



ME6.2.2 - 12. Digital control

The **COM4LAB** course entitled **Introduction to Control Engineering** is the first course on the control engineering. The basic concepts and laws of control engineering are explained and practically devised using a number of experiments. The course comprises 12 chapters.

TARGET AUDIENCE

Among others, the course can be used to support the training process for the following professions:

- Electronics technician for: automation technology, energy and building technology, devices and systems, information and system technology, machine and drive technology or aircraft
- Automation technology (bachelor's studies)
- Control engineering (bachelor's studies)

LEARNING OBJECTIVES

The students are to be able to:

- Understand the basic principles of control engineering and
- Understand and to parametrise the basic elements of control engineering

TOPICS

- Open-loop control
- Closed-loop control
- Analysis of controlled systems
- Controlled systems with compensation
- Higher-order controlled systems
- Controlled systems without compensation
- Controller types
- P, I, PI, PD and PID control
- Automatic digital control

SCOPE OF DELIVERY:

Cat. No.	Name	ME6.2.2
700 82-00	COM4LAB Board: Control Engineering	1
700 82-20	COM4LAB Course: Introduction to Control Engineering	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug, Type C*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

Directly to the COM4LAB Course



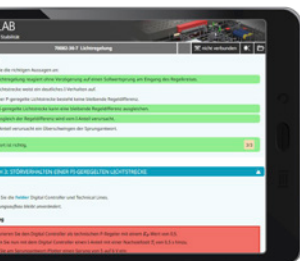
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COM4LAB

CONTROL ENGINEERING



ME6.2.3 Control loops and stability



ME6.2.3 - 7. Light control



ME6.2.3 - 9. Control with discontinuous controllers

The **COM4LAB** course entitled **Control loops and stability** is the second course on the control engineering. The basic concepts and laws of the control loops are explained and practically devised using a number of experiments. The course comprises 10 chapters.

TARGET AUDIENCE

Among others, the course can be used to support the training process for the following professions:

- Electronics technician for: automation technology, energy and building technology, devices and systems, information and system technology, machine and drive technology or aircraft
- Automation technology (bachelor's studies)
- Control engineering (bachelor's studies)

LEARNING OBJECTIVES

The students are to be able to:

- Understand the basic principle of control loops and the evaluation of control loops (stability, performance criteria),
- Understand the implementation of controllers for real technical controlled systems and
- Understand the fault identification in control loops.

TOPICS

- Stability of automatic control systems
- Performance criteria for automatic control loops
- Optimisation guidelines for PID controllers
- Controller design according to Ziegler/Nichols
- Automatic temperature control
- Automatic speed control
- Automatic light control
- Automatic control of controlled systems without compensation
- Automatic control with discontinuous controllers
- Fault simulation

SCOPE OF DELIVERY:

Cat. No.	Name	ME6.2.3
700 82-00	COM4LAB Board: Control Engineering	1
700 82-30	COM4LAB Course: Control loops and stability	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug, Type C*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

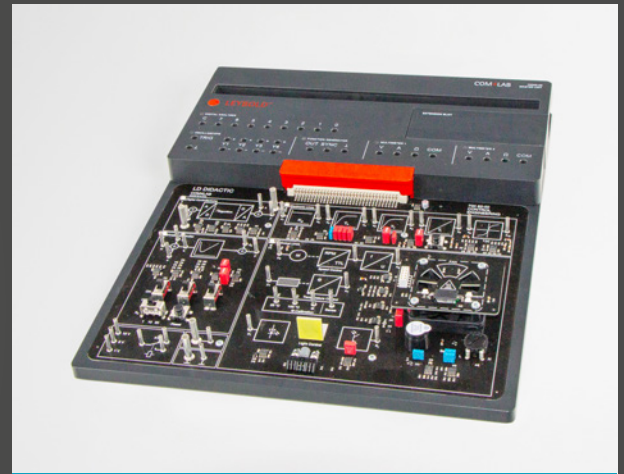
Directly to the COM4LAB Course



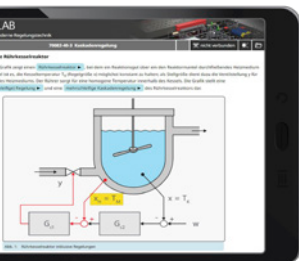
<https://www.leybold-shop.com/me6-2-3.html>

COM4LAB

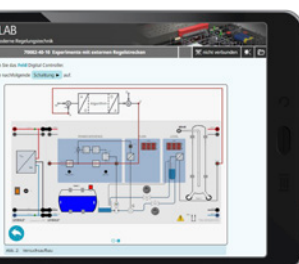
CONTROL ENGINEERING



ME6.2.4 Applied Modern Control Engineering



ME6.2.4 - 3. Cascade control



ME6.2.4 - 10. Experiments with external controlled systems

The **COM4LAB** course entitled **Applied Modern Control Engineering** is the third and final course on the control engineering. The approaches of modern control strategies for the control of complex systems (e. g. in the automotive industry or aerospace) as well as the influence of technical limitations on the control loops are explained and practically devised using a number of experiments. The final chapter offers the possibility for free experimentation with compatible external controlled systems. The course comprises 10 chapters.

TARGET AUDIENCE

Among others, the course can be used to support the training process for the following professions:

- Electronics technician for: devices and systems or aircraft
- Automation technology (bachelor's studies)
- Control engineering (bachelor's studies)

LEARNING OBJECTIVES

The students are to be able to:

- Understand the basic principle of modern control strategies,
- Understand the influence of technical limitations on the control loops and
- Apply and expand the knowledge they have acquired from all **COM4LAB** control engineering courses in free experimentation with external controlled systems.

TOPICS

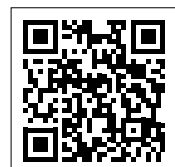
- Systems with dead time
- Constraint of the manipulated variable
- Cascade control
- Introduction to frequency response
- Frequency response of individual basic elements
- Frequency response of combined elements
- Controller desing in frequency domain
- Fuzzy control
- Adaptive control
- Free experimentation with external controlled systems

SCOPE OF DELIVERY:

Cat. No.	Name	ME6.2.4
700 82-00	COM4LAB Board: Control Engineering	1
700 82-40	COM4LAB Course: Applied Modern Control Engineering	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug, Type C*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

Directly to the COM4LAB Course



<https://www.leybold-shop.com/me6-2-4.html>



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<https://www.youtube.com/user/lddidactic>



COM4LAB

AUTOMOTIVE DIGITAL TECHNOLOGY

With both COM4LAB set-ups [Automotive Digital Technology I](#) & [Automotive Digital Technology II](#) students learn digital technology from the ground up. The subject areas are matched to automotive technology in a realistic and applied manner.

AUTOMOTIVE DIGITAL TECHNOLOGY I

The basic principles of Boolean algebra are described using logic operations. The focus of the course is also on troubleshooting. The course comprises 10 chapters.

LEARNING OBJECTIVES

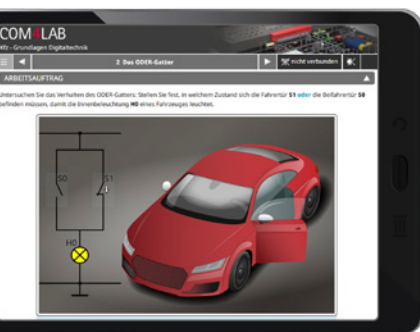
- Setup, function and functional principle of the individual gates and other logic components
- Perform troubleshooting procedures on the logic components

AUTOMOTIVE DIGITAL TECHNOLOGY II

This course explores several flip-flop types and various applications such as counters and shift registers. The course, comprising 8 chapters, also examines the troubleshooting procedure in detail.

LEARNING OBJECTIVES

- Setup, function and functional principle of the individual flip-flops
- Usage of flip-flops and other multivibrators
- Perform troubleshooting procedures on the logic components



MA3.1 - 2. OR-Gatter



MA3.2 - 7. Counter

Directly to the COM4LAB Courses on
Automotive Digital Technology I & II





MA3.1 Automotive Digital Technology I



MA3.2 Automotive Digital Technology II

COM4LAB AUTOMOTIVE DIGITAL TECHNOLOGY I

TOPICS

- TTL modules
 - AND gate
 - OR gate
 - NOT gate
 - XOR gate
 - NAND gate
- Operation with binary inputs
- Binary code
- Seven-segment display
- Multiplexer and demultiplexer
- Fault simulation

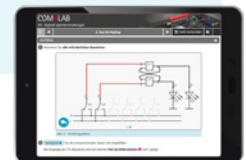


MA3.1 - 5. Logic Operations

COM4LAB AUTOMOTIVE DIGITAL TECHNOLOGY II

TOPICS

- Bistable multivibrators
 - SR flip-flop
 - Clocked SR flip-flop
 - JK flip-flop
- Monostable and astable multivibrator
- Schmitt trigger
- Flip-flop applications
 - Counter
 - Shift register



MA3.2 - 2. SR flip-flop

SCOPE OF DELIVERY:

Cat. No.	Name	MA3.1
700 17-00	COM4LAB Board: Automotive Digital Technology I	1
700 17-30	COM4LAB Course: Automotive Digital Technology I	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug (Type C)*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

Cat. No.	Name	MA3.2
700 18-00	COM4LAB Board: Automotive Digital Technology II	1
700 18-30	COM4LAB Course: Automotive Digital Technology II	1
700 00-00	COM4LAB Master Unit	1
700 00-11	USB-C Charger 45 W Europlug (Type C)*	1
700 00-22	COM4LAB Set of Safety Leads, 2 mm, 24 pcs	1

*Alternatively USB-C charger with UK-plug or US-plug

COM4LAB

WORKRELATED LEARNING

— PRACTICAL EXAMPLE HYDROPOWER PLANT PUMP STORAGE



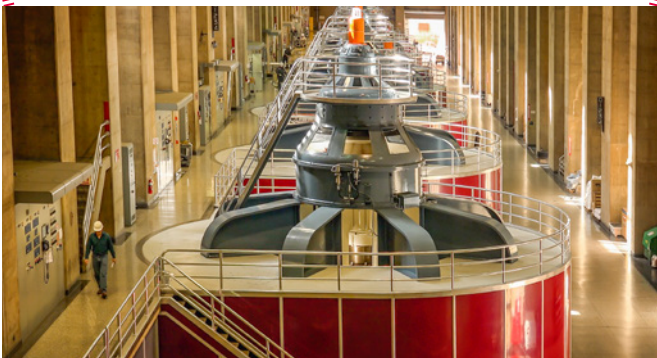
— PRACTICAL EXAMPLE ELECTRIC MOTORS



KNOWLEDGE NEEDED FOR THE WORKING WORLD:

Generating electrical energy

- Synchronous generator
- Mains synchronisation
- Load behaviour



Generating mechanical energy

- Asynchronous motor
- Load start-up
- Efficiency



COM4LAB

BRING THE REAL WORLD INTO YOUR LAB

LD DIDACTIC TRAINING SYSTEMS "ELECTRICAL DRIVES AND MACHINES"



Learning on large training systems with modular training panels covering all required training topic areas



UNDERSTAND COMPLEX INSTALLATIONS

COM4LAB ELECTRICAL MACHINES

MOST COMPACT SOLUTION ON THE MARKET FOR THE TOPIC OF ELECTRICAL MACHINES

- Highlight is the integrated machine test system
- Recording characteristics and connection techniques of electrical motors and generators



COM4LAB

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