

PHYSICS

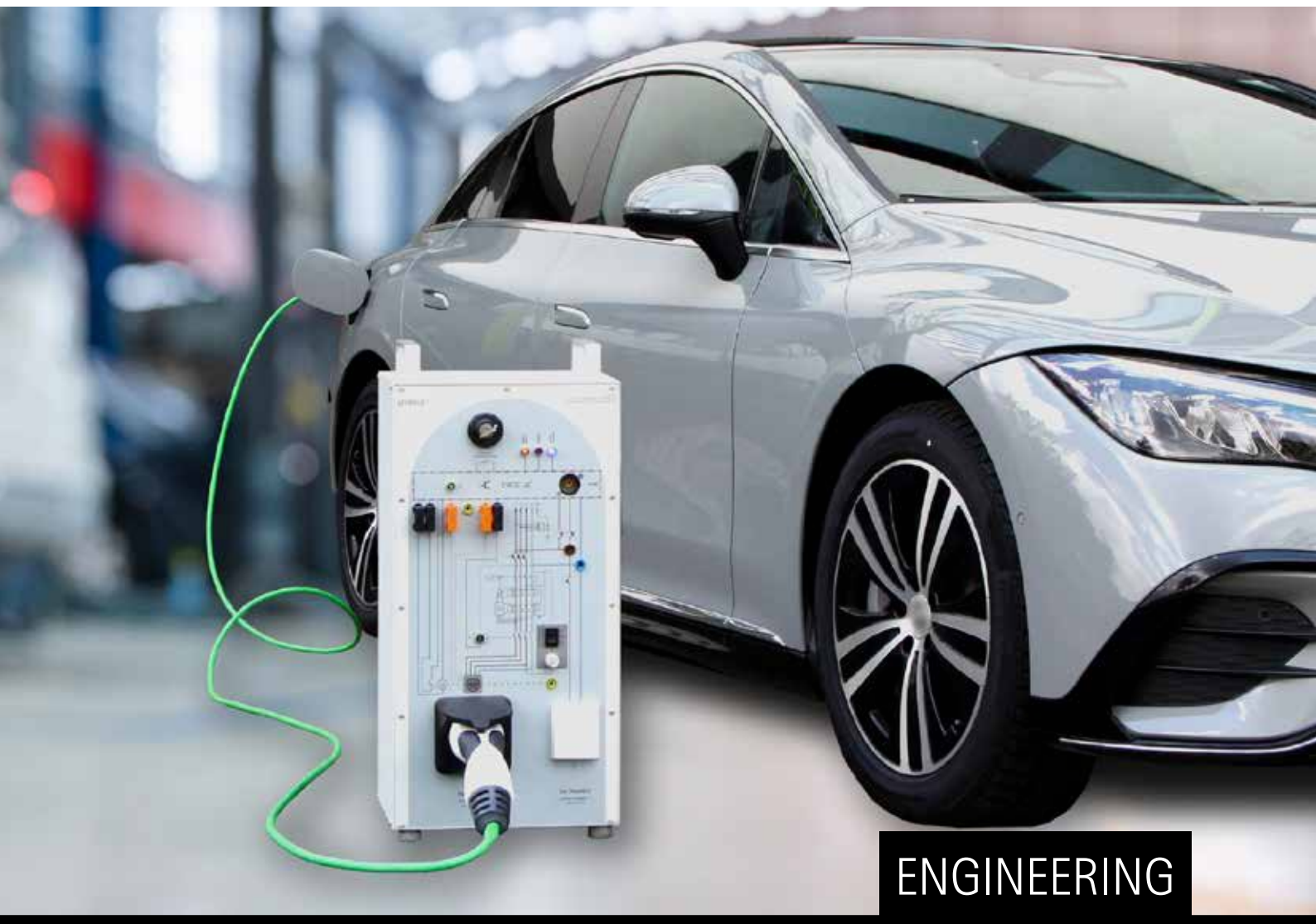
CHEMISTRY  
BIOLOGY

ENGINEERING



LD DIDACTIC

# AUTOMOTIVE TECHNOLOGY



ENGINEERING

- FUNDAMENTALS OF ELECTRONICS WITH PLUG-IN SYSTEM
- FUNDAMENTALS ELECTRONIC WITH COM4LAB
- VEHICLE ELECTRICS
- COMBUSTION ENGINE
- DRIVER ASSISTANCE & COMFORT SYSTEMS
- CHASSIS & DRIVE TRAIN
- AUTOMOTIVE NETWORKING & DIAGNOSIS SYSTEMS
- ELECTROMOBILITY

**LEYBOLD®**



# THE BEST POSSIBLE EDUCATION WITH LEYBOLD SOLUTIONS FOR AUTOMOTIVE TECHNOLOGY

With our LEYBOLD solutions, you can teach your trainees the entire range of topics in automotive technology training in a sustainable way. Our didactic devices and teaching systems ideally combine theory and practice and enable your trainees to safely learn the theory in practical exercises. Get premium quality products that are individually adapted to different learning fields and thus achieve an optimally equipped technology and workshop laboratory.

Our training systems are stand for safe experimentation and allow for group experimentation. We place great emphasis on student-centred active learning, ranging from planning to fault diagnosis and repair. We also offer future-oriented experimentation with digital devices and materials.

At LEYBOLD you get comprehensive solutions from laboratory management to products, equipment set-ups and measurement technology to software and literature. In close cooperation with the automotive industry, we ensure practical relevance and technological advancement. Prepare your trainees for the future of automotive technology - from electromobility to autonomous driving.

**Choose LEYBOLD solutions for excellent training results.**





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# BASICS OF AUTOMOTIVE ELECTRONICS

THE MODULAR,  
COMPATIBLE PLUG-IN  
SYSTEM IS THE PERFECT  
START TO AUTOMOTIVE  
TECHNOLOGY

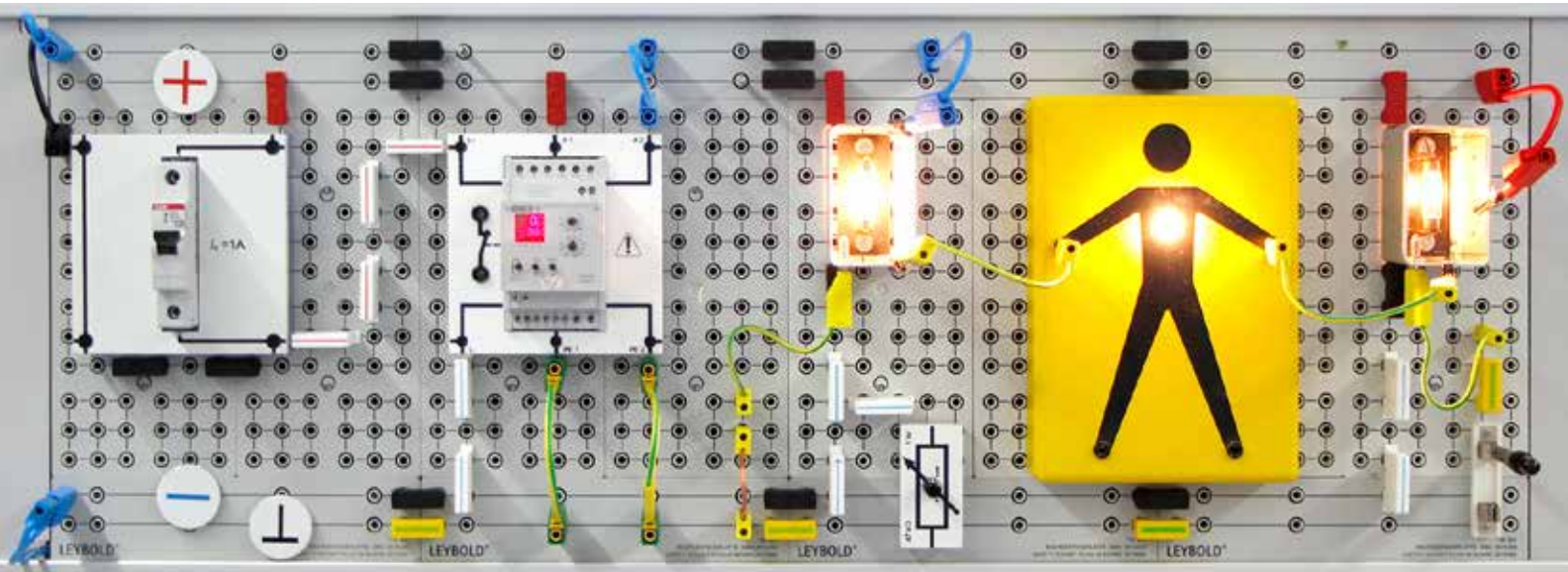
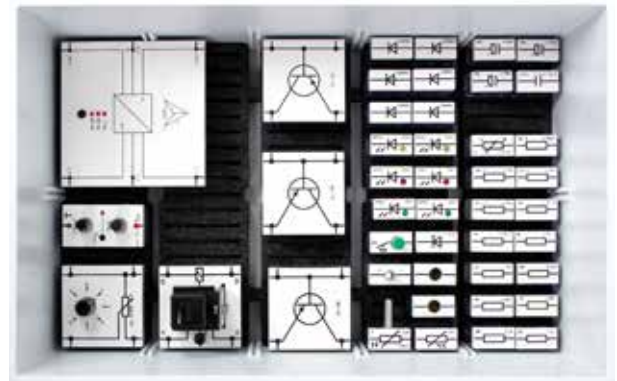
more from page 26

## WITH THE PLUG-IN SYSTEM

The LEYBOLD plug-in system is a tried and tested experimentation programme whose core piece is the plug-in board. The topic-specific sets in stackable plastic storage tray offer space-saving and clearly arranged storage of STE elements, components and accessories.

Digital experiment descriptions for the trainees and accompanying information for teachers are available for performing the experiments. During the step-by-step construction of the circuit, plug-in fasteners ensure contact-safe connections and excellent mechanical hold for all components.

The symbol imprints on the plug-in elements, connectors and boards result in circuit diagram-like views of the experimental set-ups. This facilitates the transfer between circuit diagrams in textbooks and own circuits as well as the recording of experimental set-ups and promotes thinking, learning and experimenting in circuit diagrams.



# WITH COM4LAB

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

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.

COM4LAB courses are available at any time and from anywhere via the cloud. In digital lessons, up to four students can connect their device to a COM4LAB workstation via the network. Students can save courses at any time and continue working on them from any location.



MA3.1 Automotive Digital Technology I

- COMPACT, COMPLETE LABORATORY
- COMPREHENSIVE CURRICULUM COVERAGE
- CLOUD-BASED COURSES
- EFFICIENT TRAINING SYSTEM

## COMPREHENSIVE CURRICULUM COVERAGE

With the two **COM4LAB** kits *Automotive Basics Digital Technology* and *Automotive Digital Memory Circuits*, trainees learn digital technology from the ground up. Both digital technology kits also deal in detail with troubleshooting.



DIGITAL TRAINING WITH COMBINING THEORY & PRACTICE  
more from page 36



MA3.1 - 2. The OR gate



MA3.2 - 7. The counter

# DRIVER ASSISTANCE SYSTEMS

## LEARN RELIABLY

This covers almost all fields of learning for motor vehicle mechatronics technicians.

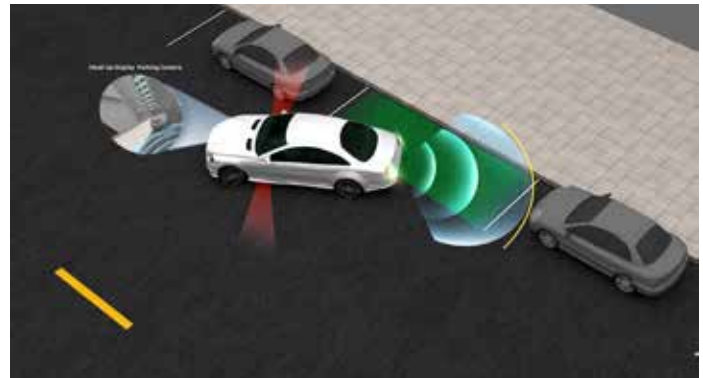
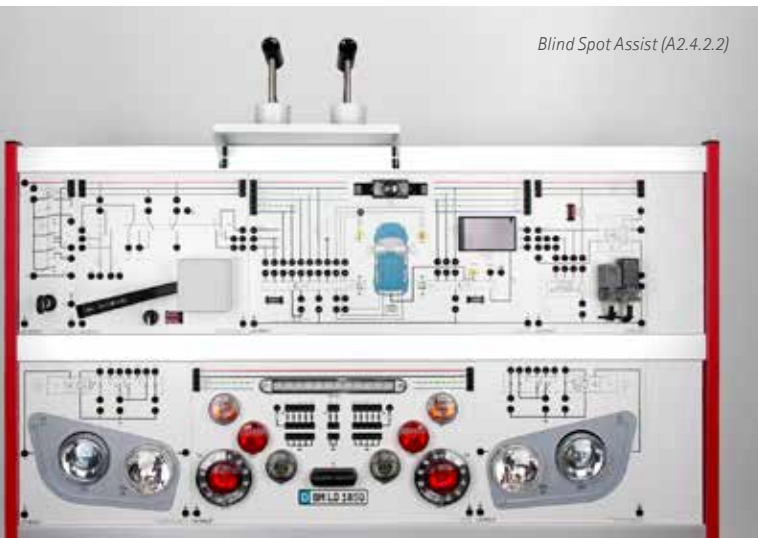
The systems presented here are used in particular in the learning fields of the 3rd and 4th year of training and thus support the trainers in the technical and practical implementation.

DRIVER ASSISTANCE  
SYSTEMS: LEARNING  
SECURITY & COMFORT  
more from page 58

## FROM THE PARKING AID TO THE BLIND SPOT ASSIST



*Blind Spot Assist (A2.4.2.2)*



## TRAIN SPECIFICALLY WITH THE TRAINING PLATE SYSTEM – TPS

- Modular teaching plate system (quick and easy expansion)
- Construction and design close to the original vehicle
- Clear front views
- Experimental literature for preparing lessons & performing experiments



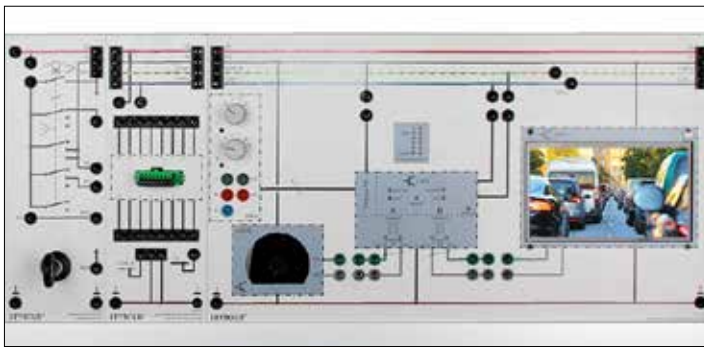
# BUS TECHNOLOGY

## FROM TROUBLESHOOTING TO REPAIR

VEHICLE DIAGNOSTICS:  
THE CRUCIAL ROLE OF  
BUS TECHNOLOGIES  
more from page 67

Modern vehicles are equipped with a multitude of control units and sensors that communicate with each other via a bus system.

A sound understanding of bus technologies is essential for trainees to efficiently diagnose vehicles, perform targeted troubleshooting and solve problems. Therefore, LEYBOLD offers a wide portfolio of teaching systems for different bus systems.

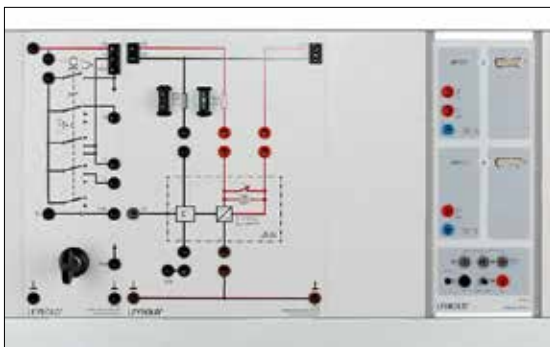


### AUTOMOTIVE ETHERNET (P. 71)

Automotive Ethernet standard 100BASE-T1 for the transmission of audio and video data in infotainment and automatic driver assistance systems (ADAS) as well as fast data transmission between diagnostic tester and vehicle.

### SENT-BUS (P. 70)

Interface for fast data exchange between a sensor or actuator and a control unit.



### LIN-BUS (P. 73)

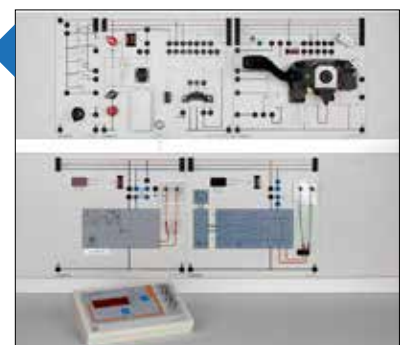
Designed as a single-wire bus, provides sensor data or triggers actuator events, low data transmission rate.

### CAN-BUS / CAN-FD-BUS (P. 67 / P. 69)

Serial bus system for communication between different control units in a vehicle, with flexible data rate (FD), efficient in communication, fast and increasingly used in time-critical systems, such as the powertrain with ABS/ESP.

### MOST-BUS (P. 68 / P. 72)

Transmits audio and video signals almost in real time and without interference via optical waveguides, is used in multimedia systems.



LD DIDACTIC offers various experimental set-ups that deal with the respective bus technology. The trainees gain the ability to understand and interpret the communication between the control units. This enables more precise diagnosis and repair of vehicles. With the training systems, systematic troubleshooting is taught and the maintenance and Bus technology repair practised.



# ELECTROMOBILITY

## TOMORROW'S MOBILITY IS ELECTRIC

1



### REALISTIC MEASUREMENT UNDER HIGH VOLTAGE

- All training systems are safe for trainees & trainers
- Low voltage (24 V) or safe measures for dangerous touch voltages

SAFE & PRACTICAL LEARNING OF MAINTENANCE OF HYBRID & ELECTRIC VEHICLES

2



### REALISTIC FREE CUTTING

- Training systems use real high voltages of >60 V for realistic automotive workshop scenarios
- Safe training on real voltages *(the safety of the trainees is guaranteed at all times)*

3



### ORIGINAL COMPONENTS & MEASURING INSTRUMENTS

- Original measuring devices for high voltage measurement as in car workshops
- Original electric vehicle components
- Ensure realistic functional testing, as in a real vehicle with all relevant aspects

High voltage system technology (A2.7.2.5)

TRAINING AID:  
EMERGENCY RESPONSE UNIT



High voltage battery technology (A2.7.2.6)





# COVERAGE OF ALL ASPECTS & TOPICS OF HIGH VOLTAGE TECHNOLOGY IN TRAINING



HYBRID & ELECTRIC VEHICLES



SAFETY INFRASTRUCTURE



SYSTEM COMPONENTS



HIGH VOLTAGE SYSTEM COMPONENTS



INFRASTRUCTURE (CHARGING STATIONS)

## COVERING THE WHOLE PROCESS OF HIGH-VOLTAGE SERVICE

Guidelines & Regulations



Planning



Testing



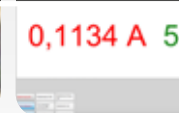
Measurement



Evaluation



Diagnosis



Repair



4

### FAULT SWITCHES

- Training systems are equipped with fault switches
- Teachers can set different tasks for fault finding
- Fault switches with lockable covers to avoid student's access and manipulation



5

### FLEXIBLE CELL CHEMISTRY

- Exchangeable cell blocks with different chemical compositions
- Simulation of batteries if not build in the training systems
- Batteries always have the required state of charge for the task at hand



High voltage vehicle technology (A2.7.2.7)



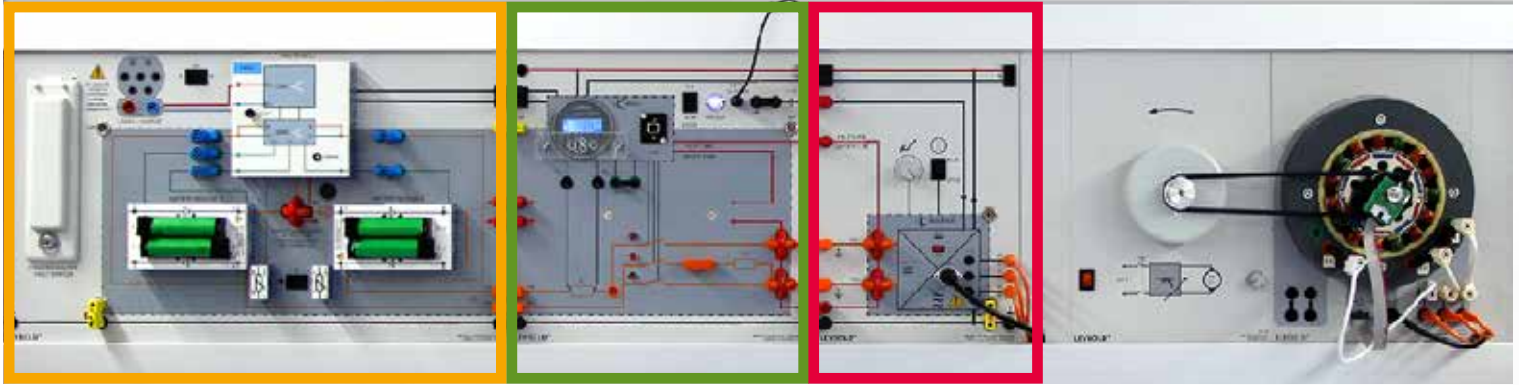
Workstation high voltage technology (A2.7.2.8)

ELECTROMOBILITY:  
TAKING RESPONSIBILITY,  
MOVING THE WORLD,  
SUSTAINABLE INTO  
THE FUTURE!

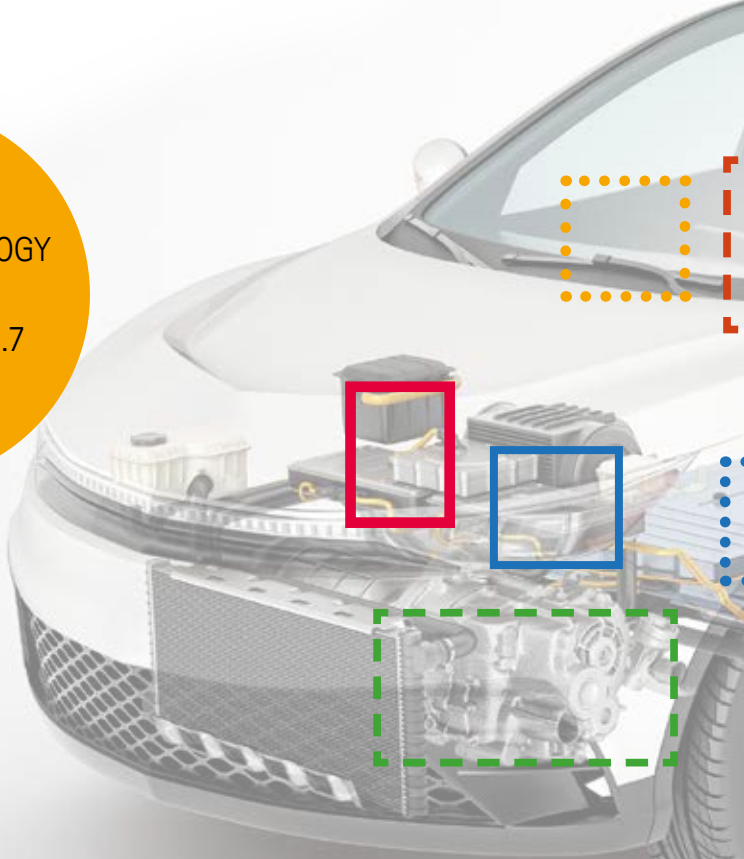
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# LEYBOLD TRAINING SYSTEMS

PRACTICAL, COMPACT & DIDACTICALLY PREPARED  
FROM THE LABORATORY TO THE VEHICLE

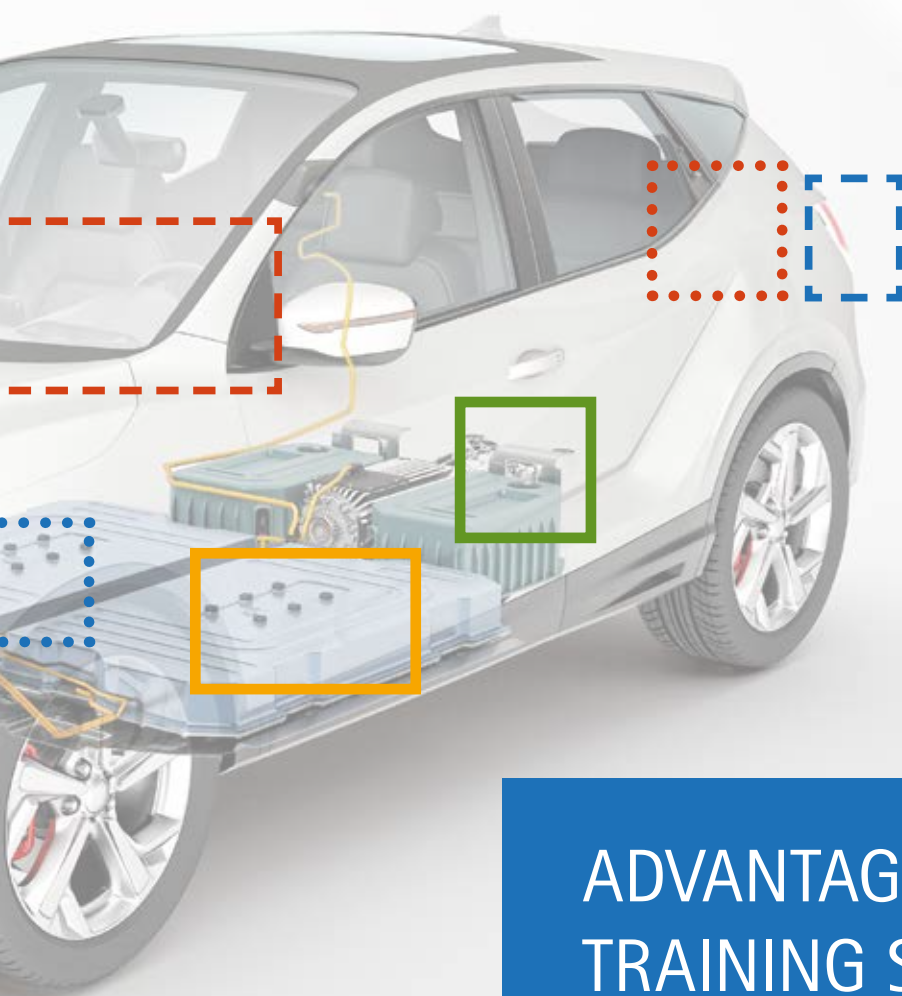
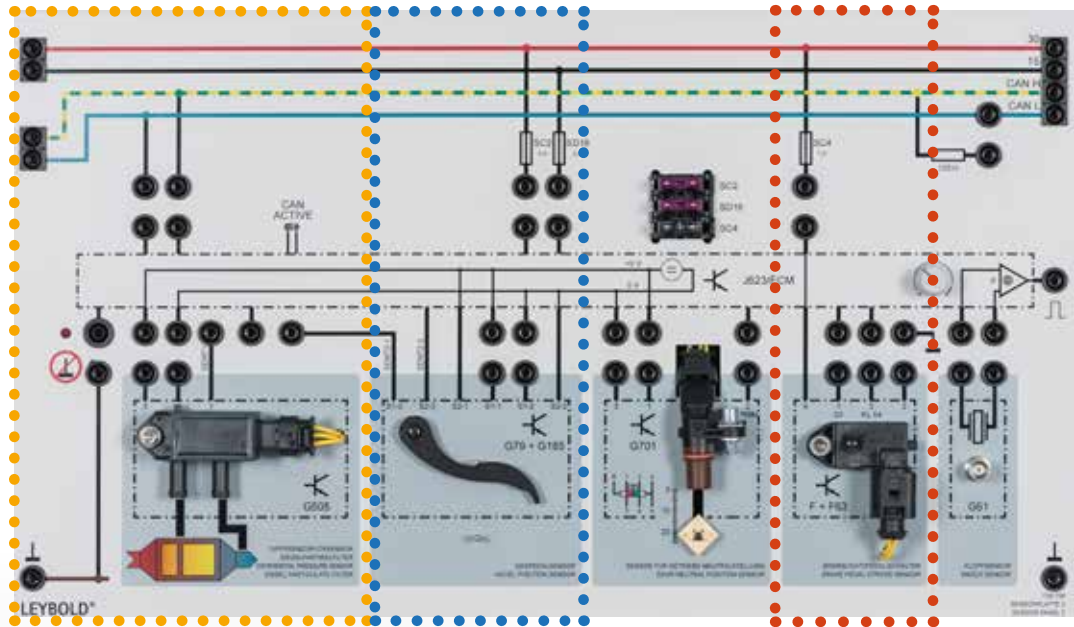


HIGH VOLTAGE  
BATTERY TECHNOLOGY  
MANAGEMENT  
A2.7.2.5 - A2.7.2.7  
more from page 78



AUTOMOTIVE  
LIGHTING  
WITH CAN-BUS  
A2.1.3.1  
more from page 46





AUTOMOTIVE SENSORS  
A2.4.1.4  
more from page 59

## ADVANTAGES OF DIDACTIC TRAINING SYSTEMS

- Practical due to original components from the automotive industry
- Faults reproducible at any time
- Modular training systems that can be continuously expanded
- Safe for teachers and trainees
- Complete experimental set-ups with all accessories and literature

# PRACTICAL DEVELOPMENT COOPERATION WITH AUDI BILDUNGSWESEN\*

## ORIGINAL COMPONENTS & MEASURING DEVICES FOR BEST LEARNING RESULTS



### AUTOMOTIVE HIGH VOLTAGE SYSTEM TRAINER

With the AUDI high voltage system trainer, it is possible to simulate insulation faults in the HV cables and components. This allows systematic troubleshooting to be trained and improved. In contrast to the vehicle, all installed HV components are easily accessible. In the event of a fault, only a detectable HV voltage is present, the current-carrying capacity of which is very low.

The system provides an overview of all installed HV components that originate from original vehicles. The work required for unlocking can be carried out identically to the vehicle but under simpler conditions.

The high-voltage system trainer takes the daunting complexity out of HV vehicle technology by providing a clear and easy-to-understand structure. The application and feel correspond to the real vehicle.

## ORIGINAL MEASURING INSTRUMENTS FROM REAL WORKING ENVIRONMENTS

- Use of original measuring equipment used in car workshops
- Measurements as they occur in everyday work, also with high voltage measurements
- Learning and understanding the expected and occurred measurement results in real time
- Deepening knowledge of electronic measurements and training in the use of measuring instruments





## BRING THE REAL WORLD INTO YOUR LABORATORY

We develop and produce our teaching systems in close cooperation with the automotive industry. This ensures that our systems have a high degree of realism and are continuously developed technologically. Learning in realistic, practice-oriented laboratories that also cover current technology and market trends ensures the best possible skilled personnel for the future.

Since 2003, we have been working closely with the AUDI AG training centre and developing teaching systems, such as the "Training panel lighting" or the "Automotive high-voltage systems trainer".

# STUDENT WORKSTATION

## PRACTICAL, FLEXIBLE & MODULAR

Student measuring stations consist of a student workstation with a measuring connection and a support mask suitable for the experiment set-up. These measuring stations are connected to each other and to the teacher's training system via two 38-pin cables - either in star or series structures.

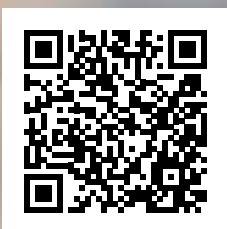
At their workstations, the trainees can record and evaluate all measured values of the system online. Furthermore, the teacher can simulate system system-specific faults, which can be examined at the student workstations using measurement technology.

- Quick assembly due to simple wiring
- Compact dimensions
- Up to 70 PINs can be used
- Original values from the vehicle or model at the student workstation
- Short-circuit proof to the control unit
- Overlay masks with wiring diagrams for many available models or vehicles
- Measurements possible with original measuring instruments



Background:  
Petrol injection A2.3.2.1

Foreground:  
Student workstation for measuring connection (740 050)  
with support mask LH Motronik (740 052)  
and Sensor-CASSY 2 (524 013SKFZ)



<https://www.id-didactic.de/en/contact/ansprechpartner-euro.html>

*You want more information or a personal offer?*

# GET IN CONTACT WITH US

# THE DIDACTIC MEASURING & DIAGNOSIS SYSTEM CASSY - THE RIGHT SOLUTION FOR AUTOMOTIVE TECHNOLOGY TRAINING

## SENSOR-CASSY 2

### INTERFACE FOR RECORDING MEASUREMENT DATA

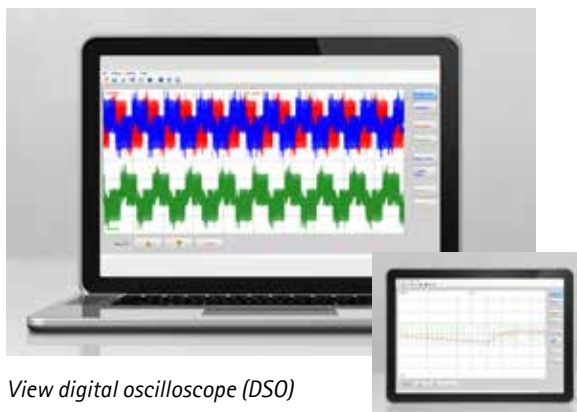
- For connection to the USB port of a computer or to another CASSY module
- Simultaneous measurement of voltage, current and two other quantities possible
- Automatic sensor box recognition
- Can be set up variably as a tabletop, desk or demo unit (also in the CPS/TPS experimental frame)



Sensor-CASSY 2 (524 013) offers two galvanically isolated voltage inputs, an alternative current input and two sensor box inputs in parallel. All inputs have switchable measuring ranges.



View digital multimeter (DMM)



View digital oscilloscope (DSO)

## AUTOMOTIVE DIAGNOSTIC TESTER

### SOFTWARE FOR MEASUREMENT DATA ACQUISITION & EVALUATION

Special software suitable for automotive technology training and from the CASSY family

- User interface modelled on an original diagnostic tester
- Supports selected automotive sensors
- Suitable for electromobility
- Integrated protocol analysis for CAN, LIN, KM and SENT
- For all workstations in your institute (single-user licence = institute licence)

# LEYLAB

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



In the online portal LeyLab, instructors can find everything they need for timesaving preparation. In addition to the appropriate equipment, the corresponding devices, including the digital experiment instructions with many tips, are quickly and clearly displayed and found in the Expert version. With one click, the instructors can share the instructions with all tablets, smart phones and PCs of the trainees.

### EXPERIMENT COLLECTION

- Access to the entire LD experiment catalogue with all relevant information on each experiment
- Find desired experiment quickly and reliably
- Easy expansion of the LD experiments
- Create your own, new experiments easily
- Collection of all kinds of documents such as PDFs, videos or links to websites

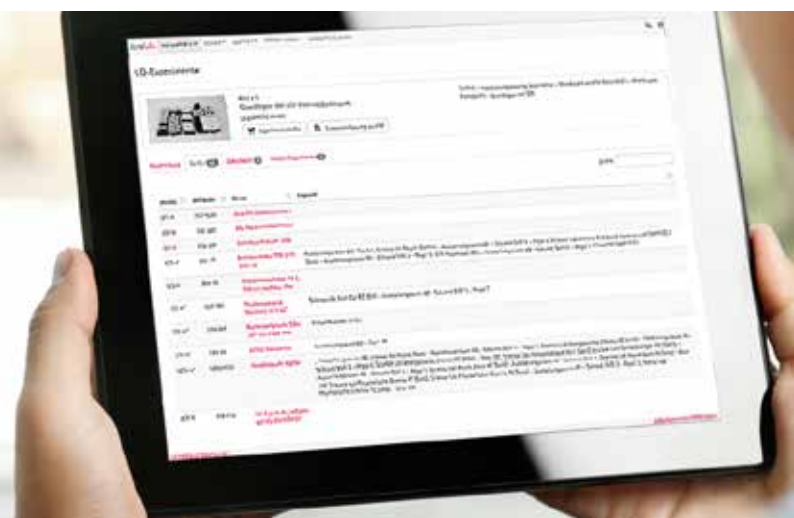


### CENTRALLY AVAILABLE LITERATURE

- Purchased LD literature is listed under associated "Documents" displayed
- Easily shareable with all trainees
- Own instructions can be integrated

### OVERVIEW OF DEVICES

- Direct overview of all available units including number and storage location
- Instructions for use
- Simple inventory of the entire collection



- No installation required
- For all platforms, tablets, smartphones, laptops or PCs
- Accessible at any time and from anywhere
- Management of LD software licences and LD literature licences in one place



# DIGITAL INSTRUCTIONS LAB DOCS

## WORK THROUGH COMPLETE COURSES ON TABLET & PC

The familiar experiment instructions in paper form are now not only digital, but interactive and editable. The trainees enter answers directly into the so-called Lab Docs on their tablets. Measured values flow into tables in real time and can be analysed immediately. In addition to the familiar instructions, tasks and evaluations, pictures and videos can also be integrated. „All in one“ creates a complete digital protocol that can be saved and easily shared for correction.

Digital courses are available from LD DIDACTIC for every topic in automotive technology. These are made up of several Lab Docs that focus on a specific field of learning. The entire course can be accessed on any tablet, smartphone or PC (of the trainees) - regardless of the manufacturer and the software platform. All problematic issues such as installations, updates, device age or mix of manufacturers are thus a thing of the past.

After opening the course, the Lab Doc is selected via a content structure. The trainees can work with it immediately.



### EXPERIMENT GUIDE

#### EASY TO USE & FUNCTIONAL

- Clearly structured worksheets with references & illustrations
- Step-by-step instructions for performing experiments and warnings for safe experimentation
- Real example measurement results & diagrams for trainees to check themselves

#### SIMPLE DISTRIBUTION OF THE LITERATURE

- Sharing Lab Docs from LeyLab with all trainees
- Via QR code on site or in online lessons
- Link via email, learning platform or online classes
- PDF file via e-mail, learning platform or online classes

## LAB DOCS EDITOR PRO

*Easily adapt digital experiment instructions or create them yourself*

To achieve the best possible learning result, the digital experiment instructions can be adapted to your own didactic and methodological concept. This is very easy with the LEYBOLD Lab Docs Editor Pro software. You can also create your own completely new experiment instructions without the necessary prior knowledge.

- Creating instructions and tasks
- Modify & adapt LD documents
- Preparation of examination papers
- Insert images, vector graphics, hyperlinks, etc.
- Embedding videos and web pages

# SPECIALIST ROOM PLANNING & FURNISHING



## YOUR NEW LEYBOLD ROOM

Based on your requirements, we plan with you to create a specialist room that meets your curriculum. Our room planners design your individual laboratory by tailoring the desired experimental equipment, furniture and storage solutions to your room situation.

Thanks to our many years of experience, we are your reliable partner in all phases of project planning through to implementation.

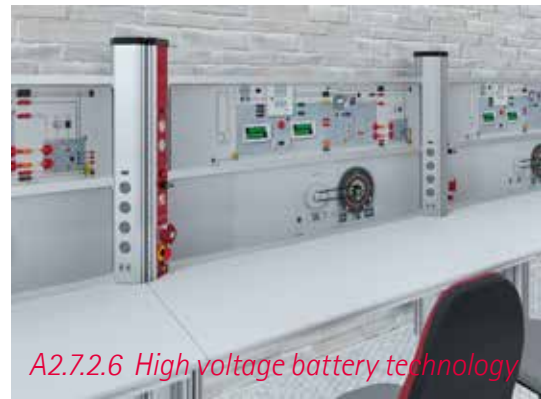
# EVERYTHING FROM ONE SOURCE

## LAB & CLASSROOM PLANNING

- Practice-related equipment
- Observance of safety standards
- Preparation of planning documents
- Preparation of service texts

## FURNITURE

- Individual solutions
- Networking of teaching systems
- Storage systems to match equipment & fittings
- Long repurchase & supplement guarantee



*A2.7.2.6 High voltage battery technology*



*A2.1.1.2 Threephase alternator*



# LEYBOLD STANDARD LAB PROPOSALS

## YOUR COMPLETE LEYBOLD AUTOMOTIVE LAB

Not sure about the selection of experiments for your department? LD DIDACTIC created two automotive standard lab proposals based on our 170 years of cooperation with many vocational training centers in Germany and worldwide. The collections of training equipment include entire set-ups, data logging devices and software, experiment instructions and all spare parts needed. Furthermore the laboratories contain LEYBOLDs digital tools for lab management, digital preparation of laboratory work and classes as well as the use of digital media.



*Go directly to automotive standard lab proposal with the QR-code*

### AUTOMOTIVE STANDARD LAB PROPOSAL

## FOR 3 YEAR COURSE VEHICLE ELECTRONICS

The lab includes equipment and curricula to learn all related topics of automotive electronics. It involves a small physics lab to learn the necessary basics. The curriculum contains:

#### YEAR 1:

- Basic physics
- Fundamentals of automotive electronics
- Maintenance and inspection of cars and systems
- Check and replacements of simple components
- Identification and repair of failures
- Retrofitting of cars

#### YEAR 2:

- Inspection and additional works
- Failures of electrical, charging and starter systems
- Diagnosis of power-train system

#### YEAR 3:

- Comfort and safety system
- Breaking system
- Diagnosis and maintenance of networks
- E-vehicles and high voltage technology



The lab is delivered including furniture on request and topics and size can be modified according to your needs. It is the perfect supplement to your workshop. The delivered management software allows to include all your content from third parties, so you can organise your training based on one platform.

The modern interfaces allow to use tablets or mobile phones of the students in the training, the documentation can also be print out and be used in a classic way on paper.

### AUTOMOTIVE STANDARD LAB PROPOSAL

## FOR ADVANCED TRAINING ON E-VEHICLES

Selection of a training set-up to run a 2 weeks course for an advanced training to learn all aspects of e-vehicles. It starts from the fundamentals of machines and safety around the electrical machine. In a second step, there are in-depth trainings for the topics of hybrid and pure electric vehicles, maintenance and charging, battery management of different battery types and finally the high voltage system trainer, which is the last step before working on a real electric car.

The topics and size can be modified according to your needs. The lab comes with a curriculum and all documentation, which can be used in a digital or paper version.

# SERVICE



## INDIVIDUAL ADVICE

Are you planning a new laboratory or the expansion of your existing equipment?

We will advise you competently and individually – our experienced and trained specialist advisors will be happy to visit you.



## INVENTORY

Would you like to adapt your equipment to current didactic requirements?

We review your equipment together with you and support you in compiling and implementing your individual teaching material requirements.

# LEYBOLD®



THE CONTACT INFORMATION  
FOR YOUR LOCAL CONSULTANT,  
CLICK HERE!



[https://www.ld-didactic.de/  
en/contact/contacts-  
worldwide.html](https://www.ld-didactic.de/en/contact/contacts-worldwide.html)

LEYBOLD NOT ONLY STANDS FOR  
THE HIGHEST PRODUCT QUALITY,  
BUT ALSO OFFERS YOU  
PROFESSIONAL SERVICES IN  
ALL PROJECT PHASES.

- Individual consulting on site
- Equipment planning & documentation
- On-site briefing
- Commissioning
- Training
- Further training
- Technical service after purchase

# HOW TO USE THIS CATALOGUE

## STRUCTURE OF THE PAGES

Subject

Subsection

Topic

Equipment

Each equipment is marked with an A - for Automotive - and a four-digit number

Product image

Overview

of the fields of learning

Further equipment

Equipment list

Short description

of the topic and the equipment

**AUTOMOTIVE TECHNOLOGY**

**ELECTROMOBILITY**

**Electric vehicle**

A2.7.2.1  
Electrical machines in hybrid and electrical cars

**FIELDS OF LEARNING:**  
1, 3, 6, R, 11P, 11S, 12P, 13S, 14S

Further equipment(s):  
A1.1.3.1 on p. 26

Electrical machines in hybrid and electrical cars (A2.7.2.1)

Cat. No.	Description	A2.7.2.1	Cat. No.	Description	A2.7.2.1
562 116	ELM coil, 500 turns	3	720 569	Software: Vehicle diagnosis	1
562 117	ELM reversing diode	1	576 52	Ignite switch 576 52/16	1
562 181	ELM brush holder coil	1	577 32	Resistor 100 Ohm, 576 27/16	3
562 12	ELM brush	2	577 44	Resistor 1 kOhm, 576 27/16	1
562 16	ELM Magnet rotor	1	576 16	Capacitor 1 µF, 576 27/16	1
562 22	ELM two-pole rotor	1	721 800	Storage ELM	1
562 23	ELM three-pole rotor	1*	562 16	Pin key	1
562 26	ELM magnetic reed switch	1	726 32	Pin key frame 1160, two-level	2
721 816	ELM set of multipole stator and rotor	1	562 31	Oil, 100 ml, in driping bottle	1
721 816	ELM PM rotor magnets, interior	1	720 9621	Safety equipment cables, set of 11	1
562 081	ELM pole shoe for magnets	2	778 621	11F digital: Electric mobility	1
562 101	ELM with-pole shoe for coils	3	720 01	Cable and plug box	1
562 201	ELM Rotating field brushes	1			
562 261	ELM Copper ring with iron disc	1			
562 191	EMIM Magnet rotor 4 pole	1			
576 48	Magnets, 36 mm diam, pair	1			
614 011	Magnetic field indicator	1			
726 722	Low Voltage Three Phase Inverter	1			
721 812	ELM rotor position sensor	1			
721 86	Drive unit	1			
721 87	Star delta load	1			
721 811	Brush machine unit	1			
721 21	Automobile Motor Zero-Center	1			
721 35	Automobile Motor Zero-Left	1			
180 0136	Eachometer (Buntefeld)	1			
524 0621	11F version 5	1			
524 0431	30-A fuse	1			
524 024	Timer 5min	1			
524 025	Sensor: CASSE 2 Starter	1			
524 012	Sensor: CASSE 2	1			

\*Additionally recommended

LEYBOLD uses components from the modular "ELM" electric training machine system for the trainees to be able to build the various types of machines by hand. This teaches basic knowledge and concepts, such as

- electromagnetism
- induction
- voltage generation
- motor
- generator etc.

The electrical machines are displayed transparently and are functionally constructed. The inverter, which converts the DC voltage of the high-voltage battery into a 3-phase AC voltage to supply the electrical machine, operates at a voltage level of <math>\approx 24\text{ V}</math> as standard, thus providing absolute safety for students and trainees.



## TAKE ADVANTAGE OF OUR EQUIPMENT FOR YOUR LEARNING FIELDS

LEARNING FIELDS	DESCRIPTION
1	Maintain and inspect vehicle systems according to specifications
2	Check, dismantle, replace and assemble systems
3	Understanding components and troubleshooting methodology
4	Management and controlling of light systems
5	Understanding and controlling of engine systems
6	Understanding the various bus/communication systems used within vehicles
7	Identifying assemblies and systems subject to wear and tear
8	Diagnosing mechatronic drive management systems
9	Investigation into comfort systems in modern vehicles
10	Diagnosis of chassis and brake systems
11 P/N/S	Diagnose and management of drives and systems in modern vehicles
12 P/N/S	Diagnosis of drives, comfort and systems
13 P/N	Identifying and checking of various drive components
13S	Identifying systems used in hybrid and electric vehicles
14 P/N/S	Understanding and fault finding and upgrading of systems

*P: Car technology | N: Commercial vehicle | S: System & high voltage technology*

# CHAPTER OVERVIEW

## EQUIPMENT ACCORDING TO THEMES

### A1 FUNDAMENTALS OF CAR ELECTRONICS

A1.1	FUNDAMENTALS OF ELECTRONIC PLUG-IN SYSTEMS	26
MA	FUNDAMENTALS ELECTRONIC COM4LAB	36

### A2 AUTOMOTIVE TECHNOLOGY

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A2.7	ELECTROMOBILITY	76





# A1 FUNDAMENTALS OF CAR ELECTRONICS

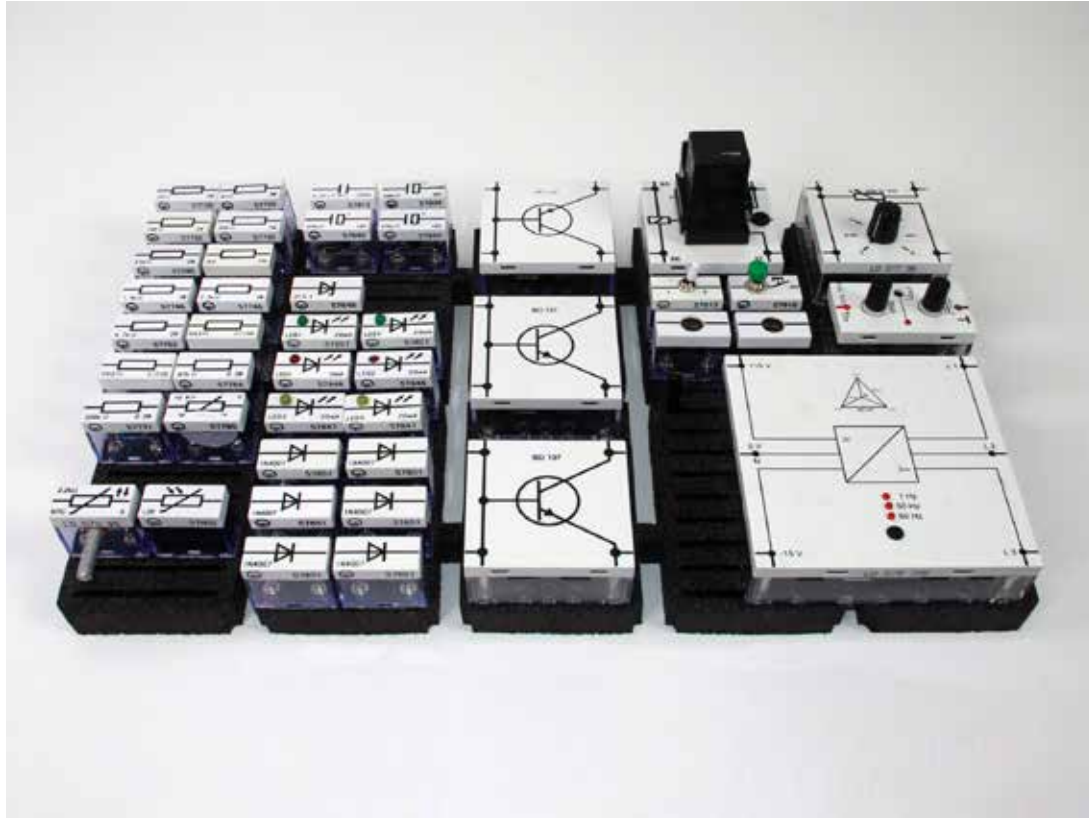
A1.1 FUNDAMENTALS OF ELECTRONIC PLUG-IN SYSTEMS  
MA FUNDAMENTALS ELECTRONIC COM4LAB

### Fundamentals with STE

A1.1.1.1  
Fundamentals of  
electrics/electronics

FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S

Further equipment(s)  
A2.1.2.1 from p. 44



Sensors in cars (A1.1.1.2)

Cat. No.	Description	A1.1.1.1
727 5201	Set automotive plug-in elements I	1
738 985	Automotive meter	2
739 007	Data bus Analyzer USB	1
501 48	Bridging plugs STE 2/19, set of 10	2
501 46	Connecting leads 19 A, 100 cm, red/blue, pair	2
562 791	Power supply unit (mains adaptor), 12 V AC	1
726 501	Safety socket plug-in board, 297 mm x 200 mm	2
726 88	AC/DC stabilizer	1
LDS 00001	Stopwatch, digital	1
778 810	LIT-digital: Fundamentals of automotive electrical systems	1

Our plug-in equipment teaches basic knowledge of electricity, electronics and digital technology specifically in view of typical applications in vehicles and is used e. g. by Volkswagen for education.

The plug-in system represents an ideal introduction to these subjects. It also distinguishes itself by:

- conventional electronic components in see-through casing,
- typical vehicle components in see-through casing,
- a particularly robust design, and
- a layout identical to circuit diagrams on the plug-in board with
- ISO-compliant symbolic representation of the components.

Electronic components, vehicle sensors and transmitters, and their applications in a complete circuit are studied.

Electronic circuits are part and parcel of every modern vehicle. A general understanding of automotive electrics therefore requires a basic knowledge of both the electrical and the electronic system. Only then can faults be quickly localised and rectified.

This understanding is also important given the increasing prevalence of electric vehicles. In this context, sensors, actuators, drives, lighting units, data transfer systems, etc. are the important components examined for their basic functionality using this equipment.

This group of components covers the following areas of the electrical/electronic systems in a vehicle:

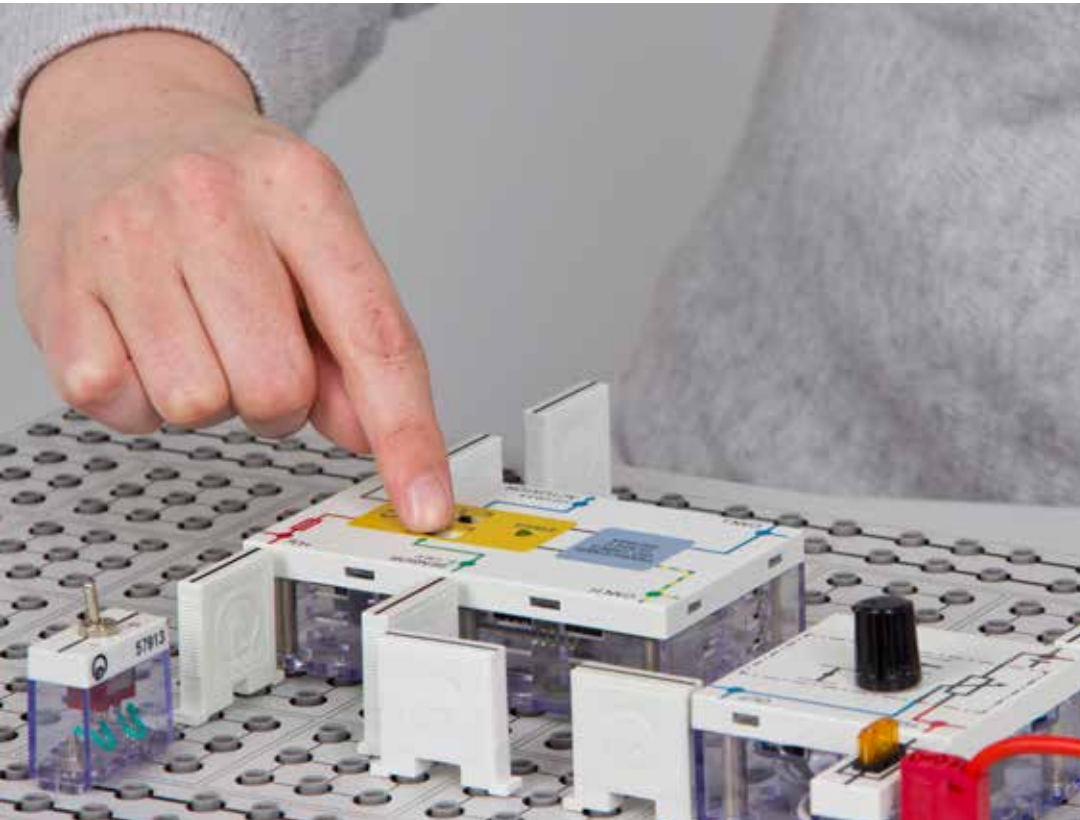
- the electrical circuit
- the ohmic resistor
- current and voltage sources
- the capacitor
- the coil
- the transformer
- the relay
- special resistors such as NTC, PTC or LDR
- the diode
- the Zener diode
- LEDs
- the transistor and
- the thyristor.

The circuits used in automotive electronics are then set up and tested, e.g.:

- an electronic rev counter
- an electronic voltage regulator for three-phase alternators or
- a transistor control device for contact-controlled ignition systems.

### Fundamentals with STE

A1.1.1.2  
Sensors in cars



FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S

Further equipment(s)  
A2.4.1.4 on p. 59

#### Sensors in cars (A1.1.1.2)

Cat. No.	Description	A1.1.1.2
727 5185	Basics of vehicle sensors, STE, set	1
727 5182	Vehicle sensors 1, STE, set	1
727 5183	Vehicle sensors 2, STE, set	1
727 5184	Vehicle sensors 3, STE, set	1
758 209	Vacuum pressure sensor, digital, STE	1
726 501	Safety socket plug-in board, 297 mm x 200 mm	3
501 48	Bridging plugs STE 2/19, set of 10	6
758 211	MAF sensor, digital, STE 4/10/200	1
758 208	DC/DC Converter, STE 4/50/100	1
739 271	Lambda Sensor, heated	1
666 711	Butane gas burner	1
666 712ET3	Butane cartridge, 190 g, set of 3	1
300 02	Stand base, V-shaped, small	1
300 41	Stand rod, 25 cm, 12 mm Ø	1
301 01	Leybold multiclamp	1
666 555	Universal clamp 0...80 mm	1
524 064	Pressure sensor S, ±2000 hPa	1
524 013S	Sensor-CASSY 2 Starter	1
739 589	Software: Vehicle diagnosis	1
739 835	Kelvin-sensing cable, set of 2	1
524 031	Current source box	1
375 58	Hand vacuum pump	1
307 70	Tubing 8 mm Ø, 1 m, plastic	1
604 504	PVC tubing, 12 mm diam., 1 m	1
580 0133	Wind Producer Plug-in Module 4/50/100	1
531 183	Digital multimeter 3340	1
726 88	AC/DC stabilizer	1
521 536	DC Power Supply 2 x 0...16 V/2 x 0...5 A	1
501 45	Connecting lead 19 A, 50 cm, red/blue, pair	4
778 810	LIT-digital: Fundamentals of automotive electrical systems	1

Cat. No.	Description	A1.1.1.2
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1*
689 0815	Set of 10 magnets	1*
727 585	STE universal case	1*

\* additionally recommended

Additionally, typical vehicle sensors are studied with the "Sensors 1" set. The included equipment enables experiments in the following topics:

- Bipolar transistor
- Hall sensor ABS
- Hall sensor distributor element
- Inductive transmitter, and
- Line protection with fuses.

The "Sensors 2" set offers additional sensors. These include:

- The pressure sensor
- The position pick-up
- The throttle valve potentiometer, as well as
- The sunlight sensor for automatic air conditioning.

A discrete-level sensor can be connected via the oxygen sensor adapter box and studied using the flame from a Bunsen burner.

Further digital sensors are offered in the set "Automotive sensors 3" such as:

- digital MAP sensor
- gear neutral position sensor
- voltage encoded switch
- digital AMR wheel sensor

### Fundamentals with STE

A1.1.1.3  
Compact set  
"Basics of automotive electrical engineering"

FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S

Further equipment(s)  
A2.1.2.1 from p. 44



Compact set "Basics of automotive electrical engineering" (A1.1.1.3)

Cat. No.	Description	A1.1.1.3
727 5202	Set electronic automotive circuits in experiment case	1
531 183	Digital multimeter 3340	2
531 120	Multimeter LDanalog 20	1
575 302	Oscilloscope 30 MHz, digital, PT1265	1
575 24	Screened cable, BNC/4 mm Plug	2
LDS 00001	Stopwatch, digital	1

The following topics are covered with the equipment set:

- The electric circuit
- The ohmic resistance
- Current and voltage sources
- The capacitor
- The coil
- The transformer
- The relay
- Special resistors like NTC, PTC or LDR
- The diode
- The Z-diode
- LEDs
- The transistor, and
- The thyristor.

Finally, with this set applied circuits in vehicle electronics can be assembled, such as:

- The electronic tachometer
- The electronic voltage regulator for three-phase generators, or
- The transistor control unit for breaker-triggered ignition systems.

The equipment in the STE suitcase lends itself for storage and as a student's workstation. It serves as a receptacle for various STE equipment sets in its cover and can be used to conduct experiments in the classroom. The cover can be separated from the base.

### Fundamentals with STE

A1.1.1.4  
Car actuators



FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S

#### Car actuators (A1.1.1.4)

Cat. No.	Description	A1.1.1.4
727 5186	Vehicle actuators 3, STE, set	1
727 5181	Automotive basic circuits, STE, Set	1
582 642	Pencil coil, STE 6/100/100	1
579 162	Simulation ABS/Ti, STE 2/50	1
578 31	Capacitor, 0.1 µF, STE 2/19	1
582 641	Stepping motor, STE 8/100/100	1
758 208	DC/DC Converter, STE 4/50/100	2
758 201	CAN-Databus node, STE 6/50/100	2
590 821	Coil, 250 turns, STE 2/50	1*
590 83	Coil 500 turns STE 2/50	1*
590 84	Coil 1000 turns STE 2/50	1*
593 21	Transformer core, demountable	1*
578 576	High power LED white, STE 2/19	1*
578 48	Light emitting diode red, STE 2/19	1*
578 47	Light emitting diode, yellow, STE 2/19	1*
579 361	Stepping motor model STE 4/50	1
579 09	IC socket, 16 pin, STE 4/50	1
579 13	Toggle switch STE 2/19	3
758 210	EGR valve, STE 6/100/200	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 220	CASSY Lab 2	1
524 0431	30-A-Box	1
738 985	Automotive meter	1
739 007	Data bus Analyzer USB	1
739 837	Set 2 4 mm oscilloscope probe adaptors	1
726 501	Safety socket plug-in board, 297 mm x 200 mm	3
501 48	Bridging plugs STE 2/19, set of 10	7
738 027	Digital power supply 1 - 16 V/40 A	1
688 131	Mains cable Type G	1*
521 210	Transformer 6/12 V	1

Cat. No.	Description	A1.1.1.4
505 22ET5	Bulbs, 12 V/6 W, E10, inert gas filling, set of 5	1
650 67	Storage tray, S33, STE	1
501 532	Connecting leads, 19 A, set of 30	1
727 585	STE universal case	1
778 810	LIT-digital: Fundamentals of automotive electrical systems	1

\* additionally recommended

Input-processing-output: this principle of data processing known as „EVA“ is based on the interaction of sensors and actuators. The actuator is the only way for the control unit to interact with the environment.

- the injection valve
- the rod ignition coil
- the transformer
- the automotive relay
- the blower motor
- the LWR servomotor
- the stepping motor

Especially for the field of electromobility, the following components are being investigated:

- the DC/DC converter
- the battery cell
- the battery management system (BMS)

These original actuators are examined in interaction with suitable sensors in practical circuits. The type of control, e.g. analogue, digital, PWM, etc., also plays a major role. The subsequent data transmission via the CAN bus rounds off the series of experiments.

### Fundamentals with STE

A1.1.1.5  
Fundamentals of electrics and high voltage technology

FIELD OF LEARNING:  
13S

Further equipment(s)  
A2.7.2.5 from p. 78



Fundamentals of electrics and high voltage technology (A1.1.1.5)

Cat. No.	Description	A1.1.1.5
727 5187	Basics of HV safety, STE, set	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
739 835	Kelvin-sensing cable, set of 2	1
739 836	Milliohm meter	1
739 004	DMM for electrical vehicles	1
739 949	HV PC measurement adapter for E-Mobility	1
500 59	Safety bridging plugs, black, set of 10	4
726 501	Safety socket plug-in board, 297 mm x 200 mm	4
500 602	Safety experiment cable, 10 cm, blue	3
500 612	Safety experiment cable, 25 cm, blue	1
500 611	Safety experiment cable, 25 cm, red	4
500 620	Safety connecting lead 50 cm, yellow/green	2
500 641	Safety experiment cable, 100 cm, red	2
500 642	Safety experiment cable, 100 cm, blue	2
726 890	DC power supply unit 1...32 V/0...20 A	1
778 810	LIT-digital: Fundamentals of automotive electrical systems	1
727 585	STE universal case	1*

\* additionally recommended

#### Protective measures in the HV intrinsically safe vehicle

A vehicle that guarantees complete protection against contact and arcing with respect to the high-voltage system by means of technical measures is called "intrinsically safe".

In an IT system, the conductive housings of the equipment are earthed, but the energy source is not. The high-voltage drive systems of electric and hybrid vehicles are constructed in this way. For example, the housings of the inverter and the e-machine are connected to each other via the body. This connection represents the potential equalisation.

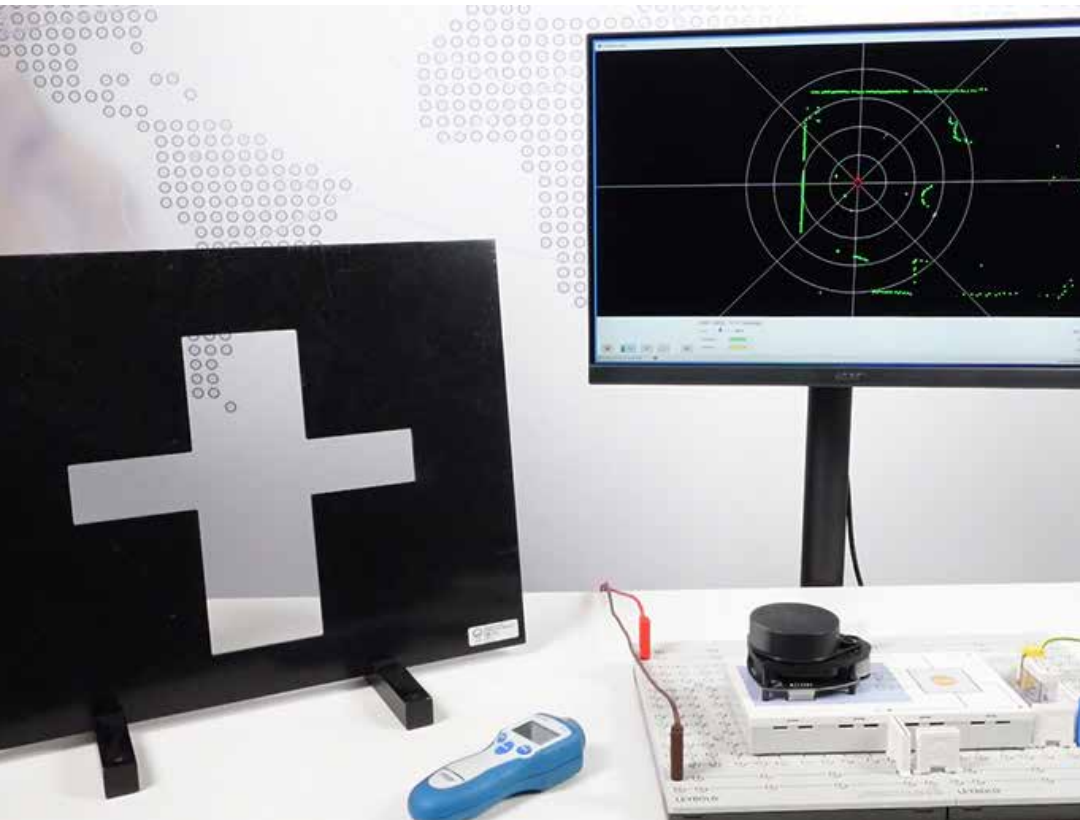
The essential features of such a system include permanent monitoring of the insulation resistance and a low-resistance potential equalisation resistor.

LEYBOLD offers all the necessary components as plug-in elements for the safe investigation of such systems. Components as plug-in elements, which are operated with a non-hazardous low voltage of voltage of 24 V.

With the CASSY 2 sensor, voltages and equipotential bonding resistance can be measured directly, while the insulation resistance is determined and evaluated with a specially designed measuring device.

### Fundamentals with STE

A1.1.1.6  
Fundamentals  
Autonomous Driving



FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S

Further equipment(s)  
A2.4.2.1 from p. 61

#### Fundamentals Autonomous Driving (A1.1.1.6)

Cat. No.	Description	A1.1.1.6
758 212	CAN-Bus LIDAR, STE 6/100/200	1
474 4025	IR converter screen 800 - 1400 nm	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
580 0136	Tachometer (handheld)	1
773 961	CAN-Bus-Multi-Adapter	1
311 78	Tape measure	1
300 11	Saddle base	1
301 339	Stand bases, pair	1
460 28	Plane mirror 14 cm x 9 cm, with ball joint	1
500 641	Safety experiment cable, 100 cm, red	2
500 642	Safety experiment cable, 100 cm, blue	2
501 48	Bridging plugs STE 2/19, set of 10	1
577 321	Resistor 120 Ohm, STE 2/19	1
726 501	Plug-in board safety socket, 297 mm x 200 mm	1
726 88	AC/DC stabilizer	1
778 810	LIT-digital: Fundamentals of automotive electrical systems	1
727 585	STE universal case	1*
	Stable box	1

\* additionally recommended

"Driver assistance" and "autonomous driving" will change mobility in the coming years. The next few years. Systems that control the movement of the vehicle - and without driver intervention. Such vehicles are thus able to manoeuvre from point A to point B independently.

To do this, the vehicle must know its static surroundings and recognise its dynamic environment. GPS takes care of the former - the vehicle knows where it is. Ultrasound, radar or lidar systems additionally ensure that the vehicle knows what is happening in its direct field of action.

LIDAR stands for Light Detection And Ranging or Light Imaging, Detection And Ranging and refers to a method of distance determination but Unlike RADAR, however, it uses light rather than radio waves. The actual determination of the distance of an obstacle is done either by measuring the transit time of the emitted light until the arrival of the reflected light or by measuring the angle between the emitted and reflected light in the so-called "triangulation". Between emitted and reflected light is detected by a photochip.

The following topics are investigated with this equipment:

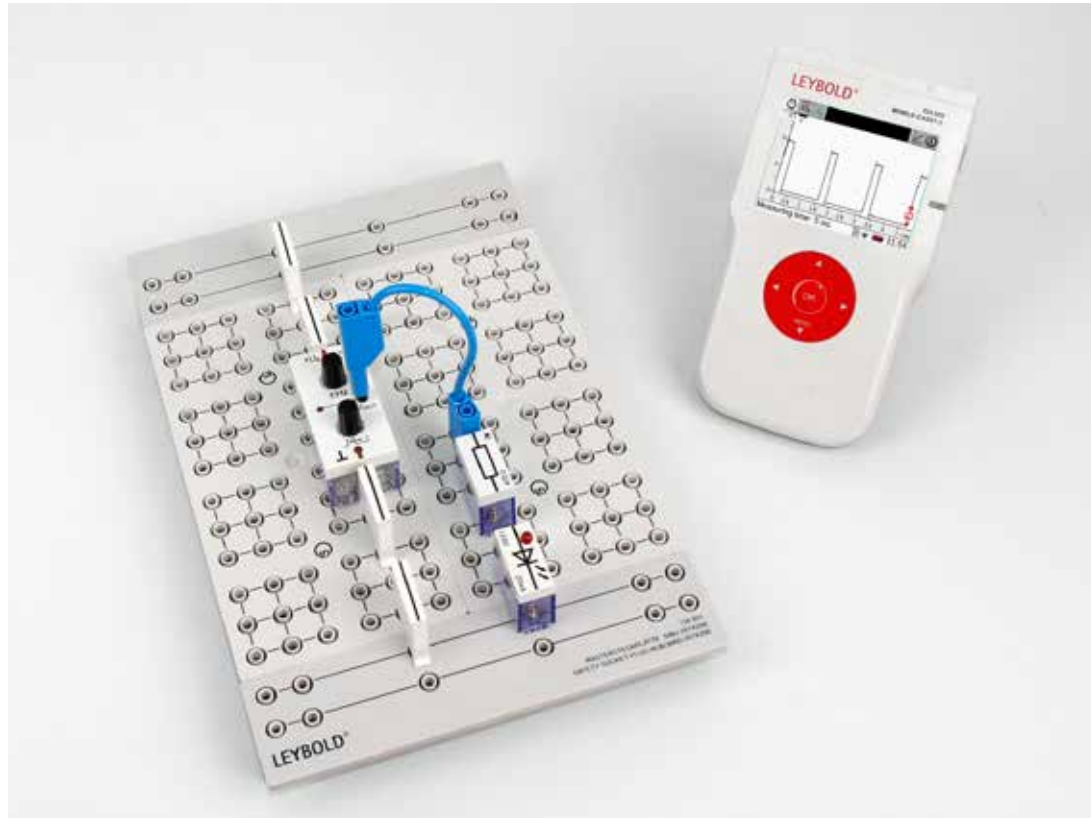
- Functional principle of LIDAR
- Applications of lidar sensors
- Determination of distance
- Data visualisation
- Digital data transmission with CAN bus

### Basics of complete systems with STE

A1.1.3.1  
Pulse Width Modulation (PWM)

FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S

Further equipment(s)  
A2.1.3.1 on p. 47



Pulse Width Modulation (PWM) (A1.1.3.1)

Cat. No.	Description	A1.1.3.1
579 163	PWM/PFM generator, STE 2/50	1
578 48	Light emitting diode red, STE 2/19	1
577 40	Resistor 470 Ohm, STE 2/19	1
521 491	AC/DC power supply 0...12 V/3 A	1
576 74	Plug-in board, DIN A4, STE	1
501 46	Connecting leads 19 A, 100 cm, red/blue, pair	1
500 401	Connecting lead, 19 A, 10 cm, red	1

This equipment offers you a set of devices with which the method of pulse width modulation and its application in the field of automotive sensors and actuators can be investigated in experiments. The method is used on the one hand to transmit information as a sensor interface and on the other hand to control actuators with voltages that are lower than the supply voltage.

- Simple circuits are constructed on the basis of the STE plug-in system.
- The PWM interface signal of a sensor for position detection is transmitted to the recorded and evaluated with the Mobile-CASSY 2 WLAN.
- An LED brake light is operated as a parking and brake light with different brightness.



### Basics of complete systems with STE

A1.1.3.2  
The car relay

FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S

The car relay (A1.1.3.2)

Cat. No.	Description	A1.1.3.2
758 207	STE Automotive relais	1
579 13	Toggle switch STE 2/19	1
579 06	Lamp holder, E10, top, STE 2/19	1
505 22ET5	Bulb 12 V/6 W, E10, inert gas, set of 5	1
577 36	Resistor 220 Ohm, STE 2/19	1
578 51	Diode 1N4007, STE 2/19	1
521 491	AC/DC power supply 0...12 V/3 A	1
726 501	Plug-in board safety socket, 297 mm x 200 mm	1
501 46	Connecting lead 19 A, 100 cm, red/blue, pair	1
501 48	Bridging plugs STE 2/19, set of 10	1

As one of the most important electromechanical energy converters, the relay is still indispensable in the modern vehicle. It decouples circuits from each other and is capable of safely switching even very large even very large load currents in the high-voltage range with the smallest control currents.

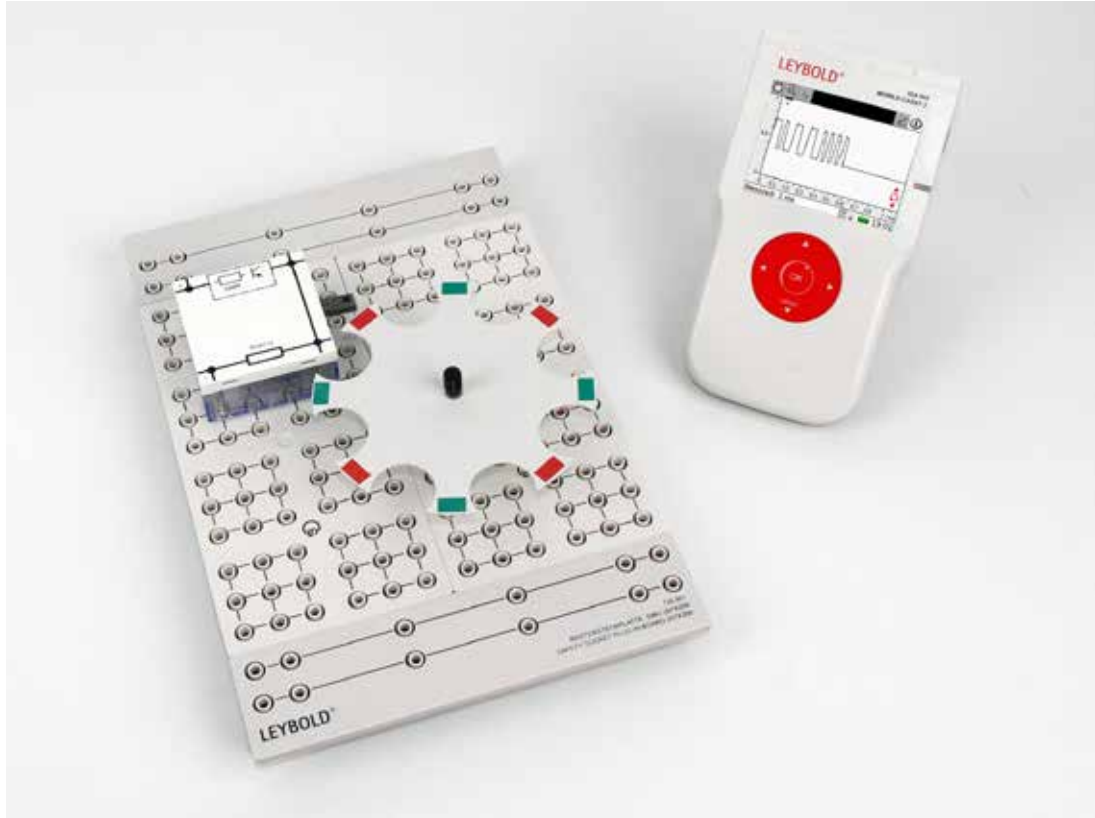
This equipment provides a set of devices with which a standard motor vehicle relay can be used in lessons as a student exercise with various experiments.

- Simple circuits with relays are constructed on the basis of the STE plug-in system.
- The basic terms such as control and load circuit, working and resting contact, extinguishing contact, extinguishing device or reverse polarity protection are explained.
- With the Mobile-CASSY 2 WLAN, electrical signals from switching operations are switching operations using the example of various extinguishing devices.

### Basics of complete systems with STE

#### A1.1.3.4 The AMR wheel sensor

FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S



The AMR wheel sensor (A1.1.3.4)

Cat. No.	Description	A1.1.3.4
582 6241	STE Automotive wheel sensor MR	1
582 628	Automotive trigger wheel STE	1
521 491	AC/DC power supply 0...12 V/3 A	1
726 501	Safety socket plug-in board, 297 mm x 200 mm	1
501 46	Connecting leads 19 A, 100 cm, red/blue, pair	1
689 0815	Set of 10 magnets	1*

\* additionally recommended

In this equipment we offer you a device combination, with which an active wheel sensor based on GMR in single-chip technology can be experimentally investigated perimentally. The sensor reacts to magnetic fields with a change in resistance. In connection with the encoder wheel, the sensor sends a speed signal and also a digital data packet with information about the direction of rotation and the distance to the encoder wheel.

The sensor has a current interface with three levels; a shunt resistor of  $47 \Omega$  is already integrated into the plug-in element. As a special feature, this sensor also sends out a digital signal when the wheel is at a standstill.

- The data packet is recorded and evaluated with the Mobile-CASSY 2 WLAN and evaluated.
- The magnetoresistive effect (change in the electrical resistance of a material of a material by applying an external magnetic field) is investigated.
- Comparison of inductive, Hall and AMR sensors in the experiment.



**COM4LAB:**  
**Automotive Electrics**

MA1.1  
Automotive Electrics



FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S

Further equipment(s)  
A2.1.1.1 on p. 41

COM4LAB: Automotive Electrics (MA1.1)

Cat. No.	Description	MA1.1
700 6101	COM3LAB Course: Automotive Electrics - COM4LAB ready	1
700 6102	COM3LAB: Automotive Electrics Accessories	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
700 00CBT	DVD: COM3LAB Software	1
	Additionally required: PC with Windows 7/8/10 64 Bit Edition and one free USB interface	1

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

The course formed in cooperation with the automotive industry strategically introduces the fundamentals of electricity. The course clarifies in a comprehensible way the variables voltage, current and resistance using graphic animations and videos, and the chapter "Counting with Variables" also examines these values. Measurements on real automotive components with analog and digital meters help understand simple electrical circuits.

The course contents are rounded off with extensive instructions for practical troubleshooting. Comprehension questions and parallel audio responses guarantee the most efficient training possible compared to traditional training methods.

**Topics:**

- Electricity in the vehicle: current - voltage - resistance
- Calculating with parameters: Ohm's law - Power
- Circuits
- Series and parallel circuits - forward slope resistances

### COM4LAB: Sensor Technology

MA2.1  
Automotive Sensor Technology



FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S

Further equipment(s)  
A2.4.1.4 on p. 59

#### COM4LAB: Automotive Sensor Technology (MA2.1)

Cat. No.	Description	MA2.1
700 6201	COM3LAB Course: Automotive Sensor Technology - COM4LAB ready	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
700 00CBT	DVD: COM3LAB Software	1
	Additionally required: PC with Windows 7/8/10 64 Bit Edition and one free USB interface	1

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

These course formed in cooperation with the automotive industry strategically introduce the fundamentals of electricity. The course gives a detailed explanation of the operating principle of electric components and sensors in a motor vehicle.

#### Topics:

- Components: switches, resistors, capacitors, diodes and Zener diodes, relays
- Schematics: reading vehicle schematics
- Sensors: inductive sensors, magnetic-field sensors
- Batteries and accumulators: Interconnecting cells, accumulator types
- Ignition: capacitors, relays, induction, ignition coil
- Generators and motors: rectification, three-phase generator, permanent magnet generator
- Transistors in the vehicle: transistor, checking transistors
- Monitoring features in vehicles, amplifier circuits, application circuits

### COM4LAB: Automotive Digital Technology

MA3.1  
Automotive Digital Technology I

FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S



COM4LAB: Automotive Digital Technology I (MA3.1)

Cat. No.	Description	MA3.1
700 17-00	COM4LAB Board: 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
	Additionally required: PC, tablet or smartphone with a current browser	1

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

The COM4LAB course looks at the basic principles of Boolean algebra using logic operations. The subject areas are matched to automotive technology in a realistic and applied manner. The course, comprising 10 chapters, also examines the troubleshooting procedure in detail.

#### 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 - 2. The OR gate

### COM4LAB: Automotive Digital Technology

MA3.2  
Automotive Digital Technology II



FIELDS OF LEARNING:  
3, 6, 8, 11P, 11N, 11S, 13S

#### COM4LAB: Automotive Digital Technology II (MA3.2)

Cat. No.	Description	MA3.1
700 18-00	COM4LAB Board: 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
	Additionally required: PC, tablet or smartphone with a current browser	1

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

The COM4LAB course looks at several types of flip-flop and various flip-flop applications, including counters or shift registers. The subject areas are matched to automotive technology in a realistic and applied manner. The course, comprising 8 chapters, also examines the troubleshooting procedure in detail.

#### 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 - 7. The counter



# A2

## AUTOMOTIVE TECHNOLOGY

A2.1 VEHICLE ELECTRICS

A2.3 COMBUSTION ENGINE

A2.4 DRIVER ASSISTANCE & COMFORT SYSTEMS

A2.5 CHASSIS & DRIVE TRAIN

A2.6 AUTOMOTIVE NETWORKING & DIAGNOSIS SYSTEMS

A2.7 ELECTROMOBILITY



POWER SUPPLY

A2.1.1.1  
Energy monitoring



FIELDS OF LEARNING:  
3, 6

Energy monitoring (A2.1.1.1)

Cat. No.	Description	A2.1.1.1
738 031	Battery monitoring	1
738 032	Battery connection with protection circuit	1
739 5881	LIN-Bus PC Interface USB	1
737 9803	OBD Adaptor CAN+USB	1
738 04	Car battery 12V	1
738 044	AGM-battery 12V	1
738 05	Connection leads I, set	1
738 103	Ignition start switch	1
738 295	Central electrics	1
738 06	12 V on-board socket	1
738 043	Vehicle battery connecting kit	1
738 963	TDI Control Relay for Preheating System	1
738 90	Parallel Glow System	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 0431	30-A-Box	1
738 9991	DC/JAC clamp-on current probe	1
739 836	Milliohm meter	1
726 18	Panel frame T130, three-level	1
738 027	Digital power supply 1 - 16 V/40 A	1
688 131	Mains cable Type G	1*
738 11	Head lamp switch	1
738 1661	Headlights right halogen + LED	1
567 18	Wrapping plate for wires	1
550 445	Constantan resistance wire, 1.0 mm diameter, 20 m	1
501 641	Two-way adapters, red, set of 6	1
738 4911	Automotive fault simulator	1
501 45	Connecting lead 19 A, 50 cm, red/blue, pair	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	5

Cat. No.	Description	A2.1.1.1
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1
775 010DE	LIT-print: Vehicle power supply, German	1
738 01	Cable and plug box	1
500 593	Fault simulation plugs, black, set of 10	1
738 021	Battery charger, automatic	1
688 161	Travel adapter	1*

\* additionally recommended

The on-board network of a vehicle includes the systems power generation, energy storage, consumers and all associated cables and wires in between.

The car battery is an essential component of the electrical system. The 738031 "Battery monitoring" educational panel contains the "diagnostic interface for data bus" with the battery's energy management functionality. This consists of software and the battery data module (BDM), directly on the vehicle battery's negative pole and connected to the diagnostic interface over a LIN bus line.

The BDM determines the battery's state with sensors recording the battery's current, voltage and temperature. This continually calculates the battery's state of charge and state of wear using, among others, battery characteristics stored in the control unit.

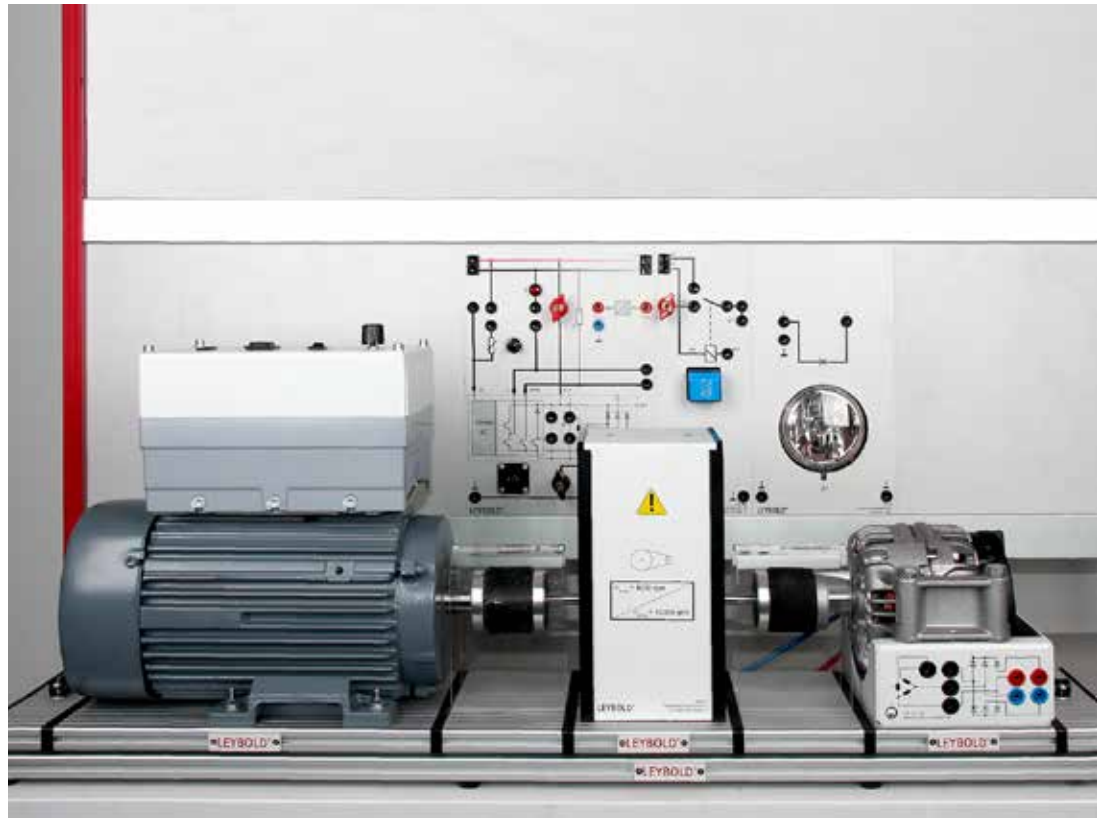
The standby current keeps the battery voltage from declining below a minimum value needed to start the vehicle. For example, operation of the auxiliary heating is disabled, and a display on the instrument cluster informs the driver.

The dynamic management distributes the energy generated while driving to the individual loads. This is especially important if the energy does is not sufficient for the demand because of the number of loads (seat heater, lights, rear window).

### Power supply

#### A2.1.1.2 Threephase alternator

FIELDS OF LEARNING:  
3, 6



Threephase alternator (A2.1.1.2)

Cat. No.	Description	A2.1.1.2
738 7111	Compact alternator	1
738 6311	Motor for Generator Experiments, 1.0 kW	1
738 6321	Automotive gear 1:3	1
738 963	TDI Control Relay for Preheating System	1
738 103	Ignition start switch	1
738 18	Auxiliary headlamp	1
738 76	Field Regulator, Generator	1
738 712	Voltage controller LIN bus	1
738 738	Gateway with battery monitoring	1
738 4911	Automotive fault simulator	1
739 589	Software: Vehicle diagnosis	1
737 9803	OBD Adaptor CAN+USB	1
577 36	Resistor 220 Ohm, STE 2/19	1
738 12	Multi-purpose switch	1
524 0135	Sensor-CASSY 2 Starter	1
524 013	Sensor-CASSY 2	1
739 5881	LIN-Bus PC Interface USB	1
738 985	Automotive meter	1
524 0431	30-A-Box	1
738 9991	DC/AC Clamp on current probe	1
524 076	AUTO-BOX i	2
773 258	Coupling / shaft end guard, 1.0, transparent	2
773 115	Machine base bench, 120 cm	1
726 10	Panel frame T150, Two Level	1
738 032	Battery connection with protection circuit	1*
738 027	Digital power supply 1 - 16 V/40 A	1
688 131	Mains cable Type G	1*
738 04	Car battery 12V	1*
738 043	Vehicle battery connecting kit	1*
739 195	Connecting Leads, set of 7	1

Cat. No.	Description	A2.1.1.2
738 05	Connection leads I, set	2
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
501 46	Connecting lead 19 A, 100 cm, red/blue, pair	1
775 011EN	LIT-print: Threephase alternator	1
738 01	Cable and plug box	1
500 593	Fault simulation plugs, black, set of 10	1
738 021	Battery charger, automatic	1
688 161	Travel adapter	1*

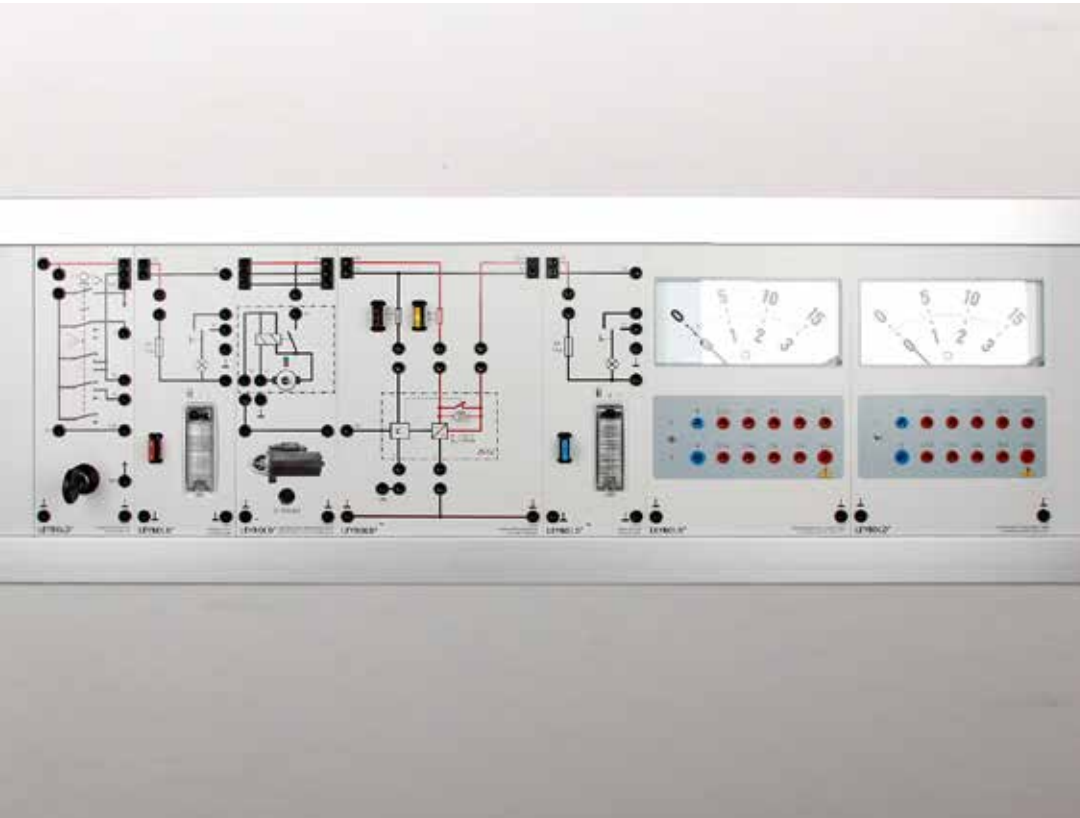
\* additionally recommended

The **three-phase generator** – also known as „alternator“ – is an induction machine operated as a generator that produces a speed-dependent three-phase alternating current using an electrical field. Since the electrical system is designed as a DC power system, this three-phase voltage must still be rectified. The control technology also comes into play: the voltage level should remain constant independently of the engine speed – the hybrid multifunction controller handles this.

In this educational system, a three-phase electric motor drives the compact alternator. The generator itself has power diodes on 4 mm safety sockets for measurement and interruption that are just as accessible as the three-phase winding.

Power supply

A2.1.1.4  
Wiring systems  
of automatic  
start stop systems



FIELDS OF LEARNING:  
3, 6, 8, 11P

Wiring systems of automatic start stop systems (A2.1.1.4)

Cat. No.	Description	A2.1.1.4
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 32	Voltage stabilizer with LIN databus	1
738 07	Interior lamp	2
738 027	Digital power supply 1 - 16 V/40 A	1
738 871	Starter substitute w. load simulation	1
738 06	12 V on-board socket	1
727 20	Automobile Meter Zero-Left	2
739 5881	LIN-Bus PC Interface USB	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
577 41	Resistor 510 Ohm, STE 2/19	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
500 441	Connecting lead 19 A, 100 cm, red	1
500 444	Connecting lead 19 A, 100 cm, black	1
500 644	Safety experiment cable, 100 cm, black	2
500 641	Safety experiment cable, 100 cm, red	2
500 6181	Safety cable, 25 cm, grey	2
726 09	Panel frame T130, two-level	1

\* additionally recommended

The electrical system describes the energy and data management's setup and function in modern vehicles. It fuses together the power's supply and distribution, including its control and regulation.

In this series of experiments, the function of the voltage stabiliser in vehicles with a start/stop system is examined.

### Lighting systems

A2.1.2.1  
Automotive lighting

FIELDS OF LEARNING:  
1, 3, 4, 6

Further equipment(s)  
A2.1.3.4 on p. 48



Automotive lighting (A2.1.2.1)

Cat. No.	Description	A2.1.2.1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 1511	Control lamps KI	1
738 871	Starter substitute w. load simulation	1
738 114	Light control	1
738 295	Central electrics	1
738 06	12 V on-board socket	1
738 11	Head lamp switch	1
738 131	Stalk with with parking light	1
738 190	Rear lights	1
738 1661	Headlights right halogen + LED	1
738 1671	Headlights left halogen + LED	1
738 152	Rear lamp monitoring	1
739 573	Automotive Set Point Potentiometer	1
738 1822	Set: Bi Xenon headlights	1
739 195	Connecting Leads, set of 7	1
738 35	Normal and High Volume Horn	1
738 373	Turn signal control	1
738 372	Convenience turn signal control unit	1
738 38	Warning Lamp Switch	1
738 361	Side turn signal light LED	2
739 760	Driver assistance 1	1
738 07	Interior lamp	1*
738 075	Luggage lamp	1*
738 08	Door contact switch	1*
738 311	Courtesy lamp control	1*
738 141	Fog lamp switch	1*
738 18	Auxiliary headlamp	2*
738 09	Fuse holder	1
738 291	Relay 1NO	2

Cat. No.	Description	A2.1.2.1
738 28	Relieving Relay	1
738 30	Relay 1 CO	1
738 044	AGM-battery 12V	1
738 043	Vehicle battery connecting kit	1
537 321	Rheostat 9.5 Ohm	1
738 12	Multi-purpose switch	1
LDS 00001	Stopwatch, digital	1
727 20	Automobile Meter Zero-Left	1
727 21	Automobile Meter Zero-Center	2
738 985	Automotive meter	2
500 990	Adapter sockets, set of 2	1
738 05	Connection leads I, set	1
738 027	Digital power supply 1 - 16 V/40 A	1
688 131	Mains cable Type G	1*
726 26	Panel frame VT180, three-level	1
500 59	Safety bridging plugs, black, set of 10	7
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9831	Sicherheitslaborkabel, Satz 102	1
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1
775 012DE	LIT-print: Automotive lighting, German	1
738 01	Cable and plug box	1*
500 593	Fault simulation plugs, black, set of 10	1*
738 021	Battery charger, automatic	1*
688 161	Travel adapter	1*

\* additionally recommended

## Lighting systems

A2.1.2.2  
Supplementary set "Trailer"



FIELDS OF LEARNING:  
1, 3, 4, 6

### Supplementary set "Trailer" (A2.1.2.2)

*See and be seen* - vehicle lighting not only serves to help the driver see the road better, but also to make him be seen better. This makes lighting one of the most important components of vehicle safety. For this reason, the development of improved lighting systems is not standing still and has led to the use of LEDs in front and rear lights. In addition, the systems are being "automated" in order to relieve the driver of the burden of operating them.

The lighting technology on the vehicle includes defined tasks of the luminaires at the front, rear and interior of the vehicle. Even though modern lighting systems are controlled via control units, it is indispensable to know conventional circuits.

The modern headlamp is therefore more than just a lamp and a beam optic. It is an intelligent mechatronic unit consisting of light sources, beam optics, electric motors and various control devices.

In polyellipsoidal headlamps, the emerging light beams are bundled in another focal point. If a diaphragm is placed near this point, an exact cut-off line is created. A little further ahead, the remaining light can then be evenly distributed on the road by a corresponding lens. Shortly after exiting the ellipsoid, the bundle of light rays is considerably smaller than with a paraboloid or free-form reflector. Only beyond the terminating lens (with a small light-emitting surface) does it become larger again.

Different loading conditions of the vehicle are to be avoided by the headlamp levelling to avoid dazzling oncoming traffic. The reflectors can be swivelled vertically and adjusted by electric motors. With automatic headlamp levelling, the position of the superstructure is detected by level sensor and the control unit sends corresponding signals to the electric motors.

Conventional indicator control does not have to forego the convenience functions of modern vehicles. For example, the motorway turn signal is a useful upgrade in the retrofit sector. Touch the indicator lever once and the indicator flashes three times, ideal for changing lanes, for example. This function can be easily retrofitted didactically by means of a module in this system.

Convenient and intelligent control of the interior lighting is now included in all passenger cars. For example, the interior lighting switches off directly when the vehicle is started - whereas it slowly dims after some time if the door is closed without starting the engine. This equipment includes all components including a boot light at a practical level.

Cat. No.	Description	A2.1.2.2
738 27	Trailer lights	1
738 251	Trailer Socket 13 pole	1
500 59	Safety bridging plugs, black, set of 10	1

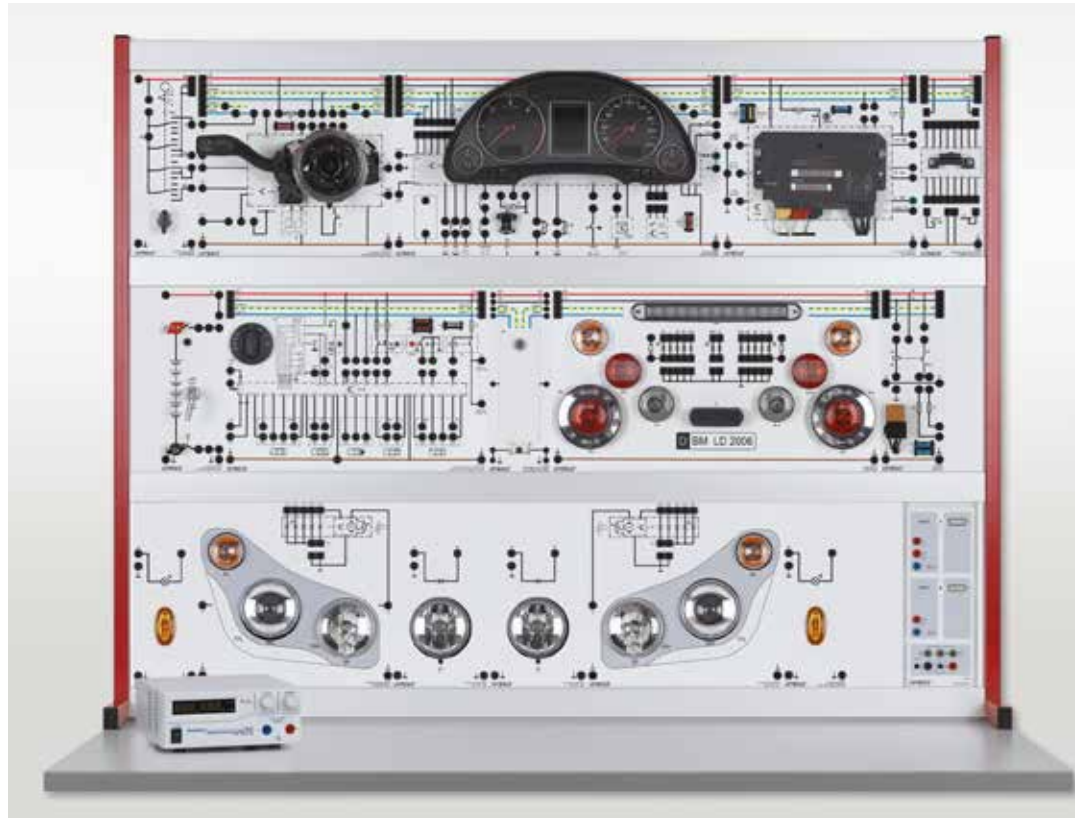
Especially when towing a trailer, there are some regulations to be observed. The correct connection of the trailer socket, the monitoring of the indicator system and the automatic switching off of the rear fog light on the towing vehicle must be ensured.

### Networking lighting systems

A2.1.3.1  
Automotive lighting  
with CAN data bus

FIELDS OF LEARNING:  
1, 3, 4, 11P, 11N, 11S

Further equipment(s)  
A2.6.1.1 on p. 67



Automotive lighting with CAN data bus (A2.1.3.1)

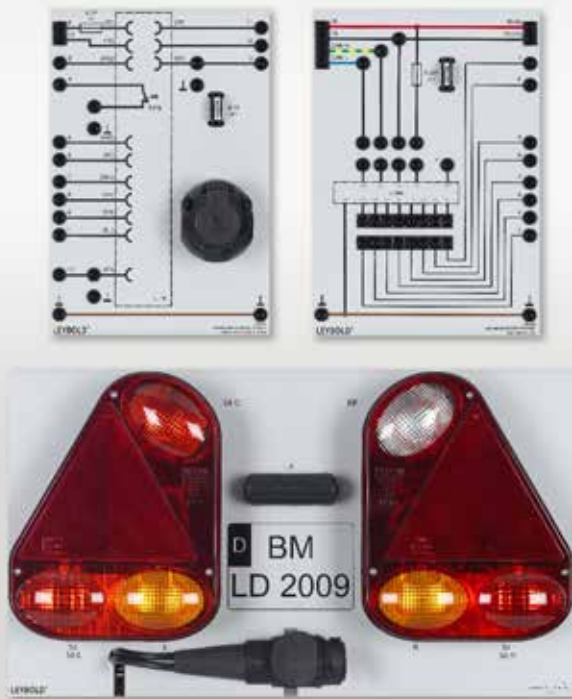
Cat. No.	Description	A2.1.3.1
738 1822	Set: Bi Xenon headlights	1
739 195	Connecting Leads, set of 7	1
738 111	Intelligent automotive lighting management system	1
738 1121	OBD adaptor	1
738 291	Relay 1NO	2
738 06	12 V on-board socket	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 190	Rear lights	1
738 361	Side turn signal light LED	2
738 18	Auxiliary headlamp	2
739 760	Driver assistance I	1
739 6021	Instrument cluster unit	1
579 13	Toggle switch STE 2/19	1
577 79	Variable resistor 1 kOhm, STE 2/19	1
577 321	Resistor 120 Ohm, STE 2/19	2
578 02	Photoresistor LDR 05, STE 2/19	1
578 611	Phototransistor STE 2/19	1
739 654	Steering angle sensor	1*
579 163	PWM/PFM generator, STE 2/50	1
738 4911S	Automotive fault simulator, start	1
738 975	Diagnostic socket 16 Pin	1
500 593	Fault simulation plugs, black, set of 10	1*
737 9803	OBD Adaptor CAN+USB	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
773 961	CAN-Databus-Multi-Adapter	1
524 0431	30-A-Box	1
738 027	Digital power supply 1 - 16 V/40 A	1
688 131	Mains cable Type G	1*
500 990	Adapter sockets, set of 2	1

Cat. No.	Description	A2.1.3.1
500 59	Safety bridging plugs, black, set of 10	14
500 592	Safety bridging plugs with tap, black, set of 10	2
738 9831	Safety laboratory cable, set 102	1
501 45	Connecting lead 19 A, 50 cm, red/blue, pair	1
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1
775 013DE	LIT-print: Automotive lighting with CAN data bus, German	1
738 05	Connection leads I, set	1
726 256	Panel frame VT160, Three Level	1
739 5835	DS vehicle door	1*
739 5836	PS vehicle door	1*
738 01	Cable and plug box	1*

\* additionally recommended

## Networking lighting systems

A2.1.3.2  
Supplementary set  
"Trailer control"



FIELDS OF LEARNING:  
1, 3, 4, 11P, 11N, 11S

### Supplementary set "Trailer control" (A2.1.3.2)

With increasing data transmission and networking in the automotive sector, lighting and on-board management in modern passenger cars is also being taken over by networked control units that exchange data with each other via CAN and LIN bus.

The teaching system consists of a steering column switch with control unit, as well as the on-board power supply control unit for controlling the front and rear lights. It can be a comfort control unit, an instrument cluster with integrated gateway and a control unit for automatic trailer recognition.

In the experiment, modern control unit functions can be investigated such as:

- Lamp cold monitoring
- Lamp warm monitoring
- Lane change flashing
- Daytime running lights
- Automatic driving lights
- Automatic ambient lighting or
- PWM-controlled rear lights.

Cat. No.	Description	A2.1.3.2
738 251	Trailer Socket 13 pole	1
738 263	CAN Trailer ECU	1
738 27	Trailer lights	1
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	1
726 09	Panel frame T130, two-level	1

In the case of CAN bus-controlled lighting systems with on-board power supply control unit the trailer socket must not simply be connected in parallel to the existing rear lights. Rather, it is necessary to interconnect a corresponding control unit and integrate it into the CAN topology.

### Networking lighting systems

#### A2.1.3.4 LED Headlights

FIELDS OF LEARNING:  
6, 12S, 14P, 14N, 14S



LED Headlights (A2.1.3.4)

Cat. No.	Description	A2.1.3.4
738 189	LED Headlight	1
738 032	Battery connection with protection circuit	1
739 5881	LIN-Bus PC Interface USB	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
467 251	Compact spectrometer, physics (spectral photometer)	1
739 580	Databus detector	1
738 027	Digital power supply 1 - 16 V/40 A	1
688 131	Mains cable Type G	1*
500 644	Safety experiment cable, 100 cm, black	2
500 647	Safety connection lead 100 cm brown	3
500 641	Safety experiment cable, 100 cm, red	1
500 59	Safety bridging plugs, black, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1
460 251	Fibre holder	1
500 990	Adapter sockets, set of 2	1
300 11	Saddle base	1
301 339	Stand bases, pair	1
747 516	Hex Driver, 6 mm	1
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1
775 015DE	LIT-print: LED Headlights, German	1

\* additionally recommended

Once LEDs (Light Emitting Diodes) could be found in the rear of the vehicle used as "Indicators", super bright LEDs can also be used in headlights as the main light for illumination purposes. LEDs offer in contrast to halogen and xenon lamps higher efficiency, longer life and above all, greater flexibility in the design of the vehicle front.

With this didactic equipment set, the following topics can be examined experimentally:

- LEDs as a lighting element
- Lighting functions (eg DRL)
- Special lighting functions (such as all-weather light)
- Headlight range adjustment
- LED lighting element according to ECE
- Legal regulations ECE
- Testing and adjustment of headlights
- Service orders and troubleshooting
- Reading circuit diagrams and diagnostic strategies
- Spectral analysis of LED light



## Backfitting electrical systems

A2.1.4.1  
Electrical systems 230 VAC



FIELDS OF LEARNING:  
6, 12S, 14P, 14N, 14S

### Electrical systems 230 VAC (A2.1.4.1)

Cat. No.	Description	A2.1.4.1
738 061	Inverter 12/230 V	1
502 05	Measuring junction box	1
505 3181	Energy saving lamp, 230 V/11 W, E 27	1
505 302	Halogen Bulb 230 V/ 46 W, E27	2
729 13	Lamp Socket E27	2
738 06	12 V on-board socket	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 02	Automotive power supply 13.8 V/36 A	1
500 597	Automobile protection measuring adaptor	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 0431	30-A-Box	1
524 220	CASSY Lab 2	1
727 293	Digital insulation tester	1
726 19	Panel frame SL85, single-level	1
500 59	Safety bridging plugs, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
738 01	Cable and plug box	1*
500 593	Fault simulation plugs, black, set of 10	1*
500 592	Safety bridging plugs with tap, black, set of 10	1*
775 014DE	LIT-print: Backfitting electrical systems, German	1

\* additionally recommended

The motor vehicle has become part of everyday life for today's motorists. This includes numerous vehicle owners who would like to use the common, portable devices and consumer appliances even in their car. So automakers optionally deliver their models with 230 V outlets already installed. Alternatively, there are various retrofitting solutions that supply 230 V - by tapping into the 12 V on-board outlet.

This situation generates brand new tasks and problems for automotive mechatronics engineers:

- May an automotive mechatronics engineer retrofit such an installation?
- May he make repairs to it?
- Are there any regulations to pay attention to?

This field of instruction exhaustively studies these questions on the one hand and of course the technology on the other hand.

- What is an inverter?
- and how does it work?
- How does it relate to personal safety?
- Which faults may arise and how can they be diagnosed and corrected?

### Backfitting electrical systems

A2.1.4.2  
Comfort system  
turn signal flashing

FIELDS OF LEARNING:  
3, 4, 9, 14P, 14N, 14S

Further equipment(s)  
on comfort systems from p. 58



Comfort system turn signal flashing (A2.1.4.2)

Cat. No.	Description	A2.1.4.2
738 373	Turn signal control	1
738 372	Convenience turn signal control unit	1
738 295	Central electrics	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 131	Stalk with with parking light	1
738 38	Warning Lamp Switch	1
738 1511	Control lamps KI	1
738 36	Turn Signal Lamp	2
738 361	Side turn signal light LED	2
738 190	Rear lights	1
739 760	Driver assistance 1	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
738 02	Automotive power supply 13.8 V/36 A	1
LDS 00001	Stopwatch, digital	1
726 10	Panel frame T150, two-level	1
500 59	Safety bridging plugs, black, set of 10	4
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
500 593	Fault simulation plugs, black, set of 10	1*
738 01	Cable and plug box	1*
775 014DE	LIT-print: Backfitting electrical systems, German	1

\* additionally recommended

That is especially convenient when passing: Lane changes as well as the return into the line of cars is clearly announced by the repeated use of turn signals, as the German Highway Code (STVO) calls for in §5. The vehicles behind receive sufficient warning, and the passing driver can fully concentrate on the flow of traffic. This "blinking sequence" is a comfort feature that is absent from many production vehicles, especially older ones, and can only be retrofitted.

This subject exhaustively and practically studies such retrofitting:

- How are the existing turn signals connected?
- How should the operating instructions' wiring diagram be read?
- And how should it be copied in the vehicle?
- Where does the aftermarket device connect?
- The module does not work – why?

To establish practical relevance, work is done with the original operating manual and the original set of cables.

## Backfitting electrical systems

A2.1.4.3  
Cornering light



FIELDS OF LEARNING:  
3, 4, 9, 11, 14

Cornering light (A2.1.4.3)

Cat. No.	Description	A2.1.4.3
738 113N	Cornering light Net	1
738 291	Relay 1NO	1
738 111	Intelligent automotive lighting management system	1
738 1822	Set: Bi Xenon headlights	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 06	12 V on-board socket	1
739 6021	Instrument cluster unit	1
738 190	Rear lights	1
739 654	Steering angle sensor	1
738 18	Auxiliary headlamp	2
739 760	Driver assistance I	1
738 361	Side turn signal light LED	2
579 163	PWM/PFM generator, STE 2/50	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
773 961	CAN-Bus-Multi-Adapter	1
313 12	Digital stop-watch	1
738 02	Automotive power supply 13.8 V/36 A	1
738 9821	Safety experiment cables, set of 51	1
739 195	Connecting Leads, set of 7	1
500 59	Safety bridging plugs, black, set of 10	10
500 592	Safety bridging plugs with tap, black, set of 10	2
577 321	Resistor 120 Ohm, STE 2/19	2
577 79	Variable resistor 1 kOhm, STE 2/19	1
726 256	Panel frame VT160, Three Level	1
738 01	Cable and plug box	1
738 05	Connection leads I, set	1
689 0808	Set 5 automotive Mini fuses	1
775 016EN	LIT-print: Cornering Light	1

Since conventional vehicle lighting is designed for straight roads, curve or side streets are not illuminated optimally when turning. Engineers therefore developed systems that move the headlights depending on the steering wheel position at first mechanically, later electrically as well. This system is still known as „dynamic cornering lights.“ As an extension the Static Cornering Light is an additional lateral facing light to normal driving light.

The following topics can be covered:

- Additional systems / auxiliary units
- Legal regulations (ECE)
- Installation instructions
- Schematics, symbols, terminal designations
- Wires, connectors
- Electric and electronic components, assemblies and systems
- Electrical and electronic circuits, basic variables and signals
- Regulations for the testing of electrical / electronic systems
- Requirements for testing and setting of headlights
- Safety and accident prevention in dealing with electrical components

### Ignition systems

A2.3.1.3  
Distributorless coil  
ignition system (DIS)

FIELDS OF LEARNING:  
1, 5, 8

Further equipment(s)  
on electromobility from p. 76



Distributorless coil ignition system (DIS) (A2.3.1.3)

Cat. No.	Description	A2.3.1.3
738 5161	Universal ignition module (UESC)	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
739 43	Distributor Drive Universal	1
738 517	DIS-Two Spark Ignition Coil	1
738 518	DIS-Ignition Cable Set	1
738 515	Crankshaft Position Sensor (CPS)	1
738 441	Spark plug holder	1
579 06	Lamp holder, E10, top, STE 2/19	4
590 83	Coil 500 turns STE 2/50	2
590 84	Coil 1000 turns STE 2/50	2
593 21	Transformer core, demountable	2
505 36	Glow lamp 110 V, E10	4
576 74	Plug-in board, DIN A4, STE	1
375 58	Hand vacuum pump	1
738 02	Automotive power supply 13.8 V/36 A	1
738 985	Automotive meter	1
524 031	Current source box	1
524 0431	30-A-Box	1
524 076	AUTO-BOX i	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
728 950	USB port isolator	1
738 989	Standard Workshop TDC Pick-Up	1
738 986	Inductive-Type Pulse Pick-Up	1
775 031DE	LIT-print: Distributorless coil ignition systems, German	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
500 596	Safety bridging plugs, STE 2/19, set of 10	1
501 48	Bridging plugs STE 2/19, set of 10	1

Cat. No.	Description	A2.3.1.3
501 46	Connecting leads 19 A, 100 cm, red/blue, pair	1
726 09	Panel frame T130, two-level	1
738 05	Connection leads I, set	1
500 593	Fault simulation plugs, black, set of 10	1*
738 01	Cable and plug box	1*

\* additionally recommended

Fuel-air mixing and ignition are the essential characteristics of a gasoline engine. After the fuel-air mixture is formed, it must be ignited safely and at the right time. The ignition is responsible for this.

Advancements in the area of ignition from conventional coil ignition (CI) and transistor ignition (TI) to electronic ignition (EI) and to fully electronic ignition (FI) have happened since 1982. While the high-voltage distribution is still mechanical for EI, it is purely electronic in FI. The latter thus contains no parts susceptible to wear. The spark advance happens electronically, taking into account different variables such as the engine speed.

With the components of this equipment set the basics of the DIS ignition can be investigated. DIS means, distributorless ignition system' and thus describes a system without rotating distributor.

### Ignition systems

A2.3.1.4  
Distributorless coil  
ignition system (SSI)



FIELDS OF LEARNING:  
1, 5, 8

Further equipment(s)  
on electromobility from p. 76

#### Distributorless coil ignition system (SSI) (A2.3.1.4)

Cat. No.	Description	A2.3.1.4
738 5161	Universal ignition module (UESC)	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
739 43	Distributor Drive Universal	1
738 515	Crankshaft Position Sensor (CPS)	1
738 481	Single Spark Ignition System (SSI)	1
738 443	Pencil coil system	2
579 06	Lamp holder, E10, top, STE 2/19	4
590 83	Coil 500 turns STE 2/50	2
590 84	Coil 1000 turns STE 2/50	2
593 21	Transformer core, demountable	2
505 36	Glow lamp 110 V, E10	2
576 74	Plug-in board, DIN A4, STE	1
375 58	Hand vacuum pump	1
738 02	Automotive power supply 13.8 V/36 A	1
738 985	Automotive meter	2
524 031	Current source box	1
524 0431	30-A-Box	1
524 076	AUTO-BOX i	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
728 950	USB port isolator	1
738 989	Standard Workshop TDC Pick-Up	1
738 986	Inductive-Type Pulse Pick-Up	1
775 031DE	LIT-print: Distributorless coil ignition systems, German	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
500 596	Safety bridging plugs, STE 2/19, set of 10	1
501 48	Bridging plugs STE 2/19, set of 10	1
738 05	Connection leads I, set	1

Cat. No.	Description	A2.3.1.4
501 46	Connecting leads 19 A, 100 cm, red/blue, pair	1
726 09	Panel frame T130, two-level	1
500 593	Fault simulation plugs, black, set of 10	1*
738 01	Cable and plug box	1*

\* additionally recommended

With the **single spark ignition coil** an ignition coil and a spark plug each form a compact unit. One side of the secondary winding goes to the ground, and the other side connects directly to the spark plug.

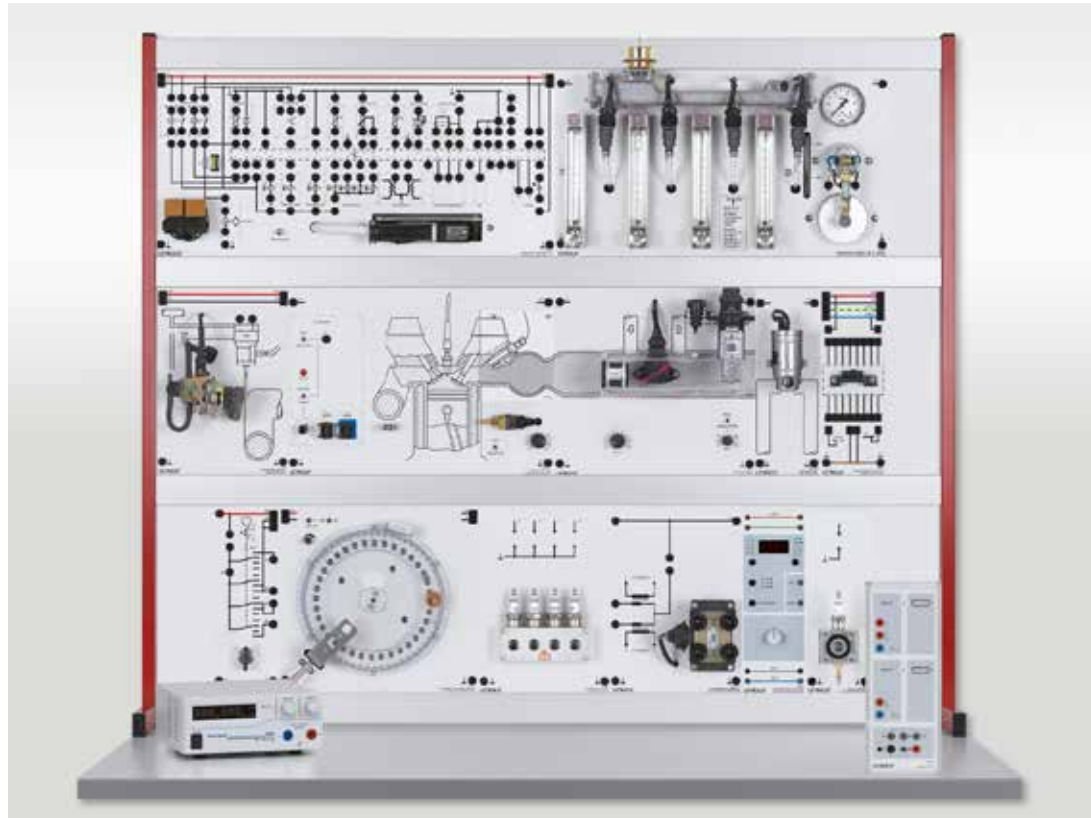
The core components are the single spark system and the pencil coils.

Because of the missing high voltage cable no capacitive voltage sensor can be connected to the spark plug's lead. The system panel "single spark ignition system" is therefore equipped with two test ports to record the secondary oscillogram.

### Motor management systems petrol

A2.3.2.1  
Fuel injection

FIELDS OF LEARNING:  
1, 5, 8, 11P, 11N, 11S, 12P, 12S



Fuel injection (A2.3.2.1)

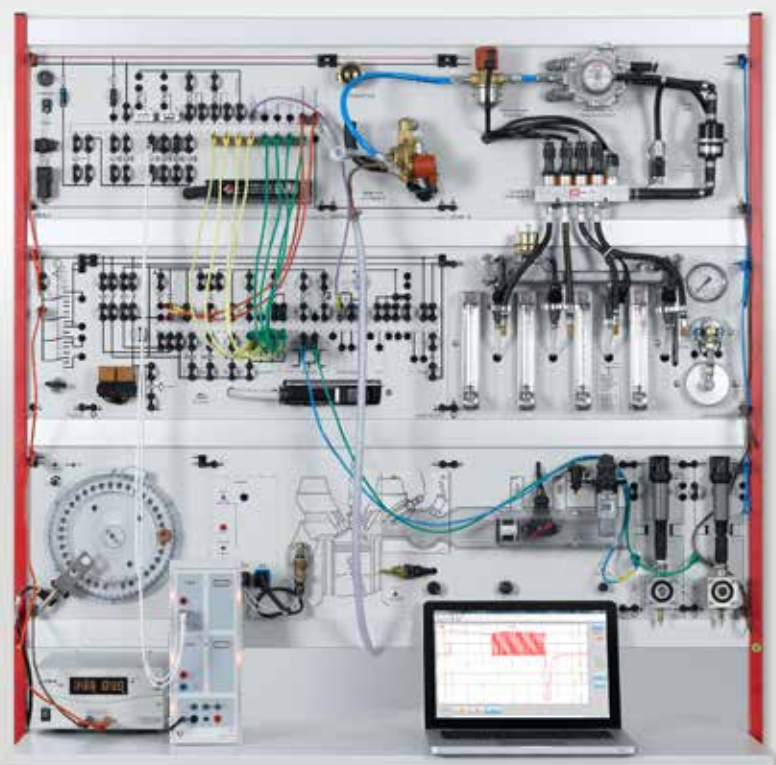
Cat. No.	Description	A2.3.2.1	A2.3.2.2
739 402	Electronic Control Unit (Petrol engine)	1	1
739 37	Evaluation Unit Motronic	1	1
738 517	DIS-Two Spark Ignition Coil	1	
739 255	Electric EGR valve	1	
739 191	Substitute Engine Panel	1	1
739 03	Knocking Sensor	1	
739 42	Crank Angle Sensor	1	1
739 421	Cable for Crank Angle Sensor	1	
739 271	Lambda Sensor, heated	1	1
739 253	Rotary Idle Actuator	1	1
739 411	Air Mass Meter, LH Motronic	1	1
738 431	Flywheel with Sensor Holder	1	1
738 441	Spark plug holder	1	
738 518	DIS-Ignition Cable Set	1	
738 103	Ignition start switch	1	1
738 032	Battery connection with protection circuit	1	1
524 013S	Sensor-CASSY 2 Starter	1	1
524 076	AUTO-BOX i	1	1
738 989	Standard Workshop TDC Pick-Up	1	1
738 986	Inductive-Type Pulse Pick-Up	1	
739 589	Software: Vehicle diagnosis	1	1
737 9807	Diagnosis adapter Opel USB	1	1
738 9811	Silicon oil M5 blue, 1 liter	2	2
726 18	Panel frame T130, Three Level	1	1
738 027	Digital power supply 1 - 16 V/40 A	1	1
688 131	Mains cable Type G	1*	1*
726 962	Function generator 200 kHz	1	
500 990	Adapter sockets, set of 2	1	1
577 80	Variable resistor 10 kOhm, STE 2/19	1	
577 38	Resistor 330 Ohm, STE 2/19	1	

Cat. No.	Description	A2.3.2.1	A2.3.2.2
577 97	Resistance decade 10 Ohm...11.1 kOhm, STE 4/50/100	1	
375 58	Hand vacuum pump	1	1
738 442	Single pressure chamber	1*	
738 998	Pressure pump, foot-operated	1*	
666 711	Butane gas burner	1	
666 712ET3	Butane cartridge, 190 g, set of 3	1	
666 555	Universal clamp 0...80 mm	1*	
666 733	Piezoelectric gas igniter	1*	
300 02	Stand base, V-shaped, small	1*	
301 01	Leybold multiclamp	1*	
300 41	Stand rod 25 cm, 12 mm Ø	1*	
500 59	Safety bridging plugs, black, set of 10	6	10
500 592	Safety bridging plugs with tap, black, set of 10	1	1
739 195	Connecting Leads, set of 7	1	1
738 9821	Safety experiment cables, set of 51	1	1
665 010	Funnel, plastic, 100 mm Ø	1*	1*
775 032EN	LIT: A2.3.2.1 Fuel injection	1	
738 05	Connection leads I, set	1	1
738 01	Cable and plug box	1*	1*
738 4911S	Automotive fault simulator, start	1*	1*
500 593	Fault simulation plugs, black, set of 10	1*	1*
739 405	LPG gas system		1
738 443	Pencil coil system		2
738 9991	DC/AC Clamp on current probe		1
738 985	Automotive meter		1
577 79	Variable resistor 1 kOhm, STE 2/19		1
577 81	Variable resistor 4.7 kOhm, STE 2/19		1
577 83	Variable resistor 100 kOhm, STE 2/19		1
739 406	LPG spark plugs; set 4 EA		1
747 800	Tool set spark plug		1

## Motor management systems petrol

A2.3.2.2  
LPG retrofitting

FIELDS OF LEARNING:  
1, 5, 8, 11P, 11N, 11S, 12P, 12S



### LPG retrofitting (A2.3.2.2)

Cat. No.	Description	A2.3.2.1	A2.3.2.2
744 600	Low-noise Compressor		1
775 036EN	LIT-print: Gas drives		1
689 0813	Set 12 automotive fuses		1*
689 0814	Set 2 automotive automatic fuses		1*

\* additionally recommended

Motor management systems are responsible for combining the electronic injection with the likewise electronic ignition in a single engine control unit.

Further functions are added over time:

- Idle speed control
- Lambda control
- Exhaust gas recirculation
- Knock control
- Self-diagnosis

The LH motronic is assembled in the classic experimental panel style with rear signal cabling. This setup enables the study of all components of an ignition and injection control with distribution at rest and single-point injection.

This includes the following sensors:

- the air mass flowmeter
- the throttle valve potentiometer
- the lambda sensor
- the motor/air temperature
- the knocking sensor
- the speed pick-up,

and actuators

- idling speed positioner
- exhaust gas recirculation valve
- DIS coil ignition
- injectors.

The error diagnostics are possible with adapted tests on the OBD socket or a blink code output.

All gasoline vehicles can be retrofit to run on compressed **natural gas (CNG)** or **liquefied petroleum gas (LPG)**. While driving at any time can be switched from gasoline to gas or vice versa. Low fuel cost and low emission of pollutants speak for this conversion.

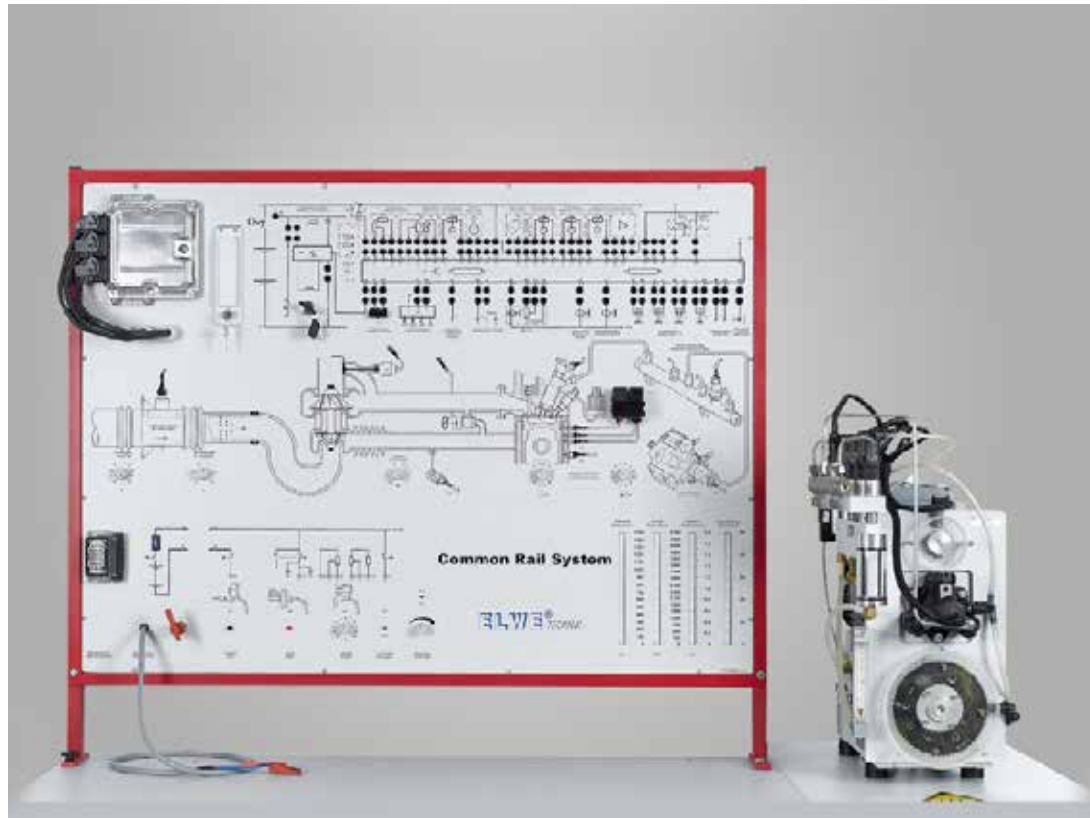
LEYBOLD provides for the system A2.3.2.1 „Fuel injection“ with the LH-Motronic an equipment set that contains all the components for an upgrade with LPG. And all completely harmless: the liquid gas is simulated by a non toxic and non flammable substitute gas so a threat of the students is excluded!

### Motor management systems Diesel

A2.3.3.4  
Common rail

FIELDS OF LEARNING:  
1, 5, 8, 11P, 11N, 11S, 12P, 12S

Further equipment(s)  
on electromobility from p. 76



Common rail (A2.3.3.4)

Cat. No.	Description	A2.3.3.4
8-1 503440-001-12-0	Experiment stand Common Rail	1
8-1 503431-100-02-0	Hydraulic aggregat Common Rail	1
854 883	Mobile Experiment stand 1300	1
738 027	Digital power supply 1 - 16 V/40 A	1
688 131	Mains cable Type G	1*
598 141	AC electrical frame	1
738 9821	Safety experiment cables, set of 51	1
500 990	Adapter sockets, set of 2	1
775 037DE	LIT-print: Common Rail, German	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 0431	30-A-Box	1
524 076	AUTO-BOX i	1
739 004	DMM for electrical vehicles	1
739 001	Infrared-thermometer	1
739 008	IR Thermal Imaging Camera	1

\* additionally recommended

Common rail technology is the most widespread diesel injection system currently used in automotive production world-wide. Instead of the previously used distribution pump with its complicated mechanical parts and injectors which determine the injection pressure, a high-pressure pump of much simpler construction with a pressure of up to 1200 bar and piezoelectric injectors are now used.

The parts of the unit belonging to the system are driven by a 3~ induction motor on a frequency converter. Thus, the speed can be adjusted continuously from idling to the limit of regulation.

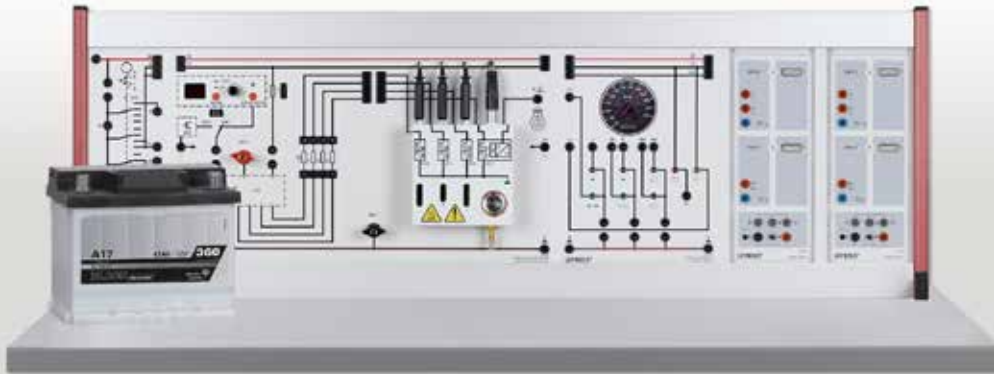
The unit consists of the following original components:

- Pre-feed and high-pressure pump
- Fuel filter
- Rail (pressure accumulator) with pressure sensor and pressure control valve
- 4 injection nozzles (injectors)
- Camshaft sensor
- Crankshaft sensor
- Fuel cooler
- Storage tank for diesel substitute fuel
- Injection quantity meter
- Sight glass for observing the injection process



## Motor management systems Diesel

A2.3.3.5  
Diesel Quick Start System



FIELDS OF LEARNING:  
1, 5, 8, 11P, 11N, 11S, 12P, 12S

Further equipment(s)  
on electromobility from p. 76

Diesel Quick Start System (A2.3.3.5)

Cat. No.	Description	A2.3.3.5
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
740 306	Diesel Quick Start System	1
738 1511	Control lamps KI	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 013S	Sensor-CASSY 2 Starter	1
524 0673	NiCr-Ni adapter S, type K	1
529 676	Temperature probe, NiCr-Ni, 1.5 mm, type K	1
739 580	Databus detector	1
739 836	Milliohm meter	1
313 033	Electronic time clock P	1*
LDS 00001	Stopwatch, digital	1
738 044	AGM-battery 12V	1
738 043	Vehicle battery connecting kit	1
738 021	Battery charger, automatic	1
688 161	Travel adapter	1*
738 05	Connection leads I, set	2
726 19	Panel frame SL85, single-level	1
500 59	Safety bridging plugs, black, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1
500 641	Safety experiment cable, 100 cm, red	4
500 617	Safety cable, 25 cm, brown	4
500 421	Connecting lead 19 A, 50 cm, red	1
775 038DE	LIT-print: Diesel Fast Glow System, German	1
590 011	Clamping plug	2

\* additionally recommended

Diesel motors are piston engines with spontaneous ignition. The fuel must be injected directly into the combustion chamber to then be compressed and heated to between 700°C and 900°C. This temperature is enough to ignite the mixture. The need for constantly increasing injection pressure has led from the distributor-type fuel-injection pump to the high-pressure systems like a unit injector or common rail.

In addition to the familiar preheating for improved starting characteristics of a compression-ignition engine, controlled post-heating quickly warms the combustion chamber, thus reducing exhaust gas emissions. A separate  $\mu\text{C}$ -controlled heat control unit is installed for activation of the heater plugs. This unit receives information on the time period and duration of the heating process from the engine controller. The heat control unit then activates the heater plugs and reports any possible disruptions to the engine controller using the integrated diagnostics feature. In order to minimise the power consumption during heating, the heater plugs are activated with a PWM signal with a delay.

Heater plugs with integrated pressure sensors are used to monitor the pressure in the combustion chamber. In this case the heat plug is mounted so that it exerts the force applied to the heat plug by the combustion chamber pressure to a measuring diaphragm. The pressure signal is also sent to the engine controller, where it is further processed. This way, for example, the injection period of the main injection can be changed as a corrective measure.

### Automating

#### A2.4.1.2 Parking aid

FIELDS OF LEARNING:  
3, 9, 11P, 11S

Additional equipment(s) on  
driver assistance systems from p. 61



Parking aid (A2.4.1.2)

Cat. No.	Description	A2.4.1.2
739 750	Park distance control	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 295	Central electrics	1
738 06	12 V on-board socket	1
416 003	Ultrasonic receiver	2
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
738 975	Diagnostic socket 16 Pin	1
737 9803	OBd Adaptor CAN+USB	1
738 02	Automotive power supply 13.8 V/36 A	1
300 02	Stand base, V-shaped, small	1
726 10	Panel frame T150, two-level	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
500 644	Safety experiment cable, 100 cm, black	2
500 647	Safety connection lead 100 cm brown	2
577 44	Resistor 1 kOhm, STE 2/19	1
775 041DE	LIT-print: Parking aid, German	1
500 593	Fault simulation plugs, black, set of 10	1*

\* additionally recommended

Comfort systems, like safety systems, are part of the basic equipment in modern motor vehicles. In contrast to driver assistance systems, however, they do not actively intervene in the driving process, but they are only useful for information and comfort.

The **park distance control** – also known as back-up warning or Parkpilot – is a useful accessory in the area of comfort electronics. Complex or closed body designs restrict sight forward and backward in many vehicles. The park distance control uses ultrasound sensors to reliably measure the distance to all kinds of obstacles, in particular to children and pedestrians. An optical and acoustic warning protects the vehicle and external objects from damage.

LEYBOLD has developed an experimental panel for the topic of park distance control, consisting of

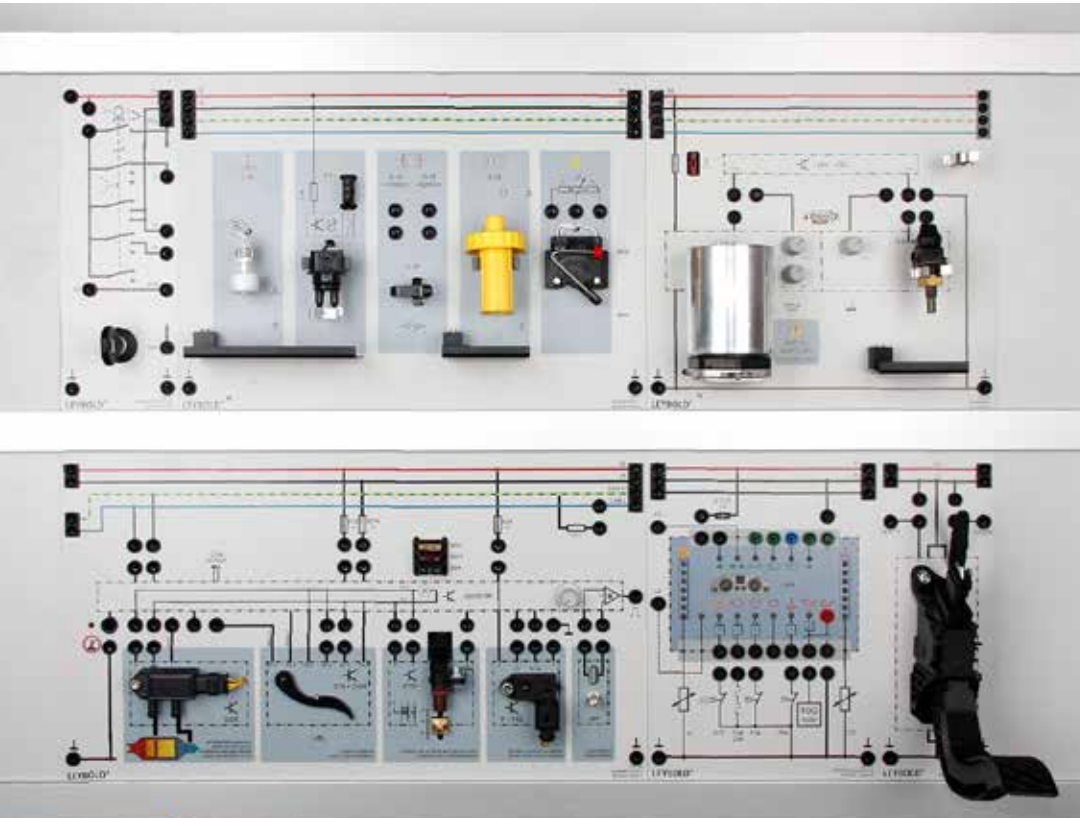
- an original control unit
- four original ultrasound sensors, as well as
- an acoustic and
- an optical indicator.

Simulated engagement in reverse gear activates the application. When switched on, the sensors – built into the vehicle's bumper – send out ultrasound signals and receive the reflected echoes. The control unit calculates the distance of an obstacle down to the centimeter. The display shows the different distance ranges with light bars of different colors or with an acoustic distance warning with changing sound sequences.

The sensor connection cables and the ground wire to the control unit are brought through bridging plugs in order to simply measure voltages and currents and simulate open circuit faults.

### Automating

A2.4.1.4  
Automotive Sensors



FIELDS OF LEARNING:  
3, 8, 10, 11P, 11N, 11S, 13P

Further equipment(s)  
MA2.1 on p. 37

Automotive Sensors (A2.4.1.4)

Cat. No.	Description	A2.4.1.4
739 707	Automotive sensors 1	1
739 708	Automotive sensors 2	1
739 709	Position sensor w. SENT	1
738 1511	Control lamps KI	1
739 706	Oil sensor	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 295	Central electrics	1
738 06	12 V on-board socket	1
738 12	Multi-purpose switch	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
773 961	CAN-Databus-Multi-Adapter	1*
739 001	Infrared-thermometer	1
738 02	Automotive power supply 13.8 V/36 A	1
590 48	Immersion heater 12 V/10 W	1
726 10	Panel frame T150, two-level	1
738 9821	Safety experiment cables, set of 51	1
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	2
739 195	Connecting Leads, set of 7	1
738 01	Cable and plug box	1*
738 49115	Automotive fault simulator, start	1*
500 593	Fault simulation plugs, black, set of 10	1*
739 03	Knocking Sensor	1
575 24	Screened cable, BNC/4 mm Plug	1
501 091	BNC T adapter	1
689 0815	Set of 10 magnets	1
775 043DE	LIT-print: On-board computer, German	1

\* additionally recommended

Traditional monitoring of fill levels and temperatures occurs with modern control units. Current measurements in conductor loops give information on a worn brake pad.

Moreover, various fill level sensors provide data that is shown to the driver optically and/or acoustically.

The "on-board computer" educational system monitors:

- the coolant and the windshield washer fluid levels,
- the brake fluid and motor oil levels,
- the wear on the brake pads,
- the motor oil and coolant temperatures.

The oil sensor is a continually measuring thermal oil level and oil temperature sensor (TOG) that can be filled with motor oil. Optionally, regulation resistors can simulate the signals. The signal produced converts the information on the oil into a combined PWM (pulse-width modulation) and PFM (pulse-frequency modulation) signal, that Sensor-CASSY 2 can chart, for example.

The signal from the coolant's temperature sensor can also either triggered either by immersion into warm water or by setting a potentiometer. An appropriate holder is available for parallel temperature measurement with a temperature sensor. In the uncoupled state, the real temperature and the resistance can for example be measured with Sensor-CASSY 2 and analyzed as an NTC curve.

### Automating

A2.4.1.5  
Air conditioning

FIELDS OF LEARNING:  
1, 2, 5, 6, 8, 11P, 11S



Air conditioning (A2.4.1.5)

Cat. No.	Description	A2.4.1.5
39- 305-230	Automotive Air-conditioning Trainer	1
739 001	Infrared-thermometer	1
739 008	IR Thermal Imaging Camera	1
739 005	Manifold gauge set	1
524 013S	Sensor-CASSY 2 Starter	1*
738 9991	DC/AC clamp-on current probe	1*
524 044	Temperature sensor S, NTC	2*
775 046DE	LIT-print: AirCon Trainer, German	1

\* additionally recommended

Have you ever wondered how the air-con system in your car actually works? The automotive air conditioning trainer enables students to find out how a typical system works whilst learning the principles of refrigeration. By using authentic components, students learn how to perform fault finding and servicing using a safe and accessible system. The product has been designed specifically with hands-on training in mind and it can also be used by students to perform the safe recovery and recharging of refrigerant.

Complete with compressor, condenser, receiver dryer, expansion valve and evaporator, the unit is pre-installed with R134a type refrigerant which is an HFC non-ozone depleting gas and is in line with global emissions guidelines. The system is furnished with high and low-side pressure service ports that facilitate easy connection of a gauge set or for the recovery and re-charging of refrigerant. These ports are typical quick coupler type as would be found on modern vehicles.

The speed of the motor which simulates the vehicle engine is variable by means of an electronic, digitally controlled three-phase inverter drive. This enables the demonstration of the effect that compressor speed has on the system performance. The system is designed to be bench mounted and run from either a 230 V or 110 V ac supply. There is a 12 V dc output socket which enables the connection of ancillary equipment, such as a UV leak detection lamp.

- Uses actual automotive components
- Suitable for both technician and vocational teaching
- Portable design
- Uses non-ozone depleting HFC refrigerant
- Enables hands-on access to all components
- Simulates common faults
- Variable speed motor simulates car engine
- Available for either 110V or 230V mains connection

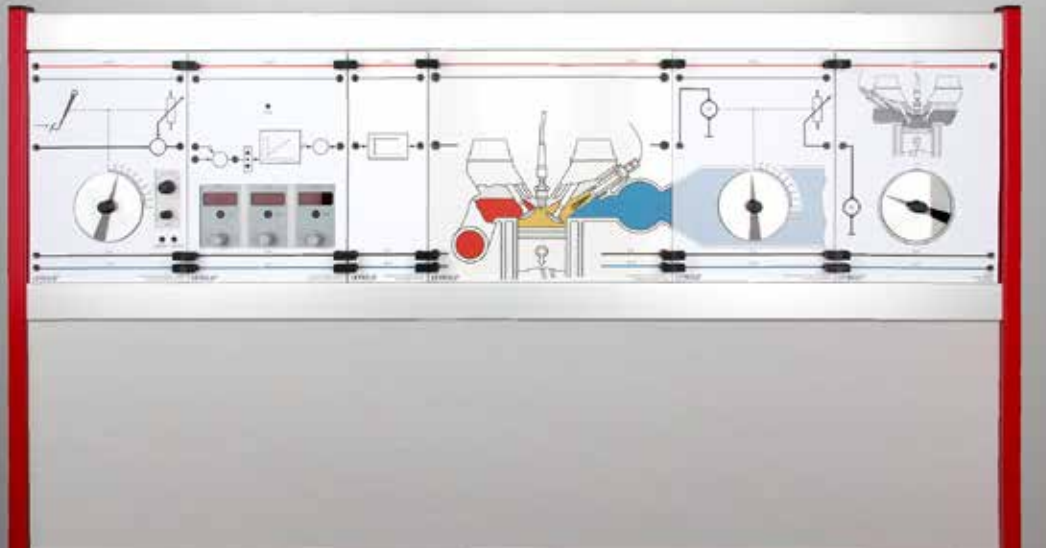
The provision of a sight glass enables students to observe the state of the refrigerant in the high pressure side of the system. This assists with the diagnosis of simulated common faults which can be applied by the instructor, e.g.:

- Blocked TEV (Thermal Expansion Valve)
- Blocked receiver drier
- Faulty valve plate

The student will observe the effect of the faults by monitoring system pressures (using optional manifold gauges) changes in the cooling duty, observing changes on the digital thermometer and observing the state of the refrigerant in the sight glass. A high pressure cut-out switch shuts the compressor down if the high side pressure becomes abnormally high.

### Driver assistance systems

A2.4.2.1  
Electronic gaspedal



FIELDS OF LEARNING:  
3, 7, 9, 11P, 11S

Electronic gaspedal (A2.4.2.1)

Cat. No.	Description	A2.4.2.1
734 064N	PID digital controller net	1
739 56	Electronic Gaspedal Accessory	1
579 161	Simulation Incline, STE 4/50	1
579 13	Toggle switch STE 2/19	2
734 10	Servo setpoint generator	1
734 13	Power amplifier	1
734 14	DC servo	2
727 20	Automobile Meter Zero-Left	1
727 21	Automobile Meter Zero-Center	1
LDS 00001	Stopwatch, digital	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
726 10	Panel frame T150, two-level	1
726 501	Safety socket plug-in board, 297 mm x 200 mm	1
726 88	AC/DC stabilizer	1
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	1
500 854	Safety leads, set of 20	1
775 044DE	LIT-print: Electronic gaspedal, German	1
738 01	Cable and plug box	1
500 593	Fault simulation plugs, black, set of 10	1

Controls and regulations have always had their place within motor vehicle technology. What began mechanically, e.g. with the ignition's vacuum adjustment, now works electrically/electronically as much as possible. The core curriculum states:

"[...] They (the students) distinguish between controls and regulations and assign hydraulic, pneumatic or electric/electronic systems to typical components and parts of vehicles. They analyze functional relationships and apply testing and measuring processes to study signal, material or energy flows."

Using the "electronic accelerator pedal" (drive-by-wire), the basic concepts of control engineering are worked out. Experiments are carried out on the following points:

- Steering and control systems
- Control and control systems
- Continuous and discontinuous controllers
- Open and closed control loops
- Behaviour of P, PI and PID controllers

### Driver assistance systems

#### A2.4.2.2 Dead spot assistance

FIELDS OF LEARNING:  
3, 9, 11P, 11S



Dead spot assistance (A2.4.2.2)

Cat. No.	Description	A2.4.2.2
739 7601	Driver assistance I	1
577 321	Resistor 120 Ohm, STE 2/19	2
579 13	Toggle switch STE 2/19	1
579 163	PWM/PFM generator, STE 2/50	1
738 103	Ignition start switch	1
738 111	Intelligent automotive lighting management system	1
738 1121	OBD adaptor	1
738 131	Stalk with with parking light	1
738 1511	Control lamps KI	1
738 1661	Headlights right halogen + LED	1
738 1671	Headlights left halogen + LED	1
738 190	Rear lights	1
738 373	Turn signal control	1
739 6021	Instrument cluster unit	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
773 961	CAN-Bus-Multi-Adapter	1
738 027	Digital power supply 1 - 16 V/40 A	1
688 131	Mains cable Type G	1*
300 11	Saddle base	2
500 59	Safety bridging plugs, black, set of 10	6
500 592	Safety bridging plugs with tap, black, set of 10	1
500 990	Adapter sockets, set of 2	1
501 45	Connecting lead 19 A, 50 cm, red/blue, pair	1
738 9821	Safety experiment cables, set of 51	1

\* additionally recommended

**Blind spot detection:** Two ultrasonic transducers detect whether another vehicle is in the side and signal this with a visual warning. As soon as the driver intends to change lanes by activating the turn signal lever, an acoustic warning is also given. As soon as the driver intends to change lanes in the direction of the detected vehicle by operating the indicator lever, an additional acoustic warning is given.

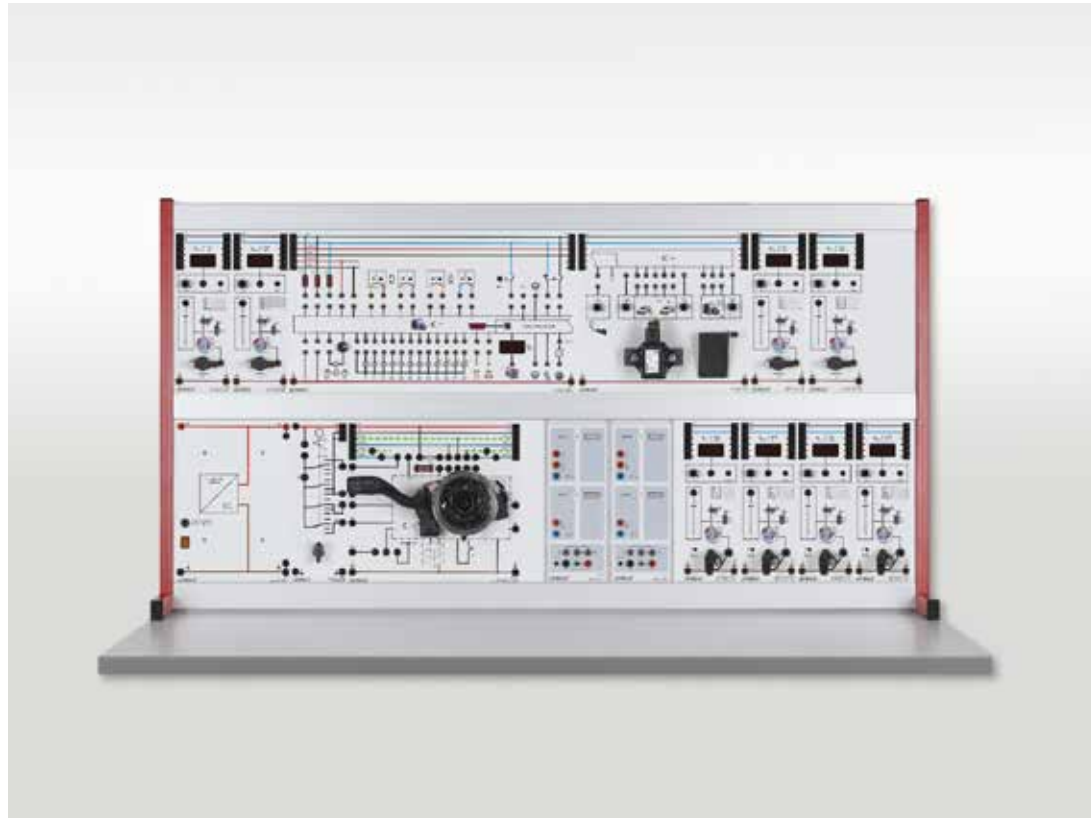
**Rear view camera:** An integrated rear view camera is activated when reverse gear is engaged. reverse gear is engaged. This detection can be done locally or via the CAN bus in conjunction with the car diagnostic adapter (738 1121). The image displayed is mirror-inverted and has distance markings. In low ambient light, the infrared auxiliary light is automatically activated. A second camera can be connected via a front socket and used as a "dashcam". The image from this camera is displayed in the monitor monitor.



### Braking systems

A2.5.1.1  
Electronic stability system  
ABS/ESP

FIELDS OF LEARNING:  
8, 10, 11S, 12P



Electronic stability system ABS/ESP (A2.5.1.1)

Cat. No.	Description	A2.5.1.1
739 650	ABS/ESP control unit	1
739 6511	ABS/ESP sensors	1
739 6521	Wheel substitute panel, inductive	4
739 6531	Wheel substitute panel, Hall	4
738 111-02	Steering column electronics	1
739 654	Steering angle sensor	1
738 02	Automotive power supply 13.8 V/36 A	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
524 013	Sensor-CASSY 2	1
524 013S	Sensor-CASSY 2 Starter	1
738 985	Automotive meter	1
726 10	Panel frame T150, two-level	1
500 59	Safety bridging plugs, black, set of 10	5
500 592	Safety bridging plugs with tap, black, set of 10	1
500 595	4 mm branching bridging plug, red	1
739 195	Connecting Leads, set of 7	1
738 9821	Safety experiment cables, set of 51	1
775 050DE	LIT-print: Electronic Stability System ABS/ESP, German	1
738 01	Cable and plug box	1*
500 593	Fault simulation plugs, black, set of 10	1*
738 4911S	Automotive fault simulator, start	1*

\* additionally recommended

The wheels' rotational speed is continuously detected by sensors and analyzed by the control unit. In case the wheel sticks, there are adjusting commands at the magnetic valves. The pressurization and depressurization phases follow. The braking effect is reduced and the wheel speeds up again. Our educational system demonstrates these phases.

The signal cabling reliably works through the back side so that the front remains clear. An oscilloscope or Sensor-CASSY can record measurements.

The electronic stability program ESP is a control system in the brakes and in the power train that prevents the vehicle from slipping to the side. The ABS prevents the wheels from getting stuck when braking; ASR avoids wheels spinning on startup. ESP ensures that the vehicle does not "slide" or become unstable.

The self-diagnosis can be executed in combination with a PC, and typical driving situations can be retraced. A software self-diagnosis and drive simulation are thus available. These can simulate the following situations:

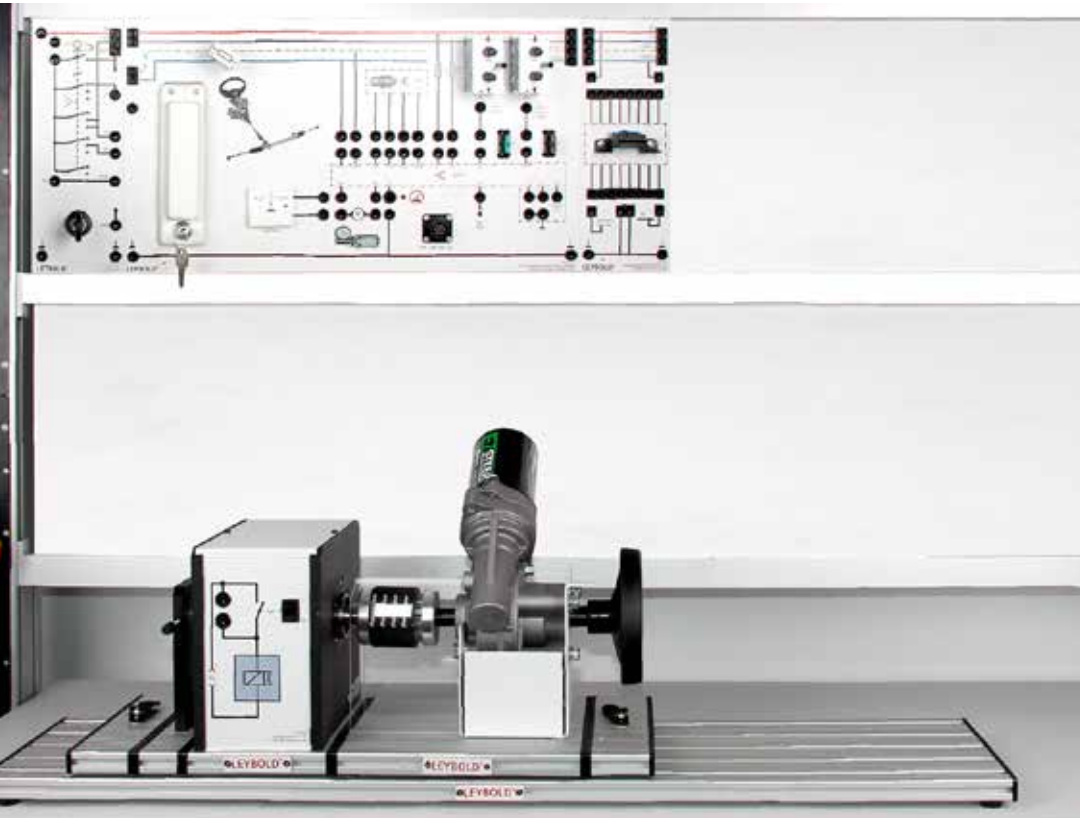
- Driving maneuver "Quick steering and countersteering"
- Driving maneuver "Lane change with emergency stop (moose test)"
- Driving maneuver "Steering and countersteering multiple times"
- Driving maneuver "Acceleration/deceleration in a tight curve"

Optionally, other student measuring stations (740 050) can be connected to the control unit. The students can record and analyze all measurements on the installation at their workstations.



## Steering system

A2.5.3.2  
Electrical assisted  
power steering



FIELDS OF LEARNING:  
2, 8, 10, 11N, 11S, 12P

Electrical assisted power steering (A2.5.3.2)

Cat. No.	Description	A2.5.3.2
739 5021	Electric Power Steering (EPS)	1
739 503	Load mechanical 1 kW	1
773 110	Machine base bench, 90 cm	1
732 56	Coupling, 1.0	1
579 163	PWM/PFM generator, STE 2/50	2
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
726 890	DC power supply unit 1...32 V/0...20 A	1
738 027	Digital power supply 1 - 16 V/40 A	1
688 131	Mains cable Type G	2*
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 0431	30-A-Box	1
773 961	CAN-Bus-Multi-Adapter	1
738 985	Automotive meter	1
LDS 00001	Stopwatch, digital	1
579 13	Toggle switch STE 2/19	2*
577 30	Resistor 62 Ohm, STE 2/19	1
315 39	Weight, 1 kg	1
738 975	Diagnostic socket 16 Pin	1*
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	1
501 44	Connecting lead 19 A, 25 cm, red/blue, pair	1
738 05	Connection leads I, set	1
500 600	Safety connection lead 10 cm, yellow/green	1
500 601	Safety connection lead 10 cm, red	3
500 620	Safety connecting lead 50 cm, yellow/green	1
500 621	Safety experiment cable, 50 cm, red	1
500 641	Safety experiment cable, 100 cm, red	2
500 661	Safety connection lead 200 cm, red	1
500 647	Safety connection lead 100 cm brown	2

Cat. No.	Description	A2.5.3.2
500 644	Safety experiment cable, 100 cm, black	2
501 85	Adapter 4-mm plug/4-mm socket	2
738 01	Cable and plug box	1*
726 09	Panel frame T130, two-level	1
775 053DE	LIT-print: Electrical power steering, German	1
500 593	Fault simulation plugs, black, set of 10	1

\* additionally recommended

Power steering: a comfort function that assists steering, in particular when driving slowly.

Electromechanical power steering systems are increasingly replacing the hydraulic steering systems. On the one hand, they form the basis for central assistance functions. On the other hand energy-efficient systems must be used to reduce the electrical power consumption of a modern vehicle.

The main advantages of the electromechanical power steering system in contrast to the hydraulic steering system are:

- Weight savings by eliminating the hydraulic system
- Reduced noise
- Improved control characteristics
- Simplified installation
- Simplified maintenance
- Reduced energy consumption

The electromechanical power steering system generates when needed - and only then - high steering assist forces from the 12-V power supply. For this purpose, a permanent-magnet DC shunt motor is used, which is located directly on the steering column. As an input signal the steering torque sensor records the torque applied by the driver on the steering wheel. For this input value a driving situation-oriented steering power is generated taking other environment variables into account, too.

### COM4LAB: Automotive Data Buses

MA4.1  
Automotive Data  
Bus Systems

FIELDS OF LEARNING:  
3, 6, 9, 11P, 11N, 11S

Further equipment(s)  
on COM4LAB from p. 36



Automotive Data Bus Systems (MA4.1)

Cat. No.	Description	MA4.1
700 6301	COM3LAB Course: Automotive Data Buses - COM4LAB ready	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
700 00CBT	DVD: COM3LAB Software	1
	additionally required: PC with Windows 7/8/10/11 64-bit and a free USB interface	1

\* Alternative USB-C charger with UK plug or US plug

The course deals with the interconnected electronic systems in automotive technology. The main aim of the equipment is to gain knowledge about bus systems and their application areas, the experiments here leading to a comprehensive understanding of the connections in a vehicle, including troubleshooting and fault correction.

#### Topics:

- Bus systems: CAN & LIN
- Measuring technology: physical signals, protocols, fault analysis
- Other applications and system components

### Networking automotive systems

A2.6.1.1  
Networking automotive systems:  
CAN Databus Lighting

FIELDS OF LEARNING:  
3, 6, 9, 11P, 11N, 11S



Networking automotive systems: CAN Databus Lighting (A2.6.1.1)

Cat. No.	Description	A2.6.1.1
739 5821	Training panel lighting NG	1
775 060DE	LIT-print: Networking lighting, German	1
738 027	Digital power supply 1 - 16 V/40 A	1*
688 131	Mains cable Type G	1
500 990	Adapter sockets, set of 2	1
738 9821	Safety experiment cables, set of 51	1
739 580	Databus detector	1
773 961	CAN-Databus-Multi-Adapter	1
739 5881	LIN-Bus PC Interface USB	1
737 9803	OBD Adaptor CAN+USB	1
524 013S	Sensor-CASSY 2 Starter	1
739 589	Software: Vehicle diagnosis	1
738 27	Trailer lights	1*
739 5835	DS vehicle door	1*
739 5836	PS vehicle door	1*

\* additionally recommended

CAN databus and its further development CAN-FD, LIN, MOST, FlexRay and, more recently, Automotive Ethernet control the communication between the control units in the vehicle. Additional sensor-actuator databus systems such as SENT, PSI 5, ASRB or DSI also provide digital data transport.

The training panel in automobile electronics consists of a modern instrument panel insert with electronic immobilizer, the full steering wheel electronics, the central control module for comfort system and the electronic and electric system. The lighting system and a windshield wiper motor round off the system. The basic vehicle electronics and modern data bus systems are clearly and simply represented. This approach places great value on the use of original vehicle parts. The focus is always on error detection, analysis and correction.

The following components are part of the training panel:

- the lighting unit
- the instrument cluster
- the electronic immobilizer
- the steering wheel electronics (LIN bus)
- the control unit for automatic trailer detection
- a 13-pole trailer socket
- the central control module for comfort system (CAN bus)
- the electronic and electric system
- the windshield wiper motor
- the rain photosensor (LIN bus)
- the relay strip
- the OBD diagnostic plug
- a CAN bus interface
- a LIN bus interface
- a fault switching box.

Models of a driver and/or passenger door can complement the training panel.

### Networking automotive systems

A2.6.1.4  
Networking automotive systems:  
MOST Databus practical exercises

FIELDS OF LEARNING:  
3, 6, 8, 9



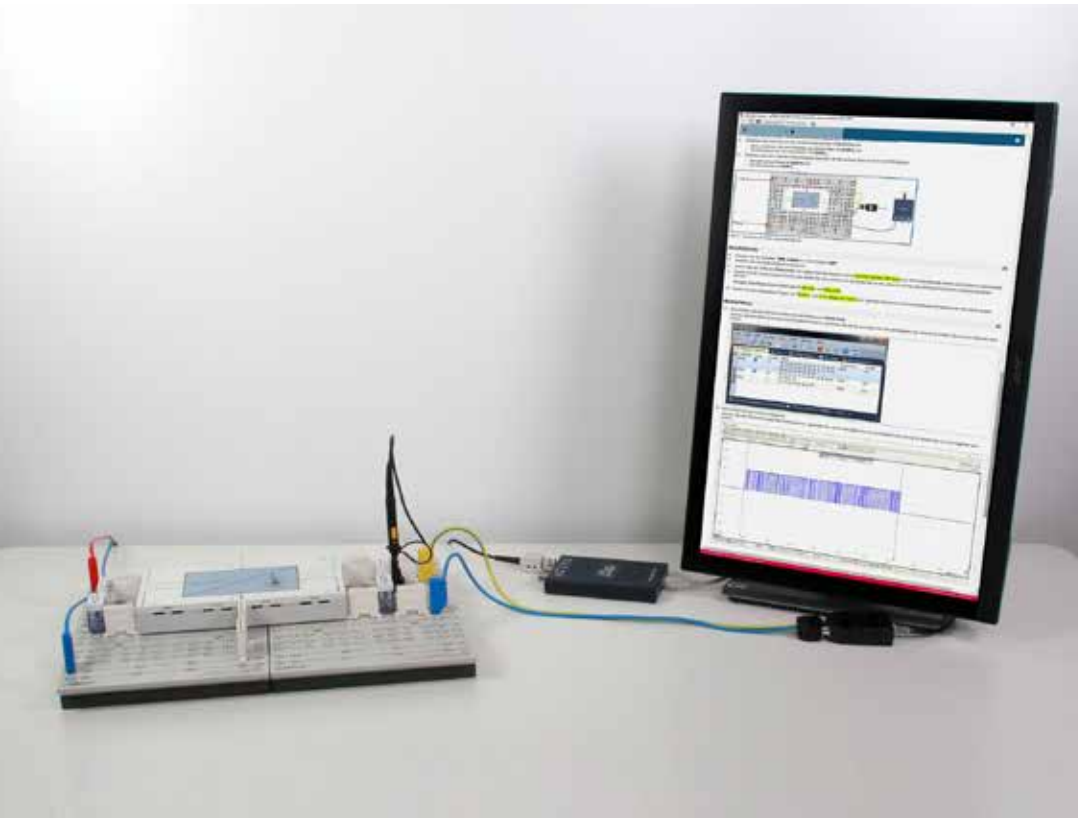
Networking automotive systems: MOST Databus practical exercises (A2.6.1.4)

Cat. No.	Description	A2.6.1.4
740 2081	MOST pliers set	1
740 2082	MOST Accessory set	1
576 74	Plug-in board, DIN A4, STE	1
578 486	STE MOST Transceiver	1
578 485	OWG coupler	1
577 44	Resistor 1 kOhm, STE 2/19	1
740 2088	Automotive fibre optic microscope	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis	1
524 0512	Optical power sensor S	1
521 231	Low-voltage power supply 3/6/9/12 V	1
501 46	Connecting leads 19 A, 100 cm, red/blue, pair	1
685 44	Battery 1.5 V (AA)	2
501 48	Bridging plugs STE 2/19, set of 10	1
775 063DE	LIT-print: Practical exercises MOST-Bus, German	1

The equipment and part sets listed here let the students assemble fiber optic lines typical in vehicles and the teacher evaluate their results. In contrast to FO tool cases like those used with the workshops, all these "consumable components" such as FO, crimp sleeves or polishing equipment come in great quantities so that the exercises can still be executed with many students.

### Networking automotive systems

A2.6.1.9  
Networking automotive systems:  
CAN FD Databus Gateway



FIELDS OF LEARNING:  
3, 6, 9, 11P, 11N, 11S

Networking automotive systems: CAN FD Databus Gateway (A2.6.1.9)

Cat. No.	Description	A2.6.1.9
773 961	CAN-Databus-Multi-Adapter	2
758 213	CAN FD Interface, STE 6/100/200	1*
577 30	Resistor 62 Ohm, STE 2/19	1
577 321	Resistor 120 Ohm, STE 2/19	2*
739 007	Data bus Analyzer USB	1
739 837	Set 2 4 mm oscilloscope probe adaptors	1
726 501	Plug-in board safety socket, 297 mm x 200 mm	2*
501 48	Bridging plugs STE 2/19, set of 10	1
726 88	AC/DC stabilizer	1
500 641	Safety experiment cable, 100 cm, red	1
500 642	Safety experiment cable, 100 cm, blue	1
500 620	Safety connecting lead 50 cm, yellow/green	1
500 621	Safety experiment cable, 50 cm, red	1
500 622	Safety experiment cable, 50 cm, blue	2
500 624	Safety experiment cable, 50 cm, black	1
775 069DE	LIT-print: CAN FD and SENT, German	1
647 001	Tray, low	1*
647 003	Lid for tray	1*
	PC with operating system Windows 7/8/10/11	1

\* additionally recommended

"Evolution instead of revolution" – that is the motto of the new CAN-Bus FD! It wasn't the integration of a completely new data bus system that was at the forefront when CAN-FD was introduced, but rather the expansion and improvement of the existing one. The result was CAN-FD: taking all known mechanisms of the CAN bus, the data transmission speed and data volume in a message were increased considerably.

"FD" means "flexible data rate", which means that as a message is being transmitted, the speed of data transmission in the data field can be increased to up to 8 MBps! But that's not all: now 64 bytes instead of the previous 8 bytes can be transmitted in a message. As a result, these two characteristics mean that with CAN bus FD, a longer message will be transmitted faster than a considerably shorter message is sent with the standard motor CAN bus.

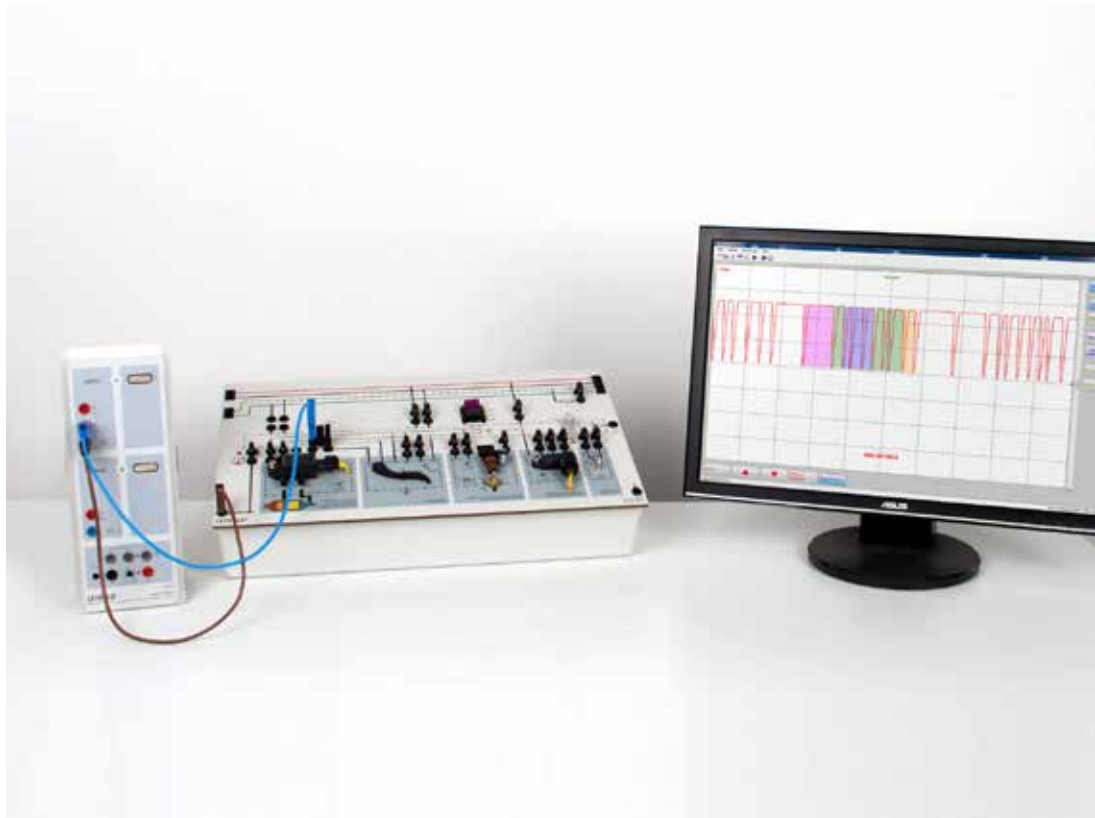
This is especially beneficial for the flash duration for controllers. Vehicle software updates can now be carried out considerably faster than before.

LEYBOLD offers a CAN FD device set with which CAN FD messages can be freely defined and transmitted. These can be recorded on the logic level on the PC and on the physical level with an oscilloscope. Of course standard CAN messages can also be produced and transmitted for comparison.

### Networking automotive systems

A2.6.1.10  
Networking automotive systems:  
"SENT" gaspedal

FIELDS OF LEARNING:  
3, 6, 9, 11P, 11N, 11S



Networking automotive systems: "SENT" gaspedal (A2.6.1.10)

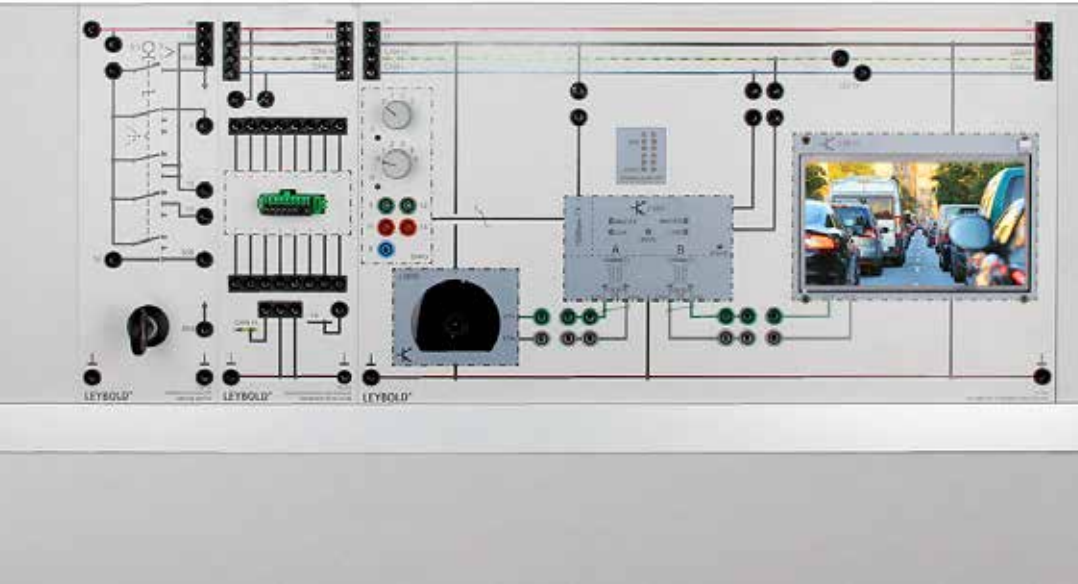
Cat. No.	Description	A2.6.1.10
739 708	Automotive sensors 2	1
739 709	Position sensor with SENT	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 12	Multi-purpose switch	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis	1
773 961	CAN-Databus-Multi-Adapter	1
739 580	Databus detector	1
738 02	Automotive power supply 13.8 V/36 A	1
500 59	Safety bridging plugs, black, set of 10	2
500 601	Safety connection lead 10 cm, red	1
500 641	Safety experiment cable, 100 cm, red	1
500 642	Safety experiment cable, 100 cm, blue	1
307 70	Tubing 8 mm Ø, 1 m, plastic	1
604 520	Connector with nipple	1
375 58	Hand vacuum pump	1
577 36	Resistor 220 Ohm, STE 2/19	1
775 069EN	LIT-print: CAN FD and SENT	1
726 19	Panel frame SL85, One Level	1
	PC with operating system Windows 7/8/10/11	1

"SENT" stands for "single edge nibble transmission" and is an interface for fast data exchange between a sensor or actuator and a controller. Standardised under SAE J2716, SENT has been considered an alternative to classic analogue and PDM interfaces since 2007. As an affordable high-speed alternative to the LIN bus, it is thus advancing to enter all vehicle classes.

LEYBOLD has developed a training system that involves two conventional sensors with a SENT interface. The signals can be practically examined using a time base diagram or also theoretically using a protocol analyser.

### Networking automotive systems

A2.6.1.12  
Networking automotive systems:  
Automotive Ethernet Camera



FIELDS OF LEARNING:  
3, 6, 9, 11P, 11N, 11S

Networking automotive systems: Automotive Ethernet Camera (A2.6.1.12)

Cat. No.	Description	A2.6.1.12
773 962	Automotive Ethernet Video System	1
773 963	Ethernet-USB Gateway	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 975	Diagnostic socket 16 Pin	1
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	1
500 6181	Safety cable, 25 cm, grey	2
500 617	Safety cable, 25 cm, brown	2
500 611	Safety experiment cable, 25 cm, red	1
738 02	Automotive power supply 13.8 V/36 A	1
778 826	LIT-digital: Automotive networking, digitization and diagnosis	1
775 077EN	LIT-print: Automotive Ethernet	1
739 007	Data bus Analyser USB	1
738 985	Automotive meter	1
	PC with Windows 7/8/10/11 and one free LAN port (RJ45)	1

The equipment provides the hardware basis for a collection of experiments with which the topic can be investigated in a practical way. The experiments presented are based on the contents of the currently valid framework curricula and can also be supplemented as desired.

In addition to basic experiments, special emphasis is placed on troubleshooting is placed. Common faults can be activated and must be detected using the tools self-diagnosis, digital multimeter (DMM) and/or digital oscilloscope (DSO). According to the state of the art, self-diagnosis via Ethernet (DoIP) and the computer-aided DSO are used.

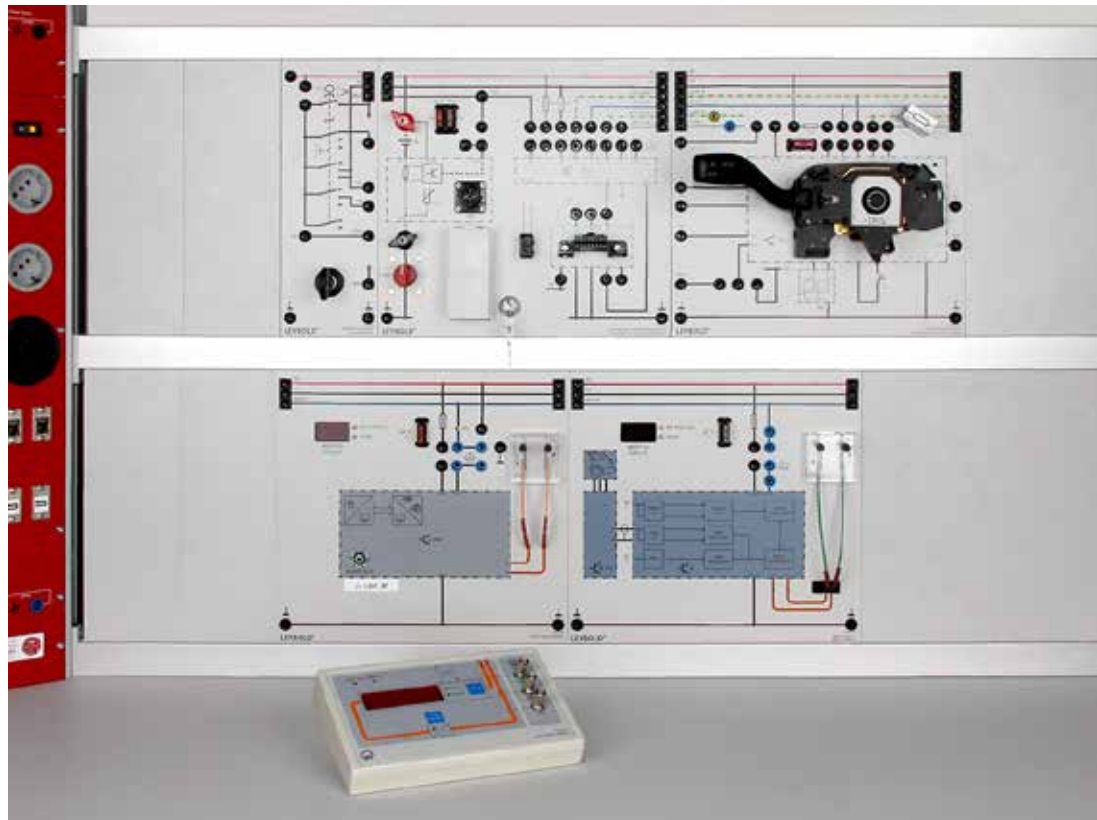
The following topics are covered:

- Measurement and interpretation of physical signals
- Self-diagnosis via Ethernet (DoIP)
- Monitoring and interpretation of network data

### Networking automotive systems

A2.6.1.13  
Networking automotive systems:  
MOST Databus Infotainment

FIELDS OF LEARNING:  
3, 6, 9, 11P, 11N, 11S



Networking automotive systems: MOST Databus Infotainment (A2.6.1.13)

Cat. No.	Description	A2.6.1.13
740 2016	MOST Tiny 3G	1
740 2013	MOST PC USB Interface	2
738 738	Gateway with battery monitoring	1
740 2085	MOST POF 1.5 m with connector	4
738 111-02	Steering column electronics	1
738 10	Ignition switch	1
739 006	CAN-Bus-Analyser DSO	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
737 9803	OBd Adaptor CAN+USB	1
577 30	Resistor 62 Ohm, STE 2/19	1
577 44	Resistor 1 kOhm, STE 2/19	1
577 38	Resistor 330 Ohm, STE 2/19	1
738 02	Automotive power supply 13.8 V/36 A	1
738 04	Car battery 12V	1
738 9821	Safety experiment cables, set of 51	1
738 05	Connection leads I, set	1
738 043	Vehicle battery connecting kit	1
500 59	Safety bridging plugs, black, set of 10	3
500 594	Set of 10 4 mm branching bridging plugs, blue	1
726 09	Panel frame T130, two-level	1
775 082EN	LIT-print: MOST Tiny 3G	1
	PC with Windows 7/8/10/11 64-bit and two free USB interfaces	1

The equipment provides the hardware basis for a collection of experiments with which the topic can be investigated in a practical way. The experiments presented are based on the contents of the currently curricula and can also be supplemented as desired.

The following topics are covered:

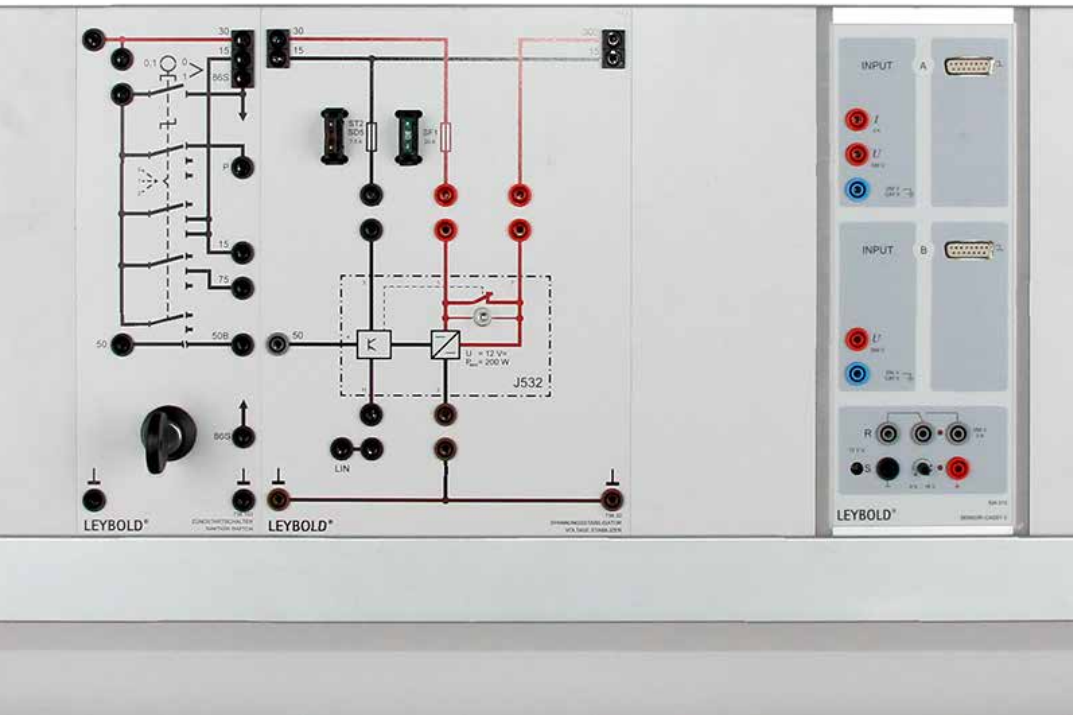
- Measurement and interpretation of physical signals
- Signal propagation in optical media
- Access to self-diagnostic data
- Monitoring and interpretation of network data
- Common errors in CAN, LIN and MOST data bus systems



### Networking automotive systems

A2.6.1.14

Networking automotive systems:  
LIN Databus DC/DC converter



FIELDS OF LEARNING:  
3, 6, 9, 11P, 11N, 11S

Networking automotive systems: LIN Databus DC/DC converter (A2.6.1.14)

Cat. No.	Description	A2.6.1.14
738 32	Voltage stabilizer with LIN databus	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 07	Interior lamp	2
738 027	Digital power supply 1 - 16 V/40 A	1
688 131	Mains cable Type G	1*
738 871	Starter substitute w. load simulation	1
738 06	12 V on-board socket	1
727 20	Automobile Meter Zero-Left	2
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
739 5881	LIN-Bus PC Interface USB	1
775 010DE	LIT-print: Vehicle power supply, German	1
577 41	Resistor 510 Ohm, STE 2/19	1
500 59	Safety bridging plugs, black, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1
726 09	Panel frame T130, two-level	1
500 441	Connecting lead 19 A, 100 cm, red	1
500 444	Connecting lead 19 A, 100 cm, black	1
500 644	Safety experiment cable, 100 cm, black	2
500 641	Safety experiment cable, 100 cm, red	2
500 6181	Safety cable, 25 cm, grey	2
689 0813	Set 12 automotive fuses	1*
689 0814	Set 2 automotive automatic fuses	1*
738 738	Gateway with battery monitoring	1
737 9803	OBd Adaptor CAN+USB	1

\* additionally recommended

As a "sub-bus" to the CAN data bus, the LIN bus is a master/slave single-wire bus whose connected LIN bus slaves provide sensor data or trigger actuator events at the request of the LIN bus master.

With the help of an active LIN bus PC adapter, complete communication cycles and the data exchange between master and slave can be examined in the experiment according to SAE 2602. Thanks to an original control unit The messages can be read out and interpreted as is usual in practice.

The automotive diagnostic tester software in conjunction with the Sensor-CASSY 2 can display the contents of the LIN messages graphically and/or hexadecimally. In this way, the protocol known from various textbooks can be vividly examined in reality.

### Diagnosis

#### A2.6.2.1 Automotive self diagnosis

FIELDS OF LEARNING:  
3, 6, 9, 11P, 11N, 11S, 12



Automotive self diagnosis (A2.6.2.1)

Cat. No.	Description	A2.6.2.1
738 165	Headlamp level control	1
579 163	PWM/PFM generator, STE 2/50	1
738 975	Diagnostic socket 16 Pin	1
738 103	Ignition start switch	1
738 032	Battery connection with protection circuit	1
738 295	Central electrics	1
738 06	12 V on-board socket	1
738 11	Head lamp switch	1
738 12	Multi-purpose switch	1
524 034	Timer box	1
524 013S	Sensor-CASSY 2 Starter	1
737 9803	OBD Adaptor CAN+USB	1
739 589	Software: Vehicle diagnosis	1
738 02	Automotive power supply 13.8 V/36 A	1
726 10	Panel frame T150, two-level	1
500 411	Connecting lead, 19 A, 25 cm, red	1
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
775 067DE	LIT-print: Automotive self diagnosis, German	1
738 01	Cable and plug box	1*
738 4911S	Automotive fault simulator, start	1*
500 593	Fault simulation plugs, black, set of 10	1*

\* additionally recommended

The legislation requires automatic headlamp level control for xenon lamps. This educational system contains an **automatic-dynamic** headlamp level control to stabilize changes in the headlamp level due to the body changing angles with the integrated acceleration/braking simulation (reversible).

The sensor inputs

- level signals of the front and rear axles and
- speed signal are detected.

This generates control signals for the actuator outputs

- headlamps' actuator and
- the malfunction indicator.

The system can self-diagnose over the K line: with a diagnostic adapter, all available measured value blocks can be displayed, and the functions

- coding
  - default setting
  - actuator diagnostics, and
  - error logging
- are executed.

Diagnosis

A2.6.2.2  
EOBD diagnosis



FIELDS OF LEARNING:  
3, 6, 9, 11P, 11N, 11S, 12

EOBD diagnosis (A2.6.2.2)

Cat. No.	Description	A2.6.2.2
739 660	EOBD/OBD2 Simulator	1
737 9803	OBD Adaptor CAN+USB	1*
562 791	Power supply unit (mains adaptor), 12 V AC	1*
689 0808	Set 5 automotive Mini fuses	1*
775 068DE	LIT-print: EOBD Diagnosis, German	1

\* additionally recommended

Reproducible error conditions in the vehicle for the OBD2/EOBD analysis for exhaust gases – impossible? No, because LEYBOLD has developed an OBD2/EOBD simulator to learn these operational procedures that simultaneously simulates the engine control unit, the control unit for automatic transmission as well as ABS.

The diagnosis CAN bus can set and a diagnostic adapter can read

- variable and
- fixed control unit data (PIDs)
- error codes (DTC), and
- the vehicle identification number (VIN)

Error codes are generated at the push of a button and signaled by illuminating the MIL indicator lamp.

### Electric vehicle

A2.7.2.1

Electrical machines in hybrid and electrical cars

FIELDS OF LEARNING:  
1, 3, 6, 8, 11P, 11S, 12P, 13S, 14S

Further equipment(s)  
A1.1.1.1 on p. 26



Electrical machines in hybrid and electrical cars (A2.7.2.1)

Cat. No.	Description	A2.7.2.1
563 115	ELM coil, 500 turns	3
563 17	ELM centring disc	1
563 181	ELM brush holder rack	1
563 13	ELM brush	2
563 19	ELM Magnet rotor	1
563 22	ELM two-pole rotor	1
563 23	ELM three-pole rotor	1*
563 28	ELM magnetic needle rotor	1
727 815	ELM set of multipole stator and rotor	1
727 816	ELM PM rotor magnets, interior	1
563 091	ELM pole shoe for magnets	2
563 101	ELM wide pole shoe for coils	3
563 251	ELM Rotating field Neodym	1
563 291	ELM Copper ring with iron disc	1
563 191	EMTM Magnet rotor 4 pole	1
510 48	Magnets, 35 mm diam., pair	1
514 011	Magnetic field indicator	1
725 722	Low Voltage Three Phase Inverter	1
727 812	ELM rotor position sensor	1
727 88	Drive unit	1
727 87	Star-delta load	1
727 811	Basic machine unit	1
727 21	Automobile Meter Zero-Center	1
727 20	Automobile Meter Zero-Left	1
580 0136	Tachometer (handheld)	1
524 0621	UIP sensor S	1
524 0431	30-A-Box	1
524 034	Timer-Box	1
524 0135	Sensor-CASSY 2 Starter	1
524 013	Sensor-CASSY 2	1

Cat. No.	Description	A2.7.2.1
739 589	Software: Vehicle diagnosis	1
579 13	Toggle switch STE 2/19	1
577 32	Resistor 100 Ohm, STE 2/19	3
577 44	Resistor 1 kOhm, STE 2/19	1
578 15	Capacitor 1 µF, STE 2/19	1
727 800	Storage ELM	1
563 16	Hex key	1
726 10	Panel frame T150, Two Level	1
563 31	Oil, 100 ml, in dropping bottle	1
738 9821	Safety experiment cables, set of 51	1
778 827	LIT-digital: Electric mobility	1
738 01	Cable and plug box	1

\* additionally recommended

LEYBOLD uses components from the modular "ELM" electric training machine system for the trainees to be able to build the various types of machines by hand.

This teaches basic knowledge and concepts, such as

- electromagnetism
- induction
- voltage generation
- motor
- generator etc.

The electrical machines are displayed transparently and are functionally constructed. The inverter, which converts the DC voltage of the high-voltage battery into a 3-phase AC voltage to supply the electrical machine, operates at a voltage level of <24 V as standard, thus providing absolute safety for students and trainees.

Electric vehicle

A2.7.2.3  
Workstation vehicle  
hybrid drive



FIELDS OF LEARNING:  
1, 3, 6, 8, 11P, 11S, 12P, 13S, 14S

Workstation vehicle hybrid drive (A2.7.2.3)

Cat. No.	Description	A2.7.2.3
739 9403	COM4LAB: Automotive Hybrid Drives	1
739 9403-20	COM4LAB Course: Automotive Hybrid Drives	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1*
739 836	Milliohm meter	1*
738 9821	Safety experiment cables, set of 51	1
778 827	LIT-digital: Electric mobility	1
689 0808	Set 5 automotive Mini fuses	1

\* additionally recommended

Study of the fundamentals of hybrid drive requires basic knowledge of the construction and function of electric machines.

Thus, each of

- the direct current machines
- the alternating and induction machines, and
- the servomotor is among the motor and generator operation modes.

Additional knowledge of power electronics and energy storage technology allows comprehension of the new "hybrid drive technology" system.

Teachers and students must also be trained for or made aware of exposure to high voltages and the risks involved. Only then can the students be trained to become professionals skilled in electrics.

LEYBOLD has developed a student workstation that enables the study of all essential aspects in a smaller scale. Equipped with

- a PMSM as an electric motor
- an inverter and
- a dual voltage electrical system

The control units are networked with the motor CAN bus.

All common operation modes are adjustable:

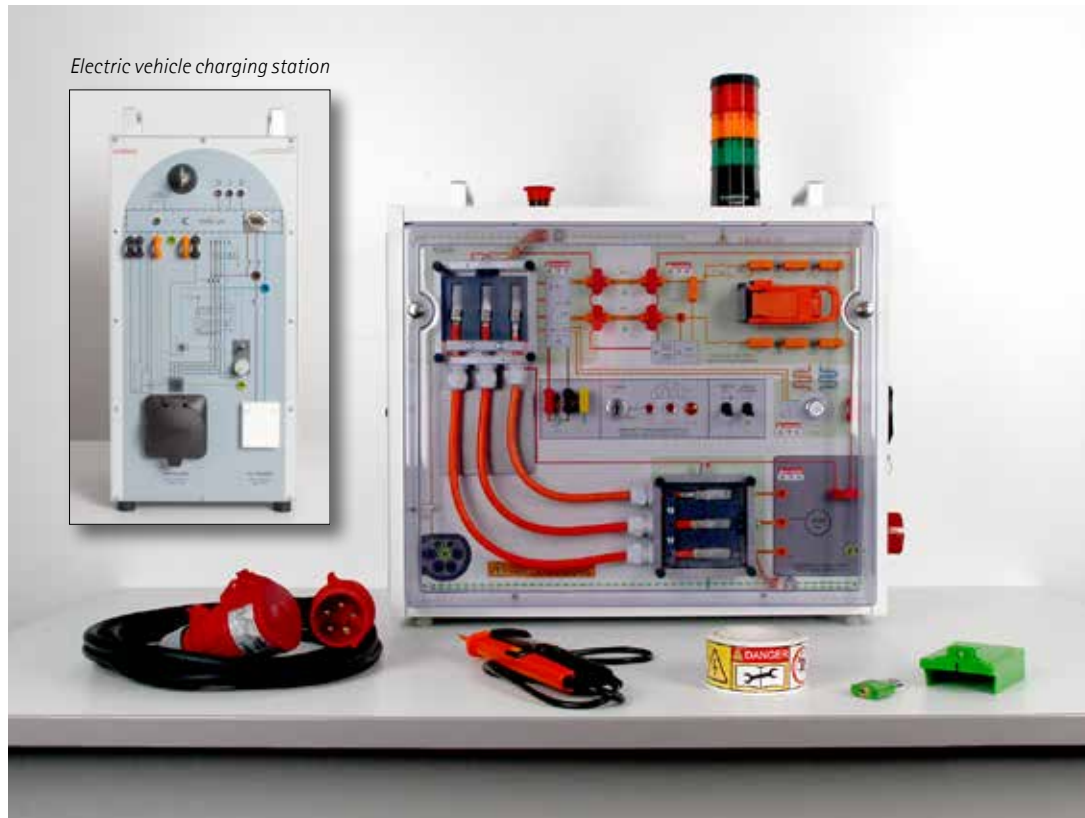
- Start
- Electric drive
- Boost
- Regenerative brakes

The student can independently study the complex issue of hybrid technology. Thanks to overlays, various systems can be selected. The workstation can be linked to the PC.

### Electric vehicle

A2.7.2.5  
Vehicle high voltage  
technology

FIELDS OF LEARNING:  
1, 3, 6, 8, 11P, 11S, 12P, 13S, 14S



Vehicle high voltage technology (A2.7.2.5)

Cat. No.	Description	A2.7.2.5
739 947	PEV High Voltage Trainer	1
739 968	HV machine stator 0.3	1
774 7729	Squirrel cage rotor, high efficiency, 0.3	1
739 948	Electric vehicle charging station	1*
739 951	Charging cable Mode 3, 3~	1*
727 293	Digital insulation tester	1
685 44	Battery 1.5 V (AA)	8
739 004	DMM for electrical vehicles	1
739 949	HV PC measurement adapter for E-Mobility	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 013	Sensor-CASSY 2	1
739 835	Kelvin-sensing cable, set of 2	1
739 836	Milliohm meter	1
739 944	Insulating gloves 1000 V	1
689 0816	Pair of cotton gloves	1
667 6123	Safety goggles, clear, scratch resistant, polycarbonate	1
689 0817	HV tool set	1
773 108	Coupling / shaft end guard 0.3, transparent	1
773 110	Machine base bench, 90 cm	1
610 210	Warning sign "Dangerous electrical current"	1
689 0822	Satz of 3 safety cable 4 mm, orange, 1 m	1
500 854	Safety leads, set of 20	1
500 595	Set of 10 4 mm branching bridging plugs, red	1
739 974	Lockable box for safety-relevant components (incl. 2 padlocks)	1
778 827	LIT-digital: Electric mobility	1
689 0820	Service Disconnect	1*
689 0818	HV cables, set of 3	1*
689 0819	HV cable	1*
689 0821	HV Safety Tape	1*
739 953	Test Adapter for Charging Stations	1

Cat. No.	Description	A2.7.2.5
735 315USB	USB/RS 485 interface convert	1
577 46	Resistor 1.5 kOhm, STE 2/19	1*
577 36	Resistor 220 Ohm, STE 2/19	1*
578 51	Diode 1N4007, STE 2/19	1*
579 13	Toggle switch STE 2/19	1*

\* additionally recommended

As vehicle electronics have, for the most part, been harmless in the past, it is now necessary to raise awareness of hazardous live voltages and new safety measures and procedures must be conveyed in a targeted manner.

This places new demands on craftsmen, automotive mechatronics engineers, and educators in the field of electromobility. The challenge is having to work with voltage under real-world conditions while still ensuring that trainers are as safe as possible during class.

LD DIDACTIC has developed a trainer for this purpose that can be practically used to practice disconnecting electric vehicles from their power sources. The device is suitable for demonstrations carried out by the trainer/instructor, as well as for practical professional practice carried out by trainees/students. Technical service companies (e.g. ADAC), testing centres (TUV, Dekra), rescue workers (fire department, THW), or users can also benefit from this training concept by using it to prepare their professional staff for this innovative segment of the automotive technology market.

Electric vehicle

A2.7.2.6  
High voltage  
battery technology



FIELDS OF LEARNING:  
1, 3, 6, 8, 11P, 11S, 12P, 13S, 14S

High voltage battery technology (A2.7.2.6)

Cat. No.	Description	A2.7.2.6
739 952	Model HV Battery "Cells"	1
739 954	STE BMS Lilo	1
739 956	STE BMS LiFe	1
739 955	STE Battery holder	4
739 957	STE LiFe battery (LFP)	4
739 958	Model HV Battery "Monitor"	1
474 346	Plug-in power supply 12 V - 2.5 A	1
739 959	Model HV Battery "Inverter"	1
739 9581	CAN Gateway	1
727 812	ELM rotor position sensor	1
727 811	Basic machine unit	1
727 815	ELM set of multipole stator and rotor	1
727 88	Drive unit	1
524 005W2	Mobile-CASSY 2 WiFi	1
524 013S	Sensor-CASSY 2 Starter	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
739 004	DMM for electrical vehicles	1*
500 59	Safety bridging plugs, black, set of 10	1
500 591	Safety bridging plugs, yellow/green, set of 10	1
500 592	Safety bridging plugs with tap, black, set of 10	1
500 595	Set of 10 4 mm branching bridging plugs, red	1
739 981	Set 10 non-isolated bridging plugs 4-mm	1
739 982	Set 10 green safety bridging plugs 4-mm	1
739 969	Equalization cable, plug-in style	3
500 614	Safety experiment cable, 25 cm, black	6
500 641	Safety experiment cable, 100 cm, red	6
500 642	Safety experiment cable, 100 cm, blue	2
500 644	Safety experiment cable, 100 cm, black	6
577 86	Variable resistor 470 kOhm, STE 2/19	2
739 960	Charger for batteries 18650, 4-fold	1

Cat. No.	Description	A2.7.2.6
739 962	Set of 2 Lithium ion batteries 18650	4*
739 963	Set of 2 Lithium iron phosphate batteries 18650	4*
689 0822	Satz of 3 safety cable 4 mm, orange, 1 m	1
571 262	Adapter lead 2/4 mm, 30 cm, red	3
501 30	Connecting lead 32 A, 100 cm, red	1
501 31	Connecting lead 32 A, 100 cm, blue	1
726 890	DC power supply unit 1...32 V/0...20 A	1
726 09	Panel frame T130, two-level	1
778 827	LIT-digital: Electric mobility	1
727 813	ELM RLG Kabeladapter	1*
537 33	Rotor position pick-up cable adapter	3*
739 974	Lockable box for safety-relevant components (incl. 2 padlocks)	1

\* additionally recommended

The lesson plan of the trainee automotive high-voltage technician deals with the "high-voltage battery" high voltage component. However, depending on the system, the hazard potential is especially high due to the high voltages of up to 800 V.

The system is remodelled and transformed to an uncritical 24 V so that the student can acquire all the knowledge required in this area with the trainer for high voltage and battery technology. The highlight: Because the cell blocks are separate, they can be exchanged to allow various battery chemistries, such as lithium-ion cells or lithium iron phosphate cells for example, to be examined. Consequently, the system is perfectly equipped even for future new cell types.

Handling high voltages in electromobility applications calls for the special safeguards that occur in the so-called "intrinsically safe electric vehicle". Including, for example, the pilot line, the monitoring of the insulation resistance or the use of an IT network.

The system trainer is also extremely well suited to these components of an intrinsically safe vehicle. As a universal and hence brand-neutral system, it also offers various solutions and technologies for performing the monitoring functions.

### Electric vehicle

A2.7.2.7  
High voltage  
vehicle technology

FIELDS OF LEARNING:  
1, 3, 6, 8, 11P, 11S, 12P, 13S, 14S



High voltage vehicle technology (A2.7.2.7)

Cat. No.	Description	A2.7.2.7
739 964	Automotive high-voltage systems trainer	1
739 965	Monitor holder for 739964	1*
739 949	HV PC measurement adapter for E-Mobility	1
739 966	Tools set e mobility	1
739 967	Safety torque wrench	1

\* additionally recommended

Training system for the experimental investigation of original high-voltage components with a focus on troubleshooting: The experiments presented are based on the contents of the currently valid curricula and can also be supplemented as desired.

With the high-voltage system trainer it is possible to simulate insulation faults in the HV cables and components in a simple way. This makes it possible to train and improve systematic troubleshooting with original factory measuring equipment.

In contrast to the original vehicle, all installed high-voltage components are easily accessible. In the event of a fault, only a detectable HV voltage is present, the current-carrying capacity of which is very low. The system provides an overview of all installed HV components that originate from original vehicles.

The work required for disconnection can be carried out identically to the vehicle under simpler conditions. The system trainer removes the daunting complexity of HV vehicle technology through its clear and easy-to-understand structure.

Application and feel correspond to those of the real vehicle.

This equipment is used to perform basic experiments on the following:

- HV battery and HV on-board network
- Intrinsic safety through the pilot line and potential equalisation
- HV consumers (electric air-conditioning compressor and electric auxiliary heater) for fault simulation
- Inverter with HV measuring points
- Measurement possibility and manipulation of various insulation resistances
- E-machine connection with measurement possibility at open line ends



### Electric vehicle

A2.7.2.8  
Workstation high voltage  
technology



FIELDS OF LEARNING:  
1, 3, 6, 8, 11P, 11S, 12P, 13S, 14S

High voltage vehicle technology (A2.7.2.7)

Cat. No.	Description	A2.7.2.8
739 980	EV High voltage workstation	1
739 949	HV PC measurement adapter for E-Mobility	1
739 944	Insulating gloves 1000 V	1
667 6123	Roma safety goggles	1
689 0816	Pair of cotton gloves	1

Study of the fundamentals of hybrid drive requires basic knowledge of the construction and function of electric machines.

Thus, each of

- the direct current machines
- the alternating and induction machines
- the servomotor is among the motor and generator operation modes.

Additional knowledge of power electronics and energy storage technology allows comprehension of the new "hybrid drive technology" system.

Teachers and students must also be trained for or made aware of exposure to high voltages and the risks involved. Only then can the students be trained to become professionals skilled in electrics.

The LEYBOLD® training systems for electromobility are ideal for use in the training of motor vehicle mechatronics technicians of all specialisations, but of course especially for the specialisation "system and high-voltage technology". The teaching systems can also be excellently used in the training of technicians, master craftsmen and engineers.

The high-voltage technology student workstation teaches the safe handling of HV vehicles. All essential high-voltage components are installed, some of them with original components. This makes the practical relevance particularly clear.

All typical tests can be carried out with standard workshop measuring equipment.

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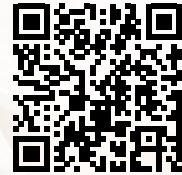
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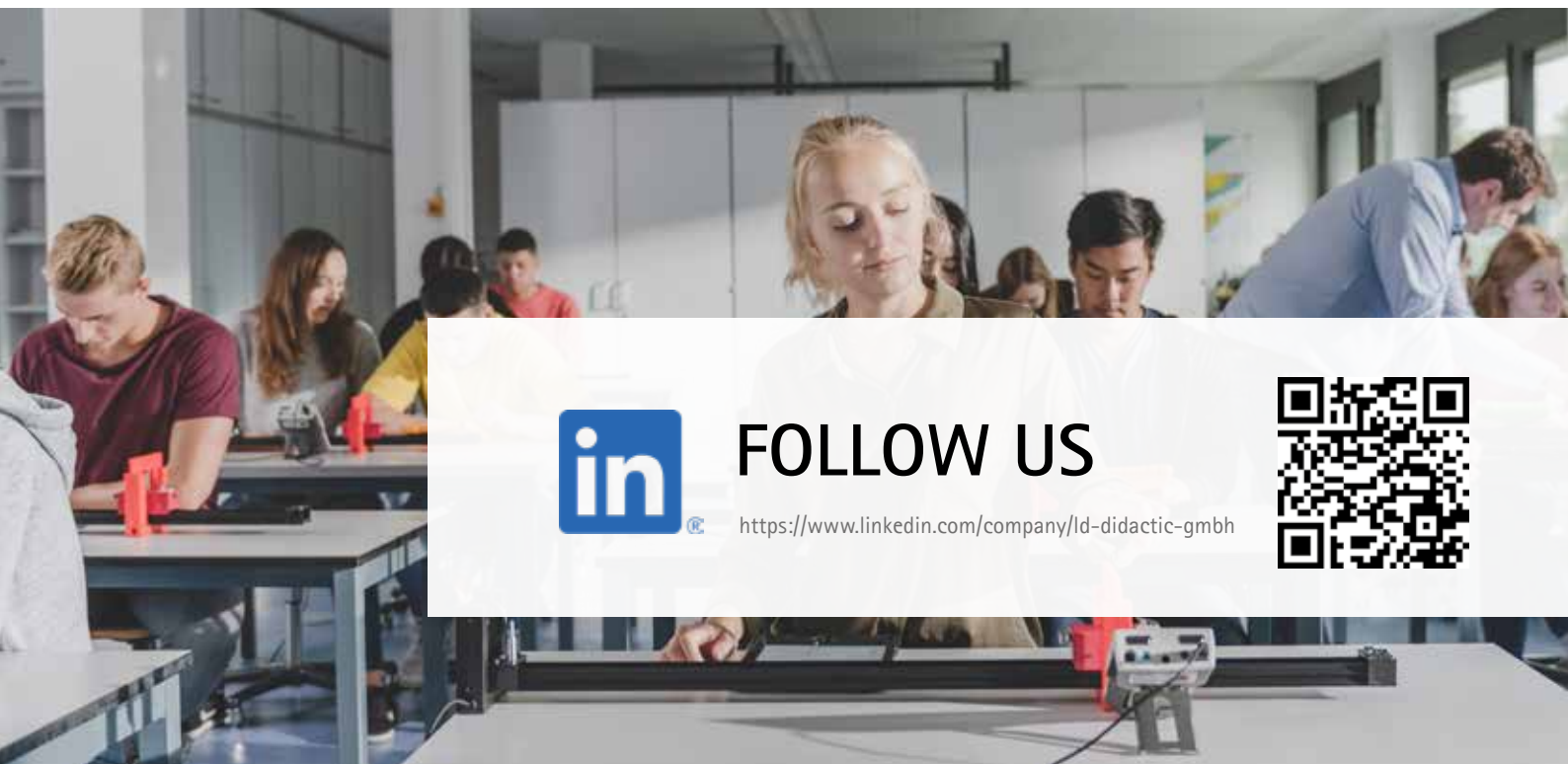


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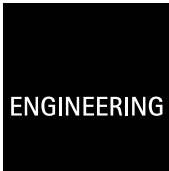
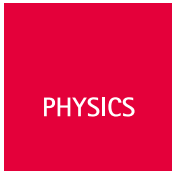
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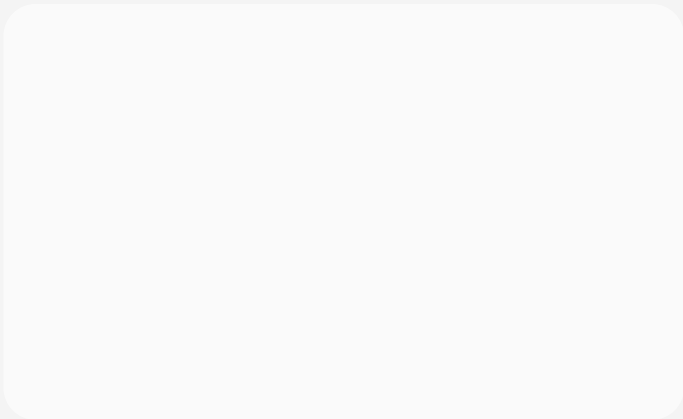


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