

LEYBOLD®

AUTOMOTIVE TECHNOLOGY



TECHNOLOGY



AUTOMOTIVE TECHNOLOGY

EASILY CONVEY CHALLENGING TOPICS WITH LEYBOLD'S SOLUTIONS

With LEYBOLD's solutions, your trainees and students can effectively learn the complex class subjects in the areas of motor vehicle technology and electrical engineering as well as renewable energy technology. Our didactic equipment and educational systems for technical vocational training ideally combine theory and practice and can be seamlessly integrated into the project work.

This catalog presents our educational systems in the area of motor vehicle technology. With us, you will receive customized solutions for your technology and workshop lab that are adapted to the individual fields of instruction.

LD DIDACTIC GmbH is a world leader in the production of high-grade scientific and technical educational systems for schools, universities and vocational training. LD DIDACTIC distributes its products and complete solutions under the brand name LEYBOLD.

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LEYBOLD®

TECHNICAL SERVICE AND CONSULTING

LEYBOLD NOT ONLY PROVIDES THE HIGHEST POSSIBLE PRODUCT QUALITY, BUT ALSO INDIVIDUAL ADVICE AND TECHNICAL AFTER-SALES SERVICE.

INDIVIDUAL ADVICE AND STOCK-TAKING

Are you planning to re-equip your laboratory or simply to add to its equipment? Our specialised advisor will be happy to give you support by suggesting a tailor-made combination suitable to your type of school.

GOODS SERVICE, INSTALLATION, COMMISSIONING AND ON-SITE BRIEFING

We would be delighted to check your new equipment on site for completeness and functionality. We can either take on the whole task of installation for you or our specialists can commission the devices and systems that you have already installed on site yourselves. We would, of course, be delighted to conduct one or more tests together with you and to explain in detail the functions of each individual device.

LEYBOLD®

TECHNICAL AFTER-SALES SERVICE

You may have a technical question on one of our devices or pieces of equipment. Our service team is available by telephone at **+49 2233 604-430** and by e-mail at **service@ld-didactic.de**

SPARE PARTS SERVICE

You can naturally order replacement parts for your equipment.

REPAIR SERVICE

If, despite our demanding quality standards, you should find a fault in your LEYBOLD product, we will naturally repair it as soon as possible. If you still cannot make the equipment work as intended after calling our technical service, you can find help quickly and easily through our "on-site service". Our service technicians come to you, to find the appropriate technical solution on site. Alternatively, you can of course also send your device for repair by post.

REPAIR GUARANTEE FOR A MINIMUM OF 10 YEARS

Our products stand for high quality and durability. If your device should become faulty even many years after purchase, generally we will still be able to repair it. We guarantee the repair of all our devices for 10 years from the date of purchase – and for much of our products, for much longer.



INDIVIDUAL
ADVICE
ON-SITE

TECHNICAL
SERVICE
AFTER-SALES

BRIEFING
ON-SITE

PRACTICAL DEVELOPMENT COOPERATION WITH AUDI

TRAINING PANEL LIGHTING

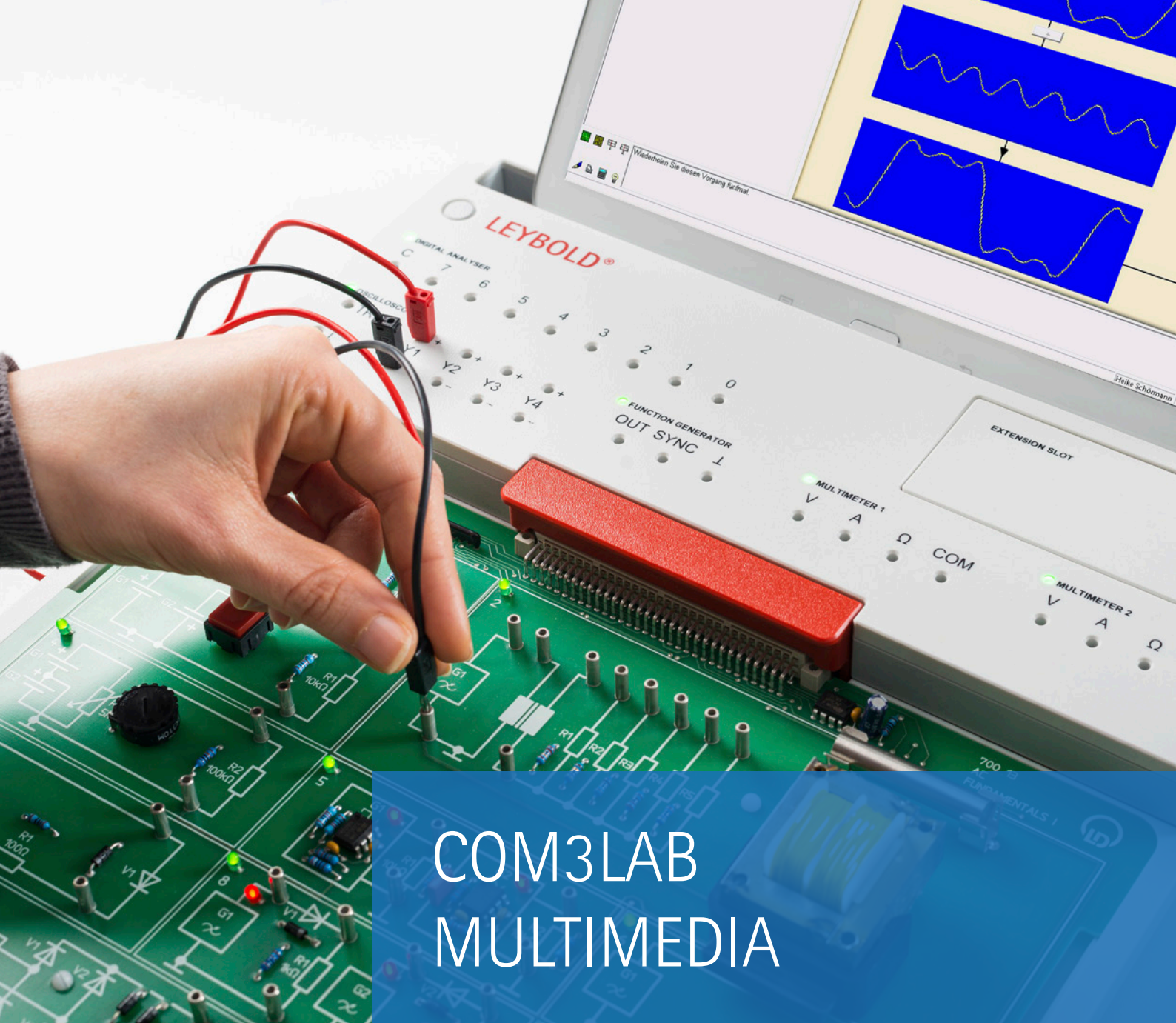
The training panel consists of a modern instrument panel insert with electronic immobilizer, the full steering wheel electronics, the central control module for comfort system and the electronic and electric system. The lighting system and a windshield wiper motor complete the system. The basic vehicle 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 on fault finding, analysis and correction.





We develop and produce our educational systems in tight cooperation with the automotive industry, so we can ensure our systems are very realistic and their technology constantly refined.

Since 2003, we have been developing educational systems, such as the training panel lighting, together with AUDI AG's training center. The trainees can learn the fundamentals of vehicle electronics and modern data bus systems with original parts of an AUDI A4.



COM3LAB MULTIMEDIA

The Master Unit is compatible with all of the courses and includes two multimetres interfaces, a function generator, a digital storage oscilloscope and a digital analyser. By simply inserting a different experiment board into the Master Unit a completely new topic area can be explored.

THE OPTIMUM COMBINATION OF THEORY AND PRACTICE

COM3LAB Multimedia combines training software with real hardware that can be used in schools, universities or vocational training centres in industry.

COM3LAB courses are well suited for both classroom presentation, self-directed home study or for project work. They are comprised of an electronic and an interactive instruction manual and the corresponding hardware.

ADVANTAGES AT A GLANCE

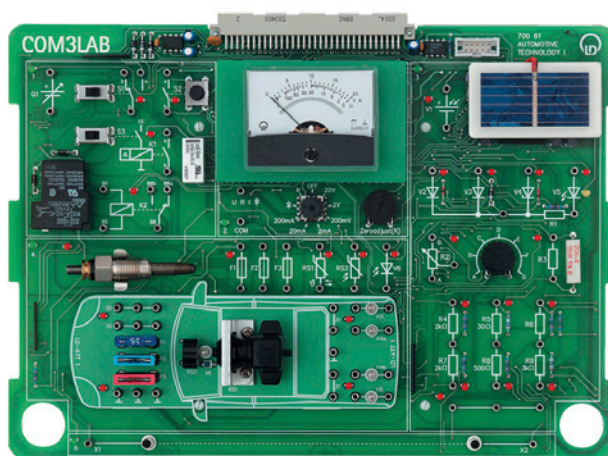
FOR INSTRUCTORS

- In-depth content
- Practically-oriented experimenting
- Visually-appealing instruction material for presentation purposes
- Documentation with solutions for flexible application in the classroom
- Time-efficient assembly

FOR STUDENTS

- Practical hands-on learning
- Results are monitored and tested
- Results are documented
- Team-based or self-study possible
- Select the language of your choice

EXEMPLARY COURSE FOR MOTOR VEHICLE TECHNOLOGY



COM3LAB COURSE: AUTOMOTIVE ELECTRICS 700 6101

This COM3LAB course prepares and conveys the fundamentals of vehicle electrics/electronics in an understandable way. Physical, chemical and mathematical properties of "electricity" thereby lead to extensive understanding of electrical operating sequences and processes in motor vehicles.

Every COM3LAB course has an electronic, interactive textbook with detailed experimental instructions. Subject-specific descriptions, images, videos and animations illustrate both theory and practice. Besides this content, the textbook includes a virtual lab and a multitude of tools, e.g. to compile distinctive documentation.



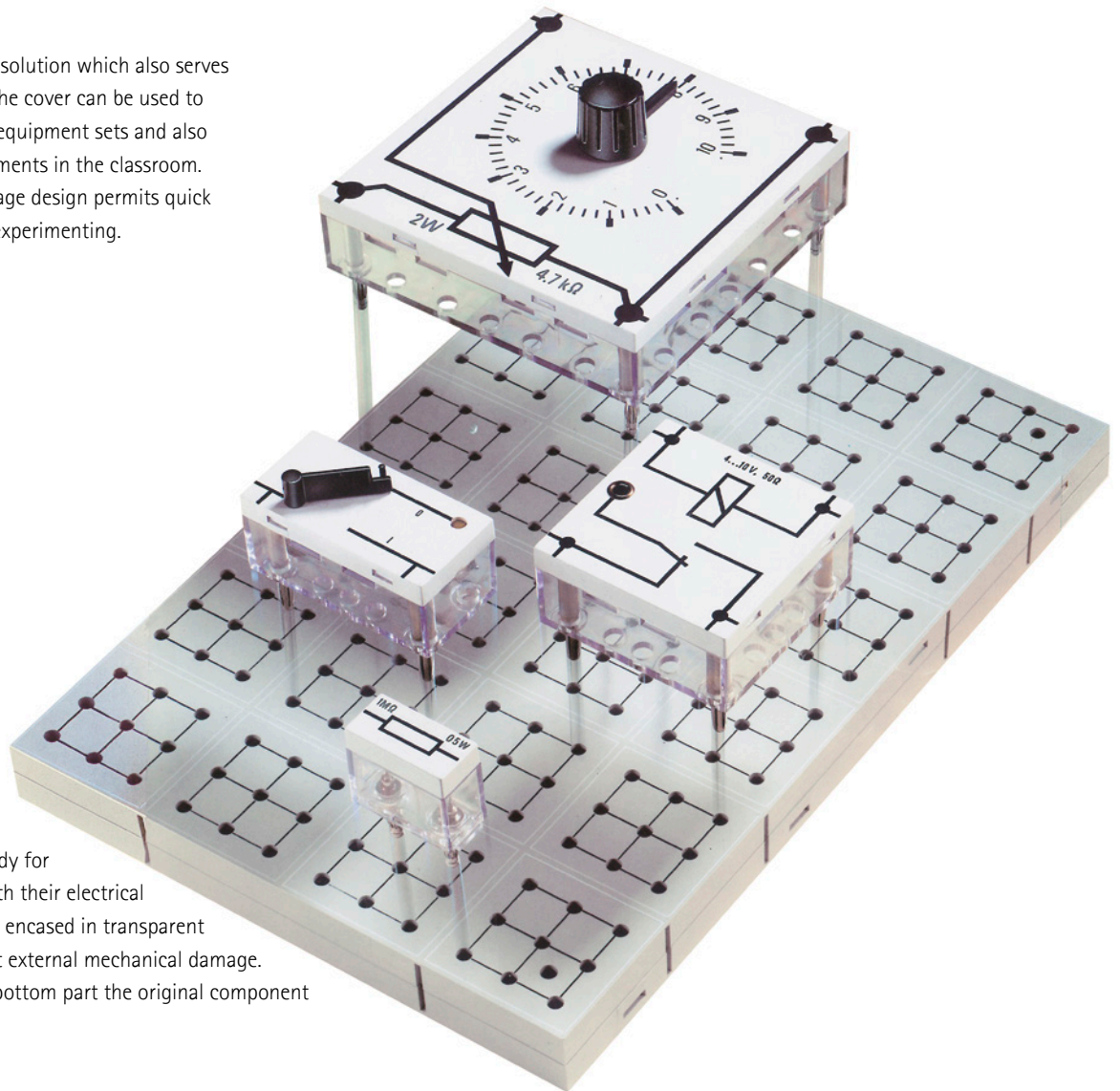


STE PLUG-IN SYSTEM

The LEYBOLD plug-in system is a tried and tested experimentation program for electrical engineering and electronics. The extensive experimentation program covers beside the basics also advanced topics, for example, communications, IT, open- and closed-loop control technology as well as areas from automotive electronics.

Instruction sheets for students and accompanying teacher information are available to assist with the performance of experiments. The printed symbols on the plug-in housing elements, connectors and training panels provide the experiment set-ups with a circuit-like appearance. This facilitates the knowledge transfer between the circuit diagrams in the text books and the circuitry being assembled and makes the documenting of the experiment set-ups easier to do and ultimately promotes circuit-based thinking, learning and experimenting.

The STE case is the storage solution which also serves as a student workstation. The cover can be used to accommodate various STE equipment sets and also assist in performing experiments in the classroom. The clearly configured storage design permits quick setup and a quick start to experimenting.



The STE elements come ready for operation and assembly with their electrical and electronic components encased in transparent housings to protect against external mechanical damage. Thanks to the transparent bottom part the original component is visible.



Stackable plastic trays offer alternatively a space saving and clear storage configuration of STE elements, components and accessories in cabinets or drawers.

PRACTICAL DIDACTIC SOLUTIONS

INCREASING DEMANDS IN TRAINING ON VEHICLES

The demands that automotive mechatronics engineers and diagnostic technicians face in their trade and in the industry are always growing in complexity: besides mastering conventional technology, they must also gain skills in the area of electronics, microprocessing and databus technology.

Only those who understand operating principles in detail and the functional relationships of electronic components like ABS, map-controlled ignition, motronics, common rail, electrical system management, etc. and the tradition mechanical, hydraulic and pneumatic components are prepared for the daily demands of the work routine. This of course includes the safe manipulation of modern diagnostic systems.

PRACTICAL DIDACTIC SOLUTIONS

LEYBOLD offers technical equipment and systems, with which trainees can effectively learn these complex subjects. These are developed in cooperation with the automotive industry and continually adjusted for technical advancements.

LOW TIME REQUIREMENT FOR LESSON PLANNING AND TEACHING

LEYBOLD solutions are not only adapted to the complex class subjects but also to the constantly increasing demands facing instructors. Lesson planning and the experimental teaching structure only require very little of their time, because the comprehensive literature accompanying the experiments provides you with a guide for demonstration experiments, which you can simultaneously hand out to your students as experimental instructions.



The experiments' literature prepared didactically facilitates lesson planning and teaching for instructors.



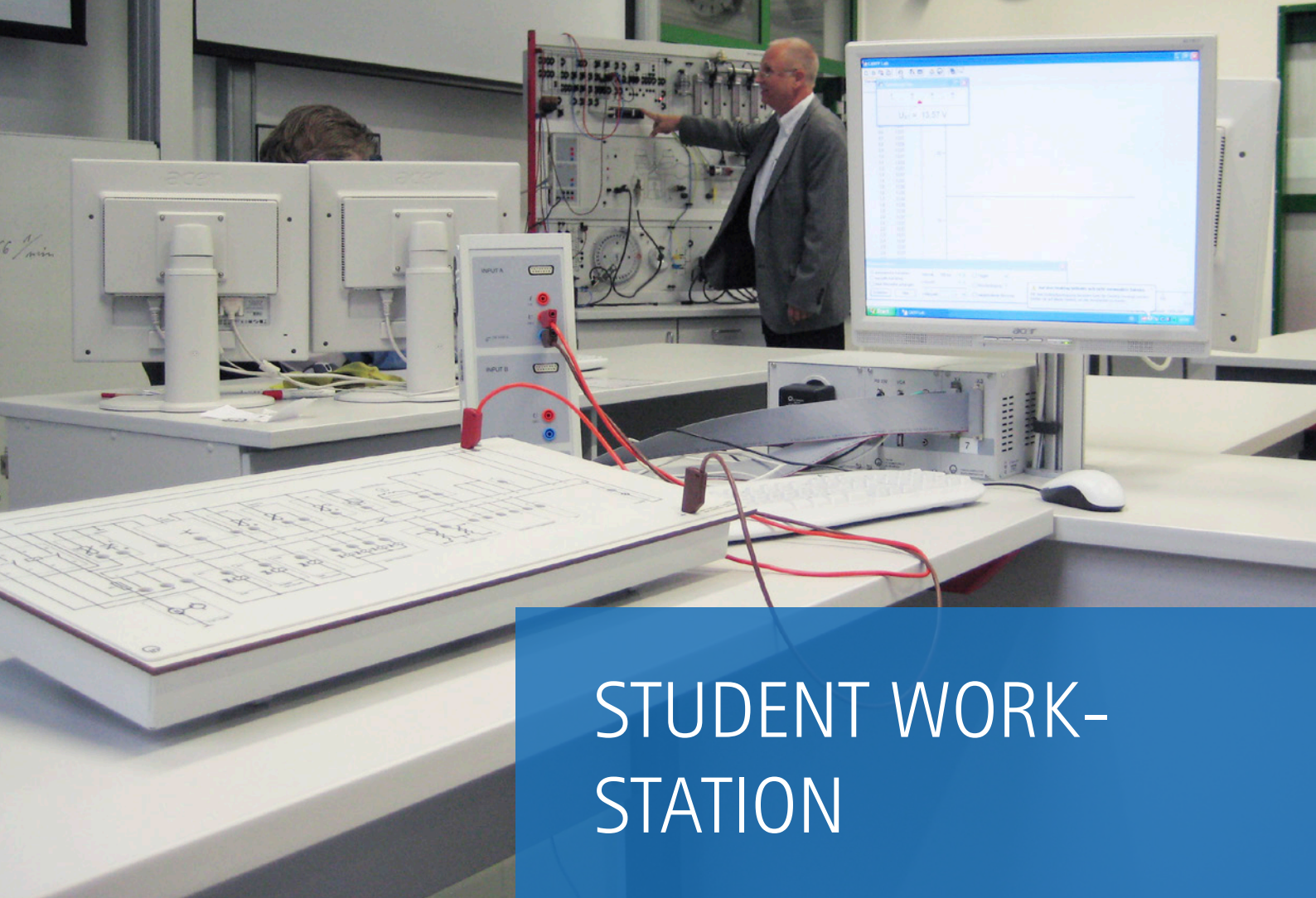
TPS – TRAINING PANEL SYSTEM

THE MODULAR TRAINING PANEL SYSTEM FOR STUDENT
EXPERIMENTS AND CLASSROOM DEMONSTRATIONS

- Construction and design similar to the original vehicle
- Self-diagnostic capability
- Use of original components
- Experiment literature for classroom preparation and experiment procedures
- Featuring clearly laid out frontal panels



Thanks to the modular design, technology labs can quickly and easily be outfitted or extended using the TPS system.



STUDENT WORK- STATION

Background:

Demo system for fuel injection A2.3.2.1

Foreground:

Student Adaptor (740 050) with overlay
mask LH Motronic (740 052) and

Sensor-CASSY

PRACTICAL, FLEXIBLE AND MODULAR

Student measuring stations consist of a student workstation with a measuring adapter and an overlay mask suitable for the experiment setup. These measuring stations are connected by two 38-pole cables and with the teacher's training system – either in star or in series structures.

The students can record and analyze all measurements from the installation online at their workstations. Furthermore, the teacher can simulate system-specific errors to be studied metrologically at the students' workstations. The student measuring stations are decoupled in reverse so that the students cannot cause any error in the teacher's demo system.

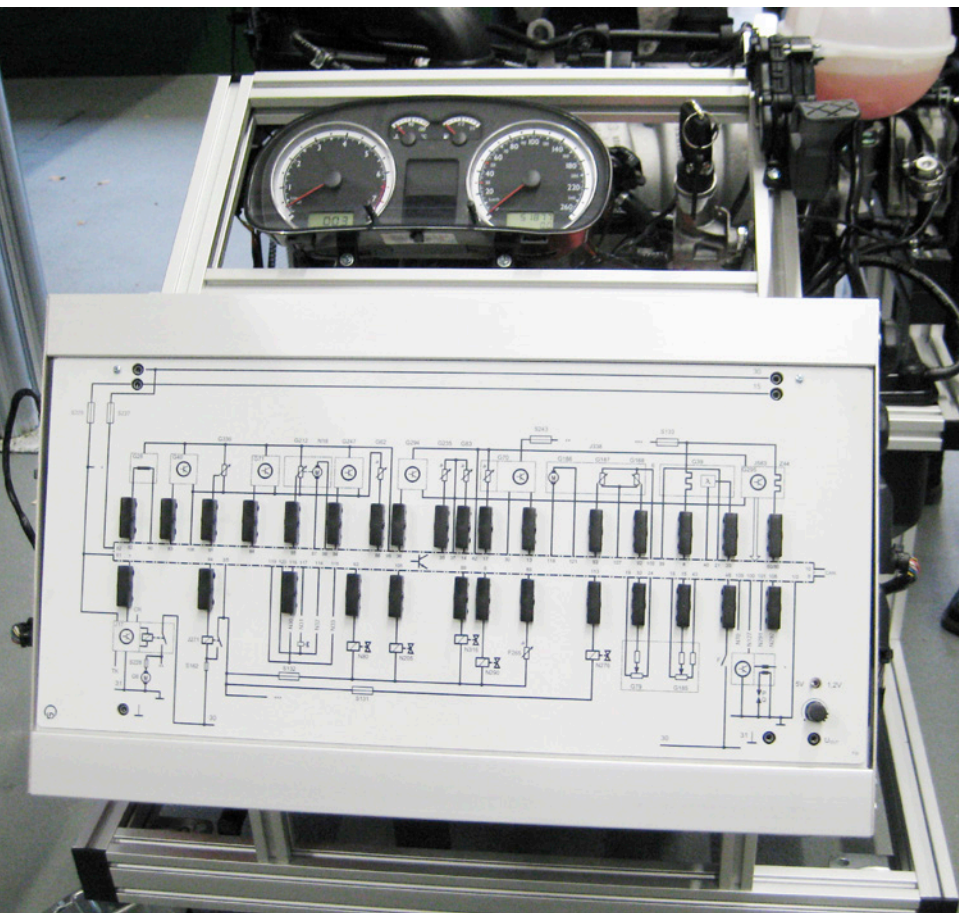
MEASURING STATION

Catalogue No.	Designation
740 052	Mask LH Motronic (Student)
740 0551	Mask ABS/ESP
740 0531	Mask CR (student)



Space-saving storage:
Example of a storage solution for student workstations and overlay masks

- Quick setup due to simple wiring
- Compact size
- Up to 70 PINs available for use
- Original values from the vehicle or model at the student's workstation
- Short-circuit proof at the control unit
- Overlay masks with circuit diagrams for all available models and vehicles
- Measurements with original meters possible



The modular concept allows the connection of function engines.

LEYLAB

EDUCATIONAL LAB MONITORING AND CONTROL

YOUR TECHNICAL LABORATORY FOR THE FUTURE

MULTIFUNCTIONAL LAB FURNISHINGS AND DEVICES

Our LEYLAB program offers you a wide selection of student, laboratory and computer desks. These are flexible, to be customized to your individual equipment and space requirements. Our power supply and experimental equipment is ideally adjusted to them. They can be connected to the available Ethernet and form the "networked learning environment" with the linked computer.

PARALLEL CONTROL OF THE EXPERIMENT SETUPS AND THE LABORATORY'S POWER SUPPLY

With LEYLAB, besides the laboratory's power supply, you can also control key devices in the complete experiment setups with the teacher's PC. The new LEYLAB.control software thereby has significant advantages over comparable products. For example, the instructor can protect experiment setups from incorrect voltages or activate and operate individual devices in the experimental setup as well as trigger faults.



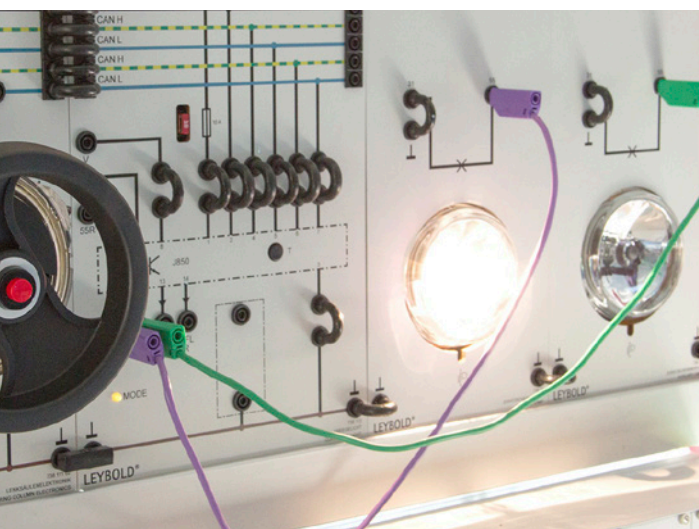
LEYLAB.POWER

The LEYLAB.control concept can integrate the laboratory's power supply with the corresponding Ethernet interface. From the teacher's PC, the instructor thus has access at any moment to the devices and can read or change settings. To protect the connected experimental environment, parameters can additionally be limited so that the students cannot manipulate them.



LEYLAB.CONTROL

The LEYLAB.control software is the software for the central control station in the networked laboratory, and it allows actuating the linkable power supply units in the LEYLAB.power series as well as the linkable experiment boards in the TPS series. The instructor can map the laboratory in the program interface and has a graphical overview of all devices connected by Ethernet. The student PCs can have access to the individual devices and can communicate directly.



TPS.NET

Network-compatible TPS modules have an Ethernet interface, with which they can be integrated into the LEYLAB.control concept. The teacher can then access the equipment from his computer either as an observer only or actively, while the students conduct the corresponding experiments. Data acquisition, parameter and limit specifications, and (safe) intrusion of errors are thus easily possible.



FACILITY & LAB PLANNING AND INSTALLATION

YOUR NEW LEYBOLD LAB FACILITY

Based on your ideas, we team up with you and plan a lab or classroom facility that fits your syllabus. Our room planners custom design your laboratory simply by tailoring the desired experiment equipment, furniture and storage solutions to your specific needs.

Thanks to our many years of experience, we are reliable partners in all phases of project planning from conception to implementation.

EVERYTHING YOU NEED FROM A SINGLE SOURCE

LAB AND CLASSROOM PLANNING

- Furnishings designed for practical use
- In compliance with safety standards
- Blueprints and planning documents
- Specification of performance features

FURNITURE

- Customised solutions
- Networked training systems
- Storage systems designed to fit equipment and equipment sets
- Long availability & supplementation guarantee

FINANCING

Leasing offers for technical equipment and furnishings



LEYBOLD®



CASSY – COMPUTER-ASSISTED MEASUREMENT AND EVALUATION

The modular CASSY system makes computer-assisted measurement and evaluation possible for all training and educational levels up to university level.

THE CASSY SYSTEM COVERS:

1. Interface for recording measurement data
2. Comprehensive offering of sensors for the detection of electrical and non-electrical variables
3. CASSY Lab 2: The intuitive and easy-to-use software for measurement and evaluation designed to fit all of the equipment and sensors

SENSORS

Catalogue No.	Designation
524 078	CAN bus box
524 081	LIN bus box
524 076	AUTO-BOX i
524 077	AUTO-BOX Z
738 989	Standard Workshop TDC Pick-Up
738 987	Capacitive-Type Pick-Up
738 986	Inductive-Type Pulse Pick-Up
524 064	Pressure sensor S
524 044	Temperature sensor S
524 0511	Lux adapter S
666 243	Lux sensor
524 031	Current source box
524 043	30 A Box
524 0512	Optical power sensor S

SENSOR-CASSY 2

INTERFACE FOR RECORDING MEASUREMENT DATA

- For connection to the USB port of a computer, to an additional CASSY module or to the CASSY display
- Simultaneous measurement of voltage, current and two additional variables possible
- Automatic sensor box recognition
- Can be setup as table-top, console or demonstration unit (also in CPS/TPS experiment frames)

PLUG & PLAY

Automatic detection and setting of Sensor-CASSY and sensor boxes

COMPATIBLE

with all CASSY sensor boxes and sensors

Sensor-CASSY 2 (524 013) provides two electrically separated voltage inputs, an alternative current input and two sensor box inputs parallel to this. All inputs have variable measurement ranges. Technical specs can be found in the individual component section of the catalogue.



VEHICLE DIAGNOSIS

CASSY diagnosis software for the automotive field. This software provides a user interface for Sensor-CASSY, which is based on original diagnosis software.

- for Sensor-CASSY 1+2
- special functions for all high-voltage measurements
- supporting of automotive sensors
- appropriate for electromobility
- protocol analyse is for CAN, LIN, KM and SENT
- for all of your school's workstations (single license = school license)

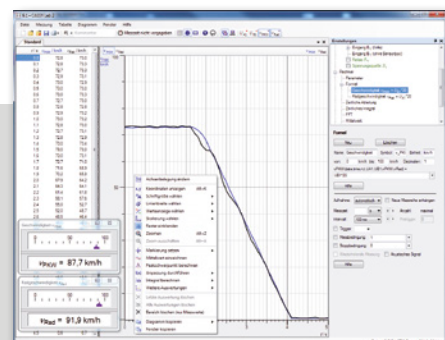


DMM high-voltage measurements with warning

CASSY LAB 2 AND VEHICLE DIAGNOSIS

SOFTWARE TO RECORD AND ANALYZE MEASURED DATA

Graphical representation of ABS speed signals with CASSY Lab 2



CASSY LAB 2 THE ALL-PURPOSE SOFTWARE

- for all basic equipment
- for all sensors
- for all of your school's workstations (single license = school license)

CHAPTER SUMMARY

A1 FUNDAMENTALS OF CAR ELECTRIC/ELECTONICS

A1.1 FUNDAMENTALS BRAND "LEYBOLD" PAGE 23

A2 VEHICLE TECHNOLOGY

A2.1 ELECTRICS PAGE 29

A2.2 ELECTRICAL MACHINE PAGE 41

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A2.5 DRIVE TRAIN PAGE 63

A2.6 NETWORKING SYSTEMS, DIGITALISATION
AND DIAGNOSIS PAGE 67

A2.7 ALTERNATIVE DRIVE TECHNOLOGY PAGE 77



A1 FUNDAMENTALS OF CAR ELECTRIC/ELECTRONICS

- A1.1 FUNDAMENTALS BRAND "LEYBOLD"
 - A1.1.1 FUNDAMENTALS
 - A1.1.1.1 FUNDAMENTALS OF ELECTRICS
 - A1.1.1.2 CAR SENSORS
 - A1.1.1.3 COMPACT SET "BASICS OF AUTOMOTIVE ELECTRICAL ENGINEERING"
 - A1.1.1.4 CAR ACTUATORS
 - A1.1.1.5 SAFEGUARDS IN AN INTRINSICALLY SAFE ELECTRIC AND HYBRID VEHICLE
 - A1.1.2 FUNDAMENTALS WITH COM3LAB
 - A1.1.2.1 AUTOMOTIVE ELECTRICS
 - A1.1.2.2 AUTOMOTIVE SENSORS
 - A1.1.2.3 FUNDAMENTALS OF DIGITAL AND DATA BUS TECHNOLOGY
 - A1.1.2.4 DIGITAL MEMORY CIRCUITS
 - A1.1.2.5 AUTOMOTIVE DATABUSSES

A1.1.1

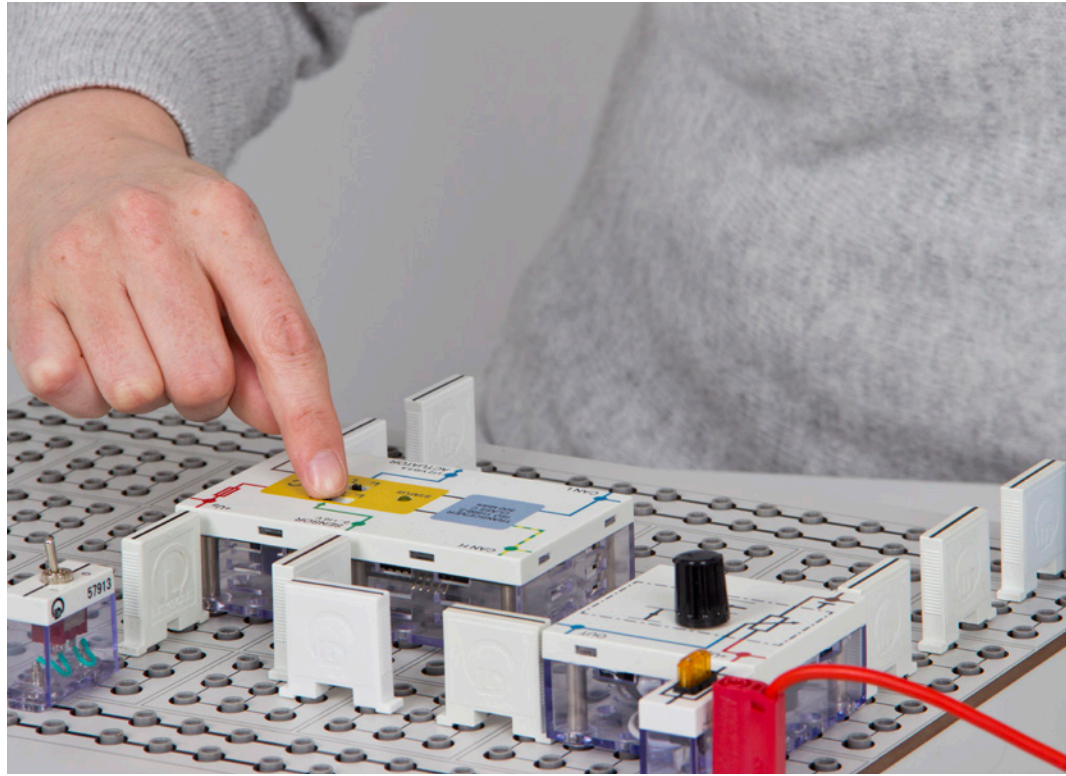
FUNDAMENTALS WITH STE

A1.1.1.1

Fundamentals of electrics

A1.1.1.2

Sensors in cars



Fundamentals of electrics (A1.1.1.1)

Cat. No.	Description	A1.1.1	A1.1.1.2
727 520N	Equipment Set A1.1.1.1, STE	1	
726 50	Plug-in board, 297 mm x 300 mm, STE	2	2
726 88	AC/DC stabilizer	1	1
726 962	Function generator 200 kHz	1	
578 774	Power Switch BTS640 12 A/12	1	
579 163	Simulation ABS/Ti	1	
582 832	STE automotive mini fuse 10A	1	
726 19	Panel frame SL85, single-level	1	
531 090	Multimeter METRAMax 12	1	
531 120	Multimeter LDanalog 20	1	
575 214	Oscilloscope 30 MHz, two-channel, analogus	1	
575 24	Screened cable, BNC/4 mm	2	
LDS 00001	Stopwatch, digital	1	
501 46	Connecting leads, 19 A, 100 cm, red/blue, pair	3	
501 48	Bridging plugs, STE 2/19, set of 10	3	
500 401	Connecting lead, 19 A, 10 cm, red	1	
500 402	Connecting lead, 19A, 10 cm, blue	1	
500 411	Connecting lead, 19 A, 25 cm, red	1	
689 0808	Set 5 automotive Mini fuses	1	
727 5185	Basic set automotive sensorics, STE		1
531 183	Digital multimeter 3340		1
727 5182	Vehicle sensors 1, STE, set		1
727 5183	Vehicle sensors 2, STE, set		1
524 013S	Sensor-CASSY 2 Starter		1

Cat. No.	Description	A1.1.1	A1.1.1.2
739 589	Software: Vehicle diagnosis, English		1
524 064	Pressure sensor S, ±2000 hPa		1
524 031	Current source box		1
375 58	Hand vacuum pump		1
577 42	Resistor, 680 W, STE 2/19		1
582 629	Air mass flowmeter STE 4/100/200		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
739 835	Kelvin- sensing cable, set of 2		1
301 01	Leybold multiclamp		1
666 555	Universal clamp, 0...80 mm		1
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair		2
775 001EN	LIT: A1.1.1.2 Sensorics in the vehicle		1
689 0813	Set 12 automotive fuses		1
689 0814	Set 2 automotive automatic fuses		1
689 0815	Set of 10 magnets		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.

The following topics are covered with the equipment set A1.1.1.1:

- 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 basic set of automotive sensors enables the setup of practice-oriented examples of experiments for:

- The simple DC circuit
 - Ohm's law
 - Nonlinear resistance
 - Capacitor in the DC circuit
 - Use of inductors in the DC circuit
 - The semiconductor diode, and
 - The semiconductor LED
- as the fundamentals of sensor circuits.

A1.1.1

FUNDAMENTALS WITH STE

A1.1.1.3

Compact set "Basics of automotive electrical engineering"

A1.1.1.4

Car actuators



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

Cat. No.	Description	A1.1.1.3	A1.1.1.4
727 520KOF	Compact set "Basics of automobile electrical engineering" in the case	1	
531 090	Multimeter METRAMax 12	1	
531 120	Multimeter LDanalog 20	1	
575 214	Oscilloscope 30 MHz, two-channel, analogous	1	
575 24	Screened cable, BNC/4 mm	2	
LDS 00001	Stopwatch, digital	1	
501 46	Connecting leads, 19 A, 100 cm, red/blue, pair	2	
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
758 201	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
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

Cat. No.	Description	A1.1.1.3	A1.1.1.4
575 303	Digital storage oscilloscope 1222		1*
726 50	Plug-in board, 297 mm x 300 mm, STE		2
501 48	Bridging plugs, STE 2/19, set of 10		2
738 027	Digital power supply 1 - 16 V/40 A		1
521 210	Transformer, 6/12 V		1
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

* additionally recommended

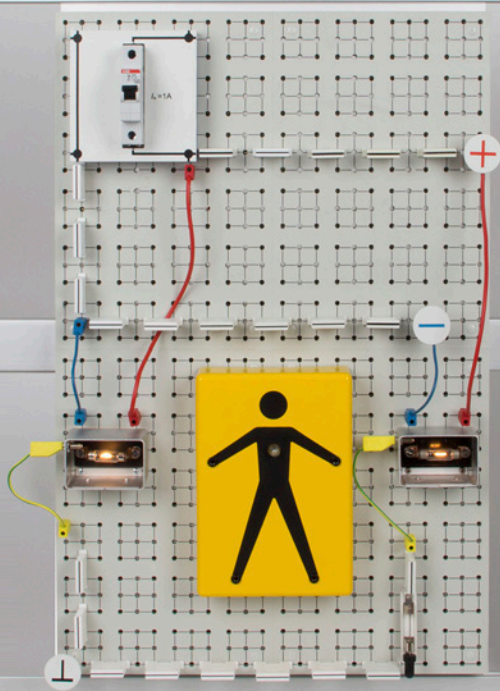
The equipment in the STE suitcase lends itself for storage and as a student's workstation. It serves as a receptacle for various STE equipment sets in its cover and can be used to conduct experiments in the classroom. The cover can be separated from the base.

A1.1.1

FUNDAMENTALS WITH STE

A1.1.1.5

Fundamentals of electrics and high voltage technology



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

Cat. No.	Description	A1.1.1.5
758 202	Isulation monitoring device, STE 6/100	1
758 203	Automatic circuit breaker Z 1 A, STE 4/1	1
582 85	Human model	1
582 73	Lamp, 24 V/10 W, with housing, STE 2/50	2
581 12	Variable resistor, 47 kW, STE 2/50	1
577 15	Resistor, 0.1 W, STE 2/19	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
739 835	Kelvin-sensing cable, set of 2	1
739 004	DMM for electrical vehicles	1
739 949	HV PC measurement adapter for E-Mobility	1
727 292	Voltage detector	1
666 425	Panel frame C50, two-level, for CPS	1
501 861	Crocodile-clips, polished, set of 6	1
501 48	Bridging plugs, STE 2/19, set of 10	3
726 54	Plug-in board, 634 mm x 400 mm, STE	1
500 402	Connecting lead, 19A, 10 cm, blue	3
500 412	Connecting lead, 19 A, 25 cm, blue	1
500 411	Connecting lead, 19 A, 25 cm, red	4
500 420	Connecting lead, 19 A, 50 cm, yellow/green	2
500 441	Connecting lead 19 A, 100 cm, red	2
500 442	Connecting lead 19 A, 100 cm, blue	2
726 890	DC-High Current Power Supp. 32/20	1

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- ISO-compliant symbolic representation of the components.

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

A1.1.2

FUNDAMENTALS WITH COM3LAB

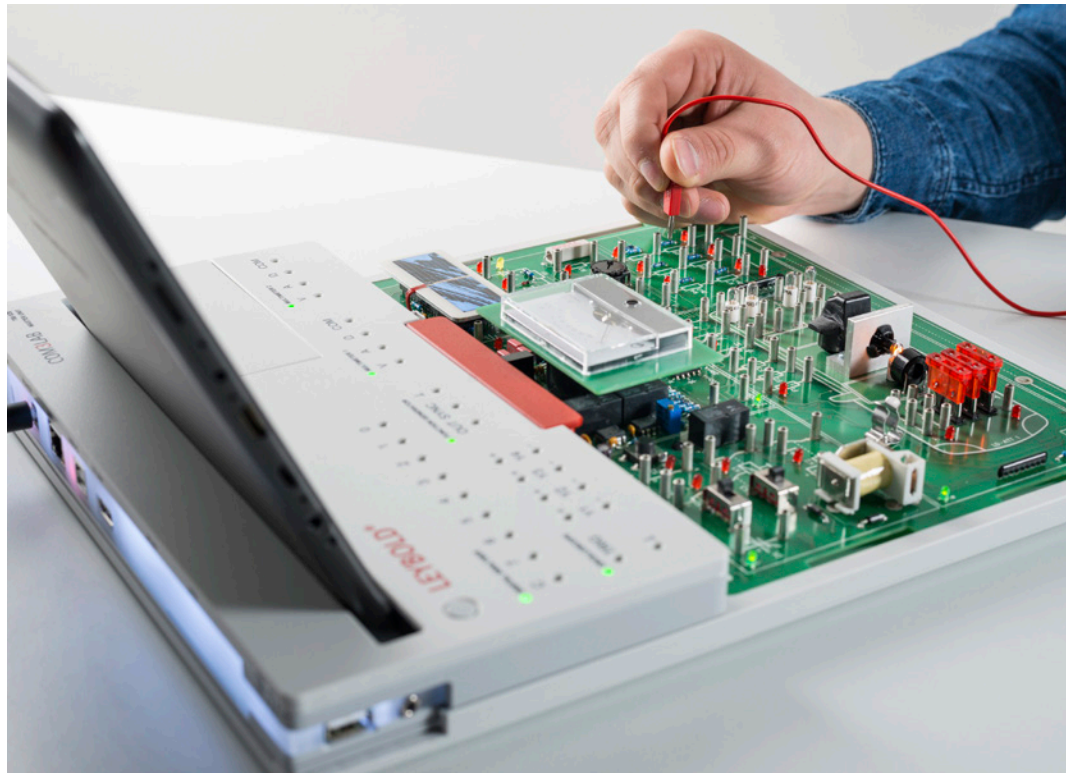
A1.1.2.1
Automotive electrics

A1.1.2.2
Automotive sensors

A1.1.2.3
Fundamentals of digital and data bus technology

A1.1.2.4
Digital memory circuits

A1.1.2.5
Automotive databusses



Automotive electrics (A1.1.2.1)

Cat. No.	Description	A1.1.2.1	A1.1.2.2	A1.1.2.3	A1.1.2.4	A1.1.2.5
700 020	COM3LAB: Master Unit	1	1	1	1	1
700 022	Set of Safety Cables (2 mm, 16 Qty., 6 x 30 cm & 10 x 15 cm)	1	1	1	1	1
700 6101	COM3LAB Course: Automotive Electrics	1				
688 129	Mains cable with hock-proof plug and cold connector	1	1	1	1	1
700 6201	COM3LAB Course: Automotive Sensor Technology		1			
700 6401	COM3LAB Course: Automotive Digital Technology I			1		
700 6501	COM3LAB Course: Automotive Digital Technology II				1	
700 6301	COM3LAB Course: Automotive Data Buses					1
739 581USB	CAN-Bus Adapter USB					1
739 588	LIN-BUS PC interface USB					1

COM3LAB is used for schooling and continuing education in electrical engineering and electronics. Electrical engineering can be taught and learned both theoretically and practically with COM3LAB. COM3LAB is the interface between theory and practice. Subject matters are not only presented theoretically but also simultaneously deepened with practical experiments.

COM3LAB consists of a master unit and several courses (experimental board + CD-ROM). The master unit is the basic device through which the software and experimental board communicate with each other.

The courses provide descriptive theory and many experiments in the widest range of subjects within electrical engineering and electronics. All experiments must be conducted personally. The measurements provide real values.

Ideal for direct transformation from theory into practice.

The COM3LAB courses Electricity and Sensors for Automotive Training formed, in cooperation with the automotive industry strategically introduce the fundamentals of electricity. The COM3LAB course "Automotive Technology I" 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 "Vehicle Sensors" gives a detailed explanation of the operating principle of electric components and sensors in a motor vehicle.

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.



A2

VEHICLE TECHNOLOGY

A2.1 ELECTRICS

- A2.1.1 POWER SUPPLY
 - A2.1.1.1 ENERGY MONITORING
 - A2.1.1.2 THREEPHASE ALTERNATOR
 - A2.1.1.4 ON-BOARD SUPPLY OF START/STOP SYSTEMS
- A2.1.2 LIGHTING SYSTEMS
 - A2.1.2.1 AUTOMOTIVE LIGHTING
 - A2.1.2.2 SUPPLEMENTARY SET "TRAILER"
- A2.1.3 NETWORKING LIGHTING SYSTEMS
 - A2.1.3.1 AUTOMOTIVE LIGHTING WITH CAN DATA BUS
 - A2.1.3.2 SUPPLEMENTARY SET "TRAILER CONTROL"
 - A2.1.3.4 LED HEADLIGHTS
- A2.1.4 BACKFITTING ELECTRICAL SYSTEMS
 - A2.1.4.1 ELECTRICAL SYSTEMS 230 VAC
 - A2.1.4.2 COMFORT SYSTEM TURN SIGNAL FLASHING
 - A2.1.4.3 CORNERING LIGHT

A2.1.1

POWER SUPPLY

A2.1.1.1

Energy monitoring



Energy monitoring (A2.1.1.1)

Cat. No.	Description	A2.1.1.1
738 031	Battery monitoring	1
739 588	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 90	Parallel Glow System	1
738 963	TDI Control Relay for Preheating System	1
738 10	Ignition switch	1
738 043	Vehicle battery connecting kit	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
738 9991	DC/AC clamp-on current probe	1
726 09	Panel frame T130, 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 connecting lead, 100 cm, black	5
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1
738 01	Cable and plug box	1
500 593	Fault simulation plugs, black, set of 10	1
738 021	Battery charger, automatic	1
775 010EN	LIT: A2.1.1.1 Energy monitoring	1

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.

The **car battery** is an essential component of the electrical system. The 738 031 "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.

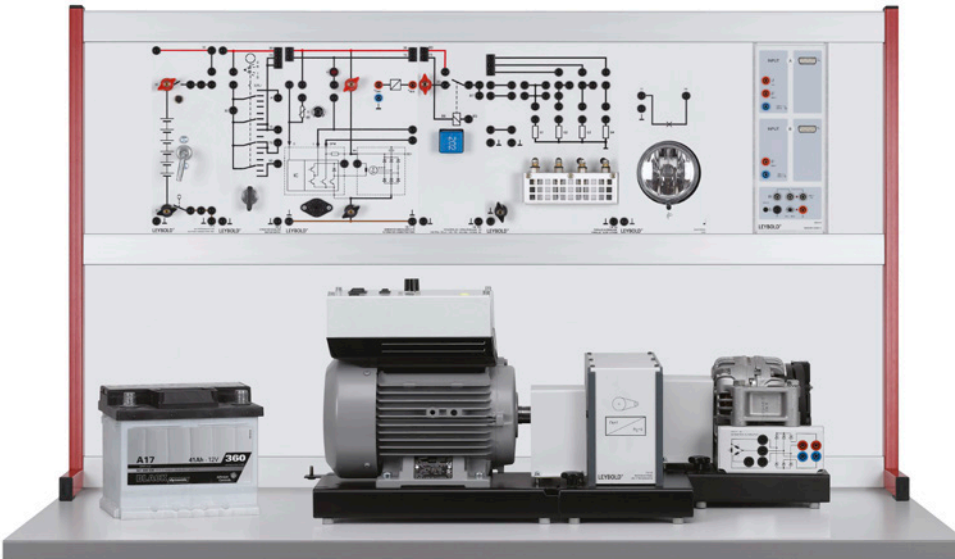
The **dynamic management** distributes the energy generated while driving to the individual loads. This is especially important if the energy does is not sufficient for the demand because of the number of loads (seat heater, lights, rear window).

A2.1.1

POWER SUPPLY

A2.1.1.2

Three-phase alternator



Three-phase alternator (A2.1.1.2)

Cat. No.	Description	A2.1.1.2
738 711	Compact alternator	1
738 631	Motor f. Generator Experiments, 1.0 kW	1
738 632	Belt drive for vehicle 1:3	1
738 963	TDI Control Relay for Preheating System	1
738 90	Parallel Glow System	1
738 10	Ignition switch	1
738 18	Auxiliary headlamp	1
738 76	Field Regulator, Generator	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 013	Sensor-CASSY 2	1
738 985	Automotive meter	1
524 076	AUTO-BOX i	1
738 9991	DC/AC Clamp on current probe	1
732 56	Coupling 1,0	2
732 58	Coupling Guard 1,0	2
726 10	Panel frame T150, Two Level	1
738 03	Battery connection unit	1
738 04	Car battery 12V	1
738 043	Vehicle battery connecting kit	1
738 05	Connection leads I, set	2
500 59	Set of 10 safety bridging plugs, black	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

Cat. No.	Description	A2.1.1.2
775 011EN	LIT: A2.1.1.2 Three-phase 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

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 multi-function controller handles this.

The excitation current and the voltage can be captured on the connection plate, and connections are available

- to the battery monitoring (sensing)
- to the load and error detection, and
- to the rotation speed detection.

The generator's output voltage can be led as a function of temperature or by the engine control unit.

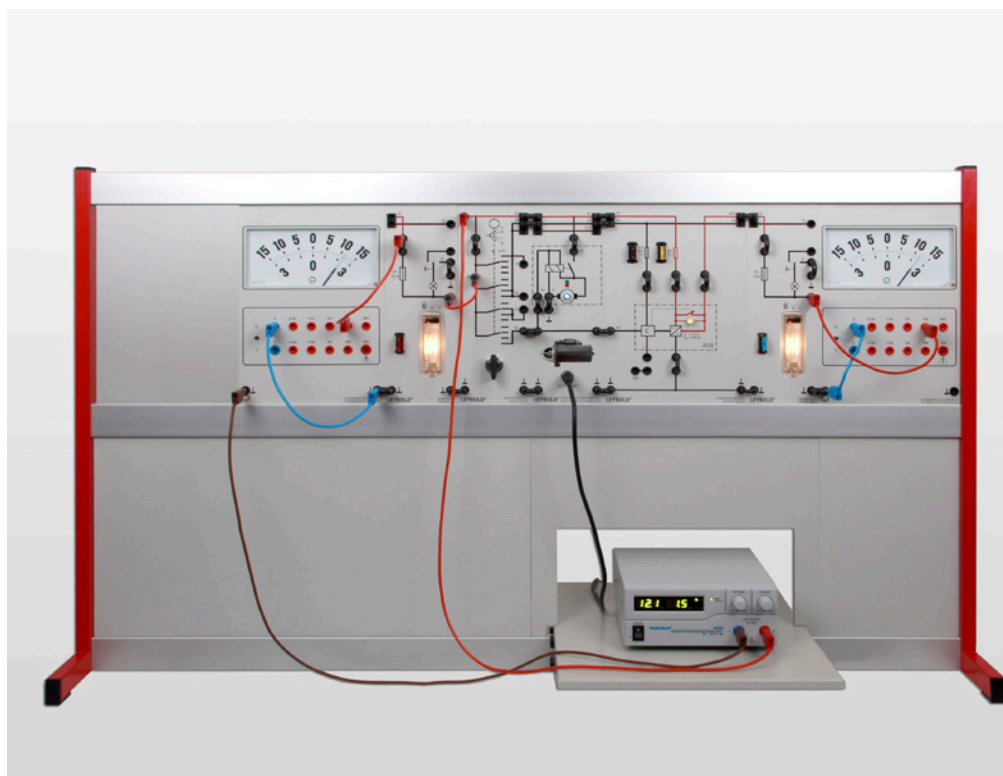
In connection with lighting components, special high-current loads and a vehicle battery, the complete electrical system can be assembled.

A2.1.1

POWER SUPPLY

A2.1.1.4

On-board supply of start/stop systems



On-board supply of start/stop systems (A2.1.1.4)

Cat. No.	Description	A2.1.1.4
738 10	Ignition 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
738 871	Starter substitute w. load simulation	1
738 32	Voltage stabilizer	1
727 20	Automobile Meter Zero-Left	2
775 010EN	LIT: A2.1.1.1 Energy monitoring	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1
726 09	Panel frame T130, two-level	1
738 05	Connection leads I, set	1
500 441	Connecting lead, 19 A, 100 cm, red	1
500 444	Connecting lead, 19 A, 100 cm, black	1
500 412	Connecting lead, 19 A, 25 cm, blue	1
500 411	Connecting lead, 19 A, 25 cm, red	2
500 401	Connecting lead, 19 A, 10 cm, red	1
500 402	Connecting lead, 19A, 10 cm, blue	1
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1

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.

The on-board power supply governs the construction and function of energy and data management in the modern vehicle. It forms a system of energy supply and distribution including drive and control.

In vehicles with start/stop systems the battery voltage will often sink below 12 V as a result of the many start processes. If a voltage stabiliser is used, the on-board voltage will remain at a constant 12 V during the starting process in order to maintain maximum convenience. The voltage stabiliser is a DC/DC transformer on the selected components, such as the instrument cluster connection to the radio as well as the ABS/ESP controller.

Suitable measures are employed in this device set to reduce the on-board power supply voltage during start processes without large currents being necessary for this. This allows the function of the stabiliser to be didactically examined by comparing the voltage in front of and after it.

The device set will only work with 738 027 power supply.

A2.1.2

LIGHTING SYSTEMS

A2.1.2.1

Automotive lighting

A2.1.2.2

Supplementary set "Trailer"



Automotive lighting (A2.1.2.1)

Cat. No.	Description		
		A2.1.2.1	A2.1.2.2
738 10	Ignition switch	1	
738 032	Battery connection with protection circuit	1	
738 151	Telltale KI	1	
738 871	Starter substitute w. load simulation	1	
738 11	Head lamp switch	1	
738 131	Stalks with with parking light	1	
738 114	Light control	1	
738 166	Headlights right	1	
738 167	Headlights left	1	
738 190	Rear lights	1	
739 573	Automotive Set Point Potentiometer	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	
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 1N0	2	

Cat. No.	Description		
		A2.1.2.1	A2.1.2.2
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 32	Rheostat, 10 ohms	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	1	
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	
726 26	Panel frame VT180, three-level	1	
500 59	Safety bridging plugs, black, set of 10	7	1
500 592	Safety bridging plugs with tap, black, set of 10	1	
738 9831	Safety experiment cables, set of 102	1	
689 0813	Set 12 automotive fuses	1	
689 0814	Set 2 automotive automatic fuses	1	
775 012EN	LIT: A2.1.2.1 Automotive lighting	1	
738 16	Main headlamp with side lamp	2	
738 01	Cable and plug box	1	
500 593	Fault simulation plugs, black, set of 10	1	
738 021	Battery charger, automatic	1	



Cat. No.	Description	A2.1.2.1	A2.1.2.2
738 27	Trailer lights		1
738 251	Trailer Socket 13 pole		1

See and be seen - the vehicle lighting is not only designed that the driver can see the road better, but also to the fact that he is seen better. Thus, the illumination is one of the most important safety components of vehicles. For this reason, the development of improved lighting systems is still going on and has led to the use of LEDs in front and rear lights. In addition, the systems are "automated" to assist the driver in the operation.

Defined functions of the lights at the front of the vehicle, at the rear and inside are part of the vehicle's lighting technology. Even if control units activate modern lighting systems, knowing conventional circuits is indispensable.

Certain physical principles, like those of polyellipsoid headlamps, xenon lamps or LED lights must also be mastered. Vehicle lighting systems require knowledge of the stipulations in the Road Traffic Type Approval Law and their requirements with regard to mechanical layout and electrical connection of lighting components.

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

With **polyellipsoid headlamps** the emitted light beams have a farther focus. Positioning a lens near it results in an exact light/dark boundary. The remaining light can then be uniformly distributed a little farther ahead on the roadway through an appropriate lens. Already shortly after exiting the ellipsoid, the bundled light beams are considerably smaller than with a paraboloid or free-form reflector. Only beyond the final lens (with a small effective reflex surface) does it grow.

For various load conditions of the vehicle, the headlamp level control should prevent blinding of oncoming traffic. The reflectors can be tilted vertically and adjusted by electric motors. If manually adjusted, these are set by a locator operated by the driver. With automatic headlamp level control, the assembly's position is detected by level sensors, and the control unit sends the corresponding signals to the electric motors.

Some provisions need to be followed, in particular with **trailers**. Correct connection of the trailer socket, monitoring of the turn-signal system and automatic shutdown of the rear fog lamps on the towing vehicle must be ensured.

A2.1.3

NETWORKING LIGHTING SYSTEMS

A2.1.3.1

Automotive lighting with
CAN data bus

A2.1.3.2

Supplementary set "Trailer control"



Automotive lighting with CAN data bus (A2.1.3.1)

Cat. No.	Description	A2.1.3.1	A2.1.3.2
738 111	Intelligent automotive lighting management system	1	
738 1121	OBd adaptor	1	
726 256	Panel frame VT160, three-level	1	
738 291	Relay 1NO	1	
579 13	Toggle switch, STE 2/19	1	
738 10	Ignition switch	1	
738 166	Headlights right	1	
738 167	Headlights left	1	
738 361	Side turn signal light LED	2	
578 611	Phototransistor, STE 2/19	1	
738 190	Rear lights	1	
738 975	Diagnostic Plug 16 Pin	1	
738 18	Auxiliary headlamp	2	
577 79	Variable resistor, 1 kW, STE 2/19	1	
577 321	Resistor, 120 W, STE 2/19	2	
578 02	Photoresistor LDR 05, STE 2/19	1	
739 654	Steering angle sensor	1	
739 585	Fault simulator CAN Bus	1	
738 4911S	Automotive fault simulator, start	1	
739 6021	Instrument cluster unit	1	
738 03	Battery connection unit	1	
579 163	Simulation ABS/Ti	1	
739 587	Software: Databus visualisation	1	
737 9803	OBd Adaptor CAN+USB	1	

Cat. No.	Description	A2.1.3.1	A2.1.3.2
524 078	CAN bus box	1	
524 013S	Sensor-CASSY 2 Starter	1	
739 581USB	CAN databus adapter USB	1	
524 0431	30-A-Box	1	
739 589	Software: Vehicle diagnosis, German and English	1	
738 027	Digital power supply 1 - 16 V/40 A	1	
500 990	Adapter sockets, set of 2	1	
500 59	Safety bridging plugs, black, set of 10	14	3
500 592	Safety bridging plugs with tap, black, set of 10	2	1
738 9831	Safety experiment cables, set of 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 013EN	LIT: A2.1.3.1 Automotive lighting with CAN databus	1	
738 01	Cable and plug box	1	
500 593	Fault simulation plugs, black, set of 10	1	
739 5835	DS vehicle door	1*	
739 5836	PS vehicle door	1*	
738 251	Trailer Socket 13 pole		1
738 263	CAN Trailer ECU		1
738 27	Trailer lights		1
726 09	Panel frame T130, two-level		1

* additionally recommended



With more data transmission and networking in the motor vehicle, networked control units also take over the management of the lighting and electrical system in modern passenger cars. The educational system consists of a steering column switch with control unit and the electrical system control unit to activate the front and rear lights. It can be expanded with a comfort control unit, an instrument cluster with integrated gateway and a control unit for automatic trailer detection.

The experiment can study modern control unit functions, such as

- Cold lamp monitoring
- Hot lamp monitoring
- Turn signals
- Daytime running lights
- Automatic headlights
- Automatic ambient lighting, or
- PWM-controlled taillights.

Furthermore, measurements relevant to the workshop can be executed on the low-speed and high-speed CAN data buses. The lockable fault simulator (738 585), which can override practical faults in addition to all the standardized faults per ISO, lends itself to the students' troubleshooting procedure, and so does the remote-controlled automotive fault simulator (738 491).

With lighting systems controlled by CAN bus with an electrical system control unit, the trailer socket may not simply connect in parallel to the available rear lights. In fact interconnecting an appropriate control unit and integrating it into the CAN topology is required.



A2.1.3
NETWORKING
LIGHTING SYSTEMS

A2.1.3.4
LED Headlights

LED Headlights (A2.1.3.4)

Cat. No.	Description	A2.1.3.4
738 189	LED Headlight	1
738 027	Digital power supply 1 - 16 V/40 A	1
775 015EN	LIT: A2.1.3.4 LED Headlights	1
739 588	LIN BUS PC interface USB	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
467 251	Compact spectrometer USB, physics	1*
739 580	Databus detector	1
500 644	Safety connection lead, 100 cm, black	2
500 647	Safety connection lead, 100 cm, brown	3
500 641	Safety connection lead, 100 cm, red	1
500 59	Set of 10 safety bridging plugs, black	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

* 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:

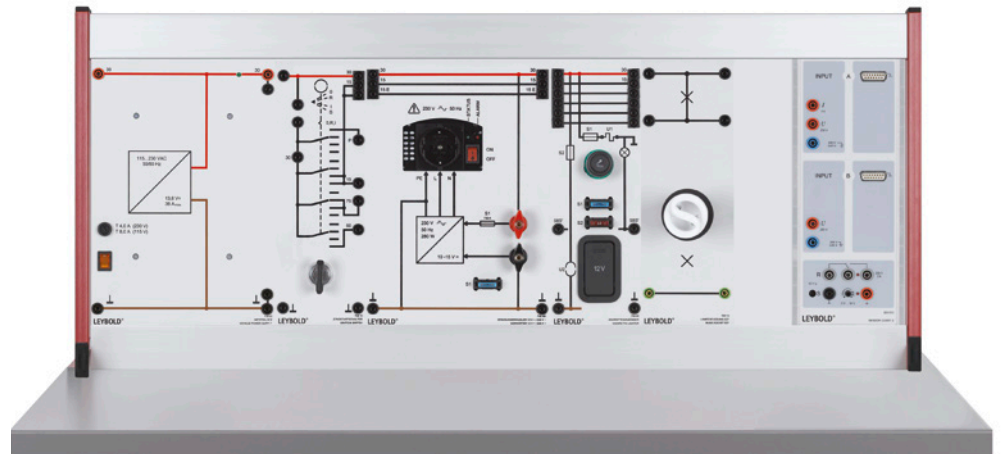
- LEDs as a lighting element
- Lighting functions (eg DRL)
- Special lighting functions (such as all-weather light)
- Headlight range adjustment
- LED lighting element according to ECE
- Legal regulations ECE
- Testing and adjustment of headlights
- Service orders and troubleshooting
- Reading circuit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

A2.1.4

BACKFITTING ELECTRICAL SYSTEMS

A2.1.4.1

Electrical systems 230 VAC



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
729 13	Lamp Socket E27	1
738 06	12 V on-board socket	1
738 10	Ignition switch	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
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 014EN	LIT: A2.1.4 Backfitting electrical systems	1

* additionally recommended

Retrofitting electric systems is now an essential part of the automotive mechatronics engineer's training.

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 car manufacturer 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 is able to retrofit such an installation?
- May he repair them to it?
- Are there any regulations to pay attention to?

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

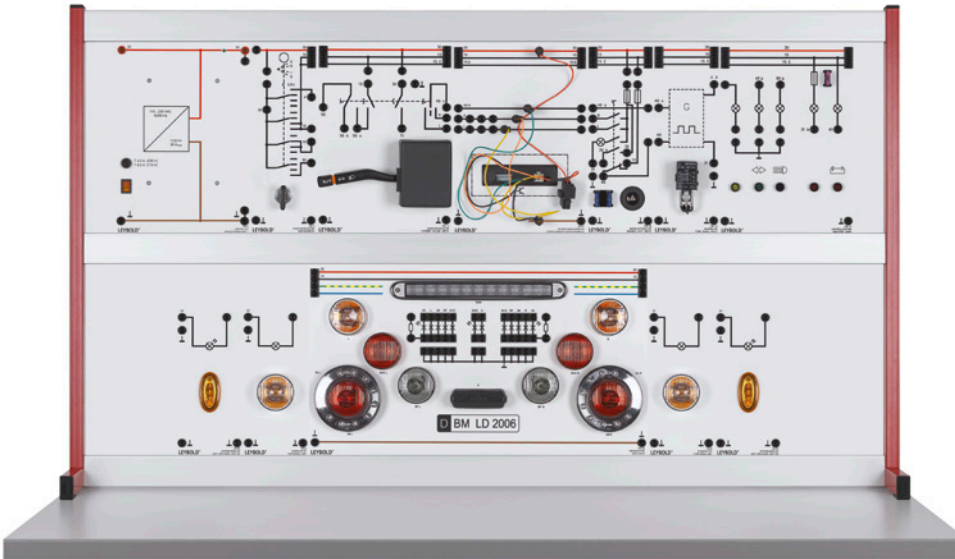
- What is an inverter?
- How does it work?
- How does it relate to personal safety?
- Which faults may arise and how can they be diagnosed and corrected?

A2.1.4

BACKFITTING ELECTRICAL SYSTEMS

A2.1.4.2

Comfort system turn signal flashing



Comfort system turn signal flashing (A2.1.4.2)

Cat. No.	Description	A2.1.4.2
738 371	Automotive 1 tip/3 flash relay	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
738 131	Stalk swith with parking light	1
738 38	Warning Lamp Switch	1
738 37	Turn Signal Relay	1
738 151	Telltals KI	1
738 36	Turn Signal Lamp	2
738 361	Side turn signal light LED	2
738 190	Rear lights	1
738 02	Automotive power supply 13.8 V/36 A	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
738 05	Connection leads I, set	1
500 593	Fault simulation plugs, black, set of 10	1*
738 01	Cable and plug box	1
775 014EN	LIT: A2.1.4 Backfitting electrical systems	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 comprehensively 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.

A2.1.4

BACKFITTING ELECTRICAL SYSTEMS

A2.1.4.3

Cornering light



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
738 166	Headlights right	1
738 167	Headlights left	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
739 6021	Instrument cluster unit	1
738 02	Automotive power supply 13.8 V/36 A	1
738 190	Rear lights	1
739 654	Steering angle sensor	1
738 18	Auxiliary headlamp	2
738 361	Side turn signal light LED	2
579 163	Simulation ABS/Ti	1
775 016EN	LIT: A 2.1.4.3 Cornering Light	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
739 581USB	CAN-Bus Adapter USB	1
313 12	Digital stop-watch	1
738 9821	Safety experiment cables, set of 51	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 W, STE 2/19	2
577 79	Variable resistor, 1 kW, STE 2/19	1
726 256	Panel frame VT160, three-level	1
738 01	Cable and plug box	1

Cat. No.	Description	A2.1.4.3
738 05	Connection leads I, set	1
725 007	Software: Leylab.control Lite	1
689 0808	Set 5 automotive Mini fuses	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

A photograph of a car's windshield during a rainstorm. The view is blurred due to the rain and the motion of the wipers. The wiper blades are visible in the foreground, and the background shows a green, hazy landscape. A blue semi-transparent overlay covers the bottom half of the image, containing text.

A2

VEHICLE TECHNOLOGY

A2.2 ELECTRICAL MACHINE

A2.2.1 ELECTRICAL MOTOR

A2.2.1.1 WIPER MOTOR

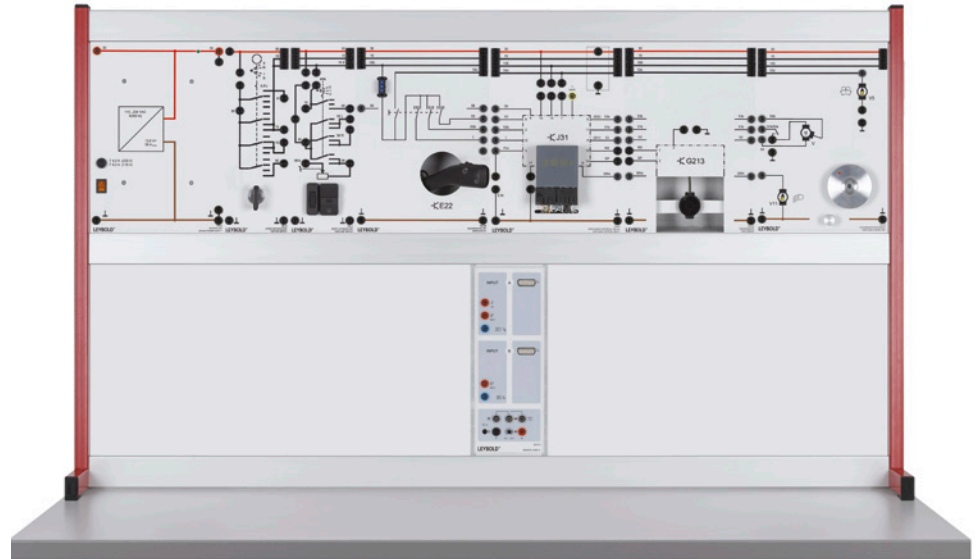
A2.2.1.2 PRE-ENGAGED-DRIVE STARTERS

A2.2.1

ELECTRICAL MOTOR

A2.2.1.1

Wiper motor



Wiper motor (A2.2.1.1)

Cat. No.	Description	A2.2.1.1
738 830	Wiper Switch	1
738 831	Wipe-Wash Interval Relay	1
738 832	Rain sensor	1
738 833	Windshield Wiper Unit	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
738 11	Head lamp switch	1
309 48ET2	Fishing line, set of 2	1
315 38	Weight, 0.5 kg	1
524 013S	Sensor-CASSY 2 Starter	1
524 013	Sensor-CASSY 2	1
738 985	Automotive meter	1
524 0431	30-A-Box	1
726 09	Panel frame T130, two-level	1
738 02	Automotive power supply 13.8 V/36 A	1
738 05	Connection leads I, set	1
500 59	Safety bridging plugs, black, set of 10	3
500 641	Safety connecting lead, 100 cm, red	3
500 647	Safety connection lead, 100 cm brown	3
500 612	Safety connecting lead, 25 cm, blue	2
500 592	Safety bridging plugs with tap, black, set of 10	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
775 021EN	LIT: A2.2.1.1 Wiper motor	1

The **windshield wiper** - clear vision, without which nothing moves in the rain! The classic windshield wiper application uses grinding machines for the front wipers. By contrast, the rear window wipers have a pole-changeable operation, since they work predominantly intermittently.

An automatic windshield wiper with rain sensor distinctly increases comfort and contributes to safety when driving.

The complete system consists of:

- a rotating windshield wiper motor
- a wipe-wash interval relay
- a washing pump simulation for the front glass
- a washing pump simulation for the headlights
- the steering column switch, and
- the rain sensor.

The generic term "automotive physics" refers to the system's mechanical side: the motor can be loaded precisely with a weight to determine the motor's efficiency and torque.

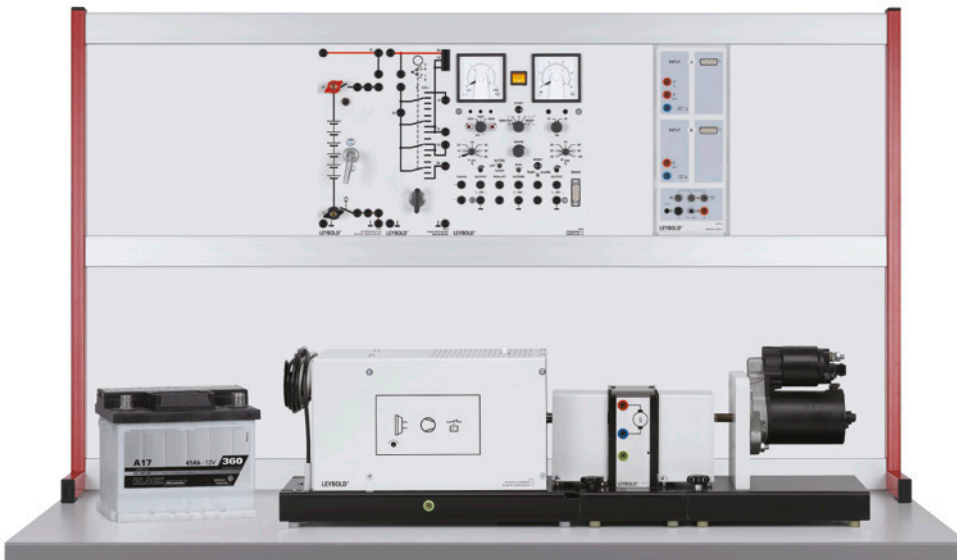
The rain sensor is studied in its capacity as an optical sensor and as part of the controlled system. It is assembled behind plexiglass to be activated upon sprinkling with water.

A2.2.1

ELECTRICAL MOTOR

A2.2.1.2

Pre-engaged-drive starters



Pre-engaged-drive starters (A2.2.1.2)

Cat. No.	Description	A2.2.1.2
738 851	Pre-engaged drive starter, perman.-excited	1
732 54	Magnetic Powder Brake 1.0	1
732 55	Control Unit 1.0	1
732 59	Tacho Generator 1.0	1
500 597	Automobile protection measuring adaptor	1
726 09	Panel frame T130, two-level	1
732 56	Coupling 1.0	2
732 58	Coupling guard 1.0	2
500 59	Safety bridging plugs, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
524 0135	Sensor-CASSY 2 Starter	1
738 9991	DC/AC clamp-on current probe	1
314 201	Precision dynamometer, 100.0 N	1
738 03	Battery connection unit	1
738 04	Car battery 12V	1
738 05	Connection leads I, set	1
738 10	Ignition switch	1
738 88	Connecting Leads II, set	1
738 042	Battery pole-clamp, set	1
738 89	Crocodile clip 32 A, set of 2	1
775 020EN	LIT: A2.2.1.2 Electrical starter	1

The electric motor – the vehicle's second torque! The principle is sound: a current flow generates a magnetic field that, together with a second magnetic field, forms energy. This process can be used to generate linear movements (e.g. valves, injectors, relays) but also rotating movements.

The starter is a DC series wound machine that can raise a sufficient torque at relatively low speeds to start the combustion engine. Maintaining the resulting power from the electric system requires correspondingly high current and conductor cross sections.

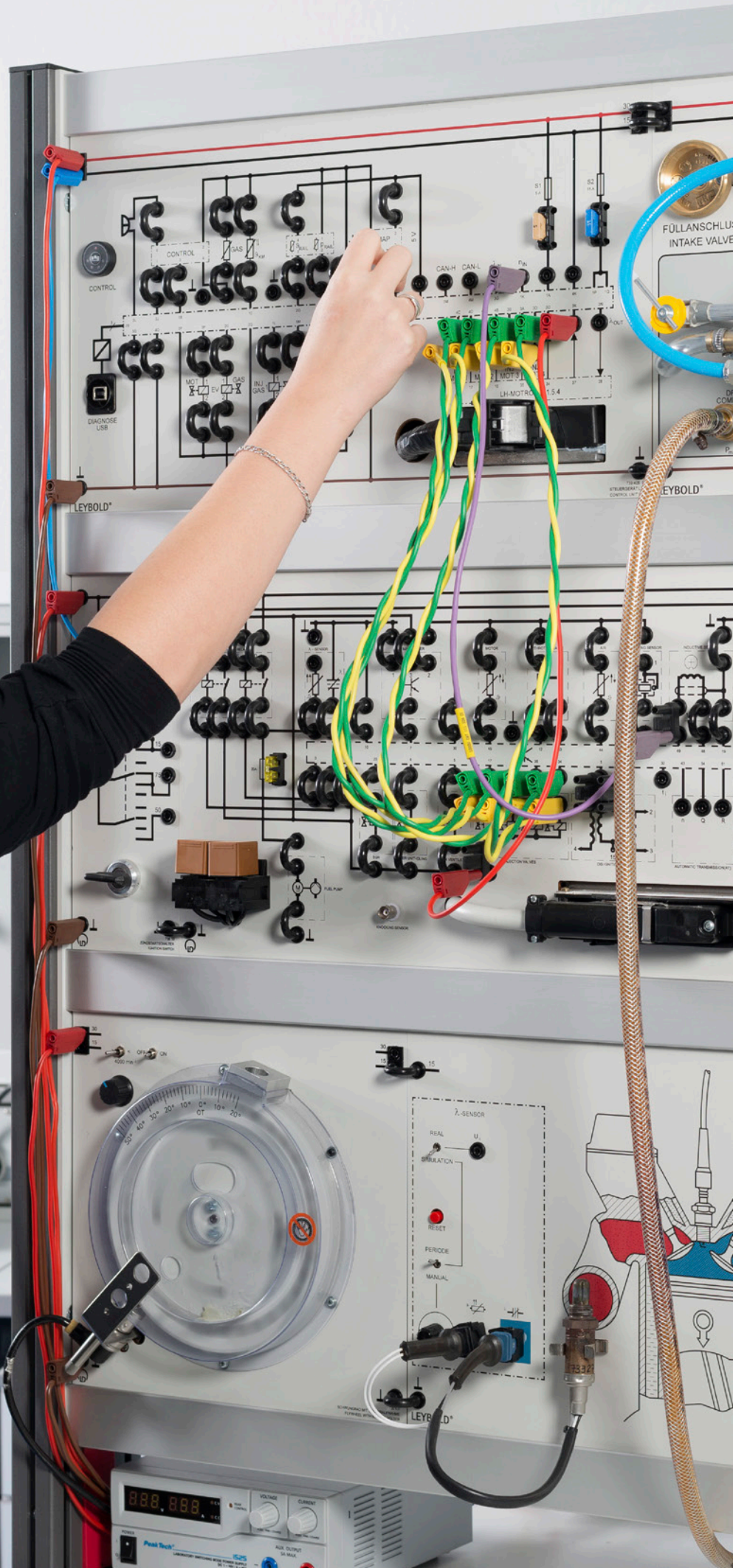
The educational system is aimed at recording the speed-torque curve. The starter is thus loaded by a magnetic powder brake.

The variables

- brake torque
- voltage
- speed, and
- current through a current probe

can be recorded with CASSY and correspondingly represented and analyzed.

LEYBOLD®





A2 VEHICLE TECHNOLOGY

A2.3 ENGINE

A2.3.1 IGNITION SYSTEMS

A2.3.1.1 BREAKER-TRIGGERED COIL IGNITION SYSTEM

A2.3.1.2 TRANSISTORIZED COIL IGNITION SYSTEM

A2.3.1.3 DISTRIBUTORLESS COIL IGNITION SYSTEM (DIS)

A2.3.1.4 DISTRIBUTORLESS COIL IGNITION SYSTEM (SSI)

A2.3.2 MOTOR MANAGEMENT SYSTEMS PETROL

A2.3.2.1 FUEL INJECTION

A2.3.2.2 GAS DRIVE

A2.3.3 MOTOR MANAGEMENT SYSTEMS DIESEL

A2.3.3.4 COMMON RAIL

A2.3.3.5 DIESEL QUICK START SYSTEM

A2.3.1

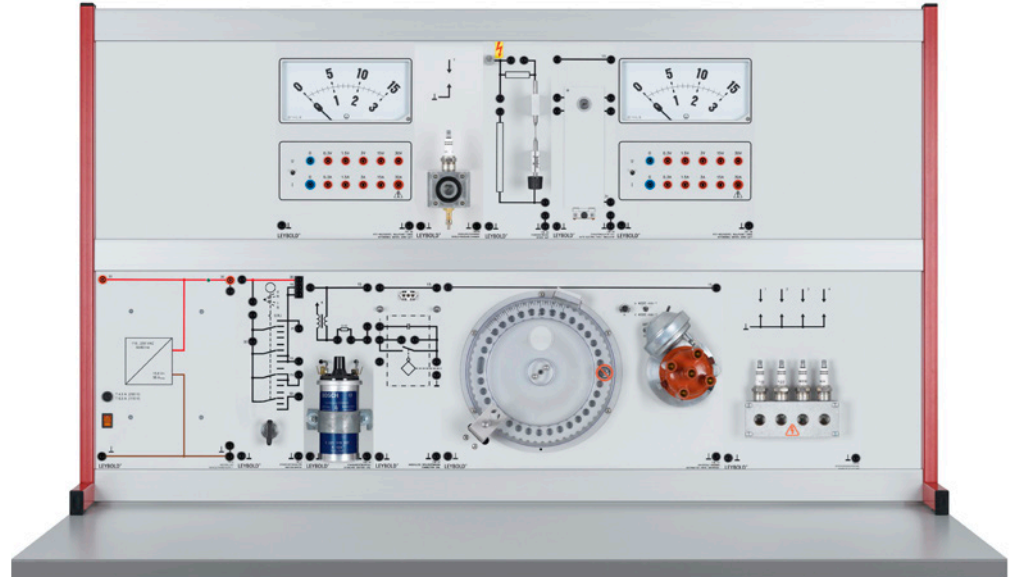
IGNITION SYSTEMS

A2.3.1.1

Breaker-triggered coil ignition system

A2.3.1.2

Transistorized coil ignition system



Breaker-triggered coil ignition system (A2.3.1.1)

Cat. No.	Description	A2.3.1.1	A2.3.1.2
738 40	Standard Ignition Coil	1	
738 42	Distributor Breaker-Triggered	1	
738 461	Distributor Cap, Transparent	1	
738 02	Automotive power supply 13.8 V/36 A	1	1
738 441	Spark plug holder	1	1
738 47	Coil Connector Unit	1	1
738 46	Accessory Set Ignition System	1	1
738 997	CASSY automotive measuring set	1	1
375 58	Hand vacuum pump	1	1
738 992	Ignition Timing Light	1	1
739 43	Distributor Drive Universal	1	1
726 09	Panel frame T130, two-level	1	1
738 10	Ignition switch	1	1
738 032	Battery connection with protection circuit	1	1
738 985	Automotive meter	1	1
524 064	Pressure sensor S, ±2000 hPa	1	2
727 20	Automobile Meter Zero-Left	2	2
738 49	Fault Simulator Automotive	1	1
8-1 503204-000-10-0	Distributor rotor with 68 kOhm resistor	1	
738 442	Single pressure chamber	1	1
738 998	Pressure pump, foot-operated	1	1
562 901	Magneto model	1	
604 541	Adapter, PP, T form, 6/7 mm, with nipple	1	1
604 520	Connector with nipple	1	1
604 481	Rubber tubing, 1 m x 4 mm diam., DIN 12865	1	1

Cat. No.	Description	A2.3.1.1	A2.3.1.2
500 59	Safety bridging plugs, black, set of 10	2	1
500 592	Safety bridging plugs with tap, black, set of 10	1	1
738 9821	Safety experiment cables, set of 51	1	1
738 05	Connection leads I, set	1	1
738 01	Cable and plug box	1*	1*
500 593	Fault simulation plugs, black, set of 10	1*	1*
738 50	Control Unit TI-H		1
738 51	Ignition Coil TI-H/I		1
738 54	Overlay TI-H		1
738 55	Ignition Distributor TI-I		1
738 56	Overlay TI-I		1
738 58	Control Unit TI-I, TD		1
738 531	Distributor TI-H		1

* additionally recommended

Ignition systems with rotating division – already quite rare today, but indispensable for the basic understanding of ignition!

The transistor ignition was developed as a result of the contact breaker's limited switching power. This uses electronic high-powered switches and the corresponding control units. The contactless transistor ignition occurs with pulse pick-ups according to the

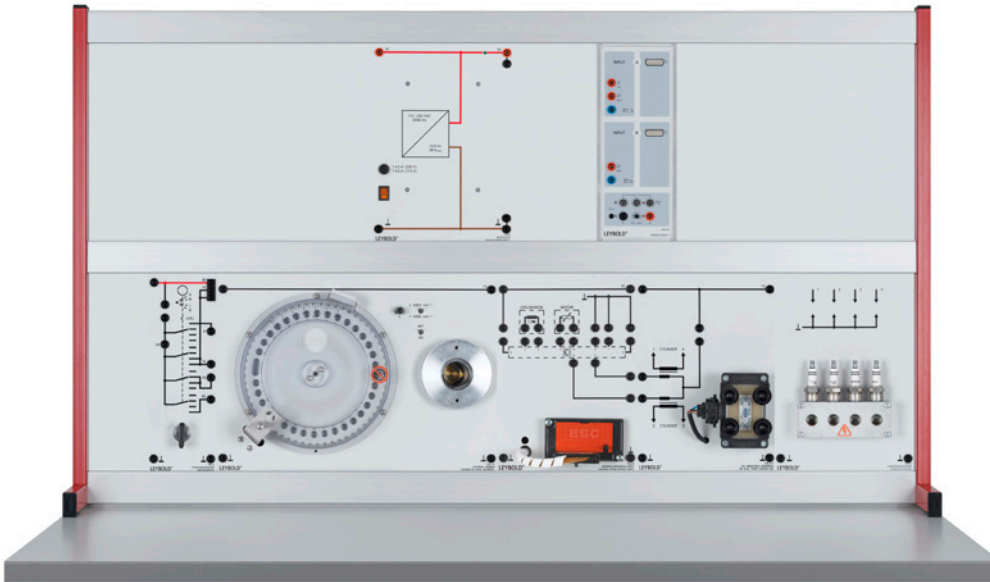
- induction principle (TI-I) and the
- Hall principle (TI-H).

A2.3.1

IGNITION SYSTEMS

A2.3.1.3

Distributorless coil ignition system (DIS)



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

Cat. No.	Description	A2.3.1.3
738 5161	Universal ignition module (UESC)	1
738 10	Ignition 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 36ET10	Glow lamps, 115 V, E10, set of 10	1
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
738 989	Standard Workshop TDC Pick-Up	1
738 986	Inductive-Type Pulse Pick-Up	1
775 031EN	LIT: A2.3.1.3/4 Distributorless coil ignition systems	1
500 59	Safety bridging plugs, black, set of 10	2

Cat. No.	Description	A2.3.1.3
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
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.

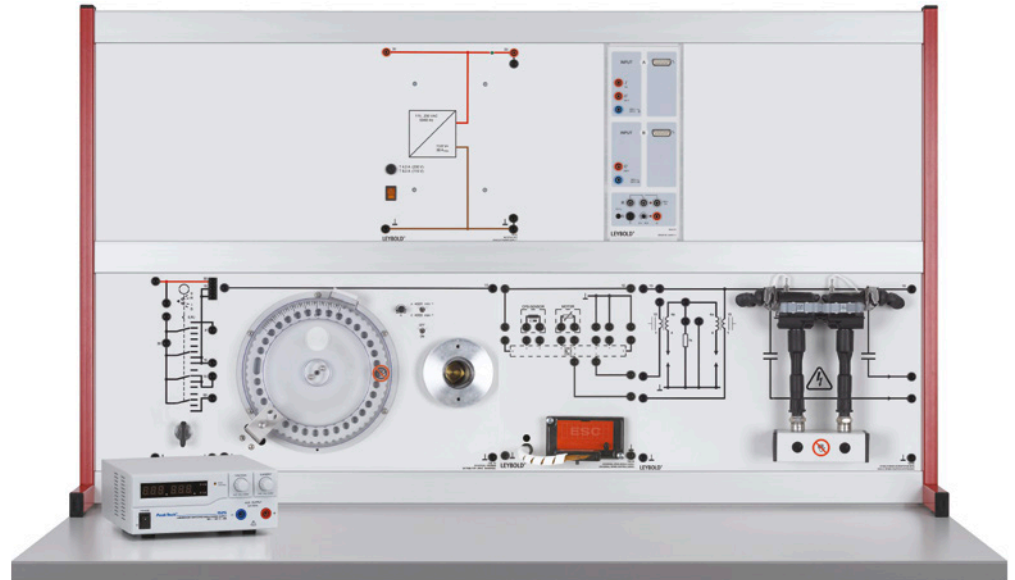
With the components of this equipment set the basics of the DIS ignition can be investigated. DIS means "distributorless ignition system" and thus describes a system without rotating distributor.

A2.3.1

IGNITION SYSTEMS

A2.3.1.4

Distributorless coil ignition system (SSI)



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

Cat. No.	Description	A2.3.1.4
738 5161	Universal ignition module (UESC)	1
738 10	Ignition 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 36ET10	Glow lamps, 115 V, E10, set of 10	1
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
738 989	Standard Workshop TDC Pick-Up	1
738 986	Inductive-Type Pulse Pick-Up	1
775 031EN	LIT: A2.3.1.3/4 Distributorless coil ignition systems	1
500 59	Safety bridging plugs, black, set of 10	2
500 592	Safety bridging plugs with tap, black, set of 10	1

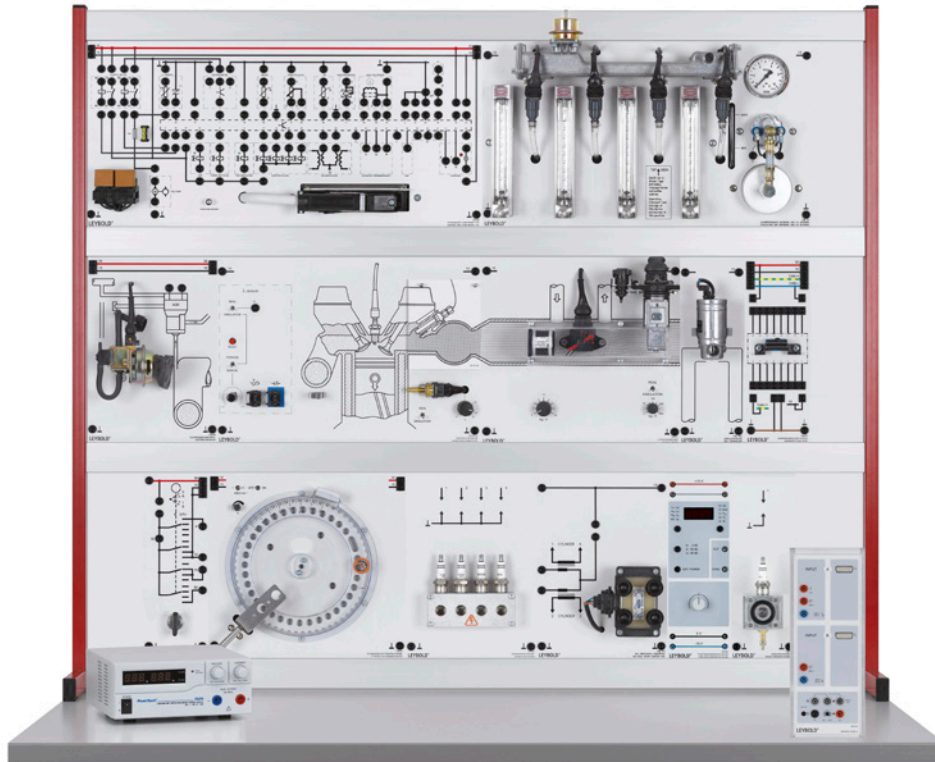
Cat. No.	Description	A2.3.1.4
738 9821	Safety experiment cables, set of 51	1
500 596	Safety bridging plugs, STE 2/19, set of 10	1
501 48	Bridging plugs, STE 2/19, set of 10	1
738 05	Connection leads I, set	1
501 46	Connecting leads, 19 A, 100 cm, red/blue, pair	1
726 09	Panel frame T130, two-level	1
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.



A2.3.2

MOTOR MANAGEMENT SYSTEMS PETROL

A2.3.2.1

Fuel injection

Fuel injection (A2.3.2.1)

Cat. No.	Description	A2.3.2.1	Cat. No.	Description	A2.3.2.1
739 402	Control Unit Motronic (M 1.5.4)	1	738 989	Standard Workshop TDC Pick-Up	1
739 37	Evaluation Unit Motronic	1	738 986	Inductive-Type Pulse Pick-Up	1
738 517	DIS-Two Spark Ignition Coil	1	375 58	Hand vacuum pump	1
739 255	Electric EGR valve	1	726 962	Function generator 200 kHz	1
739 191	Substitute Engine Panel	1	738 442	Single pressure chamber	1
739 03	Knocking Sensor	1	738 998	Pressure pump, foot-operated	1
739 42	Crank Angle Sensor	1	666 712ET3	Butane cartridge, 190 g, set of 3	1
739 271	Lambda Sensor, heated	1	666 711	Butane gas burner	1
739 253	Rotary Idle Actuator	1	300 02	Stand base, V-shaped, small	1
739 411	Air Mass Meter, LH Motronic	1	301 01	Leybold multiclamp	1
738 9811	Silicon oil M5 blue, 1 liter	2	300 41	Stand rod, 25 cm, 12 mm Ø	1
738 9812	Silicon oil M5 remover, 100ml	1	666 555	Universal clamp, 0...80 mm	1
738 431	Flywheel with Sensor Holder	1	666 733	Piezoelectric gas igniter	1
738 441	Spark plug holder	1	739 589	Software: Vehicle diagnosis, German and English	1
726 18	Panel frame T130, three-level	1	737 9807	Diagnosis adapter Opel USB	1
738 027	Digital power supply 1 - 16 V/40 A	1	500 59	Safety bridging plugs, black, set of 10	6
500 990	Adapter sockets, set of 2	1	500 592	Safety bridging plugs with tap, black, set of 10	1
577 80	Variable resistor, 10 kW, STE 2/19	2	739 195	Connecting Leads, set of 7	1
577 38	Resistor, 330 W, STE 2/19	1	738 9821	Safety experiment cables, set of 51	1
577 97	Resistance decade, 10 W...11.1 kW, STE 4/50/100	1	665 010	Funnel, PP, 100 mm diam.	1
738 518	DIS-Ignition Cable Set	1	738 05	Connection leads I, set	1
739 421	Cable for Crank Angle Sensor	1	738 01	Cable and plug box	1
738 10	Ignition switch	1	738 4911S	Automotive fault simulator, start	1*
738 032	Battery connection with protection circuit	1	500 593	Fault simulation plugs, black, set of 10	1*
524 013S	Sensor-CASSY 2 Starter	1	775 032EN	LIT: A2.3.2.1 Fuel injection	
524 076	AUTO-BOX i	1			

* additionally recommended



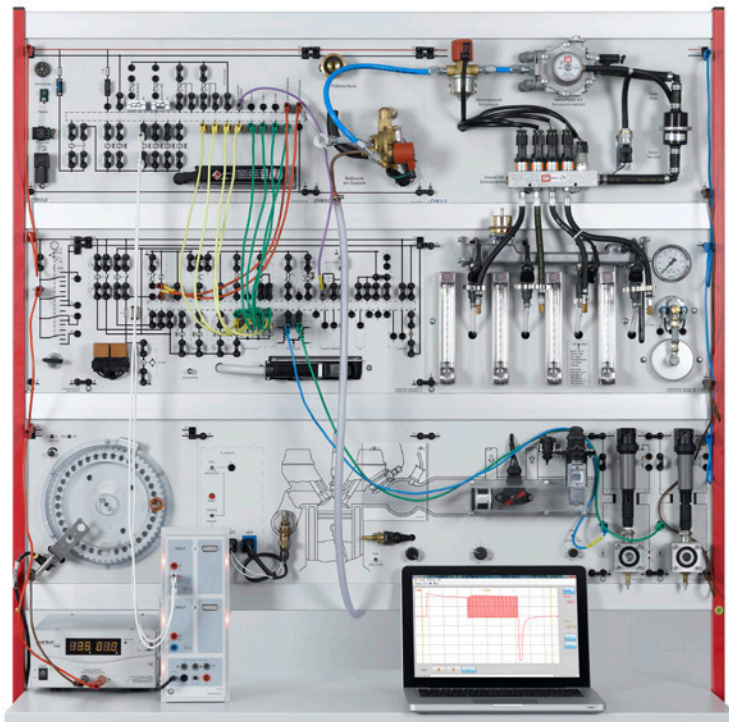
Motor management systems are responsible for combining the electronic injection with the likewise electronic ignition in a single engine control unit. Further functions are added over time:

- 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 set-up 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.



A2.3.2 MOTOR MANAGEMENT SYSTEMS PETROL

A2.3.2.2 Gas drive

Gas drive (A2.3.2.2)

Cat. No.	Description	A2.3.2.2
739 405	LPG gas system	1
738 431	Flywheel with Sensor Holder	1
739 191	Substitute Engine Panel	1
739 411	Air Mass Meter, LH Motronic	1
738 443	Pencil coil system	2
739 271	Lambda Sensor, heated	1
739 37	Evaluation Unit Motronic	1
739 402	Control Unit Motronic (M 1.5.4)	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
739 42	Crank Angle Sensor	1
739 421	Cable for Crank Angle Sensor	1
577 79	Variable resistor, 1 kW, STE 2/19	1
577 81	Variable resistor, 4.7 kW, STE 2/19	1
577 83	Variable resistor, 100 kW, STE 2/19	1
738 9811	Silicon oil M5 blue, 1 liter	2
738 9812	Silicon oil M5 remover, 100ml	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 076	AUTO-BOX i	1
737 9807	Diagnosis adapter Opel USB	1
738 975	Diagnostic Plug 16 Pin	1
738 9991	DC/AC clamp-on current probe	1
738 985	Automotive meter	1
739 406	LPG spark plugs; set 4 EA	1
747 800	Tool set spark plug	1

Cat. No.	Description	A2.3.2.2
738 05	Connection leads I, set	1
500 59	Safety bridging plugs, black, set of 10	10
500 592	Safety bridging plugs with tap, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
738 027	Digital power supply 1 - 16 V/40 A	1
689 0813	Set 12 automotive fuses	1
689 0814	Set 2 automotive automatic fuses	1
665 010	Funnel, PP, 100 mm diam.	1
375 58	Hand vacuum pump	1
500 990	Adapter sockets, set of 2	1
726 18	Panel frame T130, three-level	1
744 600	Low-noise Compressor	1
775 036EN	LIT: A2.3.2.2 Gas drives	1*

* additionally recommended

LEYBOLD provides with 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.

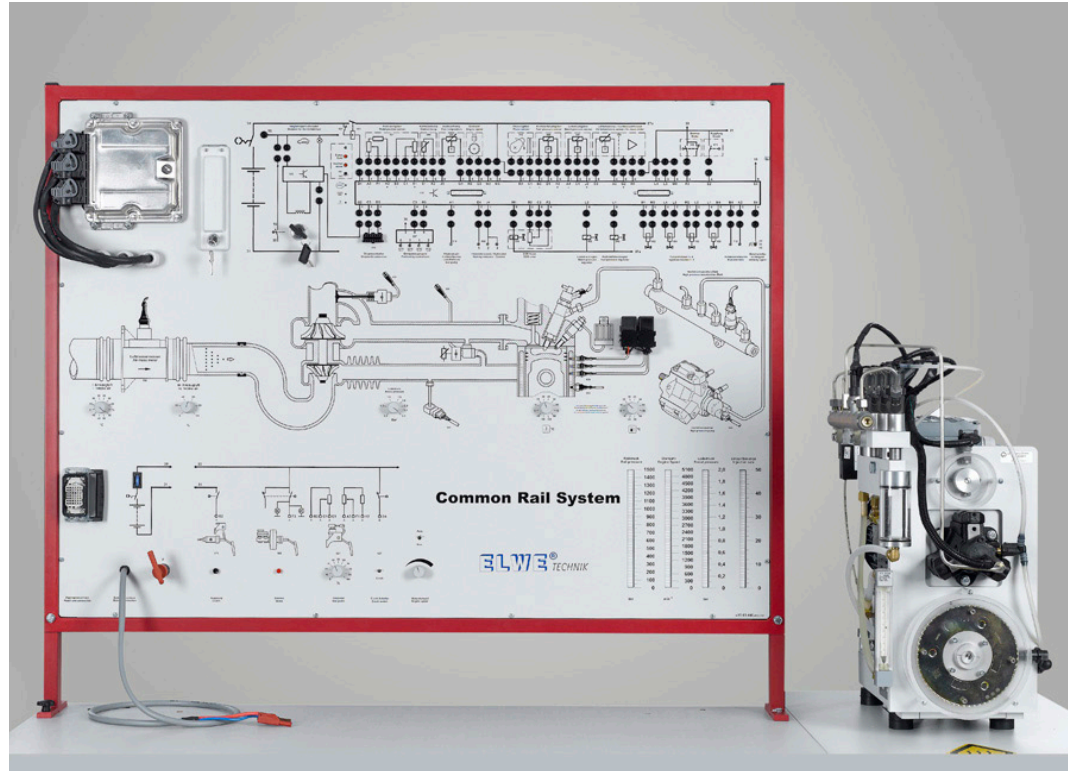
And completely harmless: the liquid gas is simulated by a non-toxic and non-flammable substitute gas so a threat of the students is excluded.

A2.3.3

MOTOR MANAGEMENT SYSTEMS DIESEL

A2.3.3.4

Common Rail



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
738 027	Digital power supply 1 - 16 V/40 A	1
598 141	AC electrical frame	1
738 9821	Safety experiment cables, set of 51	1
8-7 000001-000-10-0	Plastic cover for an experimental stand	1
775 037EN	LIT: A2.3.3.4 Common Rail	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 0431	30-A-Box	1
524 076	AUTO-BOX i	1
739 002	Scanner BOSCH KTS 200	1
739 004	DMM for electrical vehicles	1
739 001	Infrared-thermometer	1

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.

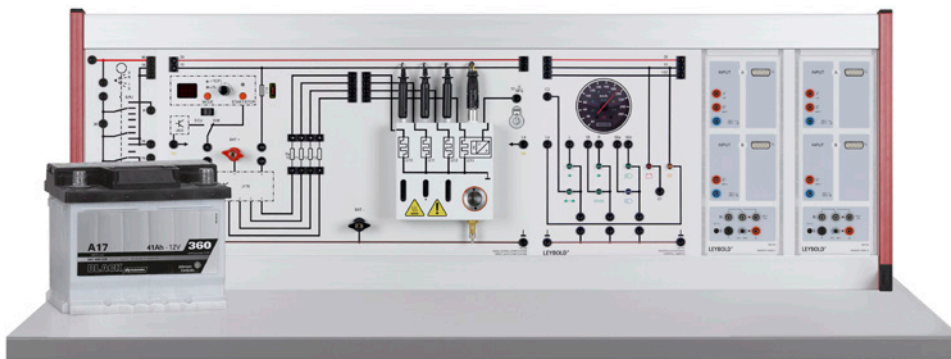
Common Rail technology is the most widespread diesel injection system currently used in automotive production world-wide. Instead of the previously used distribution pump with its complicated mechanical parts and injectors which determine the injection pressure, a high-pressure pump of much simpler construction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

A2.3.3

STARTING AID FOR DIESEL ENGINES

A2.3.3.5

Diesel Quick Start System



Diesel Quick Start System (A2.3.3.5)

Cat. No.	Description	A2.3.3.5
738 10	Ignition switch	1
740 306	Diesel Quick Start System	1
738 151	Telltales 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
738 044	AGM-battery 12V	1
738 043	Vehicle battery connecting kit	1
738 021	Battery charger, automatic	1
738 05	Connection leads I, set	1
505 15	Bulbs, 6 V/0.05 A, E10, set of 10	1
726 19	Panel frame SL85, single-level	1

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 μC -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.



A close-up photograph of a person's hand, wearing a light-colored sweater, interacting with a car's infotainment system. The hand is turning a silver rotary knob on a silver panel. The panel features a small screen at the top, several buttons, and a 'TRIP' button on the left. The background shows the steering wheel and other parts of the car's interior.

A2 VEHICLE TECHNOLOGY

A2.4 COMFORT AND DRIVER ASSISTANCE

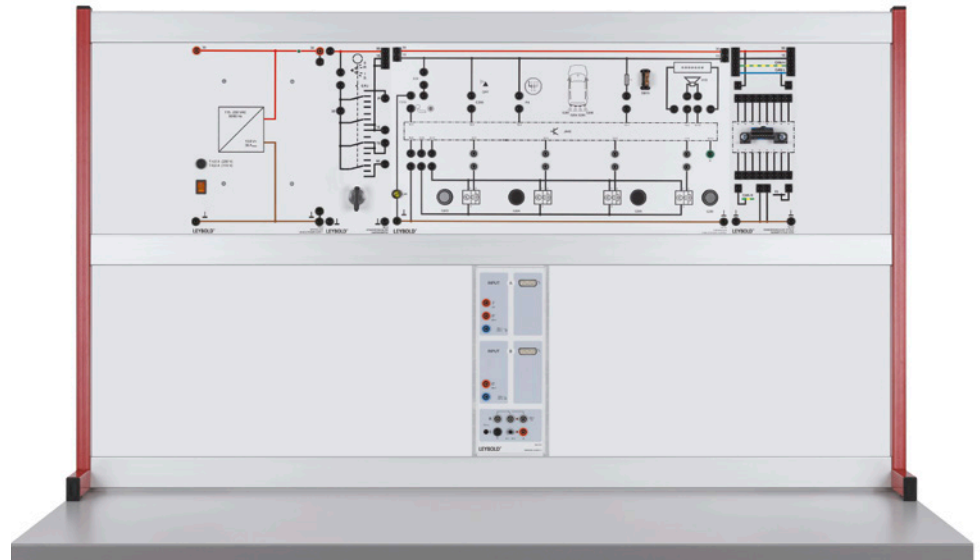
- A2.4.1 COMFORT SYSTEMS
 - A2.4.1.2 PARKING AID
 - A2.4.1.3 COMFORTSYSTEM WITH CAN-BUS
 - A2.4.1.4 ON-BOARD COMPUTER
 - A2.4.1.5 AIR CONDITIONING
- A2.4.2 DRIVER ASSISTANCE SYSTEM
 - A2.4.2.1 ELECTRONIC GASPEDAL

A2.4.1

COMFORT SYSTEMS

A2.4.1.2

Parking aid



Parking aid (A2.4.1.2)

Cat. No.	Description	A2.4.1.2
739 750	Park distance control	1
416 000	Ultrasonic transducer, 40 kHz	1
726 10	Panel frame T150, two-level	1
300 02	Stand base, V-shaped, small	2
738 10	Ignition switch	1
738 02	Automotive power supply 13.8 V/36 A	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
738 975	Diagnostic Plug 16 Pin	1
737 9803	OBD Adaptor CAN+USB	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 connecting lead, 100 cm, black	2
500 647	Safety Connection Lead 100 cm brown	2
500 593	Fault simulation plugs, black, set of 10	1*
738 01	Cable and plug box	1*
775 041EN	LIT: A2.4.1.2 Parking aid	1

* additionally recommended

The **park distance control** – also known as back-up warning or Park Pilot – 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.

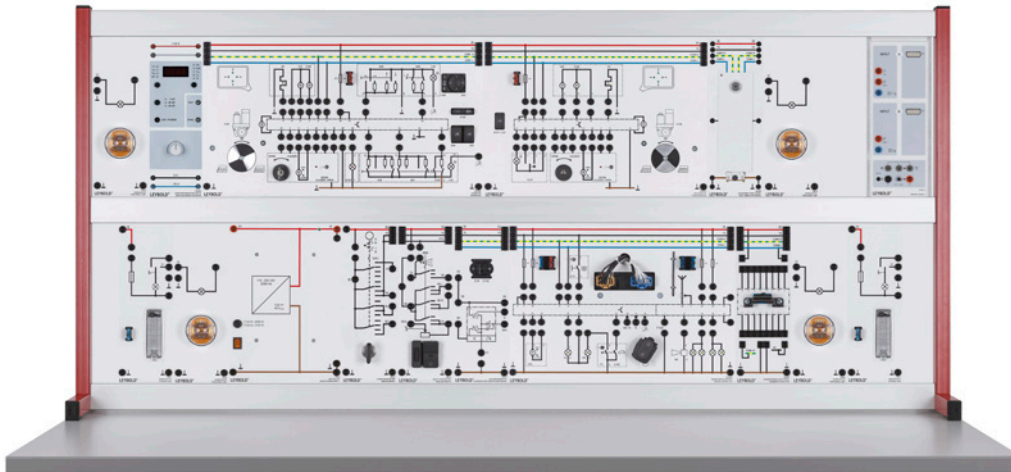
The sensor connection cables and the ground wire to the control unit are brought through bridging plugs in order to simply measure voltages and currents and simulate open circuit faults.

A2.4.1

COMFORT SYSTEMS

A2.4.1.3

Comfortsystem with CAN-Bus



Comfort system with CAN-Bus (A2.4.1.3)

Cat. No.	Description	A2.4.1.3
739 58	Comfort system with CAN - Bus	1
726 10	Panel frame T150, two-level	1
738 07	Interior lamp	2
738 11	Head lamp switch	1
738 36	Turn Signal Lamp	4
739 581USB	CAN databus adapter USB	1
738 975	Diagnostic Plug 16 Pin	1
739 573	Automotive Set Point Potentiometer	1
739 585	Fault simulator CAN Bus	1
739 580	Databus detector	1
737 9803	OBD Adaptor CAN+USB	1
739 587	Software: Databus visualisation	1
738 02	Automotive power supply 13.8 V/36 A	1
726 962	Function generator 200 kHz	1
738 10	Ignition switch	1
524 013S	Sensor-CASSY 2 Starter	1
524 078	CAN bus box	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
775 042EN	LIT: A2.4.1.3 Comfort system with CAN-Bus	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

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 CAN bus comfort training system is a classic! Connecting individual "islands" with as few wires as possible and full functional range – that was the CAN data bus' basic comfort application. The "islands" are car doors, each equipped with a control unit.

It operates the following:

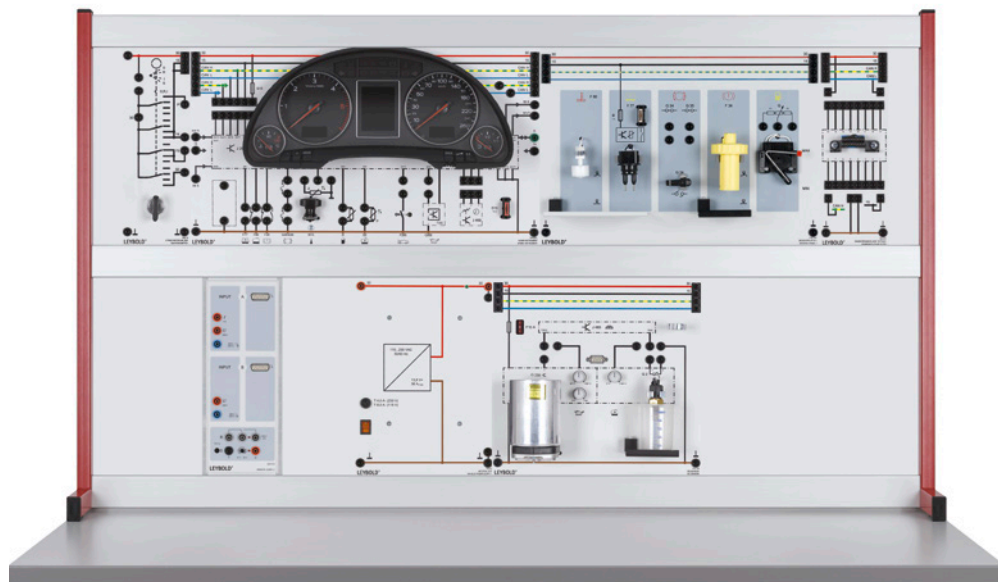
- the power windows
- the central locking system
- the side mirror adjusting motors
- the side mirror heater
- the SAFE LED depending on the sensors' states
- the door lock
- the power window buttons
- the mirror adjustment buttons
- the central locking button
- the door switch.

A2.4.1

COMFORT SYSTEMS

A2.4.1.4

On-board computer



On-board computer (A2.4.1.4)

Cat. No.	Description	A2.4.1.4
739 707	Sensor panel 1	1
739 708	Sensor panel 2	1
739 706	Oil sensor	1
739 6021	Instrument cluster unit	1
738 975	Diagnostic Plug 16 Pin	1
738 10	Ignition switch	1
737 9803	OBD Adaptor CAN+USB	1
524 013S	Sensor-CASSY 2 Starter	1
739 589	Software: Vehicle diagnosis, English	1
524 031	Current source box	1
524 076	AUTO-BOX i	1
524 044	Temperature sensor S, NTC	1
773 961	CAN-Databus-Multi-Adapter	1
738 02	Automotive power supply 13.8 V/36 A	1
650 671	Storage tray, S24, STE	1*
590 48	Immersion heater	1
577 79	Variable resistor, 1 kW, STE 2/19	1
578 40	Capacitor (electrolytic), 470 µF, STE 2/19	1
577 56	Resistor, 10 kW, STE 2/19	1
578 51	Diode, 1N 4007, STE 2/19	1
578 74	Transistor, BD 138, PNP, emitter top, STE 4/50	1
579 21	Relay with change-over switch, STE 4/50	1
579 13	Toggle switch, STE 2/19	1
579 06	Lamp holder, E10, top, STE 2/19	1
505 09	Bulbs, 12 V/0,1 A, E10, set of 10	1

Cat. No.	Description	A2.4.1.4
501 48	Bridging plugs, STE 2/19, set of 10	3
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	1
726 50	Plug-in board, 297 mm x 300 mm, STE	1
521 45	DC power supply 0...±15 V	1
577 32	Resistor, 100 W, STE 2/19	1
577 321	Resistor, 100 W, STE 2/19	1
577 35	Resistor, 100 W, STE 2/19	1
577 92	Potentiometer, 1 kW, STE 4/50	1
579 163	Simulation ABS/Ti	1
739 195	Connecting Leads, set of 7	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
510 48	Magnets, 35 mm Ø, pair	1
667 193	PVC tubing, 7 mm diam., 1 m	2
375 58	Hand vacuum pump	1
727 585	STE universal case	1
8-9 999803-000-10-0	Cold spray 400 ml	1
775 043EN	LIT: A2.4.1.4 Boardcomputer	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



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.

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 can chart, for example.

The signal from the coolant's temperature sensor can also be 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 (666 212). In the uncoupled state, the real temperature and the resistance can for example be measured with Sensor-CASSY and analyzed as an NTC curve.

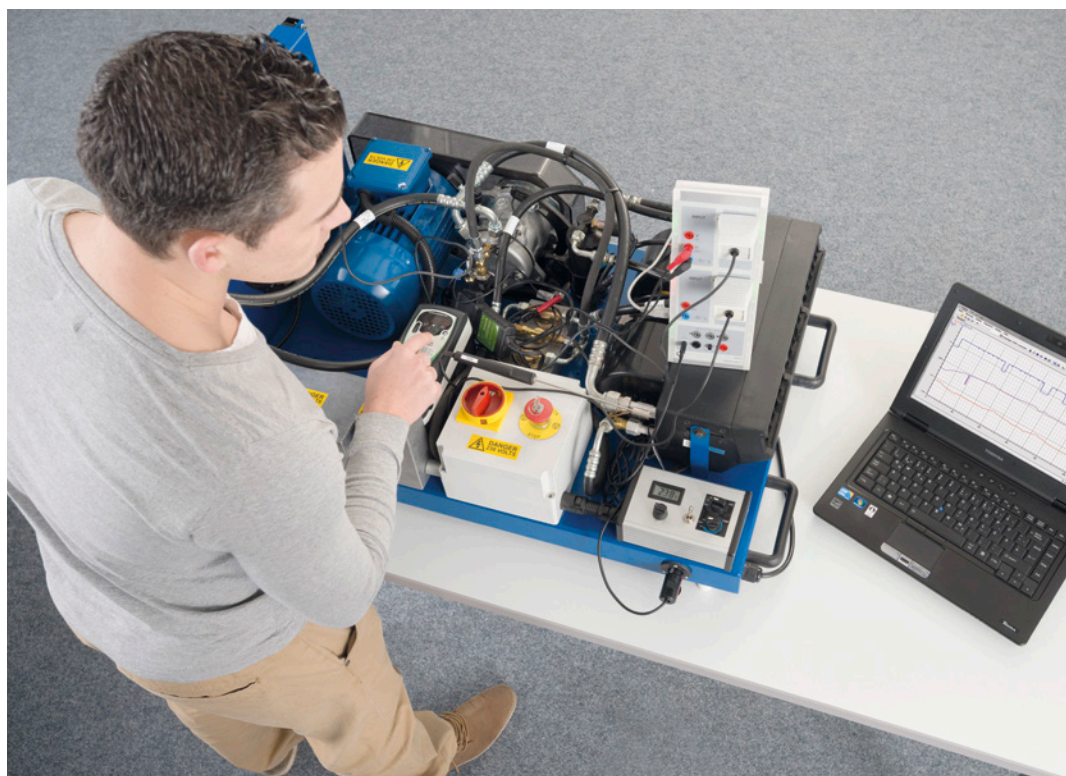
All values can also be displayed in the self-diagnosis with the instrument cluster's diagnosis line; linearized values for oil level and temperature and coolant temperature are available with a 9-pole socket for the oil sensor for measurements or integration into a CAN bus system.

A2.4.1

COMFORT SYSTEMS

A2.4.1.5

Air conditioning



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
739 005	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 046EN	LIT: A2.4.1.5 AirCon Trainer	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 recharging 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 a 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.

Features

- 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 four common faults
- Variable speed motor simulates car engine
- Available for either 110 V or 230 V 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 four simulated common faults which can be applied by the instructor. The following four simulated faults can be applied by setting the fault switch on the main control panel:

- Blocked TEV (Thermal Expansion Valve)
- Blocked receiver drier (TEV version only)
- Faulty valve plate
- Unit under condensing

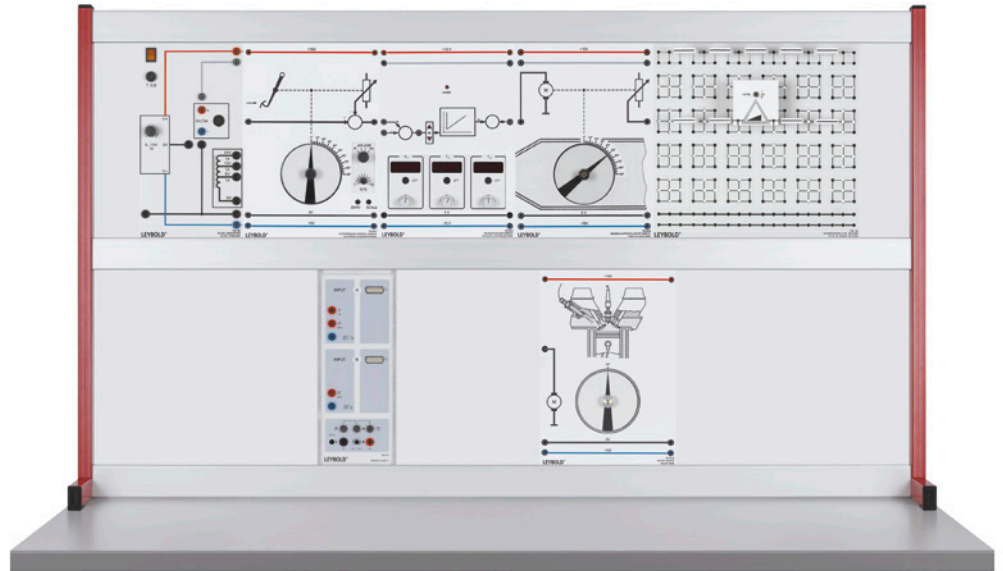
The student will observe the effect of the faults by monitoring system pressure (using optional manifold gauges) changes in the cooling duty, observing changes on the digital thermometer and observing the state of the refrigerant in the sight glass. A high pressure cut-out switch shuts the compressor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

A2.4.2

DRIVER ASSISTANCE SYSTEM

A2.4.2.1

Electronic gas pedal



Electronic gas pedal (A2.4.2.1)

Cat. No.	Description	A2.4.2.1
739 56	Electronic gas pedal Accessory	1
734 064N	PID digital controller Net	1
579 161	Simulation Incline, STE 4/50	1
313 17	Hand-held stop-watch II, mechanical	1
577 32	Resistor, 100 W, STE 2/19	1
577 35	Resistor, 200 W, STE 2/19	1
577 40	Resistor, 470 W, STE 2/19	1
578 51	Diode, 1N 4007, STE 2/19	1
579 13	Toggle switch, STE 2/19	1
734 10	Servo setpoint generator	1
734 13	Power amplifier	1
734 14	DC servo	2
726 10	Panel frame T150, two-level	1
726 50	Plug-in board, 297 mm x 300 mm, STE	1
726 88	AC/DC stabilizer	1
727 20	Automobile Meter Zero-Left	1
524 013S	Sensor-CASSY 2 Starter	1
539 000	Bridging plug, BST	10
500 592	Safety bridging plugs with tap, black, set of 10	1
501 46	Connecting leads, 19 A, 100 cm, red/blue, pair	2
500 853	Safety connecting leads, set of 25	1
501 48	Bridging plugs, STE 2/19, set of 10	2
725 007	Software: Leylab.control Lite	1
775 044EN	LIT: A2.4.2.1 Electronic gaspedal	1
738 01	Cable and plug box	1*

Cat. No.	Description	A2.4.2.1
500 593	Fault simulation plugs, black, set of 10	1*
734 064	PID digital controller	1*

* additionally recommended

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."

LEYBOLD's educational system demonstrates on typical vehicle applications the fundamental theoretical relationships in control technology. Sensor-CASSY or multimeters can record the associated measurements. In particular, the following training contents are treated:

- Control technology systems' function in motor vehicles
- IPO principle: signal input, processing and output
- Control processes
- Reference variable and correcting variable
- Open and closed regulator circuits
- How the electronic throttle works
- Study of disturbances



A2 VEHICLE TECHNOLOGY

A2.5 DRIVE TRAIN

A2.5.1 BRAKING SYSTEMS

A2.5.1.1 ELECTRONIC STABILITY SYSTEM ABS/ESP

A2.5.2 GEAR

A2.5.2.2 AUTOMATIC TRANSMISSION SYSTEM

A2.5.3 STEERING SYSTEM

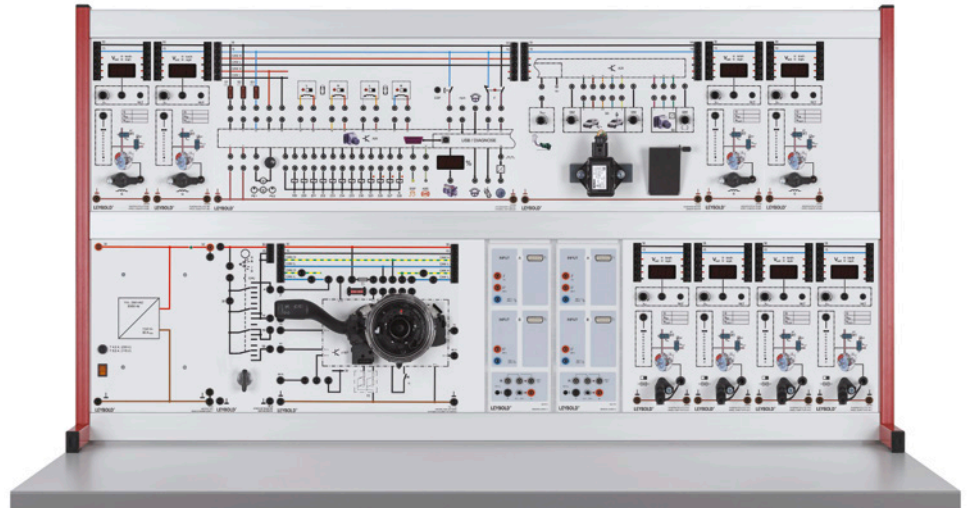
A2.5.3.2 ELECTRICAL ASSISTED POWER STEERING

A2.5.1

BRAKING SYSTEMS

A2.5.1.1

Electronic stability system ABS/ESP



Electronic stability system ABS/ESP (A2.5.1.1)

Cat. No.	Description	A2.5.1.1
739 650	ABS/ESP control unit	1
739 651	ABS/ESP sensors	1
739 6521	Wheel substitute panel, inductive	4
739 6531	Wheel substitute panel, Hall	4
739 654	Steering angle sensor	1
738 111-02	Steering column electronics	1
738 02	Automotive power supply 13.8 V/36 A	1
738 10	Ignition switch	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 050EN	LIT: A2.5.1.1 Electronic Stability System ABS/ESP	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 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 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 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"

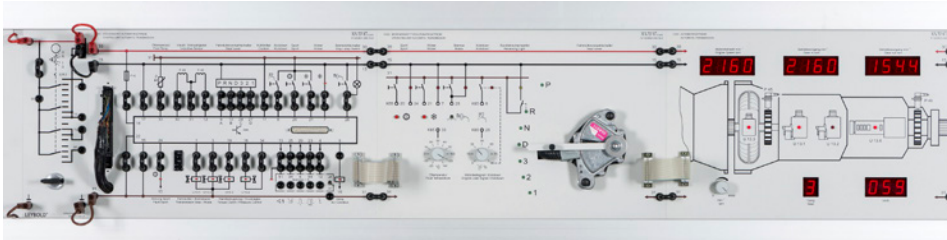
Optionally, other student measuring stations (740 050) can be connected to the control unit. The students can record and analyze all measurements on the installation at their workstations.

A2.5.2

GEAR

A2.5.2.2

Automatic transmission system



Automatic transmission system (A2.5.2.2)

Cat. No.	Description	A2.5.2.2
8-1 003601-000-10-0	P 3.601 Control unit automatic transmission	1
8-1 003602-000-10-0	P 3.602 Operating unit for automatic transmission	1
8-1 003603-000-10-0	P 3.603 Automatic Transmission Substitute	1
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
737 9807	Diagnosis adapter Opel USB	1
735 290	Connecting lead universal converter	1
500 604	Safety connecting lead, 10 cm, black	3
500 624	Safety connecting lead, 50 cm, black	3
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
738 01	Cable and plug box	1*
738 027	Digital power supply 1 - 16 V/40 A	1
775 054DE	Lit: A.5.2.2: Automatic Gear; German	1

* additionally recommended

Convenience in the car: it has been a standard in the USA for a long time, whereas in other areas it only came little by little - the automatic transmission.

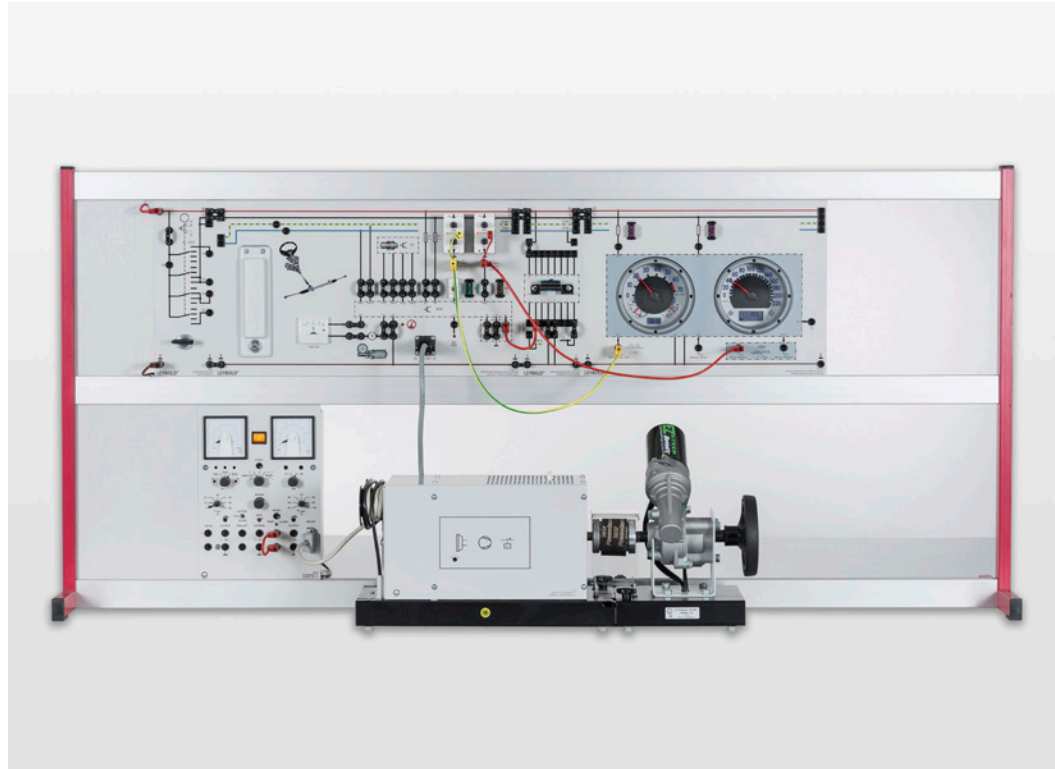
The educational system is equipped with a 4-speed automatic transmission and consists of the control unit, the operation unit and a gear substitute panel.

A2.5.3

STEERING SYSTEM

A2.5.3.2

Electrical assisted power steering



Electrical assisted power steering (A2.5.3.2)

Cat. No.	Description	A2.5.3.2
739 502	Electric Power Steering (EPS)	1
732 55	Control Unit 1.0	1
732 58	Coupling guard 1.0	1
732 56	Coupling 1.0	1
732 54	Magnetic Powder Brake 1.0	1
739 6023	Tachometer/Speedometer digital	1
579 163	Simulation ABS/Ti	2
738 10	Ignition switch	1
738 032	Battery connection with protection circuit	1
738 027	Digital power supply 1 - 16 V/40 A	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
524 0431	30-A-Box	1
773 961	CAN-Databus-Multi-Adapter	1*
739 002	Scanner BOSCH KTS 200	1*
738 985	Automotive meter	1
LDS 00001	Stopwatch, digital	1
579 13	Toggle switch, STE 2/19	2*
577 30	Resistor, 62 W, STE 2/19	1
738 975	Diagnostic Plug 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 leads, 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

Cat. No.	Description	A2.5.3.2
500 620	Safety connecting lead, 50 cm, yellow/green	1
500 621	Safety connecting lead, 50 cm, red	1
500 641	Safety connecting lead, 100 cm, red	2
500 661	Safety connection lead, 200 cm, red	1
500 647	Safety connection lead, 100 cm, brown	2
500 644	Safety connecting lead, 100 cm, black	2
8-5 900088-000-10-0	Adapter 4-mm plug/4-mm socket	2
738 01	Cable and plug box	1*
726 09	Panel frame T130, two-level	1
775 053EN	LIT: A2.5.3.2 Electrical power steering	1
500 593	Fault simulation plugs, black, set of 10	1

* additionally recommended

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 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.



A2 VEHICLE TECHNOLOGY

A2.6 NETWORKING SYSTEMS, DIGITALISATION AND DIAGNOSIS

- A2.6.1 NETWORKING AUTOMOTIVE SYSTEMS
 - A2.6.1.1 NETWORKING AUTOMOTIVE SYSTEMS: LIGHTING
 - A2.6.1.2 NETWORKING AUTOMOTIVE SYSTEMS: COMMUNICATION
 - A2.6.1.3 NETWORKING AUTOMOTIVE SYSTEMS: COMFORT
 - A2.6.1.4 NETWORKING AUTOMOTIVE SYSTEMS:
MOST BUS PRACTICAL EXERCISES
 - A2.6.1.7 NETWORKING AUTOMOTIVE SYSTEMS: BRAKE ASSIST
 - A2.6.1.9 NETWORKING AUTOMOTIVE SYSTEMS: "CAN FD DATABUS"
 - A2.6.1.10 NETWORKING AUTOMOTIVE SYSTEMS: "SENT"
- A2.6.2 DIAGNOSIS
 - A2.6.2.1 AUTOMOTIVE SELF-DIAGNOSIS
 - A2.6.2.2 EOBD DIAGNOSIS

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.1

Networking automotive systems: Lighting



Networking automotive systems: Lighting (A2.6.1.1)

Cat. No.	Description	A2.6.1.1
739 5821	Training panel lighting NG	1
738 027	Digital power supply 1 - 16 V/40 A	1
500 990	Adapter sockets, set of 2	1
738 9821	Safety experiment cables, set of 51	1
739 580	Databus detector	1
739 581USB	CAN databus adapter USB	1
739 587	Software: Databus visualisation	1
739 588	LIN BUS PC interface USB	1
737 9803	OBD Adaptor CAN+USB	1
524 0135	Sensor-CASSY 2 Starter	1
524 081	LIN bus box	1
524 078	CAN bus box	1
739 5835	DS vehicle door	1*
739 5836	PS vehicle door	1*

* additionally recommended

The following components are part of the training panel:

- the lighting unit
- the instrument cluster
- the electronic immobilizer
- the steering wheel electronics
- 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
- the relay strip
- the OBD diagnostic plug
- a CAN bus interface
- a fault switching box.

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

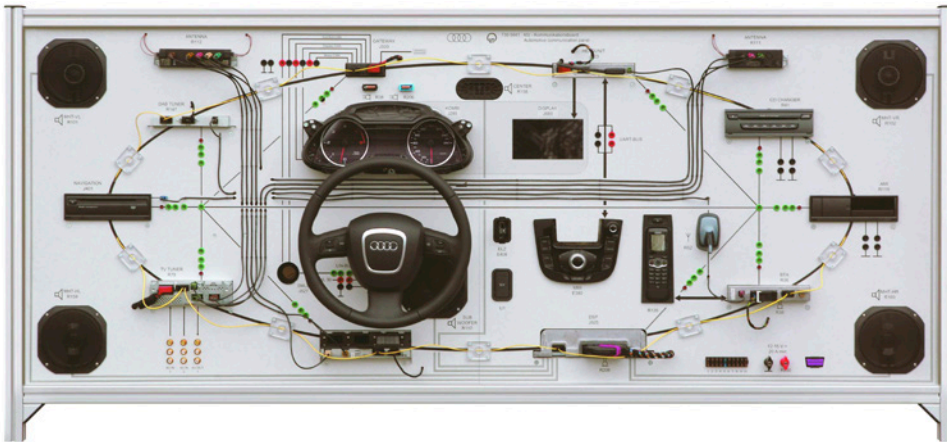
The training panel in automobile electronics consists of a modern instrument panel insert with electronic immobilizer, the full steering wheel electronics, the central control module for comfort system and the electronic and electric system. The lighting system and a windshield wiper motor round off 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.

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.2

Networking automotive systems: Communication



Networking automotive systems: Communication (A2.6.1.2)

Cat. No.	Description	A2.6.1.2
739 5841	Training panel, vehicle communications	1
739 580	Databus detector	1
524 013S	Sensor-CASSY 2 Starter	1
524 078	CAN bus box	1
524 081	LIN bus box	1
739 588	LIN BUS PC interface USB	1
739 581USB	CAN databus adapter USB	1
737 9803	OBD Adaptor CAN+USB	1
740 2013	MOST PC USB Interface	1
738 027	Digital power supply 1 - 16 V/40 A	1
500 990	Adapter sockets, set of 2	1
739 587	Software: Databus visualisation	1
500 664	Safety connection lead, 200 cm, black	2
738 9821	Safety experiment cables, set of 51	1
566 078TEN	LIT: T3.2.12.8 Infotainment with MOST Bus	1

The communications training panel includes a complete infotainment package networked via MOST (=Media Oriented Systems Transport) bus in Audi technology.

The build includes:

- an instrument cluster and gateway
- an antenna amplifier system
- a true-color display with control unit for information
- a multimedia operating unit
- a hybrid TV tuner*
- an MP3-capable CD changer
- a navigation system*
- an analog and a digital radio receiver*
- an OBD diagnostic plug
- a mobile phone connection*
- a voice-activated steering wheel remote control
- a MOST bus interface
- a CAN and LIN bus interface
- three fault switching boxes.

Specially for the vehicle communication electronics engineer, this board offers the possibility to record loudspeaker impedances, to determine the transmitting power of mobile phone antennas or to study AF and RF signals as well as to detect reception levels.

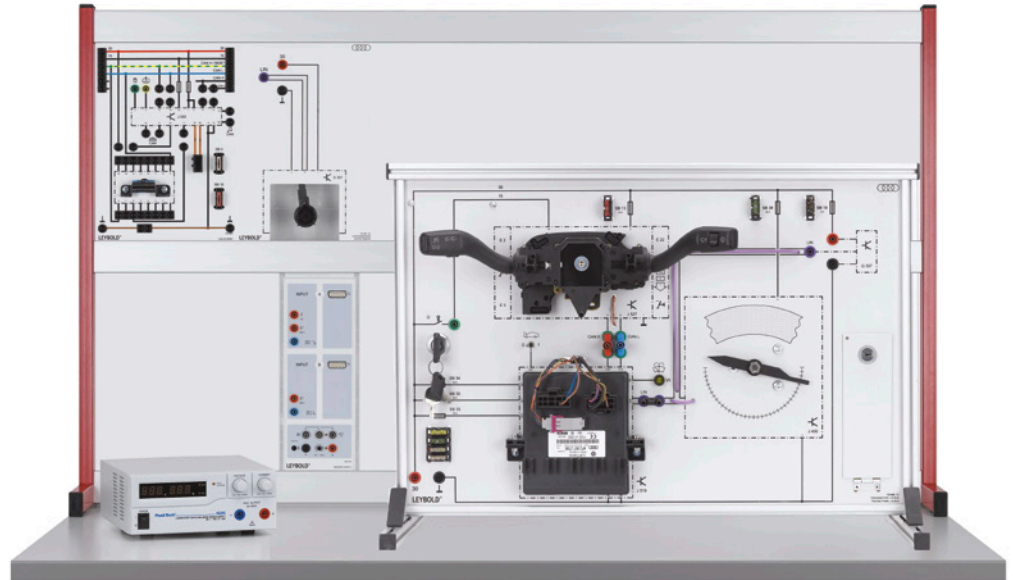
*the functional range may vary due to local conditions

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.3

Networking automotive systems: Comfort



Networking automotive systems: Comfort (A2.6.1.3)

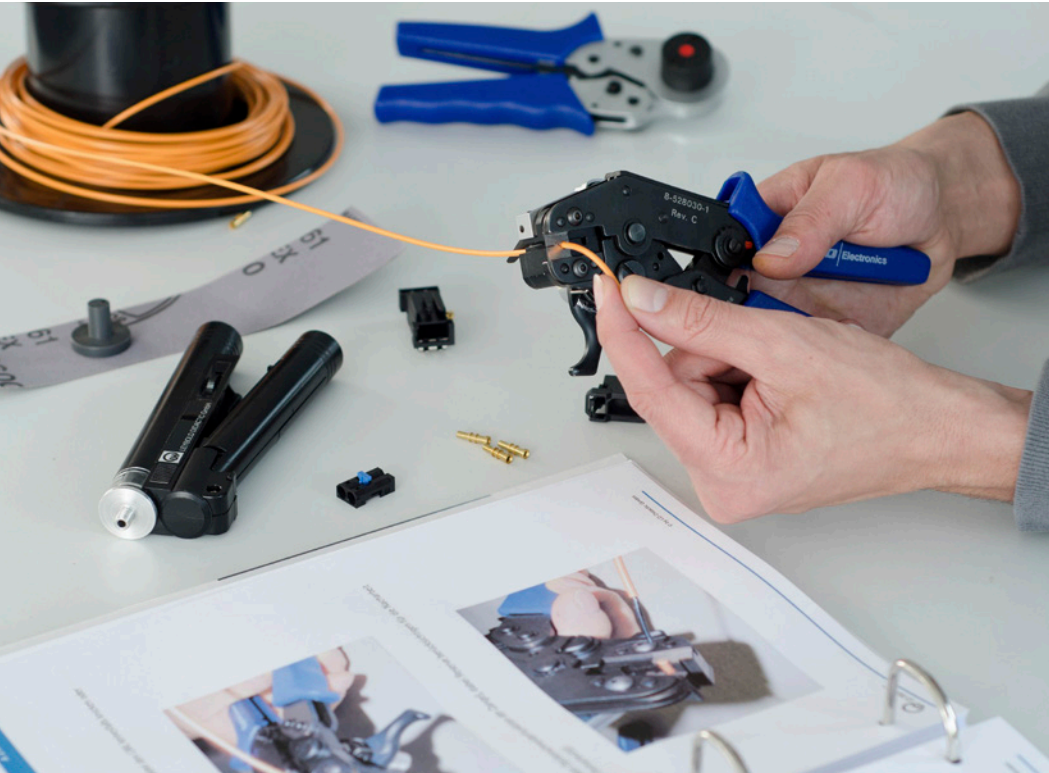
Cat. No.	Description	A2.6.1.3
739 586	Training panel LIN-Bus	1
739 5861	CAN Gateway	1
301 339	Stand bases, pair	1
524 081	LIN bus box	1
524 078	CAN bus box	1
739 588	LIN BUS PC interface USB	1
739 580	Databus detector	1
737 9803	OBD Adaptor CAN+USB	1
739 587	Software: Databus visualisation	1
524 013S	Sensor-CASSY 2 Starter	1
739 581USB	CAN databus adapter USB	1
604 120	Spray bottle, 400 ml, LDPE	1
604 2303	Photographic tray, white, 24 x 30 cm	1
738 027	Digital power supply 1 - 16 V/40 A	1
500 990	Adapter sockets, set of 2	1
500 592	Safety bridging plugs with tap, black, set of 10	1
500 59	Safety bridging plugs, black, set of 10	1
738 9821	Safety experiment cables, set of 51	1
726 09	Panel frame T130, two-level	1
775 062EN	LIT: A2.6.1.3 Networking comfort	1
738 01	Cable and plug box	1*

* additionally recommended

The LIN bus training system - his master's voice! As "subbus" to the CAN data bus, the LIN bus is a single-wire bus that, upon request by the CAN bus master, supplies sensor data or activates actuator outputs. In automatic intermittent windshield wiper mode, the rain sensor recognizes the precipitation's intensity and sends this information via LIN bus to the electrical system control unit. This activates the wiper's motor - likewise via LIN bus - at an interval corresponding to the amount of precipitation: little rain = rare repetitions, a lot of rain = frequent repetitions of the wiper's movement. Spraying from an aerosol can activate the rain sensor.

The training system includes:

- CAN-bus-capable steering column electronics with wiper lever
- a CAN and LIN-bus-capable electrical system control unit
- a LIN-bus-capable wiper motor
- a LIN-bus-capable rain sensor
- a fault switching box (CAN and LIN faults).



A2.6.1
NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.4
 Networking automotive systems:
 MOST bus practical exercises

Networking automotive systems: MOST bus 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 kW, STE 2/19	1
740 2088	Automotive fibre optic microscope	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis, German and English	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
501 48	Bridging plugs, STE 2/19, set of 10	1
775 063EN	LIT: A2.6.1.4 Practical exercises MOST-Bus	1

Modern vehicles can no longer do without networked systems. CAN bus, LIN bus, MOST bus and recently FlexRay command the communication between control units in the vehicle.

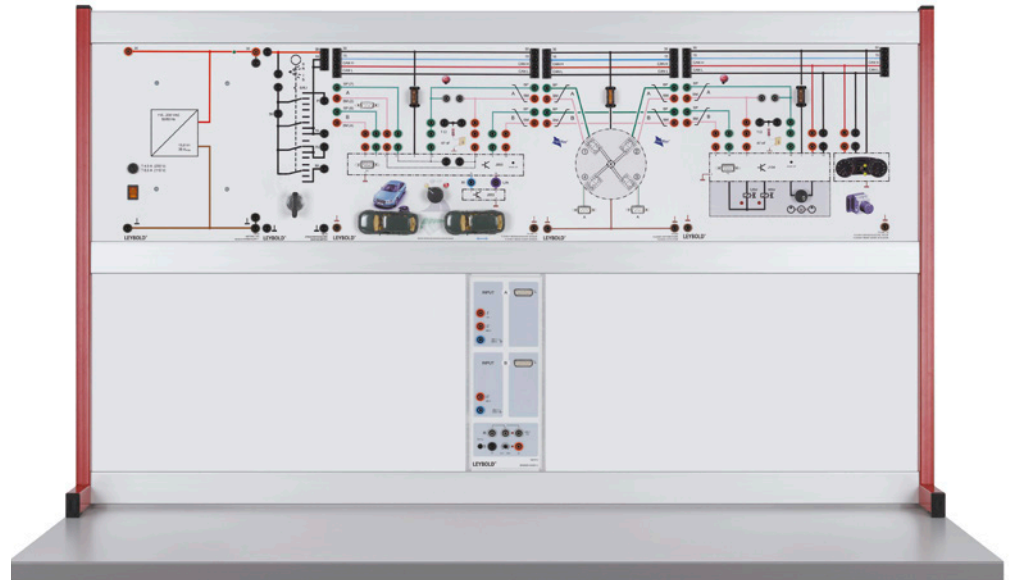
The equipment and part sets listed here let the students assemble fiber optic lines typical in vehicles and the teacher evaluate their results. In contrast to FO tool cases like those used with the workshops, all these "consumable components" such as FO, crimp sleeves or polishing equipment come in great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

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.7

Networking automotive systems: Brake assist



Networking automotive systems: Brake assist (A2.6.1.7)

Cat. No.	Description	A2.6.1.7
773 958	FlexRay Brake Assist	1
773 960	FlexRay interface USB	1
773 959	FlexRay Active Star	1
738 10	Ignition switch	1
575 303	Digital storage oscilloscope 1222	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis, German and English	1
738 02	Automotive power supply 13.8 V/36 A	1
577 28	Resistor, 47 W, STE 2/19	4
577 32	Resistor, 100 W, STE 2/19	2
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 066EN	LIT: A2.6.1.7 Brake Assist System	1*
738 4911S	Automotive fault simulator, start	1*
500 593	Fault simulation plugs, black, set of 10	1*
726 09	Panel frame T130, two-level	1
738 01	Cable and plug box	1*

* additionally recommended

The FlexRay training system contains a brake assistant function. It combines the following:

- a distance sensor control unit
- a road condition sensor
- an ABS/ESP control unit, and
- an instrument cluster.

Two model cars simulate two vehicles tailgating. The FlexRay data bus transfers this state to the control unit for ABS/ESP, which then triggers the brakes to establish the safe distance again. The default value depends on the road condition (dry, wet, slick). The LIN data bus transmits the roadway's condition to the radar sensor control unit. Activating the high-pressure switch valve and the pump displays the brake's function. A high-speed CAN bus connection controls the corresponding indicator lamp in the instrument cluster.

The system can be expanded to an "active star" (773 959) with FlexRay components. The sensor control unit also has an available connection for a FlexRay/USB interface (773 960) to analyze the protocol on the computer.

The FlexRay lines can be completed with external resistors and are set for signal registration with an oscilloscope.

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.9

Networking automotive systems: "CAN FD databus"



Networking automotive systems: "CAN FD databus" (A2.6.1.9)

Cat. No.	Description	A2.6.1.9
773 961	CAN-Databus-Multi-Adapter	2
738 975	Diagnostic Plug 16 Pin	1
577 30	Resistor, 62 W, STE 2/19	1
575 303	Digital storage oscilloscope 1222	1
775 069EN	LIT:A2.6.1.9+10 CAN FD and SENT	1
	Personal computer with operating system required !!!	1

"Evolution instead of revolution" – that is the motto of the new CAN Bus FD! It was not 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.

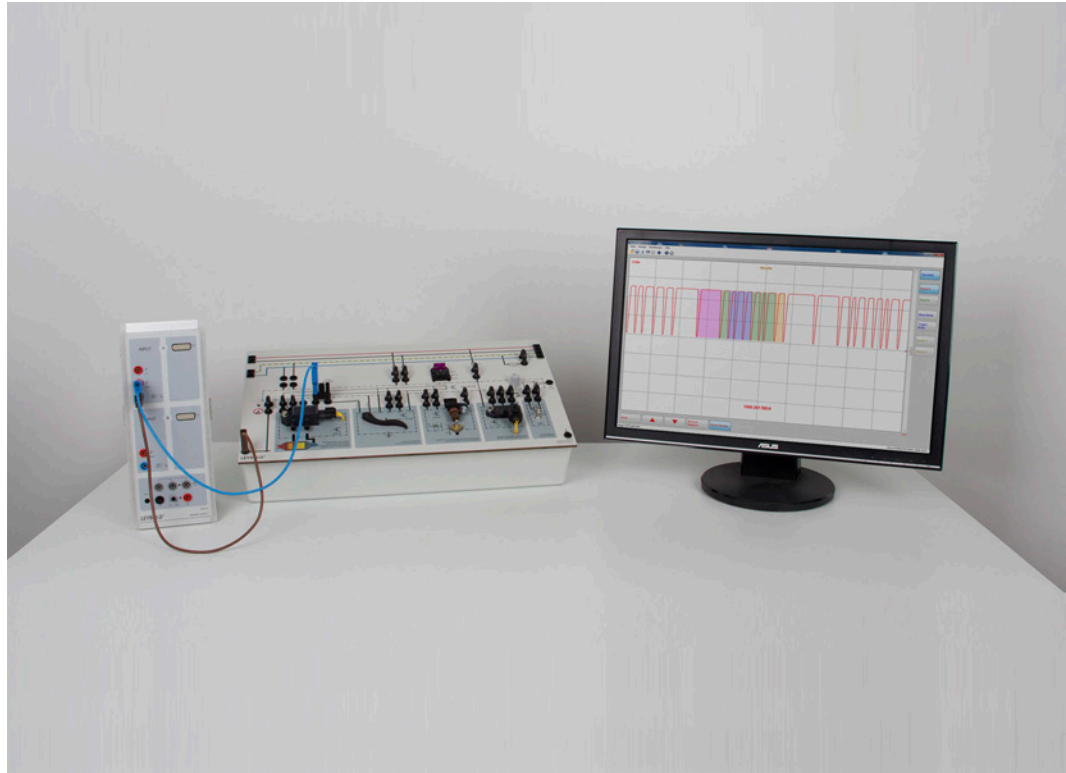
LEYBOLD offers a CAN FD device set with which CAN FD messages can be freely defined and transmitted. These can be recorded on the logic level on the PC and on the physical level with an oscilloscope. Of course standard CAN messages can also be produced and transmitted for comparison.

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.10

Networking automotive systems: "SENT"



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

Cat. No.	Description	A2.6.1.10
739 708	Sensor panel 2	1
738 10	Ignition switch	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis, German and English	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 connecting lead, 100 cm, red	1
500 642	Safety connecting lead, 100 cm, blue	1
775 069EN	LIT:A2.6.1.9+10 CAN FD and SENT	1
726 19	Panel frame SL85, single-level	1
	Personal computer with operating system required !!!	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.

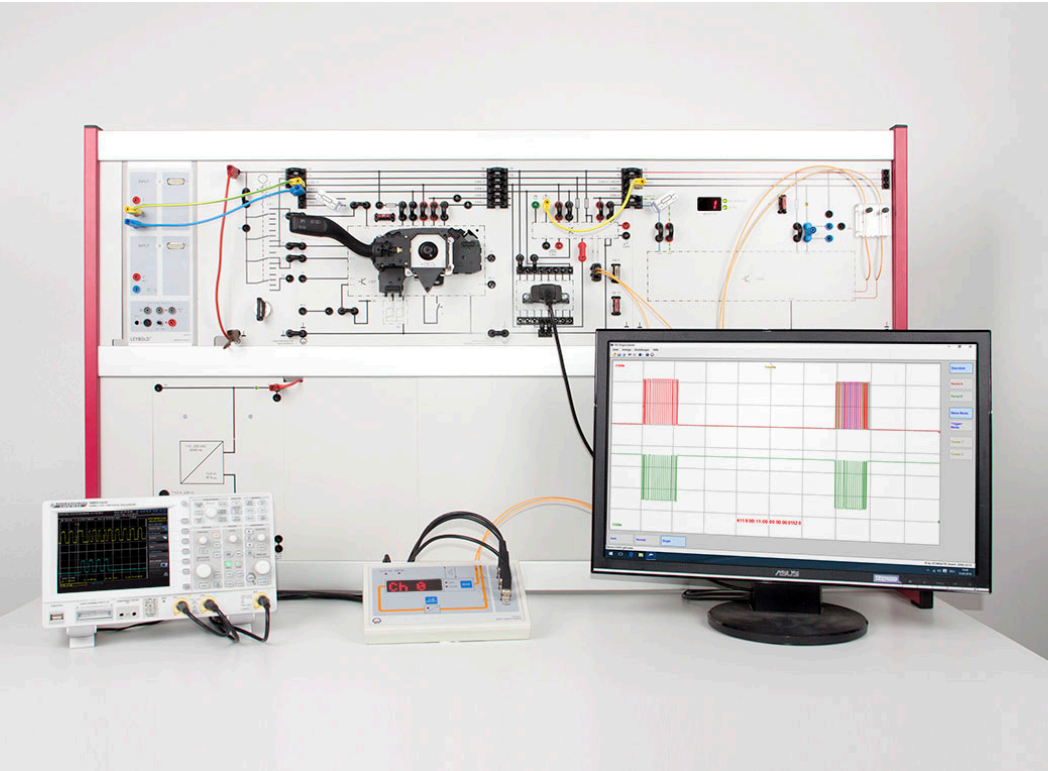
LEYBOLD has developed a training system that involves two conventional sensors with a SENT interface. The signals can be practically examined using a time base diagram or also theoretically using a protocol analyser.

A2.6.1

NETWORKING AUTOMOTIVE SYSTEMS

A2.6.1.11

Networking systems: MOST Tiny



Networking systems: MOST Tiny (A2.6.1.11)

Cat. No.	Description	A2.6.1.11
740 2015	MOST Head Unit	1
740 2013	MOST PC USB Interface	1*
739 5861	CAN Gateway	1
738 10	Ignition switch	1
738 111-02	Steering column electronics	1
740 2014	MOST DAB radio	1*
740 2012-08	MOST BT Phone preparation	1*
736 415	Fiber Micropositioner	1*
575 303	Digital storage oscilloscope 1222	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis, German and English	1
739 580	Databus detector	1
577 30	Resistor, 62 W, STE 2/19	1
577 44	Resistor, 1 kW, STE 2/19	1
577 38	Resistor, 330 W, STE 2/19	1
500 59	Safety bridging plugs, black, set of 10	3
500 592	Safety bridging plugs with tap, black, set of 10	1
737 9803	OBD Adaptor CAN+USB	1
666 425	Panel frame C50, two-level, for CPS	1
738 027	Digital power supply 1 - 16 V/40 A	1
738 9821	Safety experiment cables, set of 51	1

* additionally recommended

Today the fast MOST data bus is widespread in the infotainment sector of all car manufacturers. As a result, it would be impossible to imagine class without this high-performance, reliable system – especially when it comes to the digitalisation of cars.

LEYBOLD offers a device set that you can use to construct and examine a small MOST experimenting system. This system is exclusively designed for the practical examination of the MOST data bus characteristics and concentrates on typical characteristics that differentiate the MOST bus from other data bus systems.

Supplementing the examination of bus signals are the practical professional exercises for producing a fibre optic cable and troubleshooting using the self-diagnosis functions and suitable diagnosis testers.

Equipment digitalisation: Networked car systems "MOST Tiny" is the perfect supplement for equipment digitalisation: Networked car systems comfort "CAN and LIN bus", A2.6.1.3. As all central devices are then present and serve as the basis for expansion of the system with a high-speed CAN bus and the MOST data bus.

A2.6.2

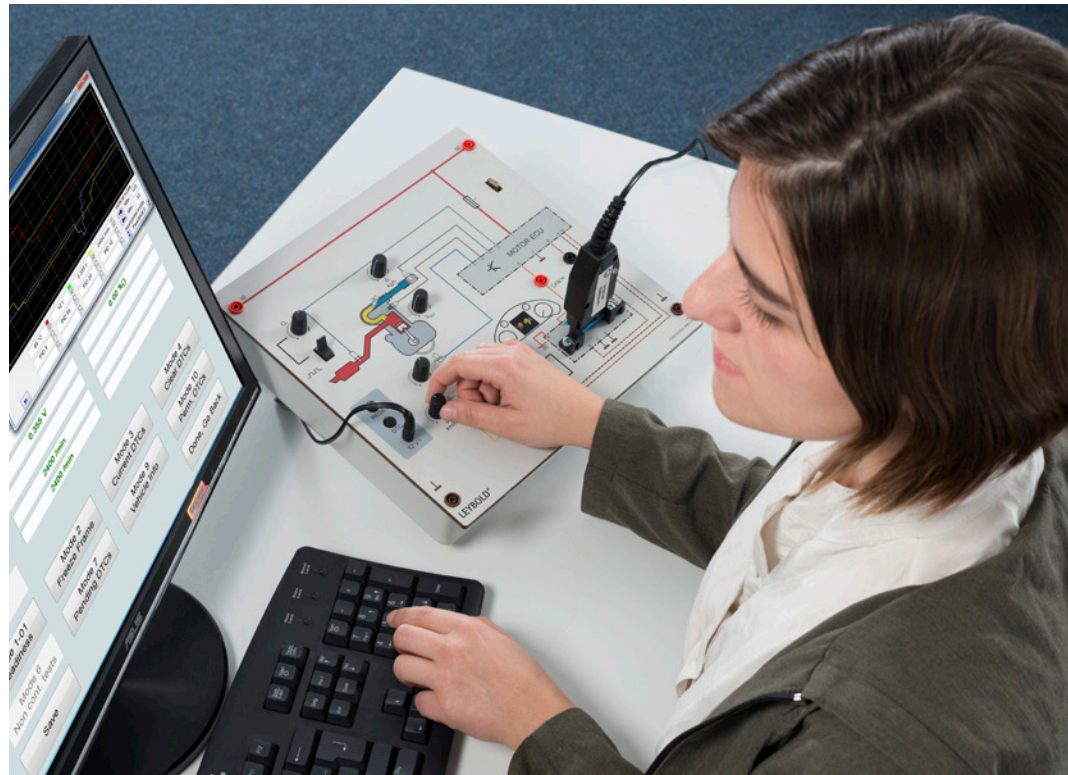
DIAGNOSIS

A2.6.2.1

Automotive self-diagnosis

A2.6.2.2

EOBD diagnosis



Automotive self-diagnosis (A2.6.2.1)

Cat. No.	Description	A2.6.2.1	A2.6.2.2
738 165	Headlamp level control	1	
579 163	Simulation ABS/Ti	1	
738 975	Diagnostic Plug 16 Pin	1	
737 9803	OBD Adaptor CAN+USB	1	1
738 10	Ignition switch	1	
738 02	Automotive power supply 13.8 V/36 A	1	
738 11	Head lamp switch	1	
738 1821	Xenon headlight unit	1	
524 034	Timer box	1	
524 013S	Sensor-CASSY 2 Starter	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 067EN	LIT: A2.6.2.1 Automotive self diagnosis	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*	
739 660	EOBD/OBD2 Simulator		1
737 9804	OBD data logger CAN+USB		1
562 791	Plug-in power supply, 12 V AC		1
689 0808	Set 5 automotive Mini fuses		1
775 068EN	LIT: A2.6.2.2 EOBD diagnosis		1

* additionally recommended

Engine control unit self-diagnosis and OBD2/EOBD

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.



A2 VEHICLE TECHNOLOGY

A2.7 ALTERNATIVE DRIVE TECHNOLOGY

A2.7.2 HYBRID DRIVES

A2.7.2.1 ELECTRICAL MACHINES IN HYBRID AND ELECTRICAL CARS

A2.7.2.2 EXPERIMENT STAND HYBRID DRIVES

A2.7.2.3 WORKSTATION VEHICLE HYBRID DRIVE

A2.7.2.4 HIGH-VOLTAGE CIRCUIT DISCONNECTION

A2.7.2.5 VEHICLE HIGH VOLTAGE TECHNOLOGY

A2.7.2

HYBRID DRIVES

A2.7.2.1

Electrical machines in hybrid and electrical cars



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

Cat. No.	Description	A2.7.2.1
300 01	Stand base, V-shaped, large	1
563 115	ELM coil, 500 turns	3
563 17	ELM centring disc	1
563 18	ELM brush holder rack	1
563 13	ELM brush	2
563 19	ELM magnet rotor	1
563 22	ELM two-pole rotor	1
563 28	ELM magnetic needle rotor	1
727 812	Rotor position pick-up	1
727 815	ELM set: Multipole stator and rotor	1
727 816	ELM PM magnet rotor with inner magnets	1
563 091	ELM pole piece for magnets	2
563 101	ELM wide pole piece for coils	3
563 251	ELM Rotating field Neodyn	1
563 291	ELM Copper ring with iron disc	1
563 191	EMTM Magnet rotor 4 pole	1
510 48	Magnets, 35 mm Ø, pair	1
727 811	Basic machine unit	1
727 88	Drive unit	1
727 87	Star-delta load	1
727 21	Automobile Meter Zero-Center	1
727 20	Automobile Meter Zero-Left	1
579 13	Toggle switch, STE 2/19	1
524 0621	UIP sensor S	1
524 0431	30-A-Box	1

Cat. No.	Description	A2.7.2.1
524 034	Timer box	1
524 013S	Sensor-CASSY 2 Starter	1
524 013	Sensor-CASSY 2	1
739 589	Software: Vehicle diagnosis, German and English	1
577 32	Resistor, 100 W, STE 2/19	3
577 44	Resistor, 1 kW, STE 2/19	1
578 15	Capacitor, 1 µF, STE 2/19	1
727 800	Storage ELM	1
563 16	Allen key	1
726 10	Panel frame T150, two-level	1
725 721G	Three-phase generator in case	1
563 31	Oil, 100 ml, in dropping bottle	1
738 9821	Safety experiment cables, set of 51	1
775 071EN	LIT: A2.7.2.1 Basics of automotive electrical machines	1
738 01	Cable and plug box	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, and
- the servomotor is among the motor and generator operation modes.



A2.7.2
HYBRID DRIVES

A2.7.2.3
Workstation vehicle hybrid drive

Workstation vehicle hybrid drive (A2.7.2.3)

Cat. No.	Description	A2.7.2.3
739 9401	Workstation vehicle hybrid drive	1
524 013SKFZ	Sensor-CASSY 2 Starter, Automotive	1
738 9821	Safety experiment cables, set of 51	1
775 073EN	LIT: A2.7.2.3 Workstation vehicle hybride drive	1
689 0808	Set 5 automotive Mini fuses	1
688 129	Mains cable with hock-proof plug and cold connector	1*

* additionally recommended

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.

In addition to the "hybrid propulsion" demo equipment, 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
- a dual voltage electrical system, and
- a touchscreen display for the operation and to display energy flows.

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.

A2.7.2

HYBRID DRIVES

A2.7.2.5

Vehicle high voltage technology

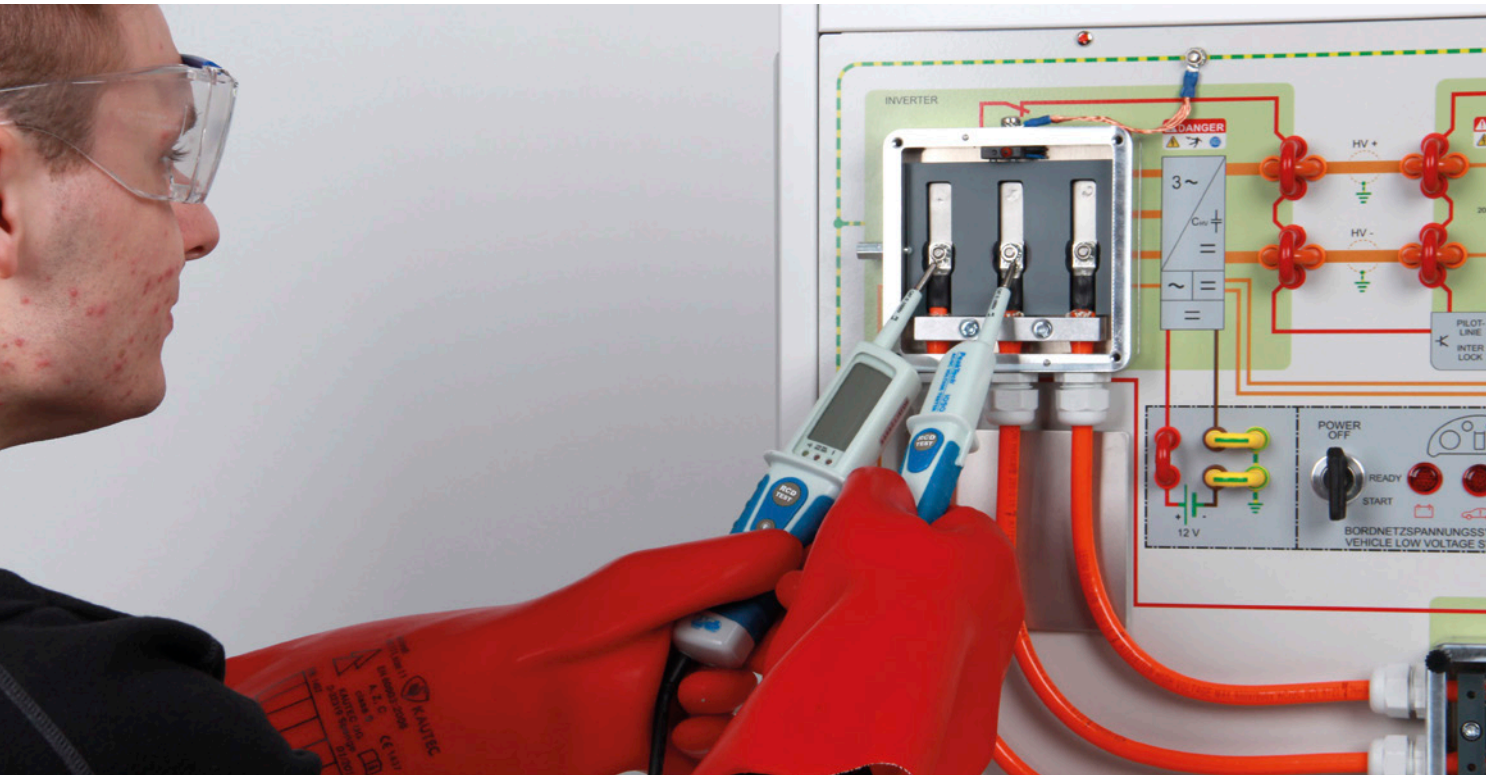


Vehicle high voltage technology (A2.7.2.5)

Cat. No.	Description	A2.7.2.5
739 947	PEV High Voltage Trainer	1
739 948	Electric vehicle charging station	1
732 11	Squirrel cage motor 400/690/0.3	1
727 293	Digital insulation tester	1
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	Roma safety goggles	1
689 0817	HV tool set	1
577 36	Resistor, 220 W, STE 2/19	1
577 46	Resistor, 1.5 kW, STE 2/19	1
578 51	Diode, 1N 4007, STE 2/19	1
739 950	Charging cable Mode 2, 1~	1
739 951	Charging cable Mode 3, 3~	1
731 07	Shaft end guard 0.3	1
610 210	Warning sign „Dangerous electrical current“	1
775 074EN	LIT: A2.7.2.5: Vehicle high voltage trainer	1
500 641	Safety connecting lead, 100 cm, red	2
500 644	Safety connecting lead, 100 cm, black	1
500 647	Safety connection lead, 100 cm, brown	1

Cat. No.	Description	A2.7.2.5
500 6481	Safety lead 100 cm grey	1
500 640	Safety connecting lead, 100 cm, yellow/green	1
500 604	Safety connecting lead, 10 cm, black	3
500 612	Safety connecting lead, 25 cm, blue	1
500 592	Safety bridging plugs with tap, black, set of 10	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

* 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 (TÜV, 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.

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.

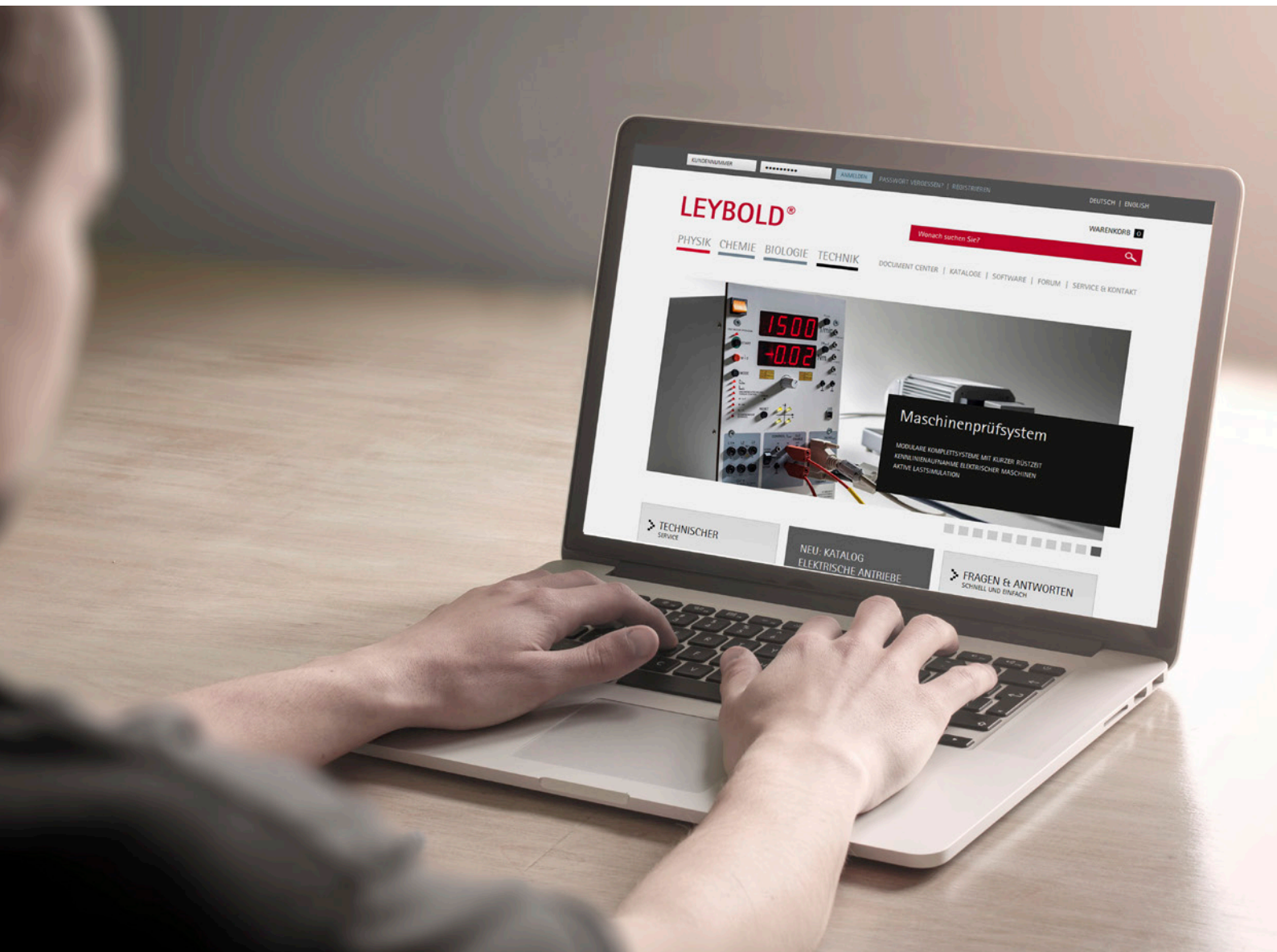
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PHYSICS

CHEMISTRY
BIOLOGY

ENGINEERING

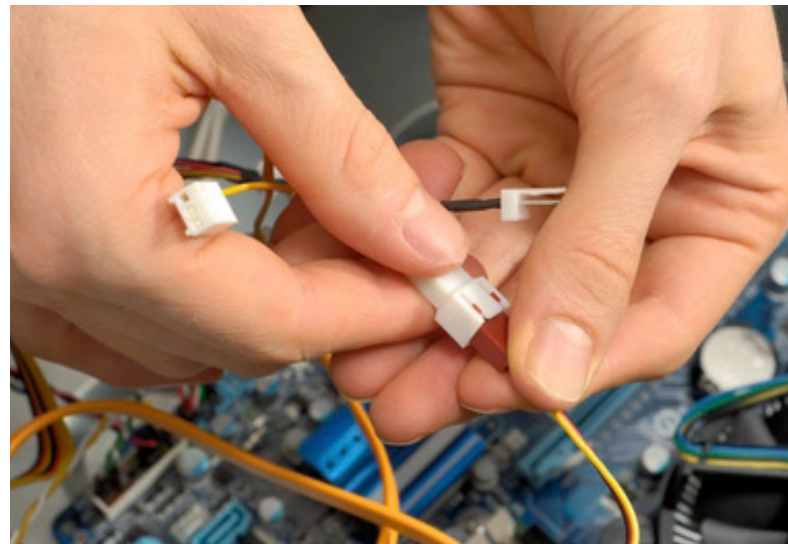
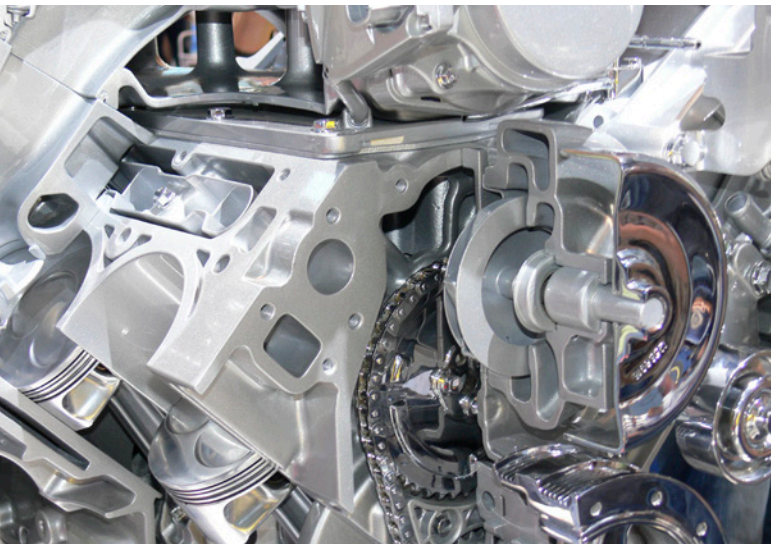


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134 0100EN 11.2016 LD
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