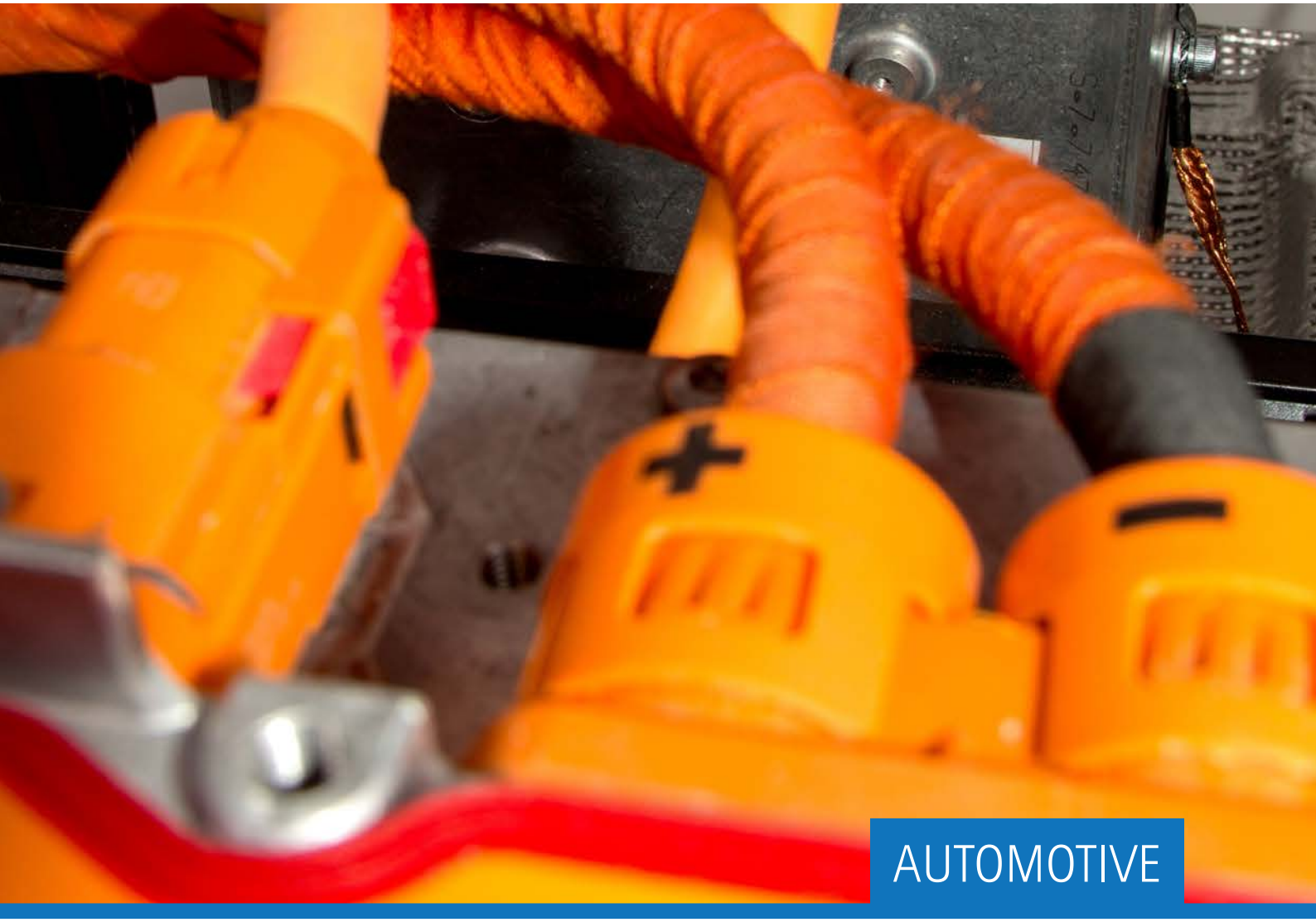
PHYSICS
CHEMISTRY
BIOLOGY
ENGINEERING

LD DIDACTIC

E-MOBILITY

THE MOBILITY OF TOMORROW IS ELECTRIC



AUTOMOTIVE

- BASIC PRINCIPLES OF HIGH-VOLTAGE TECHNOLOGY
- HIGH-VOLTAGE BATTERIES & ELECTRIC MOTORS
- DIDACTIC HIGH-VOLTAGE & ORIGINAL SYSTEM TRAINER

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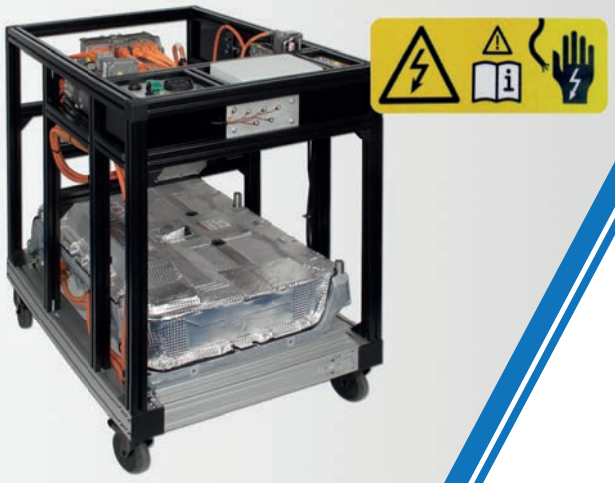

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GENERATION E - FOR "ELECTRIC"
eVolution of eMobility

New registrations of purely electric cars are gradually increasing throughout the world. It is true that even in 2030, 3 out of 4 new vehicles will still be driven by a conventional drive, but these will at least be supported by electric motors, power electronics and batteries, e.g. in the 48 V on-board electrical system.

Even today, professional automotive training is facing these new challenges and is benefiting from the LEYBOLD® training material for electromobility.

From the basic principles of vehicle electrics based on the proven STE plug-in system and numerous topics in the training panel system right up to compact training guides, LD DIDACTIC offers solutions for demonstration and practical use during training. Conventional or also digital.

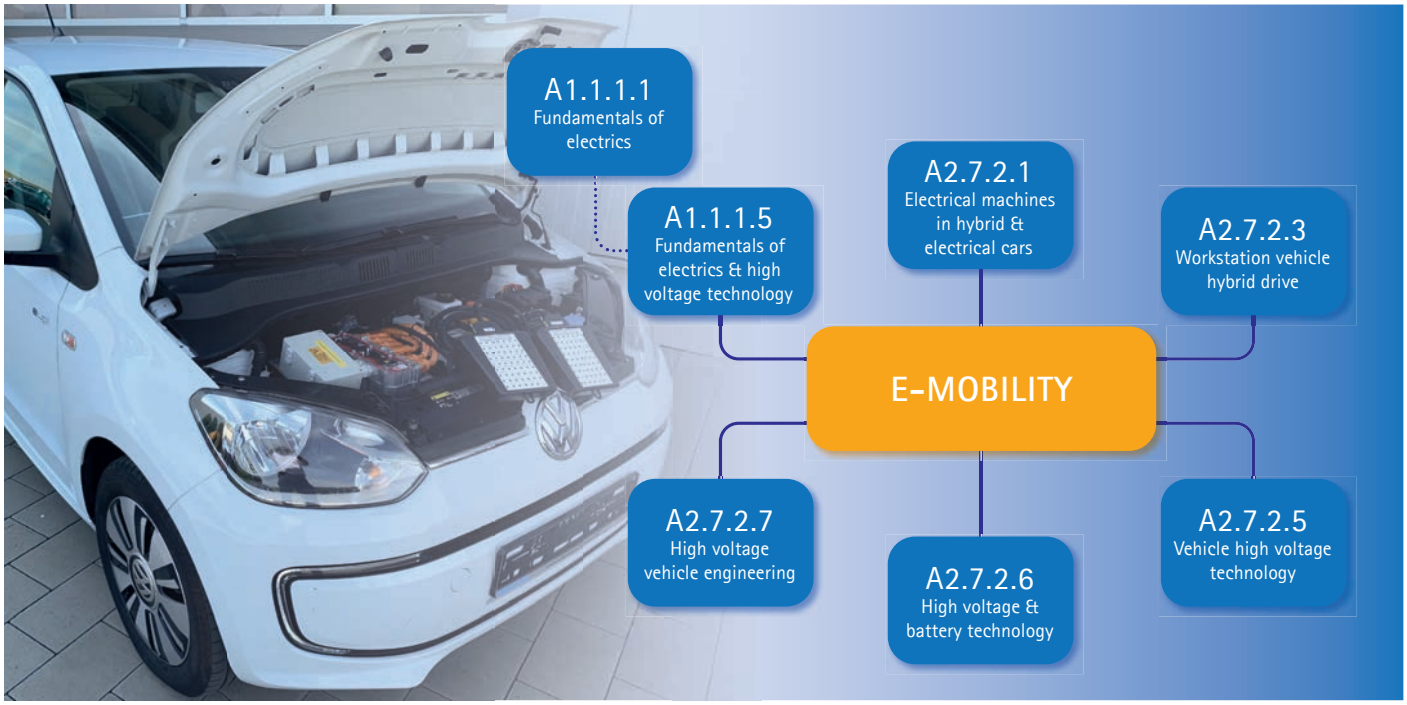
Naturally, safety is paramount with all of the concepts presented here. Non-hazardous low voltage and special high-voltage systems in the low voltage range guarantee safe use of our high-voltage training systems.

LEARNING GOALS

- **Learning field 11S:**
  Diagnose and repair networked drive, convenience and safety systems
- **Learning field 12S:**
  Prepare vehicles for safety inspections and approvals
- **Learning field 13S:**
  Check and repair components of hybrid and electric vehicles

The objective of our training systems is formed by the real vehicle on which the knowledge gained can be implemented in everyday workshop practice.

Electric vehicles with didactic conversions, such as e.g. the VW e-up, can be offered on request.



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A1.1.1.1
FUNDAMENTALS OF ELECTRICS

Our STE plug-in actuators system equipment is used to convey the basic principles of electrical and electronic engineering as well as digital technology, especially with respect to applications that are typical in the automotive industry. The equipment is collated in a practical manner and are suitable for all brands e.g. Volkswagen, BMW, Tesla, Toyota etc.

Motor vehicles

The STE plug-in actuators system represents an ideal introduction to the subject areas. Furthermore, it is distinguished by:

- conventional electronic components in transparent housings,
- typical automotive components in transparent housings,
- particularly robust design,
- and plug-in board with circuit diagram layout
- ISO conformant component symbol representation.

Here, electronic components and automotive sensors and actuators are investigated together with their application in a complete circuit.

Hybrid and electric vehicles

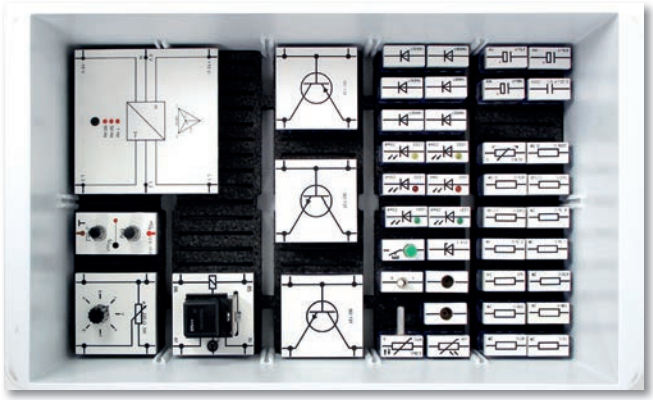
In addition, the basic principles of the system and high-voltage technology in the area of electromobility can also be imparted. The DC/DC converter or the high-voltage battery management (HV-BMS) as well as other protective measures of the IT network of an inherently safe electric vehicle can be thoroughly investigated.

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

- the electric circuit
- the ohmic resistance
- current and voltage sources
- the capacitor
- the coil
- the transformer
- the relay
- special resistances such as NTC, PTC or LDR
- the diodes
- the Z diodes
- LEDs
- the transistor and
- the thyristor.

Then the circuits of the automotive electronics that are used in the vehicle' equipment are built up and tested, such as e.g.:

- an electronic tachometer,
- an electronic voltage regulator for three-phase generators or
- a transistor control unit.



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A1.1.1.5
FUNDAMENTALS OF ELECTRICS & HIGH VOLTAGE TECHNOLOGY

Protective measures in the intrinsically safe HV vehicle

A vehicle that has a complete contact and arc protection by means of technical measures in comparison to the high-voltage system is known as "inherently safe".

In an **IT system** (IT: French **I**solé **T**erre), the conductive housing of the equipment is earthed but the energy source is not. The high-voltage drive system of electric and hybrid vehicles is designed so that e.g. the housing of the inverter and the electric motor are connected together via the chassis. This connection represents the potential equalisation.

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

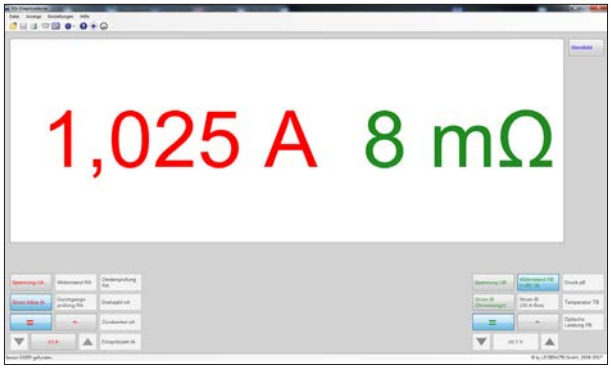
For hazard-free testing of such systems, LEYBOLD® offers all necessary components as plug-in elements that are operated with a extra low voltage of 24 V.

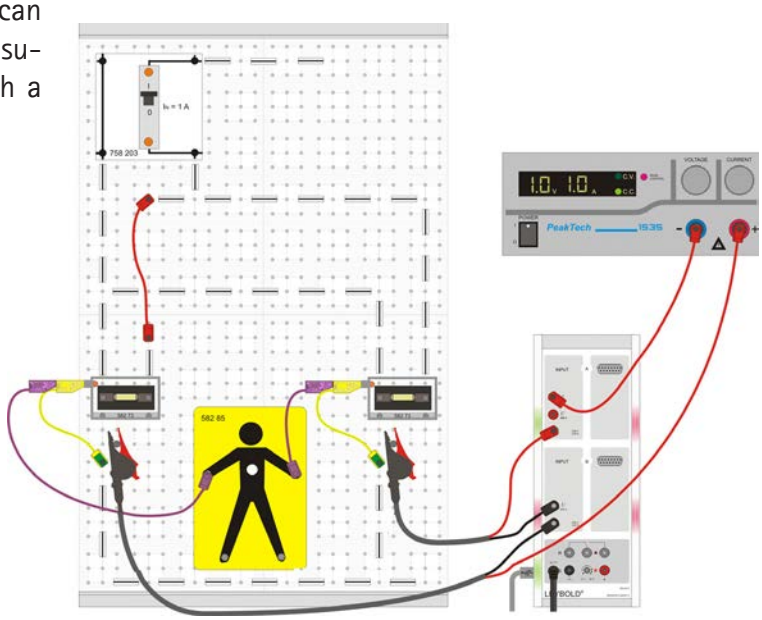
Voltages and the potential equalisation resistance can be directly measured with Sensor-CASSY 2, the insulation resistance is determined and evaluated with a specially designed measuring device.

PRODUCT HIGHLIGHTS

- Operation with non-hazardous low voltage
- Genuine insulation monitoring unit
- Visualisation of flow through body
- Metal objects with potential equalisation

582 73	Lamp, 24 V/10 W, with housing, STE 2/50
582 85	Human model
758 202	Isulation monitoring device, STE 6/100
758 203	Automatic circuit breaker Z 1 A, STE 4/1





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A2.7.2.1
ELECTRICAL MACHINES IN HYBRID & ELECTRICAL CARS

The inspection of the basic characteristics of hybrid and electric vehicles requires a fundamental knowledge of the design and functionality of electric motors and the associated power electronics.

This includes:

- DC motors,
- AC and induction motors,
- servomotors and
- power electronics (inverters).

For basic motor training, LEYBOLD® uses the components of the modular electrical machine teaching models **"ELM"**. When conveying the basic principles of power electronics, a modern inverter is used to power the different motor types. In this way, the trainee can put together entire systems that not only teach traction but also recuperation in an experiment.

And in this way, fundamental knowledge and terminology are imparted such as e.g.

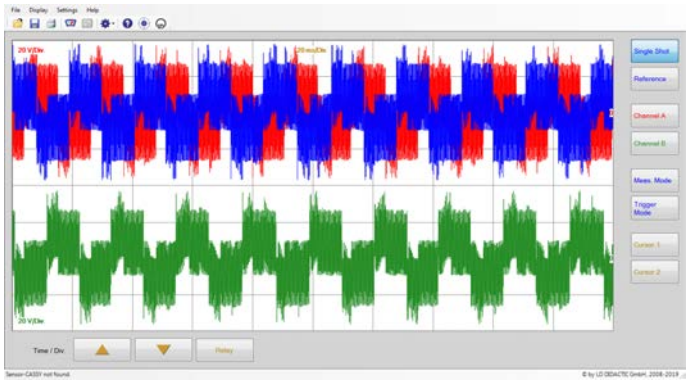
- electromagnetism,
- induction & voltage generation,
- DC/DC & DC/AC converters,
- use of an electric motor as a motor & generator and
- power and energy flow.

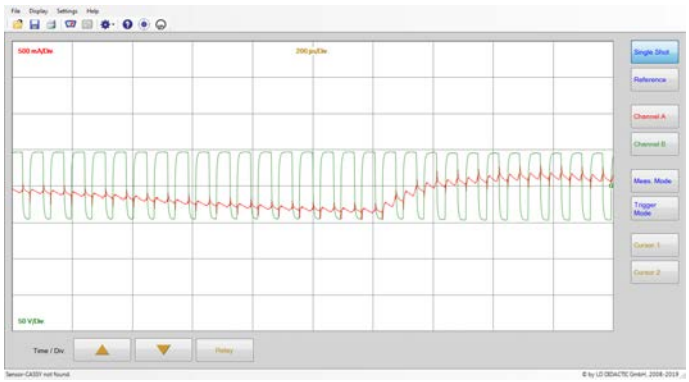
The electric motors are designed to be transparent and fully functional. As standard, the inverter which converts the DC voltage of the high-voltage battery into three-phase AC voltage to supply the electric motor works on a voltage level of less under 24 V and thus provides absolute safety for students and trainees.

PRODUCT HIGHLIGHTS

- ★ Modular design
- ★ Operation with rotor position sensors
- ★ Rotors with internal or external magnets
- ★ Traction operation as motor
- ★ Recuperation operation as a generator

725 721G	Three-phase generator in case
727 812	Rotor position pick-up
727 815	ELM set: Multipole stator and rotor
727 816	ELM PM magnet rotor with inner magnets





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A2.7.2.3
WORKSTATION VEHICLE HYBRID DRIVE

LEYBOLD® has developed a student workplace in which all important aspects of hybrid drives can be investigated using the smallest amount of space. The unit is equipped with:

- a PMSM as electric motor,
- an inverter and
- a dual-voltage on-board electrical system.

The control devices are networked via the motor CAN bus.

All common operating modes can be reconstructed:

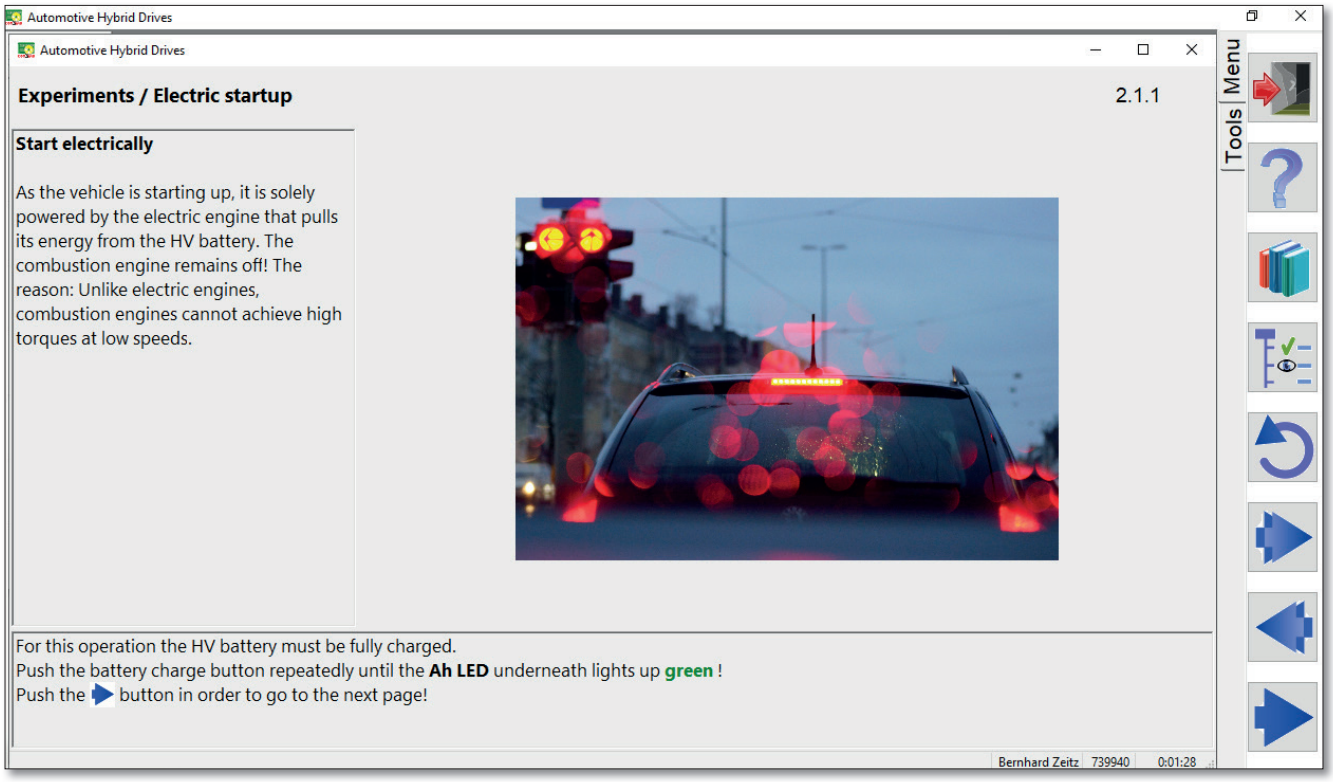
- starting
- electric driving
- boosting
- regenerative braking

The student can independently investigate the complex theme of hybrid technology. Different systems can be selected using overlay masks. The workplace can be connected to the PC to show e.g. the energy flow display.

PRODUCT HIGHLIGHTS

- ★ Self-supporting learning environment
- ★ COM4LAB course software support
- ★ Operation with non-hazardous low voltage
- ★ Can be used without other devices

739 9402	Workstation Vehicle Hybride Drive



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A2.7.2.5
VEHICLE HIGH VOLTAGE TECHNOLOGY

Since vehicle electrics have been generally regarded as non-hazardous up to now, awareness of hazardous contact voltage must be raised and new safety measures and procedures must be conveyed in a targeted manner.

In this way, the automotive mechatronics engineer and also the trainer are faced with new challenges in the field of electromobility. It is difficult having to work with voltage under real conditions but still guarantee maximum safety for trainees during the lesson.

To this end, LEYBOLD® has developed a trainer in which electric vehicles can be activated in a realistic manner. The device is suitable both for demonstration by the trainer/teacher and also for practical training by the trainee/student. Even technical service companies, inspection bodies, emergency services (fire brigade, technical relief organisations) or recyclers can benefit from this training concept to prepare their technical staff for this innovative segment of automotive technology.

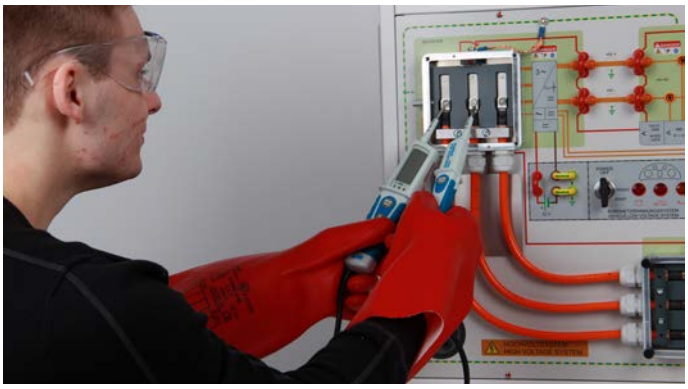
As a supplement, a private charging station is also offered. With this, the charging process can be reproduced in states A to F since a genuine charge controller is used.

The high-voltage trainer is designed that the charging process can be started and stopped at any time without affecting the functionality of the trainer.

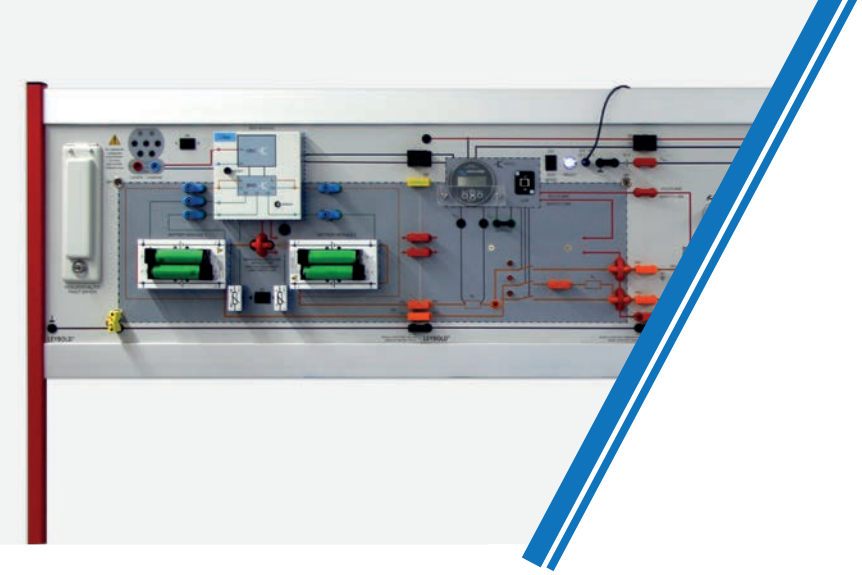
727 293	Digital insulation tester
739 947	PEV High Voltage Trainer
739 948	Electric vehicle charging station
739 949	HV PC measurement adapter for E-Mobility

PRODUCT HIGHLIGHTS

- ★ Operation with low voltage
- ★ Additional personal protection
- ★ No maintenance-intensive batteries
- ★ Metal objects with potential equalisation



Electric vehicle charging station



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A2.7.2.6
HIGH VOLTAGE & BATTERY TECHNOLOGY

SAFELY LEARN ABOUT HIGH-VOLTAGE BATTERIES

There are many further developments with respect to the high-voltage battery, which is still often the weak point of an electric vehicle. Inadequate ranges due to insufficient capacities and excessive charging times due to cells being less than perfect are the main causes of this.

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

Hence, LEYBOLD® offers the high-voltage battery trainer as a supplement to the high-voltage trainer. Modelled and transformed to uncritical voltages of 24 V, the trainee can acquire all skills in this area. The highlight: Due to the separate battery blocks, these can be exchanged and hence different battery chemistry can be investigated such as e.g. lithium-ion cells or lithium iron phosphate cells.

PRODUCT HIGHLIGHTS

- ★ Intrinsic safety on 24-volt basis
- ★ Supplement to the system of electrical machine teaching models and high-voltage trainers
- ★ Operation with different cell chemistry structures
- ★ Use of LiIo or LiFe cells and future new cells in the same system
- ★ Integrated fault switch box

739 952	Model HV Battery „Cells"
739 954	STE BMS LiIo
739 958	Model HV Battery „Monitor"
739 959	Model HV Battery „Inverter"

The system contains:

- individually exchangeable battery blocks
- exchangeable battery management units
- main contactor with switching logic
- monitoring via a safety line
- selective service disconnect between the battery blocks or in the main contactor
- battery data collection
- battery temperature simulation
- fault switch e.g. to simulate defective cells
- on-board electrical system charging infrastructure
- optional insulation monitoring

As a supplement, an inverter unit is available that allows the assembly of a complete traction drive in combination with the electrical machine teaching models (ELM) system. The detection of the engine system with traction and recuperation operation including the signals of the rotor position sensor are easily possible with the sensor-CASSY 2.

In addition, the activation of an electric vehicle can be implemented in the complete system. All necessary components are already integrated and can thus be used for practical work.

LEARNING GOALS

- Diagnosis and repair networked drive, convenience and safety systems
- Prepare vehicles for safety inspections and approvals
- Check and repair components of hybrid and electric vehicles

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A2.7.2.7
HIGH VOLTAGE VEHICLE ENGINEERING

With the high-voltage system, it is possible to simulate insulation faults in the HV cables and components. In this way, systematic troubleshooting can be trained and improved in a targeted manner. Unlike in the vehicle, all installed HV components are easily accessible. In the event of a fault, a detectable HV voltage is present but it has a very low current carrying capacity.

The system provides an overview of all installed HV components that come from genuine vehicles. The necessary steps for activation can be performed under more simple conditions, identical to the vehicle.

With the system trainer, the dissuasive complexity is removed from the HV vehicle technology due to the clear and easily comprehensible layout. Application and haptics correspond to the real vehicle.

PRODUCT HIGHLIGHTS

- ★ Mobile compact trainer
- ★ Switch box for the simulation of faults
- ★ High-voltage battery housing with mains adaptor
- ★ Equipotential bonding cable
- ★ Mechanical work according to repair guide

739 965	Monitor holder
739 966	Tools set e mobility
739 967	Safety torque wrench

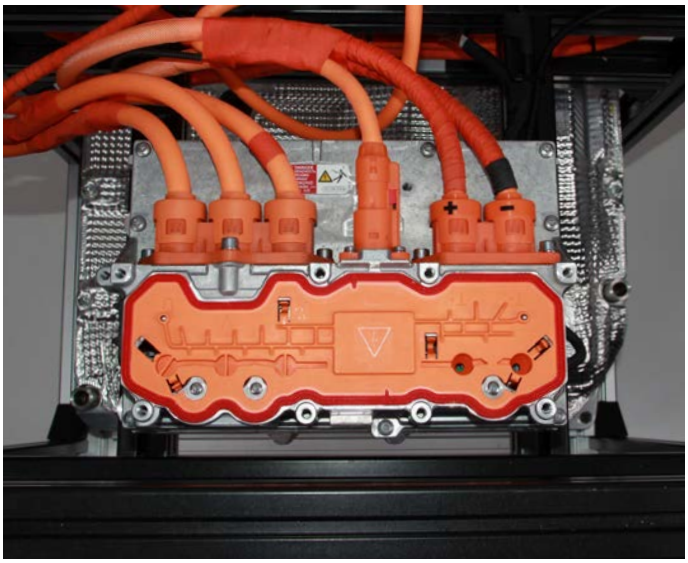
Equipment:

- HV on-board electrical system
- Two consumers (PTC heater and air conditioning compressor) for fault simulation
- Electric motor connection with measuring options on open cable ends
- Charging socket
- Various 4 mm safety test sockets

Further components:

- Power electronics
- Charger
- HV battery housing

The system can be activated with an ignition key, deactivation of the system is effected via the service disconnect.



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LAB DOCS & LAB DOCS EDITOR

Interactive boards, PCs, tablets and smartphones have found their way into schools.

In order to include all of these end devices in classes, LD DIDACTIC has developed new equipment literature in the HTML format, under the name of Lab Docs, which can hence be used in any browser.

What exactly are Lab Docs?

Lab Docs are not only digital experiment instructions, they are also multiply interactive.

The students and trainees can enter their responses, record measured values, evaluate these and represent them graphically directly in the Lab Doc.

For institutions that are not yet able to provide complete digital learning, all Lab Docs are also available as PDF files with adapted layout for printing.

The Lab Docs Editor

To give teachers the possibility of editing purchased Lab Docs or creating their own Lab Docs, LD DIDACTIC has developed the Lab Docs Editor. A user-friendly tool was developed in collaboration with competent authors and allows the editing or creation of interactive experiment instructions.

With the easy-to-understand tool, the creation of experiment instructions is quick and easy. It is also easy to share the instructions with colleagues.

With the Lab Docs Editor you can:

- Edit & delete tasks
- Add text & answer fields
- Integrate & adapt interactive diagrams & tables
- Insert pictures, vector images, hyperlinks, etc.
- Create & generate material lists
- Create formulas

LeyLab - Central management of experiment instructions & devices & literature

LeyLab is an online portal for the central administration of experiment instructions, experiments and devices. With LeyLab, all devices of a school (department) can be inventoried. A great advantage is that LeyLab can be accessed from anywhere – even from home.

Lab Docs can be uploaded quickly and easily to LeyLab for each experiment. You can also store Lab Docs from LD literature packages with the respective experiments. The experiment instructions can be easily distributed to students or trainees via the share function in LeyLab with a QR code or a link.

Once the devices have been inventoried, all the necessary equipment for an experiment is listed with details of the devices and their storage location. The highlight: The experiments with all the associated equipment can be easily borrowed or returned to the teacher/lecturer, which means that all colleagues always have an up-to-date overview.

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DIGITAL MEASURING DEVICES

For experiments, the LEYBOLD CASSY system offers a complete data-logging and measuring system. The ultimate measuring devices work with all CASSY S sensors and the popular CASSY Lab 2 software. It offers simple operation and handling of both hardware and software.

Furthermore, CASSY opens the door to digital teaching by means of a WiFi adapter for Sensor-CASSY 2. This makes it possible for you to easily incorporate interactive whiteboards. Also the software CASSY Lab 2 let teachers/lecturers share measurement data with students/trainees online and in real-time. Students/trainees can observe the measurements on their tablet/smartphone and can follow the measurement from their workstation. The measured values can then be evaluated by them as well.

Sensor-CASSY 2 with WiFi adapter

Intuitive measuring devices for the highest measuring demands

Sensor-CASSY 2 Starter, Automotive
Two Sensor-CASSYs can be connected to represent three-phase voltages for the field of "electromobility". In addition, a high-voltage warning is present in DMM mode that appears in the display as soon as the displayed voltage exceeds 25 V AC or 60 V DC. With the help of the integrated Sensor-CASSY voltage source, measurement of the potential equalisation resistance can be performed in accordance with the four-wire method ("Kelvin" measurement).

Software: Vehicle diagnosis
The Sensor-CASSY 2 automotive edition contains its own diagnostic software that is specially developed for the automotive sector and that is recreated from a genuine diagnostic tester. A digital multimeter (DMM) and digital storage oscilloscope (DSO) are implemented with an adaptation for the measurement of voltage and current as well as resistance, temperature, pressure, injection duration or ignition angle via corresponding sensor boxes. In addition, other functions for data protocol analysis of CAN, LIN, SENT Fast Channel, SENT Slow Channel and KMI data are available incl. a trigger function on an ID (CAN and LIN bus).

524 013SKFZ	Sensor-CASSY 2 Starter, Automotive
524 013W	Sensor-CASSY 2 WiFi
739 589	Software: Vehicle diagnosis

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