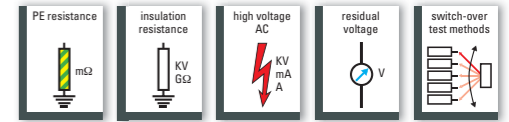


**Innovative Testing and
Measurement Technology**
for electrical safety and functional tests





- RS232
- PC
- LabView®
- SPS
- I/O
- Analog
- Print



Article Number

	GLP1-e 60204 V1 401854	GLP1-e 60204 V2 401855
high-voltage test AC 500VA	•	•
maximum high voltage	6000V AC	3000V AC
high voltage potential-free	•	–
safety high-voltage test pistols	2	1
ground-continuity test 10A	•	•
insulation resistance test 500Vdc (stepless100 - 1000Vdc)	•	•
residual-voltage test	◇	◇
V1 > PE/IR ground-connection lead in 4-wire configuration	5 m	–
V1 > PE/IR test probe with switch-over and 3-color LED (green/yellow/red)	10 m	–
V2 > PE/IR/HV ground-connection lead in 4-wire configuration	–	10 m
V2 > PE/IR/HV test pistols with integrated push-button	–	1
V2 > PE/IR/HV test pistol length of connection lead	–	6 m
V2 > PE/IR/HV control panel with 3-color LED (green/yellow/red)	–	•
warning lamp	•	•
foot switch	•	–

• Standard | ◇ Option | – not available



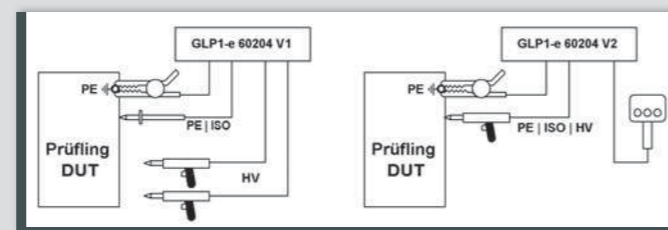
Mobile caddy

Highlights

- ground-continuity test with 10A AC in 4-wire configuration: indication of resistance or voltage drop
- insulation-resistance test: indication of resistance or current
- high-voltage test with manual voltage adjustment
- 3 modes: manual, automatic with time target and burning
- optional residual-voltage test
- acoustic error message and optical indication via signal lamps at the front panel
- integrated result storage for later data transmission
- interface for printer, remote control or result transmission
- PrintCom software for storing and printing the test results on a PC
- digital I/O interface and analog actual-value outputs
- designs: table-top unit, mobile caddy, 19" installation
- ideal pre-conditions for OEM applications
- self-test via black-box according to VDE

GLP1-e-60204 testers perform electric safety tests at machines and devices according to the Machine Guideline (EN60204/VDE0113).

They are ideal for fast and easy testing in factories and on site. It is possible to perform ground-continuity tests, insulation-resistance tests, high-voltage tests and residual-voltage tests. Two models are available – differing only in the contact method.



With Model V1, the ground-continuity tests and the insulation-resistance tests with a test probe with an integrated operating unit are performed first. The high-voltage test with two safety test pistols follows. The test pistols can be delivered with or without integrated start switch and with varying cable lengths.

With model V2, the test object is contacted at ground (central PE-point). All three tests can be performed against this ground point with the same test pistol. By activating the selection switches

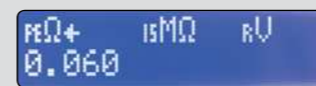


on the control panel, test methods can be changed. To ensure the operator's safety, it is necessary that the high-voltage switch is activated permanently during the high-voltage test. To start the test, the test probe needs to be pushed against the test object.

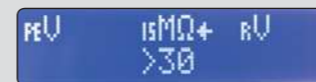
The integrated RS232 interface allows to print the test results directly. You can use our Windows® software PrintCom to store and process the test results directly on the PC.



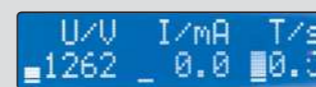
EN60204 test at a service cabinet



PE resistance



Insulation resistance



High voltage

Possible combinations of test methods

	high voltage AC KV mA	PE resistance mΩ	insulation resistance KV GΩ	residual voltage V
Basic	•	•	•	–
Full	•	•	•	•

Refer to:

Windows® software PrintCom	58
HV pistols and warning lamps	68
Mains-connection adapters	70
Contacting devices for leads	72
Special contacting devices	74
Rolling tables	78
Calibration and black boxes	82
Test methods	94



Storing and printing test results in Excel®



- RS232
- Ethernet
- USB

Highlights

- reading-in test results during the test and from the temporary storage of the tester
- ideal e.g. for EN60204 tests with predefined test steps in a test sequence
- ideal for storing test results within production
- storage of test results in Excel® format
- print-out of the test results via Excel® protocols
- you can design your own Excel® protocols, e.g. with your company logo in any number and with any desired configuration
- freely configurable protocol forms for the print-out of test results
- various storage modes (single or total results)
- compatible with OpenOffice® and MS Excel®

PrintCom offers the fastest and most simple way for storing and logging test results. The print protocol is very impressive. It is not only a list of measured values - you will have a protocol especially designed for your company including logo, graphical symbols and all that is necessary for the perfect presentation of your company.

Reading in

The software displays the test results clearly structured on the monitor of the PC. In addition, you can enter further information, like order data, name of the operator, etc.

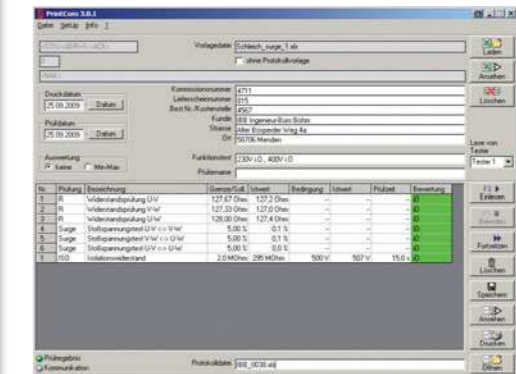
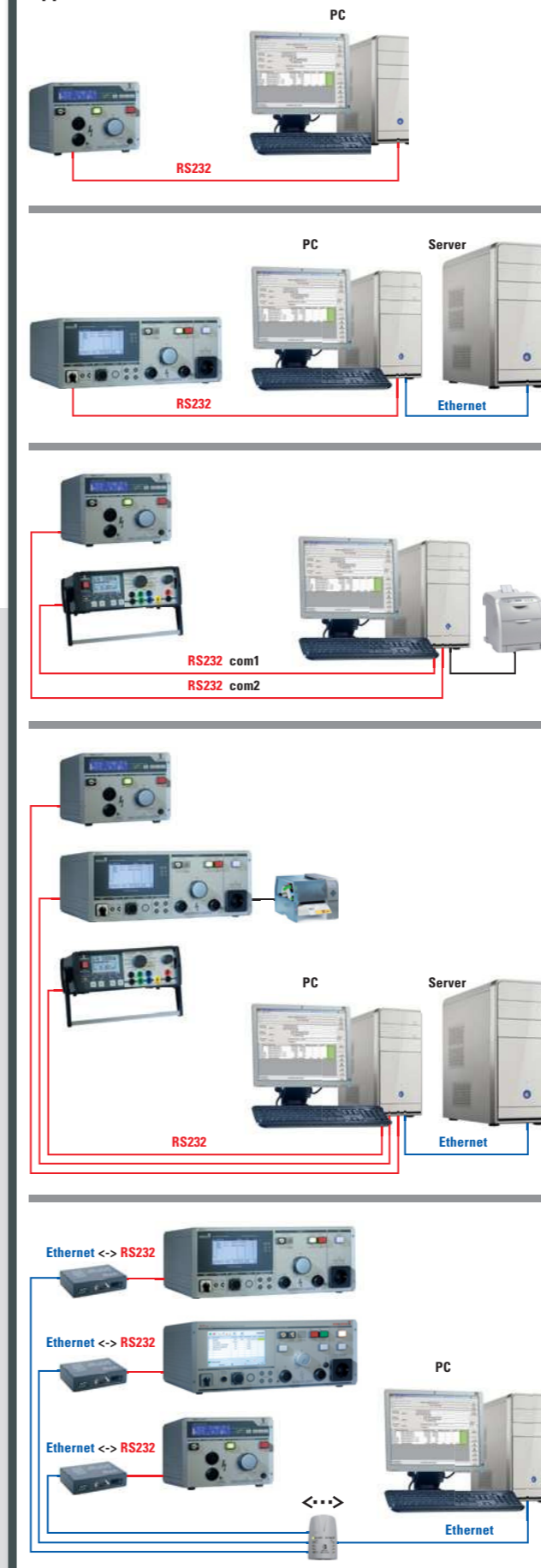
Storing

The test results are stored in the user-friendly Excel® format on the basis of a preconfigured Excel® form. The delivery extent comprises a large selection of easily adaptable protocol forms in different languages. You can, of course, also generate completely new protocols.

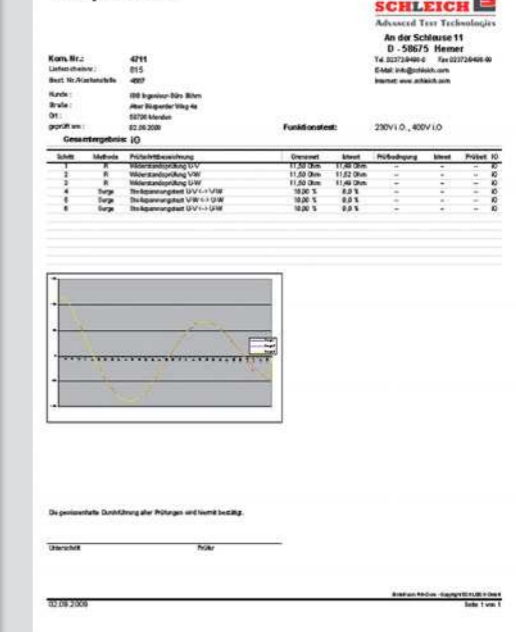
Printing

The transmission of the test results into an Excel® file allows you to print the test results directly and document the tested quality.

Applications



Prüfprotokoll



Refer to:

Handheld	18
GLP1-e	20
GLP2-e	26
GLP2-ce	28
MotorAnalyzer	46
NetCom Xi	60

HV pistols and warning lamps

HV test pistols | safety equipment | test probes



Resistance test probe

With the probes for the resistance test, the resistance to be measured is detected in 4-wire configuration.



Resistance test probe in 4-wire configuration



Test probes for the armature test

Warning lamps and result lamps

Warning lamps serve to indicate, whether the test object is connected to voltage or not.

Result lamps indicate the overall test result of the test process. Customer-specific special displays, which can be controlled by the tester, also belong to our extent of delivery.



Warning or result lamp



High Voltage

For a secure manual high-voltage test, safety test pistols are required. There are various designs depending on the level of the test voltage. For convenient handling, we offer test pistols with integrated start function. The high-voltage test does not start before activating the switch.



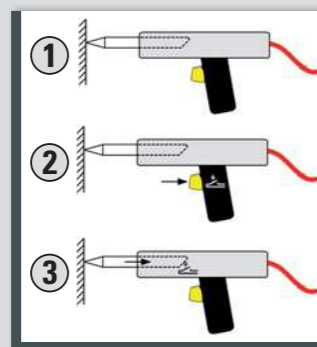
High-voltage test probe up to 1500V safety-current limited



High-voltage connection lead



Test pistol up to 8KV AC/10KV DC



High-voltage test pistol without start function ①, with start function ②, with start via mechanical pressure switch ③



Test pistol up to 12KV AC/15KV DC



Adapter between test object and test pistol

PE test probes

PE test probes serve for contacting the PE connections manually. Test probes with integrated start function and colored LED can be used not only for starting the PE test, but also for starting the complete test process, for confirming test steps for visual examination and for confirming other messages.



Large PE test probe with integrated start function



Test probe with switch-over for limit values and test methods

Safety

For safety reasons, the high-voltage test without protection cover and without safety test pistols requires a two-hand start. For operating test stations, it is necessary to observe the respective standards.



Two-hand start



Small PE test probe



Test probe with start function



Safety chain with warning sign



Barrier posts with warning lamps and emergency stop

Refer to:

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Mains-connection adapters



Mains-connection adapters for 13 test objects



3-phase connection box



1-phase connection box with quick-fastening clamps



Connection box for earthed plug

Highlights

- various standard contactings
- durable mechanical design
- universal sockets for different standards
- line-terminal adapters of all kinds
- lamp adapters
- quick exchange of wearing parts

Many test objects can be contacted via a Mains-connection adapters.

The operator inserts the mains plugs into the test socket of the Mains-connection adapters. The sockets can be either national and international standard sockets for single-phase or three-phase operation or standardized special sockets.

Mains-connection adapters can be equipped with more than one standard socket, so that the adapter can be used for various mains plugs.

For contacting free cable ends, the Mains-connection adapters can be equipped only or additionally with quick-fastening clamps.

We manufacture the Mains-connection adapters according to your requirements following a modular concept.

Of course, we also have the right solution for contacting terminal blocks or luster terminals.

In addition to mains terminals, the lighting industry also needs lamp-holder terminals. It goes without saying that we also offer suitable adapters.



Universal socket



Adapter between test object and high-voltage test pistol



Lamp adapter



Lamp adapter



Clamp adapter/
luster terminal adapter

Refer to:

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Contacting devices for leads



Test objects often only have cable ends without any plug connections. Therefore, a typical task is the contacting of free cable ends.

For contacting free cable ends, we offer an extensive range of contacting units. They can be used, for example, for contacting the windings of stators, which can be designed in both, 2-wire and 4-wire configuration.

For the 4-wire resistance or voltage measurement, Kelvin clamps are used. Kelvin clamps are perfect to measure low resistance values with high accuracy. The 4-wire measurement compensates the contact resistances at the contact point.

The special design of our Kelvin clamps guarantees highest contact reliability, a solid grip and low wear-and-tear. For less demanding contactings, we use our multifunctional spring-terminal clamps.

Fast and easy contacting can also be realized via pneumatic terminal blocks. The cable ends are inserted into the hole of the pneumatic terminal block. An automatic clamping mechanism



Single pneumatic clamp in 2-wire configuration



Attachable pneumatic clamps in 4-wire configuration for a modular design



Connection box with pneumatic clamps in 2-wire configuration

Highlights

- large selection of standard contactings
- modular concept
- durable, long-life mechanical design
- 4-wire contacting units – Kelvin clamps
- 2-wire and 4-wire pneumatic clamps
- customer-specific solutions on the basis of our standard products
- quick and easy exchange of wearing parts



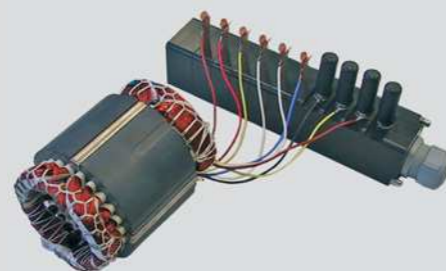
Terminal block, modular design



8 x Kelvin terminal block



11 x spring-terminal block



6 x 4-wire contact blades and 4 x spring-terminal block



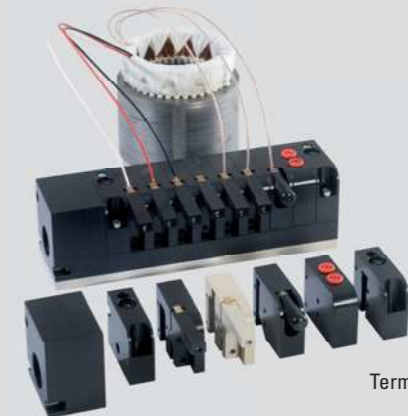
contacts the cable end. After the test, if the results are OK, all terminal blocks can be released automatically by the tester, so that all leads are instantly free. If the results are "not OK", this needs to be confirmed by the operator, before the clamps open.

The contacting units are available as single contacting units or integrated into a terminal block.

The terminal blocks can either be firmly installed within a test cover or they are moveable within the test area, which has the advantage that they can always be brought into an optimum position for connecting the leads.



Block with Kelvin clamps with automatic release



Terminal block, modular design



Kelvin contacting device in a test cover with prism



Small, medium and large Kelvin clamps

Refer to:

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Special contacting devices

Special contacting devices | contacting of motor terminal plates

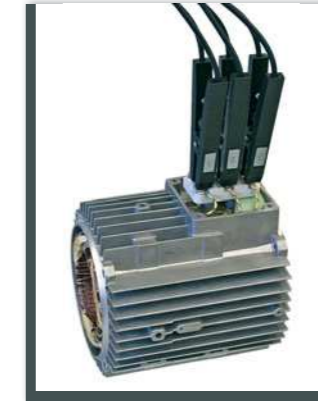


Plugs for motor-terminal plates

Every manufacturer of electric motors is familiar with the time-consuming contacting of motor-terminal plates. Without the respective contacting device, however, the motor cannot be tested. SCHLEICH offers a variety of contacting methods, saving you a lot of time.

We have designed special plugs for motor-terminal plates that are very easy to handle. They are equipped with collets that grip every stud of the motor-terminal plate individually granting a stable contact. After the plug has been attached, the collets are locked with a lever. The contacting of the frame has also been integrated into our plugs for motor-terminal plates.

We make plugs for motor-terminal plates for any number of connection studs and for various dimensions. Our plugs for motor-terminal plates are also available in 4-wire configuration, worldwide unique, allowing you to measure extremely low resistances with the highest accuracy.



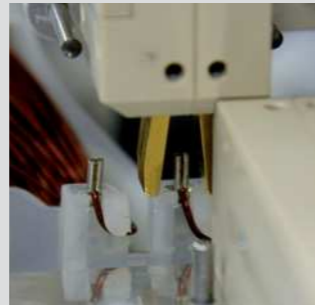
Individual Kelvin clamps for motor-terminal plates



Plug for motor-terminal plates

Highlights

- durable mechanical design
- 2-wire or 4-wire contacting devices
- high-current contacting devices
- special solutions for manual contacting
- special solutions for automatic production lines
- contacting devices for handling systems
- Kelvin clamps suspended movably, allowing automatic contacting in various positions
- spring-loaded testprobes in 2-wire and 4-wire configuration
- plug for motor-terminal plate in 2-wire and 4-wire configuration
- quick and easy exchange of wearing parts



Contacting of contact pins with Kelvin clamps



Contacting of contact pins with Kelvin clamps

Special contacting devices

SCHLEICH's strength lies particularly in the adaptation of test objects and their special contacting devices. Tester and mechanical components are manufactured to match your testing task precisely. We often use pneumatically controlled, extremely small Kelvin clamps or resilient contactings from our product range that follows a modular principle.

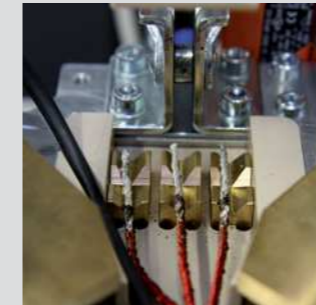
The design is performed at in-house 3D-CAD workplaces. State-of-the-art CNC machines guarantee the production of professional long-life components at low prices.



Basic contacting on a pallet



Special solution / contacting unit for leads



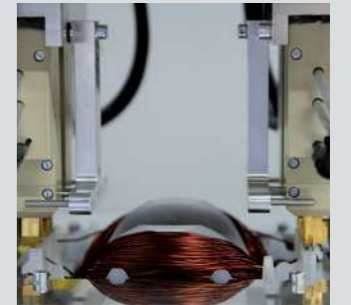
Contacting of motor-connecting wires



Contacting a test object from the top



Contacting of a PCB



Contacting of contact pins with Kelvin clamps



Contacting of clamps and plugs of all kinds

Refer to:

HV pistols and warning lamps	68
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Rolling tables



Rolling table with sloped table board and integrated HV test



Rolling table with sloped table board and drawer element



Rolling table with sloped table board, drawer element and cable holders

Highlights

- solid design / made of aluminum profiles
- steplessly adjustable table boards
- horizontal or sloped table boards
- sloped table board with horizontal front part, e.g. for a keyboard
- drawers with full extension, steplessly adjustable in height
- holders for test probes, steplessly adjustable in height
- holders for test leads, steplessly adjustable in height
- integrated LED warning lamps in the side bars – protected design
- the rolling tables are delivered completely mounted and ready-to-use

Rolling tables are ideally suited for transporting a tester or a combination of a tester and a test cover from one test object to the next. The large and stable rubber castors guarantee a good maneuverability. The optional handle at the front of the table is used for pushing and steering.

The rolling tables can be equipped with fully-extendable drawers, where you can store, for example, adapters, tools or documentation.



Rolling table with horizontal table board and handle



Rolling table with horizontal table board, handle and LED warning lamps integrated in the side bars



Rolling table with integrated test cover, handle, LED warning lamps in the side bars and holders for cables, test pistols and test probes



Rolling table with integrated test cover, drawer element and cable holders



Refer to:

HV pistols and warning lamps	68
Mains-connection adapters	70
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Black boxes

Black boxes are used for the daily check of your testing device. They are connected to the testing device and it is checked, whether the measured values match the values of the black box. If the values do not match, the tester is disabled. The tester will only be enabled after a black-box test with a "GO"-result. We only deliver testing devices with digital evaluation. Therefore, this test is not performed with a "GO / NO GO black box". We are using only one black box and evaluate the measured values within narrow tolerance limits.

Every black box consists of one connection for the tester and one or more resistances and/or inductivities. They can be designed either for one test method or for a combination of several test methods.

Every black box is delivered with the resistance values indicated and with a calibration certificate. This enables the operator to adjust the tests correctly.



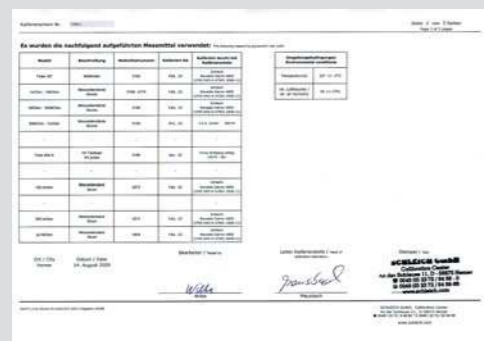
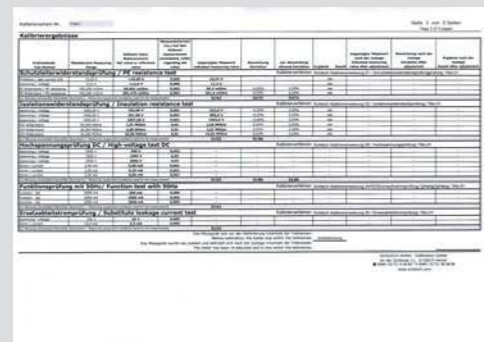
Black box for PE



Black box for PE/IR/HV



Black box HV for test-pistols



Calibration

For every company, the monitoring of the test equipment is very important. The regular calibration of your test equipment is an important pre-condition for assuring the quality of your products. Therefore, we calibrate the test equipment of our customers according to standards.

We offer three types of calibration:

- "In-House Calibration" means, we calibrate at the premises of the customer.
- "At-SCHLEICH Calibration" means, we calibrate in our factory.
- "Remote Calibration" means, we support the calibration in your factory via remote maintenance.

Calibrations are performed within the shortest possible time. If necessary, we can provide testing devices on loan for the duration of time we need for the calibration. If required, we can also calibrate devices from other manufacturers – this can save you costs.

If the calibration shows deviating measured values, the test equipment is adjusted. The adjustment is part of our service and is included in the delivery extent of a calibration. A calibration certificate documents the measured values before and after the adjustment.

Our calibrations are based on international standards. Of course, our ISO9001-certified Calibration Center also works with additional standards, like DIN EN ISO 10012 "Requirements for measurement processes and measuring equipment".

Calibration resistors

In addition to measuring instruments, precise calibration resistors are necessary for the calibration of testers. The calibration resistors enable the respective test currents for individual test methods and test voltages.

The high-precision resistors withstand high temperatures and have a long service life. In order to dissipate the heat resulting from high test currents or long-time measurements, all our calibration resistors are delivered in special heatsink enclosures. In addition, the resistors have a low-capacity and low-inductivity design.

All resistors for high test currents and low test voltages are designed in 4-wire configuration.

Every resistor is delivered with a calibration certificate indicating the resistance value, which can be used for calculations.



Calibration resistor in 4-wire configuration



Calibration resistor, high-voltage proof

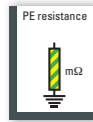


High-current resistor in 4-wire configuration

Refer to:

HV pistols and warning lamps	68
Test methods	94

Test methods



PE resistance

The PE test is performed at devices of protection class I. It is checked, whether the PE resistance is below the normative limit value.

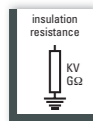
The test serves to detect, whether possible leakage currents inside the test object are grounded correctly. If the PE connection is not OK, this can result in too high a voltage at exposed metallic parts of the device.

In order to determinate the PE resistance, a very high AC test current (typically 10A or 25A/30A AC), conforming to standards, is led through the PE. Via the voltage-drop measurement at the PE resistance and the measurement of the test current, the tester calculates the PE resistance.

The PE test is performed with the precise 4-wire resistance measurement (Kelvin measurement). With this method, the resistance in the leads up to the test probe is compensated automatically.

PE tests are often performed by contacting the PE connection points manually with a PE test probe.

We supply testing devices with test currents up to 100A.



Insulation resistance

The insulation-resistance test is performed at devices of protection class I and protection class II. It is checked whether the ohmic insulation resistance exceeds the normative limit value.

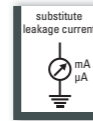
The test serves to detect, whether there is too high a leakage current in the test object. If the insulation resistance is too low or if there is a fault at the PE, this could cause too high a touch voltage at exposed metallic parts of the device.

In order to detect the insulation resistance, a test voltage (according to standards) as high as possible (typically 500V DC) is connected to the current-carrying leads (L+N) of the test object against PE. With the flowing current and the connected test voltage, the tester calculates the insulation resistance.

At devices of protection class II, the test is performed by means of a probe, which is held against the exposed metallic enclosure parts of the test object. In addition, the test can be performed between the current-carrying leads (L against N).

If required, the insulation-resistance test is performed with a security-current limitation to max. 3mA. This protects the operator if the test voltage is touched accidentally.

We supply testing devices with test voltages up to 40KV DC.

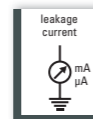


Substitute leakage current

Exactly like the insulation-resistance test, the substitute-leakage-current test is performed between the current-carrying leads L+N against PE. In contrast to the insulation-resistance test, the substitute leakage current test is, however, performed with AC voltage.

The test is called substitute-leakage-current test, because the test is not performed with the nominal voltage of the test object between L+N against PE, but with reduced test voltage. The test voltage and the leakage current are measured and afterwards the current is projected to the leakage current, that would be flowing with nominal voltage. It is checked, whether this leakage current is below the normative limit value.

I.e. it is checked with a low voltage, how the test object behaves under nominal voltage



Leakage current

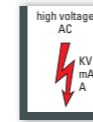
The leakage current test can be performed at devices of protection class I and protection class II. It is checked, whether, owing to the insulation, the leakage current is below the normative limit value.

For detecting the leakage current, the test object is usually operated with a test voltage "nominal voltage +10%". The tester selects the measuring circuit matching the required standard.

At devices of protection class I, the earth leakage current can be measured in the PE. At devices of protection class I and II, the enclosure leakage current can be measured with a test probe at many different exposed parts.

At electro-medical products, all necessary tests according to standard EN60601 and other international standards can be performed, as well.

An increasing number of electronic products is operated with electronic modules and switching power supplies. Through this, leakage currents with the frequency of the fundamental wave (50Hz / 60Hz) and, additionally, with the clock frequency and various harmonic waves of the electronic modules are flowing. For measuring these high-frequency leakage currents, we offer a leakage-current test up to 1MHz according to standards.



High voltage HV-AC

The high-voltage test with AC voltage serves to find insulation faults at electric products of all kinds.

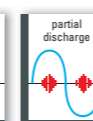
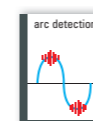
The level of the test voltage for the individual electronic products is determined in the respective standards.

Testing with AC voltage is the most common high-voltage test method. However, the HV-test with AC voltage has disadvantages, that have to be considered. If there is a parasitical capacity in the insulation of the test object, this will cause a capacitive current during the test. This capacitive charge-discharge current can be much higher than the leakage current through the ohmic insulation resistance R_{iso} , because R_{iso} is mostly highly resistive. The result is, that the charge-discharge current through the capacitor, strongly superimposes the fault current that normally should be measured. In addition, the charge-discharge current can affect the test object in a negative way.

The capacitive current is not a fault current caused by defective insulation, but inevitable based on physical facts. Because of the before mentioned points, it has to be kept in mind that the HV-test is more a breakdown test than an accurate measurement of the fault current via the insulation.

Touching currents over 3mA is for the operator potentially lethal. Testing devices with test currents over 3mA, therefore, must be operated with the respective safety measures. Suitable protection devices are safety test pistols or, ideally, test covers or test cages. High-voltage testers with currents below 3mA AC are referred to as "safety-current limited".

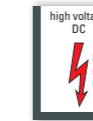
We supply testing devices with up to 100KV test voltage and high test currents.



Partial discharge / ARC detection with HV-AC

Partial discharge describes the discharges at insulations, which can not be identified right away through a disruptive breakdown when connecting the high voltage. Only part of the isolator is damaged. The field strength at this damaged spot becomes so large that there is a partial discharge (PD). The remaining, good insulation still withstands the connected test voltage. This type of fault is detected in the isolator via ARC detection or a special partial-discharge measuring technique. This test is of special importance for the production of electric motors in order to locate production errors, like damaged windings.

It is often tried to distinguish between "inner PD" and "outer PD". Outer PD occurs on surfaces – often between bare and damaged leads. Inner PD occurs within the insulating material, e.g. in the impregnating resin of the motor.



High voltage HV-DC

The DC high-voltage test serves to detect insulation faults at electric products of all kinds. The test with direct voltage can often be used as an alternative to the test with alternating voltage. In principle, this is the standard insulation-resistance test, often, however, with much higher test voltages. Therefore, a testing device evaluates either the current or the insulation resistance.

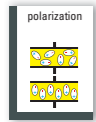
The capacitive current that is flowing during the test with alternating voltage, does not flow during the high-voltage test with DC. The capacities in the test object are charged only once. After this, only a leakage current is flowing through the ohmic resistance R_{iso} . The high-voltage test with DC thus allows more precise statements on the quality of the insulation than it would be possible with AC. Since no permanent capacitive charge reversal takes place, the test object is not affected too much.

It must, however, be noted that currents over 12mA are hazardous for the life of the operator. Testing devices, which can supply test currents over 12mA, must, therefore, be operated with the respective safety measures. Suitable protection devices are safety test pistols or, ideally, test covers or test cages. High-voltage testers with currents below 12mA DC are referred to as "safety-current limited".

The level of the test voltage for the individual electric products can be found in the respective standards. As a rule of thumb, however, the DC test voltage should be 1.5 times the AC test voltage.

We supply testing devices with test voltages up to 40KV.

Test methods



Polarization index

The polarization index is a very important value to determine the quality of the insulation, which deteriorates with increasing age of the motor.

Polarization is the ability of the charge carriers in the isolator to spin and align to the electric field – i.e. to polarize. The mobility of the charge carriers deteriorates with increasing age of the insulation. This results in deteriorated insulating properties and the motor is more likely to be damaged.

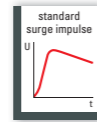
The force that is necessary to spin the charge carrier inside the isolator can be measured during the high-voltage test DC in the form of a small current.

The polarization of the charge carriers is not finished directly after connecting the test voltage – it can take up to 10 minutes. It is assumed that one minute after charging the capacity of the test object the polarization is still in process. The mobility of the charge carriers can thus be determined by the ratio between the strong spinning at the beginning and the reduced current after the spinning.

$$PI = \frac{\text{current}_{1\text{minute}}}{\text{current}_{10\text{minutes}}} \text{ or } \frac{\text{insulation resistance}_{10\text{minutes}}}{\text{insulation resistance}_{1\text{minute}}}$$

In case of a good isolator, the current has, after 10 minutes, decreased by four or five times, because all charge carriers have polarized. The result is a good PI of, for example, 4 to 5. In case of a bad isolator, the current has hardly changed after 10 minutes, because the immobile charge carriers can no longer polarize correctly. This results in a bad PI of, for example, 1.5. In this case, the device needs urgent maintenance.

After the polarization, therefore, the real current is measured through the insulation resistance. If the insulation resistance of a motor is measured too fast, the resistance is indicated too low, because you are still measuring the charging of the capacity of the test object and the polarization.



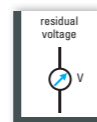
Standard surge impulse

The standard-surge-impulse test is another alternative to the high-voltage test AC and/or DC. The standard surge impulse is more like a lightning-impulse voltage.

The standard surge impulse has a temporal definition of the curve shape. Therefore, it is often defined as “1.2/50 impulse”. The two time values define the rise time and the falling time to half-value. The pulse shape during the test should differ from this definition only to a small extent.

The test impulse is created between the leads and between the lead and ground. During the test, the test impulse is applied between the leads and ground and/or successively between every lead and ground.

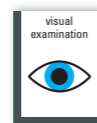
We supply testing devices with test voltages up to 6KV.



Residual voltage

The residual-voltage test serves to detect dangerous residual voltages at connection leads or at the mains plug of a test object after the mains voltage has been switched off.

Residual voltages are created through internal capacities inside the test object. For safety reasons, these electric charges must disappear within a time period defined in the standards.

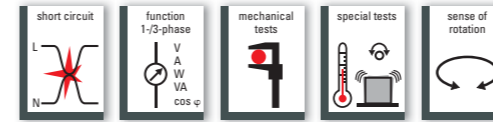


Visual examination

The operator checks and evaluates the test object visually. The result is entered manually at the tester.

In order to facilitate the testing procedure, it is, depending on the tester, possible to show digital photos on the monitor.

Visual examinations are performed as individual test steps or as combined test steps within a test process. Just like safety tests, the results of visual examinations are stored and documented in protocols.



Function

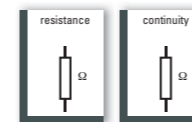
The safety tests are followed by the functional test. If the test object has no short circuit, the desired test voltage is connected to the test object.

The current consumption is the most commonly used criterion for the evaluation of the function. However, other electric variables, like power or phase shift can also be the basis of the evaluation. On top of that, it is possible to measure and evaluate other physical parameters like:

- RPM
- sense-of-rotation
- torque
- temperature
- pressure
- caliper measurement
- vibration
- noise
- flow rate
- optical measurements and more

Due to the modular design of our testing devices, we are in a position to offer both, simple functional tests and more complex and challenging functional tests, e.g. for vehicle drives.

We supply testing devices with functional tests up to 1000A.



Resistance

The ohmic resistance test is performed either in 2-wire configuration or in 4-wire configuration. With 2-wire configuration, the resistances of the test leads, the relay switch-overs and the contact points influence the test result. This variant is, therefore, only used for resistances over 1...10Ω – here, this fault is only a small percentage of the measured value.

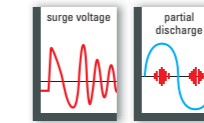
In order to compensate the contact resistances in the test leads and at the contact points, it is, for low-resistance test objects, always necessary to use the 4-wire measurement configuration.

For an optimum 4-wire contacting, we recommend Kelvin clamps and 4-wire test probes.

When measuring temperature-dependent resistances, e.g. at motor coils made of copper wire, it is necessary to consider the temperature. For this purpose, either the ambient temperature

or the temperature of the test object is measured. The measured resistances are converted to 20 degrees celsius temperature.

We supply testing devices with measuring ranges from 1μΩ to 1MΩ.



Surge voltage and partial discharge

For the surge test, the testing device connects a so-called surge capacitor to the desired test voltage. The testing device connects the charged capacitor abruptly to the winding to be tested. This takes only a few hundred nanoseconds. Subsequently, the surge capacitor and the winding to be tested form an RLC circuit. A surge oscillation, typical for the winding, appears in the RLC circuit.

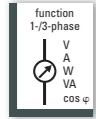
For fractions of seconds, there are high voltage differences from turn to turn inside the winding, which can cause local flashovers at possible damaged spots. This way, winding errors can be detected even visually.

Inside the tester, the surge curves are digitized and indicated on the screen.

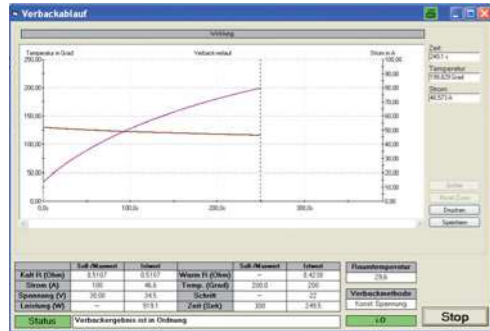
The evaluation takes place either through a visual examination by the operator or fully-automatically by the testing device. The automatic evaluation is based on the comparison between the windings of a stator or to a stored reference part.

Various automatic analyzing methods allow precise statements on the equality of windings. Short circuits in the windings or in the phases of the winding cause asymmetries of the surge curves. They are detected by the software and automatically evaluated GO or NO GO. The process is performed reliably and doesn't require any special knowledge from the operator.

We supply testing devices with test voltages up to 30KV.



Bonding

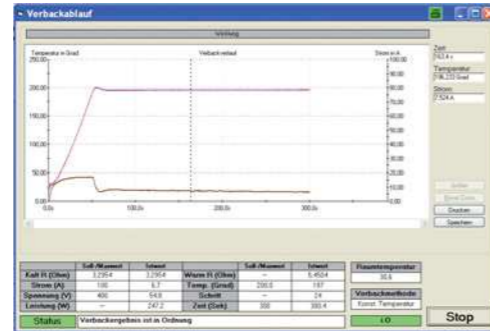


Bonding with constant voltage – constant-voltage method

A constant voltage is connected to the winding to be bonded. The growing heat causes the resistance of the winding to rise, which results in a decreasing current. An increase of the temperature thus has the effect that less power is released to the winding.

The advantage of this method is that the temperature rises relatively slow, allowing the stator to be heated up evenly. When reaching the bonding temperature, the temperature difference between winding head and slot is, therefore, optimally low.

Since the maximum current density in the wire is only reached at the beginning of the bonding process, it is possible to achieve very short bonding times.

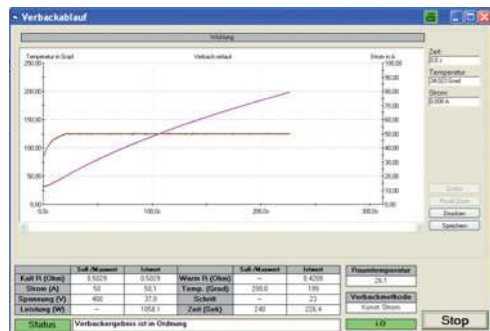


Bonding with constant temperature

If you use the constant-voltage method or the constant-current method, the bonding process stops as soon as the bonding temperature has been reached.

With these two methods, the time period, during which the coating of the enameled wire can melt and form a connection with the adjacent wires is relatively short. It is, therefore, possible that the wires are not bonded properly at those parts that go through the slot, because, owing to the winding head, at these points the wires are somewhat cooler.

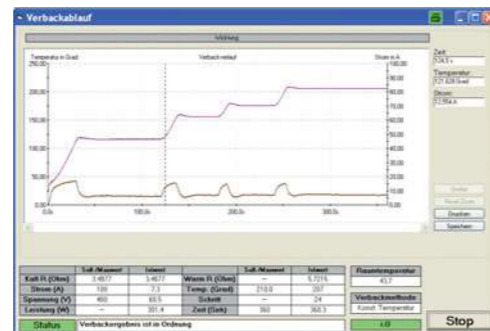
When using the constant-temperature method, after reaching the target temperature, the temperature is kept at a constant level for a certain period of time. This prolongs the time during which the coating of the enameled wire can melt and form a connection with the adjacent wires.



Bonding with constant current – constant-current method

During the bonding process, this method keeps the current at a constant level. Owing to the increasing resistance, the current decreases. In order to stabilize the current, the bonding machine increases the voltage continuously during the bonding process. For this reason, the final temperature is reached much faster than with constant voltage. However, the temperature in the winding may be distributed unevenly.

The advantage of this method is that you can reach very short bonding times. In most cases, however, the temperature is distributed unevenly.



Bonding with temperature profile

In principle, bonding with a temperature profile corresponds to bonding with constant temperature. With this method, however, the process has several temperature steps.

The temperature difference between winding head and slot can be balanced, even in case of low initial temperatures, before starting the bonding process.

This method is primarily used in case of very long stacks compared to very short winding heads and/or if the stack is very large.

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|-------------------|--------------------|---------------|
| ABB | Grundfos | Salmson |
| AEG | Hanning | Saeco |
| Arcelik | Heidelberger Druck | Salzgitter AG |
| Airbus Industries | HILTI | Sauer-Danfoss |
| Alcatel | Hirschmann | Schabmüller |
| AMK | IFM | Severin |
| Ansorg | Ihne + Tesch | SEW |
| ATB | Indramat-Rexroth | Siemens |
| Audi | Juno | Siteco |
| AUMA | Jungheinrich | Stahl |
| Aumann | KaVo | Staff |



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| Becker Antriebstechnik | Kärcher | Stöber |
| Bega | Kress | TCM |
| Bernal Tore | KSB | Tecumseh |
| BMW | Leica | TEE |
| Bosch | Lenze Antriebstechnik | Trilux |
| Braun | LEONI | TÜV |
| BSHG | Liebherr Aerospace | UPS |
| Continental | Lufthansa | USK |
| Daimler | Maiko | Vaillant |
| Danfoss | MDEXX | Vestas |
| DAL | Miele | VDE |
| Dematig Cranes | Murr Elektronik | Vossloh-Schwabe |
| DOM | Nettelhof | VW |
| Dometic | Nilfisk | WAP-ALTO |
| Durst | Novoferm Tore | WDR |
| E.G.O. | Oase Pumpen | Weidmüller |
| Electrolux | Ocean | WEG |
| Elmotec | Opel | WILO |
| ELNOR | Osram | XHL |
| Embraco | Papst | Zanussi |
| EMU | Philips | Zeiss |
| Enercon | Philips medical | ZF |
| Engel | Phoenix | Zumtobel |
| ERCO | Preh | |
| Fagor | Premiere | |
| Festool | Q.Cells | |
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| Franklin Electric | Rexroth | |
| Gildemeister | Rittal | |
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