Technical Specification

System: Transformer test system and extension for applied voltage testing
Type: WV 80-250/3.7

Offer No.: A-113047-00

Date: 2014-08-12

System description

The transformer test system is designed to test distribution transformers in test field. The following tests can be performed at three-phase and single-phase distribution transformers according to IEC 60076:

Test	Standard	Test object[1)]
Induced voltage test	IEC 60076-3, pos. 12	up to approx. 2.5 MVA
No-load losses test	IEC 60076-1, pos. 10.5	up to approx. 2.5 MVA
Load losses / short-circuit test	IEC 60076-1, pos. 10.4	up to approx. 2.5 MVA
Temperature rise test	IEC 60076-2, pos. 5	up to approx. 2.5 MVA
Applied voltage test	IEC 60076-3, pos. 11	up to approx. 2.5 MVA

1) Due to the wide variation of parameters of the test objects, the given statements concerning testable devices are a rough estimation. The system parameters listed in the given Technical Specification are binding parameters and shall be used for exact calculation of the testing performance.

The test field is designed to perform routine and heat-run tests for distribution transformers with following parameters:

For 3-phase transformers:

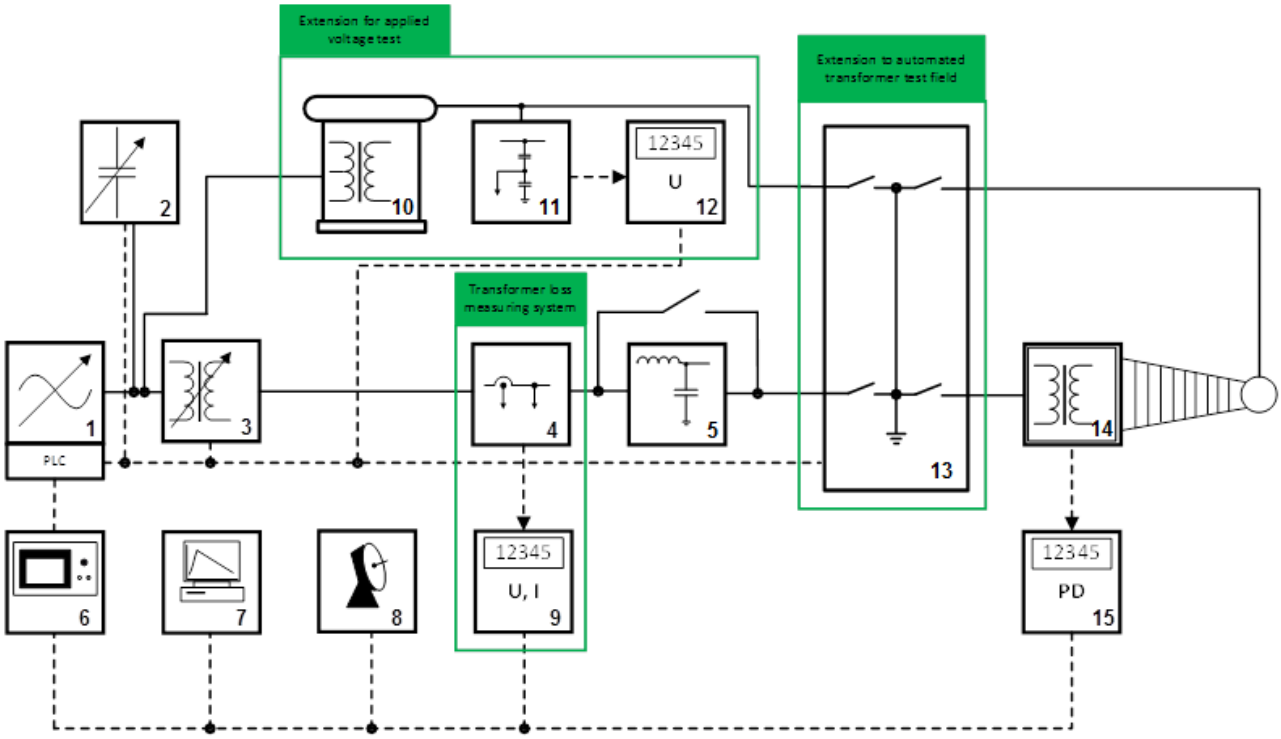
Rated power: 25 kVA to 2500 kVA
Voltage of high-voltage side: 3.6 kV to 36 kV (phase to phase)
Voltage of low-voltage-side: 230 V to 1000 V (phase to phase)
Impedance voltage: 4 % - 8 %

For 1-phase-transformers:

Rated power: 20 kVA to 800 kVA
Voltage of high-voltage side: 3.6 kV to 20 kV (phase to phase or phase to ground)
Voltage of low-voltage-side: 250 V to 1000 V (phase to phase or phase to ground)
Impedance voltage: 4 % - 8 %

Considering the wide range of requested test voltages and powers applies:

- feeding of the test system by a static frequency converter of variable frequency and variable output voltage with a related step-up transformer.
- multiple application of certain components for different tests in order to reduce space requirements.
- compact design, fully assembled and mounted on steel frame (suitable for forklift).



1 Static frequency converter	7 Industrial PC	13 Extension to automated transformer test field
2 Low voltage comp. unit	8 Remote access module	
3 Step-up transformer	9 Power analyzing unit	14 Test object *)
4 Voltage / current sensors	10 HV transformer	15 PD measurement system
5 Medium voltage filter	11 HV divider	
6 Operator device	12 Peak voltmeter	

*) Not included

**) Optional

Fig. 1 Block diagram of test system

The static frequency converter (1) provides the active power and supplies a sinusoidal voltage with variable amplitude and frequency.

The integrated low voltage capacitive compensation unit (2) increases the capacitive reactive power to compensate the inductive reactive power of the device under test.

The step-up transformer (3) transforms the lower output voltage of the static frequency converter into the needed test voltage. Voltage stage adaptation is possible by an automatic off-load tap changer.

An operator device with operator panel (6) is used as basic control. The control system can be completed by an industrial personal computer (7) with control software for data collection and evaluation.

The Transformer loss measurement system consists of the power analyzing unit (9) with integrated voltage and current sensors (4). It is used for measurement of test voltages and losses in the test object. It collects the data of voltage, current and other related parameters of the transformer under test. By a separate connection to a personal computer further data evaluation and test report generation is possible.

System parameters:

3-phase		
Rated voltage[1] (phase-phase)	V	40 – 3700 (3~), 8 steps
Rated apparent power continuously	kVA	80
Rated active power[2] (continuously)	kW	80
LV compensation (continuously)	kVA	250
2-phase		
Rated voltage[1] (phase-phase)	V	40 … 3700 (2~), 8 steps
Rated apparent power continuously	kVA	45
Rated active power[2] (continuously)	kW	45
LV compensation (continuously)	kVA	140
1-phase		
Rated voltage[1] (phase-ground)	V	25 … 2100 (1~), 8 steps
Rated apparent power continuously	kVA	45
Rated active power[2] (continuously)	kW	45
LV compensation (continuously)	kVA	140
Frequency	Hz	40 … 220 ± 0.1 Hz
Sound level	dB(A)	83 at 1 m
Mains supply[3][4][5]		3NPE
	V	400 ± 10 %
	Hz	50/60 Hz ± 1 Hz
	kVA	100[6] from stiff network
Dimensions and weight (approx.)		
Length (L)	mm	3500
Width (W)	mm	2500
Height (H)	mm	2800
Weight	kg	7500
Installation		Indoor, movable

Applied voltage tests

Rated voltage	kV	70
Rated current	A	0.4
Duty cycle		1h ON / 1h OFF / 6x per day

1) tap voltages according to the step-up transformer specification
2) @ cosφ =1
3) The PD level at the mains supply provided by the customer should be < 100 pC.
4) recommended u_K of distribution transformer below 6 %
5) No current-operated earth-leakage protection

The system is designed for the following environmental conditions:

Indoor use only

Ambient temperature		
for HV components and static frequency converter	°C	5 … 40 (above 40 °C with reduced parameters)
for controls, etc.	°C	10 … 25
Daily mean temperature	°C	≤ 35
Max. relative humidity	%	95 (no condensation on surfaces)
Height above sea level	m	≤ 1000 (at higher altitude with reduced system parameters)
Ambient temperature for storage and transportation	°C	-10 … 50
with additional electrical cubicle heaters	°C	-25 … 50

The dielectric strength of the external insulation of the test system applies to the following climatic conditions:

Atmospheric pressure	MPa	0.1
Temperature	°C	20
Atmospheric humidity	g/m³	11

Scope of supply

Item	Pieces	Description	Sheet[1)]	HG
1	**1**	**Power supply and regulation**		
1.1	1	Control and feeding converter CFI 80-80		57
2	**1**	**Low voltage compensation unit**		
2.1	1	LV compensation unit LVCC 250		89
3	**1**	**Step-up transformer**		
3.1	1	Step-up transformer		11
3.2	1	Automatic off-load tap changer		11
4	**1**	**Control and measuring system CMS 23TT**		
4.1	1	Operator device BG 8TT E	1.61	51
4.2	1	Computer control consisting of:		53
	1	Industrial PC (English) for OD		
	1	Software for computer-aided testing HV Suite including Test Bay Commander		
	1	Remote diagnostics and access module RDA 23	1.56	
4.3	1	Operator desk OD 200	7.31	56
4.4	1	Transformer loss measuring system		42
5	**1**	**Option: MV Filter and PD measuring system**		
5.1	1	Option: Medium voltage filter MVF 3-16		
5.2	3	Option: AC coupling capacitor consisting of:		34
	1	Option: AC capacitor WC 0.1/100	1.31	
	1	Option: PD measuring impedance MIVC 5	6.54	
5.3	1	Option: PD analyzer PiDAS MPD 600/3 consisting of:		41
	1	Option: Digital PD measuring basic device	6.50	
	3	Option: Sensor Unit MPD 600	6.50	
	1	Option: base software iDAS	6.50	
	1	Option: PD calibrator CAL 542 C	6.50	
	2	Option: FO cable 5 m		
	1	Option: FO cable 50 m		
	3	Option: Power pack		
	1	Option: Additional software package for transformers iDAS-TRA	6.50	

6	**1**	**Option: Extension for applied voltage testing**		
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	1	Option: AC capacitor WC 0.1/100	1.31	
	1	Option: LV measuring branch MC	5.20-1i	
6.3	1	Option: HV connections / earthing devices consisting of:		62
	1	Option: Connecting element VE 1	4.9	
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6.5	1	Option: DAkkS calibration of alternating voltage measuring system	10.31	91
6.6	1	Option: DAkkS calibration certificate		91
7	**1**	**Option: Equipment for the automatic transformer test field**		
7.1	1	Option: Set of remote-controlled disconnector switches		21
7.2	1	Option: Set of accessories for disconnector switches		
7.3	1	Option: Auxiliary control cabinet		21
7.4	1	Option: Supervisory module		21
8	**1**	**Special accessories**		
8.1	1	Power, control and measuring cables		61
8.2	1	Safety equipment (provided by the customer)		73
8.3	3	Rod for earthing ES 1	4.11	62
8.4	1	Steel frame		
9	**1**	**Miscellaneous**		
9.1	1	Documentation (paper copy)		98
9.2	1	Transportation packing (sea freight)		98
9.3	1	Factory acceptance test		96

Description of items

Item	Pieces	Description	
1	**1**	**Power supply and regulation**	
1.1	1	Control and feeding converter CFI 80-80	HG 57

The control and feeding converter CFI 80-80 is used as an AC power supply with variable output voltage and frequency. The converter can operate with two or three active output phases.

The heart of the CFI 80-80 is a three-phase converter with a LC-Filter at the output side. The three-phase line voltage is rectified and boosted up by an active front-end line inverter. The direct voltage is buffered by a capacitor bank. The output inverter generates sinusoidal modulated voltage pulses of adjustable frequency. A power sine wave filter is used to filter the fundamental wave. The converter generates a sinusoidal output voltage of adjustable frequency and amplitude with a low THD at rated output voltage. It is characterized by:

- control system with programmable logic controller (PLC)
- control of test voltage using high accuracy measuring system
- precise regulation of output voltage with "closed loop"
- preselection of output voltage (rms value) and frequency
- application of extended control features
- connection of a laptop for advanced control and measuring features

Main parameters:

Output voltage	V	40 … 400
Rated current	A	115
Frequency	Hz	40 ... 200
Power factor		0.2 cap ... 1 ... 0.2 ind
Mains supply		3PE [1]
	V	400 ± 10 %
	Hz	50/60
	kVA	100 from stiff network
	kVA	160 from diesel generator
THD output voltage	%	≤ 5 [2]
Dimensions (approx.)		
Length (L)	mm	1000
Width (W)	mm	600
Height (H)	mm	2000
Total weight (approx.)	kg	850

1) power supply without RCD-protection required
2) at rated voltage of the CFI; the THD depends on the harmonic current of the inverter and its output impedances

2 1 Low voltage compensation unit

2.1 1 LV compensation unit LVCC 250 HG 89

The LV compensation unit is applied to increase the reactive power capacity of the transformer test system type WV. Since the power capacity of the CFI-inverter is limited, the capacitive group of the compensation unit can be applied for load losses tests and heat-run tests of distribution transformers.

The LV compensation unit is connected in parallel to the output of the CFI-inverter. The selection of the proper compensation group is done automatically by the PLC.

Main parameters:

Rated voltage	V	400 (3~ / 2~)
Rated power	kVar	250 cap.

3 1 Step-up transformer

3.1 1 Step-up transformer HG 11

The step-up transformer (together with the appropriate compensation) is designed to feed the test object in transformer test circuits with well adapted power and voltage. It is used for induced overvoltage tests as well as for no-load and load losses tests.

An additional low-amp HV-winding is used to generate a test voltage for the applied voltage test on LV-windings on distribution transformers.

Main parameters:

Input		
Rated voltage	V	400
Rated current	A	500
Frequency	Hz	40 ... 220 @ rated parameters
Impedance voltage at 50Hz	%	approx. 7.0
Cooling		AN
Output 1		
Rated voltage (3~) (ph-ph)	V	470 ... 3700 (8 steps)
Rated current	A	500 ... 58 (depending on taps)
Output 2		
Rated voltage (1~) (ph-earth)	V	3300
Rated current	A	1.5

3.2 1 Automatic off-load tap changer HG 11

The automatic off-load tap-changer is used to change the output-taps of the step-up transformer automatically. It allows fast adaption of the needed output voltage at powered-off status.

To protect the switches against negative ambient influences such as dirt or humidity they are encapsulated.

The switches have to be considered as wear parts. They are installed at well accessible positions for quick and easy exchange after service life.

Switches only from selected suppliers are used to ensure high level of quality. The high quality is ensured by service life tests in HV test laboratory.

4 1 Control and measuring system CMS 23TT

4.1 1 Operator device BG 8TT E HG 51

The operator device is used to operate test systems for transformer testing based on static frequency converters. This device is designed as plug-in 19" unit. It contains a SIEMENS operator panel which acts as a Human Machine Interface (HMI) between the operator and the test system. The panel has a high-resolution 16 million colors widescreen touch screen with a large viewing angle and the capability of dimming backlight. Furthermore, it ensures an easy handling, operation and visualization of the test system. Manual and simple automatic test procedures can be carried out.
The communication between the operator device and the test system is realized via a fiber-optic link (ETHERNET) to eliminate electromagnetic interferences.

Main functions:

- emergency stop pushbutton
- control on/off
- main operating switch on/off
- status indication of main/operating switch
- status, warning and failure messages of the test system
- voltage increase/decrease
- preselection of test voltage, frequency and test time
- preselectable regulating speed
- limits for voltage and current for system protection
- operation of compensation (optionally)
- password protection of essential system settings

Main parameters:

Supply voltage	V	230
Frequency	Hz	50/60
Operating temperature	°C	5 ... 40
Operating humidity (rel.)	%	≤ 95, no condensation
Display resolution	pixel	800 x 480
Dimensions (approx.)		
Width	mm	462
Height	mm	293 (6 HU)
Depth	mm	440
Weight	kg	9
Interface		ETHERNET, fiber optic

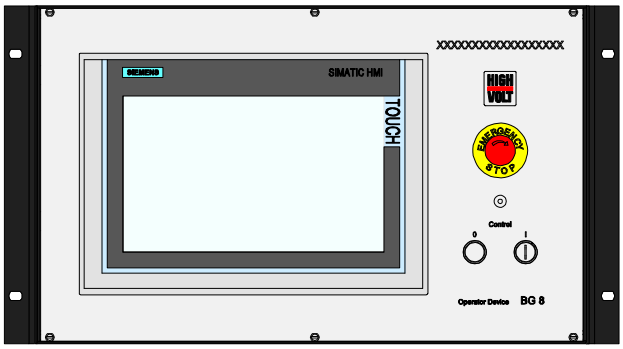

Fig. 2 Schematic sketch of operator device as plug-in 19" unit

4.2 1 Computer control HG 53
consisting of:

1 Industrial PC (English) for OD

The industrial computer is characterized by:

- central processing unit with up-to-date clock frequency
- working memory (RAM) with up-to-date capacity
- hard disk with up-to-date capacity
- DVD-R/W drive
- network adapter: 10/100 Mbit, optical
- plug-in 19"-unit with a height of 4 HU
- keyboard (wireless, English) / mouse
- display: TFT, 19"-diagonal, 19"-built-in
- uninterruptible power supply (UPS) for controlled shutdown
- MS operating system (English)
- MS Office Basic ® (English)

1 Software for computer-aided testing HV Suite including Test Bay Commander

The software is able to capture, process, store and log numerous measurement results when testing several devices with several systems.

It greatly simplifies the procedure as all the included test systems and measurement devices are operated by an intuitive, full-automatic control unit.

Thus, the test systems can be controlled using a standard user interface and the measurement results can be stored in a central database.

The software for computer-aided testing including Test Bay Commander is designed for HVAC testing with variable frequency. It can control different components/sub-systems of the test system via one IPC/Laptop.

Supported features are:

- operation of the HVAC test system
- voltage measurement
- compensation control (as far as included)
- check of the safety circuits; information about feedings and test circuit
- recording of data and printing of the protocol
- help functions

The advanced software including Test Bay Commander enhances the performance of the test system significantly.

Advanced features in this version are:

- full automation of test procedures
- application MANUAL Test (manual test control including data recording)
- application FREETEST (up to 20 predefined voltage steps with variable step height, test frequency and duration)

Remark: A proper operation of the software can only be guaranteed if the IPC/Laptop.

1 Remote diagnostics and access module RDA 23

The remote diagnostic and access module is a hard- and software package which can be incorporated in HV control system based on SIMATIC S7.

- technical support
- software updates
- trouble shooting

The above mentioned service is included for 1 year.

HV will be enabled to check the complete control system via RDA 23 and can react quickly on-line.

Remark: The internet access has to be supplied by the customer.

4.3 1 Operator desk OD 200 HG 56

The desk is provided for equipment for control and measurement. The desk top as well as the center piece is made of a sandwich material, the latter with additional shielding sheets.

Main parameters:

Material		aluminium / steel sheet / sandwich
Color		light and black grey
Dimensions (approx.)		
Width	mm	2036
Depth	mm	1100
Height	mm	1215
Total weight (approx.)	kg	250

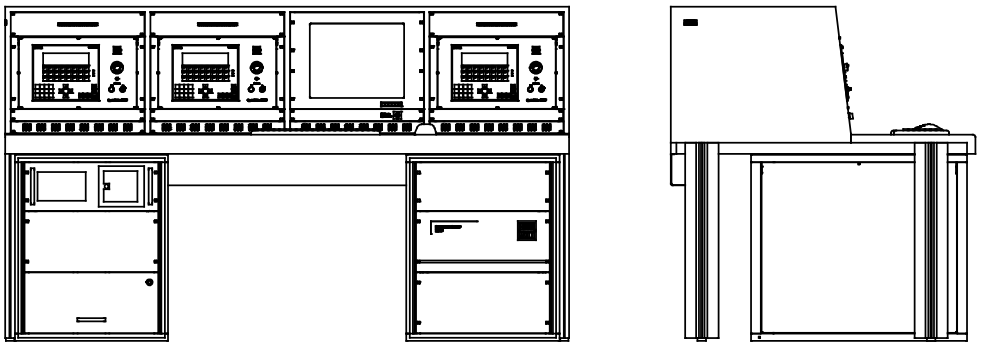

Fig. 3 Schematic sketch

4.4 1 Transformer loss measuring system HG 42

The Transformer loss measuring system is developed for accurate measurement of power losses in transformers. The set consists of three voltage measuring units and three current measuring units. The optimal measuring range for the test can be adjusted manually or set to change automatically. An additional safety function,

including protection of the test transformer and the measurement system, completes the Transformer loss measuring system.

Each measuring unit is connected to a central control unit. The measured values are displayed on the PC.

The control unit offers a communication protocol and is used to save all measured data into a documentation file. This matched equipment set enables a fully software-controlled test sequence and helps to optimize the operating procedure in the test field.

Main parameters:

Primary voltage	kV	0.1 … 5 (phase-phase)
Primary current	A	1 … 1000
Power measurement accuracy		
cos φ = 1	%	0.3
cos φ = 0.1	%	1
Environmental conditions		
Operating temperature	°C	+10 ... + 40 (HV components)
		+15 ... + 30 (control desk or rack)
Relative humidity	%	80 (no condensation)

5 1 Option: MV Filter and PD measuring system

5.1 1 Option: Medium voltage filter MVF 3-16 HG

The MV filter is used during induced voltage tests in combination with the PD measuring system. It suppresses the disturbances, caused by the static frequency converter and other background noises. The MV filters consist of a L-C combination arranged in vertical position with L serving as blocking impedance.

Main parameters:

Rated voltage	kV	0 ... 3 (phase-earth)
Rated current	A	16
Number of filter stages		1
Max. filter frequency	Hz	220
Attenuation @ f ... 30kHz	dB	8

5.2 3 Option: AC coupling capacitor HG 34
consisting of:

1 Option: AC capacitor WC 0.1/100

The stationary HV capacitor is designed for indoor operation. HV capacitor consists of 1 stage, a HV top electrode and a base frame. The capacitors have a PD-free, liquid-impregnated paper or foil-paper insulation inside a GRP tube. The thermal expansion of the liquid is compensated by means of special bellows.

Main parameters:

Rated voltage	kV	100
Rated capacitance	nF	0.1
Frequency range	Hz	20 … 300

Dimensions (approx.)		
Diameter (D)	mm	188
Height (H)	mm	970
Footprint (A x A)	mm	435 x 435
Weight (approx.)	kg	11

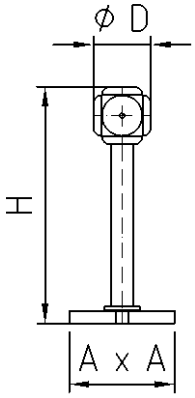

Fig. 4 Schematic sketch of HV capacitor

1 Option: PD measuring impedance MIVC 5

The impedance is designed for an optimized frequency response. Together with the test object and a coupling capacitor it forms a PD circuit in accordance with IEC 60270:2000.

Connected measurement devices are reliably protected from dangerous overvoltages. Equipped with a voltage output, the measuring impedance synchronizes the PD measuring system to the high voltage. An adaption of the internal low voltage capacitor to the capacitance and the rated voltage of the coupling capacitor is done by internal jumpers.

Main parameters:

Max. current	A	5
Max. voltage of voltage signal	V	60, peak value
Low voltage capacitance	µF	10 ... 120, adjustable in steps of 10 µF
PD output	kHz	25 ... 18000
Connectors		
Input		2x Banana
Output		2x BNC for PD and voltage signal
Material		extruded aluminum
Dimensions (approx.)		
Length	mm	210
Width	mm	110
Height	mm	58

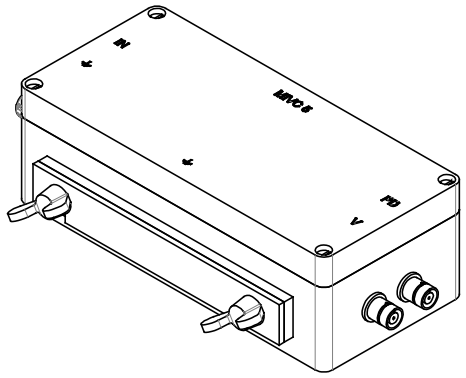

Fig. 5 Schematic sketch of measuring impedance

5.3 1 Option: PD analyzer PiDAS MPD 600/3 HG 41
consisting of:

1 Option: Digital PD measuring basic device

The MPD 600 Partial Discharge Analysis System is a high-end, high-precision, modular acquisition and analysis toolkit for detecting, recording, and analyzing partial discharge (PD) events in many applications. Its versatility and robustness make the MPD 600 system equally well-suited for laboratory and on-site measurements of high-voltage cable systems, power transformers, switchgears and rotating machines. Advanced monitoring features and the MPD600's extraordinary scalability uniquely position the system for large-scale deployment, for example in power grid applications. The MPD 600 system employs the unique high-speed fiber optical network technology, which provides superior safety, scalability and synchronicity between acquisition units. High-resolution digital processing technology delivers exceptional measurement accuracy. The easy-to-use integrated software features various real-time visualization and analysis options, giving the user full control over all PD detection and analysis parameters.

The MPD 600 system consists of a measurement unit, an USB controller and the sophisticated software. USB 2.0 technology allows for seamless plug-and-play with any recent commercial off-the-shelf PC, including desktop, rack-mount, and laptop computers. The system can be expanded easily by adding additional acquisition units. The fiber optical network provides extraordinary scalability by allowing up to 960 fully synchronized acquisition units to be connected to a single control PC. Each network segment can be up to 2 km in length, allowing large distances between PD detection locations. True plug-and-play functionality means that acquisition units can be added to a fielded MPD 600 system easily, keeping service disruptions to a minimum.

Main features:

- supports frequency domain and time integration
- charge evaluation fully compliant with IEC 60270
- high measurement accuracy due to completely digital data processing
- recording and playback of measurements with full function control

Ambient conditions and dimensions:

Relative humidity	%	5 … 100, no condensation
Ambient temperature		
Operation	°C	0 … 55
Storage	°C	-10 … 70
Dimensions of sensor (approx.)		
Height	mm	44
Width	mm	110
Length	mm	190
Total weight of sensor (approx.)	kg	0.6

3 Option: Sensor Unit MPD 600

The digital PD acquisition unit provides PD measurement at most modern digital PD acquisition technology. Fiber optic connection between the acquisition unit and the USB converter avoids any interference to the measuring cable and ensures loss-free data transfer. During battery operation no noise from mains power supply enters the measuring circuit. This way the measurement unit can also operate at high-voltage potential.

Main parameters:

Power supply	V	8 … 12 DC
Max. power dissipation	W	4
Stand-by	mW	< 10
External charger included		110 … 240 V, 50/60 Hz
Plug connection cable		type CEE 7
Fiber optics connectors		1 fiber optical network (master/slave)
Input connectors		2 BNC low-frequency voltage input (V), high-frequency partial discharge input (PD)
V input		
Frequency	kHz	0 … 2.1
Impedance	MΩ	1
Maximum voltage	V	60 (rms)
Dynamic range	dB	102
PD input		
Frequency	MHz	0 … 20
Impedance	Ω	50
Maximum voltage	V	10 (rms)
Dynamic range	dB	132 overall
	dB	70 per input range selection
PD input range control	dB	7.4 gain per level; 11 levels
System noise	pC	< 0.015
PD event time resolution	ns	< 2
Max. double pulse resolution	ns	< 200

1 Option: HV base software iDAS

The integrated software running on a PC receives data from each unit via the fiber optical network for analysis, display, and storage. The software is also responsible for controlling and configuring the acquisition units, and for performing timed measurements during PD monitoring.

All data acquired by the acquisition units during a measurement session, including PD event data, PD input data, and voltage data, can be recorded to a file in real time. All visualization options that are available during on-line operation are also available during measurement session replay. Additionally, stored sessions offer the possibility for extensive off-line analysis that is not bound by real-time computational constraints.

iDAS is designed to work in an integrated environment together with HV control to enrich it with functionalities for fully automatic partial discharge measurement. This includes improved possibilities in reporting.

1 Option: PD calibrator CAL 542 C

The PD calibrator generates charge pulses required for calibration of the PD measuring circuits by steep voltage steps injected into a capacitor. It is designed and calibrated according to IEC 60270.

Main parameters:

Range of charge pulses pC 10 … 1000

2 Option: FO cable 5 m

The Duplex fiber optical cable is used for connection between the acquisition units or between acquisition unit and basic device.

1 Option: FO cable 50 m

The Duplex fiber optical cable is used for connection between the acquisition units or between acquisition unit and basic device.

3 Option: Power pack

The power pack consists of a battery pack of type MPP 600, a battery charger and the necessary cables.

- extruded aluminum
- 110mm x 170mm x 28mm
- 11 V, 4.8 Ah, Li-On rechargeable
- 12h battery life time

1 Option: Additional software package for transformers iDAS-TRA

The software supports a special transformer testing mode with adapted analyzing tools, e.g. 3-PARD©.

6 1 Option: Extension for applied voltage testing

6.1 1 Option: Test transformer T 100 HG 11

The test-transformer is an insulating case design with oil insulation. The oil-filled case is a fiberglass reinforced plastic (FRP) tube with steel covers. The lower cover is connected to the grounded base frame, the upper cover carries the HV potential and is connected to the top electrode. The exciting winding is divided into two parts. For the rated voltage the two parts are switched in parallel, for voltages up to 50 % they might be switched in series to improve the voltage adjustment.

It is equipped with a transfer winding which allows to form HV transformer cascades for higher voltages. The internal partial discharge (PD) level of insulating case transformers is very low. Therefore they are well suited for PD measuring circuits.

Contrary to other HV modules, the transformer does not need to be complemented by junction- or base-elements.

Main parameters:

Rated voltage	kV	100
Primary voltage	V	230
Rated power at		
Continuous operation	kVA	6.6
1h ON - 23h OFF	kVA	11
Frequency	Hz	50/60
Dimensions (approx.)		
Diameter (D)	mm	500
Height (H)	mm	980
Total weight (approx.)	kg	270

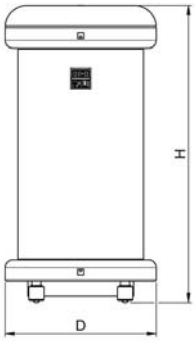

Fig. 6 Schematic sketch of T 100

6.2 1 Option: AC measuring divider HG 31
consisting of:

1 Option: AC capacitor WC 0.1/100

The stationary HV capacitor is designed for indoor operation. HV capacitor consists of 1 stage, a HV top electrode and a base frame. The capacitors have a PD-free, liquid-impregnated paper or foil-paper insulation inside a GRP tube. The thermal expansion of the liquid is compensated by means of special bellows.

Main parameters:

Rated voltage	kV	100
Rated capacitance	nF	0.1
Frequency range	Hz	20 … 300
Dimensions (approx.)		
Diameter (D)	mm	188
Height (H)	mm	970
Footprint (A x A)	mm	435 x 435
Weight (approx.)	kg	11

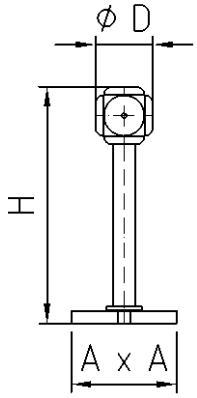

Fig. 7 Schematic sketch of HV capacitor

1 Option: LV measuring branch MC

The low-voltage measuring branch is a small metal cubicle mainly containing the LV capacitor itself and special components for overvoltage protection. It forms together with a HV capacitor (separate HV capacitor, HV bushing tap, HV measuring probe, etc.) the capacitive HV measuring divider. The LV output signal supplied by connector of type N 50 Ohm fits to the input requirement of the AC/DC peak voltmeter to achieve a high measuring accuracy in full accordance with IEC 60060-1 and IEC 60060-2.

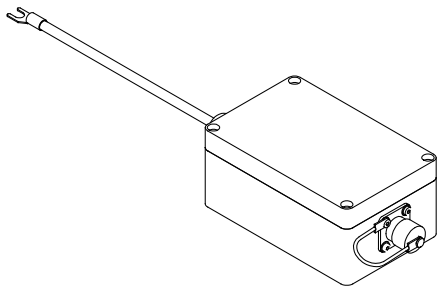

Fig. 8 Schematic sketch of low-voltage measuring branch MC

6.3 1 Option: HV connections / earthing devices HG 62
consisting of:

1 Option: Connecting element VE 1

The connecting element is used as electrical connection.

Main parameters:

Rated voltage	kV	140
Dimensions (approx.)		
Length (L)	mm	722
Diameter (D)	mm	60.3
Total weight (approx.)	kg	3.2

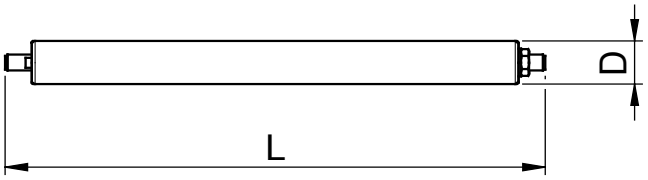

Fig. 9 Schematic sketch of VE 1

1 Option: Rod for earthing ES 1

The ES 1 is designed for earthing and short-circuiting of AC test systems. The test system has to be switched off before the rod for earthing can be used. It is designed for indoor operation.

Main parameters:

Dimensions (approx.)		
Length total (l_g)	mm	1125
Length handle (l_h)	mm	300
Length isolation (l_i)	mm	700
Weight (approx.)	kg	4

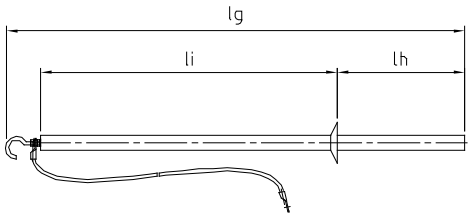

Fig. 10 Schematic sketch of ES 1

6.4 1 Option: AC/DC peak voltmeter MU 18 HG 32

The peak voltmeter MU 18 is designed as built-in unit. It is used for all measurements of AC and DC voltages especially in HVAC and HVDC test systems in connection with HV dividers.

The measured voltage is displayed on the operator device and/or control computer of the system control. All pre-selection as well as handling the measured data and the display is also done via the operator device or control computer.

Advantageous for practical measurements is the immediate storage of the latest value in case of a disruptive discharge at the test object.

The unit MU 18 is always built into another device of the HV control system.

The AC/DC peak voltmeter is in accordance with the related international standard IEC 60060-2.

The peak voltmeter is calibrated according to IEC 60060-2 by the HV Calibration Laboratory D-K-19153-01-00, accredited by the German Accreditation Service DAkkS. A respective DAkkS calibration certificate is issued. The certificate documents the traceability to national standards, which realize the units of measurements according to the International System of Units (SI).

Main parameters:

Input voltage	V	0 … ±1000
Input impedance	MΩ||pF	10||50
Frequency range	Hz	10 … 500 and DC
Measuring uncertainty	%	≤ 0.5
Temperature range	°C	5 … 40
Relative humidity	%	10 … 80
Input connector		coaxial, type N
Scale factor		typical 1...20000; possible 1...9.999E09

6.5 1 Option: DAkkS calibration of alternating voltage measuring system HG 91

The HV calibration laboratory D-K-19153-01-00 is accredited by the German Accreditation Service DAkkS according to DIN EN ISO/IEC 17025:2005. The DAkkS is signatory to the multilateral agreements of the European co-operation for Accreditation (EA) and of the International Laboratory Accreditation Cooperation (ILAC) for the mutual recognition of calibration certificates.

The laboratory performs the calibration according to IEC 60060-2 by comparison measurement against reference standards.

The assigned scale factor of the measuring system is determined and it is verified if the measurement uncertainty is within the limits of ± 3 % defined in IEC 60060-2.

The measurement uncertainty is estimated according to the ISO/BIPM guide GUM ("Guide to the Expression of Uncertainty in Measurement").

6.6 1 Option: DAkkS calibration certificate HG 91

Subsequent to the calibration a DAkkS calibration certificate in English language is issued. The certificate documents the traceability to national standards, which realize the units of measurements according to the International System of Units (SI).

7 1 Option: Equipment for the automatic transformer test field

7.1 1 Option: Set of remote-controlled disconnector switches HG 21

The change of test set-up for different tests (load and no-load-loss, induced voltage, applied voltage) is performed by various types of remote-controllable disconnect switches mounted on a steel frame. The size of the frame and the layout of the switching devices will be determined during order processing and after consultancy according to the situation on site.

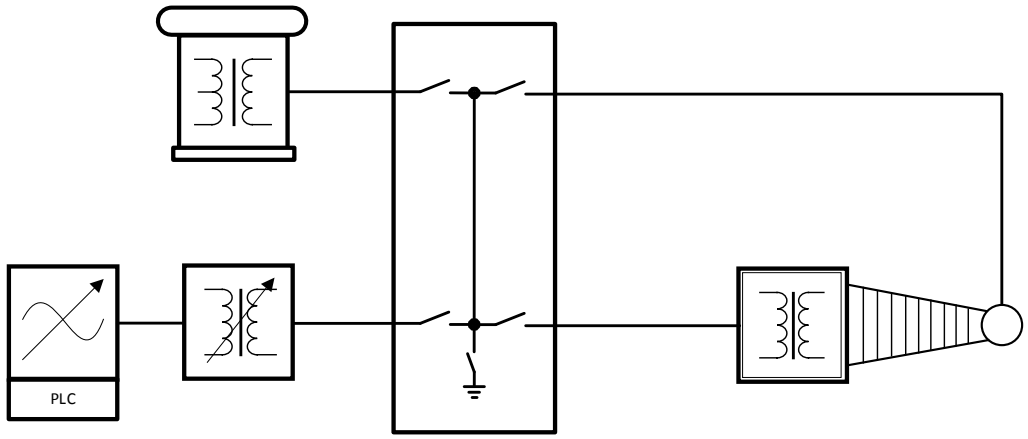

Fig. 11 Principle circuit of remote-controlled disconnector switches with interconnections

7.2 1 Option: Set of accessories for disconnector switches HG

The set includes following components:

- steel frame for mounting the switching devices
- electrical connections between the switching devices
- connection cables from step-up transformer to test object and from HV transformer to test object up to a total length of 30 m
- assembly of steel frame and electrical connections

Preconditions for layout and exact connection scheme of the automatic transformer test field are fulfilled after the consultancy which is not included in this offer.

Please note: Further equipment that might be necessary, for example:
- wall bushings,
- cable ducts
- further construction works
- shielding elements (Faraday-cage)

are not included in this offer and have to be provided by the customer.

7.3 1 Option: Auxiliary control cabinet HG 21

The auxiliary control houses a decentralized part of the PLC to control the state of the disconnector switches in the automated test field.

It mainly consists of:

- fuses for the control
- coupling relays, contacts for devices
- decentralized part of the programmable logic controller, type SIMATIC S7
- overvoltage protection for all inputs and outputs for control and measuring cables
- PROFIBUS coupling for the control by operator device
- terminals for connection of external EMERGENCY-STOP switches, safety circuit, warning lamps and horn

Main parameter:

Rated voltage	V	400
Rated current	A	16
Dimensions (approx.)		
Length	mm	500
Width	mm	310
Height	mm	500
Total weight (approx.)	kg	150

7.4 1 Option: Supervisory module HG 21

The module includes a supervisory PLC and an additional TFT display for the visualization of the current state of the plant (state of disconnectors, main parameters, position of the test field distribution).

8 1 Special accessories

8.1 1 Power, control and measuring cables HG 61

The set of control, measuring and optical fiber cables is specially designed for connecting of all parts of the entire system.

A complete interconnection diagram as well as installation instructions are provided when the system is delivered.

Additionally will be delivered:

From	To	remarks
mains supply	test system's supply input	3x50 mm², 30 m included
test system	test object	3x190 mm², 30 m included
test system	HV-Transformer	2x16 mm², 30 m included

Please note: The included cables have lengths according to average experience. For this particular case other lengths might be necessary. The determination of cable lengths is part of consultancy and is not included in the scope of supply. Additional cables or lengths longer than stated in this specification will be charged separately or can be provided by the buyer.

Terminals with sufficient current carrying capability, high-current cables for the short-circuit tests and any kind of cable trays are not included in this offer and have to be provided by the customer.

8.2 1 Safety equipment (provided by the customer) HG 73

Safety fences, safety cable interconnections and warning lamps need to be installed by the customer according to the site conditions and are not included in the scope of supply.

Customer's safety systems can be implemented into the HV control system and safety concept.

8.3 3 Rod for earthing ES 1 HG 62

The ES 1 is designed for earthing and short-circuiting of AC test systems. The test system has to be switched off before the rod for earthing can be used. It is designed for indoor operation.

Main parameters:

Dimensions (approx.)		
Length total (l_g)	mm	1125
Length handle (l_h)	mm	300
Length isolation (l_i)	mm	700
Weight (approx.)	kg	4

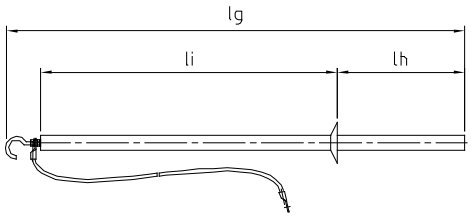

Fig. 12 Schematic sketch of ES 1

8.4 1 Steel frame HG

The following components are mounted on a steel frame:

- the CFI including sine wave filter
- the low voltage compensation
- the step up transformer
- the medium voltage measuring system

Main parameters:

Length (L)	mm	4500
Width (W)	mm	2500
Height (H)	mm	2800
Weight of frame and mounted components	kg	9600

The steel frame is designed to be lifted by a forklift.

9 1 Miscellaneous

9.1 1 Documentation (paper copy) HG 98

The technical documentation is provided with the order in English language as paper copy.

9.2 1 Transportation packing (sea freight) HG 98

- waterproof packing
- 12 months preservation
- stackable under deck

9.3 1 Factory acceptance test HG 96

The objective of the factory acceptance test is to verify, that the Test System for Transformer to be accepted was manufactured properly and complies with the Technical Specification, including the relevant standards.

The following points are part of the acceptance test:

(1) Checking the scope of delivery for completeness and explanation of the test reports of the main components;
(2) Explanation of the main components and the assembly of the test system;
(3) Checking the safety features (earthing devices, EMERGENCY STOP, safety loop, overcurrent and overvoltage protection, etc.);
(4) Demonstration and explanation of the specified voltage measuring systems (and, if applicable, current measuring systems) and all other measuring devices, including explanation of calibration of the high-voltage measuring system;
(5) Demonstration of the control functions in the manual and (if applicable) automatic modes, as well as explanation of the operator device and the computerized control system (if installed);
(6) No-load test with the adaption transformer of the test system in three-phase mode at rated voltage for 15 min;
(7) Capacitive load test with externally connected capacitor bank (3x 0.66 µF / 24 kV) in single-phase mode and three-phase mode each at 125 Hz;
(8) Measuring of harmonics;