

Test Fields, Systems and Components  
for Power Transformer Testing



# Requirements for Transformer Testing

# Transformer Test Systems



Factory tests on manufactured transformers as well as testing of transformers under service have to verify the sufficient quality of the windings, insulation, mounting and to ensure the specified electrical parameters. The test procedures have to be performed according to the relevant standards, mainly based on the IEC Standard 60076 series.

Transformers have to pass the procedures given in table 1, depending on the power and design of the transformer and the special demands of the purchasers:

**Routine tests** are required to be performed on all new or repaired transformers in order to ensure compliance with the safety standards and to demonstrate the integrity and quality of the transformer.

**Type tests** are required to be performed before supply on a general commercial basis on a type of transformer in order to demonstrate satisfactory performance characteristics to meet the intended application.

**Special tests** have to be carried out when required by agreement between the purchaser and the supplier.

**On-site tests** are performed after on-site repair or for diagnostic purposes.

The main equipment to perform Routine, Type and Special tests is summarized in Tab. 1. For details of the test field circuit see principal electrical scheme in Fig. 1.

The necessary equipment for realization of the test procedures is described in the following. For information regarding the measuring systems please refer to page 4. Any additional equipment can be supplied on request.

**Motor-generator-sets:** The Motor – Generator Set consists essentially of a DC-variable speed driving motor and a synchronous generator. Alternatively an asynchronous motor with build on frequency converter can be used instead of the DC machine. The MG-set will be used for supplying intermediate test transformers with regulated voltage.

The temperature rise test, as well as the load- and no-load tests have to be carried out by using power frequency. The induced overvoltage test has to be performed with at minimum double power frequency to avoid over-saturation of the core of the test object. This means, the M-G-set has to comply two frequencies: The power frequency of 50 or/and 60 Hz and additionally in minimum 120 Hz.

Therefore mostly two MG-sets with different power and different frequency range will be used, for 50 / 60 Hz with higher power than for 120 ... 200 Hz.

**Static frequency inverters:** Motor generator sets can be replaced by HIGHVOLT static frequency inverters, which can supply AC voltages of the frequency range 50 to 200 Hz. For more details see Data Sheet 8.73, 8.74 and 8.75.

Tab. 1: Tests according to IEC 60076 and related equipment in the transformer test field

		Frequency / waveshape	Routine Test	Type test	Special Test	Main Equipment
Dielectric Tests	Induced overvoltage test	> 2 <sup>f</sup> <sub>rated</sub>	x			M-G-Set (> 2 <sup>f</sup> <sub>rated</sub> ) or frequency converter + intermediate transformer(s) PD measuring device
	Partial discharge test					
	Applied withstand voltage test	50/60 Hz	x			Regulating transformer or frequency converter + HV test transformer Impulse Voltage Generator
	Lightning impulse voltage test	1.2 / 50	(x)	(x)		
	Switching impulse voltage test	1.2 / 50 chopped 100 / 1000-200	(x) (x)	(x) (x)		
Capacitance and Dissipation factor	50/60 Hz			x	C- / tan delta measuring device + Standard capacitor	
Losses Tests	Short circuit impedance and load losses	50/60 Hz	x			Regulating transformer or M-G-Set (50/60 Hz) or frequency converter + intermediate transformer(s) + Loss measurement system
	No-load losses and current	50/60 Hz	x			
	Harmonics of the no-load current				x	
	Temperature Rise Test	50/60 Hz		x		Regulating transformer or M-G-Set (50/60 Hz) or frequency converter + intermediate transformer(s) + Loss measurement system + Long-term winding resistance- & Temp. Tester
LV Tests	Measurement of winding resistance	DC	x			Winding resistance tester
	Phase displacement	50/60 Hz	x			Transformer ratiometer
	Voltage ratio	50/60 Hz	x			
	Transfer of surge voltages	surge impulse			x	Surge Impulse Tester
	Measurement of the power taken by fan and oil pump	50/60 Hz			x	Loss measurement system
Other Tests	Insulation resistance	DC			x	Insulation resistance tester
	Zero sequence impedance	50/60 Hz			x	Regulating transformer or M-G-Set (50/60 Hz) or frequency converter + intermediate transformer(s) + Loss measurement system
	On-load tap changers	50/60 Hz			x	Regulating transformer or M-G-Set (50/60 Hz) or frequency converter + intermediate transformer(s) + Loss measurement system
	Determination of sound levels	50/60 Hz			x	Regulating transformer or M-G-Set (50/60 Hz) + intermediate transformer(s) + Sound level meter

# Systems for Losses Tests, Induced Overvoltage Test

# Applied Voltage Test, Impulse Voltage Test



**3-phase regulating transformer:** The Regulating Transformer can be used instead of the M-G-set for 50 / 60 Hz (see also Data Sheets 1.26 and 1.27). This has the advantage of mostly lower costs, low noise level and faster and easier handling. The regulating transformer cannot be used in case of testing both 50 Hz and 60 Hz test objects.

**Intermediate transformer(s):** The Intermediate Transformer(s) will be used together with the M-G-Set (or alternatively with the Regulating Transformer) to provide voltages between 3 ... 70 kV for the test procedures according to Tab. 1.

If a high number of taps or taps with voltages > 30 kV are required, two Intermediate Transformers may be useful.

**Compensation capacitor bank:** The compensation capacitor bank provides the several test sets with capacitive power to compensate the inductive power of the test object for decreasing the necessary overall power of the test field equipment (see also Data Sheet 1.19). Therefore the installed capacitors have to be adapted to the parameters of all kinds of the transformers to be tested. The Capacitor bank is equipped with cable or clamping connectors for adjusting the dedicated compensation power.

**Compensation reactor:** Sometimes the transformer under test acts as a capacitive load and the M-G set requires an inductive load. For those cases compensation reactors are applied. HIGHVOLT supplies fixed reactors with taps as well as tunable reactors (see Data Sheets 1.17 and 1.18).

**AC HV test system:** The AC High Voltage Test system will be used for dielectric tests to verify the withstand voltage of the test object (see also Data Sheets

1.10 and 1.20). For the applied voltage test of distribution transformers and smaller power transformers conventional AC test systems, type WP, with transformers are applied (Data Sheet 1.10), whereas AC resonant test systems, type WRM, are more and more used for medium and large power transformers (Data Sheet 1.20).

The AC HV Voltage Test System consists mainly of:

- AC HV Transformer or Tunable Modular Resonant Reactor
- Switching cubicle
- Measuring and control system
- (Compensation capacitors, if necessary)

**Impulse voltage test system:** The Impulse Voltage Test has to be used for type and routine tests of power transformers. The following waveforms have to be applied according to IEC 60076-3, 4 and IEC 60722:

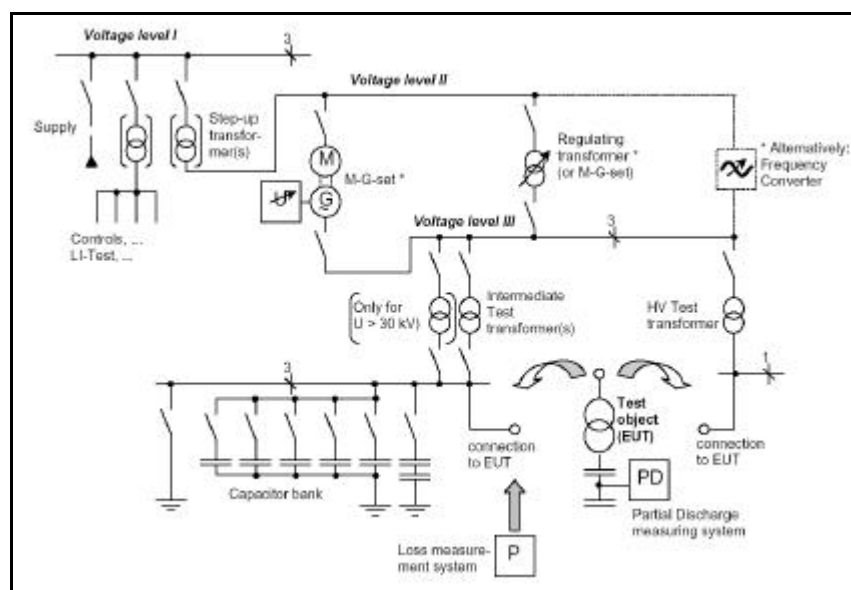
- LI – waveform with 1.2/50  $\mu$ s
- LIC – waveform chopped on the tail
- SI – waveform 20...250/>500  $\mu$ s

HIGHVOLT supplies three lines of impulse test systems (Data Sheet 3.10) consisting of the following main components:

- Impulse Voltage Generator (series L, M, G) (Data Sheets 3.11; 3.12; 3.13)
- Set of Resistors
- Charging and Control Unit (Data Sheet 3.21)
- Chopping gap (Data Sheet 3.62 and 3.64)
- Impulse voltage measuring system (Data Sheet 3.51)
- (Glaninger extension unit)

**Accessories:** For connection of all components suited cables, spare parts and connectors can be optionally supplied. Also the installation of all necessary cable trays and busbar systems can be realized.

Fig. 1: Principle scheme of a transformer test field:



## Measuring Equipment



**PD measurement system:** To verify the occurrence and the level of partial discharges, the PD measurement will be carried out mainly during the induced overvoltage test. The PD measurement can indicate weak points of the winding insulation of the test object. The PD pulse is decoupled from the HV circuit either by a measuring impedance connected to a coupling capacitor (often the bushing of the transformer) or optionally by a HF current transformer. The PD signal is processed to the apparent charge in the PD instrument and displayed on the monitor of the Control and measuring system. HIGHVOLT delivers the necessary PD measuring instruments including accessories (see Data Sheet 6.21).

For multichannel measurement on all windings a multiplexer unit can be supplied optionally for realizing quasi-simultaneous PD measurement of up to 12 input channels (see Data Sheet 6.27). Optionally also a real-time PD measurement of max. 8 channels can be quoted on request.

**Dissipation factor (tan d) and capacitance measuring system:** The dissipation factor (tan d) is an indicator for overall properties of the winding insulation. Therefore it is sometimes measured as a supplement to the PD measurement. HIGHVOLT supplies the necessary equipment consisting of the tan d measuring instrument (Data Sheet 6.22) and the standard capacitor (Data Sheet 6.11).

**Winding resistance test set:** Measurements of the winding resistance are performed with well filtered, regulated currents up to 10 A on any configuration of windings over a wide range from 1  $\mu\Omega$  to 2000  $\Omega$ . Two independent displays enable testing of 2 series windings or primary and secondary windings with simultaneous readout.

**Loss measurement System:** The Loss Measurement System fulfills all requirements of power frequency test measurement. It includes mainly the Waveform analysis, Voltage, Current and Power measurement (see also Data Sheets 7.5 and 7.51).

**Digital recorder:** For recording impulse voltage and current during LI impulse voltage test, different types of digital recorders up to 200 MS/12 bit including software for complete data evaluation are available (see Data Sheet 5.60).

If you require HV test equipment from HIGHVOLT, please apply our technical Questionnaire T.

## Computer Control and Test Data Processing

**Computer control and test data Processing:** The computer control system of the test field (Fig. 2) is able to cover the full control of all single test systems, all related measuring equipment and the safety system of the test hall (see also Data Sheet 1.52 and 3.51). It supplies help functions for the operator, enables the comfortable performance of the tests, guarantees the recording of the test data and their evaluation including printing a test record. The high reliability of the system is based on the application of standard industrial components (e.g. PLC of type Simatic S7, industrial PC) and interference-free optical links. The software can simply be adapted to all necessary test procedures.

By the remote diagnostics and access module (Data Sheet 1.56) the computer control can be integrated into the local area network (LAN, e.g. Ethernet) for internal data transfer (e.g. data of the transformers under test, test parameters, test results). Furthermore a connection to wide area networks (e.g. Internet) is provided and enables remote service by HIGHVOLT. In the latter case HIGHVOLT can supply software updates or support the trouble shooting by diagnosing all different test systems directly from Dresden HIGHVOLT Service Center. The application of these modern information technologies improves the cooperation between customers and HIGHVOLT.

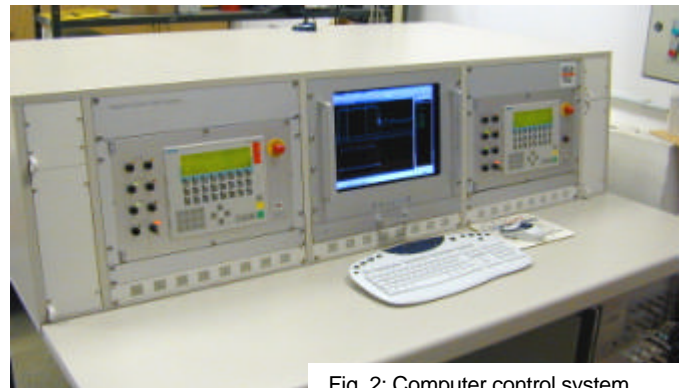


Fig. 2: Computer control system

**Data Sheets:** For additional information and Data Sheets of the described components you may also visit our website: [www.highvolt.de](http://www.highvolt.de)

- \* system solutions which include all necessary components
- \* Important components will be manufactured by HIGHVOLT, other components will be supplied by leading manufacturers
- \* HIGHVOLT can be with the client from the first idea up to commissioning of the test field
- \* nearly 100 years experience in transformer manufacturing and equipping transformer test fields
- \* HIGHVOLT computer control system covers the full control of all single test systems incl. PD and tan d measurement
- \* remote diagnostic access by HIGHVOLT service center
- \* excellent worldwide after-sales 72 h service

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