

HV IMPULSE TEST SYSTEMS

- Lightning Impulse
- Chopped Lightning Impulse
- Switching Impulse
- Fast Transient



HIGH-VOLTAGE IMPULSE TEST SYSTEMS



Fig. 1 Impulse voltage test system series G with Connection Point

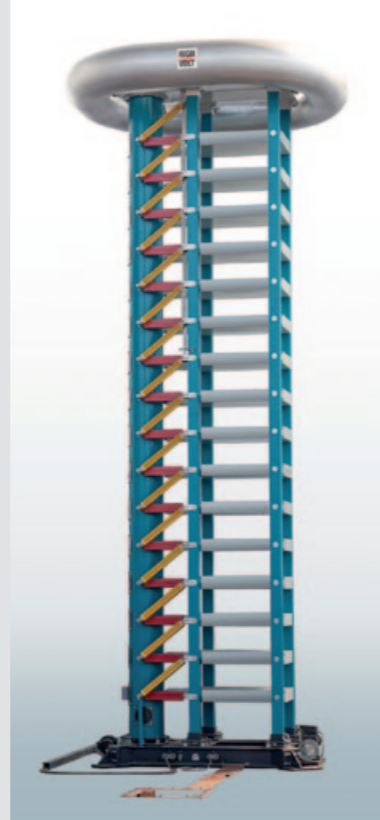


Fig. 2 Impulse voltage generator series M

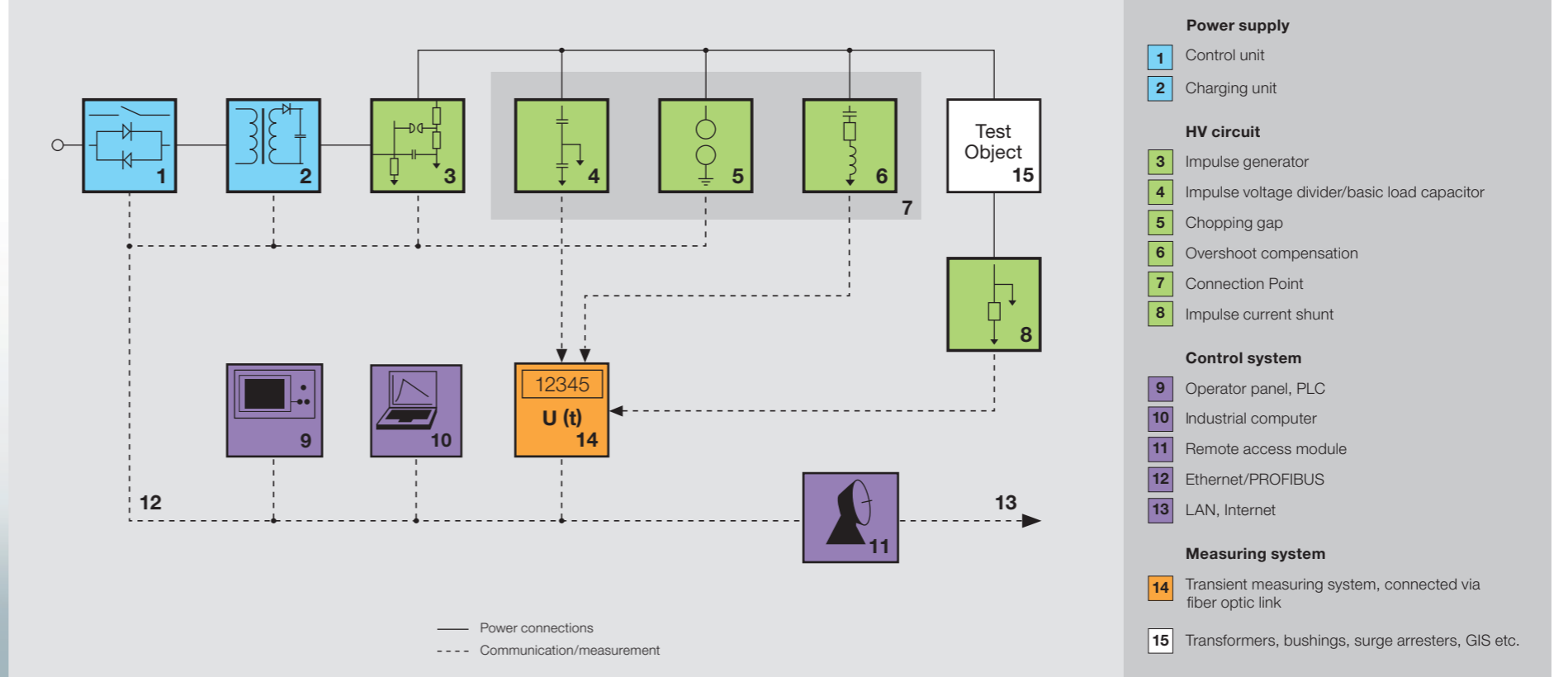


Fig. 3 Block diagram of impulse voltage test system

FACTS IN BRIEF

Impulse voltage test systems generate high artificial impulse voltages that model transient overvoltage wave shapes occurring in the power grid.

HIGHVOLT offers three series of impulse test systems:

- Series L for medium voltage applications designed as a simple and robust system for the demands of test bays for large numbers of specimens, with easy operation
- Series M for higher medium voltage and high voltage applications designed as an effective solution for routine and type test bays. This series is easily extendable.
- Series G for extremely high test voltages and test power, with handling made easy by e.g. by an inner ladder and platforms, encapsulated spark gaps and resistor storage at each stage. It is designed as a high end test system for all applications from routine testing to research.

All series are equipped with the HiRES transient recorder. It complies with or exceeds all relevant IEC and IEEE standards.

APPLICATION

The impulse voltage test systems are applied to test the ability of power grid equipment to withstand transient voltage peaks, such as those resulting from lightning strokes or switching.

Main applications for impulse voltages are:

- Routine tests for power transformers, shunt reactors and bushings
- Acceptance tests on surge arresters
- Sample tests or type tests for medium and high voltage cables
- Type tests on GIS/GIL
- Type tests on instrument transformers

Furthermore, the impulse voltage test systems are also able to generate fast transient impulses and impulse currents. All test procedures are in accordance with the relevant IEC and IEEE standards.

SYSTEM AND COMPONENTS

The impulse generator (3) is charged by the charging unit (2), which is connected via the control unit (1) to the power supply [see fig. 3]. The impulse voltage divider (4), which is capacitively damped, measures full and crest-chopped lightning and switching impulses. The chopping gap (5) provides a fast voltage breakdown. The overshoot compensation (6) improves the impulse voltage wave shape for highly capacitive test objects.

The voltage measuring system is completed by a HiRES transient recorder (14). The test system is operated by an industrial computer (10), which is connected via an optical Ethernet cable (12) to the control unit and additionally by the operator device (9) that is connected via an optical PROFIBUS system (12) to the control unit. In addition the trigger signals for the generator are supplied via optical links. This guarantees an operation free from interferences. An integrated software solution provides semi-automatic and fully automatic operation of even complex test procedures, data storage, and generation of test reports.

The Connection Point, CP (7), is an innovative patented solution that fulfils the following functions:

- Measuring of all relevant testing wave shapes
 - Lightning impulses (LI) 1.2/50 μ s,
 - Chopped lightning impulses (LIC),
 - Switching impulses (SI) 250/2500 μ s and AC voltages
- Chopping of lightning impulses, and
- Compensation of overshoots

The CP integrates impulse voltage divider, chopping gap, and overshoot compensation into one device. If one component is not required, the CP can also be implemented in a reduced configuration. Thanks to its compact design, the CP requires less floor space. Furthermore, the chopping gap does not need to be disconnected when changing from LI/LIC to SI, which leads to a time saving test procedure and easy handling. Moreover, one high-voltage connection (between chopping gap and test object) is omitted, resulting in a lower inductance of the test circuit. The overshoot compensation covers a wide load range of test objects without any modification.

BENEFITS

- DESIGNED FOR LOW INDUCTANCE OF IMPULSE GENERATOR
- MODERN IMPULSE MEASUREMENT AND CONTROL SYSTEM HiRES
- INTEGRATED SOFTWARE SOLUTION FOR DATA EVALUATION
- PREPARED FOR STATE-OF-THE-ART SAFTY LEVEL SIL 3

BENEFITS

- EASY HANDLING/ TIME SAVING
- SPACE SAVING DESIGN
- LOW INDUCTIVE TEST CIRCUIT
- ONE OVERSHOOT COMPENSATION FOR ALL TEST CASES

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TECHNICAL PARAMETERS / BACKGROUND

For distribution transformers, cables and other devices in the medium voltage range:

- Impulse test system of series L
- Lightning impulses up to approx. 1000 kV
- Switching impulses up to approx. 850 kV

For power transformers, cables and other devices up to approx. 230 kV:

- Impulse test system of series M
- Lightning impulses up to approx. 2200 kV
- Switching impulses up to approx. 1700 kV

For power transformers, cables and other devices up to extremely high voltage ratings:

- Impulse test system of series G
- Lightning impulses up to approx. 5000 kV or more
- Switching impulses up to approx. 3000 kV or more

Impulse test systems and additional components for special applications are also available, for example for **University and research labs:**

- Entire range of voltage levels for different applications
- Adapted resistor sets for special wave shapes

Mobile impulse testing:

- System installed on trailer with self-raising system
- Mobile control system installed in air conditioned container
- Up to 2200 kV charging voltage

GIS/GIL testing:

- Special inductors for generation of oscillating lightning and switching impulses

Combined and composite voltage testing:

- Phase controlled triggering of the impulse generator

Overshoot compensation

HIGHVOLT impulse generators have a low inductive design. In comparison with a traditional impulse test system with a separate divider and chopping gap, the circuit inductance is further reduced due to the compact design of the Connection Point. Impulse tests with peak voltages higher than $U_p = 2000 \text{ kV}$ require longer dielectric distances between the components of the test circuit. The effective parasite inductance of the entire test circuit is not negligible under the assumption that the connections between the test circuit components have a specific inductivity of $L = 1 \mu\text{H/m}$. An overshoot with a value of more than $\beta' = 5 \%$ can appear, depending on the load of the test object. An additional overshoot compensation, which is integrated into the chopping gap, reduces the overshoot and allows the testing of high capacitive load by maintaining the allowed overshoot and the permitted front time T_1 . The overshoot β' is explained in IEC 60060-1.

Fig. 4 gives an example using $C_{\text{Load}} = 5 \text{ nF}$ and $U_{\text{Peak}} = 1800 \text{ kV}$ for the effectiveness of the integrated overshoot compensation. The length of the example testing circuit is assumed using $l = 25 \text{ m}$, and a parasite inductance of the test circuit of $L = 25 \mu\text{H}$. In practice the length depends on the detailed test bay arrangement. The lightning impulse without overshoot compensation (see red curve in fig. 4) results in an overshoot of $\beta' = 7.5 \%$ and a front time of $T_1 = 1.66 \mu\text{s}$ and would be within the IEC 60060-1 tolerance. The overshoot compensation reduces the overshoot to under $\beta' = 5 \%$ (see blue curve). Similar figures are yielded by other voltages and load capacitances. See the second example in table 1.

Ch1 test setup with overshoot compensation
Ch2 test setup without overshoot compensation

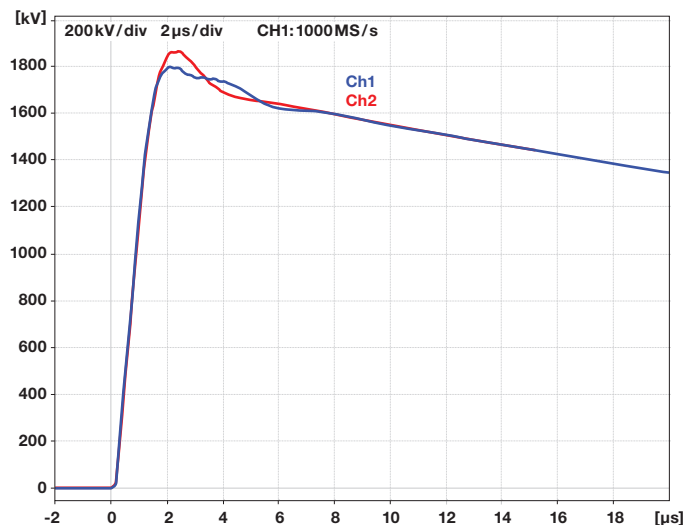


Fig. 4 Example of overshoot compensation

Table 1 Measured examples for overshoot compensation

	T_1 in μs	β' in %
$U_{\text{Peak}} = 1800 \text{ kV} / C_{\text{Load}} = 5 \text{ nF}$		
Without compensation	1.66	7.5
With compensation	1.52	4.2
$U_{\text{Peak}} = 2400 \text{ kV} / C_{\text{Load}} = 4 \text{ nF}$		
Without compensation	1.74	8.5
With compensation	1.52	5.0

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