Impulse Voltage Test Systems
From 100 kV up to 6 MV – Series L, M, G
HV power equipment must be tested according to the relevant apparatus standards with lightning (LI) and switching (SI) impulse voltage in minimum during type tests, but more and more also in routine and even on-site tests. The requirements to LI and SI test voltage generation are fixed in IEC 60060-1, to their measurement in IEC 60060-2 and IEC 61083-1 and 2.

HIGHVOLT supplies three series of impulse voltage test systems, all full in line with those standards. They cover a very wide range of impulse voltages and energies (Fig. 1) not only related to equipment testing, but remarkably wider for research work and development.

The smallest Series L is designed for testing medium and high-voltage equipment up to rated voltages of 245 kV, but very well suited also for research work and student’s training. The medium Series M is for testing equipment up to 525 kV, whereas Series G is well suited up to the highest transmission voltages. Its comfortable, low-inductance design recommends itself for transformer testing, multi-purpose testing in large test organizations and research work.

All three lines enable the modification of the impulse voltage generators to impulse current generators necessary for lightning protection equipment, EMP tests and related research work.

Modification of the impulse test systems on special demand of customers is a well introduced practice. A special design of Series L and M is available for on-site testing. These systems can be assembled easily and quickly.

The system configuration for all three series is identical (Fig. 2). The parallel capacitors of the impulse generator (3) are charged via a thyristor controller (1) and a DC generator (2) to a stage voltage $U_s$ up to 100 kV (Series L, M) respectively 200 kV (Series G). By firing the switching gap triggered form the control, all $n$ stages are connected in series for a cumulative charging voltage $U = nU_s$ (principle of the Marx multiplier circuit). Then the total load capacitance consisting of the capacitances of the basic load (4) and of the test object (6) is first charged and then together with the generator capacitors discharged. Depending on the resistors in the circuit, a LI voltage (1.2/50) or a SI voltage (250/2500) is generated. If a chopped LI voltage is required, the chopping gap (5) is triggered at the pre selected time. The voltage is measured via the divider (4) by a peak voltmeter (10) and/or a digital impulse analyzer (11). Also the impulse current is measured via a shunt (7) by the digitizer (11). The measured data are processed and compared with the pre-selected parameters by the computer control and measuring system (9). Controllers, including an additional operator device (8), are connected via an optic PROFIBUS.

The three options of the control and measuring system are applicable to all three series of impulse generators. The wide range of output parameters (Fig. 1) is realized by the modular principle of the generators of all, three series and by well adapted accessories.

For a HV test circuit, the impulse voltage generator must be selected according to the parameters of the test objects (test voltages, impedances), the requirements of the test field (test sequence, available space, transportability, etc.) and the available investment cost. The three series L, M, G are determined by the related generators.

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**Fig. 1**: Ranges of voltages and impulse energy

**Fig. 2**: Principle circuit diagram

Type designation: IP a/b X, where “a” means the rated energy in kJ, „b“ means the rated voltage in kV and “X” means the series L or M or G: IP 100/2000 M is a series M system of 100kJ/2000kV.
Generators

Types IG ... L and M

This smallest series (Fig. 1; 3) has a stage voltage of 100 kV and a robust and reliable design with five fiberglass columns. They carry the capacitors, the resistors (which can easily be exchanged by clamping) and one sphere of the switching gaps. The opposite spheres are fixed on a moveable, motor driven column which enables the precise adjustment of the gap. The related motor is fixed in the base frame together with other accessories for triggering, grounding, ignition and breakdown detection. The types up to a charging voltage of 1000 kV are optionally moveable on castors. Further modifications, e.g., for on-site testing, can be supplied on request. For more details and survey of parameters see Data Sheet 3.11.

Generators IG ... M: This medium series has also a stage voltage of 100 kV and a similar design as the small one, but equipped with switching gaps enclosed in a fiber glass tube and driven via gears by a motor. Its top electrode can be adapted to the switching impulse voltage to be generated and the available space in the test field. All types up to a charging voltage of 1200 kV can be supplied on air cushions or rollers, with a stage energy of 5 kJ even up to 1600 kJ. Modifications for on-site testing, impulse current testing or EMP testing are available. See also Data Sheet 3.13.

Generators IG ... G: The largest series G (Fig. 5 and 6, also title) is characterized by its modified Marx circuit with charging voltages of +100 kV and –100 kV (resulting in a stage voltage of 200 kV). This “symmetric charging” has the advantages of a safe triggering of the generator and lower DC stresses during the charging period. Special care is given for a low internal inductance which results in low overshoot. All components of the impulse generator are supported by four insulating columns made of glassfibre reinforced plastic. A stable construction is achieved by rectangular frames in each generator stage. In each third stage there is a folding platform that can be entered by a ladder for a convenient changing-over of the resistors. All resistors for different impulse shapes can be stored on the related stage. The switching spark gaps are commonly housed inside a fifth insulating column with a slight air over-pressure to guarantee clean air for a safe triggering. For safety the test generator is equipped with two earthing switches and two motor driven earthing ropes. The common sectional steel base can be designed either as stationary or as a mobile type, the latter having rollers or receptacles for air cushions. The frame carries also the DC generator including the cubicle for the thyristor controller. For details see Data Sheet 3.12, further information e.g., for pollution testing transformer testing, impulse current generation, are supplied on request.

Fig. 3: Impulse Test System IP 6.25/500 L (Siemens AG, Berlin)

Fig. 5: Impulse Test System IP 120/2400 G (TU Dresden)

Fig. 6: Outdoor Test System IP 400/4000 G (KEPRI, Korea)

Fig. 4: Impulse Test System IP 90/1800 M (BTU Cottbus)

Fig. 7: Control desk including an impulse voltage control
Standard and Optional Components

Charging and control units, types GES/GEOS: For optimum adaptation to the stage energies and the number of stages six different types are available. All of them contain a cubicle for the thyristor controller and related PLC’s, a H. V. transformer, the rectifier for DC generation and the DC voltage measurement. For details see Data Sheet 3.21.

Computer Control systems, types CMS, in connection with digital impulse analyzers, types MIAS, can be applied to all three series of impulse voltage test systems. The systems its components in a rack or desk enables manual and automatic operation, measurement with highest precision, connection to local computer networks (LAN) and even remote service via Internet. For details see Data Sheet 3.51; 3.52; 5.60; 7.31.

Operator device, type BG, is for the conventional manual and semi-automatic operation of impulse voltage test systems, often used in redundancy to a computer control. For details see Data sheet 3.53.

Impulse voltage dividers/basic load, types SMC: Capacitors for the double function of impulse front shaping and voltage measurement are available for the complete range of generators, for details see Data Sheet 3.61.

Chopping spark gaps, types AFC and AFS for the generation of chopped lightning impulse voltages are available for LI voltages up to 3600 kV, for details see Data Sheets 3.62 and 3.63.

Impulse peak voltmeter, type MU 27/28, for peak voltage measurement if no digital impulse analyzer is necessary see Data Sheet 5.57.

Further accessories:
- resistors for special impulse shape,
- air cushions, castors and wheels for mobile generators;
- weather-protecting towers for outdoor systems;
- adapted top electrodes to HV laboratory conditions;
- taylor-made software for automation;
- Glaninger circuits for transformer testing (Data Sheet 3.32);
- fast resistive dividers for front-chopped impulse (Data Sheet 5.21);
- overshoot compensation for large test circuit (Data Sheet 3.31);
- equipment for impulse current generation (Data Sheet 3.40)

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