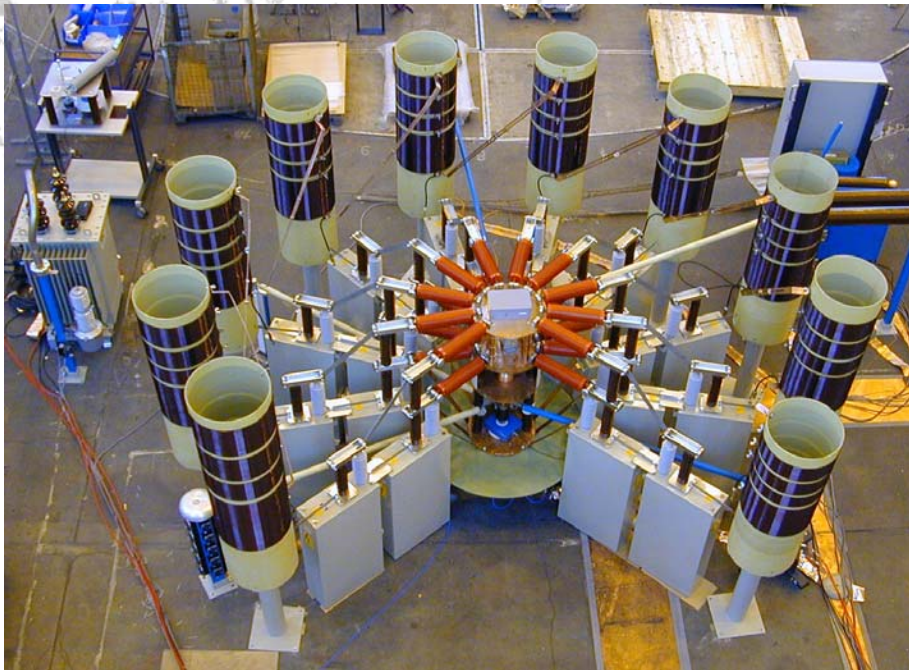


Impulse Current Test Systems
Type IP ... / ... S up to 240 kA



Application

Impulse Current Test Systems are manufactured for testing equipment applied in medium and high voltage transmission & distribution systems against the effects of lightning strokes (direct or indirect) or against electromagnetic interference effects.

The main application fields of impulse current testing are:

- arresters and varistors (elements or complete systems)
- lightning protection elements (for buildings, components of communication and distribution networks)
- vehicles (cars, bus, trucks, trains)
- aircrafts
- wind generators (whole system or blades)
- transmission lines with integrated fibre optic cables

Additional applications of high impulse currents are material processing and recycling. Depending on the broad range of the different designs and tasks of the various equipment to be tested, impulse current test systems have to be adapted for the special testing purposes. For example special designed impulse current generators are available to perform EMP tests, to generate impulse magnetic fields or to test components of lightning protection systems (IEC 61000-4-2: 2001).

Primary application of Impulse Current Test Systems is the testing of surge arresters, nowadays mainly of the metal-oxide type. The tests to be performed are described in various standards, e.g. IEC 60099-4: 2006, or IEC 61643-1: 2005. Due to the large range of applications of surge arresters, Impulse Current Test Systems can have many different realizations. Within this leaflet the focus is laid on impulse current test systems for testing of surge arresters. Generators for further application are available.

Table 1: Exponential Impulse Current tests for surge arresters recommended by IEC 60099-4: 2006

Line discharge class	Peak current for ¹⁾ 1/<20µs	Peak current for ³⁾ 4/10µs	Peak current for ^{1) 2)} 8/20µs	Peak current for ¹⁾ 30...100 / 60...200µs	Peak current for ³⁾ 30/80µs
Class 1	10	100 ³⁾	20	0.125 0.5	--
Class 2	10	100 ²⁾	20	0.125 0.5	--
Class 3	10	100 ²⁾	20	0.25 1	--
Class 4	20	100 ²⁾	40	0.5 2	--
Class 5	20	100 ²⁾	40	0.5 2	--
IEC 60099-4 Annex C	20	--	40	--	40

¹⁾ Residual voltage test; ²⁾ Conditioning ³⁾ Operation duty test

Fundamentals

According to IEC 60099-4: 2006 surge arresters are classified by their standard nominal discharge currents into five classes. This standard recommends, depending on the arrester class and application purposes, a broad range of different tests and performance characteristics. The following tests (selected ones or all) have to be performed at surge arresters:

- exponential impulse current tests (Table 1)
- long-duration impulse current tests, line discharge test (Table 2)
- exponential impulse current tests followed by AC voltage (operating duty tests)
- AC voltage test for determination of reference voltage at the reference current

Depending on the test requirements to be fulfilled, the necessary impulse currents (wave shape and amplitude) can be realized with generators especially designed for this purpose.

In general Impulse Current Test Generators can be divided into four major groups:

- **Single stage generators** in star/coaxial arrangement to produce selected or all exponential impulse currents (Table 1), see Fig. 1, 2, 3, 4 and title figure
- **Generators arranged in-line or circular** to produce selected rectangular shaped, long duration impulse currents (Table 2, Fig. 3)
- **Crowbar circuits.** They are used to produce long duration impulse current up to 500 µs. The principle is based on impulse capacitors which are connected in-line with an inductance and in parallel with a crowbar spark gap
- **Multi-stage generators,** designed according to the principle of the Marx Generator, Fig. 7, to generate exponential impulse currents

To perform exponential impulse current tests on surge arresters with a multistage generator, existing impulse voltage generators can be upgraded with additional inductances and resistors, Fig. 7. A strong restriction occurs, if long duration impulse currents have to be produced. In this case an in-line or circular arranged generator with at least 8 capacitors is necessary.

Table 2: Long duration impulse current tests

Line Discharge Tests	Wave shape µs
Class 1	2000
Class 2	2000
Class 3	2400
Class 4	2800
Class 5	3200

Coaxial Impulse Current Test System

Impulse current test systems in star / coaxial arrangement enable to carry out all impulse current tests and performance characteristics on surge arrester discs with rated voltages up to 12 kV. Due to their compact design the stray inductances of the impulse circuits are so low, that steep impulse currents ($1 < 20 \mu\text{s}$) can also be produced.

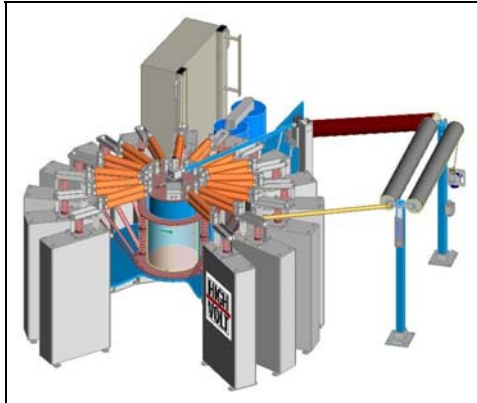


Fig. 1: Impulse current test generator, type IP 176/12 S; max. energy 176 kJ, charging voltage 12 kV; max. peak current 60 kA

As an example, Fig. 1 shows an impulse current test system for testing lightning protection devices with a rated voltage up to 2 kV. The $10/350 \mu\text{s}$ impulse current can be realized with a maximum amplitude of 60 kA. Charging voltage is 12 kV with a maximum stored energy of 176 kJ.

The test system in Fig. 2 can produce impulse currents of $1 < 20$, $4/10$, $8/20$ and $30/60 \mu\text{s}$ with a maximum current up to 120 kA. Charging voltage is 100 kV and maximum stored energy is 80 kJ.

With suited coils and eight capacitors (or more) long duration currents can also be produced with the design in Fig. 3 & 4. Furthermore this generator includes the operating duty tests for all line discharge classes. Therefore, beside the impulse current generator for exponential and long duration waves one AC test transformer (50 Hz / 60 Hz) and the additional necessary coupling components are needed, Fig. 3 and title figure.



Fig. 2: Type IP 80/100 S; 80 kJ, charging voltage 100 kV; max. peak current 120 kA

In Fig. 4 the central part of such an impulse current generator is shown. Visible is the coaxial or star arrangement to keep the stray inductances of the whole circuit elements as low as possible. The spark gap with the trigger unit is located in the centre. Located below is the housing for the test samples. Also recognizable are the inductances (red) to produce impulse currents of $30/80 \mu\text{s}$ and the vertical arranged coils needed for long duration impulse currents.

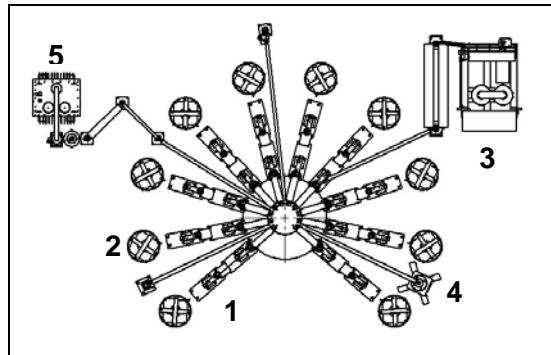


Fig. 3: Drawing of the main components of a complex impulse generator, IP 250/100 S, see also Fig. 4

- 20 capacitors in star arrangement (1)
- Vertical mounted coils for long duration impulse currents (2)
- Charging and control unit, type LS (3)
- Damped capacitive impulse voltage divider, type SMC or universal divider MCR (4)
- AC source with change-over switch for operating duty tests (5)

This very complex and compact impulse current test system is able to perform all necessary tests on surge arresters of all five line discharge classes with rated voltages up to 12 kV. Due to the star arrangement of the 20 capacitors and the very compact design of the central part, all impulse currents of Table 1 can be produced. The maximum achievable peak values is 240 kA for the impulse current $4/10 \mu\text{s}$. Together with the vertical arranged coils all long duration impulse currents (up to $3200 \mu\text{s}$) as listed in table 2 are producible. Operating duty tests can be performed with a special constructed AC source very left on title figure. To measure the wide range of impulse current amplitudes special designed shunts and current transformers are used.

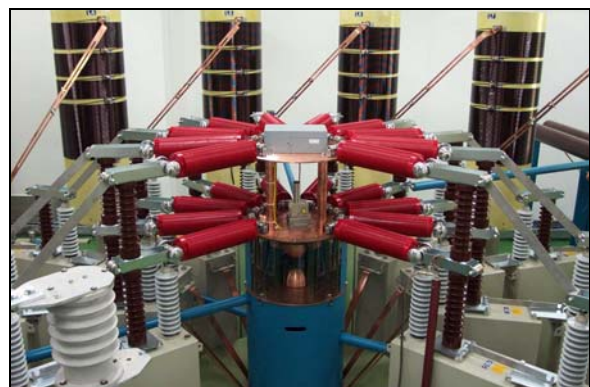


Fig. 4: Central part of impulse current generator IP 250/100 S;

Control and Measurement

To perform all tests and to analyze the measured data, a complex control, measuring, evaluation and data storage system is available. The system is controlled by one PC. Data, plots etc. are clearly arranged on one display, Fig. 5.



Fig. 5: Operator desk with control and measuring system for the impulse current generator IP 250/100 S shown in Fig. 3 & 4

The control system is based on the standard control and measuring system of HIGHVOLT, both for AC and impulse currents & voltages (see Catalog Sheets 1.52 and 3.51). Current and voltage measurements, AC and impulse, are done by a digital measuring system, type MIAS, with four channels, see Data Sheet 5.60. A typical result is shown in Fig. 6 for the steep impulse current $1/<20 \mu\text{s}$.

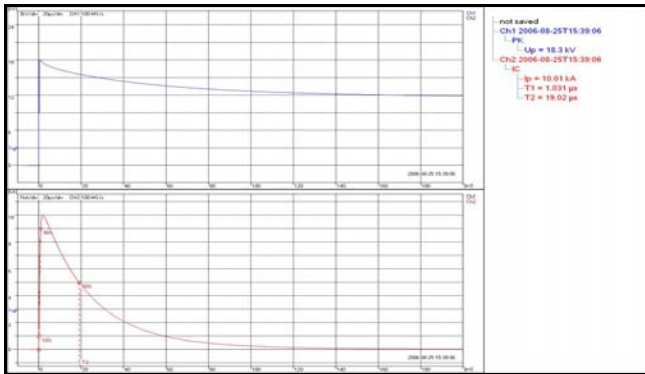


Fig. 6: Typical display of a measured and analyzed $1/<20 \mu\text{s}$ impulse current with surge arrester of 4 kV rated voltage ($T_1 = 1.03 \mu\text{s}$, $T_2 = 19.02 \mu\text{s}$)

Use of Impulse Current Generators

An existing multi-stage impulse voltage generator (Fig. 7) can be modified with additional current shaping components to achieve the wave shapes 30/80, 4/10 or 8/20 μs respectively. Impulse currents up to 70 kA can be realized with this impulse voltage test system 120 kJ/2400 kV.



Fig. 7: Multi-stage Impulse voltage test generator (120 kJ/2400 kV) with modifications to produce currents up to 70 kA.

How to Order? The request for an Impulse Current Test System should be given to HIGHVOLT using the Questionnaire 3.102 which can be found on the HIGHVOLT homepage (see below). Then a quotation will be provided based on the related demand and the appropriate HIGHVOLT principle design.

General type designation for impulse current generators is as follows:

IP a/b S: a - energy ; b - charging voltage,

Example:

IP 250/100 S means an impulse current test system with 250 kJ charging energy and 100 kV charging voltage

For further information please contact:

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