IMPULSE CURRENT TEST SYSTEMS

FUNDAMENTALS

Primary applications of Impulse Current Test Systems are the testing of surge arresters, nowadays mainly of the metal-oxide type (MOA), and surge protection devices (SPD).
The tests to be performed are described in various standards, e.g. IEC 60099-4 and IEC 61643-11. Due to the large range of applications of surge arresters, Impulse Current Test Systems can have many different realizations.

According to IEC 60099-4, surge arresters are classified by a new classification based on repetitive charge transfer rating, as well as thermal energy rating and thermal charge transfer rating, respectively. Requirements depend on the intended arrester application, being either a distribution or a station class arrester. The standard IEC 60099-4 recommends, depending on the arrestor class and application purposes, a broad range of different tests and performance characteristics.

The following tests (selected one or all) have to be performed at surge arresters:

- Exponential impulse current tests (*Table 1*)
- Long duration impulse current tests, line discharge test
- Exponential impulse current tests followed by AC voltage (operating duty test)
- AC voltage test for determination of reference voltage at reference current

A strong restriction occurs, if **long duration impulse currents** have to be generated. In this case an in-line or circular arranged generator with at least 8 capacitors is necessary. Depending on the arrester class and designation, the long duration current and wave shape have to be adapted. Typical long duration currents are between 550 and 1500 A, the duration of the peak varies between 2000 and 3200 µs.

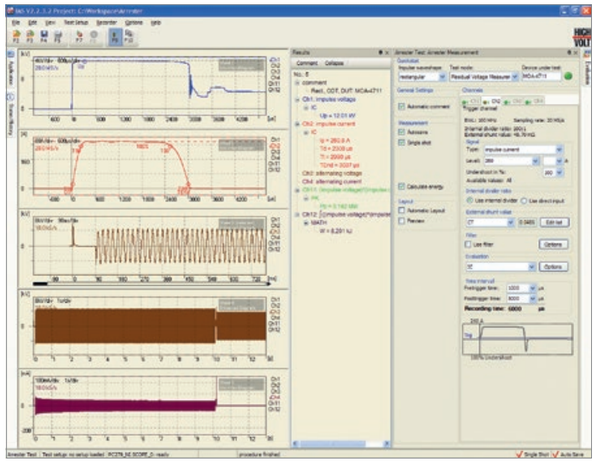

Fig. 6 **Screenshot of typcial residual voltage measurement**

Table 1 **Exponential impulse current tests for surge arresters recommended by IEC 60099-4**

Arrester class	Station			Distribution		
Designation	SH	SM	SL	DH	DM	DL
Nominal discharge current [kA]	20	10	10	10	5	2.5
Repetitive charge transfer rating [C]	≥ 2.4	≥ 1.6	≥ 1.0	≥ 0.4	≥ 0.2	≥ 0.1
Thermal energy rating [kJ/kV]	≥ 10	≥ 7	≥ 4	-	-	-
Thermal charge transfer rating [C]	-	-	-	≥ 1.1	≥ 0.7	≥ 0.45
Line discharge class	4 and 5	3	1 and 2	-	-	-
Peak current for residual voltage test (1/< 20 µs) [kA]	20	10	10	10	5	2.5
Peak current for operating duty test (4/10 µs) [kA]	100	100	100	100	65	25
Peak current for residual voltage and conditioning test (8/20 µs) [kA]	40	20	20	20	10	5
Peak current for residual voltage test (30…100/60…200 µs) [kA]	2	1	0.5	-	-	-

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IMPULSE CURRENT TEST SYSTEMS

- **Impulse current tests on**
  – Arresters and varistors
  – Lightning protection elements
  – Circuit breakers
  – Vehicles and aircrafts
  – Military and plasma applications

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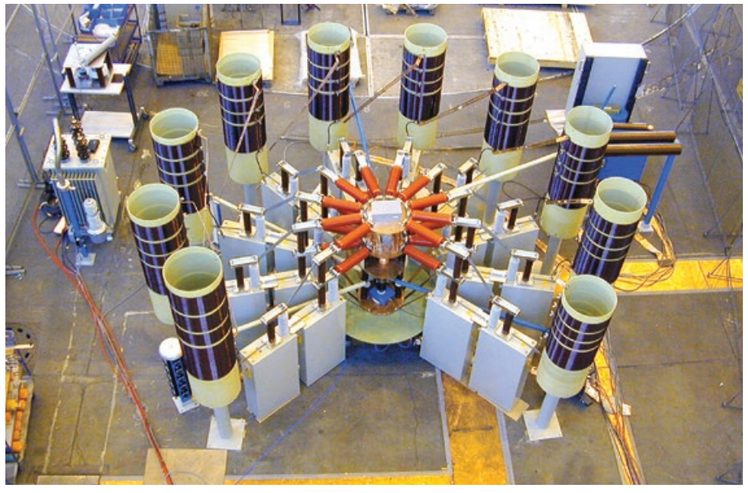

Fig. 1 **Single-stage Impulse Current Test System with impulse energy 250 kJ, charging voltage 100 kV and max. peak current 150 kA (4/10 µs) with additional equipment for operating duty test**

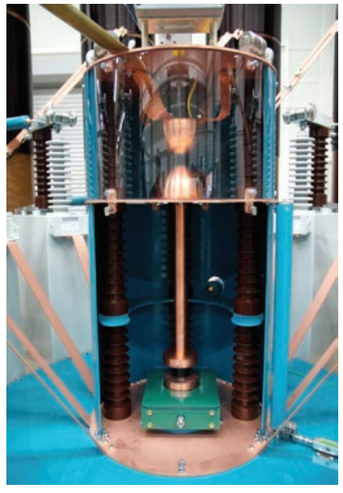

Fig. 2 **Central part of Impulse Current Test System with spark gap, current measuring device and test object**

Fig. 3 **Multi-stage Impulse Voltage Test System with modification to generate impulse currents**

Fig. 4 **Impulse Current Test System with impulse energy 128 kJ, charging voltage 80 kV and max. peak current 100 kA (10/350 µs) with additional crowbar circuit**

FACTS IN BRIEF

Impulse Current Test Systems (IP S) are manufactured for testing equipment applied in low, medium and high voltage transmission and distribution systems against the effects of lightning strokes (direct or indirect) or against electromagnetic interference (EMI) effects. The test systems generate impulse currents up to peak value of 240 kA in accordance with IEC 60060-1; as well as IEC 60099-4 for surge arresters, IEC 62305-1 for lightning protection elements, and IEC 61643-11 for surge protection devices.

HIGHVOLT provides an individual design and customized adaptation depending on the test requirements to be fulfilled (wave shape, amplitude, energy, etc.). The compact structure makes it possible to save space and to achieve a low stray inductance to generate even steep impulse currents (1/< 20 µs).

Peak currents of up to 240 kA are achievable for impulse current with a wave shape of 4/10 µs. Furthermore long duration impulse currents up to 3200 µs can be generated. The charging voltage is adapted to the requirements of the customer, but the maximum is 100 kV.

APPLICATION

The main application fields of impulse current testing are:

- Arresters and varistors (elements or complete systems)
- Lightning protection elements, e.g. for buildings
- Circuit breakers
- Vehicles (cars, bus, trucks, trains)
- Aircrafts and helicopters
- Military and plasma applications
- Wind generators (whole system or blades)
- Transmission lines with integrated fibre optic cables
- 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 electromagnetic pulse (EMP) tests and to generate impulse magnetic fields. The handling of EMP effects is an important application of electromagnetic compatibility (EMC) engineering. For special test cases various Impulse Current Test Systems can be combined to generate sequential impulse currents.

GENERATOR TYPES

In general impulse current generators can be divided into four major groups:

- **Single-stage generators** in star/coaxial arrangement to produce long duration impulse currents and selected exponential impulse currents (see *Fig. 1*)
- **Generators arranged in-line or circular** to produce selected rectangular shaped, long duration impulse currents up to 3200 µs
- **Multi-stage generators**, designed according to the principle of the Marx Generator to generate exponential impulse currents (see *Fig. 3*)
- **Crowbar circuits**, which are used to produce long duration impulse currents 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 (see *Fig. 4*)

SYSTEM AND COMPONENTS

The standard Impulse Current Test System mainly consists of an impulse current generator with different capacitors, resistors, inductors and a spark gap (see *Fig. 1 and 2*). The impulse current generator is usually carried out in star arrangement to save space and achieve a low stray inductance to generate even steep impulse currents (1/< 20 µs). The impulse generator is charged by the charging and control unit, which is connected to the power supply.

To perform the operating duty test according to the IEC standards, one HV AC test transformer (50/60 Hz), a HV changeover switch as well as a low-pass filter are additionally needed (see *Fig. 1*).

The voltage is measured via a separate universal voltage divider; the impulse current via current measuring device. As a standard feature the test system has a transient measuring system HiRES. It delivers precise current and voltage measurements and offers a variety of features for controlling the impulse current system as well as capturing and evaluating measurement values. In combination with our HiRES Probes, which are especially designed for use in environments with highst EMI level, reliable EMI proof and potential-free measurements are done close to the test object.

The test system is operated by the operator device that is connected via an optical PROFIBUS system to the control unit. An industrial computer, which is connected via an optical Ethernet cable to the control unit, can be used for semi-automatic and fully automatic operation of even complex test procedures, data storage, and generation of test reports. In addition the trigger signals for the generator are supplied via optical links. All this guarantees an operation free from interferences.

BENEFITS

- UNIQUE, CUSTOMIZED AND SPACE SAVING DESIGN
- EASY ADAPTATION OF TEST CIRCUIT
- COMBINATION OF IMPULSE CURRENT TEST SYSTEMS
- LONG SERVICE LIFE

- STEEP IMPULSE CURRENTS (1/< 20 µs)
- PEAK CURRENTS UP TO 240 kA
- CHARGING VOLTAGE UP TO 100 kV
- LONG DURATION IMPULSE CURRENTS UP TO 3200 µs

- ALL IMPULSE CURRENTS ACCORDING TO IEC 60060-1, IEC 60099-4, IEC 62305-1 AND IEC 61643-11
- VARIOUS GENERATOR TYPES FOR WIDE RANGE OF APPLICATIONS