

# SG $\Delta$ A

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Impulse Voltage Test System, 200 – 3'000 kV / 10 – 300 kJ

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1400 kV Impulse Voltage  
Generator

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## APPLICATION

SG $\Delta$ A impulse test systems can be used to generate impulse voltages simulating lightning strokes and switching surges. The total charging voltage ranges from 200 kV to 3'000 kV with a per-stage energy of 5 or 10 kJ. Due to its unique  $\Delta$ -structure, the SG $\Delta$ A impulse generator are perfectly suited for transportation and on-site erection. The system has all our experience acquired, in building Impulse Generators since 1932, behind it.

Applications covered include testing according to IEC, ANSI/IEEE as well as other national standards.

A number of optional additional circuits and components can be included to optimise the impulse test system for tests on:

- Power transformers
- Instrument transformers
- Cables (type tests)
- Arresters (impulse current tests)
- Insulators
- Bushings
- GIS and air-insulated breakers

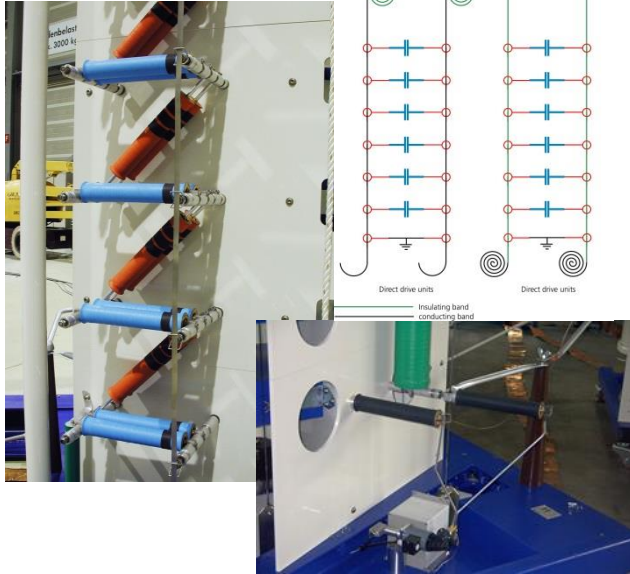
in the factory or on-site. For the latter tests, the SG $\Delta$ A system can be mounted in modules on a trailer or installed in an air-conditioned weather-resistant tower for permanent outdoor operation.

## BENEFITS

### Quality

The electronic measurement and control components are designed and manufactured in-house in an ISO 9001 certified factory. Our many years of experience in dealing with electromagnetic compatibility of electronic devices in high voltage test bays provide the requisite expertise and a trouble-free operation and a long service life are thereby ensured.

### Safety of Operation



Motorized safety earthing system

The grounding device with three grounding strips and two grounding switches guarantees safe operation. The controls provide clear alarm messages and guide the user through the operations.

### Grounding system

Safety grounding system consists of 3 direct drives and 3 spring loaded reels. No complex gear boxes, no redirection wheels and no adjustments are required which greatly improves reliability and is also designed to work automatically even when there is a power outage.

### Protection of Test Objects and Test Systems

The test system is shut down in case of over-voltage, over-current or fast voltage transients.

### Extension Possibility

The impulse generator can be extended for the generation of higher peak values (by adding of some stages) or for the generation of other wave shapes (by adding resistors and or other external circuits). Load range can also be extended by adding external Glaninger circuit or an external Overshoot Compensation device.

### Ease of Operation with Modern Control System

The generator controls are very comfortable and flexible, safety features are implemented in the hardware too, independent of software. All components of the control system are EMC tested.



GC 257 Controls

### Main features of the SGΔ system are:

- Sleek and flexible design
- Total charging voltage from 200 kV up to 3'000 kV.
- Energy per stage 5 kJ or 10 kJ.
- Computerized and microprocessor based control system.
- Equipped with resistors for lightning voltages and resistors for switching impulse voltages are available optionally.
- Unique protective grounding device, the fastest available on the market.
- Ingenious extensions of load range (Glaninger Circuit, Overshoot Compensation, Special Resistor sets for transformer, cable or GIS testing).
- Short reconfiguration times by utilizing handy plug-in resistors and connections.
- Series resistors can be interchanged with one another as can be the parallel resistors. Different values of a resistor type can be supplied.
- Spark gaps and bushings of impulse capacitors situated in Delta structure with filtered air-flow.
- Base frames with very small foot print.
- Liquid insulation in the impulse capacitors is made of castor oil (no PCB's) making sense ecologically.
- Feedback loop between measuring system and control allows the determination of the efficiency and to work with test voltages instead of charging voltages
- Top electrodes adjustable according to customers' impulse test requirements.
- SGΔA is not only technically competent and takes up little space, but is also aesthetically pleasing and complements the quality image of the customer's facilities

### Immunity to Electromagnetic Interference

The SGΔA test system is designed especially for minimizing the influence of interference fields to ensure correct functioning of the controls and measuring instruments. The measurement signal from the high voltage divider is in the range of 100 V to 1'600 V in order to ensure a high signal to noise ratio.

## THEORY

SG $\Delta$  generators are based on MARX multiplier circuits.

The impulse test system operates under a control system which charges the impulse generator through the charging unit. This is achieved as the stages in the impulse generator are connected in parallel via the charging resistors. Charging time and charging voltage can be selected by the operator.

Once the selected charging voltage has been reached, a trigger pulse initiates firing of the first spark-gap of the impulse generator. The resulting over-voltage triggers the successive stages. As all the spark-gaps fire, the stages which are in series now, multiply the charging voltage to reach the test voltage.

An impulse voltage divider reduces the impulse voltage to a value that the measuring and recording instruments can use.

The major impulse circuit elements such as capacitors and resistors are arranged in an optimum manner to simultaneously satisfy the two major requirements viz. smallest possible internal inductance and operating convenience.

## OPERATING RANGE

The minimum output voltage is 10 kV positive and negative. This is obtained with only one stage operating. The other stages are shorted or connected in parallel. The maximum output voltage is between 85% and 95% of the total charging voltage, depending on the load and the waveform. Details about the load range and output voltages are given in our offers/quotes.

## COMPONENTS OF THE IMPULSE TEST SYSTEM

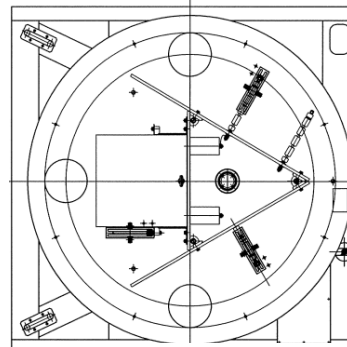
The test system comprises the following main components:

- Impulse Generator stack
- Charging Rectifier
- Impulse Voltage Divider
- Control System
- Measuring System

## ACCESSORIES

- Air cushion system
- Top electrodes
- Shunts
- Termination resistors
- Chopping Gaps
- Additional circuits for transformer testing
- Additional circuits for Impulse Current generation
- External series overshoot circuit
- Matching and isolating transformers
- Weather proof enclosures

## IMPULSE GENERATOR STACK



Top view of a module

### Support frame

Fiberglass plates form the famed  $\Delta$ -structure. The structure encloses the spark gaps and holds the impulse capacitors too. The resistors holders are affixed to these plate as well on the outside

Each Module holds either 2 or 3 capacitors.

Expansion of stages in future is extremely easy. Just involves adding necessary number of stages

### Impulse capacitors

Each impulse capacitor consists of flat elements built into a steel housing and impregnated with castor oil. The housing walls are flexible so that the impregnating oil can expand. Castor oil insulation offers optimal ecological safety (no PCB's).

### Resistors



They are the wave shaping elements and wire-wound for high stability and linearity and are wound on tubes and protected by shrink wrap or compound moulding.

Each resistor value has a specific colour for easy identification. These resistors have a plug-in connection for quick and easy reconfiguration.

The basic system includes a set of resistors for lightning impulse voltages according to IEC 60060-1.

Connection rods with multiple slip-in sockets are mounted and can hold up to 4 resistors

Combination of Multiple series- and parallel connections of resistors are possible to obtain additional values.

Accidental interchange of Series and parallel resistors is prevented by making their connections are of different lengths

### Encapsulated spark gaps

The spark gaps of the generator type SG $\Delta$  consists of Al electrodes. Fiber glass chimney protects the spark gaps and bushings of impulse capacitors from dust. Precision translatory gears are used to adjust gap distance. The gap drive motor is automatically controlled from the control unit.

### Top electrodes

The use of top electrodes makes it possible to raise preliminary discharge voltage to very high values. Several models of top electrodes, made of aluminium toroids are available

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### CHARGING RECTIFIER LGR 100

The charging rectifier type LGR 100 is used to charge the impulse capacitors with stage voltages up to 100 kV and is located on its own wheeled base frame.

- Compact & rugged design.
- Short circuit protected.
- Automatic motor-driven polarity reversal.
- Current - 40 mA or 150 mA



LGR 100-150 and LGR 100-40

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### DAMPED CAPACITIVE VOLTAGE DIVIDERS

Multiple options exist. Please refer catalogues of

- CR
- CS
- CZ



CR 4800-300

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### CONTROLS

Two systems differing in sophistication and technical specification are available. Please refer to individual Control System's catalogues

- Competitive and well established **GC 223**
  - Standalone desk top unit
  - EMC shielded and proof tested
- Fully computerised **GC 257-** operating under Windows.
  - Sophisticated sequence programs
  - User-friendly software equipped with a flat screen colour monitor

### Safety and Protection Functions

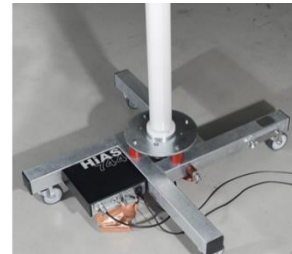
The control unit has a connection for a safety circuit and is equipped with a connection for warning lights.

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### IMPULSE ANALYSING SYSTEMS

- **HiAS<sup>®</sup> 744**
  - A multi-channel capable precision digital impulse analyzing system of the highest performance class.
  - 11 / 16 bit real vertical resolution at 250 MS/s
  - Automatic evaluation of all common impulse shapes and their parameters
  - Fiber Optic Communication to control room with galvanic separation

Please refer individual catalogue of HiAS 744



**OPTIONS**

**Shunts**

Haefely shunts can be used for the measurement of impulse currents. They consist of a metal cylinder with coupling flanges and coaxial measuring connector. Different models are available depending on the application

**Chopping Gaps**

■ **KFS Series**

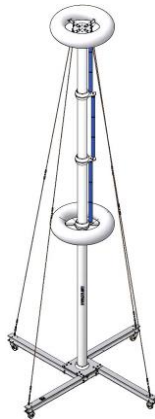
- Simple Straightforward Sphere Gaps useful for measurement, calibration as well as chopping.
- Available in Vertical-Motorized and Horizontal-Manual versions
- Voltage rating ranges from 150kV to 750 kV



■ **MAFS Series**

- Original and Patented by Haefely
- Used for front and tail chopping
- Voltage rating ranges from 600 kV to 3600 kV

Please refer individual catalogues for more details.



OC 1400

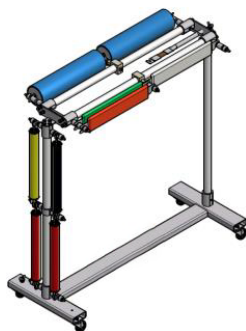
**Overshoot Compensation**

An overshoot compensation circuit (OC) can be used to test very high capacitive loads according to the standard impulse shapes. The overshoot compensation is connected on the top of the Impulse Divider

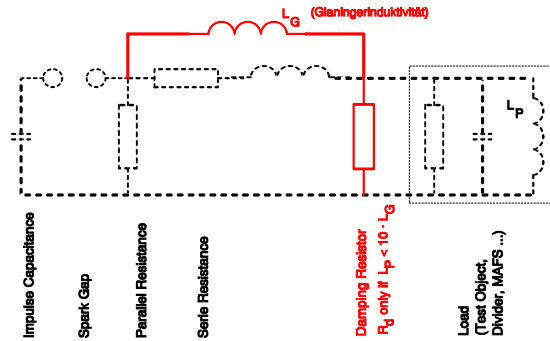
**Glaninger Circuit.**

For testing low voltage windings of transformers, an additional circuit is available as an option. This external circuit permits the testing of very low inductive loads.

The Glaninger circuit presupposes the existence of the tail resistor set SGD RP.



**Glaninger Circuit**



**Impulse Current generation**

Only additional resistors and wave shaping inductances are necessary for generating impulse currents up to 20 kA with an impulse voltage generator. Exponential impulse currents acc. IEC 60099-4 can be generated on test objects having very high residual voltages.



Impulse current testing arrangement for MV arresters

**Protective cylinder for outdoor operation**

For outdoor operation, the standard indoor generator is enclosed in an air-conditioned weather-resistant tower.

Modifications to generator aren't necessary. Internal lighting and fire protection system are provided. Our design is also resistant to natural lightning.



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## TECHNICAL SERVICES

A high level of customer service is essential in view of the complexity of high voltage test systems and the high reliability demanded by the customer.

The full warranty of the impulse voltage test system is conditional on the performance of the following Haefely services:

- Expert installation and on-site testing of the system
- Training of the operating personnel
- Maintenance of the test system throughout its service life, but for a period of at least 10 years (other than computers)
- Availability of spare parts

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## TRAINING OF OPERATING PERSONNEL

After acceptance testing, the client's personnel assigned to operate the impulse voltage test system will be trained. Installation and operator training is conducted by our customer-service personnel and will be adapted to suit the particular test facility and test specimen. This is an important contribution to reliable operation of the test system.

## 10 YEARS MAINTENANCE GUARANTEE

Because of the high degree of vertical integration with respect to high-voltage components and electronic equipment, Haefely is virtually independent of the product policies of suppliers. A large stock of replacement parts is held for maintenance purposes. This makes it possible for Haefely to ensure the maintenance for 10 years (other than computers)

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## OTHER SERVICE OPTIONS

### ON-SITE CALIBRATION SERVICE

Simple and unified calibration methods which apply to complete measuring systems give high-voltage test equipment manufacturers, users and customers the assurance of comparable quality requirements and tests involving such equipment.

Haefely Test performs following services on-site or in our works:

- Calibration of divider
- Calibration of measuring device
- Calibration of entire system

### MAINTENANCE AGREEMENT

Haefely Test offers a maintenance agreement tailored to the customer's special needs. In this way, the value of the test system can be preserved over a long period of time.

Further services are offered for support in integration tasks or during operation