

# S<sup>3</sup> – Speed, safety and savings

## ABB's new ultra-fast earthing switch

DIETMAR GENTSCH, VOLKER GRAFE, HANS-WILLI OTT, WOLFGANG HAKELBERG, ANDREAS BRANDT – ABB's well-known and fast acting vacuum interrupter and the world's fastest limiting and switching device, the I<sub>s</sub>-limiter, have been in service for decades. Now the technologies from these devices have been cleverly combined to form an arc-fault protection system for medium-voltage switchgear that operates in the ultra-fast range. As a product, the extremely short switching time of less than 1.5 ms of

this special vacuum device combined with the rapid and reliable detection of fault currents and light intensity of a new dedicated electronic unit, will ensure all arcs are almost immediately extinguished. In technical terms, this means that system availability and operator safety are greatly enhanced for rated voltages up to 40.5 kV and rated short-time withstand currents (1s) up to 63 kA. From an economic point of view, downtimes and repair costs resulting from faults will be drastically reduced.

## 1 Arc fault duration in electrical systems and the associated consequences.

### Using a conventional protection device

- Arc fault duration: 200–300 ms
- Detection by standard relay
- Clearing of arc fault current by the upstream circuit breaker

### Possible dramatic consequences include

- Fire/explosion
- Serious injuries to personnel (depending on the switchgear design)

### Fast-acting protection relay with supplementary equipment (eg, $I_n$ -limiter)

- Arc fault duration: 50–100 ms
- Fast detection by special protection relay
- Clearing of arc fault current by the upstream circuit breaker

### Limited damage to equipment and personnel (depending on the switchgear design)

### Ultra-fast earthing switch (UFES)

- Arc fault duration:  $\leq 4$ ms after detection
- Ultra-fast detection by UFES electronic unit (type QRU)
- Ultra-fast extinction of the internal arc by switching of the UFES primary-element
- Final clearing of fault current by the upstream circuit-breaker

### No damage expected

ronment. From a dielectric point of view, the chamber actually constitutes two vacuum gaps separated by a membrane. One gap contains a contact pin at earth potential while the other accommodates a fixed contact at high-voltage potential. Each element also features an integrated ultra-fast micro gas generator (SMGG), which is comparable in type and functionality to the gas generators in automobile airbags → 2. The SMGG drives a piston and is designed as a single-shot piston actuator. The electronic unit, based on durable and fast analog technology, is phase independent in structure, and ensures current and light detection and reliable tripping within the shortest possible time.

When an internal arc fault occurs in a switchgear system, the electronic unit detects the fault current (supplied by a current transformer) and the arc light in the compartment (measured by optical sensors). At almost the same time, the gas generator is activated. More specifically, the gas pressure drives the movable piston. This piston slides into the first part of the vacuum chamber and eventually causes the contact pin to penetrate the membrane and engage with the fixed contact permanently and without bouncing to create a solid metal short-circuit to earth. The arc fault can then be short-circuited and extinguished in less than 4ms after it is first detected. The entire sequence, illustrated in → 3, leads to the safe connection of the piston to earth potential via a moving contact system.

### Processing that all-important information

The electronic unit has three input channels that enable continuous monitoring of the instantaneous current. The response level, the criterion for detection of a fault current, can be adjusted to suit a wide variety of protection conditions by means of simple controls. With a low input burden of less than 1 VA, the current measurement system can simply be looped into the secondary wiring of the existing current protection transformers.

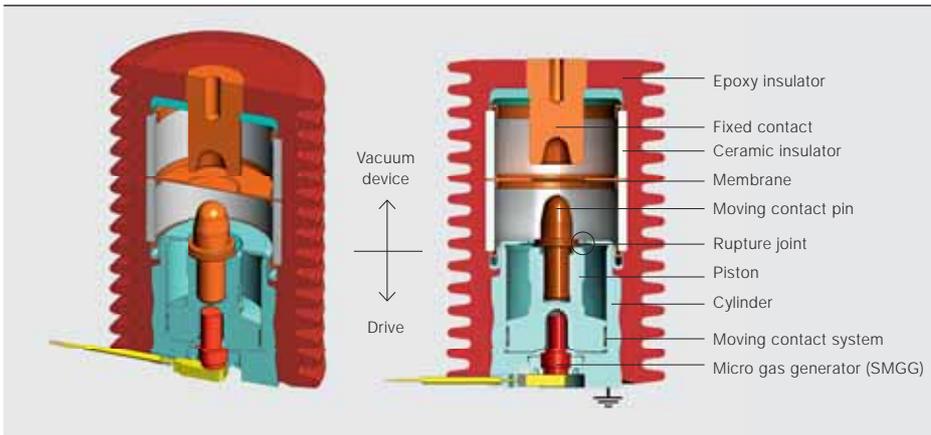
In addition to current monitoring, nine optical inputs are available for arc-fault detection. The status of the arc-fault protection system is indicated by LEDs and a 7-segment display on the front panel of the unit → 4. Various floating

In rare cases, failure inside a switchgear cubicle due to a defect, an exceptional service condition or mal-operation may initiate an internal arc, which constitutes a hazard → 1. While the absolute protection of all personnel is by far the most important concern during such an event, users would also like to prevent system components from being destroyed. ABB's new internal arc protection system ensures that this is the case.

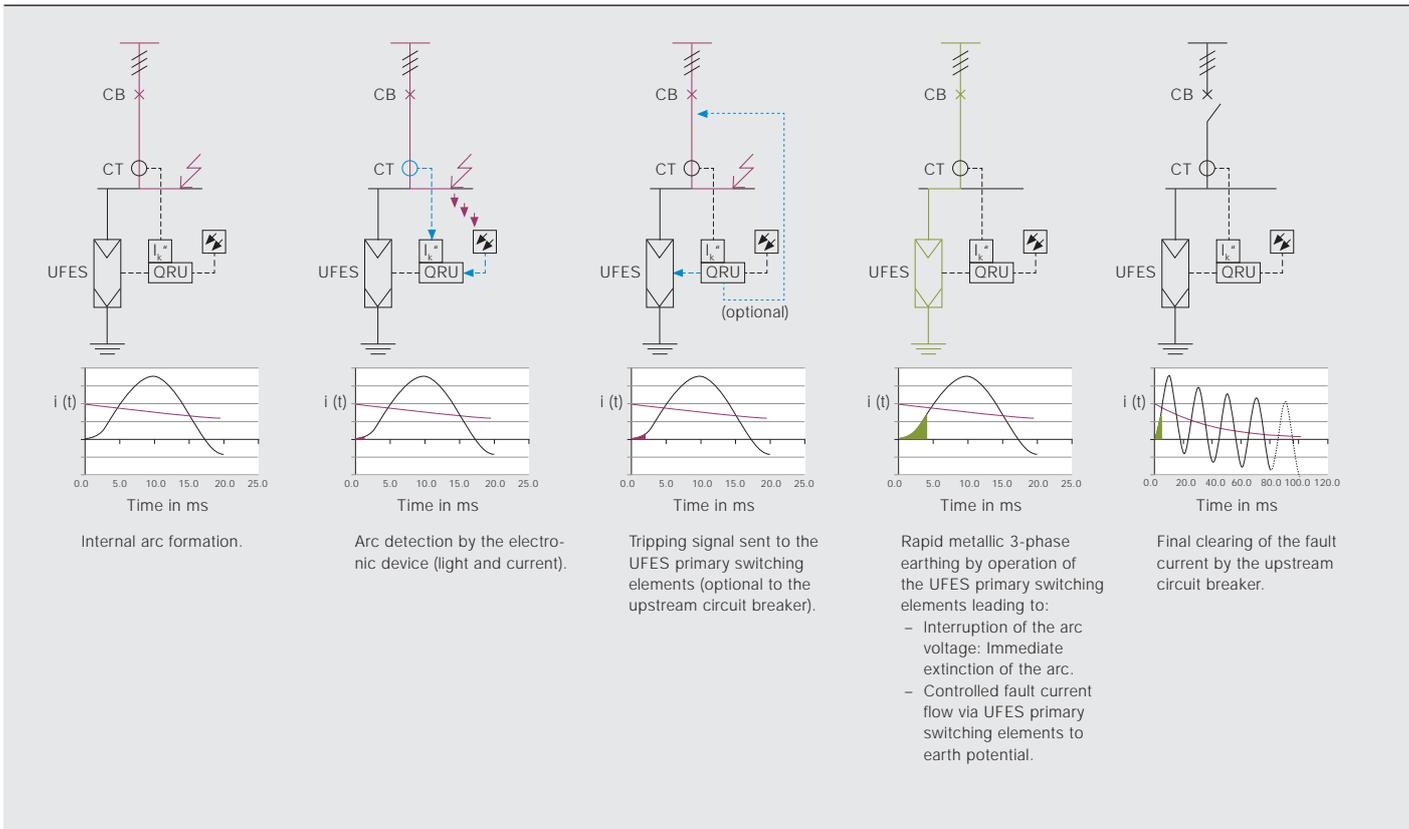
The system operates on the principle that the uncontrolled release of energy from an internal arc fault is prevented by rapid metallic 3-phase earthing. Characterized by a significantly low impedance, this type of connection causes the short-circuit current of an arc fault to commutate immediately to the fast-acting earthing switch and extinguish the arc.

The new ultra-fast earthing switch (UFES) contains three complete primary switching elements type U1 (see picture on page 84) and an electronic unit type QRU (quick release unit). Each primary switching element is similar in dimensions (height 210 mm, diameter 137 mm), shape and fastening points to a 24 kV pin-type insulator, and consists of a two-part vacuum chamber embedded in epoxy resin to protect it from the envi-

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3 Event sequence description



Standard	IEC	
<b>Electrical maximum characteristics (different basic types)</b>		
Rated voltage (rms)	kV	40.5
Rated power frequency withstand voltage (rms)	kV	85 / 95
Rated lightning impulse withstand voltage (peak)	kV	170 / (200)
Rated frequency	Hz	50 / 60
Rated short-time withstand current (rms)	kA	50 / (63)
Rated peak withstand current	kA	170
Rated duration of short-circuit	s	3 / (1)
Rated short-circuit making current	kA	170
<b>Mechanical characteristics</b>		
Dimension (diameter x height)	mm	~ 137 x 210
Closing time	ms	< 1.6
Contact bounce duration	ms	0
<b>Lifetime</b>		
Mechanical life operations		1
Number of short-circuit operations		1
Shelf life	years	30
Micro gas generator	years	15

ABB's system is an active internal arc fault protection solution for medium-voltage switchgear systems, which greatly increases both system availability and personnel safety.

contacts are provided as interfaces to other units. These can be used:

- To transmit the status of the electronics to a remote control room
- To send commands to a circuit breaker feeding into the arc fault
- As an interlock to block the reclosing of a circuit breaker directly after tripping.

Together with the electronic watchdog function, the functional capability of the SMGG-igniter is also continuously monitored. The electronic unit can be switched to test mode in which all the response

criteria for the switchgear can be simulated and checked by the user, and the corresponding trips displayed but not transmitted to the SMGG's.

In combination with the TVOC light detection system, up to 54 compartments in a switchgear system (three compartments per panel) can be monitored using one electronic unit. The TVOC extension modules, each of which contains nine optical inputs, can be directly connected to the five interfaces provided. Because detection of an arc fault by these modules is also monitored by the electronic unit, at least 18 panels in a switchgear system are provided with active protection. As each compartment is individually monitored, the location of the fault can be easily determined.

#### The power to protect

ABB's system, suitable for rated voltages up to 40.5 kV and rated short-time withstand currents up to 63 kA (1s) → 5, is an active internal arc fault protection solution for new internal arc classified medium-voltage switchgear as well as for existing older generation switchgear. It helps to avoid serious damage to the switchgear, the equipment and the direct environment. Therefore, it greatly increases both system availability and personnel safety in the event of internal arc fault. Furthermore it enables the minimization of pressure relief arrangements in



poorly accessible switchgear installation rooms.

The UFES primary switching elements can be installed in the switchgear cable connection compartments or simply in each separate busbar section to ensure the entire system is covered. The UFES will be available as a complete unit in a type-tested ABB service box for simple installation in existing switchgear systems → 6 and later as a "loose device" (ie, the electronic unit and three primary switching elements).

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