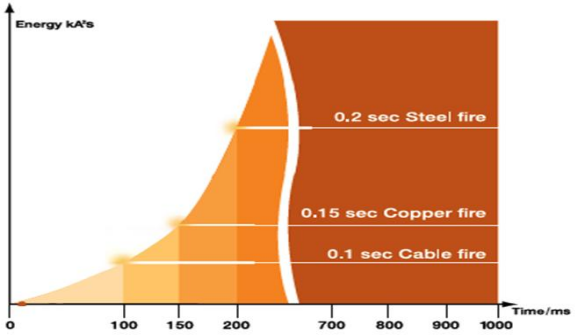


AUGUST 2018

Arc fault protection - a matter of time

Arc faults generally cause serious damage Fault characteristics





- An arc arises when at least part of the current passes through a dielectric, usually air
- Maximum peak power up to 40 MW
- Arc core plasma temperature up to five times the surface temperature of the sun (20 000°C)
- Light intensity may rise up to 100 000 – 200 000 lux

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Arc fault protection – a matter of time



Arcing time 35ms

Arcing time 500ms



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Internal arc faults

Reasons of formation



Typical human and operational errors:

- Work in a wrong cubicle
- Operation of a wrong isolator
- Forgetting to ground the working area
- Forgetting to test the presence of voltage in the working area



Technical reasons to arc faults:

- Faults in equipment and false operation of equipment
- Ageing of insulation and mechanical wear
- Overvoltage / Overheating
- Moisture, dirt



Other technical reasons to arc faults:

- Corrosion
- Foreign objects (e.g. forgotten tools) or small animals in the switchgear
- Installation errors
- Bad workmanship of cable terminations and loose busbar joints

Arc faults generally cause serious damage

An uncontrolled arc causes

Comments:
CB after internal arc impact



Heat

– Hot gases, melt drops and thermal radiation may cause severe burns and other injuries to personnel and fire with escalating damages

Pressure

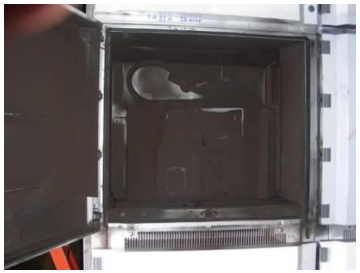
– A rapid temperature rise may lead to a violent explosion and ejection of loose parts like shrapnel

Poison

– Toxic chemical compounds may be formed at high temperatures, copper busbar vapor extremely harmful

Internal arc faults

Impacts to switchgear



- Circuit breaker compartment after internal arc impact



- Cable connection compartment after internal arc impact



- Contact terminal after internal arc impact

Main drivers for investing in arc protection

Personnel safety

Most of the fatal accidents in the power network are caused by human errors during the maintenance and repair work

Risks for human errors result due to the facts that

– Local operation and maintenance of the power network equipment are seldom required

– Network equipment typically consists of devices with varying ages and construction, e.g. new internal arc classified and old open-type MV switchgears

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Main drivers for investing in arc protection

Personnel safety

Risks resulting from the ever increasing power consumption

– Higher load rate of the power network is stressing the network components, such as breakers, disconnectors, and busbar joints
– Short-circuit power has increased significantly which also amplifies the effects of possible arcs

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Main drivers for investing in arc protection

Asset management

When adding arc protection solution into the protection system

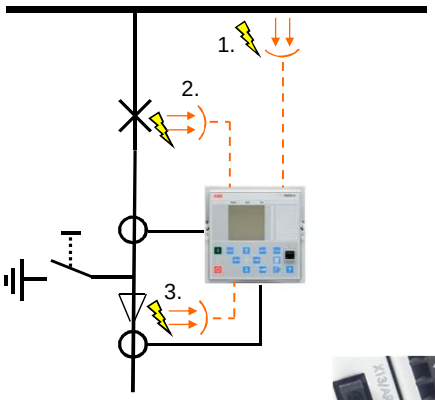
– Damages to switchgear, equipment and direct environment caused by an arc fault can be limited to minimum. Therefore, required repair and replacement investments can be kept in a moderate level.

– The life-cycle of an older generation switchgear can be extended approximately between 5 and 10 years. This offers to the asset owners flexibility to schedule the renewal of the switchgear later in the future.

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ABB offering

Arc protection solutions







Relion® 615 & 620 Series IEDs with arc protection option

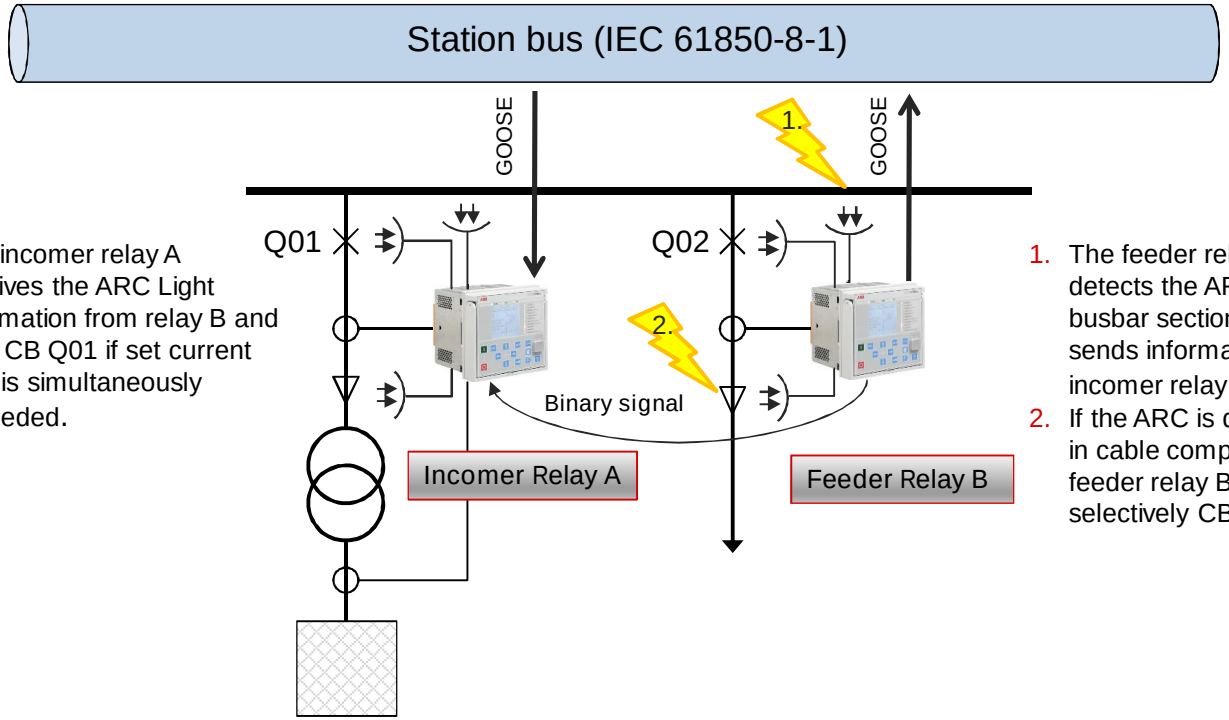
- Arc protection is affordably integrated into the main protection system and therefore recommended per default to all air-insulated switchgears with single busbar substation layouts
- Selective detection of arcs in the busbar (1.), CB (2.) and cable termination (3.) compartments, also in case of earth-faults
- In industrial power distribution systems the main overcurrent based protection against the arcs can be insufficient due to the multiple protection stages with long operating times (time grading)
- Fast IEC 61850 Goose message communication enables sophisticated protection solutions e.g. for applications including distributed power generation where the feeding is coming from many directions

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REF 615 Arc Fault Protection

Operate Time Tests – Simulated System

ARC fault light detected –information was sent from Feeder relay B to Incomer relay A as hardwired signal or as IEC 61850 GOOSE message



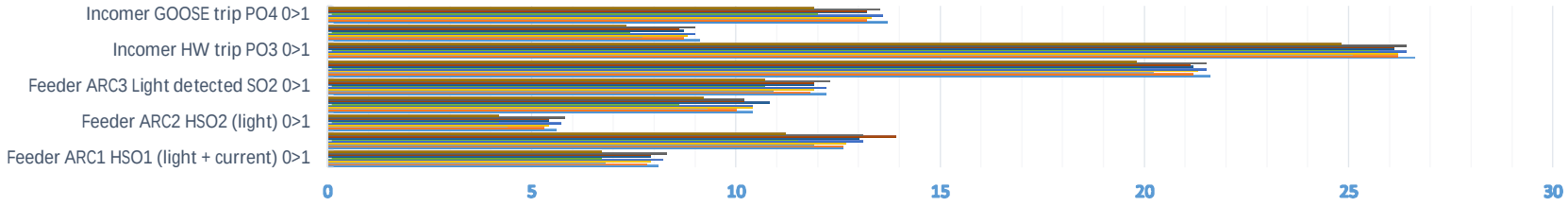
The incomer relay A receives the ARC Light information from relay B and trips CB Q01 if set current limit is simultaneously exceeded.

1. The feeder relay B detects the ARC in busbar section and sends information to incomer relay A.
2. If the ARC is detected in cable compartment, feeder relay B trips selectively CB Q02.

REF 615 Arc Fault Protection

- Operate time tests were done with Omicron CMC256-6 test set and arc flash simulator
- 3 phase fault current was 10 x In (Arcsarc FB O/C threshold setting was 2.5 x In)
- Fault current was injected simultaneously with arc light flash

REF615 Arc fault protection operate time [ms], measured data



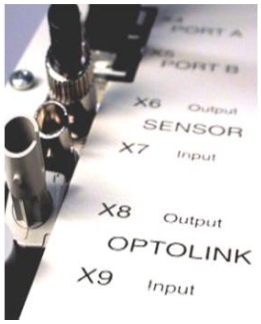
	Feeder ARC1 HSO1 (light + current) 0>1	Feeder ARC1 PO3 (light + current) 0>1	Feeder ARC2 HSO2 (light) 0>1	Feeder ARC2 PO4 (light) 0>1	Feeder ARC3 Light detected SO2 0>1	Incomer HW trip HSO1 0>1	Incomer HW trip PO3 0>1	Incomer GOOSE trip HSO2 0>1	Incomer GOOSE trip PO4 0>1
Series10	6.7	11.2	4.2	9.2	10.7	19.8	24.8	7.3	11.9
Series9	8.3	13.1	5.8	10.2	12.3	21.5	26.4	9	13.5
Series8	7.9	13.9	5.4	10.2	11.9	21.1	26.1	8.6	13.2
Series7	7.9	13	5.4	10.8	11.9	21.2	26.1	8.7	13.2
Series6	6.7	11.5	4.2	8.6	10.7	19.9	25.7	7.4	12
Series5	8.2	13.1	5.7	10.4	12.2	21.5	26.4	9	13.6
Series4	7.9	12.7	5.4	10.4	11.9	21.3	26.2	8.8	13.3
Series3	6.8	11.9	4.4	9.3	10.9	20.2	25.1	7.7	12.3
Series2	7.8	12.6	5.3	10	11.8	21.2	26.2	8.7	13.2
Series1	8.1	12.6	5.6	10.4	12.2	21.6	26.6	9.1	13.7

ABB offering

Arc protection solutions

REA101 REA103 REA105 REA107







REA 10_ Arc Fault Protection System

- Targeted to customers who desire to keep the arc protection system separate from the main power system protection in retrofit and greenfield investments
- Optical arc flash detection in less than 2.5 ms with fiber loop type sensors up to 60 m or “retrofit-friendly” lens type sensors
- Solid state trip outputs, integrated CBFP
- Main module REA101 provides independent overcurrent/earth-fault current detection and one light sensor input for basic application
- Additional main units REA101 and extension units REA103, REA105 or REA107 (up to 10 per each REA101) with several sensors can be applied for systems including e.g. two or more incomers and single or double busbar switchgear layouts requiring fast and selective protection

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REA 10_Arc protection system- Example of an application

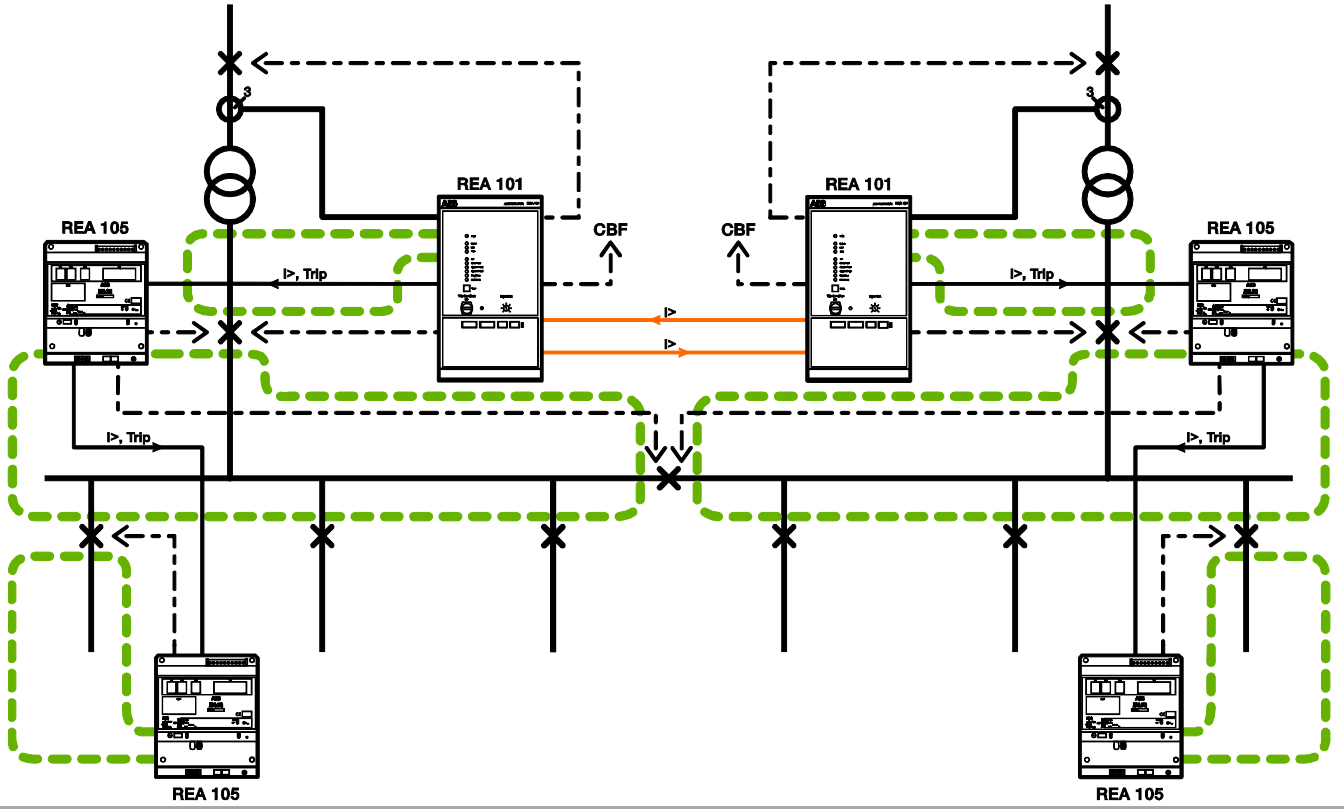


ABB offering

Arc protection solutions



UFES (Ultra Fast Earthing Switch) with REA 10_ Arc Protection System

- Targeted to customers for whom arc faults and associated power outages can cause extremely high negative financial impacts
- Targeted to customers who are retrofitting their protection system or installing new equipment requiring highest possible protection for switchgear in regard to the hazardous impacts caused by an internal arc
- Suitable also for marine applications
- In industry greenfield investments savings are possible in cabling costs due to the fact that the switchgear can be located near to the power consumption point

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UFES (Ultra Fast Earthing Switch) with REA 101 - Example of an application

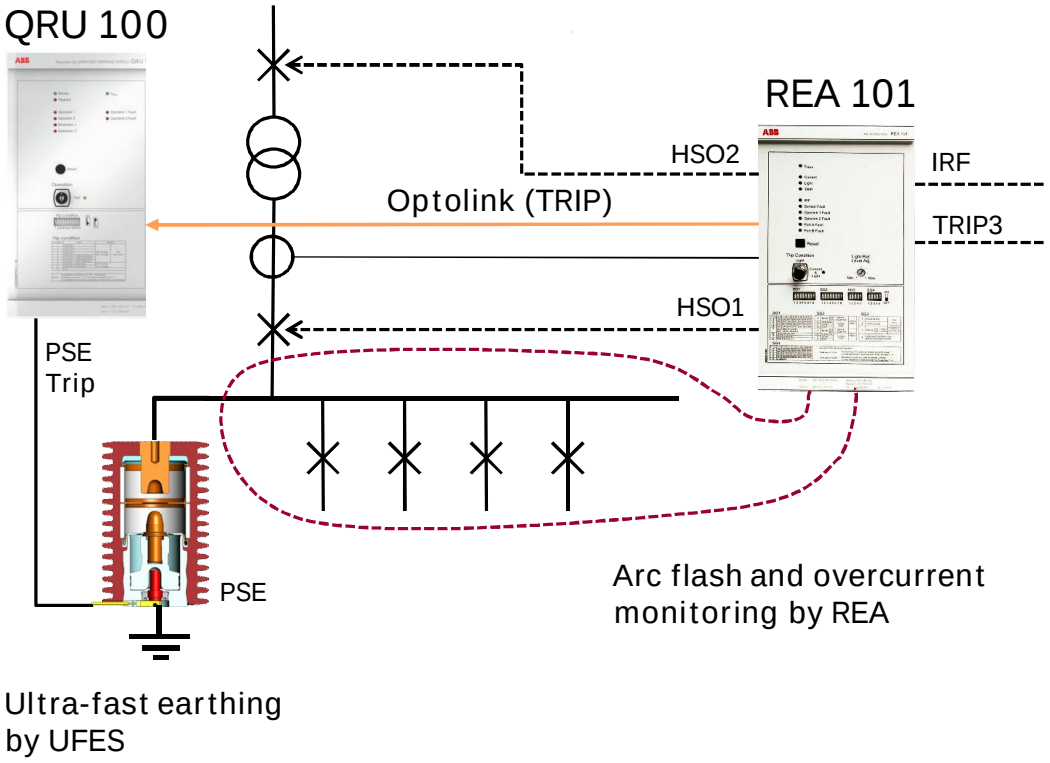
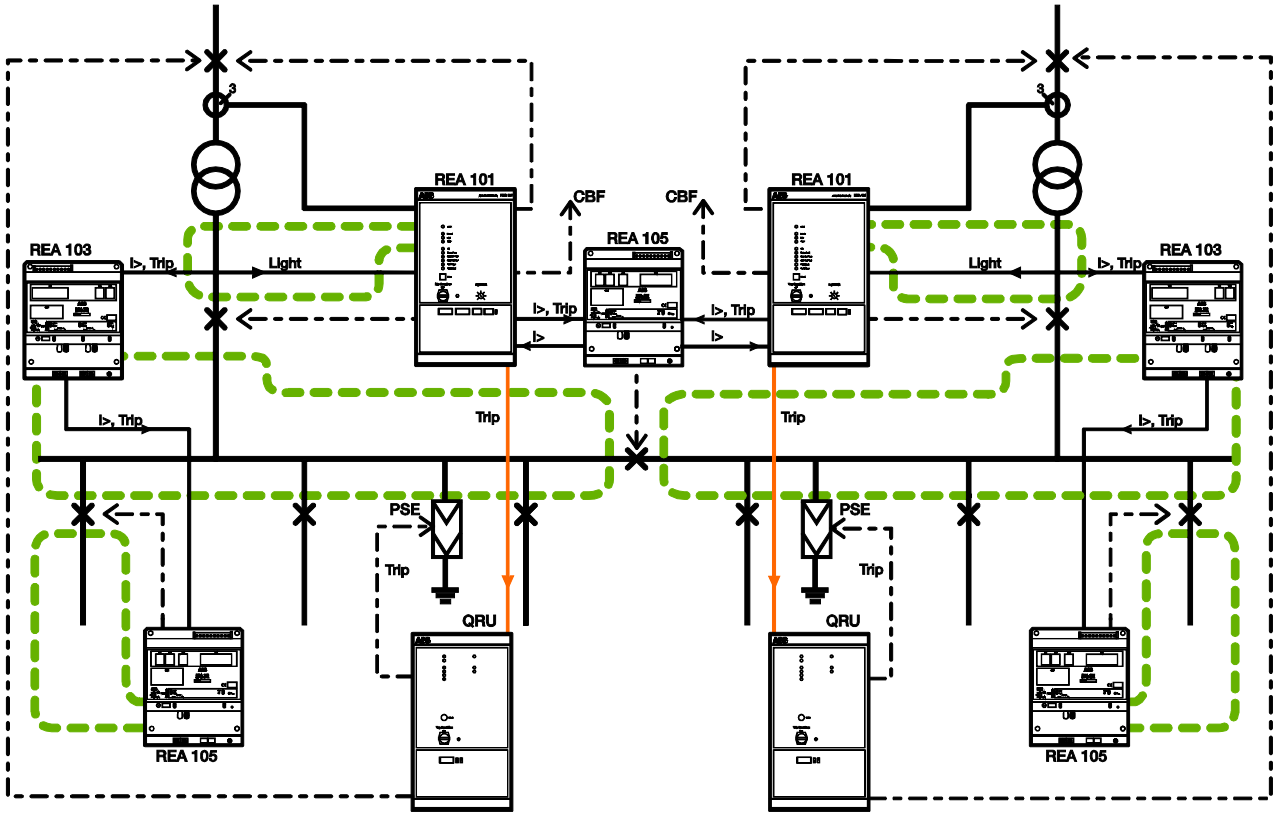


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UFES (Ultra Fast Earthing Switch) with REA 101 - Example of an application



Comparison of different solutions

Speed and selectivity

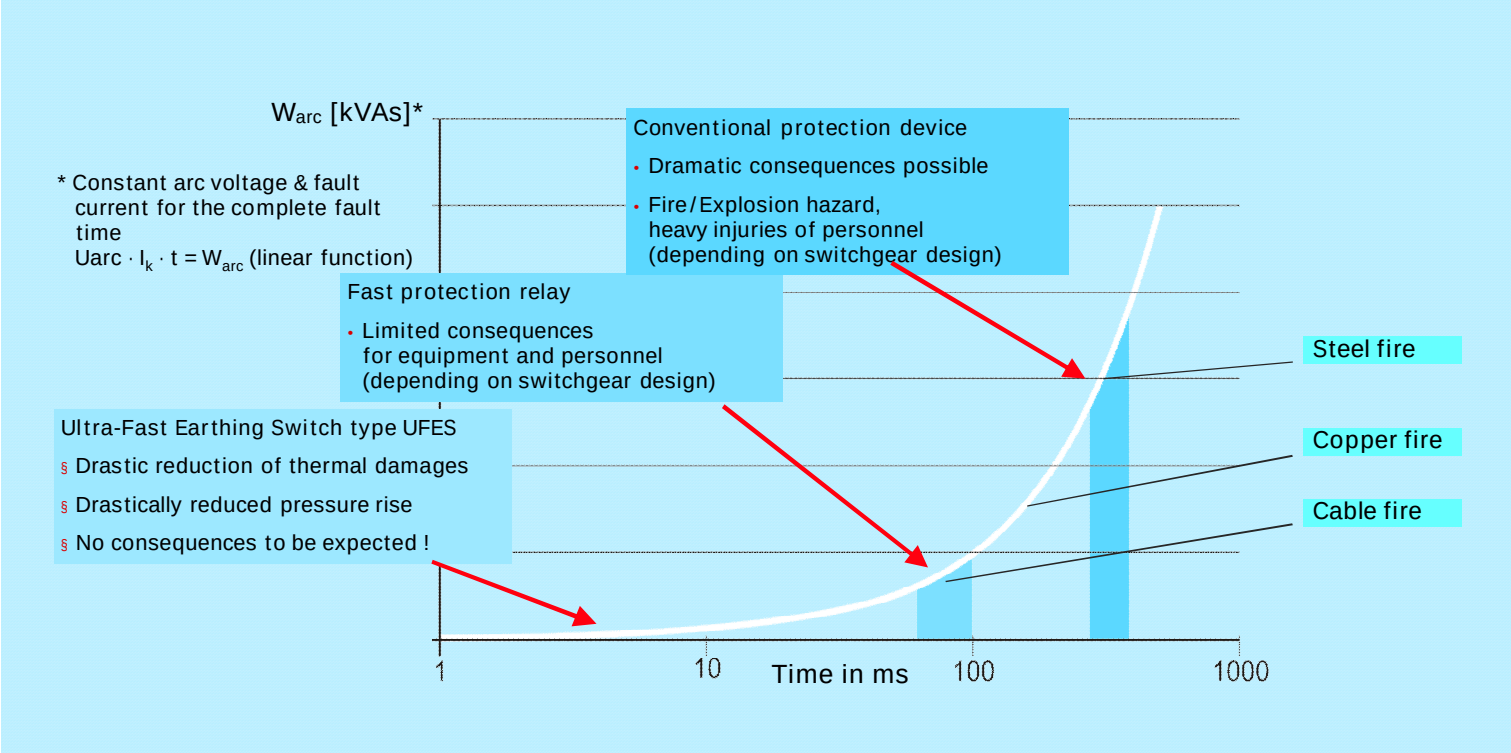
	Protection time	Switching time	Selectivity
No arc flash detection based protection	Typically 300ms	~50ms (*	No
REA101	~2ms	~50ms (*	No
REA101 + UFES	~2.5ms	~1.5ms	No
Relion® 615 Series IED with arc option	~10ms	~50ms (*	Yes
REA10_ System	~2.5ms	~50ms (*	Yes
REA10_ System + UFES	~2.5ms	~1.5ms	Yes

- Arc extinction time is Protection time + Switching time

*) Switching time = Breaking time of the infeed CB

Ultra-Fast Earthing Switch type UFES

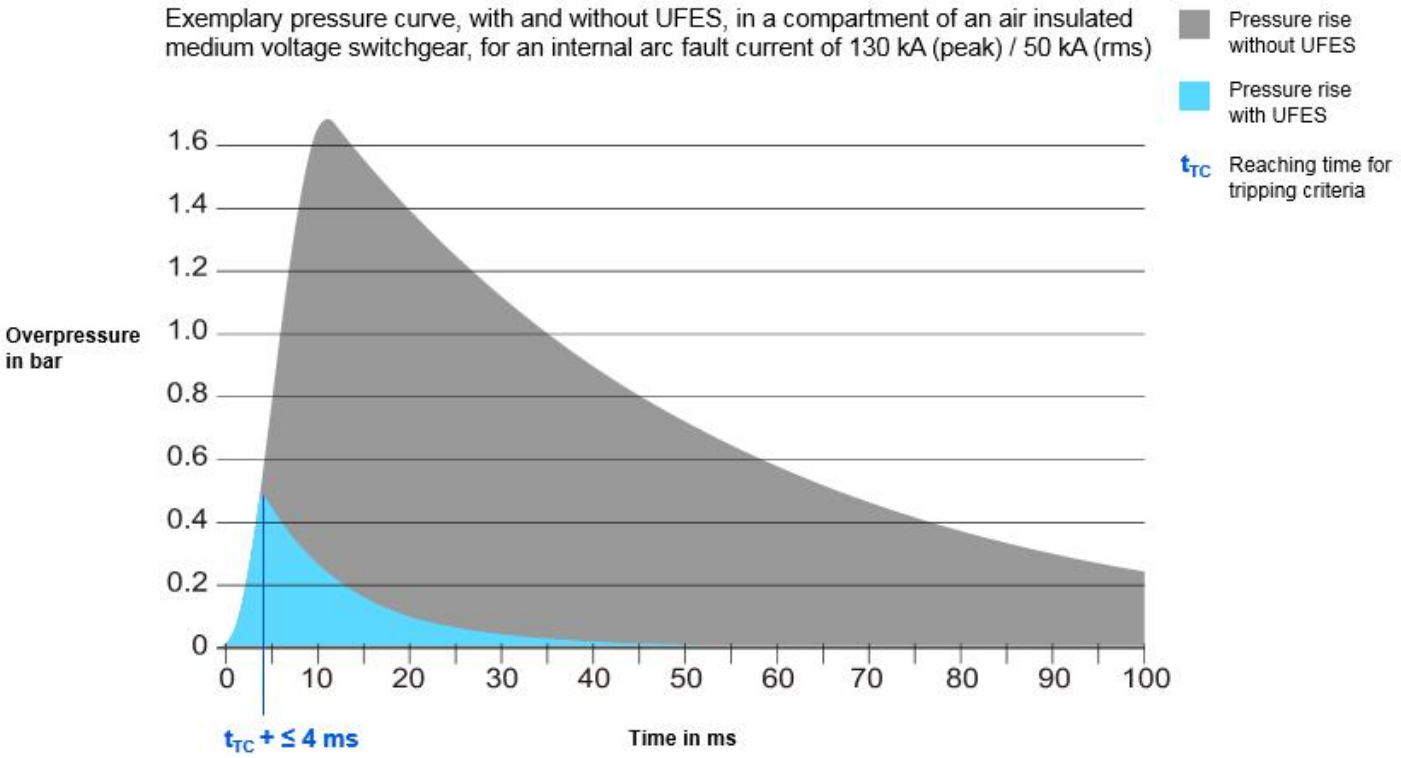
Speed – Differentiation



§ Effective limitation of damage requires fastest intervention

Ultra-Fast Earthing Switch type UFES

Speed & Safety – Pressure curves



Ultra-Fast Earthing Switch type UFES

The basis for effective protection





Electronic tripping unit

– Fast and reliable interface to external arc detection systems

– Tripping of the UFES primary switching elements

3 Primary switching elements

– Ultra-fast initiation of a 3-phase short-circuit earthing after detection of a fault by the electronic unit

– Elimination of the arc by immediate breakdown of the internal arc voltage

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Ultra-Fast Earthing Switch type UFES

UFES electronic unit QRU100



Electronic tripping unit type QRU100

- Fully compatible to the ABB arc protection system of type REA
- 2 Optolink inputs for connection of the REA101 relay
- 2 high-speed inputs (HSI) for connection of external arc detection systems
- Self monitoring including the Optolink connection to the REA system
- Logical combination of the external detection units by use of DIP-switches
- Testing mode for functional check

Ultra-Fast Earthing Switch type UFES

Combinable arc protection by ABB



UFES + REA

Versatile monitoring options with REA system:

– Optical arc flash detection via fiber type or lens sensors
– Independent overcurrent detection
– Selective protection
– Circuit-breaker failure protection

Ultra-fast arc extinction by UFES

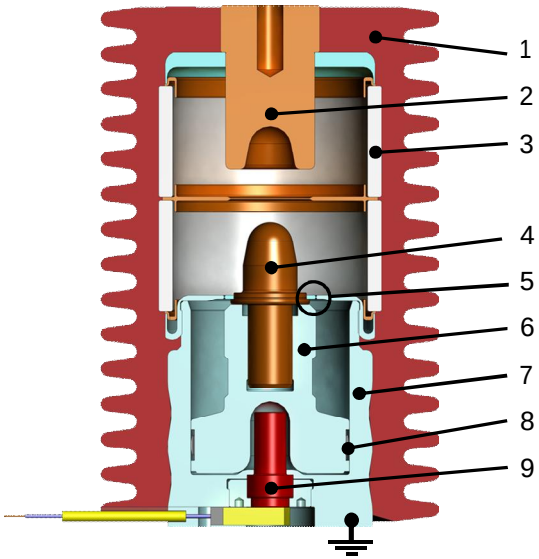
Certified interfaces

Extremely short tripping times < 4 ms (after detection)

Ultra-Fast Earthing Switch type UFES

Primary switching element

Primary switching element – section view



1. Epoxy insulator
2. Fixed contact
3. Ceramic insulator
4. Moving contact pin
5. Rupture joint
6. Piston
7. Cylinder
8. Moving contact system
9. Micro gas generator

- Primary switching element type U1
- Vacuum interrupter and operating system integrated in one compact unit
- Fast and reliable micro gas generator operating mechanism
- Fast switching time of ~ 1.5 ms
- Easy handling
- Low-maintenance
- Flexible installation

Ultra-Fast Earthing Switch type UFES

Comparison of arc impact



§ Busbar compartment after internal arc impact with active UFES protection



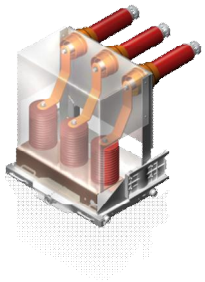
§ Busbar compartment after internal arc impact without active UFES protection (50 kA / 100 ms)

Ultra-Fast Earthing Switch type UFES

Available as ABB Service retrofit solution



Service-Box



Draw-out unit



Service-Box
(Illustration: Side-mounted)



Draw-out technology

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Ultra-Fast Earthing Switch type UFES

Available as loose components

Standard: UFES-Kit-100* as OEM product, consisting of:



Electronic tripping unit type QRU100



1 set (3 off) Tripping cables (10 m) with special plug for PSE and electronic



3 Primary switching elements (PSE)

* Full compatibility to the ABB Arc Fault Protection System type REA which needs to be ordered separately.

Ultra-Fast Earthing Switch type UFES

Available for ABB switchgear (AIS)



UFES in UniGear –
Top-Box installation



UFES in UniGear -
Installation in
cable compartment

Ultra-Fast Earthing Switch type UFES

Unbeatable advantages







Indirect benefit

Greatly increased system and process availability by avoidance of heavy damages inside the switchgear, of the equipment and the direct environment

Drastic reduction of downtimes and repair costs

Example for a production site
(e.g. chemical-, paper- or oil industry)

Risks: Exchange of damaged switchgear panel(s) or equipment necessary

Consequence: Loss of production for possibly some days or weeks

Costs: Up to multiple 100.000 EUR / day possible

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Ultra-Fast Earthing Switch type UFES

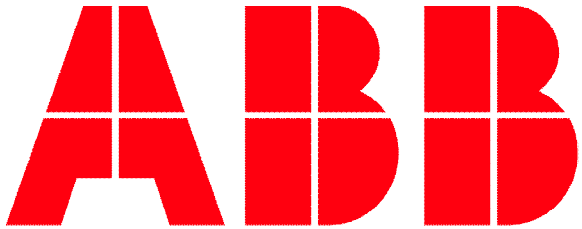
Unbeatable advantages



Direct benefit

Greatly increased operator safety for switchgears

Minimization of pressure rise and gases in the faulty compartment and surrounding switchgear building


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