$I_s$-limiter
Is-limiter
Fault Current Limiter (FCL)

Fault current limiter – type 1 (with current interruption)
Fault current limiter – type 2 (without current interruption)

Fault current (without limitation)
## Iₘ-limiter
Fault Current Limiter – Commercially available

<table>
<thead>
<tr>
<th></th>
<th>Rated current</th>
<th>Power loss</th>
<th>Voltage drop</th>
<th>Current interruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current limiting reactor</td>
<td>≤ 4000 A</td>
<td>high</td>
<td>high</td>
<td>No (type 2)</td>
</tr>
<tr>
<td>Fuse</td>
<td>≤ 200 A</td>
<td>very low</td>
<td>zero</td>
<td>Yes (type 1)</td>
</tr>
<tr>
<td>Iₘ-limiter</td>
<td>≤ 4000 A</td>
<td>very low</td>
<td>zero</td>
<td>Yes (type 1)</td>
</tr>
</tbody>
</table>
Iₜ-limiter – Function
Insert-holder and insert
$I_s$-limiter – Function
Breaking of a short-circuit current with $I_s$-limiter

Current curve at the short-circuit location

$T_1$  
$I_k^* = 50$ kA  
$i_1$  
$i = i_1 + i_2$  
$I_{k,\text{perm.}}^* = 50$ kA

$T_2$  
$I_k^* = 50$ kA  
$i_2$  
$I_{k,\text{perm.}}^* = 50$ kA

$250$ kA  
$125$ kA  
$50$ kA $X \times \sqrt{2}$  

$i = i_1 + i_2$

without $I_s$-limiter

with $I_s$-limiter

$u$

$i_1$

$i_2$
### I_S-limiter

#### Technical data

<table>
<thead>
<tr>
<th>Rated voltage</th>
<th>Rated current</th>
<th>Switching capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75 kV</td>
<td>... 5000 A</td>
<td>... 140 kA RMS</td>
</tr>
<tr>
<td>12.00 kV</td>
<td>... 4000 A</td>
<td>... 210 kA RMS</td>
</tr>
<tr>
<td>17.50 kV</td>
<td>... 4000 A</td>
<td>... 210 kA RMS</td>
</tr>
<tr>
<td>24.00 kV</td>
<td>... 3000 A</td>
<td>... 140 kA RMS</td>
</tr>
<tr>
<td>36.00 kV</td>
<td>... 2500 A</td>
<td>... 140 kA RMS</td>
</tr>
<tr>
<td>40.50 kV</td>
<td>... 2500 A</td>
<td>... 140 kA RMS</td>
</tr>
</tbody>
</table>

For higher rated currents, I_S-limiter can be connected in parallel.
$I_s$-limiter – Structure
Typical System Components

3 CT’s
1 Tripping cabinet
3 Inserts holders with inserts
$I_s$-limiter – Structure
Truck mounted panel

Type tested
- acc. IEC 62271-200

Internal arc classification
- IAC: A FLR
\( I_s \)-limiter – Application Installations

- Petrobras, Shell, BP, Repsol……
- Vale, Toromocho, Minings in Australia
- Aluminium works
- Oil / Gas platforms world-wide
- Refineries world-wide
- Utilities
- Los Alamos National Laboratories / USA
- MIT / Boston USA
- Rolls Royce / Great Britain
- Deutsche Bundesbank (German state bank)
- …
I\textsubscript{s}-limiter – Application
I\textsubscript{s}-limiter mounted in bus section

Advantages:

- Improving „power quality“
- Increasing the reliability of the system
- Reduction of the network-impedance
- Optimal load flow
- Existing busbar system and cabling have not to be changed
Advantages:

- Generator can be connected independent on the short-circuit capability of the system
- Existing busbar and cable systems have not to be changed
- No need of expensive generator breaker
$I_s$-limiter – Application

$I_s$-limiter in parallel to reactor

Advantages:

- Avoid copper losses of the reactor
- Avoid voltage drop of the reactor
- No electromagnetical field of the reactor
- Greenhouse aspects ($CO_2$ and heating)
**I_s-limiter – Application**  
**Calculation of savings**

**Technical Data:**  
U_r = 13.8 kV, I_r = 4000 A  
Reduction:  
50 kA to 40 kA  
(L = 0.172 mH, P = 42.5 kW/ phase)

**Copper losses per year:**  
42.5 kW * 3 * 24h * 330d = 1.009.800 kWh (I_{service} = 4000 A)  
10.625 kW * 3 * 24h * 330d = 252.450 kWh (I_{service} = 2000 A)
I_s-limiter – Application
I_s-limiter with summation of currents

Advantages:
- Only I_s-limiters close to fault location trip
- Existing busbar and cable systems have not to be changed
- Reduction of the network-impedance
- Optimal load flow
- Greenhouse aspects (CO_2 and heating)
Arc fault protection – a matter of time

UFES
Ultra Fast Earthing Switch type UFES
Internal arc test without active protection device

Illustration:
Internal arc test - 50kA / 1s
Fault initiation in CB compartment
Internal arc faults

Impacts

- Circuit breaker compartment after internal arc impact
- Cable connection compartment after internal arc impact
- Contact terminal after internal arc impact
Internal arc faults
Impacts
Arc faults generally cause serious damage
An uncontrolled arc causes

- **Heat**
  - Hot gases, melt drops and thermal radiation may cause damage even farther away

- **Pressure**
  - A rapid temperature rise may lead to a violent explosion

- **Poison**
  - Toxic chemical compounds may be formed at high temperatures, copper busbar vapour

Comments:
CB after internal arc test
Arc fault protection – a matter of time

UFES
### ABB offering Arc protection solutions

- **615 series IED with optional arc lenses**
  - Arc protection is integrated into the main protection system and therefore recommended per default to all air-insulated switchgears with single busbar substation layouts.
  - Provides a sophisticated protection solution for applications including distributed power generation where the feeding is coming from many directions.
  - Provides also protection capability which enables selective detection of arcs in the cable end compartment, also in case of earth-faults.
  - In industrial power protection systems the main protection against the arcs can be insufficient due to the multiple protection stages with long operating times.
ABB offering Arc protection solutions

- REA 10_ Arc protection system
  - Targeted to customers for whom short power outages do not cause extremely high negative financial impacts
  - Targeted to customers who desire to keep the arc protection system separate from the main power system protection in retrofit and greenfield investments
  - Safe to install also "in live" switchgears in substations where a power outage is difficult to arrange
  - For applications including two or more main transformers and double busbar substation layouts requiring fast and selective protection, also in case of earth-faults
ABB offering Arc protection solutions

- **UFES (Ultra Fast Earthing Switch) with REA arc protection system**
  - Targeted to customers for whom arc faults 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
  - Specially suitable for marine customers
  - 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
### ABB offering
Comparison of different solutions

<table>
<thead>
<tr>
<th></th>
<th>Protection time</th>
<th>Switching time</th>
<th>Selectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>No arc protection</td>
<td>~300ms</td>
<td>~50ms</td>
<td>No</td>
</tr>
<tr>
<td>615 Series</td>
<td>~10ms</td>
<td>~50ms</td>
<td>Yes</td>
</tr>
<tr>
<td>REA10_ system</td>
<td>~2ms</td>
<td>~50ms</td>
<td>Yes</td>
</tr>
<tr>
<td>REA10_ system + UFES</td>
<td>~2ms</td>
<td>~2ms</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Ultra Fast Earthing Switch type UFES
New active internal arc protection by ABB
Ultra Fast Earthing Switch type UFES
Primary switching element

Position after tripping

Service position

Ø 137 mm
Max. weight ~ 5,5 kg

Vacuum device

Moving direction

Current flow after tripping

Drive
Ultra-Fast Earthing Switch type UFES
Sequence of tripping operation

1. Arc formation
2. Arc detection
3. PSE tripping
4. Arc extinction
5. Fault current clearing

Optical sensor  \( I_k^* \) Current detection unit  UFES Primary switching element (PSE)
Ultra Fast Earthing Switch type UFES $S^3$ - Comparison
Ultra Fast Earthing Switch type UFES
$S^3$ - Comparison
The new Ultra Fast Earthing Switch type UFES
Arrangement of the components
Ultra-Fast Earthing Switch type UFES
Applicable for highest requirements

Maximum rated voltage:
\[ U_r = 40.5 \text{ kV} \rightarrow I_k = 40 \text{ kA (3s)} \]

Maximum rated short-time withstand current for medium voltage:
\[ I_k = 50 \text{ kA (3s), 63 kA (1s)} \rightarrow U_r = 17.5 \text{ kV} \]

Maximum rated short-time withstand current for low voltage:
\[ I_k = 100 \text{ kA (0.5s)} \rightarrow U_r = 1.4 \text{ kV} \]
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)

* For extension of existing or new arc protection systems. Full compatibility to the ABB arc protection system type REA.
Ultra Fast Earthing Switch type UFES
Available as … ABB Service retrofit solution
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 S³ - 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 / hour possible
Ultra Fast Earthing Switch type UFES 
$S^3$ - Unbeatable advantages

Direct benefit

- Greatly increased operator safety for switchgears
- Minimization of pressure rise and gases in the faulty compartment and surrounding switchgear building
Ultra-Fast Earthing Switch type UFES
UFES = S³

Are you attracted by the UFES?

Please contact…
ufes@de.abb.com
Power and productivity for a better world™
Application
$I_S$-limiter with summation of currents
Application

$I_s$-limiter with summation of currents

```
25kA

13kA

13kA

13kA

3kA

3kA

13kA

46kA

3kA

M

VFD

VFD

M
```
**I₅-limiter + UFES/REA**

**Protection on the highest possible level**

Fast splitting of the systems with the I₅-limiter
- Short circuit limitation before the first currents rise (0,6ms after detection)

Arc protection by the UFES system
- Ultra fast extinguished of the arc (< 4ms after detection)