ABB AG - Calor Emag Medium Voltage Products

$I_S$-limiter
The world's fastest switching device

- Reduces substation cost
- Solves short-circuit problems in new and extended substations
- Optimum solution for interconnection of switchgears and substations
- In most cases the only technical solution
- Reliability and function proofed in thousands of installations
- In service worldwide
- The peak short-circuit current will never be reached
- The short-circuit current is limited at the very first current rise
### 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&lt;sub&gt;RMS&lt;/sub&gt;</td>
</tr>
<tr>
<td>12.00 kV</td>
<td>... 4000 A</td>
<td>... 210 kA&lt;sub&gt;RMS&lt;/sub&gt;</td>
</tr>
<tr>
<td>17.50 kV</td>
<td>... 4000 A</td>
<td>... 210 kA&lt;sub&gt;RMS&lt;/sub&gt;</td>
</tr>
<tr>
<td>24.00 kV</td>
<td>... 3000 A</td>
<td>... 140 kA&lt;sub&gt;RMS&lt;/sub&gt;</td>
</tr>
<tr>
<td>36.00 kV</td>
<td>... 2500 A</td>
<td>... 140 kA&lt;sub&gt;RMS&lt;/sub&gt;</td>
</tr>
<tr>
<td>40.50 kV</td>
<td>... 2500 A</td>
<td>... 140 kA&lt;sub&gt;RMS&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

At higher rated currents parallel installation of I<sub>S</sub>-limiters is possible.
More than 3000 $I_S$-limiters in service in approx. 80 countries

**Customers:**

- **Industry**
  - Paper mills
  - Refineries
  - Chemical industries
  - Car industries
  - Power stations
  - Steel-, Aluminum mills
  - On-Off-shore platforms
  - Ships / Vessels

- **Town’s utilities**

- **Utilities**

- **Test-laboratories**
Comparison: $I_s$-limiter – Circuit-breaker

- $T_0$: Response time of protection relay: 10 - 20 ms
- $T_1$: Operating time of protection relay: 30 - 40 ms
- $T_2$: Operating time of circuit-breaker: 40 - 80 ms
- $T_3$: Arc duration: 10 - 20 ms, 90 - 160 ms
**Iₜ-limiter**

Comparison: Iₜ-limiter – Circuit-breaker

- **T₀**: Response time of protection relay: 10 - 20 ms
- **T₁**: Operating time of protection relay: 30 - 40 ms
- **T₂**: Operating time of circuit-breaker: 40 - 80 ms
- **T₃**: Arc duration: 10 - 20 ms
  
  90 - 160 ms

Current flow time by use of Iₜ-limiter: T = 5 - 10 ms
**I_s-limiter – Function**

Breaking of a short-circuit current with $I_s$-limiter

**Current curve at the short-circuit location**

- $I_k^{\text{perm.}} = 50$ kA
- $I_k = 50$ kA

$50\text{ kA} \times \sqrt{2}$
**I_s-limiter – Function**

*Breaking of a short-circuit current with I_s-limiter*

\[ i = i_1 + i_2 \]

- **T_1**
  - \( I_k^1 = 50 \text{ kA} \)
  - \( i_1 \)
  - \( i = i_1 + i_2 \)
  - \( I_{k \text{ perm.}}^1 = 50 \text{ kA} \)

- **T_2**
  - \( I_k^2 = 50 \text{ kA} \)
  - \( i_2 \)
  - \( I_{k \text{ perm.}}^2 = 50 \text{ kA} \)

**Current curve at the short-circuit location**

- \( u \)
- \( i_1 \)
- \( i = i_1 + i_2 \)

Without I_s-limiter

\( 250 \text{ kA} \)

\( 125 \text{ kA} \)

\( 50 \text{ kA} \times \chi \times \sqrt{2} \)
**I_s-limiter – Function**

Breaking of a short-circuit current with \( I_s \)-limiter

\[ i = i_1 + i_2 \]

Current curve at the short-circuit location

- \( T_1 \) \( I_k' = 50 \text{ kA} \)
- \( T_2 \) \( I_k'' = 50 \text{ kA} \)
- \( I_k \text{perm.} = 50 \text{ kA} \)

\( I_k' = 50 \text{ kA} \)

\( I_k'' = 50 \text{ kA} \)

\( 50 \text{ kA} \times \chi \times \sqrt{2} \)

\( 125 \text{ kA} \)

\( 250 \text{ kA} \)

\( i_1 \)

\( i \)

\( t \)

\( u \)
**I_s-limiter – Function**

**Breaking of a short-circuit current with I_s-limiter**

\[
I = I_1 + I_2
\]

- **Without I_s-limiter**
- **With I_s-limiter**

**Current curve at the short-circuit location**
I_s-limiter – Function
Insert-holder, insert and current flow
**I_s-limiter – Structure**

**Typical System Components**

- 3 CT’s
- 3 Tripping units
- 3 Inserts holders with inserts
Is-limiter – Structure
Truck mounted panel

Type tested
- acc. to IEC 62271-200

Internal arc classification
- IAC A FLR
Self monitoring

Redundancy
(separate independent system for each phase)

Protection against EMI
- EMC tested according to IEC 61000
- Special current transformers
  (low impedance shield between primary and secondary winding)
- Filters for incoming / outgoing wires
- Special tripping and measuring wires
  (each pair tightly twisted and protected by steel conduit)

Test equipment
(quick, complete and easy test by user)
$I_s$-limiter – Reliability

Test equipment

$I_s$-limiter insert holder with test insert

Test equipment
**$I_s$-limiter – Function**

Detection of short-circuit currents

1. Short-circuit current without $I_s$-limiter
I_s-limiter – Function
Detection of short-circuit currents

1 Short-circuit current without I_s-limiter
$I_s$-limiter – Function
Detection of short-circuit currents

Short-circuit current without $I_s$-limiter

Short-circuit current - $I_s$-limiter tripped -

$\mathbf{\text{i}_{\text{limit}} \wedge \left(\frac{\text{di}}{\text{dt}}\right)}$

$\wedge \equiv \text{logical „and“}$
**I_s-limiter – Function**

Detection of short-circuit currents

1. **Short-circuit current without I_s-limiter**
2. **Short-circuit current**
   - I_s-limiter tripped -
3. **Overcurrent**
   - I_s-limiter not tripped -
4. **Peak value of service current**

\[ i_{\text{limit}} \land \left( \frac{\text{di}}{\text{dt}} \right) \]

\( \land \) ≡ logical „and“
Is-limiter – Function
Sequence of tripping

- **T₀**: Time to cross tripping criteria (threshold current $i_{\text{limit}}$ and gradient $di/dt$)
- **T₁**: Response time of electronic ~15 µs
- **T₂**: Time to break main current path and commutate current to fuse ~85 µs
- **T₃**: Melting time of fuse ~500 µs
- **T₄**: Arc duration in fuse

- $i_A$: RMS current at crossing tripping criteria (threshold current $i_{\text{limit}}$ and gradient $di/dt$)
- $i_B$: RMS current at start of fuse melting
- $i_C$: Maximum RMS current
Advantages:

- Improving „power quality“
- Increasing grid’s reliability
- Reducing network-impedance
- Optimizing load flow
- Existing busbar system and cabling does not have to be changed
Advantages:

- Connecting generator independent of grid's short-circuit capability
- Existing busbar system and cabling does not have to be changed
- Separate generator breaker needless
Advantages:

- Avoid ohmic losses (copper losses) of the reactor
- Avoid voltage drop of reactor
- Avoid electro-magnetic field of reactor
- Greenhouse aspects (CO₂ and heating)
I_s-limiter – Application
Connection of a generator to a network with current-direction comparison

Advantages:

- Connect private / industrial generator feeder to the fully loaded grid ①
- Selective tripping of the I_s-limiter (Tripping only at faults within grid section ①, not at faults within grid sections ②)
**Benefits for utility/municipal networks:**

- IPPs can also be connected to utility/municipal networks in which short-circuit capacity is fully utilized.
- Rising energy demand in the public networks can be covered.
- No conversion of the public networks (for increased short-circuit current carrying capacity) is required.
- There are no negative effects from these additional IPPs on the customers already connected to the public network.
I_s-limiter – Application
Distributed power generation

Benefits for IPPs:

- Connection of IPPs is not detrimental to public grid
- Use of renewable energies possible
- Distributed power generation close to consumers possible
- Customer established power supply system independent of the public grid possible
- Redundancy
- Return of Investment by selling power to public grid
- Improving public image due to use of renewable energies
Is-limiter – Application
Is-limiter with summation of currents

Advantages:

- Tripping of dedicated Is-limiter close to fault location
- Existing busbar system and cabling does not have to be changed
- Reducing network-impedance
- Optimizing load flow
- Greenhouse aspects (CO₂ and heating)
Power and productivity for a better world™