Coordination System of Low Voltage Circuit Breaker

ABB circuit breaker
About Myself
Product Marketing Director

Tar
Norrarat Navaratgulchai

16 Years
ABB Electrification (Thailand) Co., Ltd
Electrification business – Low Voltage Products

Responsible for

- Electrical Solution & Technical Advisor
- Products, Innovation and Marketing Strategy
About Myself
Sales specialist

Gink Suparada Chaowarat

5 Years
Sales specialist for ABB channel partner

3 Years
Technical Promotion team and Digital solution for Low voltage system

Responsible for

- Technical Promotion team for consultant and designer
- Digital solution for Low voltage system
Agenda and The key takeaways

07 Webinar: Coordination System of Low Voltage Circuit Breaker

60 Minutes training duration

The key takeaways

• Definitions & standards
  • Selectivity (or Discrimination)
  • Back-Up protection (or Cascading)
• Selectivity and Back-Up techniques
• Understand Coordination table
• ABB Tools & Support
Definitions & standards

• Selectivity (or Discrimination)
• Back – Up protection (or Cascading)
Definition of selectivity

IEC 60947-1 Standard: “Low voltage equipment Part 1: General rules for low voltage equipment”

“Trip selectivity (for overcurrent) is a coordination between the operating characteristics of two or more overcurrent protection devices, so that, when an overcurrent within established limits occurs, the device destined to operate within those limits trips whereas the others do not trip”
Definitions & standards
Selectivity definitions & standards

Example
If selectivity is provided

- When a fault occurs (Overload or Short-circuit)
- The protection device closes to the fault opens.
Partial & Total selectivity

A and B connected in series:

partial selectivity and total selectivity.
Definitions & standards

Selectivity definitions & standards

Total selectivity

“Total selectivity is an overcurrent selectivity where, in the presence of two protection devices against overcurrent in series, the load side protection device carries out the protection without making the other device trip.”

- Only B trips for every current value lower or equal to the maximum short-circuit current.

\[ I_s = I_k \]

(\( I_k \) - The maximum prospective short-circuit current on the load side of B)
Partial selectivity

“Partial selectivity is an overcurrent selectivity where, in the presence of two protection devices against overcurrent in series, the load side protection device carries out the protection up to a given level of overcurrent, without making the other device trip.”

- B opens only according to fault current lower than a certain current value;
- values equal or greater than $I_s$ will give the trip of both A and B.

$$I_s = I_{mA}$$

$I_s$ is the ultimate selectivity value!
Selectivity techniques
Selectivity techniques

1. Current selectivity

Current selectivity

Basic concept

When the point of fault is closer to the source, the fault current will be higher.

- In order to guarantee selectivity, the protections must be set to different values of current thresholds.
- The ultimate selectivity value is equal to the instantaneous trip threshold of the upstream protection device.
- Other methods are needed to have a total selectivity.
Selectivity techniques

1. Current selectivity

Current selectivity

Example

Circuit breaker A will be set to a value which does not trip for faults which occur on the load side of B. \( I_{3A_{\text{min}}} > 1\text{kA} \)

Circuit breaker B will be set to trip for faults which occur on its load side \( I_{3B_{\text{max}}} < 1\text{kA} \)

\[ I_s = I_{3A_{\text{min}}} \]

Here the selectivity is a total selectivity, because it is guaranteed up to the maximum value of the short-circuit current, 1kA.
Selectivity techniques

2. Time selectivity

Time selectivity

Basic concept

Time selectivity is based on a trip delay of the upstream circuit breaker, so to let to the downstream protection the time suitable to trip

- Setting strategy:
  Progressively increase the trip delays getting closer to the power supply source

- On the supply side:
  The S function is required (short circuit protection with time delay)
Selectivity techniques

2. Time selectivity

**Time selectivity**

Example

Circuit breaker A will be set with the current threshold $I_2$ adjusted so as not to create an overlapping trip and with a trip time $t_2$ adjusted so that B always clears the fault before A.

B will be set with an instantaneous trip against short-circuit.

The ultimate selectivity value is:

$I_s = I_{3\text{min}A}$ (if function I = ON)

$I_s = I_{cWA}$ (if function I = OFF, S = ON)
Energy selectivity

A circuit-breaker in which the opening of the contacts occurs after the passage of the peak of the short-circuit current, or in which the trip occurs with the natural passage to zero, allows the system components to be subjected to high stresses, of both thermal and dynamic type.
To reduce these stresses, current-limiting circuit-breakers have been designed which are able to start the opening operation before the short-circuit current has reached its first peak, and to quickly extinguish the arc between the contacts.
Selectivity techniques

4. Energy selectivity

**Energy selectivity**

Basic concept

Energy selectivity is based on the current-limiting characteristics of some circuit breakers.

Current-limiting circuit breaker has an extremely fast trip time, short enough to prevent the current from reaching its peak.

The ultimate current selectivity values are given by the manufacturer (Coordination tables).
# Selectivity techniques

## 4. Energy selectivity

### 3.2 Discrimination tables

### MCCB - S2.. C @ 415 V

<table>
<thead>
<tr>
<th>Supply s: XT2</th>
<th>XT1 - XT2</th>
<th>XT1 - XT2 - XT3</th>
<th>XT3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Character Lc [kA]</td>
<td>12.5</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>42</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>3</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>4</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>5.6</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>8</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>10</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>13</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>16</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>20</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>32</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>-</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>-</td>
</tr>
<tr>
<td>S200</td>
<td>S200M</td>
<td>S200P</td>
<td>63</td>
</tr>
</tbody>
</table>

**CB-A**

- **Upstream**: XT1 - XT3

**CB-B**

- **Downstream**: MCB - S200

**Selectivity between MCCB XT and MCB S200**

- **T**: Total selectivity
- **X**: Selectivity up to “X” kA

Note:

- Icu of both CB A and CB B shall >Ik at the installation point

---

1. Value valid only for XT2 magnetic only supply side circuit-breaker
2. Value valid only for XT2-XT3 magnetic only supply side circuit-breaker
3. Value valid only for XT3 magnetic only supply side circuit-breaker
4. Value valid only for XT4 magnetic only supply side circuit-breaker
5. Value valid only for XT4 in 160 supply side circuit-breaker
## Selectivity techniques

### 4. Energy selectivity

#### ACB - MCCB @ 415 V

<table>
<thead>
<tr>
<th>Supply s.</th>
<th>X1</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
<th>E6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version</td>
<td>B</td>
<td>N</td>
<td>L</td>
<td>B</td>
<td>N</td>
<td>B</td>
</tr>
<tr>
<td>Release</td>
<td>EL</td>
<td>EL</td>
<td>EL</td>
<td>EL</td>
<td>EL</td>
<td>EL</td>
</tr>
<tr>
<td>Load s.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XT1</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>S</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>TM</td>
<td>160</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>1000</td>
<td>1000</td>
<td>1250</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>1000</td>
<td>1000</td>
<td>1250</td>
<td>1600</td>
<td>1600</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>800</td>
<td>1600</td>
<td>1600</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>1250</td>
<td>1250</td>
<td>1600</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>1250</td>
<td>1250</td>
<td>1600</td>
<td>2500</td>
<td>3200</td>
<td>3200</td>
</tr>
<tr>
<td></td>
<td>1600</td>
<td>1600</td>
<td>3200</td>
<td>3200</td>
<td>3200</td>
<td>3200</td>
</tr>
<tr>
<td>Selectivity between ACB Emax2 and MCCB XT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

- Icu of both CB A and CB B shall >I_k at the installation point

#### CB-A
**Upstream:** ACB Emax 2 E1.2 - E6.2

#### CB-B
**Downstream:** MCCB XT1 - XT4

---

**Selectivity between ACB Emax2 and MCCB XT**

**CB-A**
**Upstream:** ACB Emax 2 E1.2 - E6.2

**CB-B**
**Downstream:** MCCB XT1 - XT4

**Note:**

- Icu of both CB A and CB B shall >I_k at the installation point

- **T** Total selectivity
- **X** Selectivity up to “X” kA
Zone selectivity

Basic concept

Zone selectivity is an evolution of the time selectivity, obtained by means of an electrical interlock between devices.

The circuit breaker which detects a fault communicates this to the one on the supply side, sending a locking signal.

Only the downstream circuit breaker opens, with no need to increase the intentional time delay.
Selectivity techniques

5. Zone selectivity

Zone selectivity

Example

A Does not open
B Does not open
C Opens
Definitions & standards

• Selectivity (or Discrimination)
• Back-Up protection (or Cascading)
**Definitions & standards**

**Back-Up protection**

---

**Definition of Back-Up protection**

The definition of back-up is given by

**IEC 60947-1 Standard: “Low voltage equipment Part 1: General rules for low voltage equipment”**

‘Back-up is a coordination of two overcurrent protective devices in series, where the protective device on the supply side, with or without the assistance of the other protective device, trips first in order to prevents any excessive stress on downstream devices”.'
**Definitions & standards**

Back-Up protection

---

**Back-Up protection**

**Basic concept**

Back-up is used by those who need to contain the plant costs.

The use of a current-limiting circuit breaker on the supply side permits the installation of lower performance circuit breakers on the load side.

Both the continuity of service and the selectivity are sacrificed.
Back-Up protection

What is Back-Up protection?

Back-Up protection (or Cascading)

Is a type of coordination of two protective devices in series which is done in electrical installations where continuous operation is not an essential requirement.

Back-up protection **excludes the use of selectivity!!!**
Back - Up technique
# Back-Up technique

## Back-Up protection

In the event of fault $I_k$ short-circuit current values higher than the breaking capacity of circuit breaker “B”, circuit breaker “A” must provide a specific let-through energy limiting function, limiting it to a value that can be withstood by circuit breaker “B” and the protected conductors.

### Table

<table>
<thead>
<tr>
<th>Technology</th>
<th>MCCB T5</th>
<th>Tmax T</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S</td>
<td>H</td>
</tr>
<tr>
<td>XT2N 160</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>XT2N 160</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>XT2N 160</td>
<td>120</td>
<td>150</td>
</tr>
<tr>
<td>XT2N 160</td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

### Diagram

- **XT2N...Icu = 36 kA**
- **T5S...Icu = 50 kA**

**XT2N...Icu = 36 kA >>> breaking capacity up to 50 kA**
Back-Up technique
Back-Up protection

3 Protection coordination

MCCB - MCB @ 415 V

<table>
<thead>
<tr>
<th>Load s.</th>
<th>Carat.</th>
<th>I&lt;sub&gt;s&lt;/sub&gt; [A]</th>
<th>I&lt;sub&gt;cu&lt;/sub&gt; [kA]</th>
<th>S200</th>
<th>S200M</th>
<th>S200P</th>
<th>S280</th>
<th>S290</th>
<th>S800N</th>
<th>S800S</th>
</tr>
</thead>
<tbody>
<tr>
<td>XT1</td>
<td>XT2</td>
<td>XT3</td>
<td>XT4</td>
<td>XT1</td>
<td>XT2</td>
<td>XT3</td>
<td>XT4</td>
<td>XT1</td>
<td>XT2</td>
<td>XT3</td>
</tr>
<tr>
<td>Version</td>
<td>B</td>
<td>C</td>
<td>N</td>
<td>S</td>
<td>H</td>
<td>L</td>
<td>V</td>
<td>H</td>
<td>L</td>
<td>V</td>
</tr>
<tr>
<td>S200</td>
<td>0.5...10</td>
<td>13.63</td>
<td>10</td>
<td>18</td>
<td>25</td>
<td>30</td>
<td>36</td>
<td>36</td>
<td>16</td>
<td>40</td>
</tr>
<tr>
<td>S200M</td>
<td>0.5...10</td>
<td>13.63</td>
<td>15</td>
<td>18</td>
<td>25</td>
<td>30</td>
<td>36</td>
<td>36</td>
<td>16</td>
<td>40</td>
</tr>
<tr>
<td>S200P</td>
<td>0.5...10</td>
<td>13.25</td>
<td>25</td>
<td>30</td>
<td>36</td>
<td>36</td>
<td>36</td>
<td>30</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>S280</td>
<td>80..100</td>
<td>13.63</td>
<td>15</td>
<td>18</td>
<td>25</td>
<td>30</td>
<td>36</td>
<td>36</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>S290</td>
<td>80..125</td>
<td>13.63</td>
<td>15</td>
<td>18</td>
<td>25</td>
<td>30</td>
<td>36</td>
<td>36</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>S800N</td>
<td>10..125</td>
<td>13.63</td>
<td>15</td>
<td>18</td>
<td>25</td>
<td>30</td>
<td>30</td>
<td>50</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>S800S</td>
<td>10..125</td>
<td>13.63</td>
<td>50</td>
<td>70</td>
<td>70</td>
<td>85</td>
<td>120</td>
<td>85</td>
<td>150</td>
<td>85</td>
</tr>
</tbody>
</table>

Upstream:
- MCCB - XT2N
- I<sub>cu</sub> = 36 kA.

Downstream:
- MCB - S200
- I<sub>cu</sub> = 10 kA

Back-Up protection
S200 >>> breaking capacity up to 36 kA
ABB Tools & Support
Selected Optimized Coordination (SOC)

Online Selection: https://applications.it.abb.com/SOC/Selectivity

- Motor protection
- Selectivity
- Back-up
- Other Devices protection

SOC - Selected Optimized Coordination

Main Features:
- Online Selection
- Coordinates of various types
- Motor protection
- Selectivity
- Back-up
- Other Device protection

Export report
Curves เป็นส่วนหนึ่งของโปรแกรม e-Design
สามารถดาวน์โหลดเพื่อติดตั้งโปรแกรม ได้ฟรี!!
https://new.abb.com/low-voltage/support/software/e-design/download

หน้าที่หลักของโปรแกรม

- ปรับจังหวะการป้องกันแบบ L,S,I,G
- การตรวจสอบการป้องกันสายไฟจากกระแสโหลดเกิน กระแสลัดวงจร และกระแสรั้ว
- การตรวจสอบการทำงาน selectivity และ Back – Up ของอุปกรณ์ป้องกัน
- สามารถบันทึกค่าปรับจังหวะการป้องกัน Curves ลงหน่วยประมวลผลของเบรกเกอร์ได้ ผ่านโปรแกรม Ekip Connect
ABB Tools & Support

Useful links for download


Looking for a document about selectivity?
Here are some extracts from ABB Library to get deeper information about theory, basic techniques, applications and case studies.

Theory and practice

- Technical Application Paper n°1
- White Paper n°2
- White Paper n°3
- White Paper n°6

https://new.abb.com/low-voltage/solutions/selectivity
ABB on social media

Website: www.abb.co.th

Facebook: ABB Thailand

Line official: @askabb