ACB MODULE
SETTING
WELKOM
2017
Rated current & Breaking capacity

1. Rated current of "A"
   - \(400\text{(kVA)} / (\sqrt{3} \times 0.38\text{(kV)}) = 607\text{A}\)
   - Considering Safety rate, 1.5 times of rated current,
   - The rated current would be, 911.6(A).

2. Assuming % impedance %Z = 5% and calculating short circuit current at 'A' point,
   - \(400\text{(kVA)} / (\sqrt{3} \times 0.38\text{(kV)} \times 5\%) = 12,154\text{A}\)
   - Considering Safety rate, 1.5 times of rated current,
   - The short circuit current would be, 18232.7 (A)

3. The specification of ACB should have a rating above the rated current and breaking capacity. In this case,
   - 1,000Amps and 20kA ACB is recommended.
- **TYPICAL TRIPPING CURVE**

1. **NO TRIP**: area below which no trip occurs
2. **TRIP**: area above which trip occurs
3. **RATED CURRENT**: the set threshold
4. **OVERLOAD**: over-current zone of long trip
5. **INSTANTANEOUS**: high current zone of short trip
4. $I_u, I_r$: Long-time current setting, $tr$: Long-time tripping delay setting
5. $I_{sd}$: Short-time current setting, $t_{sd}$: Short-time tripping delay setting
6. $I_i$: Instantaneous current setting
7. $I_g$: Ground fault current setting, $t_g$: Ground fault tripping delay setting
8. Test terminal: OCR test terminal (Connected with OCR tester)

### Protection

**Long time**

<table>
<thead>
<tr>
<th>Current setting (A)</th>
<th>$I_u = I_n x ...$</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$I_r = I_n x ...$</td>
<td>0.8</td>
<td>0.83</td>
<td>0.85</td>
<td>0.85</td>
<td>0.9</td>
<td>0.93</td>
</tr>
<tr>
<td>Time delay (s)</td>
<td>$t_{sd}(1.5 \times I_r)$</td>
<td>12.5</td>
<td>25</td>
<td>50</td>
<td>100</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>Accuracy: ±15% or below</td>
<td>$t_{sd}(0.0 \times I_r)$</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>100ms</td>
<td>$t_{sd}(7.2 \times I_r)$</td>
<td>0.34</td>
<td>0.69</td>
<td>1.38</td>
<td>2.7</td>
<td>5.5</td>
<td>8.3</td>
</tr>
</tbody>
</table>

**Short time**

<table>
<thead>
<tr>
<th>Current setting (A)</th>
<th>$I_{sd} = I_n x ...$</th>
<th>1.5</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy: ±10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time delay (s)</td>
<td>$t_{sd}$</td>
<td>0.05</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$t_{sd}$ (On)</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min. Trip Time(ms)</td>
<td>20</td>
<td>80</td>
<td>160</td>
<td>260</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Trip Time(ms)</td>
<td>80</td>
<td>140</td>
<td>240</td>
<td>340</td>
<td>440</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Instantaneous**

<table>
<thead>
<tr>
<th>Current setting (A)</th>
<th>$I_i = I_n x ...$</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>15</th>
<th>Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripping time</td>
<td>below 50ms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ground fault**

<table>
<thead>
<tr>
<th>Pick-up (A)</th>
<th>$I_g = I_n x ...$</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>1.0</th>
<th>Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy: ±10%(g &gt; 0.4m)</td>
<td>$I_g = I_n x ...$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>±20%(g ≤ 0.4m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Time delay (s)      | $t_{g}$          | 0.05 | 0.1 | 0.2 | 0.3 | 0.4 |
|                      | $t_{g}$ (On)     | 0.1 | 0.2 | 0.3 | 0.4 |
| Min. Trip Time(ms)  | 20 | 80 | 160 | 260 | 360 |
| Max. Trip Time(ms)  | 80 | 140 | 240 | 340 | 440 |
Long-time delay

The function for overload protection which has time delayed characteristic in inverse ratio to fault current.

1. Standard current setting knob: \( I_r \)
   1) Setting range in P type and S type: (0.4–1.0)×\( I_n \)
   2) Setting range in N type and A type: (0.4–1.0)×\( I_n \)
      - \( I_u \): (0.5–0.7)×\( I_n \)
      - \( I_f \): (0.8–0.95)×\( I_n \)
2. Time delay setting knob: \( \tau \)
   - Standard operating time is based on the time of \( 0 \times I_r \)
   - Setting range: 0.5–20 sec
3. Relay pick-up current
   - When current over (1.15)×\( I_r \) flows in, relay is picked up.

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**Long time**

<table>
<thead>
<tr>
<th>Current setting (A)</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>( I_u = I_n \times \ldots )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( I_f = I_u \times \ldots )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \tau = (1.5 \times I_r) )</td>
<td>12.5</td>
<td>25</td>
<td>50</td>
<td>100</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>( \tau = (6.0 \times I_r) )</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>( \tau = (7.2 \times I_r) )</td>
<td>0.34</td>
<td>0.39</td>
<td>1.38</td>
<td>2.7</td>
<td>5.5</td>
<td>8.3</td>
</tr>
</tbody>
</table>

\[ H = \text{current setting} \times 10^3 \text{mA} \]

\[ L = \text{setting range} \times 10^3 \text{mA} \]

\[ I_u = I_n \times \ldots \]

\[ I_f = I_u \times \ldots \]

\[ \tau = (1.5 \times I_r) \]

\[ \tau = (6.0 \times I_r) \]

\[ \tau = (7.2 \times I_r) \]
Short-time delay

- Setting range: (2-3-4-6-10-15-30)×ln
- Inverse time: 0.1-0.3-0.5-0.7-1.0-1.5-2.0×ln
- Time delay: 0.1-0.3-0.5-0.7-1.0-1.5-2.0×ln
- Time constant: 0.1-0.3-0.5-0.7-1.0-1.5-2.0×ln

1. Setting range: (2-3-4-6-10-15-30)×ln
2. Inverse time: 0.1-0.3-0.5-0.7-1.0-1.5-2.0×ln
3. Time delay: 0.1-0.3-0.5-0.7-1.0-1.5-2.0×ln
4. Time constant: 0.1-0.3-0.5-0.7-1.0-1.5-2.0×ln

The function for breaking ground fault current above setting value after time delay to protect the circuit from ground fault.
Instantaneous(I), Ground fault(G)

The function for breaking fault current above the setting value within the shortest time to protect the circuit from short-circuit.

1. Standard current setting knob: li
   - Setting range: (2-3-4-6-8-10-12-15-Off) × In
2. Relay operates basing on the largest load current among R/S/T/N phase.
3. Total breaking time is below 50ms.

The function for breaking ground fault current above setting value after time-delay to protect the circuit from ground fault.

1. Standard setting current knob: lg
   - Setting range: (0.2-0.3-0.4-0.5-0.6-0.7-0.8-1.0-Off) × In
2. Time delay setting knob: tg
   - Inverse time (Rt On): 0.1-0.2-0.3-0.4 sec
   - Definite time (Rt Off): 0.05-0.1-0.2-0.3-0.4 sec
3. Ground fault current is vector sum of each phase current. Therefore, 3Pole products may operate under its phase-unbalance including ground fault situations: (R=S+T+(N) Phase)
4. When ZSI function was set, the protection operation will take place instantaneously with input absence by downstream devices. It is advised to disable its ZSI function on the last downstream device.
5. Ground-fault functions are basically provided with products equipped with a trip relay through its internal CT that is embedded in each phase. (But, it can't be used with earth-leakage protection function at the same time)
A type: Over Current Relay

- Overload protection
  - Long-time delay
  - Thermal
- Short-circuit protection
  - Short-time delay / instantaneous
  - Flt On/Off optional (for short-time delay)
- Ground fault protection
  - Flt On/Off optional
- Realization of protective coordination by ZSI (Zone Selective Interlocking)
- High-performance and high-speed MCU built-in
  - Accurate measurement with tolerance of 1.0%

- Fault recording
  - Records up to 10 fault information about fault type, fault phase, fault data, occurrence time of fault
- SBO (Select Before Operation)
  - High reliability for control and setting change method
- 3 DO (Digital Output)
  - Fixed
- Communication
  - Modbus/RS485
  - Profibus-DP

4. lu, lr: Long-time current setting, tr: Long-time tripping delay setting
5. Isd: Short-time current setting, tsd: Short-time tripping delay setting
6. li: Instantaneous current setting
7. Ig: Ground fault current setting, tg: Ground fault tripping delay setting
8. Test terminal: OCR test terminal (Connected with OCR tester)
The $I^2t$ protection works as a long time protection and the over-current as an immediate protection.

Let's take the over-current protection first. We assume that the over-current value is 4 A for 500 ms. With this setting, a current of 4 A or higher that is maintained through the motor for more than 500ms will trigger the protection. Now, if we think a little about the reason for the over-current protection, we come to the conclusion that this is also a thermal protection — after all, a too big current in the motor can melt the windings to a complete disaster (worst case), or the motor will stop before the winding insulation is destroyed by the temperature, resulting (only) in a short circuit.

Coming back to the settings of the over-current protection, you must keep in mind that the protection will be triggered beyond 500 ms as well, for a current of 16.5 A (because it is higher than 4 A). Needless to say that as concerns the motor there is a very big difference between 4 A for 500ms, and 16.5 A for 500ms. To overcome this, you must also set the current limit of the drive, so if you want to be sure that the current through the motor won’t exceed 4 A, you must set the current limit to 4 A - thus ensuring a maximum current through the motor of 4 A (due to the current limit parameter) and a maximum time that this current is allowed of 500ms (due to the over-current protection). However, in some cases, you can let the current limit to be higher than 4 A, to allow for good accelerations/decelerations.

Now, if we think one step further and imagine the worst case scenario, where the motor is supplied with 4 A for 450ms, and then 3.9 A for 10ms; and then again, 4 A for 450ms and then 3.9 A and so on - the result is that the motor will overheat and burn out without having the over-current protection triggered!

In this scenario, we can’t use the current limit anymore to prevent it, but we can use the $I^2t$ protection. The $I^2t$ protection keeps track of the motor temperature by monitoring the motor current and computing the over-temperature. Any current above the nominal value will produce a bigger or a smaller overheat to the motor, and - on the same basis - a current below the nominal value will allow the motor to decrease its temperature (down to the ambient temperature, in the best case = current zero = motor stopped). And this is how the $I^2t$ works: while the motor has a current higher than the nominal one, the drive will consider that the motor temperature is increasing; and when a certain threshold (based on the settings of the $I^2t$ protection from Drive Setup dialog) is reached, the protection will be triggered.
**Summary:**

SET current rating to actual circuit conditions

- **Low:** general loads, general motor loads, non inrush expectations
- **Mid:** general loads, some motors
- **High:** mostly motor loads, high inrush expectations

**SET instantaneous level**

- SET current rating to actual circuit conditions

**SET time settings**

- **Low-50%** 
  - non \( i^t \)
- **50%-max**
  - \( i^t \)

Eg 20% above expectations, more if a motor