Knowledge base No. 011

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Current transformer installation
Knowledge base information

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Knowledge base No. 011 – Current transformer connection
Version: 01
1 Current transformer

1.1 Specifications

Please observe the following instructions for installing current transformers.

- Three external current transformers must be connected for correct ECOsine® active operation. Here it doesn’t matter whether it is a 3-wire or 4-wire filter.
- For parallel operation of more than one ECOsine® active the current transformers must be installed on the load side of the filter. For stand-alone operation of one ECOsine® active the current transformers can be installed on the mains or load side of the filter.
- Separate current transformers are mandatory for proper operation of ECOsine® active. Dedicated current transformers must be used. Current transformer secondary circuits must not be looped through additional sense-loads.
- A current transformer terminal-block with separable short-circuit plugs must be installed between the external transformers and the X2 connecting terminal on ECOsine® active. This is necessary in order to be able to short-circuit the current transformers before disconnecting the X2 terminal on the ECOsine® active during any kind of service work. (for Example see Fig. 1). The apparent ohmic resistors of the current transformers are inside the ECOsine® active.
- The electrical loses of the current transformer wiring has to be considered (See for more information Table 1 and Table 2).
- There is no need for a ground connection of the current transformers.

Fig. 1: Example for short-circuit plugs
Table 1: Current transformer specification

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated secondary current</td>
<td>5 A</td>
</tr>
<tr>
<td>Rated primary current</td>
<td>The primary current has to be selected for the peak RMS current (example: starting current 1800 A → use current transformer 2000 A : 5 A). For more information see: Getting the nominal current of the CTs needed.</td>
</tr>
<tr>
<td>Accuracy class</td>
<td>1.0 (or better)</td>
</tr>
</tbody>
</table>

The total accuracy calculated from CT primary current and CT class should not exceed 10% of the AHF nominal current.

Example 1:
CT 1000:5 A (class 1.0), AHF 100 A
Accuracy 10 A (1% von 1000 A) ≤ 10 A (10% von 100 A) → ok

Example 2:
CT 2000:5 A (class 1.0), AHF 50 A
Accuracy 20 A (1% von 2000 A) ≥ 5 A (10% von 50 A) → not ok

Type                              | 50 / 60 Hz – depends on grid. (It is no special current transformer for high frequency's necessary.) |

Output power                      | Recommended 15 VA                                                                 |
|                                  | At least 2.5 VA (1 ECOsine® active in parallel operation)                         |
|                                  | At least 5.0 VA (2 ECOsine® active parallel operation)                            |
|                                  | At least 7.5 VA (3 ECOsine® active parallel operation)                            |
|                                  | At least 10.0 VA (4 ECOsine® active parallel operation)                           |
|                                  | At least 12.5 VA (5 ECOsine® active parallel operation)                           |
Table 2: Power consumption of wires

<table>
<thead>
<tr>
<th>Cable cross-section</th>
<th>Power in Watt per meter at 5A (Consider up-and-down line!)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,5 mm² (AWG 16)</td>
<td>0,2717 W/m</td>
</tr>
<tr>
<td>2,5 mm² (AWG 14)</td>
<td>0,1750 W/m</td>
</tr>
<tr>
<td>4 mm² (AWG 12)</td>
<td>0,1094 W/m</td>
</tr>
<tr>
<td>6 mm² (AWG 10)</td>
<td>0,0729 W/m</td>
</tr>
</tbody>
</table>

Table 3: X2 terminal – connection terminals for external current transformers

<table>
<thead>
<tr>
<th>X2 terminal</th>
<th>Designation</th>
<th>remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>X2.1</td>
<td>k, S1</td>
<td>Current transformer phase L1</td>
</tr>
<tr>
<td>X2.2</td>
<td>l, S2</td>
<td>Current transformer phase L1</td>
</tr>
<tr>
<td>X2.3</td>
<td>k, S1</td>
<td>Current transformer phase L2</td>
</tr>
<tr>
<td>X2.4</td>
<td>l, S2</td>
<td>Current transformer phase L2</td>
</tr>
<tr>
<td>X2.5</td>
<td>k, S1</td>
<td>Current transformer phase L3</td>
</tr>
<tr>
<td>X2.6</td>
<td>l, S2</td>
<td>Current transformer phase L3</td>
</tr>
</tbody>
</table>

Table 4: Cable cross section external current transformers

<table>
<thead>
<tr>
<th>Device</th>
<th>Cable cross-section external current transformers</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECOsine® active - 30/50/60/100/120-xxx-x</td>
<td>X2: 2.5 mm² (AWG 14)</td>
</tr>
<tr>
<td>ECOsine® active - 200/250/300-xxx-x</td>
<td>X2: 4.0 ... 6.0 mm² (AWG 12 ... 10)</td>
</tr>
</tbody>
</table>

1.2 Specification for UL conformity
To ensure UL conformity, UL-compliant external current transformers must be used.
1.3 Getting the nominal current of the CTs needed

The peak value of the current which should be measured has to be smaller than the nominal current of the current transformer multiplied with the square root of 2. If the peak value of the current is only for a shot time higher, the measurement will be cut off at the maximum current the current transformer is able to see. In this case the harmonics compensation is not working correct.

For this all starting cycles and short high current peaks has to be considered, because also they have to be measured correct. The current in Fig. 2 is displayed correct all of the amplitude is in the range of the current transformer. The current in Fig. 3 is cut off at the highest and lowest values. This causes a wrong calculation of the harmonics in this signal.

\[ I_{\text{Max}} \leq \sqrt{2} \times I_{\text{CT nominal}} \]

*Fig. 2: without damage of the current signal*

\[ I_{\text{Max}} > \sqrt{2} \times I_{\text{CT nominal}} \]

*Fig. 3: current signal is damaged because of too small current transformers*
1.4 Installation position of current transformers

The current transformers have to be installed in the correct direction. Take care that the current flow is from the grid to the load side, in the current transformer this is side P1 (also named as K) to side P2 (also named as L). The contacts of the current transformer (S1 and S2) have to be connected to the ECOsine® active as shown in Table 3.

Abb. 4: Installation of current transformers
2 Connection possibilities for current transformers

2.1 Current transformers on load side – single ECOsine® active

The installation of the current transformer on the load side is the recommended way of installation. In this case the current transformers measure the distorted signal and the ECOsine® active injects a compensation current to the grid depending on the measured distortion. In this case the advantage is that more than one ECOsine® active can be set in parallel mode to get a higher compensation current (open loop).

Fig. 5: Current transformer on load side with one ECOsine® active
2.2 Current transformers on mains side – single ECOsine® active

When it is not possible to install the current transformers on the load side, it is possible to install them on the mains side. The disadvantage in this case is that here no parallel operation of ECOsine® active is possible. In the case of a current transformer installation on the mains side, the filter injects a compensating current to the grid until the measured current is sinusoidal (close loop).

Abb. 6: Current transformer on mains side with one ECOsine® active
2.3 Installation of the current transformers to one ECOsine® active

For the correct current measurement the correct orientation of the current transformers and the functional assignment to the phases is essential.

![Diagram](image)

**Fig. 7: Wiring of the current transformers with one ECOsine® active**

**Note**

90% of the problems during commissioning are caused by a wrong wiring of the current transformers. This could be:

- Interchange of the current transformers to the phases (See Table 3)
- Wrong current direction through the current transformers
- Invert of the wires from the current transformers to the ECOsine® active
2.4 Current transformers on load side – multiple ECOsine® active

To operate more than one ECOsine® active in parallel for getting a higher compensation current it is necessary to install the current transformers on the load side. In this case the signal of the current transformers is connected through all parallel ECOsine® active, but in maximum 5 ECOsine® active at a current transformer power of 15VA.

![Diagram of current transformer connection](Image)

**Fig. 8: Parallelization of more ECOsine® active**

**Note**

Due to the maximum power of the current transformers it is not allowed to operate more than 5 ECOsine® active with one set of current transformers. To operate more than 5 ECOsine® active in parallel, the power of the current transformers has to be increased or there has to be additional current transformers installed. (See also Table 1 and Table 2)

For parallel operation of the ECOsine® active the current transformer has to be on **load side**.
2.5 Installation of the current transformers to multiple ECOsine® active

With the parallelization of ECOsine® active the compensation current could be exceeded. The Signal of the current transformers has to be connected through all ECOsine® active like in the following schematic shown. In this case it is necessary to install the current transformer on the load side.

**Fig. 9: Wiring of the current transformers with multiple ECOsine® active**
3 Parallel operation of ECOsine® active and power factor correction

To operate an ECOsine® active in parallel to a power factor correction, it is necessary that the power factor correction is detuned. Otherwise there is no guarantee that the ECOsine active does not get into resonance with the plain capacitors of the power factor correction.

3.1 Power factor correction downstream

3.1.1 Current transformers on load side – single ECOsine® active

The easiest way to install an ECOsine® active in parallel to a power factor correction (PFC) is to install it on the mains side of the PFC and the load. The current transformers will be installed on the load side of the ECOsine® active as it is recommended from Schaffner. In this constellation it is possible to add more ECOsine® active if necessary and on the ECOsine® active it is possible to switch on the power factor correction to get the rest of the reactive power compensated.

![Diagram of current transformers on load side with one ECOsine® active and PFC downstream](image)

Fig. 10: Current transformers on load side with one ECOsine® active and PFC downstream
3.1.2 Current transformers on load side – multiple ECOsine® active

This is the same as shown in 3.1.1, with two ECOsine® active in parallel operation.

![Diagram of current transformers on load side with multiple ECOsine® active and PFC downstream]

Fig. 11: Current transformers on load side with multiple ECOsine® active and PFC downstream

**Note**

Due to the maximum power of the current transformers it is not allowed to operate more than 5 ECOsine® active with one set of current transformers. To operate more than 5 ECOsine® active in parallel, the power of the current transformers has to be increased or there has to be additional current transformers installed. (See also Table 1 and Table 2)

For parallel operation of the ECOsine® active the current transformer has to be on load side.
3.1.3 Current transformers on mains side – single ECOsine® active

If there is no space to place the current transformers on the load side of the Filter, it is also possible to install them on the mains side. In this case it is also possible to compensate the reactive power with the ECOsine® active to get a better power factor than only with the PFC. But no parallel operation of ECOsine® active is possible.

![Diagram showing current transformers on mains side with ECOsine® active and PFC downstream.]

Fig. 12: Current transformers on mains side with one ECOsine® active and PFC downstream
3.2 Power factor correction upstream

3.2.1 Current transformers on load side – single ECOsine® active

To install the ECOsine® active on the load side of the PFC the power factor correction hast to be switched off in the ECOsine® active. The harmonics compensation works in this constellation without any problems. The advantage of this constellation is that the harmonics are compensated before they can destroy the capacitor banks of the power factor correction. Here it is also no problem to add more ECOsine® active in parallel.

Abb. 13: Current transformers on load side with one ECOsine® active and PFC upstream

In this case it is not allowed to switch on the power factor correction of the AHF!
3.2.2 Current transformers on load side – multiple ECOsine® active

This is the same as shown in 3.2.1, with two ECOsine® active in parallel operation.

In this case it is not allowed to switch on the power factor correction of the AHF!

Abb. 14: Current transformers on load side with multiple ECOsine® active and PFC upstream

Note

Due to the maximum power of the current transformers it is not allowed to operate more than 5 ECOsine® active with one set of current transformers. To operate more than 5 ECOsine® active in parallel, the power of the current transformers has to be increased or there has to be additional current transformers installed. (See also Table 1 and Table 2)

For parallel operation of the ECOsine® active the current transformer has to be on load side.
3.2.3 Current transformers on mains side – single ECOsine® active

It is also possible to measure the current of the ECOsine® active on the mains side. Here it is not allowed to switch on the power factor correction of the ECOsine® active in this case and it is not possible to add additional ECOsine® active in parallel.

Abb. 15: Current transformers on mains side with one ECOsine® active and PFC upstream

In this case it is not allowed to switch on the power factor correction of the AHF!
4 Check the current transformers for correct installation

4.1 Check the rotating field

Start with the AHF-Viewer a single measurement and report the following parameters:

- **Voltage**
  - Line voltage Phase 1 (P113)
  - Line voltage Phase 2 (P114)
  - Line voltage Phase 3 (P115)

- **Current** (depends on installation of the current transformers)
  - **Current transformers on load side:**
    - Load current Phase 1 (P133)
    - Load current Phase 2 (P134)
    - Load current Phase 3 (P135)
  - **Current transformers on mains side:**
    - Line current Phase 1 (P123)
    - Line current Phase 2 (P124)
    - Line current Phase 3 (P125)

When the current transformers are installed correct, the direction of the rotating field of voltage and current are the same. If the direction of the rotating field is reversed, two current transformers are inverted in the phases.

**Fig. 16: Check rotating field of voltage and current**
4.2 Check phasing

When the rotating field is correct, with the same measurement the phasing of voltage and current could be checked.

Example 1:
Phasing of voltage and current is correct.

Fig. 17: Phasing of voltage and current is correct
Example 2:
Phasing of voltage and current is 180° displaced. In this case the connection points (S1 and S2) from the current transformer are inverted or the current transformer is installed the wrong way round. This could be seen in two different ways. Like in Fig. 18 shown, the current is 180° shifted according to the voltage of the same phase. On the other hand it is like in Fig. 19, for this case all three currents have to be shown. In this case there is no balance between the currents on the upper and lower side of the zero-line.

Fig. 18: Phase of voltage and current 180° shifted

Fig. 19: Current of phase 1 shifted 180°
Example 3:
When the current transformers of two phases are inverted, this is found during the testing of the rotating field. Another indication is the phase shifting of more than 90° between the voltage and the current like shown in Fig. 20.

![Graph showing current transformer outputs](image)

**Fig. 20: Current transformer of phase 1 and 3 inverted**
4.3 Check neutral wire current

At 3-wire ECOsine\textsuperscript{®} active and 4-wire ECOsine\textsuperscript{®} active with balanced load there could also be seen a wrong wiring of the current transformer at the neutral wire current. But there is no detection which current transformer is wrong.

At balanced load with only low third harmonics the neutral wire load current (P148) has to be less than the load current of the phases (P130 – P132). If the value of P148 is higher than the values of P130 - P132, this is an indication of a wrong wiring of the Current transformers. In this case the connection of S1 and S2 of one current transformer is wrong or the current transformer is installed the wrong way round.

Fig. 21: Neutral wire current OK

![Neutral wire current OK](image)

Fig. 22: Neutral wire current to high

![Neutral wire current to high](image)