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Application Note

Testing ABB relays with sensor inputs

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Abstract

This application note explains the steps required for configuring a test for protection devices with inputs for Rogowski current sensors and voltage sensors using the *Test Universe* software. Therefore, the configuration of the test object and hardware-configuration is explained. The sensor specific settings for the correction factors of amplitude and propagation delay are also described. Additionally, points which must be considered when using a sensor test adapter are shown.

General information

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The product information, specifications, and technical data embodied in this Application Note represent the technical status at the time of writing and are subject to change without prior notice.

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1 Safety instructions

This Application Note may only be used in conjunction with the relevant product manuals which contain all safety instructions. The user is fully responsible for any application that makes use of OMICRON products.

Instructions are always characterized by a ▶ symbol, even if they are included in a safety instruction.

NOTICE

Equipment damage or loss of data possible

- ▶ Carefully read and understand the content of this Application Note as well as the manuals from the systems involved before operating them.
- ▶ Please contact OMICRON support if you have any questions or doubts regarding the safety or operating instructions.
- ▶ Follow each instruction listed in the manuals, especially the safety instructions, since this is the only way to avoid the danger that can occur when working on high voltage or high current systems.
- ▶ Only use the equipment involved according to its intended purpose to guarantee safe operation.
- ▶ Existing national safety standards for accident prevention and environmental protection may supplement the equipment's manual.
- ▶ Before starting a test always check that the test signals are suitable for your system under test.

Only experienced and competent professionals that are trained for working in high voltage or high current environments may implement this Application Note. Additionally, the following qualifications are required:

- Authorization for working in environments of energy generation, transmission or distribution, and familiarity with the approved operating practices in such environments.
- Familiarity with the five safety rules.
- Proficiency in working with the CMC test sets.

2 Introduction

Protection relays from ABB's Relion 605, 615, 620 and 640 range are also available with Rogowski current sensor inputs and voltage sensor inputs instead of analog inputs for conventional instrument transformers. These sensor inputs use RJ45 connectors.

To test such protection relays, a CMLIB REF6xx adapter for the CMC test set is required. It has three RJ45-sockets, each with the signals from the simulated voltage and current sensor of the respective phase.

The LLX1 accessory with the LAB1 test cable can be used for with CMC430 test sets.

This application note explains the steps required for configuring a test for protection devices with sensor inputs using the *Test Universe* software.

Figure 1: CMLIB REF6xx and LLX1 accessory

Figure 2: ABB REF615 relay

3 Sensor data

3.1 Voltage sensor

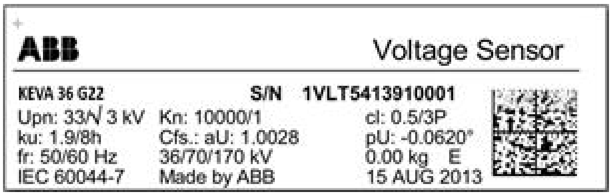

Figure 3: Voltage sensor label

The following data is required:

- Rated primary voltage Upn: 33/√3 kV
- Rated transformation ratio Kn: 10000/1
- Amplitude correction factor aU: 1,0028
- Phase correction factor pU: -0,0620°

3.2 Rogowski current sensor

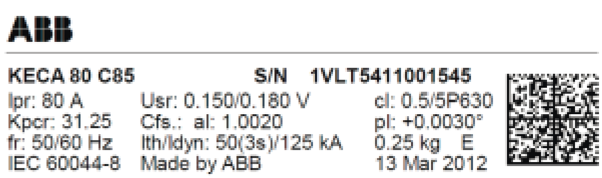

Figure 4: Rogowski current sensor label

The following data is required:

- Rated primary current Ipr: 80 A
- Rated secondary output Usr: 0.150 V (50 Hz) / 0.180 V (60 Hz)
- Amplitude correction factor aI: 1,0020
- Phase correction factor pI: +0.0030°

4 Test configuration

4.1 Test object

Go to the Test object and open by double-clicking the RIO/Device the Device settings. The primary nominal values of the protected object have to be entered in the “Nominal Values” block.

Sensors have a linear response covering a wide range. Therefore, the nominal primary values of the protected object and the rated primary values of the sensor can be significantly different.

Enter the same values for the nominal secondary values as the nominal primary values, as transformation ratios of the sensors are part of the Hardware Configuration.

Adapt the limits “V max” and “I max” to the suitable primary values.

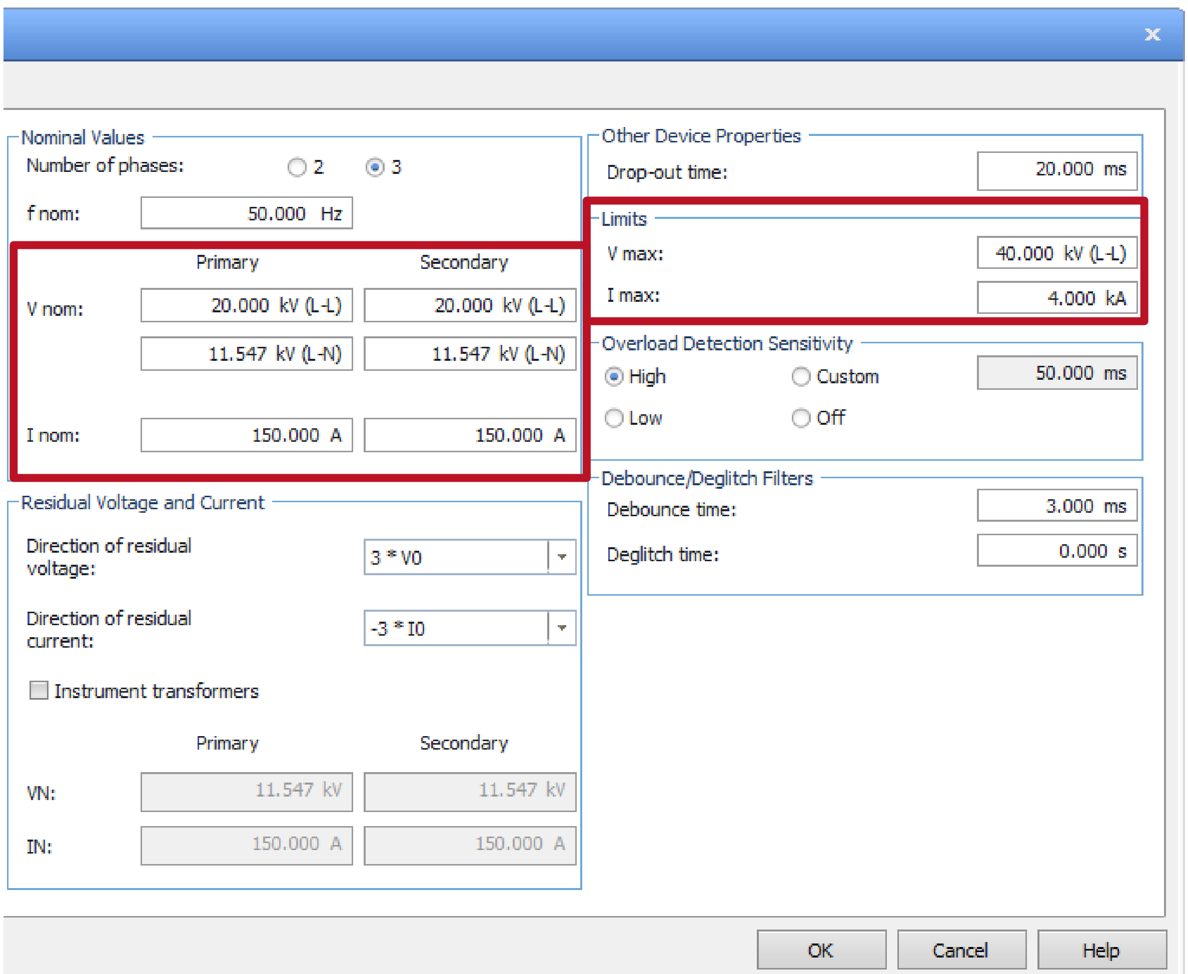

Figure 4: Device settings: Nominal values and Limits

4.2 Hardware Configuration

At first, it is recommended to set the number of **Voltage systems** and **Current systems** to „0“, to keep the existing mapping of the analog outputs.

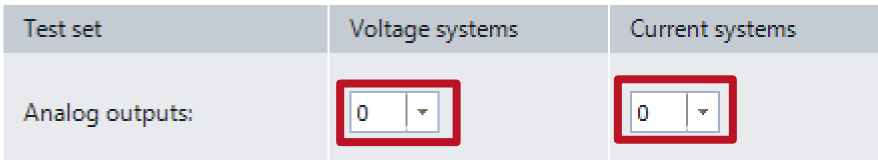

Figure 5: Configuration of the analog outputs

When using a CMC 430, the „LLX1“ accessory must be selected from the drop-down menu “Extension devices”.

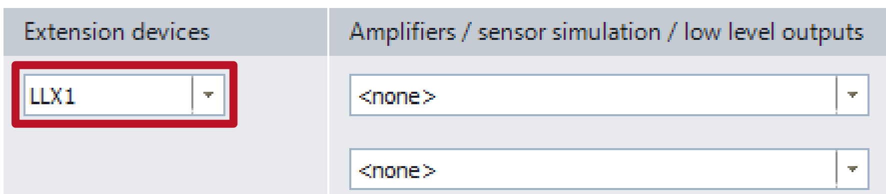

Figure 6: Selection of the extension device LLX1

4.2.1 Voltage sensor configuration

In the drop-down menu for “Amplifiers / sensor simulation / low level outputs”, select “Add voltage sensor”.

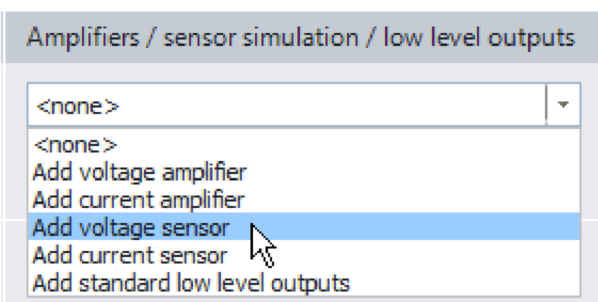

Figure 7: Adding of a voltage sensor

For “Low level output” select “LL out 1-3”.

The transformation ratio is set with “Display value (RMS)” and “Output value (RMS)”. E.g. for a transformation ratio of 10000:1, set the “Display value (RMS)” to 20,00 kV and the “Output value (RMS)” to 2,00 V.

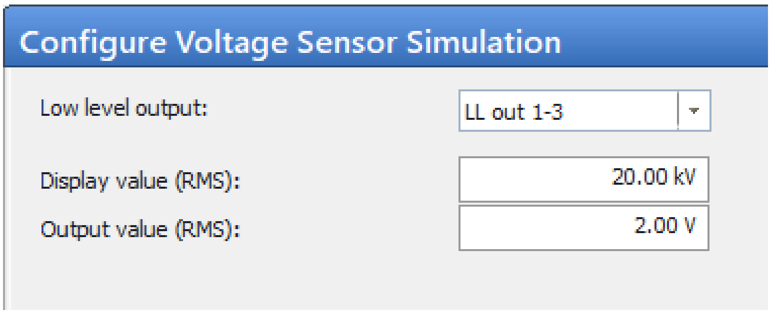

Figure 8: Voltage sensor configuration

The explanation on how to set the correction factors can be found in sections 5.2.1 and 5.2.2.

4.2.2 Current sensor configuration

In the drop-down menu for “Amplifiers / sensor simulation / low level outputs”, select “Add current sensor”.

For “Low level output” select “LL out 4-6”.

For the nominal frequency 50 Hz by using the current sensor from Figure 4, the “Display value (RMS)” can be set to 80,00 A and the “Output value (RMS)” to 150,00 mV.

Additionally, select the sensor type “Rogowski” and the dynamic range to “High range”.

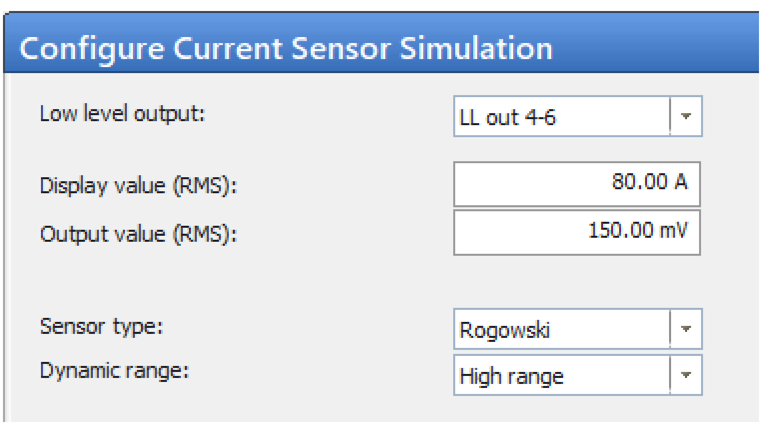

Figure 9: Current sensor configuration for CMLIB REF6xx

When using the LLX1, the signal type (single-ended or differential) must be selected depending on the protected relay according to the documentation from the LAB1 cable.

The explanation on how to set the correction factors can be found in sections 5.2.1 and 5.2.2.

5 Correction factors

5.1 Definition

Sensor correction factors are determined by the manufacturer and can be found on the sensor's nameplate. These factors are set in the protection device's configuration to compensate for sensor inaccuracies and to meet the specified accuracy class.

5.1.1 Phase correction factor

The protection device adds the phase correction factor to the measured phase angle.

Accordingly, the phase correction factor has a:

- positive sign for a sensor with a lagging output signal
- negative sign for a sensor with a leading output signal

5.1.2 Amplitude correction factor

The protection device multiplies the measured amplitude by the amplitude correction factor.

Accordingly, the amplitude correction factor is:

- greater than 1 for a sensor with an output signal that is too small
- less than 1 for a sensor with an output signal that is too large

5.2 Usage in Test Universe

The correction factors for the current and voltage sensors can be set if the check box "Use correction factors" is ticked.

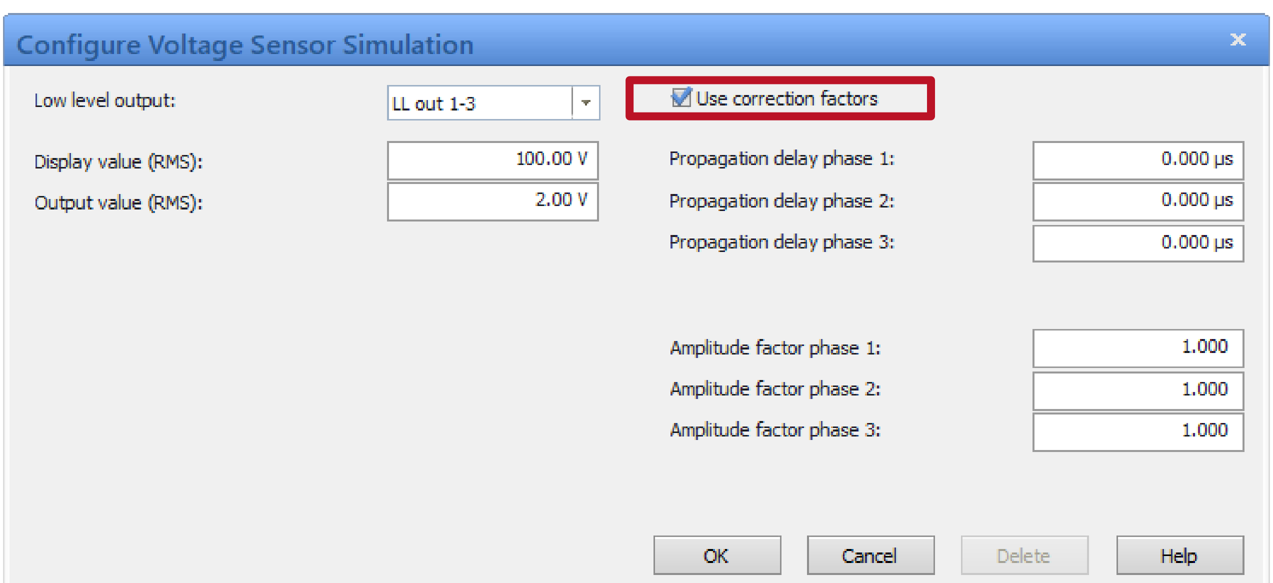

Figure 10: Correction factors for current and voltage sensors

5.2.1 Propagation time

The phase error of the sensor is simulated with “Propagation delay phase 1/2/3”. As the set propagation time is compensated by software, this is a correction factor. The phase correction factor of the sensor must be converted into a propagation delay that considers the rated frequency.

Example:

$$propagation\ delay = \frac{\mathrm{pI}}{f_r * 360°} = \frac{+0.0030°}{50\ Hz * 360°} = 0.17\ \mu s$$

Note: Type “u” to enter a value in microseconds.

Note that only positive values can be entered for propagation delays. Therefore, if one or more phase correction factors are negative, all phase correction factors must be adjusted so that none of them are negative.

Example:

The following phase correction factors

$$\mathrm{pU} = -0.0620°$$

$$\mathrm{pI} = +0.0030°$$

have to be adjusted as follows

$$\mathrm{pU} = -0.0620° - (-0.0620°) = 0°$$

$$\mathrm{pI} = +0.0030° - (-0.0620°) = +0.0650°$$

and afterwards converted into a propagation delay

$$V: propagation\ delay = \frac{\mathrm{pU}}{f_r * 360°} = \frac{0°}{50\ Hz * 360°} = 0\ s$$

$$I: propagation\ delay = \frac{\mathrm{pI}}{f_r * 360°} = \frac{0.0650°}{50\ Hz * 360°} = 3.61\ \mu s$$

5.2.2 Amplitude factors

The amplitude error of the sensor is simulated with “Amplitude factor phase 1/2/3”. Therefore, the reciprocal of the amplitude correction factor from the sensor’s nameplate must be formed.

Example:

$$amplitude\ factor = \frac{1}{\mathrm{aU}} = \frac{1}{1.0028} = 0{,}9972$$

6 Sensor Test Adapter

ABB offers "Sensor Test Adapters" which divide the output signal of the current sensor in a ratio of 3:1 or 10:1. This divider ratio only applies to the current sensor (not to the voltage sensor).

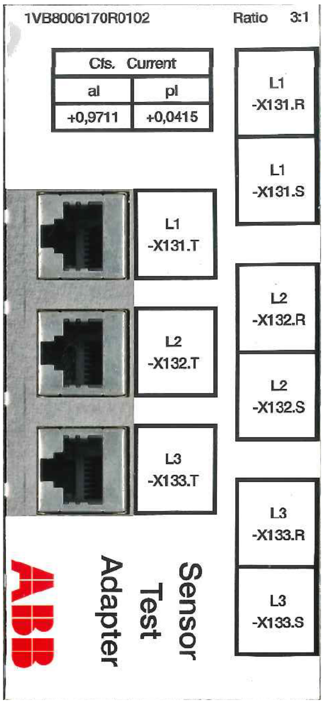

Figure 11: ABB Sensor Test Adapter with 3:1 divider ratio

If a “Sensor Test Adapter” with an ohmic divider is used, the current sensor can be considered an 80 A / 50 mV sensor (ratio 3:1) or an 80 A / 15 mV sensor (ratio 10:1).
As can be seen in Figure 12, the adapter also has correction factors for the current signals. To calculate the resulting amplitude factor, the amplitude correction factor of the current sensor and the test adapter must be multiplied. Afterwards the reciprocal must be formed. To calculate the resulting propagation delay, the phase correction factor of the current sensor and the test adapter must be added and afterwards converted into a propagation delay considering the rated frequency.

Example:

$$sensor: aI = 1.0020$$
$$adapter: aI = 0.9711$$
$$total: aI = 1.0020 * 0.9711 = 0.9730$$
$$amplitude\ factor = \frac{1}{aI} = \frac{1}{0.9730} = 1.0277$$

$$sensor: pI = 0.0030°$$
$$adapter: pI = 0.0415°$$
$$total: pI = 0.0030° + 0.0415° = 0.0445°$$
$$propagation\ delay = \frac{pI}{f_r * 360°} = \frac{+0.0415°}{50\ Hz * 360°} = 2.31\ \mu s$$

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