APPLICATION NOTE

SIPROTEC 7SY82 – LPIT Technology and Secondary test injection steps

APN-104, Edition 1

SIEMENS

SIPROTEC Application

SIPROTEC 7SY82 – LPIT Technology and Secondary test injection steps

APN-104, Edition 1

Content

1 SIPROTEC 7SY82 – LPIT Technology and Secondary test injection steps

1.1 Introduction

The constant change in distribution networks, the presence of new loads, new agents in the market, distributed generation, renewable energy sources, new regulations, digitalization of substations, drives the need for DSOs to use new technologies to increase their sustainability, flexibility, reduction of carbon footprint, cost reduction and safety for workers. One mean to reach these goals are the so-called Low Power Instrument Transformers (**LPIT**) who are beginning to have a greater relevance.

These **LPIT**s, which are regulated under the standard **IEC 61869,** have several operating principles and technical data (Nameplate) that are not necessarily managed by the commissioning personnel. Additionally, the use of the tools provided for secondary injections require additional data which is not used in tests with conventional technology today.

This document provides an overview of the LPIT technology covered by the standard as well on secondary test methods and test tools applicable for Universal device **7SY82** protection and **LPIT** technology. Examples with different **LPIT** manufacturers and the necessary considerations for the performance of overcurrent tests will be shown.

As this document covers the test for the new Universal **SIPROTEC 5 7SY82** and the module **IO141** (at the time when document has been released) we only focus on the **LPIT** for medium voltage switchgears with technology covered in the standard **IEC 61869 -10 and 11**, in this context is not covered **LPIT** technology as current transformers that works whit Hall or optical principles (i.e. Faraday Effect).

Target persons:

- Engineers and technical experts working in Technical Sales department who are defining **LPIT** solutions.
- Engineers and technical experts who are configuring & commissioning **7SY82** Universal protection device.

Required skills:

- SIPROTEC 5 –DIGSI 5
- Omicron Test Universe

1.2 Glossary of Terms and Abbreviations

BCU	Bay Control Unit
BI	Binary Input
BO	Binary Output
Derivative LPCT [1]	Low-power passive current transformer providing an output signal proportional to the derivate of the input signal, LPCT based on non-magnetic-core coil technology without a built-in integrator (e.g., Rogowski coils) are derivate LPCT.
FAT	Factory Acceptance Test
IED	Intelligent Electronic Device
IT	Instrument Transformer
LPCT	Low Power Current Transformer
LPIT	Low Power Instrument Transformer
LPVT	Low Power Voltage Transformer
MU	Merging Unit
Proportional LPCT [1]	low-power passive current transformer providing an output signal proportional to the input signal, LPCT based on iron-core technology with a built-in primary converter providing output voltage are proportional LPTC.
Voltage Divider [2]	Device comprising resistors, inductors, capacitors (or a combination of these components) such that, between two points of the device, a desired fraction of the voltage applied to the device as whole can be obtained.

1.3 Low Power Instrument Transformer basics.

This section provides a technical background about the **Lower Power Instrument Transformer**, including a description of the most common operating principles that are included within the standard.

1.3.1 Technical background – LPIT Technology

The Low Power Instrument Transformer or also called **LPIT** are current and/or voltage measurement devices which do not provide a significant output power, for example ≥ 2.5 VA and it is one important change besides the conventional technology. This document covers the **LPIT** described in the Standard **IEC 61869 Parts -6, -10 & -11**.

<table>
<tr><th colspan="2">PRODUCT FAMILY STANDARDS</th><th>PRODUCT STANDARD IEC</th><th>PRODUCTS</th><th>OLD STANDARD IEC</th></tr>
<tr><td rowspan="14">IEC 61869-1 GENERAL REQUIREMENTS FOR INSTRUMENT TRANSFORMERS</td><td rowspan="4"></td><td>61869-2</td><td>ADDITIONAL REQUIREMENTS FOR CURRENT TRANSFORMERS</td><td>60044-1
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Table 1. IEC 61869 Family standard.

1.3.2 Low Power Passive Current Transformers.

The low power passive current transformers (**LPCT**) are based on passive technology without any active electronic components, **LPCT** can provide an output signal proportional to the primary input. The standard covers two different types:

- Iron core coils, also called LoPo (as a conventional but low power) or proportional LCPT.
- Rogowski coils.

1.3.2.1 Iron core coils.

The Standard **IEC 61869-10** defines*: "proportional LPCT consist of an inductive current transformer with primary winding, small core and a secondary winding with minimized losses which is connected to a shunt resistor R_{sh}. This resistor is an integral component of the proportional LPCT and of great importance for the function and stability of the transformer. The voltage across this shunt resistor is the output signal of the proportional LPCT". [1]*

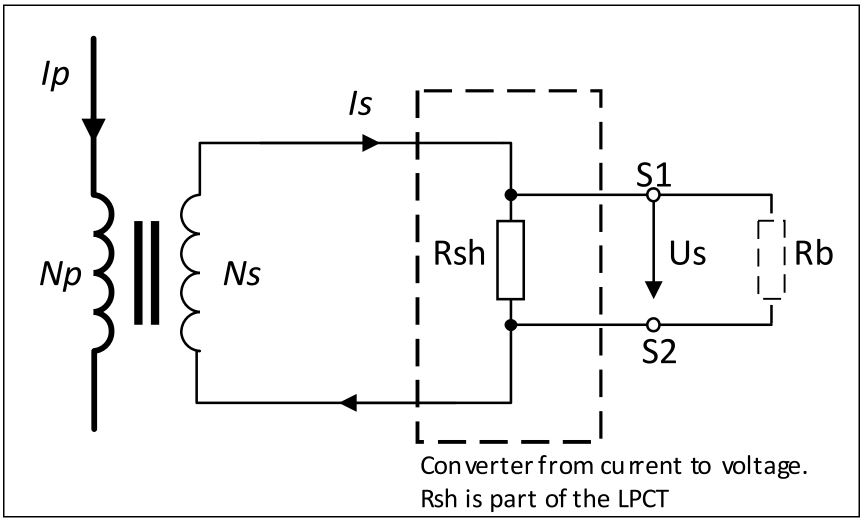


Figure 1. Iron Core coil Current Transformer.

Where:
I_P primary current.
R_{sh} shunt resistor (converter from current to voltage).
U_S secondary voltage.
R_b burden in ohms.
N_p number of turns in primary winding.
N_s number of turns in secondary winding.
P_1, P_2 primary terminals.
S_1, S_2 secondary terminals.

Some benefits of Iron Coil Current Transformers include:

- Current converted into proportional voltage (not additional integration).
- Output signal proportional to the Primary current (not need of derivative elements).
- Output can directly be connected to measurement equipment.
- No temperature drifts.

- Less energy consumption compared to conventional measurement.

The following Figure shows some of the components for an Iron Core.

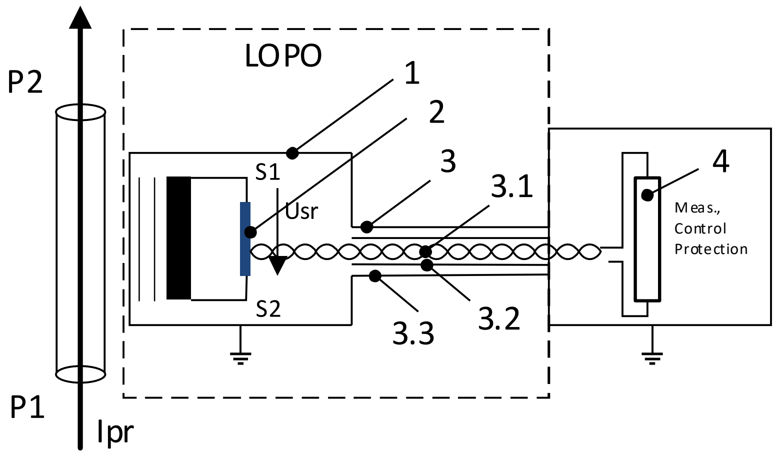


Figure 2. Iron Core (LoPo) Components [3].

Where:

1. Metal Housing.
2. High stability shunt.
3. Double shielded cable.

3.1 Twisted cable pair.
3.2 Internal screen.
3.3 External screen.

4. Input circuit impedance (burden impedance).

1.3.2.2 Rogowski coils.

The Standard **IEC 61869-10** defines the Rogowski coils principle of operation as: *"... operate on the same magnetic field principles as conventional iron-core current transformers (CTs). The main difference between Rogowski coils and CTs is that Rogowski coil windings are wound over a non-magnetic core (air-core), instead of over an iron core. As a result, Rogowski coils are linear since the air-core cannot saturate. However, the mutual coupling between the primary conductor and the secondary winding in Rogowski coils is much smaller than in CTs, resulting in small output power. Therefore, Rogowski coils cannot drive currents through the low-resistance burden as CTs are able to do. Rogowski coil output signals are strong enough to drive microprocessor-based devices that have a high input resistance, and they practically measure voltage across the Rogowski coil's secondary output terminals". [1]*

The conventional Rogowski coils consist of a wire wound on a non-magnetic core; the U_s voltage at the winding terminals is proportional to the rate of change of the current trough the main conductor.

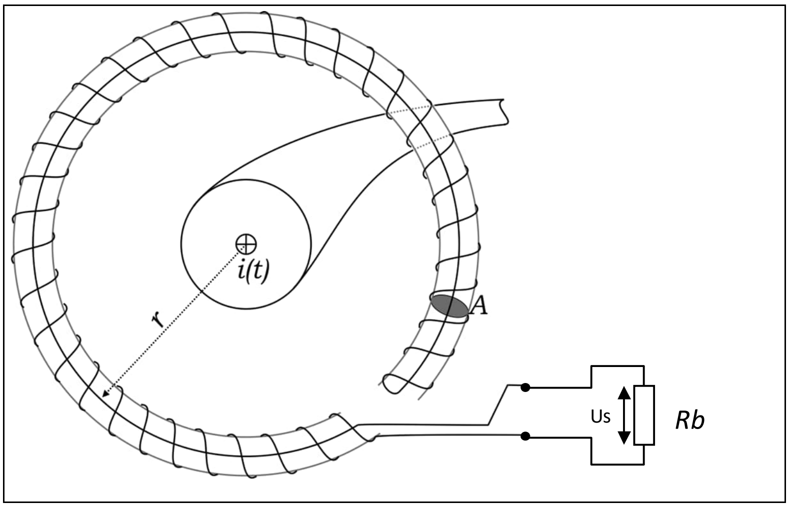


Figure 3. Rogowski coil.

The formula for U_s is:

$$U_s = -M\frac{di(t)}{dt}$$

Where M is the mutual inductance.

At the output, the phase angle between the Rogowski primary current and the secondary voltage is close to 90°, due the coil inductance L_s and resistance R_s of the equivalent circuit.

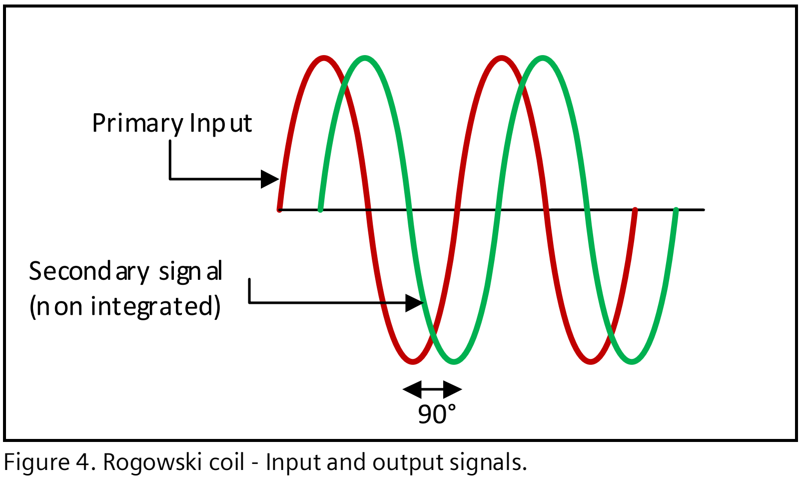


Figure 4. Rogowski coil - Input and output signals.

To measure a signal proportional to the primary current flow the Rogowski coil requires an integration of the output voltage by the measuring device (**7SY82 LPIT** Inputs fulfil this requirement).

Some benefits of Rogowski coils include:

- No danger of opening the secondary winding
- Linear response over wide primary current range – No saturation
- Very small size compared to conventional current transformers.
- Smaller ecological footprint
- Less energy consumption

Considerations for protection usage between the two technologies covered by standard:

Item	Rogowski Coil	Iron core coil
Frequency range	Up to 1 MHz	Up to 150 kHz
Saturation	No	Yes
Nominal primary current	Wide range of values possible	Specific transfer ratio must be chosen (i.e. 300A/225mV)
Signal processing	Integration required	Proportional
Positioning requirements	Required	Neglectable
Cost	Medium (in case of good coil quality)	Low

Table 2. Comparison between Rogowski and Iron core coil.

1.3.2.3 Design types for LPCT.

Since the introduction of the first Rogowski Coil various construction techniques have been implemented, many of these variants are related to each manufacturer's own electrical and mechanical solutions, for example, some Rogowski Coil designs are intended for portable solutions and others to be permanently installed on the primary conductor. Here are some of the designs that can be found in the market.

- Flexible coil.

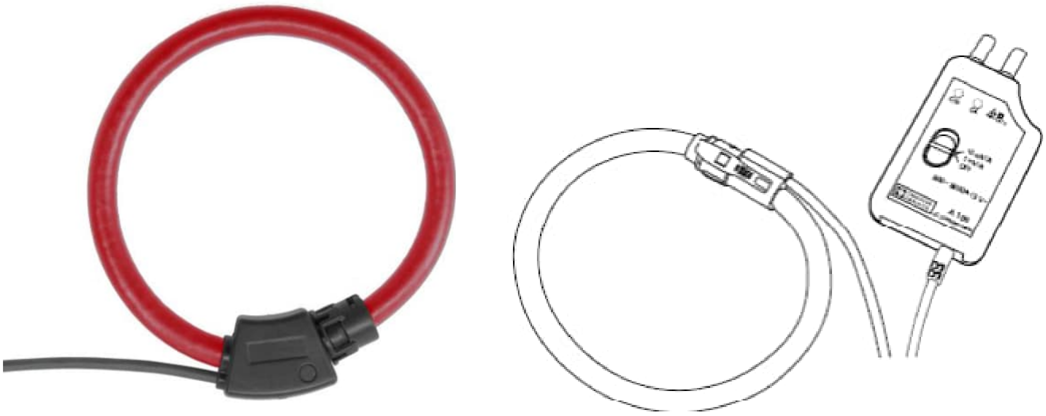


Figure 5. Flexible Rogowski Coil with Integrator [4].

Flexible Rogowski Coils are usually delivered together with a device that integrates the coil output signal, are split-core style and can be installed without any need for electrical or mechanical interruption of the current carrying conductor, while also ensuring galvanic insulation. This makes them easy to use. Accuracy of flexible coils is not too high.

- Split core type.

Split-core current transformers are generally based on the same working principle as solid-core transformers, but the magnetic core is made up of two parts that can be separated. However, unlike a solid-core design, split-core transformers can easily be fitted into an existing installation.

Figure 6. Rogowski coil with split core type [5]

- Rigid non-Split wound core Rogowski coil.

Rogowski Coils ar**e** wound over a non-magnetic core usually having toroidal shape. This core may be made of plastic, epoxy, or other insulating material.

Figure 7. Rigid non split Rogowski coil types.

- Iron core design for earth fault detection.

In case of earth fault in a three-phase network, a current occurs due to the displacement of the neutral point. This current is implemented with a specific ratio in the output of the sensor. Therefore, the system enables to detect fault and short-circuit currents. The following Figure shows an Iron Core Current sensor solution, with a Split core. For this technology the shunt is installed inside the case.

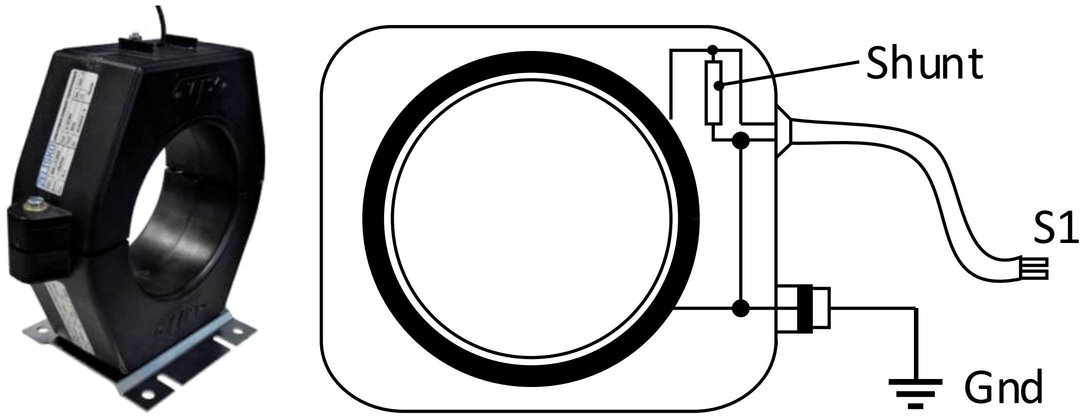


Figure 8. Iron Core Current Transformer Design for Ground Fault Detection [6].

1.3.3 Low Power Passive Voltage Transformers

Low-power passive voltage transformers are based on the voltage divider principle. They can be built as resistive dividers, capacitive dividers, or resistive-capacitive dividers. This guideline covers the secondary test using resistive and capacitive dividers as is the LPVT used with **7SY82**. Neither Resistive nor capacitive divider do not use an active primary converter (i.e., without any active electronic component); therefore, there is no need for primary power supply.

The next Figure shows the types of divider principle covered by **IEC61869-11**.

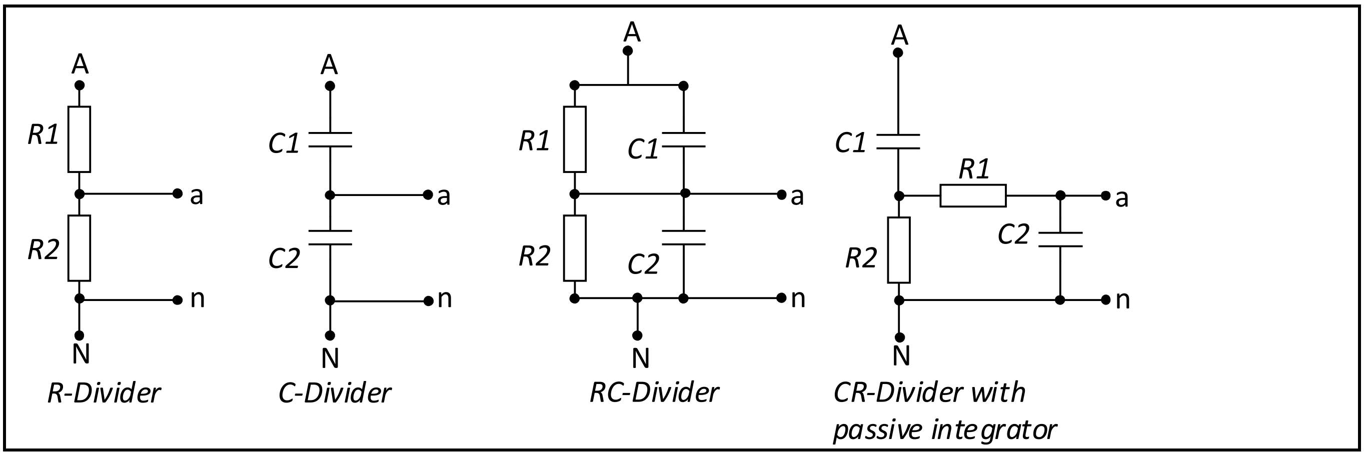


Figure 9. Different divider types covered by IEC 61869-11.

1.3.3.1 R divider

As shown in the Figure 9 the R divider consists of two series Resistance, the drop voltage on the terminal a-n can be calculated by the following formula:

$$V_{a-n} = V_{A-N} \frac{R_2}{R_1 + R_2}$$

Where the Ohmic value of R_1 must be larger than R_2.

Some benefits of R-Divider include:

- Linear response over whole measurement range.
- Provides non-inductive coupling, No ferro resonance effects.
- No temperature drifts.
- New installations and retrofit possible.
- No danger due secondary voltages.
- Sensor applicable for AIS or GIS.
- Improves operational efficiency.

The components mainly are cast in resin. Against electromagnetic fields the components (active part) can be encapsulated in a metallic housing or shielded with an electrode or screen.

1.3.3.2 C divider

The C divider consists of two series capacitors, where the impedance formula for a capacitor is given by:

$$X_c = \frac{1}{2\pi f C}$$

The voltage drop in terminal a-n is given by:

$$V_{a-n} = V_{A-N} \frac{X_{C2}}{X_{C1} + X_{C2}}$$

Some benefits of C-Divider include:

- Eliminates primary switching transients and resonance problems.
- Eliminates the space required for VT compartments.
- Improves operational efficiency.
- Frequency range up to 1 MHz.
- Efficient use of resources, Reduce CO2 impact.
- Smaller weight and size of the Switchgear due to smaller dimensions of the sensors.

Note:
For improved accuracy of C dividers, a temperature compensation could be implemented. Since the Capacitance is temperature dependent, the accuracy can be influenced with rising temperatures, especially if the sensor is placed closed to conducting material. A PT100 element, contained in the sensor, can be connected to the 7Y82 according to **[2] Table 1104**, the pin assignment for Temperature sensor are pins 4&5.

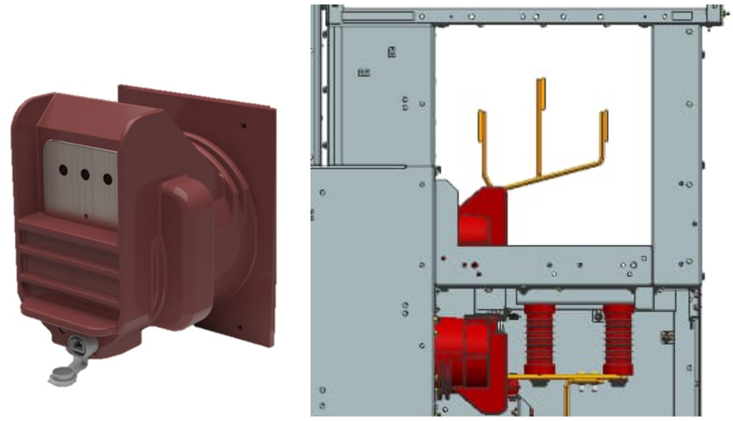
1.3.3.3 Design types for LPVT.

The design of voltage measurement sensors will depend, for example, on the final installation, outside or indoor LPIT as well a difference in the design depending on the insulating mode of the switchgears (**AIS** or **GIS**). This section covers the indoor LPIT technology.

For air-insulated switchgears, a recurrent solution of manufacturers is the conventional insulator-type design, as can be seen in Figure 10. Its design allows it to be used as a post insulator but can be used as a stand-alone unit as well.

Figure 10. Voltage divider sensor for AIS as post insulator.

Other solution for AIS is a bushing-type design, in this case the use of components within the switchgear is optimized, the Figure 11 shows an example of Bushing-type LPIT (a) and the LPIT installed in the busbar compartment of an AIS switchgear (b).



(a) (b)

Figure 11. LPIT bushing type for AIS.

For **GIS**, the conventional design is as shown in Figure 12. These insulators are usually mounted on the cable outlet at the back of the T-connector. Therefore, the insulating plug is replaced by the voltage sensor. The cone of the voltage sensor is designed in accordance with EN50181, type C. Due to the standardized design it is possible to equip different T-connectors, as also can be seen in Figure 12.

Figure 12. Voltage divider sensor for GIS Switchgear. [6]

The following Figure shows the internal components of this kind of sensor type, based on a resistive divider.

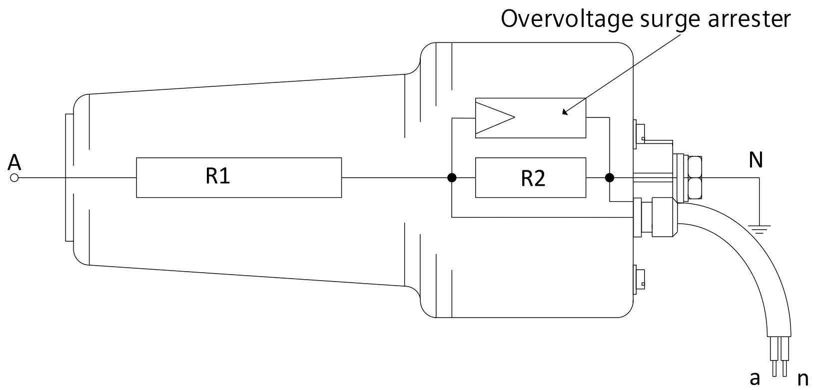


Figure 13. Resistive Divider sensor for **GIS** solution components. [6]

Finally, it is possible to find combinations of the measurement technologies on the market (also called as combi-sensor), i.e. in the same case it is possible to measure voltage and current by means of sensors. The following figure illustrates some examples of combined LPITs.

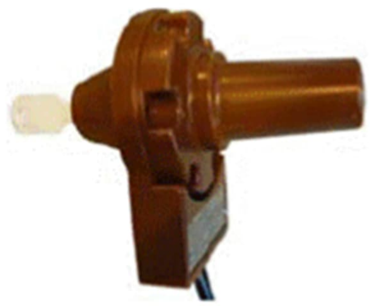


Figure 14. Combination Voltage and Current Sensors. [4]

For GIS solution, **SIEMENS** has developed the SIBushing, an outside-cone bushing type C with integrated measurement of current, voltage and temperature. For this technology the sensors used are Capacitive divider and Rogowski coil for voltage and current measurement respectively.

Figure 15. SIBushing for SIEMENS GIS Solution in Medium Voltage.

1.4 SIPROTEC 5 7SY82 - new components and considerations

7SY82 universal control and protection device is the new IED of the **SIPROTEC 5** family. It contains the **IO141** board with 4 RJ45 inputs for the **LPIT**s (please refer to Hardware Manual for more detailed information). The terminal assigned to the module are identified by the frame in the next Figure.

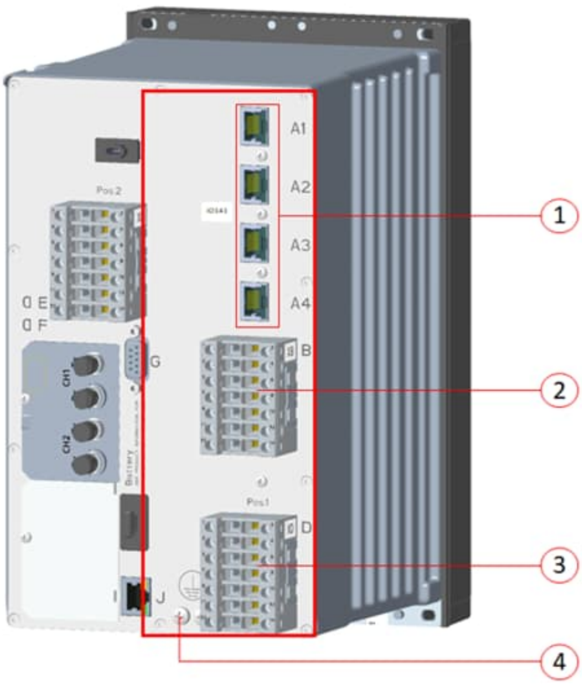


Figure 16. **7SY82** device with IO141 module.

Where:
(1) LPIT measuring inputs A1-A4
(2) Binay Inputs terminal B
(3) Binary inputs and outputs terminal D
(4) Protective grounding terminals

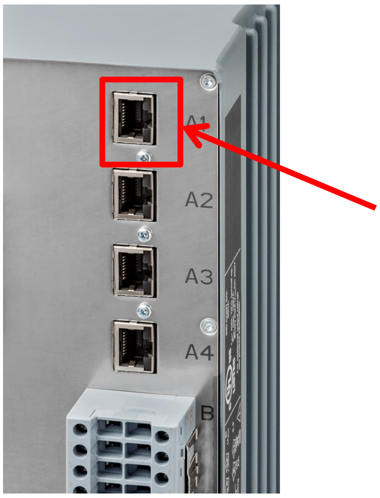
LPIT measuring inputs **A1** to **A4** are divided into groups. The inputs of a group can only be used together. The following table shows the available groups:

Group 1	Group 2	Group 3	Group 4
RJ45 socket 1 to 3	RJ45 socket 1 to 3	RJ45 socket 4	RJ45 socket 4
Pins 1 and 2 respectively	Pins 7 and 8 respectively	Pins 1 and 2	Pins 7 and 8
3-phase current sensors	3-phase voltage sensors	1-phase current sensor	1-phase current/voltage sensor

Table 2. Group Assignment.

Note:
When a secondary test will be performed this assignment takes relevance regarding the secondary injection equipment used. This guideline will show the use of an **OMICRON CMC 430** device and the relevant accessories, please be careful when other tests equipment will be used.

To fulfil with the **IEC61869-10/11** standards, the RJ45 input connectors have the Pinout shown in the following Figure.



Pin	Function
1	LPCT S1
2	LPCT S2
4,5	Temp. measurement (2 wire)
7	LPVT a
8	LPVT n

Figure 17. RJ45 connector pin out based on standard IEC61869-10 Table 1003.

Note:
The **7SY82** relay is compatible with LPITs that meet the requirements of standards **IEC61869-6, 10 and 11**.

Because **LPIT** technology allows for a greater range of use independently of the nominal bay current, it is important to consider the maximum tolerable ranges on the **LPCT** and **LPVT** inputs. In the Figure 18 taken from the **7SY82** manual, the measurement range and continuous rating for both currents and voltages is showed. Take an example of a substation with a rated short time withstand current (I_k) of **25 kA,** the Rated peak withstand current (I_p) is **62.5** kA (with a DC time constant of 45 ms and 50 Hz) [7] then, if the solution includes a Rogowski coil with a ratio of 80 A /150 mV, the secondary voltage at the 7SY82 input will be:

$$V_{peak,7SY82\_input} = \frac{I_k}{Ratio\ LPCT} = \frac{62.5kA}{(80V/150mV)} = 117.2V_{peak}$$

117.2 V is above the maximum tolerable voltage in the LPCT input (35 V*$\sqrt{2}$) =**49** $\mathbf{V_{peak}}$

Low-Power Inputs (via IO141 Module)

All current, voltage, and power data are specified as RMS values.		
Rated frequency f_{rated}	50 Hz, 60 Hz	
LPCT input	Rated-voltage range	Measuring range
	$V_{rated,\ LPCT}$ For Rogowski coil: 14 mV to 565 mV For iron-core coil: 14 mV to 515 mV	Protection channel: 0.9 mV to 50 · $V_{rated,\ LPCT}$ Measuring channel: 0.9 mV to 1.6 · $V_{rated,\ LPCT}$
LPVT input	Rated voltage	Measuring range
	$V_{rated,\ LPVT}$: 381 mV to 5 V	0.001 · $V_{rated,\ LPVT}$ to 2.0 · $V_{rated,\ LPVT}$
Input impedance at 50 Hz / 60 Hz	2 MΩ +5 % to -5 % and 50 pF +0 % to -100 %	
Continuous voltage rating	Max. input voltage LPCT: 35 V LPVT: 10 V	

Figure 18. LPCT and LPVT input ratings.

Same substation data, but in this case a Rogowski coil with a ratio of 50 V / 22.5 mV, then the secondary voltage at 7SY82 input will be:

$$V_{7SY82\_input} = \frac{I_k}{Ratio\ LPCT} = \frac{62.5kA}{(50V/22.5mV)} = 28.1V_{\ peak}$$

For the above example, the specified Rogowski coil is set to substation Rated peak withstand current (62.5 kA) and the LPCT input of the protection relay.

This tolerable range is equally important when developing the protection test, due to the adjustment of maximum currents or voltages that can be injected by the test equipment.

1.5 7SY82 Universal protection basics relevant to testing and commissioning.

This part of the document shows via three cases the configuration settings in **DIGSI**, the considerations that are necessary to consider for **LPIT** of 3rd party and the configuration using an Omicron Test device. Please consider that **DIGSI 5 Version ≥ 9.60** counts with a data base of different references for an easy configuration.

NOTE:
For a detailed setting explanation please refer to the **7SY82** Manual and the document "**Interpretation of technical data for protection functions Edition 1"**

1.5.1 Case 1. Using SIBushing – Integrated Siemens LPIT sensor solution

For Siemens **LPIT** sensor solution **SIBushing** the following Figure shows an example of the Nameplate data.

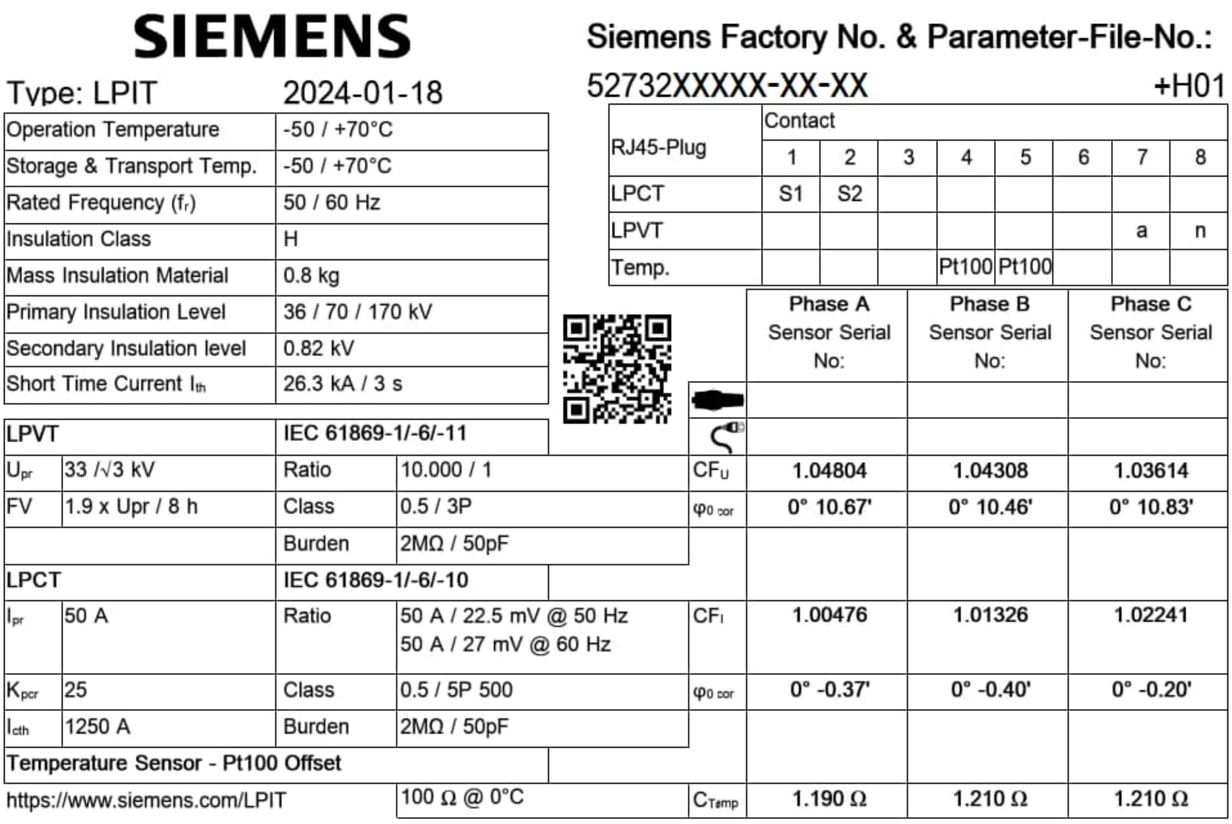


Figure 19. **SIBushing** Nameplate.

The first step is to configure the **LPIT type** in DIGSI. This menu is found in the settings of **IO141** module (*FG Analog Units -> FB LPIT-IO141)* . For **SIBushing** the **LPIT** technologies used are Rogowski coil and C divider.

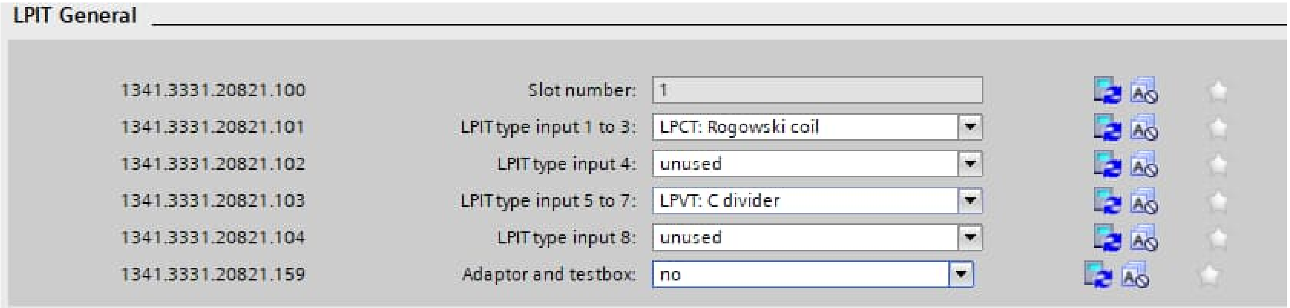


Figure 20. LPIT General data in DIGSI for **7SY82** device.

Taking the information contained in the Nameplate, it can be identified that each Nameplate has a Production ID number of the phases, in addition to containing the information of correction factors (*CFu, CFI*) and the angle correction values per phase. In this example the ID number is 52732xxxx-xx-xx, with this ID it is possible to download all the information directly from the database, to do this, it is necessary to follow the following steps.

Click on the indicated icon to download the updated database (**JSON file**).

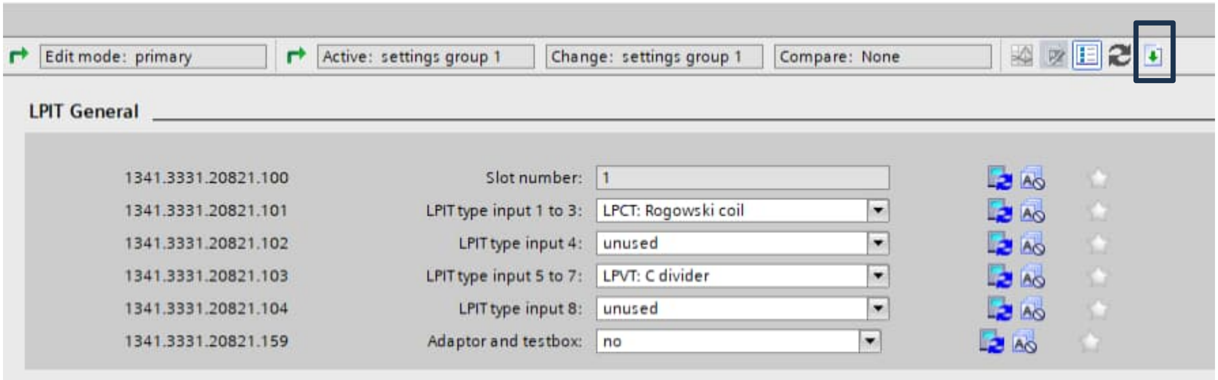


Figure 21. Icon for updated database download.

Once the above icon is selected, the menu in Figure 22 will be displayed. At this point the user will have to choose the vendor and the year of production as appropriate. In this case, **SIEMENS SI-MV-GIS**.

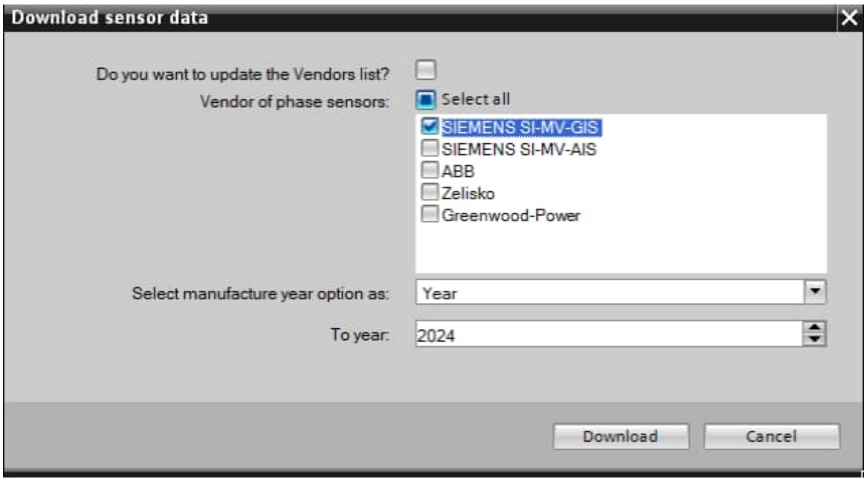


Figure 22. Download sensor data menu.

Once the download has been successful, the following message will be displayed by **DIGSI**.

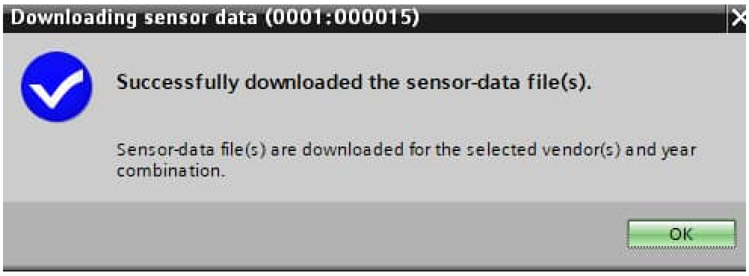


Figure 23. Successful database download.

Now that the database has been downloaded, it is possible to configure the information requested in DIGSI with the **SIBushing** serial number.

First, for current measurement, in the Rogowski coil menu, select **SIEMENS SI-MV-GIS** in the setting ***23101.101 Vendor of Phase LPIT*** and **SI Bushing Current Sensor** in the Setting ***23101.162 in Sensor Type***, as shown in Figure 24.

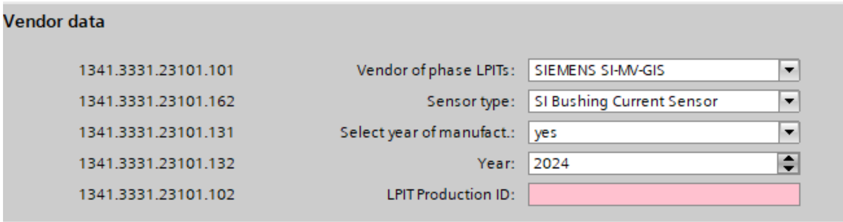


Figure 24. Vendor data for SIBushing.

In Figure 24 it is possible to observe that once the Sensor type is selected, **DIGSI** will show 3 new settings, in this example the user will be able to indicate if they know the year of production of the sensor with the setting ***23101.131*** in **Yes** then in the setting ***23101.132*** indicate the year according to the Nameplate information.

Now, in the setting ***23101.102 LPIT Production ID***, enter the serial number identified in the Nameplate, in this example (Figure 19) is 52732xxxxx-xx-xx.

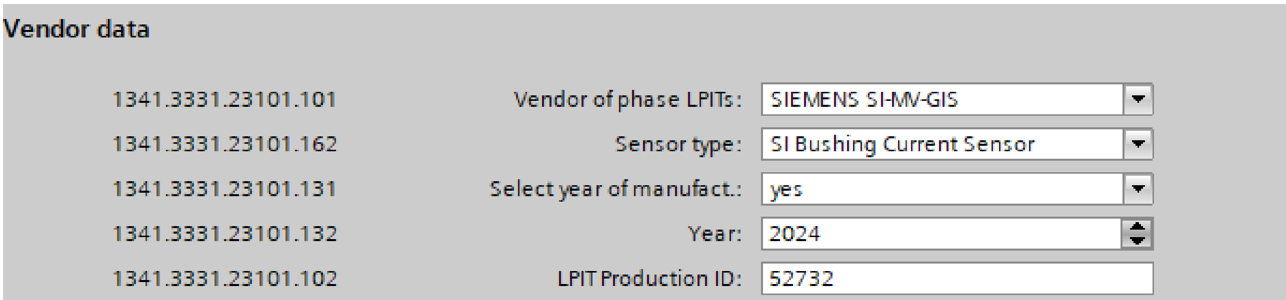


Figure 25. Vendor data for current measurement.

Once the serial is entered, **DIGSI** will search the downloaded database, and if this serial is found within it, the settings will be downloaded and assigned correctly, as can be seen in Figure 26.

Sensor data

1341.3331.23101.103	Rated primary current:	50.0	A
1341.3331.23101.104	Rated secondary voltage:	22.50	mV
1341.3331.23101.111	Rated phase offset:	90.0	°
1341.3331.23101.112	Nominal burden:	2 MΩ, 50 pF	
1341.3331.23101.105	Corr. factor for Kr phsA:	1.0048	
1341.3331.23101.106	Corr. factor for Kr phsB:	1.0133	
1341.3331.23101.107	Corr. factor for Kr phsC:	1.0224	
1341.3331.23101.108	Corr. angle phsA:	-0.4	°
1341.3331.23101.109	Corr. angle phsB:	-0.4	°
1341.3331.23101.110	Corr. angle phsC:	-0.2	°

Figure 26. Automatic Sensor Data Generation for current measurement.

Data such as Correction Factor Kr per Phase and Correction Angle are automatically assigned, and it is not possible to change the value.

Same process for the Capacitive Divider. By entering the sensor Production ID, DIGSI will show the respective correction factors.

Vendor data

1341.3331.23341.101	Vendor of phase LPITs:	SIEMENS SI-MV-GIS
1341.3331.23341.162	Sensor type:	SI Bushing Voltage Sensor
1341.3331.23341.142	Select year of manufact.:	yes
1341.3331.23341.143	Year:	2023
1341.3331.23341.102	LPIT Production ID:	52732

Sensor data

1341.3331.23341.103	Rated primary voltage:	10.0	kV
1341.3331.23341.104	Rated secondary voltage:	1.00	V
1341.3331.23341.111	Rated phase offset:	0.00	°
1341.3331.23341.112	Nominal burden:	2 MΩ, 50 pF	
1341.3331.23341.105	Corr. factor for Kr phsA:	1.0480	
1341.3331.23341.106	Corr. factor for Kr phsB:	1.0431	
1341.3331.23341.107	Corr. factor for Kr phsC:	1.0361	
1341.3331.23341.108	Corr. angle phsA:	10.7	°
1341.3331.23341.109	Corr. angle phsB:	10.5	°
1341.3331.23341.110	Corr. angle phsC:	10.8	°

Figure 27. Automatic Sensor Data Generation for voltage measurement.

As mentioned in section ***1.3.3. Low Power Passive Voltage Transformers***, capacitive dividers will need to include a compensation due to temperature. At this point, it is important to note that once the Production ID of the **LPIT** is added, not only are the correction factors updated, but also the compensation values are updated.

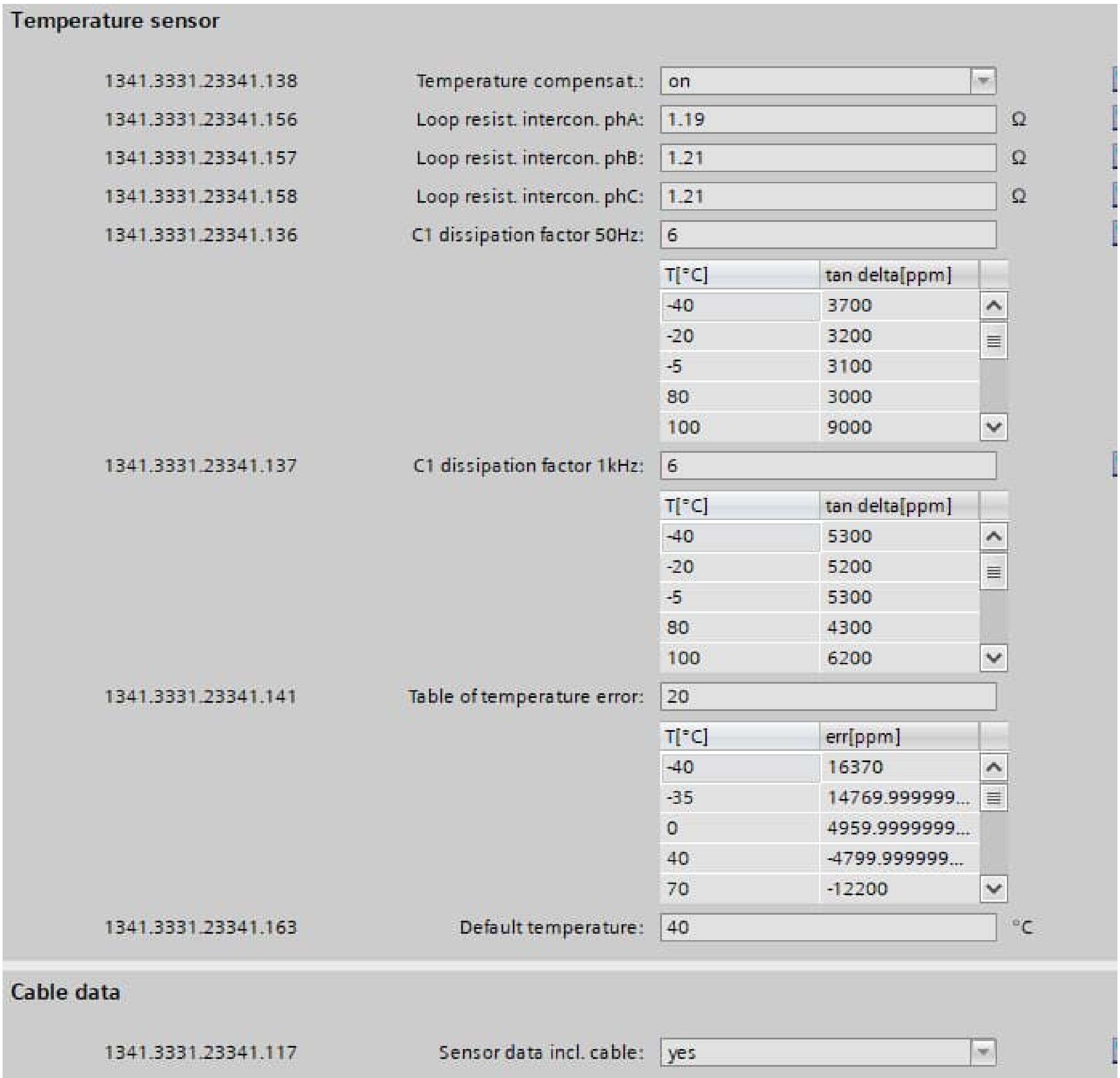


Figure 28. Temperature compensation for Capacitive Divider.

This sensor temperature will be obtained by the **7SY82** device on pins 4 and 5 of the RJ45 input as shown in Figure 17.

OMICRON Test Set and Settings

Now that was added the **LPIT** settings on **DIGSI** it is possible to reply to the data in **OMICRON** using the software **Test Universe** and all the components showed in the Figure 28.

OMICRON CMC430

LLX1 BOX

Cable type	Suitable for	Connector type	Item no.
LAB1	ABB Relion	RJ45	B1960000
LAB2	ABB REF542plus	2x Twin-BNC	B1960100
LAB3	ABB CSU-2	RJ45	P0000782
LSE1	Schneider Electric Sepam	RJ45	B1960300
LSE2	Schneider Electric Easergy Schweitzer Engineering Laboratories SEL-751	2x RJ45	B1960500
LSI1	Siemens Siprotec 4 Compact	RJ45	B1960200
LST1	Siemens 7SY82 [1] Sprecher Automation SPRECON-EDIR [1]	RJ45	P0002259

CABLE SET

Figure 29. OMICRON test devices and accessories required.

First, create a New Test Document in OMICRON, then open the menu "**Device Settings**". In this menu change the values of **Vnom** and **Inom** with same values in Primary and Secondary as it is observed in the Figure 19.

As **LPIT**s covered a high primary value without a saturation, also is important to set the Limits V max and I max, in this case it is important to consider the rating voltages at the LPCT and LPVT inputs. This setting limits the maximum voltage that the test equipment would inject and therefore does not affect the inputs of the **7SY82**. For this example, Vmax will be 30% the nominal voltage and for I max, the short current of the system, for example 20 kA.

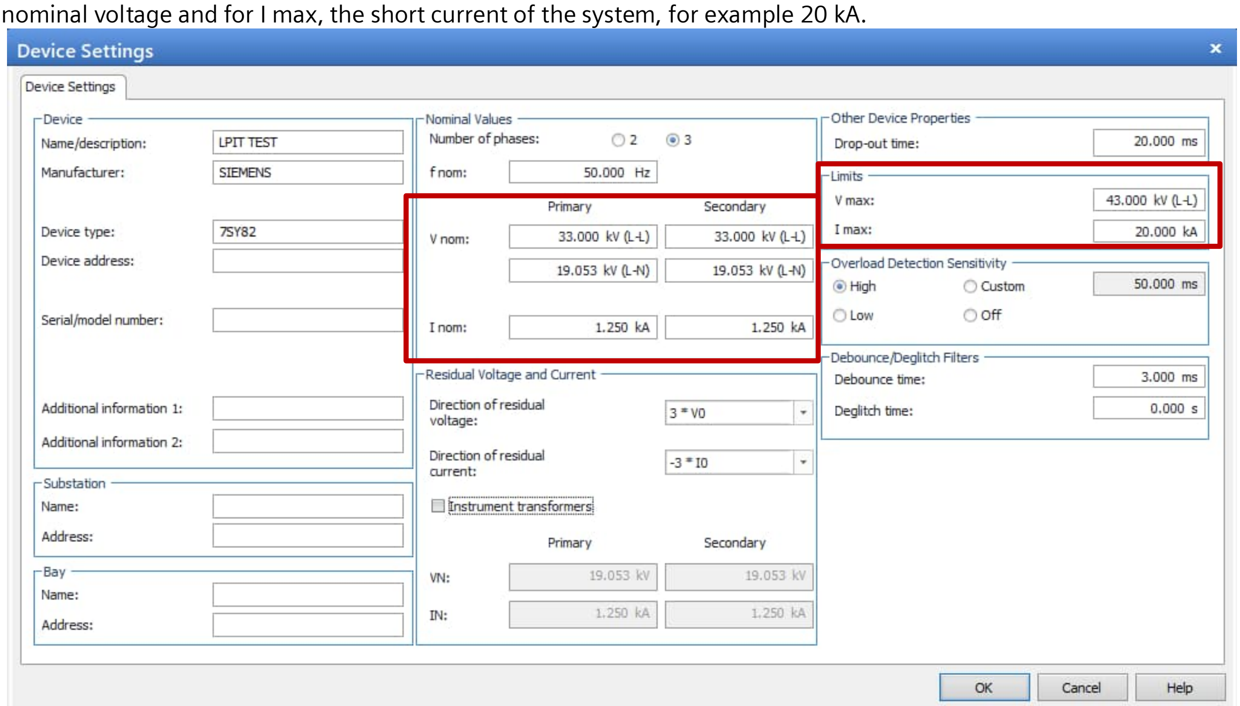


Figure 30. Device Settings in Omicron Test Universe.

In Global Hardware configuration, Menu extension devices please select **LLX1**.

In the menu **Amplifiers/sensor simulation/low level outputs**, please select "**Add Voltage sensor**", then the menu of the Figure 31 will appear.

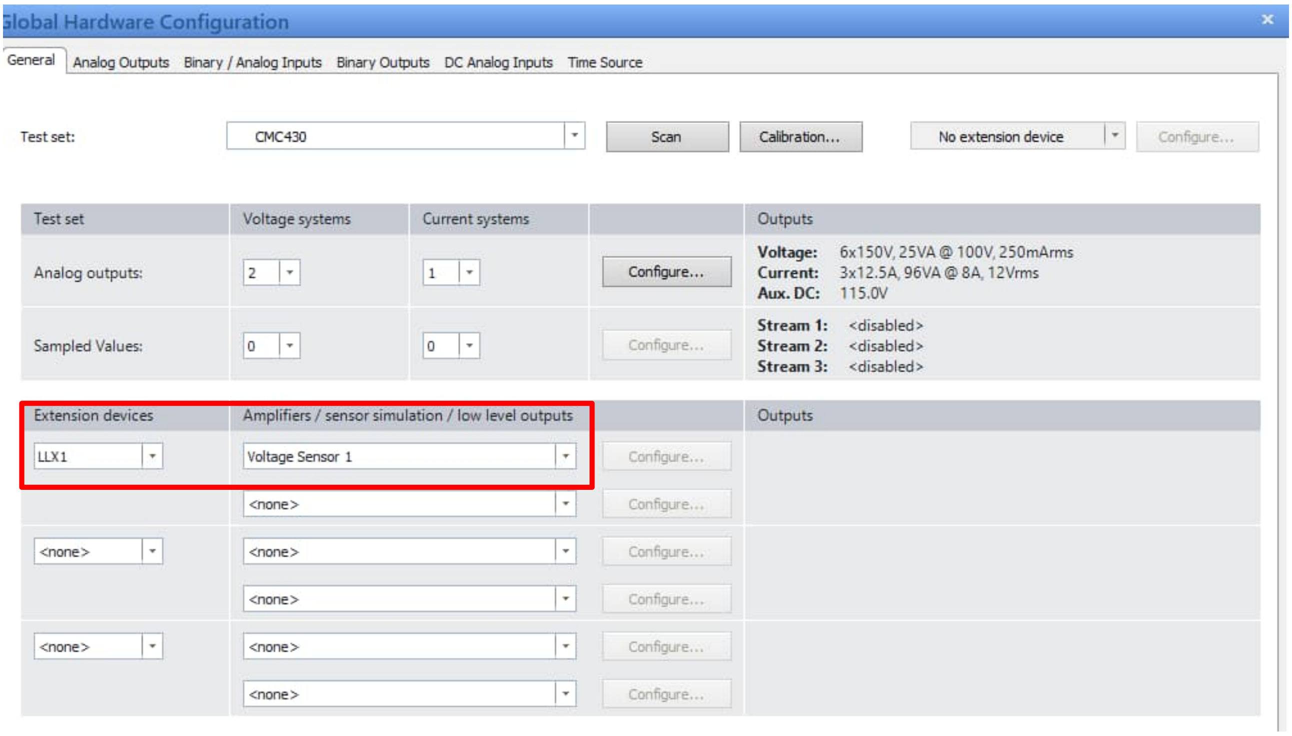


Figure 31. Global Hardware Configuration, adding a Voltage Sensor.

At this point the user can add the **Voltage divider** ratio values showed in Figure 19. Please note that these values are Phase to Phase.

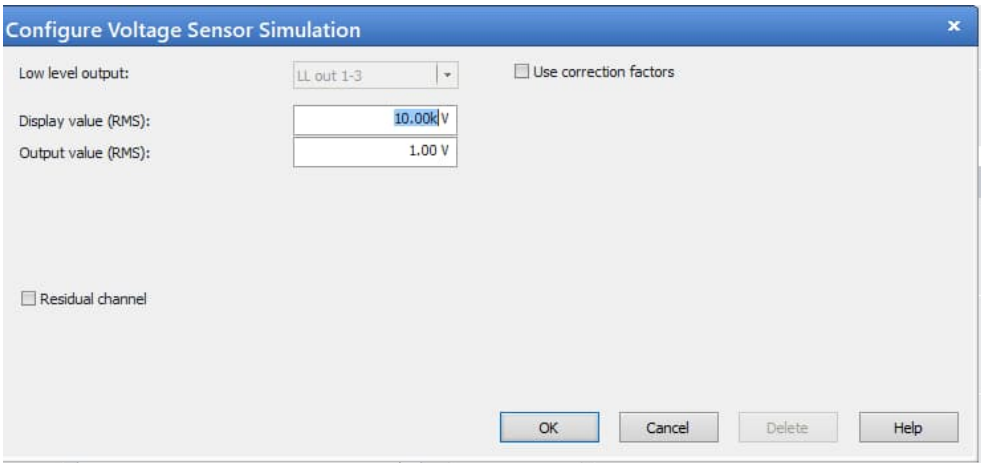


Figure 32. Configure Voltage Sensor Simulation.

As the Voltage divider has correction factor, please select the option "**Use correction factors**" then, the following option will be showed.

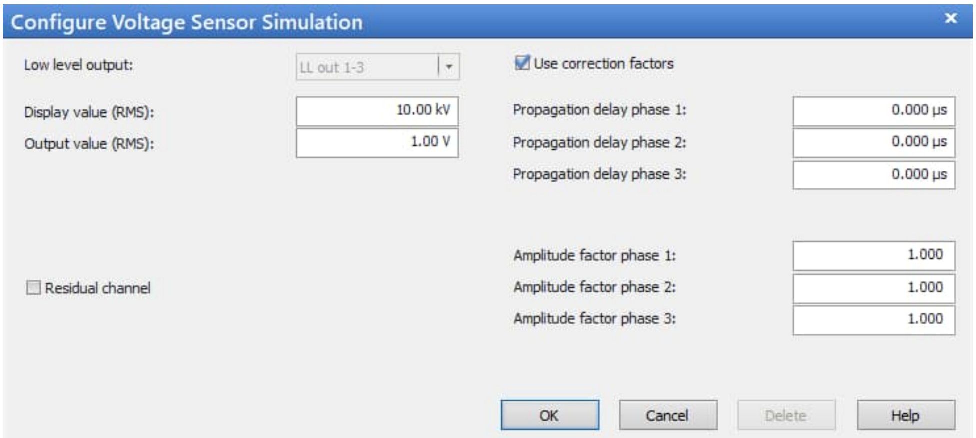


Figure 33. Configure Voltage Sensor Simulation with correction factors.

The phase Error or correction angle in OMICRON Test Universe software is named "**Propagation delay phase x**:" and the values must be entered in microseconds (**not in minutes as in DIGSI**), then it is necessary to convert the values from **minutes** to **µs**, please take in count that this formula depends on the system frequency.

First, converts the angle from minutes to degrees.

Phase A correction angle:

$$correction\ angle\ in\ degrees = \frac{(\,minutes')}{60} = \frac{(\ 10.67')}{60} = 0.1778^{\circ}$$

Now, following the recommendation given in [8], to convert from degrees to microseconds the following formula must be used:

$$propagation\ delay = \frac{pl}{fr \times 360^{\circ}} = \frac{0.1778^{\circ}}{50Hz \times 360^{\circ}} = 9.879\ \mu s$$

Same procedure for remain phases.

Phase B: 9.685 µs
Phase C: 10.028 µs

Now for this example it is necessary to add the "**Amplitude factor phase x**", from the **SIBushing** Nameplate the user can calculate this value with this formula:

$$Amplitude\ factor\ A\ = \frac{1}{CF_U} = \frac{1}{1.0.4804} = 0.9541$$

Same formula for the remaining phases:

$$Amplitude\ factor\ B\ = \frac{1}{CF_I} = \frac{1}{1.0438} = 0.9587$$
$$Amplitude\ factor\ C\ = \frac{1}{CF_I} = \frac{1}{1.03614} = 0.9651$$

Once the calculation was made, the Current Sensor the data is:

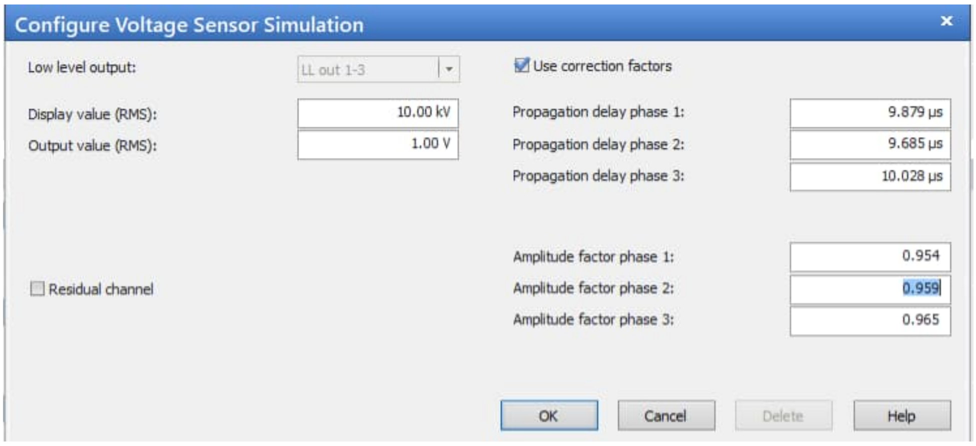


Figure 34. Data for Voltage Sensor according to **SIBushing** Nameplate.

Same procedure for Current Sensor, In the menu Amplifiers/sensor simulation/low level outputs, please select "**Add Current sensor"**, then the menu of the Figure 35 will appear. Choose the correct option for Sensor Type and Signal Type.

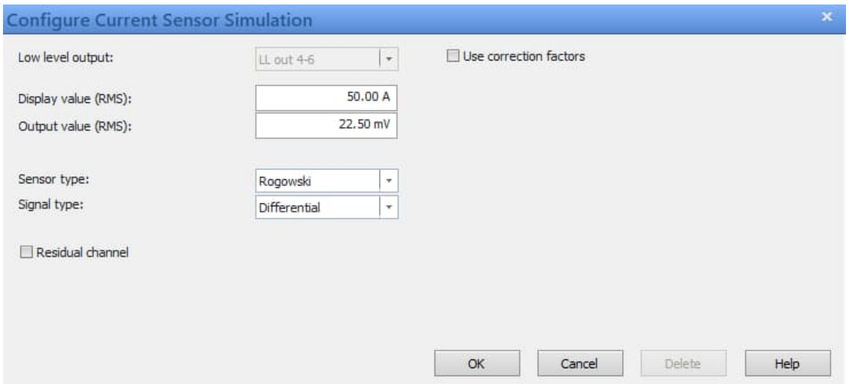


Figure 35. Current Sensor configuration menu.

As in DIGSI, in Test Universe software the user should add the correction factor, then select the check box on the right side of the menu.

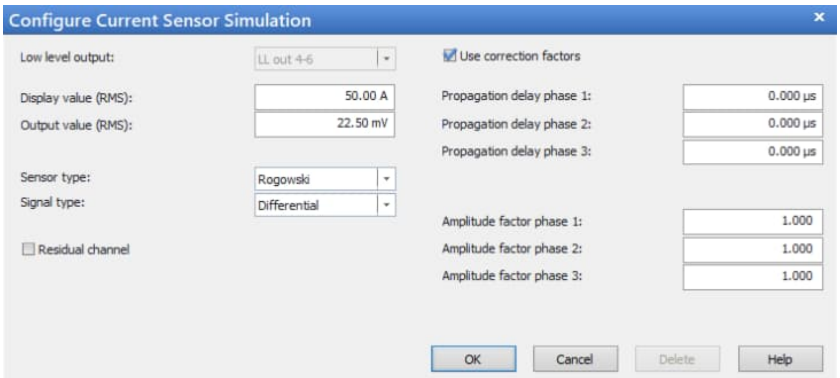


Figure 36. Current Sensor configuration menu including correction factors.

As shown with the Voltage Divider to convert the values given in the **SIBushing** Nameplate into the magnitudes received by Omicron, please follow the next steps.

First, convert the angle from minutes to degrees.

Phase A correction angle:

$$correction\ angle\ in\ degrees = \frac{(\ minutes')}{60} = \frac{(\ -0.37')}{60} = -0.0061667^{\circ}$$

Now, following the recommendation given in [8], to convert from degrees to microseconds the following formula must be used:

$$propagation\ delay = \frac{pl}{fr \times 360^{\circ}} = \frac{-0.0061667^{\circ}}{50Hz \times 360^{\circ}} = -0.3426\mu s$$

Same procedure for remaining phases.

Phase B: -0.03703 µs
Phase C: -0.01851 µs

Now for this example it is necessary to add the “**Amplitude factor phase x**”, from the **SIBushing** Nameplate it is possible to calculate this value with the following formula:

$$Amplitude\ factor\ A\ = \frac{1}{CF_I} = \frac{1}{1.00476} = 0.9953$$

Same formula for the remain phases:

$$Amplitude\ factor\ B\ = \frac{1}{CF_I} = \frac{1}{1.01326} = 0.9869$$
$$Amplitude\ factor\ C\ = \frac{1}{CF_I} = \frac{1}{1.02241} = 0.9781$$

Once the calculation is done, the Current Sensor data is entered:

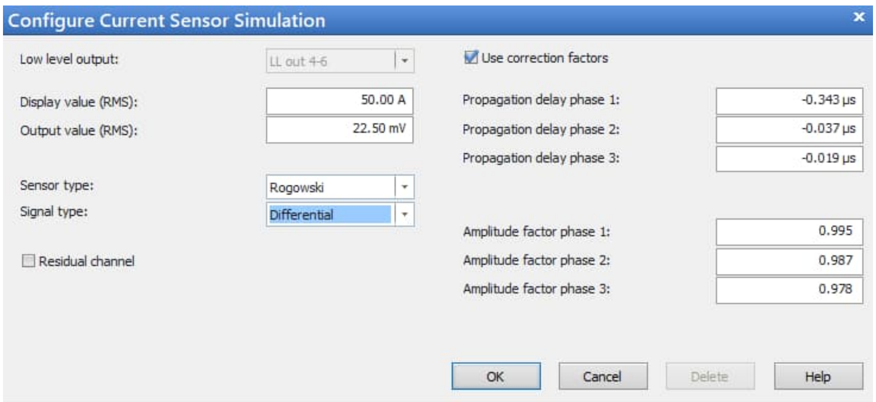


Figure 37. Current sensor data registered in Test Universe software.

Now that the hardware has been configured in OMICRON, it is possible to perform an overcurrent test in the conventional way, only it is necessary to consider that the settings in DIGSI for the protection functions are given in primary values.

In this example the test will performed according to the following settings.

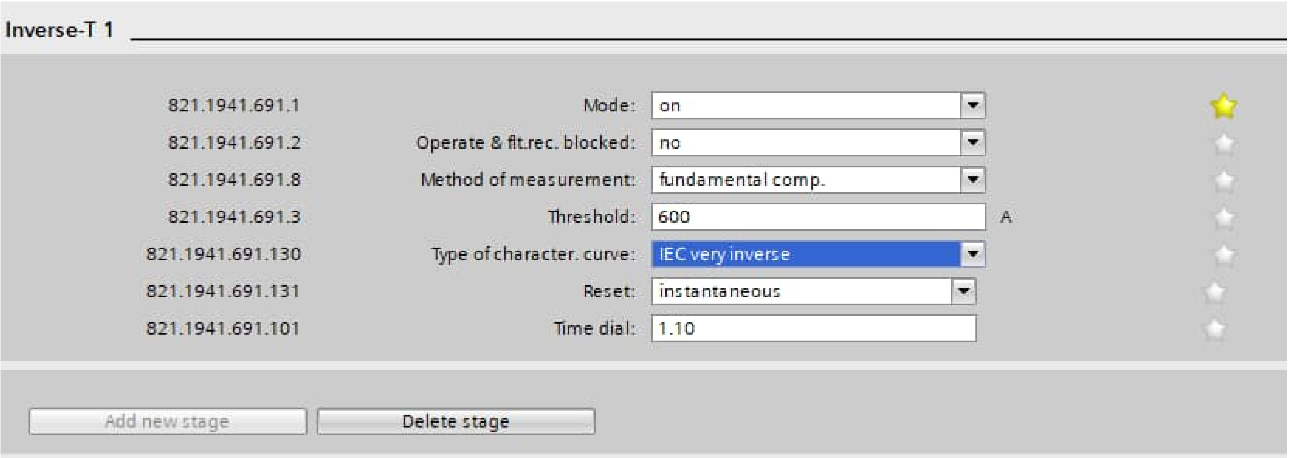


Figure 38. Overcurrent settings in DIGSI.

As the values defined in Test Universe are the same in Primary as in Secondary, the values in OMICRON as are follow:

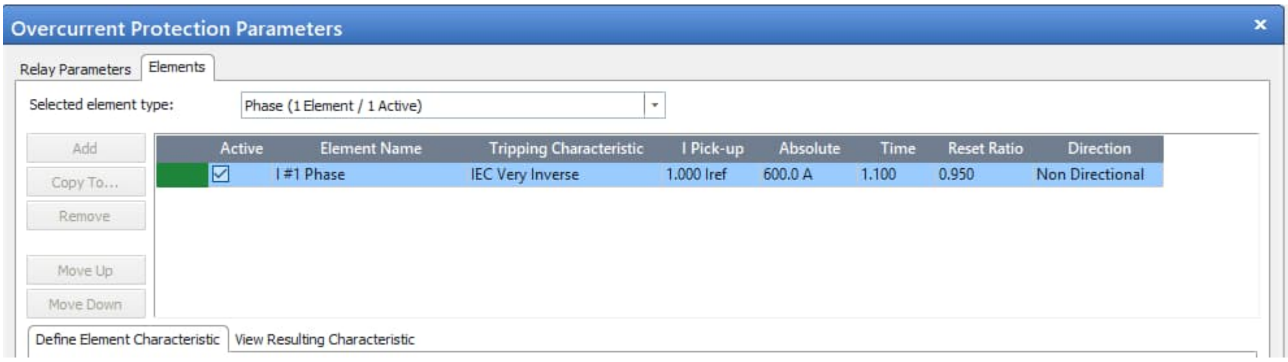
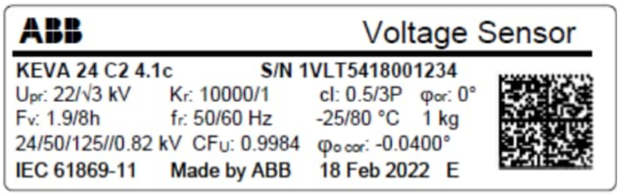


Figure 39. Overcurrent Protection Parameters in Test Universe.

Please take into consideration the polarity of the Rogowski coil when directional test will perform.

1.5.2 Case 2. Using ABB LPIT sensors

This example considers the following Nameplate information for two different sensors (voltage and current sensors).



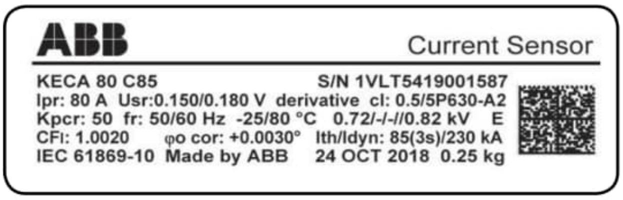


Figure 40. ABB Rogowski coil KECA 80 C85 and R divider KEVA 24 C2.

In the Figure 40 the burden value of the **LPIT** is missing, then is necessary to check in the **LPIT**s vendor catalogue:

- KECA 80 C85 Rated burden according to catalogue: **2 MΩ; 50 pF.**
- KEVA 24 C2 Rated burden according to catalogue: **2 MΩ; 50 pF.**

In this case the quantity of **LPITs** is 6, 3 Rogowski coils and 3 Resistive dividers, then the following picture shows the secondary connection to **7SY82**.

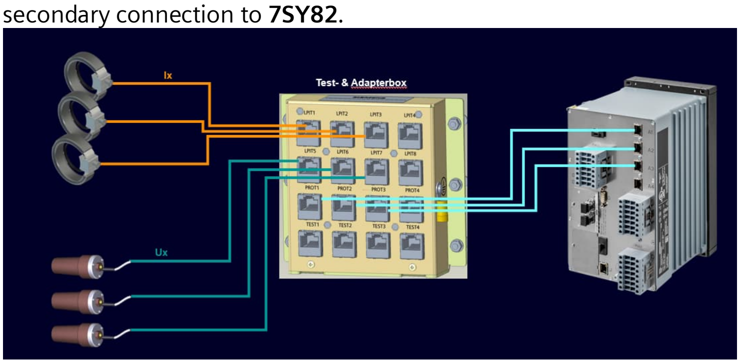


Figure 41. Connection example using an Adapter box.[1]

Like with **SIBushing**, the first step is to configure the **LPIT** type, including the data for adaptor test.

Please pay special attention to the units used in the Nameplate compared to the units used in DIGSI, in this case there is a difference between the angle units. To convert from degrees to minutes, the user needs to multiply by 60.

Note:

[1] The expected Sales Release for SIEMENS Test Box Accessory is End of September 2024.

In this example the angle correction factor is +0.0030° for a **LPCT KECA 80 C85**, then in minutes the value +0.18'. At the time of release this document, in DIGSI 5 the angle correction settings (***23101.108, 23101.109 & 23101.110***) can only be adjusted to negative values, however, due to the tolerance in the angle measurement of the 7SY82 (0.2° at rated current) and the low value of correction factor in this example, an approximation to 0.0' is valid.

The Figures 42 and 43 show the settings registered according to ABB Nameplate in DIGSI.

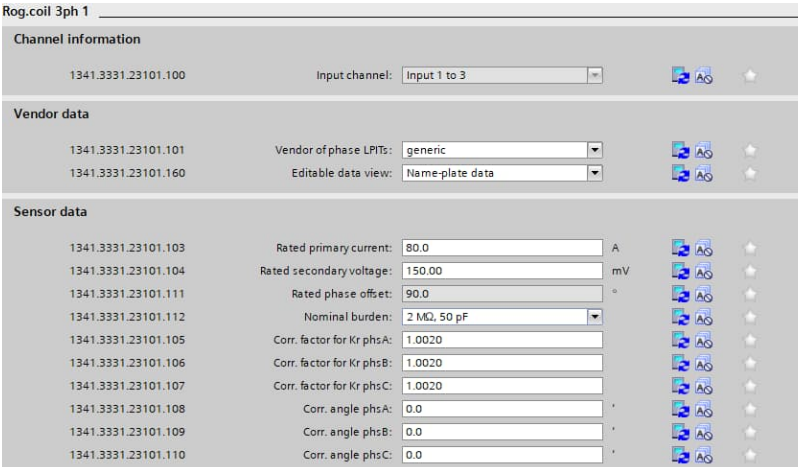


Figure 42. ABB Rogowski coil data.

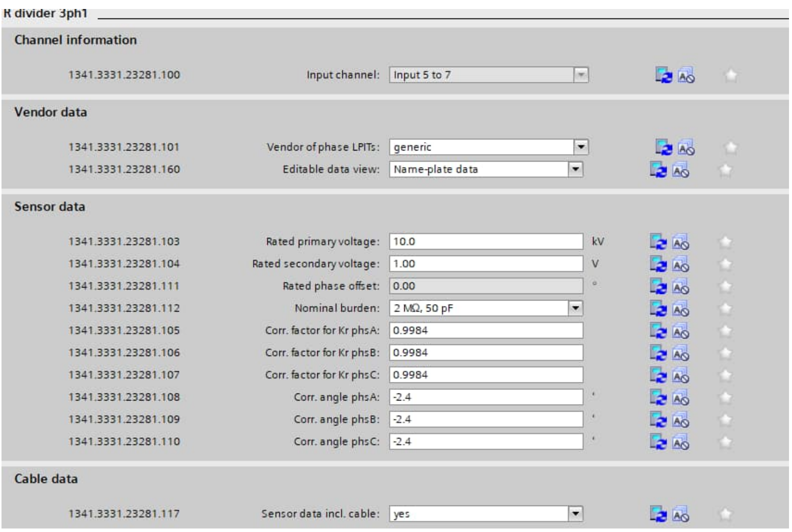


Figure 43. LPIT data for ABB R divider.

OMICRON Test Set and Settings

Now that was added the **LPIT** settings on DIGSI it is possible to reply to the data in OMICRON using the software Test Universe as was showed in 1.5.1.

After user creates a New Test Document in OMICRON, open the menu "**Device Settings**". In this menu change the values of **Vnom** and **Inom** with same values in Primary and Secondary as it is observed in the following picture.

As **LPIT**s covered a high primary value without a saturation, it is important to also set the Limits V max and I max.

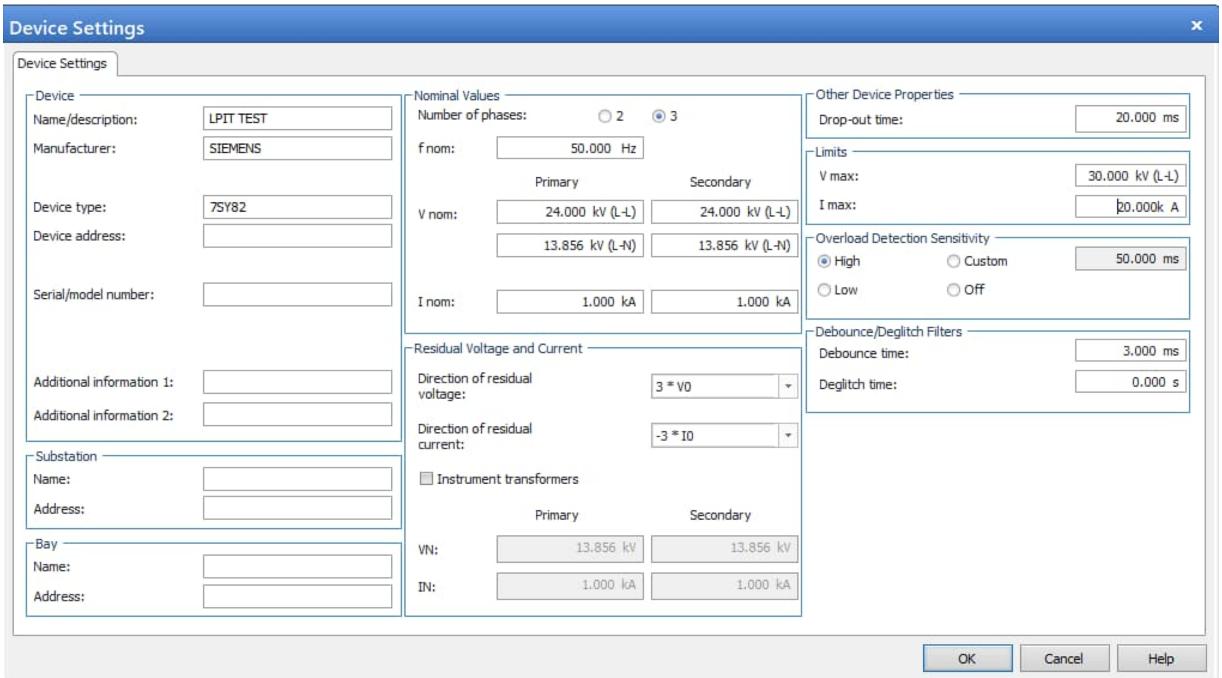


Figure 44. Device Settings in OMICRON Test Universe software.

In Global Hardware configuration, Menu extension devices please select **LLX1**.

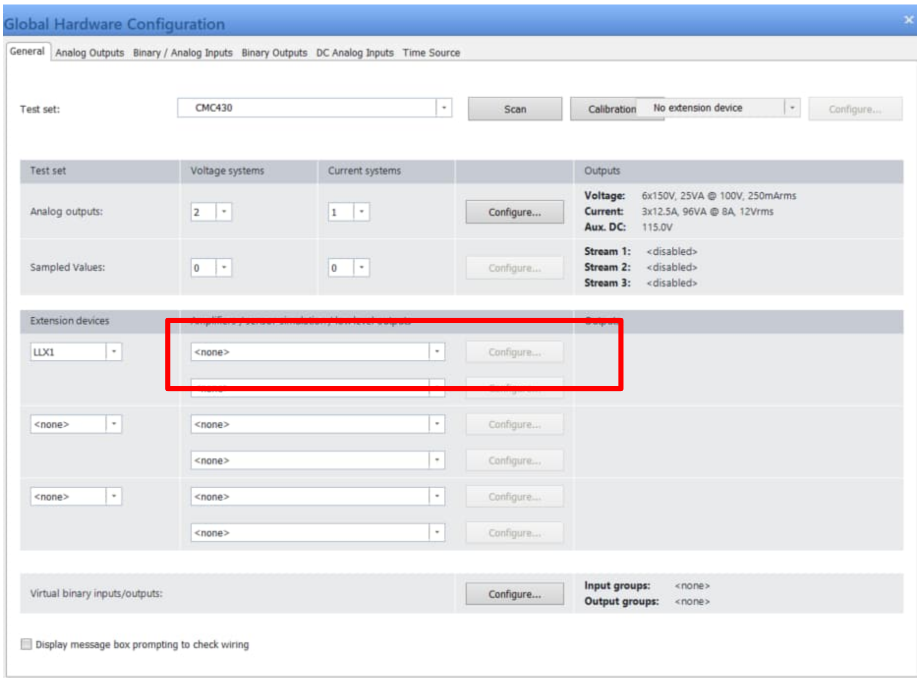


Figure 45. Hardware configuration.

In the menu **Amplifiers/sensor simulation/low level outputs**, please select "**Add Voltage sensor**" in the first option, then the follow menu will appear:

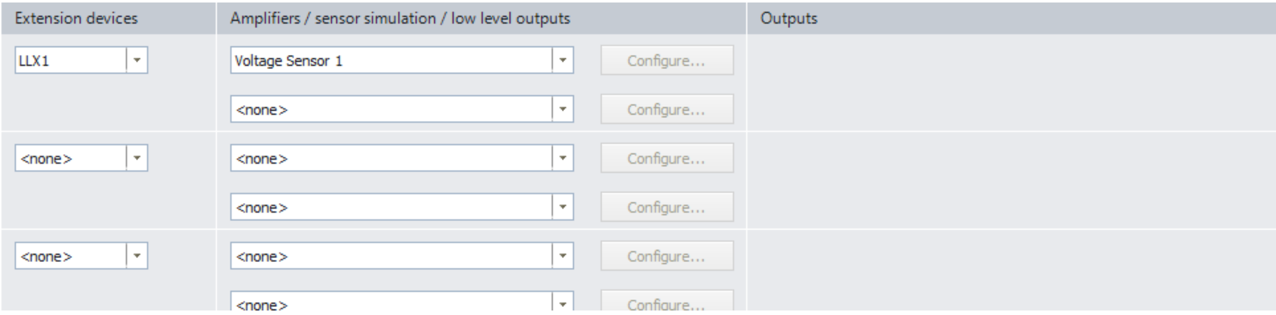


Figure 46. Adding a Voltage sensor.

Now, the menu **Configure Voltage Sensor Simulation** will automatically appear, at this point add the Voltage Divider Ratio.

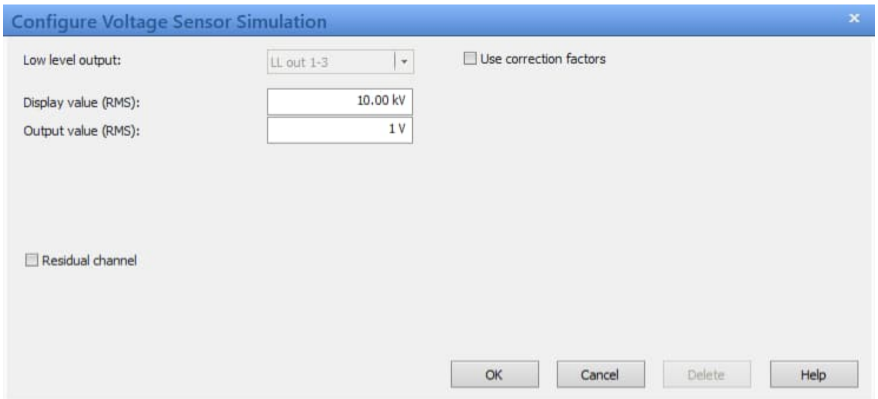


Figure 47. Voltage divider ratio.

As in DIGSI, in OMICRON the user should add the correction factor, then select the check box on the right side of the menu.

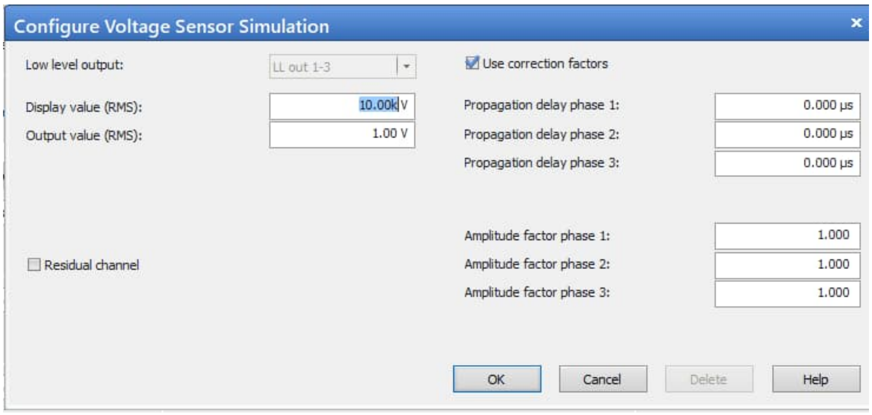


Figure 48. Voltage Sensor menu with correction factor option.

Now it is necessary to convert the angle correction from degrees to µs, please consider that this formula depends on the frequency.

For KEVA 24 C2 the angle correction is **-0.04°,** then for a frequency of 50 Hz the Propagation delay is given by the following formula:

$$propagation\ delay = \frac{pl}{fr \times 360°} = \frac{-0.04°}{50Hz \times 360°} = -2.22\mu s$$

Now for this example it is necessary to add the "**Amplitude factor phase x**", from the Nameplate of **KEVA 24 C2** it is possible to calculate this value using this formula:

$$Amplitude\ factor\ = \frac{1}{CF_U} = \frac{1}{0.9984} = 1.0016$$

Once the calculation was made, the Voltage Sensor data is:

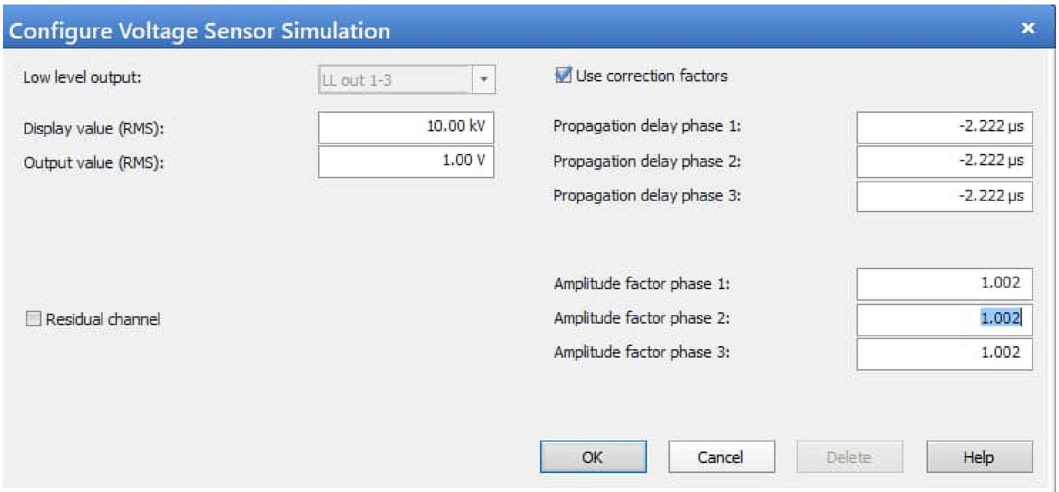


Figure 49. Final configuration for Voltage Sensor.

Once the **Voltage Sensor** has been added, the **Current Sensor** also needs to be added.

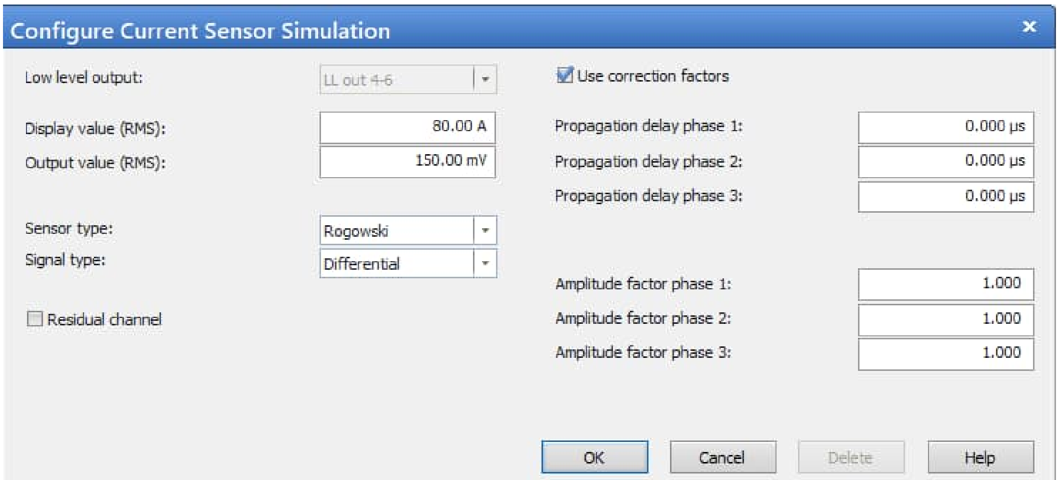


Figure 50. Current sensor menu.

For KECA 80 the angle correction is +0.0030°, then for a frequency of 50 Hz the Propagation delay is given by the following formula:

$$propagation\ delay = \frac{pl}{fr \times 360°} = \frac{+0.0030°}{50Hz \times 360°} = 0.17\mu s$$

Now for this example it is necessary to add the "**Amplitude factor phase x**", from the Nameplate of KECA 80 it is possible to calculate this value using this formula:

$$Amplitude\ factor\ = \frac{1}{CF_I} = \frac{1}{1.0020} = 0.9980$$

Once the calculation was made, the Current Sensor data is:

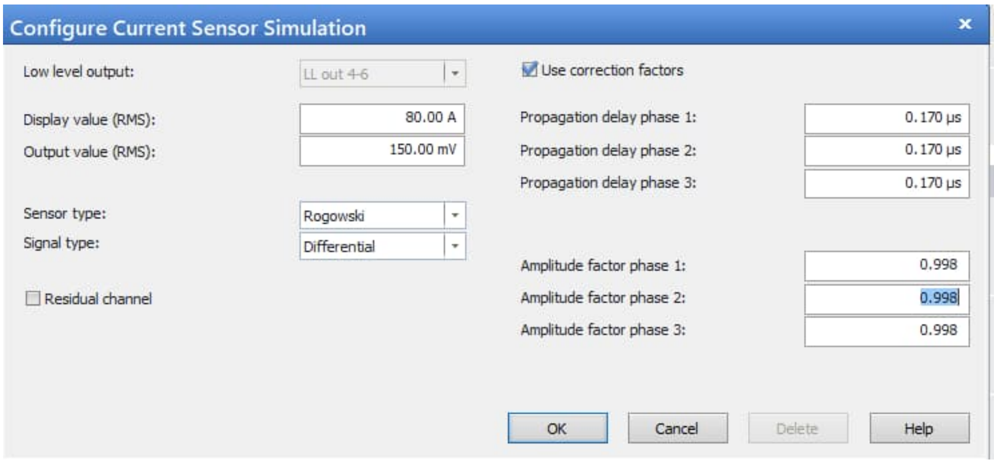


Figure 51. Configure Current Sensor including correction factors.

Afterwards, the Protection test can now be configured and performed.

1.5.3 Case 3. Using Zelisko LPITs

In this third case, the DIGSI option to download the LPIT information database will be used, for a step-by-step please review the DIGSI manual "**DIGSI5_Onlinehelp_en**", section "**Low-Power Instrument Transformer (LPIT) Universal Non-Modular Device (7SY82)**".

The reference of LPITs used in this case would be the following:

- Current Measurement: LPIT Type, Iron core coil, reference **SMCS/T – JW1001**
- Voltage Measurement: LPIT Type, R divider, reference **SMVS – UW1001**

With the above information, it is possible to configure the IO141 module in DIGSI:

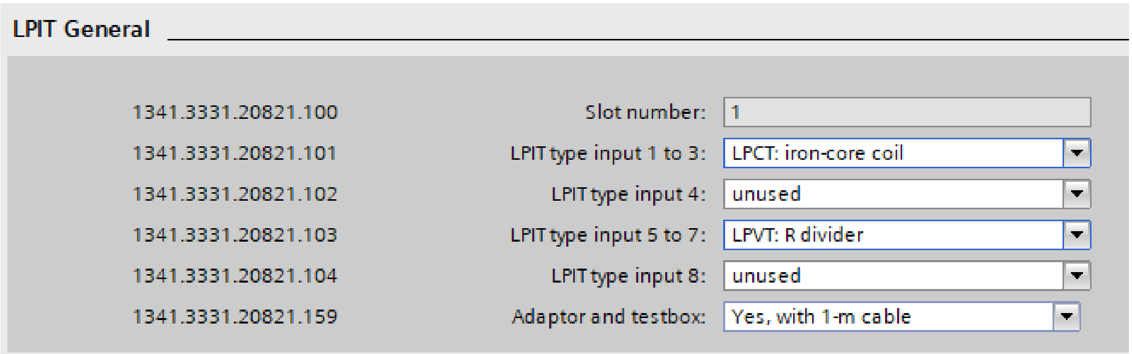


Figure 52. General data according to Zelisko technology.

Click on the indicated icon to download the updated database (JSON file).

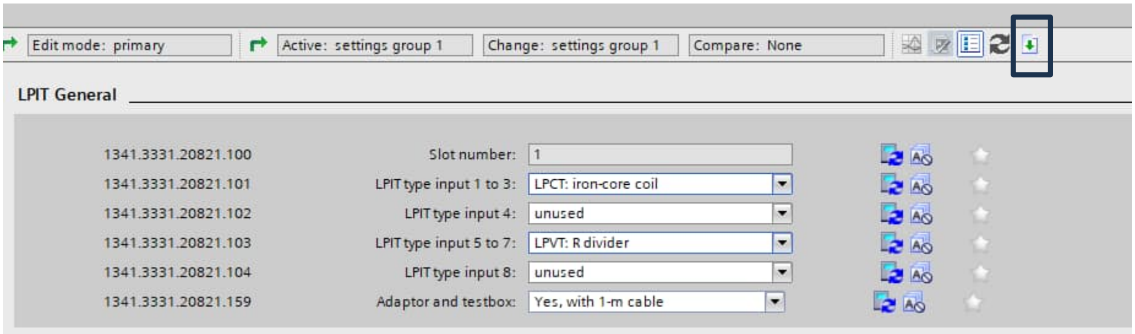


Figure 53. Icon for updated database download.

Once the above icon is selected, the menu in Figure 53 will be displayed. At this point the user will have to choose the vendor and the year of manufacture as appropriate.

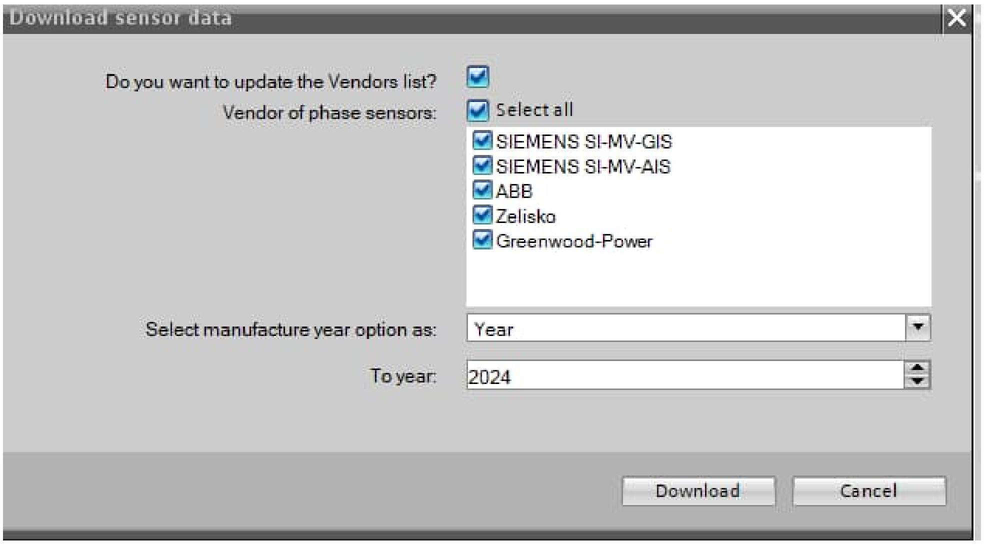


Figure 54. Download sensor data menu.

Once the download has been successful, the following message will be displayed by **DIGSI**.

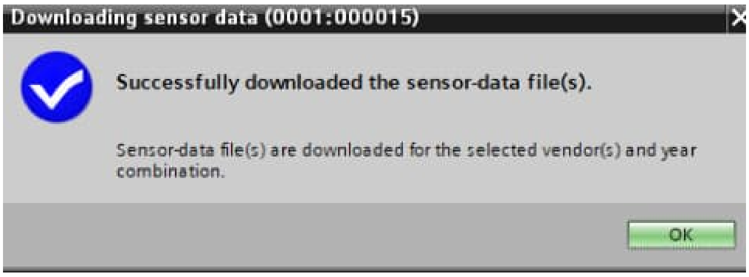


Figure 55. Successful database download.

Now that the database has been downloaded, the next step is to adjust the LPITs according to the selected vendor reference.

R divider 3ph1

Channel information			
1341.3331.23281.100	Input channel:	Input 5 to 7	
Vendor data			
1341.3331.23281.101	Vendor of phase LPITs:	Zelisko	
1341.3331.23281.162	Sensor type:	SMVS - UW1001	
Sensor data			
1341.3331.23281.103	Rated primary voltage:	24.0	kV
1341.3331.23281.104	Rated secondary voltage:	3.25	V
1341.3331.23281.111	Rated phase offset:	0.00	°
1341.3331.23281.112	Nominal burden:	200 kΩ, 350 pF	
1341.3331.23281.105	Corr. factor for Kr phsA:	1.0000	
1341.3331.23281.106	Corr. factor for Kr phsB:	1.0000	
1341.3331.23281.107	Corr. factor for Kr phsC:	1.0000	
1341.3331.23281.108	Corr. angle phsA:	0.0	'
1341.3331.23281.109	Corr. angle phsB:	0.0	'
1341.3331.23281.110	Corr. angle phsC:	0.0	'

Figure 56. Voltage measurement data for LPIT.

Once selected, data such as correction factors, primary voltage, secondary voltage will be automatically recorded.

Now, same procedure for Iron Core data.

Iron coil 3ph1

Channel information			
1341.3331.23131.100	Input channel:	Input 1 to 3	
Vendor data			
1341.3331.23131.101	Vendor of phase LPITs:	Zelisko	
1341.3331.23131.162	Sensor type:	SMCS/T - JW1001	
Sensor data			
1341.3331.23131.103	Rated primary current:	80.0	A
1341.3331.23131.104	Rated secondary voltage:	150.00	mV
1341.3331.23131.111	Rated phase offset:	90.00	°
1341.3331.23131.105	Corr. factor for Kr phsA:	1.0000	
1341.3331.23131.106	Corr. factor for Kr phsB:	1.0000	
1341.3331.23131.107	Corr. factor for Kr phsC:	1.0000	
1341.3331.23131.108	Corr. angle phsA:	0.0	'
1341.3331.23131.109	Corr. angle phsB:	0.0	'
1341.3331.23131.110	Corr. angle phsC:	0.0	'

Figure 57. Zelisko LPIT Iron coil data.

As can be seen from **Figures 56** and **57**, both the **Kr** and **angle correction** factors have a value of 1,000 and 0.0 minutes respectively, therefore, at the time of configuring the test in Test Universe software it is not necessary to choose the option of using correction factors. Now simply record the ratio values for both types of sensors.

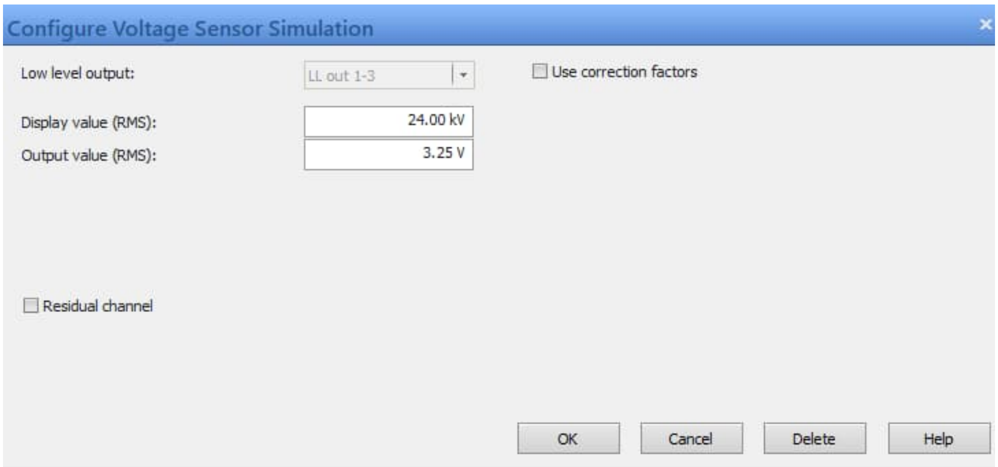


Figure 58. Voltage Sensor configuration.

In case of current sensor, take in count that the type of sensor is linear (Iron Core technology).

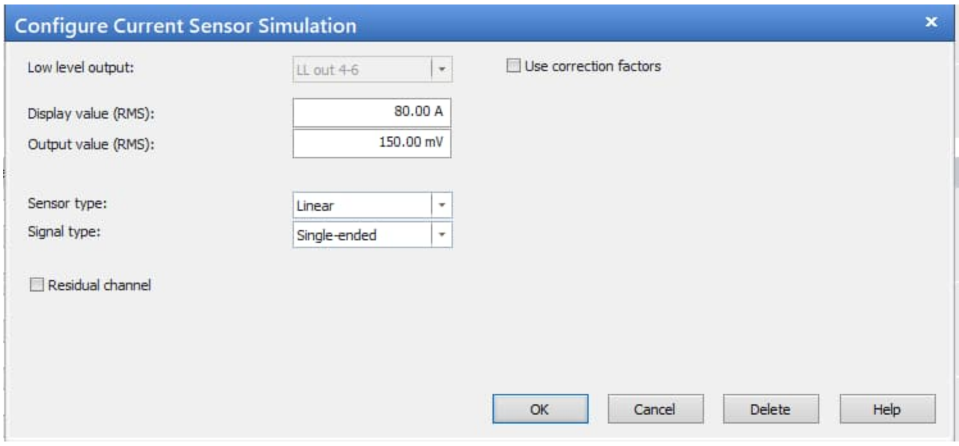


Figure 59. Current sensor configuration.

Now the tests can be developed following the conventional steps.

1.6 Tipps & Tricks

1.6.1 LPIT Checklist

This section provides a useful checklist to verify if the 3rd party **LPIT** vendor match with the **7SY82** protection device, please check all items and the Action/Conclusion described per each one. In some cases, with the answer, you can define if the solution requires an additional reviewing.

Criteria	Current measurement	Voltage measurement	Action/Conclusion
Sensor principle supported by **7SY82/ IO141**.	☐Rogowski coil ☐Iron Core	☐R divider ☐C divider	If no option was selected, the LPIT technology doesn't match with 7SY82 LPIT inputs.
Compatibility with standard	☐IEC 61869-10	☐IEC 61869-11	If no option was selected, please contact to your Siemens sales representative.
"Nominal secondary value", calculated using sensor transfer ratio and **Rated peak withstand current** of application, is fixed according with **IO141** module input range	Prot. channel: 0.9 mV to 50 · Vrated, LPCT Meas. channel: 0.9 mV to 1.6 · Vrated, LPCT ☐Yes ☐No	0.001 · Vrated, LPVT to 2.0 · Vrated, LPVT ☐Yes ☐No	If option "No" was selected, please contact to your Siemens sales representative.
Continuous voltage rating. The maximum voltage and current of the circuit, e.g. short circuit or overvoltage is adjusted to the continuous voltage rating of the 7SY82 input and LPIT ratio.	35 V	10 V	If option "No" was selected, please contact to your Siemens sales representative. Change the LPIT for one whose ratio is set to the maximum continuous voltage rating.
Rate burden	☐2 kΩ, 5000 pF ☐20 kΩ, 500 pF ☐200 kΩ, 350 pF ☐2 MΩ, 350 pf ☐2 MΩ, 50 pF ☐10 MΩ	☐2 kΩ, 5000 pF ☐20 kΩ, 500 pF ☐200 kΩ, 350 pF ☐2 MΩ, 350 pf ☐2 MΩ, 50 pF ☐10 MΩ	If no option was selected, the LPIT technology data doesn't match with 7SY82 LPIT inputs.
Connection cable pin according to standard	☐RJ45 pin 1-2	☐RJ45 pin 7-8	If no option was selected, you require to add a Test box to match with the standard pin-out. Please contact to your Siemens Sales Representative.

Cable shielding SF/FTP	☐Yes ☐No	☐Yes ☐No	If not, cable shielding is used, the solution requires extra test to check the accuracy, please contact to your SIEMENS Sales representative.
Cable length < 10 m according to **61869-13 Nr.13C.6**	☐Yes ☐No	☐Yes ☐No	If option "No" was selected, please contact the LPIT manufacturer.
Data available in Nameplate	☐Ratio ☐Corr. Factor Kr ☐Corr. angle	☐Ratio ☐Corr. Factor Kr ☐Corr. angle	If this information is not available, please contact the LPIT manufacturer.
For C divider, additional information		☐Temperature rating ☐Accuracy acc. Temp.	Additional data due to technology used(optional). If no additional information is available, please contact the LPIT manufacturer.
Combisensor	☐Yes ☐No		In case of "No" please continue to the next question.
If No combi sensor, just one measurement (Voltage or Current)	☐Yes ☐No		In case of "No" your solution requires a Test Box accessory. Please contact to your Siemens Sales representative.
If LPVT and LPCT, test box accessory is used?	☐Yes ☐No		In case of "No" your solution requires a Test Box accessory. Please contact to your Siemens Sales representative.
Test box data	☐Corr. Factor Kr ☐Corr. angle		If no additional information is available, please contact the Test Box manufacturer.

1.6.2 OMICRON Protection Testing Library

The OMICRON Test Universe software offers a library for the development of protection tests which can be applied by the test engineer. Figure 60 shows the menu where the user can open the test library for the **7SY82**.

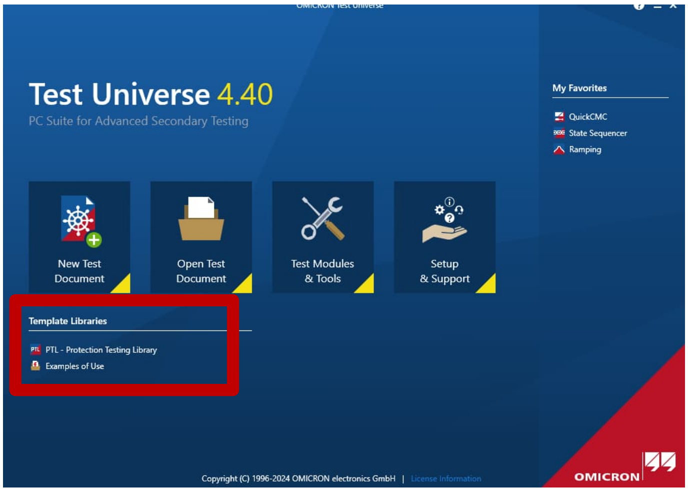


Figure 60. PTL – Protection Testing Library Menu.

Then, the following menu will appear, click on 7SY82 V9.600 Feeder Folder

Name	Date modified	Type	Size
7SL82 V9.50 Line	1/11/2024 3:10 PM	File folder	
7SL86 V9.50 Line	1/11/2024 3:10 PM	File folder	
7SX82 V9.50 Line	1/11/2024 3:10 PM	File folder	
[illegible]	1/11/2024 3:10 PM	File folder	
7SY82 V9.60 Feeder	4/17/2024 2:06 PM	File folder	

Figure 61. Siemens Protection Testing Library Menu.

Finally, in the 7SY82 folder the user will find the files developed for testing and the user manual. Open the corresponding files and adjust them according to the solution.

Name	Date modified	Type	Size
Siemens 7SY82 V9.60 Feeder ENU TU4.31 V1.000.occ	3/1/2024 1:43 PM	OMICRON Contro...	4,792 KB
Siemens 7SY82 V9.60 Feeder ENU TU4.31 V1.000.xrio	3/1/2024 1:43 PM	xrio_auto_file	1,551 KB
Siemens 7SY82 V9.60 Feeder PTT User Manual ENU.pdf	3/1/2024 1:43 PM	PDF Document	371 KB

Figure 62. 7SY82 V9.60 Feeder Folder.

1.7 References

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[8] Testing ABB relays with sensor inputs, Christian-Marcel Hintea, Jakob Siemayr, Oct 14, 2022

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1.8 Conclusion

With the development of new technologies such as those implemented in digital substations and in this specific case the use of non-conventional measurement requires that specialists in commissioning tests, engineering, among others, be trained and have more knowledge about the test techniques associated with this technology.

This application provides support to the personnel involved in the Universal relay 7SY82 protection testing, achieving a correct conversion of units and settings required by the **DIGSI** software and **OMICRON Test Universe**.

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