

SIEMENS



APN-090 IO240 and LPITs

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SIPROTEC 5 Application

Configuration Rules for Protection Systems with IO240 and LPITs

SIPROTEC 5 Application

APN-090 IO240 and LPITs

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1 Introduction

So-called Low Power Instrument Transformers (LPIT) are based on a new technology which differs from conventional instrument transformers. Accordingly, the low power signals are processed by a dedicated processing unit IO240, which has been developed to connect the GIS LPITs from Siemens Energy and which can be used like any other IO unit with the SIPROTEC 5 product family.

This document provides a summary of configuration rules applicable for this new type of substation protection and control systems with LPITs interfacing IO240 module in combination with SIPROTEC 5 protection functions.

The content and recommendations provided in this Application Note are based on the at its editing date latest available firmware version DDD V09.40 and DIGSI 5 version V09.40. With upcoming new releases and new features this document will be updated and revised versions released.

For IO240 please consult also the following manuals:

The IO240 description as part of the SIPROTEC 5 protection device manuals, e.g. chapter 5.6.11 in:

[SIPROTEC 5 7SA87, 7SD87, 7SL87 LineProt 1-/3-pol - Manual - ID: 109742440 - Industry Support Siemens](#)

Chapter 3.2.20 "Input and Output Module IO240" in the SIPROTEC 5 Hardware Manual:

[SIPROTEC 5 Hardware - Manual - ID: 109742193 - Industry Support Siemens](#)

Supplementary note on IO240 connection:

[SIPROTEC 5 IO240 Connections of GIS-LPIT Sensors – Supplementary Note - ID: 109801262 - Industry Support Siemens](#)

When using the IO240 in combination with 6MU85 to provide sampled measured values on the process bus please also refer to:

6MU85 inside the SIPROTEC 5 catalog in chapter 2.18:

[SIPROTEC 5 Catalog - ID: 109792143 - Industry Support Siemens](#)

6MU85 manual:

[SIPROTEC 5 6MU85 Merging Unit – Manual – ID: 109773599 - Industry Support Siemens](#)

Process bus manual:

[SIPROTEC 5 Process Bus – Manual – ID: 109742460 - Industry Support Siemens](#)

Especially the restrictions chapter at the end of the Process bus manual should be considered for systems with process bus. At the relevant passages of this document this chapter will be referred explicitly.

2 The Siemens Energy LPIT

2.1 Description

Siemens Energy LPITs are innovative voltage and current transformers providing a safe, reliable and standardized solution for measurement and protection applications in GIS. Without saturation nor ferro-resonance phenomena, the LPIT provides a digital output signal according to IEC 61850-9-2 or can be plugged directly into a Siemens SIPROTEC 5 device.

The LPIT combines a Low Power Voltage Transformer (LPVT) and a Low Power Current Transformer (LPCT) fully compliant to the IEC 61869 series of standards.

The measurement is based on Rogowski coils for current and capacitive voltage sensors. Both sensors are integrated in the same GIS cast resin partition.

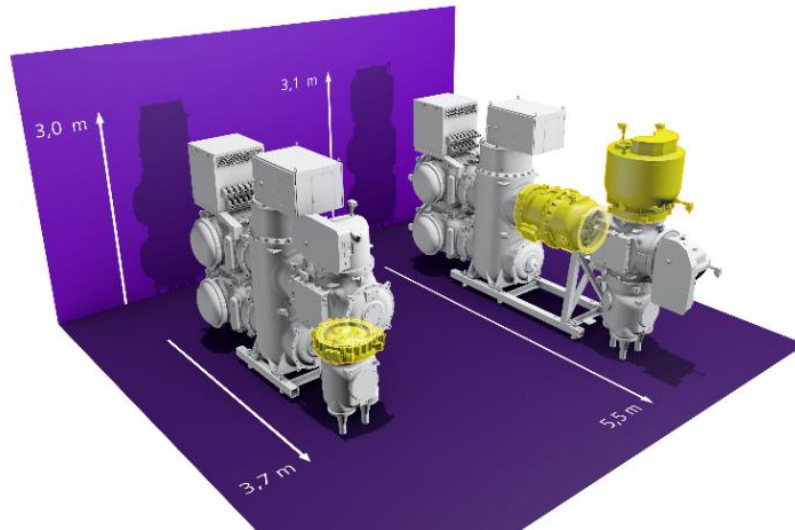


Figure 1: LPIT left and conventional CT/VT right as installed in a GIS switchgear

2.2 Benefits

- **Smaller size and weight of the GIS** due to smaller dimensions of the sensors and their integration into a GIS partition
- **Easy connection** and lower cabling and wiring effort
- **High reliability and long lifetime expectancy** due to the robust design of the sensors in the cast resin
- **Less insulation gas** in the switchgear
- Excellent overvoltage performance - **no need for disconnection** during GIS or HV cable tests
- **No hazardous overvoltage** at open terminals
- **A single LPIT covers all** protection and metering requirements and thanks to its linearity also a wide range of primary currents and voltages, simplifying stock management, engineering and logistics.
- **Flexible definition and modification** of the settings for rated primary current and voltage in SIPROTEC 5 at any phase of the project and afterwards. In this way the GIS remains flexible for future increases of nominal current.

Furthermore, the LPIT sensors provide improved measurement performance due to high linearity, no saturation (unlike conventional CTs), no ferro-resonance effects (unlike conventional VT) and a wide frequency range for measuring harmonics up to the 50th harmonic frequency.

2.3 The LPIT scope of supply

There are three different options:

1. *The digital substation approach - "LPIT with digital interface"*

Siemens Energy delivers a GIS with the LPIT partition and a tested 6MU85 Merging Unit wired and installed inside the local control cubicle of the GIS (LCC). The 6MU85 provides a output interface according to IEC 61850-9-2 and IEC 61869-6. The parametrization of the Merging Unit can either be done by Siemens Energy or the PACS (Protection And Control System) supplier. This approach gives you maximum flexibility in the choice of suppliers for the different functions and applications.

There are two standard versions of the 6MU85 which can be delivered together with the LPIT:

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- without display (product code P1M35617)
- with small display (product code P1M35732)

A detailed technical description of both devices can be obtained by entering above product code into the SIPROTEC 5 configurator: <https://new.siemens.com/global/en/products/energy/energy-automation-and-smart-grid/protection-relays-and-control/siprotec-5.html> (Web search for 'siprotec 5 configurator' => SIPROTEC 5 | Protection relays for digital substation | Siemens Global). The 6MU85 may also be extended with additional IOs so that all input and output signals of the GIS are collected, and the GIS bay can be connected to the PACS only via optical fibers (the "*Digital bay*").

2. *The conventional split - "analog interface"*

Siemens Energy delivers a GIS with the LPIT partition built in. The secondary device (i.e. a 6MU85 Merging Unit or another SIPROTEC 5 device with an IO240 module) to which the LPIT partition is connected is ordered directly from Siemens AG. This is similar to the common practice for conventional instrument transformers and allows you to build a highly integrated protection system. The LPIT comes with a commissioning report, which includes all information to parametrize the IO240 correctly.

3. *Turn-key*

Siemens Energy delivers both the GIS with the LPIT partition and the PACS or part of it as a package - for example, highly integrated SIPROTEC 5 devices (control, protection, MU) installed inside the GIS LCC. No need for a protection room anymore!

2.4 Division of work between primary and secondary

The scope of supply has also an impact on the division of work between secondary engineering/commissioning and primary engineering/commissioning:

Scope of supply option	Siemen Energy / GIS Commissioning Engineer (GIS CE)	PACS supplier/ Secondary test engineer (STE)
Option 1a "Including MU"	<ul style="list-style-type: none"> Siemens Energy delivers a Merging Unit installed inside the LCC and performs the LPIT commission test with a temporary parametrization 	<ul style="list-style-type: none"> Final parametrization of the Merging Unit using the LPIT commission report provided by the GIS CE as described in this document PACS commissioning test using SMV injection (or analog secondary injection)
Option 1b "Including MU and final configuration"	<ul style="list-style-type: none"> Siemens Energy delivers a parametrized Merging Unit with IEC 61850 output Exchange of SCD files LPIT test as above 	<ul style="list-style-type: none"> Exchange of SCD files PACS commissioning test using SMV injection (or analog secondary injection). As PAC supplier/STE you may skip this and the following chapter and continue reading with chapter 4.
Option 2: "Conventional Split"	<ul style="list-style-type: none"> Wires the LPIT up to a test block or provides a cable of sufficient length to the protection cabinet. Checks the LPIT accuracy with primary injection using an Omicron CPC100 and a temporary merging unit or the final SIPROTEC 5 device provided by the PACS supplier 	<ul style="list-style-type: none"> Installs and checks the correct wiring from test block to SIPROTEC 5 or connects the cable provided by Siemens Energy to the IO240. IMPORTANT: The correct cable type must be used! Cable assembly instructions can be found in chapter 12. Install the SIPROTEC5 devices with IO240 preferably in time to be ready for the LPIT commissioning test. For this purpose the device must have a BD module and a parametrization with MU function enabled and an IEC 61850-9-2 LE process bus configuration to communicate with an Omicron CPC100 (200FP). Final parametrization of the Merging Unit using the LPIT commission report by the GIS CE as described in this document. PACS commissioning test using analog injection into the test block
Option 3: "Turn-key"	<ul style="list-style-type: none"> Siemens Energy arranges the division of work internally 	

2.5 The Two LPIT Channels

For redundancy purposes the LPIT is equipped with two sets of sensors: the first set of sensors provides its measurement through Channel 1 (CH1) and the second through Channel 2 (CH2).

The two Channels are connected to two different IED / Merging Units having each one a IO240 module.

Furthermore, for current measurement with IO240 the configuration tool DIGSI 5 offers two measuring options: one for protection applications called LP-PT and one for measuring applications called LP-MS. This is just as if you had two

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different CT cores. For more details see chapter '3.4 Measuring Point routing and settings'. The voltage measurement is called LP-VT.

Typically, the LPIT measurements are used as follows:

LPIT measurement	Used for application
Channel 1 (LP-VT and LP-PT)	Main 1 protection, Bus bar protection, Fault recorder
Channel 1 (LP-VT and LP-MS)	Control, measurement and metering applications, Power quality
Channel 2 (LP-PT)	Main 2 protection, 2 nd bus bar protection
Channel 2 (LP-MS)	

The three phase LPIT-145 (8DN8), LPIT-145 (8VN1) and LPIT-170 (8DN8) have only current sensors in Channel 2.

How to deal with this:

- Chose a differential or overcurrent protection relay as Main 2 protection, which does not require voltage signals
- or take the voltage measurements from the bus bar LPIT
- or install a second LPIT

2.6 LPIT Parameters

For each sensor set an individual parameter set is generated by Siemens Energy during production and marked with the LPIT Production ID and Channel Number: one parameter set for the sensor set of Channel 1 and a second parameter set for the sensor set of Channel 2. The parameter set data is uploaded by Siemens Energy into the Siemens cloud database in JSON file format from where it can be downloaded via DIGSI 5. In special cases the JSON file can also be provided by Siemens Energy upon request. Hence the correct parameter set can always clearly be assigned by the Production ID of the LPIT and the Channel Number.

The Production ID can be found on the LPIT partition rating plate or in the Siemens-Energy Commissioning Test Report.

2.7 LPIT Commissioning Test

The LPIT commissioning test is done by Siemens Energy using primary injection. If available, the customer's SIPROTEC 5 device with IO240 is used for the test. The SIPROTEC 5 device must have a ETH-BD-2FO module, the MU function enabled and the IEC 61850-9-2 LE process bus interface configured to communicate with an Omicron CPC100.

Otherwise, the commissioning engineer uses a temporary Merging Unit.

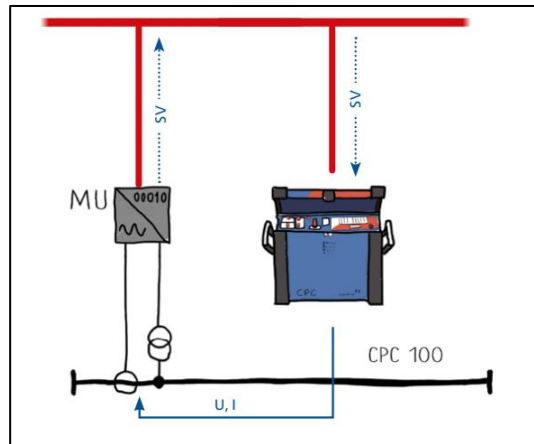


Figure 2: Example primary injection test set-up using an Omnicron device

The commissioning engineer provides a commissioning test report with all data required to parametrize the IO240 correctly. In case of any troubles entering the correct LPIT data please contact the Siemens Energy GIS Know-How Center (khc.berlin.energy@siemens-energy.com)

High Voltage Switchgear Type 8D . . 72,5 kV and above Low-Power Instrumental Transformer

Hochspannungsschaltanlagen 8D . . ab 72,5 kV Kleinsignalwandler

Test report / Prüfprotokoll		TR 3012			SE GP T SP 07/2022		
Customer: Kunde:	Sample Customer	Contract No.: Vertragsnr.:	12341234				
Consultant: Berater:	-	Bay/Feeder: Abzweig:	3				
Substation: Anlage:	Big Valley substation	Serial No.: Fabrik-Nr.:	LP00432				
Switchgear type: Schaltanlagenotyp:	8VN1	Rated voltage: Bemessungsspannung:	132 kV				
LPIT: LPIT:	LPIT-145 (8VN1)	in direction in Richtung	Reference designation: Betriebsmittelkennzeichen:				
Serial-No.: Fabrik-Nr.:	LP00432	Installed acc .to HZ / SLD Installiert gemäß HZ / SLD	<input checked="" type="checkbox"/>				
		Channel 1	Channel 2				
		Pol I	Pol II	Pol III	Pol I	Pol II	Pol III
LPIT Production ID		LP00432CH1			LP00432CH2		
Phase Assignment GIS Phasenzurdnung GIS		B	C	A	B	C	A
Cable length Kabellänge		10 m	10 m	10 m	10 m	10 m	10 m
Insulation test of cable Isolationsmessung des Kabels		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Cable screen earthed acc. to device drawing Schirmbehandlung gem Geräteplänen		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Temperature LPIT Temperatur		22,1 °C	22,0 °C	22,1 °C	22,1 °C	22,2 °C	22,1 °C
Ambient temperature Umgebungstemperatur		19,8 °C			19,8 °C		

Figure 3: Commissioning Report filled with test results

2.8 LPIT Connection to IO240

Depending on the scope of supply agreed with Siemens Energy you may have to do some wiring, please refer to section '12 Cable Assembly and Hardware connection'.

2.9 Maintenance and Replacements

The LPIT partition and the IO240 are maintenance-free. In case an IO240 module fails, it can be replaced without an impact on the accuracy class of the LPIT. In case the accuracy shall be verified nevertheless this can be done via primary injection when the bay is deenergized (see chapter '2.7 LPIT Commissioning Test'). A plausibility check can be done by comparing the different voltage measurements within one substation.

The self-supervision functions of the IO240 are described in chapter '10 IO240 Supervision Functions'.

3 IO240 Configuration in DIGSI 5

This chapter describes the LPIT specific configuration tasks in the configuration tool DIGSI 5, which to be done for a Merging Unit or an IED that is interfaced to a LPIT. It highlights the differences to a conventional MU or IED, which is interfaced to a conventional Instrument Transformer.

Starting point of this section is a DIGSI 5 project containing a MU/IED with the specific MLFB containing a IO240 module that interfaces the LPIT hard-wired with a LPIT as per previous section. It is expected that the reader has basic skills in DIGSI 5 and is able to create a DIGSI 5 project containing such a MU/IED device.

You have to do the configuration as described in this chapter only if you've purchased LPIT partition and IO240 separately. If Siemens-Energy delivers a Merging Unit installed inside the GIS local control cubicle, the IO240 configuration is done by Siemens-Energy.

3.1 IO240 Firmware

It is generally recommended to use the most recent IO240 firmware available in the Siemens SIOS portal. The IO240 firmware is always contained in an IED or Merging Unit firmware package (so called DIGSI Device Driver DDD). When loading the specific IED or Merging Unit firmware version on a device automatically also the same version of IO240 firmware will be loaded implicitly.

Ordinary firmware updates or DIGSI software updates have no impact on the overall measurement accuracy of the LPIT; it is the same principle as it applies for conventional instrument transformer connected to a SIPROTEC 5 board like IO202, also here firmware upgrades have no impact on the overall measurement accuracy.

ATTENTION:

- In the extraordinary case that special measures have to be taken due to a firmware update, the release note is marked with the following words:
"IO240: ATTENTION please contact Siemens Energy before upgrading to this release".
- Before upgrading old firmware versions below V8.83, please also consult Siemens Energy (khc.berlin.energy@siemens-energy.com).

3.2 LPIT Hardware Parameters

The principle of IO240 LPIT configuration in DIGSI 5 is shown in the figure below. Provided that the Laptop / PC on which DIGSI 5 is running is connected to the internet, the LPIT parameters are automatically loaded from the cloud when the LPIT Production ID (serial number) is entered.

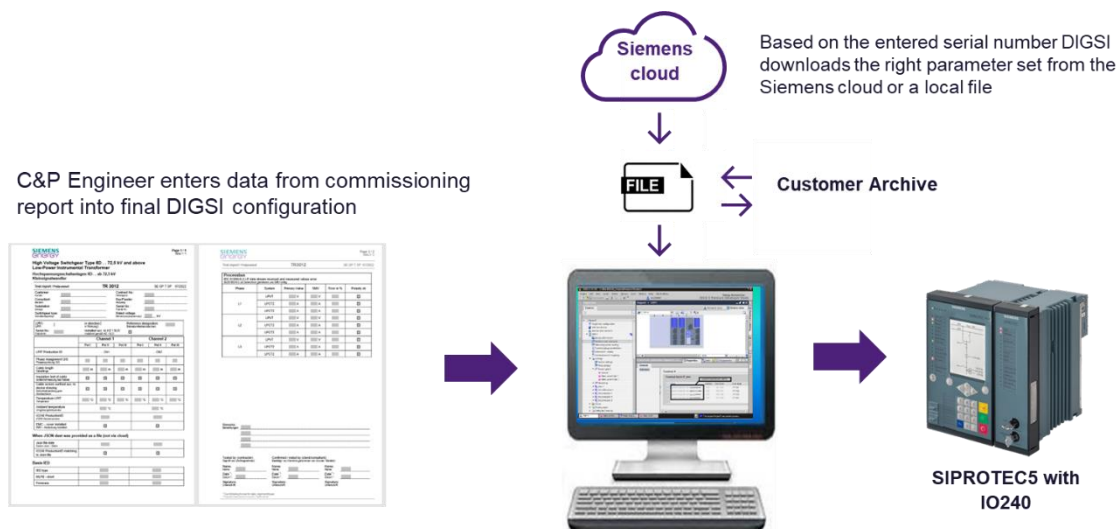


Figure 4: IO240 parametrization overview

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You can find the Production ID in the commissioning report, which to be provided by the test engineer who did the LPIT commissioning test (refer to '2.7 LPIT Commissioning Test'). In case of any troubles entering the correct LPIT data please contact the Siemens Energy GIS Know-How Center (khc.berlin.energy@siemens-energy.com)

The parameter file is downloaded from the cloud and named NCITSensorSettings.json. It is stored in the directory 'C:\ProgramData\Siemens Energy\DIGSI 5\Data' (DIGSI 5 ≤ V9.70) / 'C:\ProgramData\SIEMENS\DIGSI 5\Data' (DIGSI 5 ≥ V9.80) as per following principle, refer to figure below:

- For DIGSI V9.30 and older version in directory "..\Data"
- DIGSI Version V9.40 and later in a subdirectory of "..\Data\NCIT-IO240 Sensors Settings" path

You may make a back-up copy of this file and store it in your company archive.

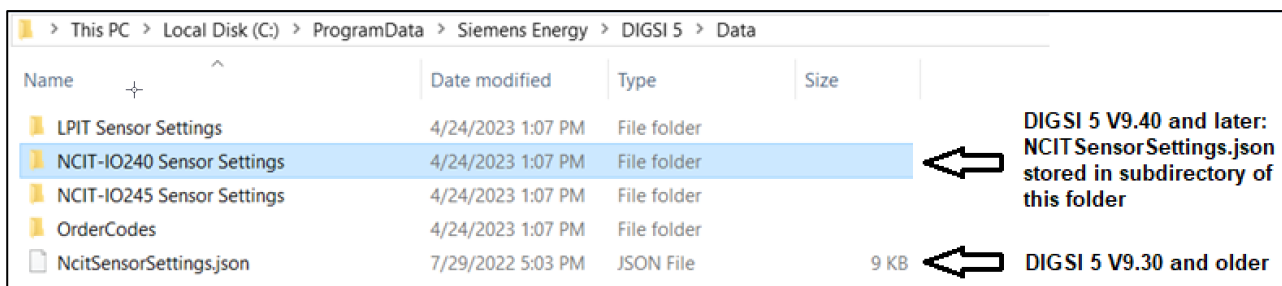


Figure 5: Folders, in which the NCITSensorSettings.json are stored – applicable for installation of DIGSI 5 ≤ V9.70)

Note:

You have to enable in your Windows explorer the setting "Show hidden elements" to make the folder 'C:\ProgramData\Siemens Energy\DIGSI 5\Data' (DIGSI 5 ≤ V9.70) / 'C:\ProgramData\SIEMENS\DIGSI 5\Data' (DIGSI 5 ≥ V9.80) visible.

The above-described principle works automatically, if the DIGSI PC has internet access. The parameter file is available independently from the DIGSI 5 version and can be updated any time. To update the local copy of the parameter file, you can click the refresh button on the IO240 configuration page in DIGSI. The feedback of a successful or unsuccessful update of the parameter file is given in the Info tab. When you enter a Production ID which cannot be found you will also be asked whether the LPIT parameter file shall be updated. Make sure that you have an internet connection when you try to download from the cloud.

Note:

In case the configuration PC, on which DIGSI 5 is installed, does not have internet access the above shown file structure can be updated manually by copy & replace of the existing files of the default installation.

Dummy LPIT Productions IDs for trial and testing

In the NCITSensorSettings.json file (refer to 'Figure 5: Folders, in which the NCITSensorSettings.json are stored') contain the following Production IDs for trial and test purpose, which are always available, also offline:

Production ID LPIT Type

20190101	for a single phase LPIT channel with current and voltage measurement
20190104	for a three phase LPIT channel with current and voltage measurement
20190108	for a three phase LPIT channel with current measurement only

You can verify the correct download of the LPIT parameters into the SIPROTEC5 device via the WebUI or the display. Check that the correct LPIT Production ID is shown there.

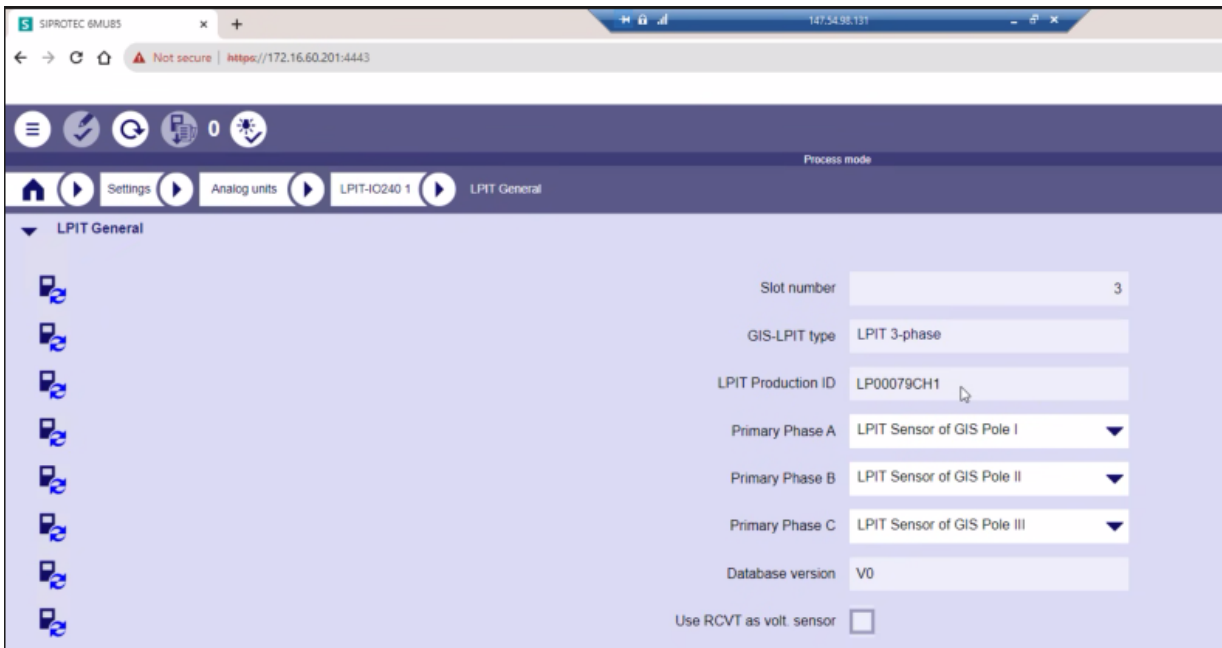


Figure 6: LPIT settings in the SIPROTEC5 Web UI

3.3 The IO240 configuration steps in DIGSI 5 in detail

Access to the DIGSI 5 configuration page, in which the Production ID has to be entered, is shown next.

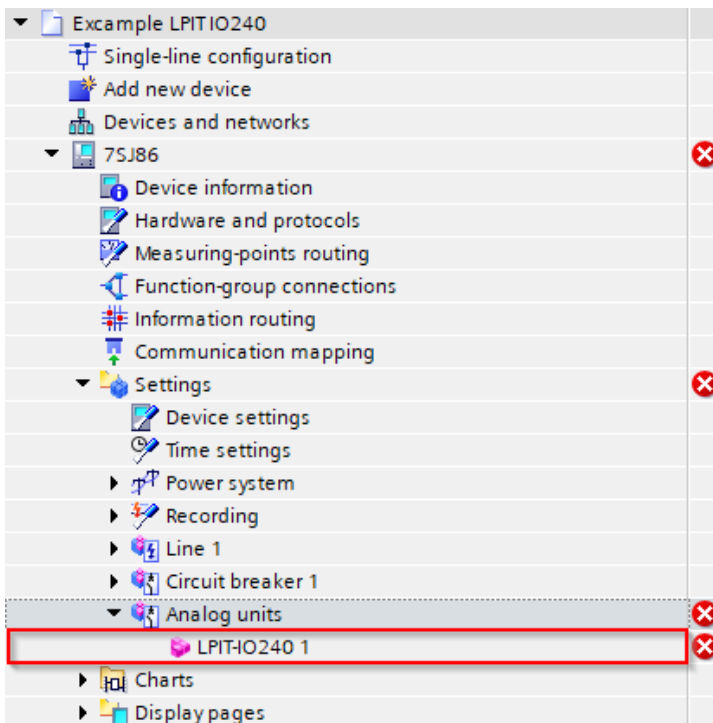
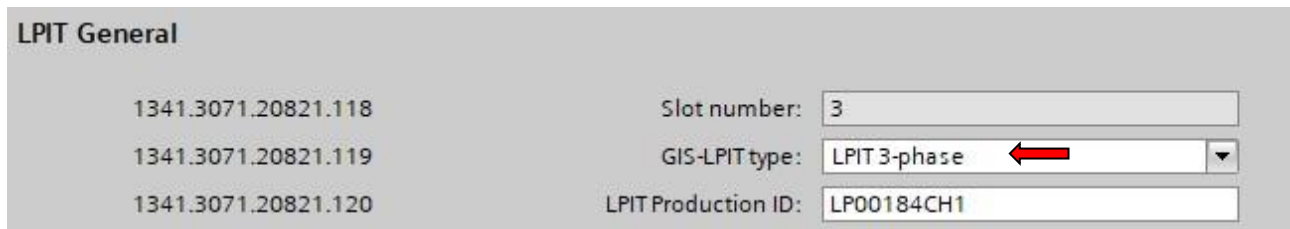


Figure 7: Access to the IO240 configuration window in DIGSI 5

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Before entering the LPIT Production ID you have to select the right 'GIS-LPIT type':



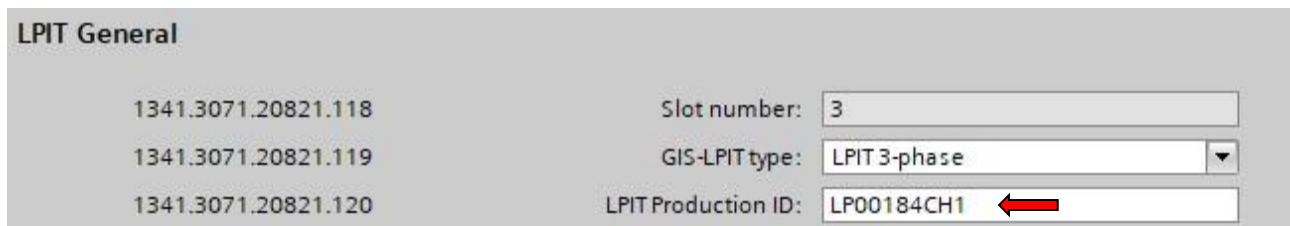
The screenshot shows the 'LPIT General' configuration form. On the left, there are three rows of IP addresses: 1341.3071.20821.118, 1341.3071.20821.119, and 1341.3071.20821.120. On the right, there are three input fields: 'Slot number' with the value '3', 'GIS-LPIT type' with a dropdown menu showing 'LPIT 3-phase' (indicated by a red arrow), and 'LPIT Production ID' with the value 'LP00184CH1'.

Figure 8: Selection of the LPIT type

The following types are available:

LPIT Type	GIS type	Description
LPIT 3-phase	8DN8-5, 8DN8-6, 8VN1 for Channel1	for a three phase LPIT channel with current and voltage measurement
3-phase without LPVT	8DN8-5, 8DN8-6, 8VN1 for Channel2	for a three phase LPIT channel with current measurement only
LPIT 1-phase	8DQ1-6, both channels	for a single phase LPIT channel with current and voltage measurement

The next step is to input the LPIT Production-ID, which has to be taken from the commissioning report.



The screenshot shows the 'LPIT General' configuration form. On the left, there are three rows of IP addresses: 1341.3071.20821.118, 1341.3071.20821.119, and 1341.3071.20821.120. On the right, there are three input fields: 'Slot number' with the value '3', 'GIS-LPIT type' with a dropdown menu showing 'LPIT 3-phase', and 'LPIT Production ID' with the value 'LP00184CH1' (indicated by a red arrow).

Figure 9: Entry of the LPIT production ID

With entering the ProductionID the parameters of the LPIT partition are automatically downloaded from the cloud and loaded into DIGSI 5.

The parameters are LPIT pole-specific, whereas the connection to the IO240 is phase-specific.

This means for proper operation the pole-to-phase assignment must be parametrized correctly in DIGSI.

At site the phases are connected to clamps according to the standard rule:

- Terminal xA = L1
- Terminal xB = L2
- Terminal xC = L3

The proper pole-to-phase assignment is parametrized in DIGSI 5 using the parameters of the 'LPIT General' section, as shown below. You get the correct settings as part of the Siemens Energy Commissioning Test Report.

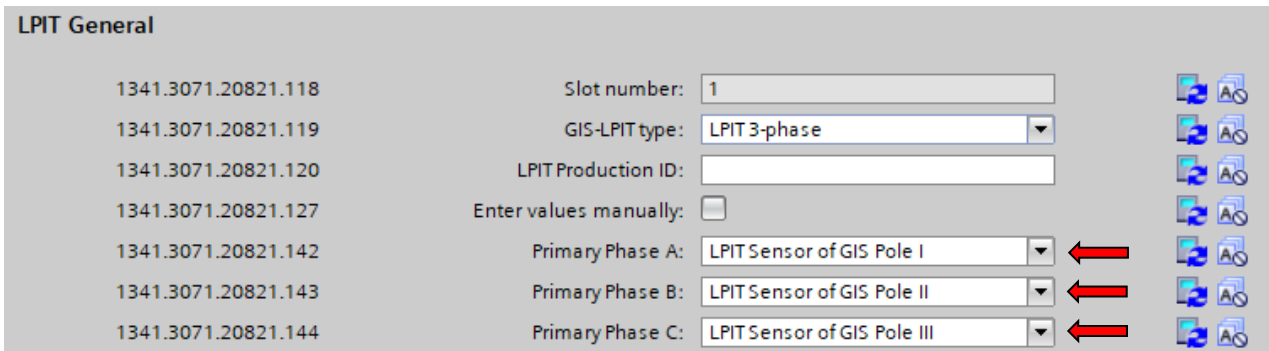


Figure 10: Pole to phase assignment (available in DIGSI V8.40 and later)

For correct polarity the installation direction of the LPIT is designated with P1 and P2 as usual. Correct polarity as well as correct LPIT pole to IO240 phase connector wiring is checked during commissioning test. Polarity can also be changed via configuration in the IO240.

Finally, the total length has to be entered correctly as per installation on site. It can also be taken from the Commissioning Test Report. If a terminal block is installed the length from terminal block to IO240 has to be added to the value in the Commissioning Test Report to get the total cable length.

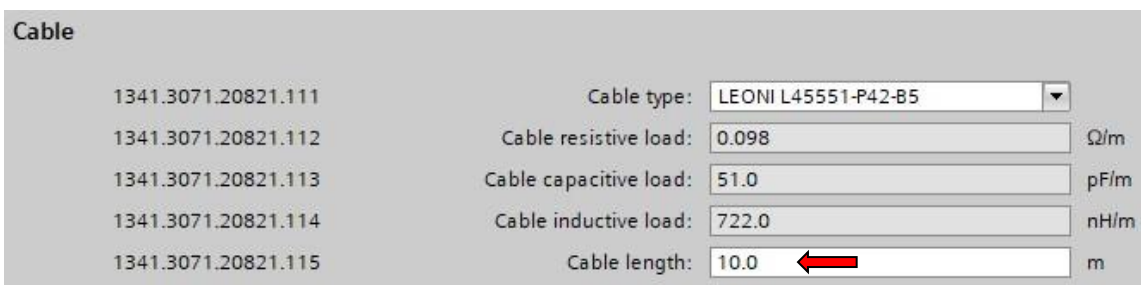


Figure 11: Entry of the cable length

3.4 Measuring Point routing and settings

The measuring point routing for the LPVT is the same as for conventional VTs. Like for conventional GIS VTs, there is no direct measurement of the neutral voltage. For the LPVT the summation of the phase voltage is done on the digital side, i.e. no neutral measuring point exists. Therefore DIGSI 5 allows only a "Connection type" without Neutral as shown below.

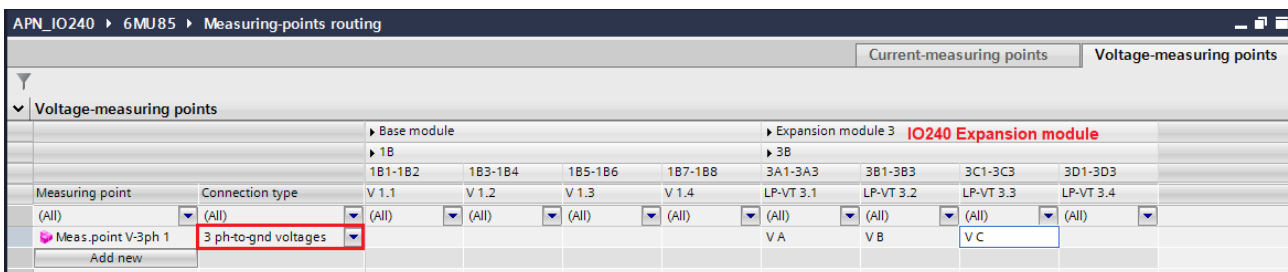


Figure 12: 'Measuring points routing' for voltages in DIGSI 5 (IO240 as expansion module)

For current measurement two measuring methods are available: the measuring method designated with 'LP-PT' for protection applications and the measuring method designated with 'LP-MS' for measuring applications of bay controllers, etc. The following figure shows an example of measuring point routing of current measurement originated from one LPIT, which is assigned to two measuring points: one for protection applications and one for measurement applications – just like two CT cores in the conventional world. You may use only one of them or both.

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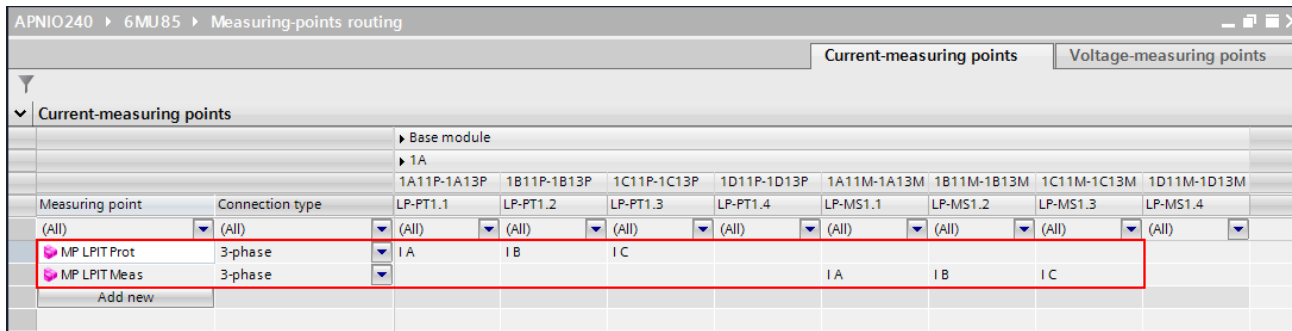


Figure 13: 'Measuring points routing' for currents in DIGSI 5 (integrated IO240)

Also, for currents the LPITs provides no measurement of the neutral current, hence DIGSI 5 allows only a "Connection type" without Neutral.

The difference of LP-PT and LP-MS is their resolution and range:

- LP-PT measures up to 100 x the rated primary current parametrized for LP-PT
- LP-MS measured up to 1.6 x the rated primary current parametrized for LP-MS

In case of short circuit current beyond 100 x of its parametrized rated primary current, for LP-PT the amplitude peaks will be clipped. Same happens for the measuring point LP-MS for currents above 1.6 x of its parametrized rated primary current.

The rated primary current I_{pr} on which the accuracy designation of the LPIT is built upon and which is 200A (see 'Table 1') must not be confused with the "Rated primary current" value to be entered in the "Rated primary current" input field of DIGSI as shown below 'Figure 14' for LP-MS and LP-PT in the power system settings menu.

The LPIT is type and routine tested for the whole possible current and voltage range of the GIS. The rated current is 200A and the so called extended rated primary current is equal to the maximum continuous thermal current of the GIS (3150A/4000A). In between the LPIT maintains the accuracy specified for rated current as defined by IEC 61869. The rated current you parametrize in DIGSI 5 for the IO240 is just the spot where you put the "magnifying glass".

So, the "Rated primary currents" parametrized for LP-PT and LP-MS shall be chosen according to the following rules:

- The rated primary current for LP-MS can be set to any value (DIGSI V8.40 and later) according to the needs of your application (see also Chapter 4.1).
- The rated primary current for the measuring point LP-PT should not be set too high, since this reduces the signal-to-noise ratio.
- The rated primary current for the measuring point LP-PT should not be set too low, since clipping may occur during a high current short circuit.

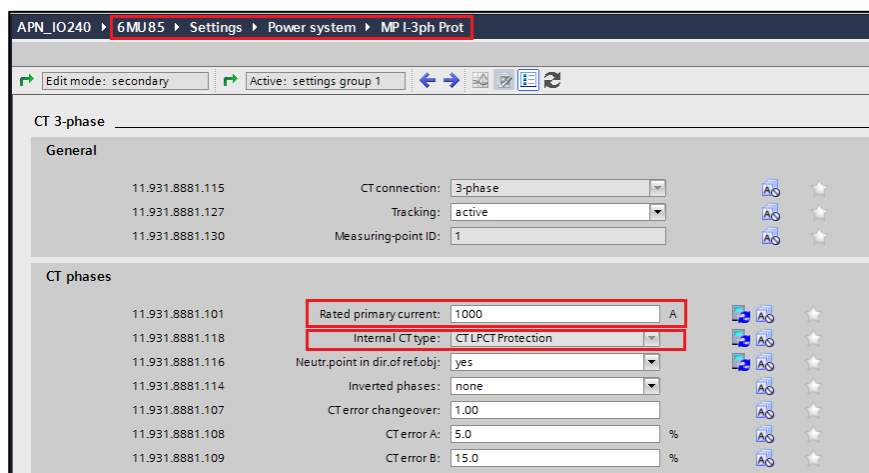


Figure 14: Rated primary current settings in DIGSI 5 of IO240

The screenshot below shows automatic setting in DIGSI 5 of the protection IED, which subscribes the measurements of the IO240 Merging Unit.

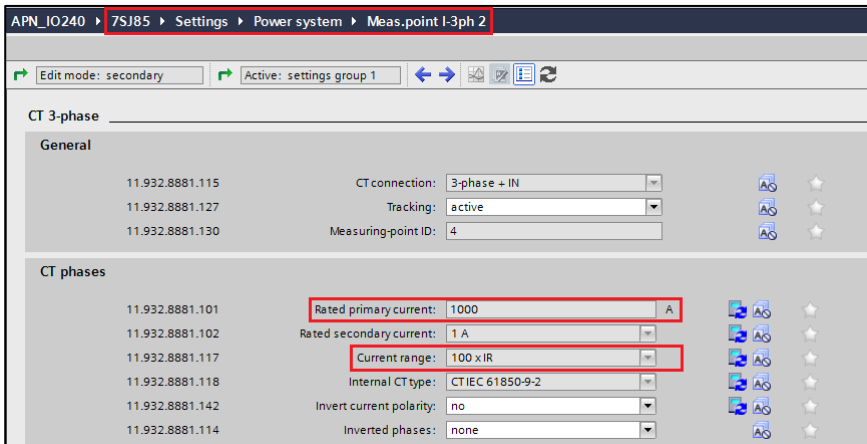
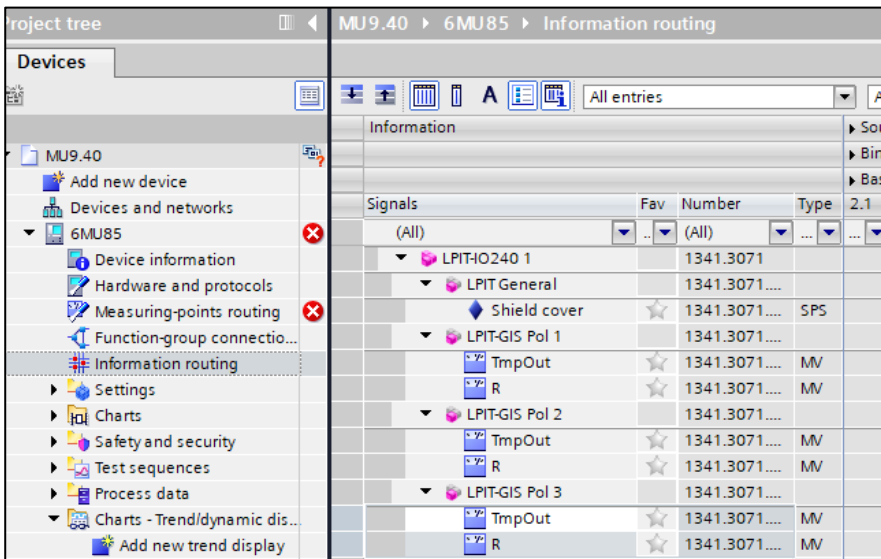


Figure 15: Rated primary current settings of subscriber (automatically set by DIGSI 5)

3.5 Temperature Measurement

The LPIT has temperature sensors integrated: one per phase and channel, which are connected to the IO240. The temperature measurements are available in DIGSI 5 in the "information routing" (see below screenshot) and can be used for monitoring the GIS condition, refer to 'Table 4' in section '10.1 Measuring Circuit Supervision Functions' on using this feature for broken wire detection.



4 Configuration rules for SIPROTEC 5 protection functions with LPIT

4.1 Siemens Energy LPIT technical data relevant for protection settings

Following table provides an overview on the technical data of the standard Siemens Energy LPITs.

	LPIT-145 (8DN8)	LPIT-145 (8VN1)	LPIT-170 (8DN8)
Rated primary current I_{pr}	200A	200A	200A

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Rated maximum continuous thermal current I_{cth}	3150A	3150A	4000A
Rated extended primary current $I_{epr} = K_{pcr} * I_{pr}$	I_{cth}	I_{cth}	I_{cth}
Rated short time thermal current I_{th}	50kA	50kA	63kA
Rated dynamic current I_{dyn}	$I_{th} * 2,7$	$I_{th} * 2,7$	$I_{th} * 2,7$
Rated accuracy limit primary current ALF * I_{pr}	I_{th}	I_{th}	I_{th}
Rated primary short circuit current for transient performance $I_{psc} = K_{ssc} * I_{pr}$	I_{th}	I_{th}	I_{th}
Specified primary time constant for transient performance T_p	100ms	100ms	100ms* (for 63kA/60Hz $T_p = 15ms$, higher T_p possible for smaller I_{psc} , please consult Siemens Energy)
Specified Duty Cycle	COCO	COCO	COCO
Rated accuracy class (current)	0,2S / 5P / 2TPM	0,2S / 5P / 2TPM	0,2S / 5P / 2TPM
Rated accuracy class (voltage)	0,2P	0,2P	0,2P

Table 1: Technical data of the Siemens Energy standard LPITs

Above details have following implications for the configuration of the SIPROTEC 5 functions:

1. The LPCT fulfills its accuracy specification (0.2) at rated current ($I_{pr} = 200A$) up to the extended rated primary current which is equal to the rated maximum continuous thermal current of the GIS (e.g. $I_{epr} = I_{cth} = 3150A$).
2. As rated current setting for the measuring channel in DIGSI any value in between 200A and the rated maximum continuous thermal current (refer to item 1.) can be chosen.
3. Protection accuracy classes are fulfilled between the rated maximum continuous thermal current I_{cth} and rated short time thermal current I_{th} (e.g. 3150A and 40kA).
4. The accuracy class for transient performance 2TPM as specified in IEC 61869-13 is equivalent to conventional TPZ but with a maximum instantaneous peak error of only 2% instead of 10%.

4.2 Recommended Sampling rates

In case the LPIT is interfaced to a Merging following sampling rates are recommended for protection applications:

- 4000 Hz / 1 ASDU - Protection, Measurement BCU (for compatibility with IEC61850-9-2 LE 50 Hz)
- 4800 Hz / 1 ASDU - Protection, Measurement BCU (for compatibility with IEC61850-9-2 LE 60 Hz)
- 4800 Hz / 2 ASDU - Protection, Measurement BCU (recommended by IEC61869-9)

Note:

SIPROTEC 5 acting as a subscriber interpolates one missing sample. In case a higher error tolerance is required Siemens recommends to use sampling rates with one ASDU; in case one SMV telegram is getting lost the one missing sample will not result in blocking of a protection function (contrary to using settings with 2 ASDUs).

4.3 3-phase Overvoltage protection (ANSI 59) in combination with Auto Reclosure (ANSI 79)

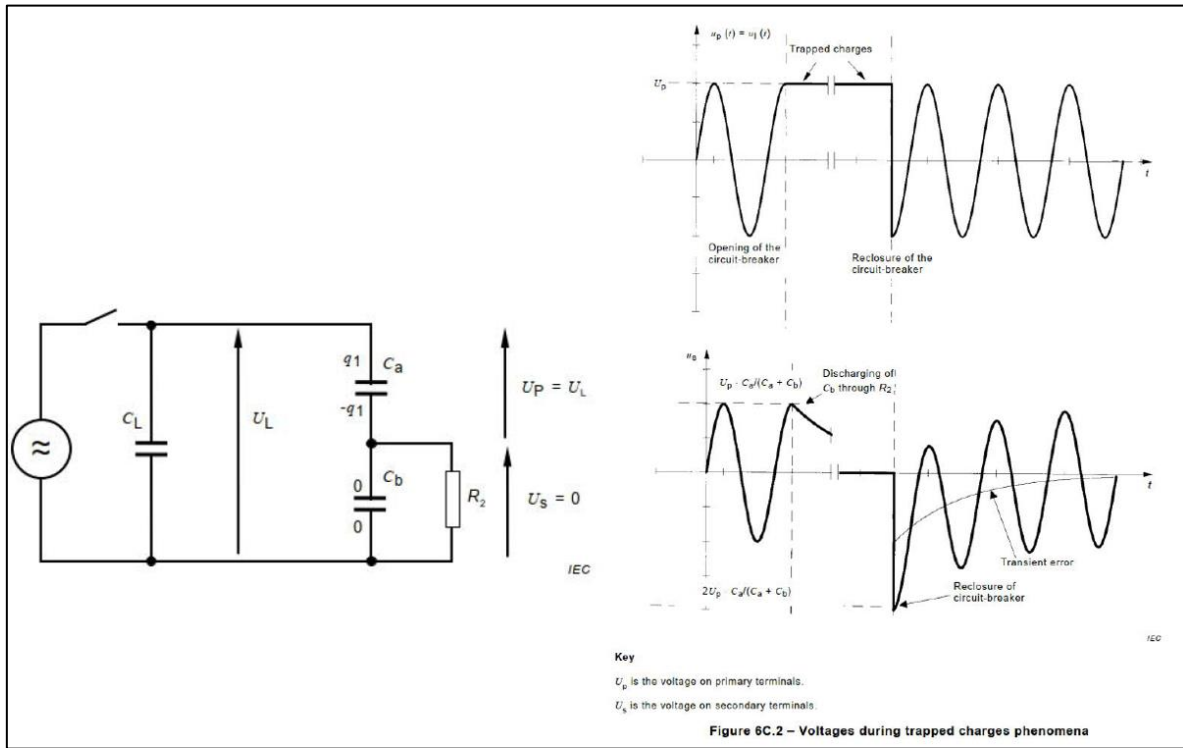


Figure 16: Extract from IEC 61869-6 standard, described trapped charges phenomena (from IEC 61869-6, figure 6C.2)

Voltage measurement in the LPIT is based on the well-known principle of a capacitive voltage divider as it is used in conventional CVTs. In case of a switch-off a DC offset may occur, as shown in figure above, which has an impact on the auto-reclosing function.

Due to this so-called trapped charges phenomenon, it is recommended to use always the setting 'fundamental comp' as 'Method of Measurement' for the 3-phase overvoltage protection function.

Following general rules must be considered:

- With overvoltage threshold setting $\leq 5\%$ of the rated voltage (when secondary rated voltage is 100 V, overvoltage setting ≤ 105 V), then the stabilization counter to be set to 1
- With overvoltage threshold setting $\leq 2\%$ of the rated voltage (when secondary rated voltage is 100 V, overvoltage setting ≤ 105 V), then the stabilization counter to be set to 2 (very sensitive settings, hence extremely unlikely)

Following rules are recommended when 'Negative-Sequence Voltage' principle is used:

- Only 'fundamental comp' as 'Method of Measurement' is allowed
- Overvoltage threshold setting must be $> 7\%$ of the rated voltage

Following rules are recommended when 'Positive-Sequence Voltage' principle is used:

- Only 'fundamental comp' as 'Method of Measurement' is allowed
- Overvoltage threshold setting must be $\geq 2\%$ of the rated voltage

Attention:

It is recommended not to use 'RMS value' as 'Method of Measurement', because when this principle is used the DC

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components cause problems. In case 'RMS value' setting is used, then the overvoltage protection function must be blocked during a switching operation and for the time period of first second after switching operation!

4.4 Ground fault protection

For ground fault protection nothing needs to be considered in the protection settings when a LPIT is used, except for the special case of transient ground fault protection as described in next sub-section.

4.4.1 (Directional) Transient Ground Fault

Basically, the sampling rates

- 4000 Hz / 1 ASDU (IEC 61850-9-2 LE)
- 4800 Hz / 2 ASDU (IEC 61869-9)

are applicable for the Transient Ground Fault function.

All earth fault cases contained in the Siemens database (several hundred of field errors) have been tested successfully with a sampling rate of 4000 Hz. This means the reliability of the protection function was the same as for conventional schemes with CTs / VTs hardwired to the secondary interface of the protection IED with an internal sampling rate of 8000 Hz used for sampling of the conventional signals.

Siemens recommends following approach:

- In grids with a size >100 km – ring or radial topology (the size is calculated as sum of all lines that are galvanically connected) - the use of the protection function Transient Ground Fault is generally possible.
- In grids with a size <100 km the grid characteristics have to be evaluated in detail; in the most cases the use of the protection function Transient Ground Fault will be possible, but in exceptional cases higher SMV sampling rates have to be used.

For the evaluation of the grid characteristics the transient charging of the healthy phases has to be analyzed. The Transient Ground Fault function will be tested with simulation of the transient charging behavior under the specific power grid condition.

Note:

Recommendations given in this section are not related to LPITs and their signal characteristics. The observation results from sampling and resampling of the measurements for transmission via process bus. Hence an alternative option is to activate the Transient Ground Fault protection directly in the Merging Unit itself.

4.5 Distance protection

Siemens has tested in their test environment the distance protection function with LPIT signals as per IEC 60255-121. For achieving results in transient operation conditions additional test cases with switching the line on and off have been performed.

All tests have been successfully passed:

- Test result of switching the line on / off were without any findings or abnormalities.
- The test results had the same level as for conventional protection systems.
- Overreaching has been observed when zone settings have been configured very small (200 m Ω).
- No overreaching has been observed with zone settings > 1 Ω secondary.

Siemens recommends following approach:

- When the lines are very short, use of the signal comparison function (to be configured in Function Group '85-21 Perm.overr.')
- For auto reclosure function on a short circuit configure the auto reclosure zone (AR zone to be assigned in 'Circuit-breaker interaction' matrix)

4.6 7SS8x Busbar Differential Protection

In general, same settings as applicable for conventional current transformers can be used for protection systems containing only LPITs. There is no need to increase the stabilization factor k neither for the check zone nor for the selective zone above standard values.

As applicable for busbar protection systems with conventional current transformers, also for systems with bays partly interfacing LPITs and partly interfacing conventional CTs the current transformer requirements as specified in the busbar differential protection manual have to be fulfilled for the conventional CTs.

4.7 7UT8x Transformer Differential Protection

The 7UT8xx transformer protection device can be used with LPITs on both voltage levels or with LPIT on one voltage level and conventional current transformer on the second voltage level. All combinations have been tested successfully.

When on both voltage levels of the 7UT8xx transformer protection device LPITs are connected Siemens SI EA recommends following settings to adapt the protection functions to the measurement characteristics without saturation.

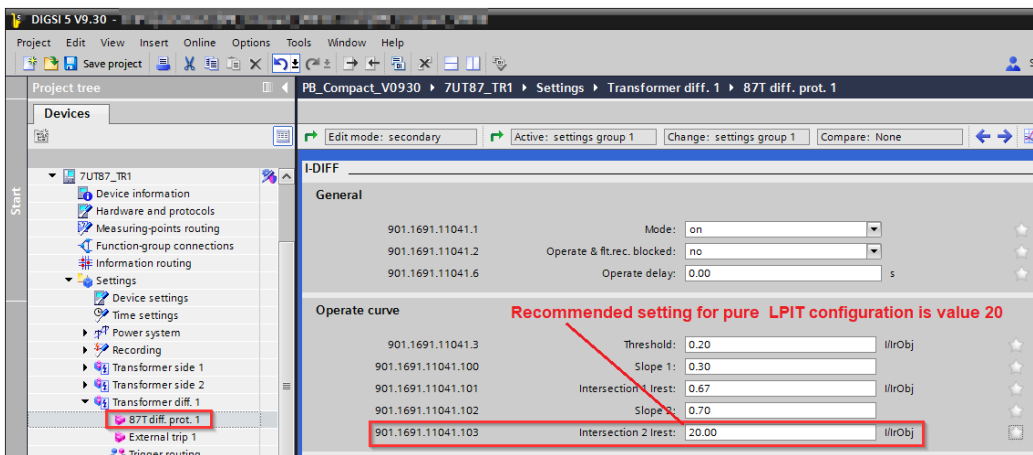
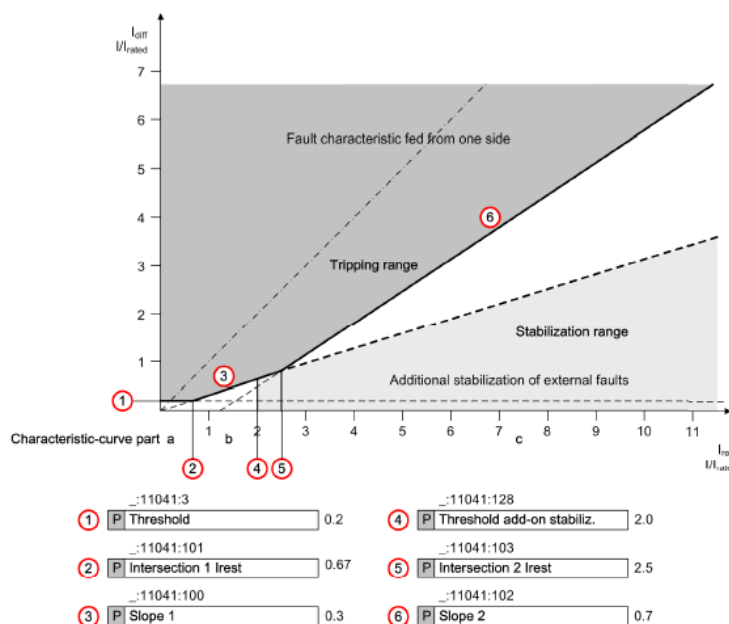


Figure 17: Setting of 'Intersection 2 rest' parameter when on both side LPITs are interfaced

The 'Intersection 2 rest' parameter of the Operate curve is recommended to be set to the maximum value '20.00'. The next two figures provide an overview on the technical background for this recommendation.



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Figure 18: Characteristic Curve with the Default Settings, from 'SIPROTEC 5 Transformer Differential Protection' manual

The setting of parameter 'Intersection 2 Irest' results from the saturation effects of conventional current transformer.

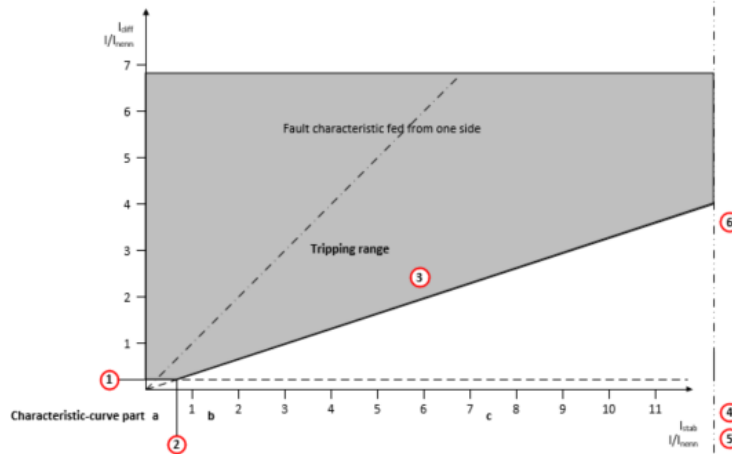


Figure 19: Recommended Characteristic Curve for LPITs without saturation.

The non-existence of saturation allows to shift the parameter 'Intersection 2 Irest' to its maximum value.

The parameter 'Factor increasing char. DC' in the 'DC offset detection' is recommended to be set to allowed minimum value '1.0'. In the 'Ext. fault detection' function the 'Threshold add-on stabiliz.' Parameter is recommended to be set to its allowed maximum value '20.00', the parameters 'Time of add-on stabiliz.' And 'Crossblk. Time add-on st.' to its allowed minimum values '0.00' seconds.

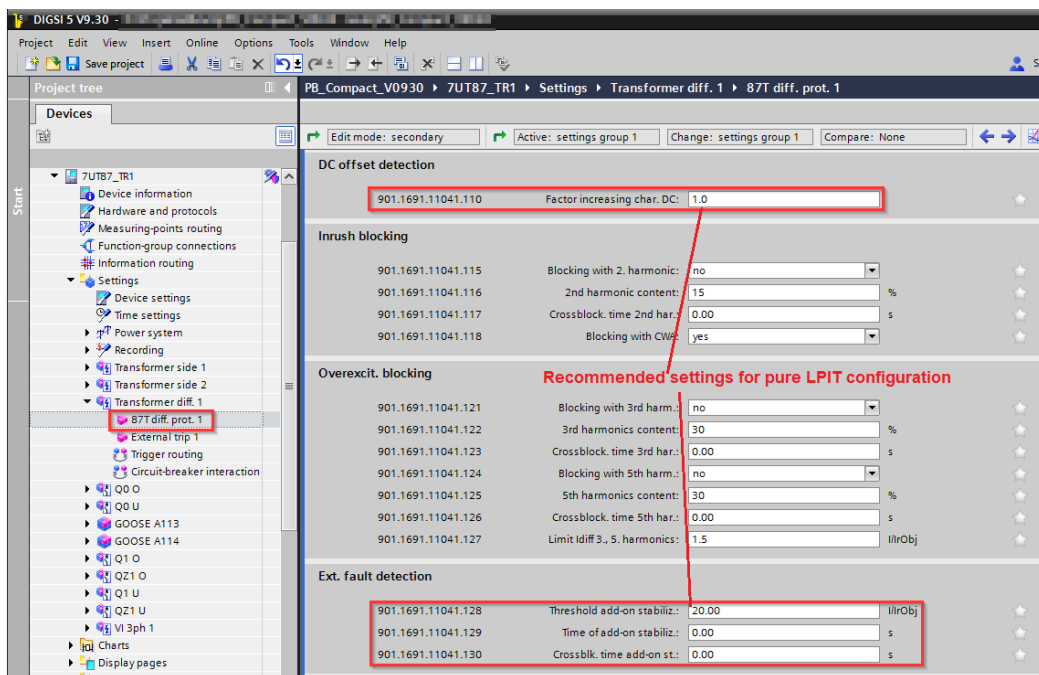


Figure 20: Setting of 'DC offset detection' and 'Ext. fault detection' parameters when on both side LPITs are interfaced

4.8 7SL8x Line Differential Protection

Mixed configuration with LPIT and IO240 at one end and conventional instrument transformer directly hardwired to protection IED at remote end have been tested successfully and are released for use in projects.

However, for the LPIT configuration following rules should be considered

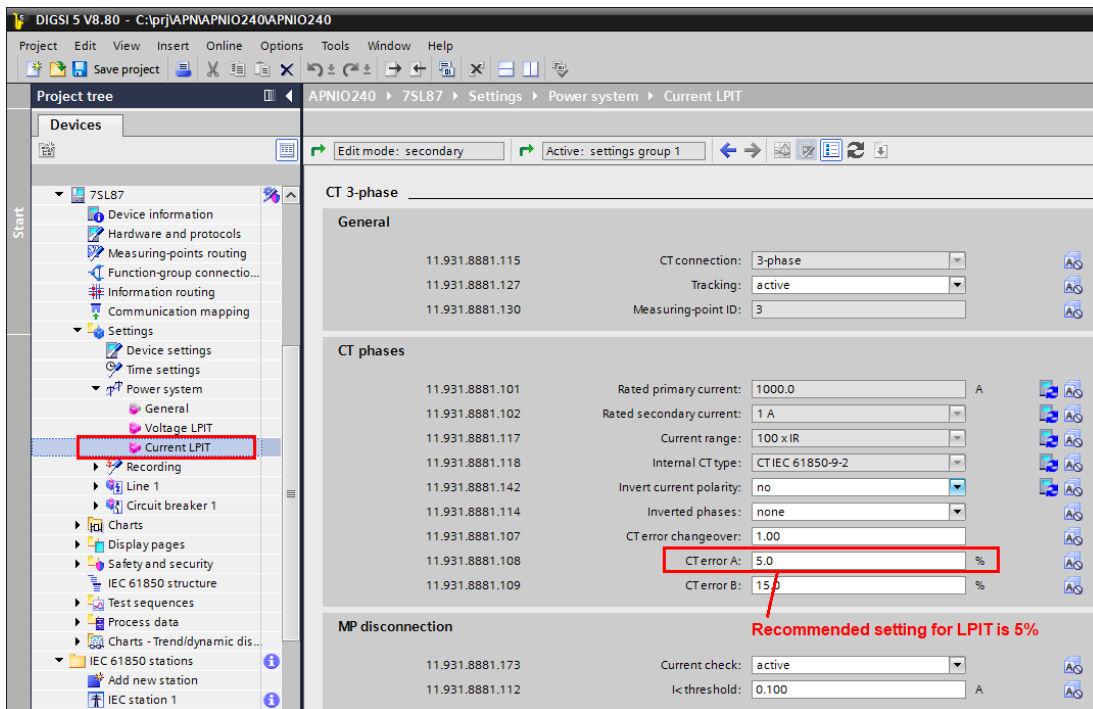


Figure 21: CT error setting for 87L protection

For the Siemens Energy LPCT the 'CT error A' has to be set to value '5 %', as shown in screenshot above.

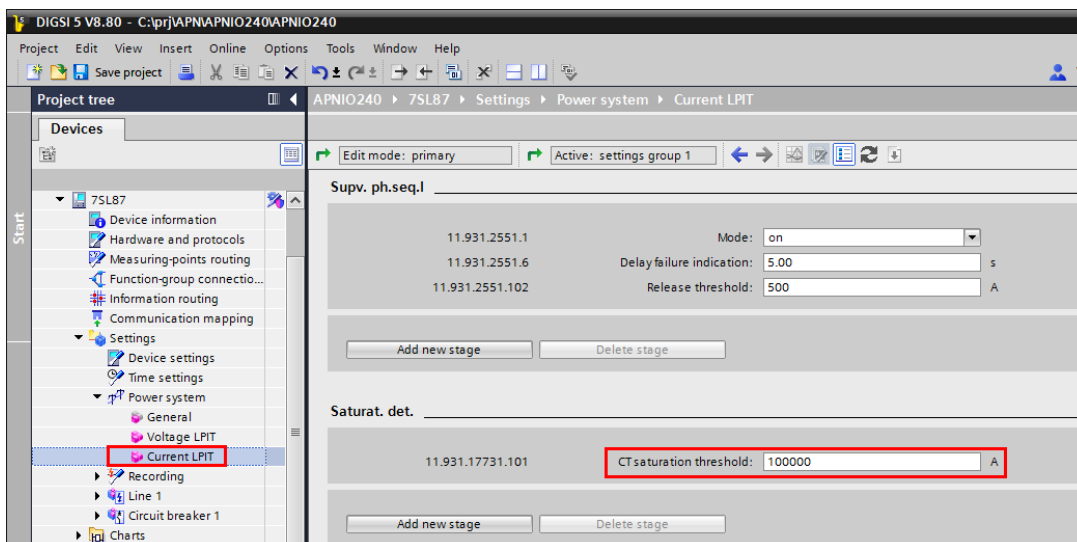


Figure 22: Setting for saturation detection applicable for 87L

The saturation detection in the current LPIT settings should be set to the specific clipping value that has been configured for the LPCT. In case the clipping value is higher than the allowed range then the Saturation detection has to be set to maximum value.

Note:

Please consider as additional hint that following setting does not have any impact on the 87L function.

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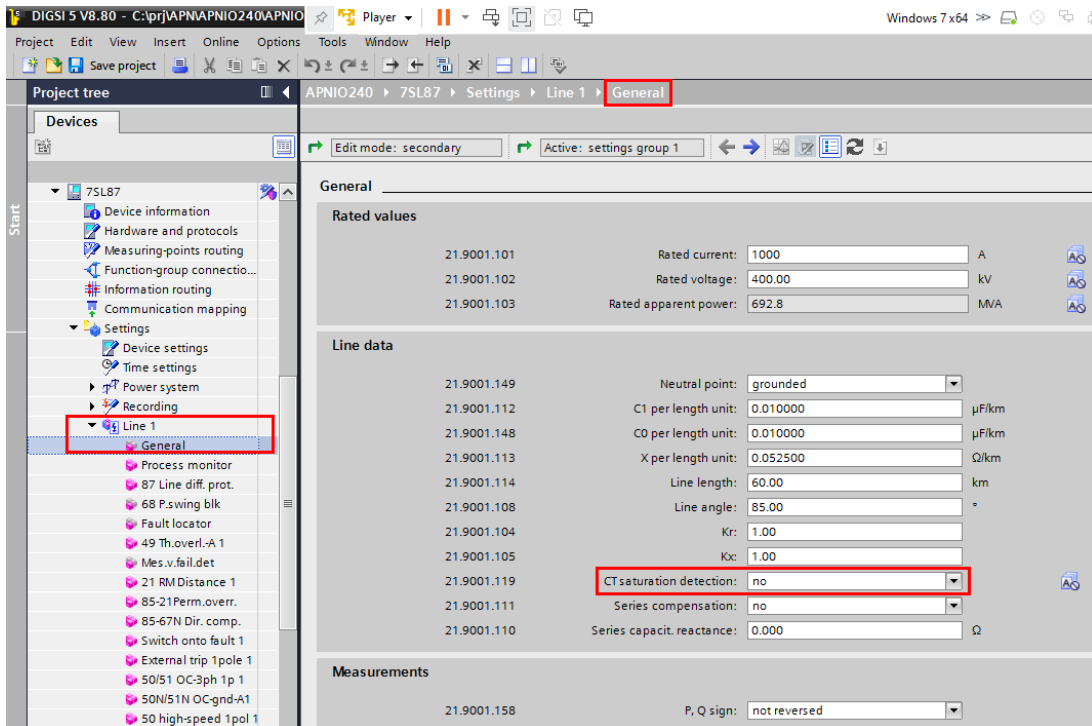


Figure 23: Settings with no impact on 87L

4.9 Generator Protection

LPITs are not suitable for generator protection. Therefore, please contact the Product Lifecycle Manager (PLM) at Siemens SI EA responsible for Generator Protection for any requests and more technical details.

5 Measurement of Harmonics and Low Frequency for Power Quality

The IO240 can be used together with the 7KE85 fault recorder and its power quality measurement functions according to IEC 61000-4-30 Ed. 2, Class S. The accuracy across the whole measuring chain starting with primary currents and voltages is better than 5% up to the 50th harmonic frequency.

On a 7KE85 only maximal two IO240 modules can be mounted. This limitation results from the power consumption of the IO240 modules and the processing power of a 7KE85 IED.

3rd party power quality measuring devices can be connected via process bus, provided they support the IEC 61850-7-4 "CorCrv" correction mechanism.

For a description of the SIPROTEC 5 7KE85 fault recorder refer to

<https://new.siemens.com/global/en/products/energy/energy-automation-and-smart-grid/protection-relays-and-control/SIPROTEC-5/fault-recorder.html>.

Recommended Sampling rates for Power Quality

In case the LPIT is interfaced to a Merging following sample rates are recommended for power quality applications:

- 12 800 Hz / 8 ASDU – PQ (for IEC61850-9-2 LE 50 Hz)
- 15 360 Hz / 8 ASDU – PQ (for IEC61850-9-2 LE 60 Hz)
- 14 400 Hz / 6 ASDU – PQ (recommended by IEC61869-9)

Note:

SIPROTEC 5 Merging Unit can publish two Sampled Measured Value Stream with different sampling rates in parallel originated from the same instrument transformer. For example, a Merging Unit can provide a stream with 4000 samples per second for protection applications *and* with 15 360 samples per second for power quality applications.

6 Metering

For metering applications, the IEC 61850-9-2 LE compatible digital meter Landis & Gyr E880 is available.

<https://www.landisgyr.eu/product/landisgyr-e880/>

7 Connecting 3rd Party Relays / IEDs

7.1 General information

General information related to compatibility you find in the

6MU85 manual:

[SIPROTEC 5 6MU85 Merging Unit – Manual – ID: 109773599 - Industry Support Siemens](#)

Process bus manual:

[SIPROTEC 5 Process Bus – Manual – ID: 109742460 - Industry Support Siemens](#)

The compatibility of SIPROTEC 5 protection relays and bay controllers with the SIPROTEC 5 Merging Unit was tested by Siemens and also external labs. However, when combining protection IEDs and Merging Units from different suppliers, compatibility is not guaranteed. The two aspects of compatibility as stated in the following two subsections need to be considered.

7.2 Process bus communication compatibility

For communication compatibility all member of a process bus network must have implemented the same version of standard IEC 61850-9-2 (edition 1, edition 2, edition 2.1, LE, etc.). This guarantees that all members can exchange SMV data with each other on process bus.

SIPROTEC 5 process bus components support all of those standards, they just must be configured in DIGSI 5 accordingly.

7.3 Protection function compatibility

Naturally the SMV output data of various LPIT/Merging Unit solutions from different manufacturers have individual characteristics particularly with respect to frequency spectrum. This is caused by the different technologies and signal processing methods which are implemented by the various manufacturers.

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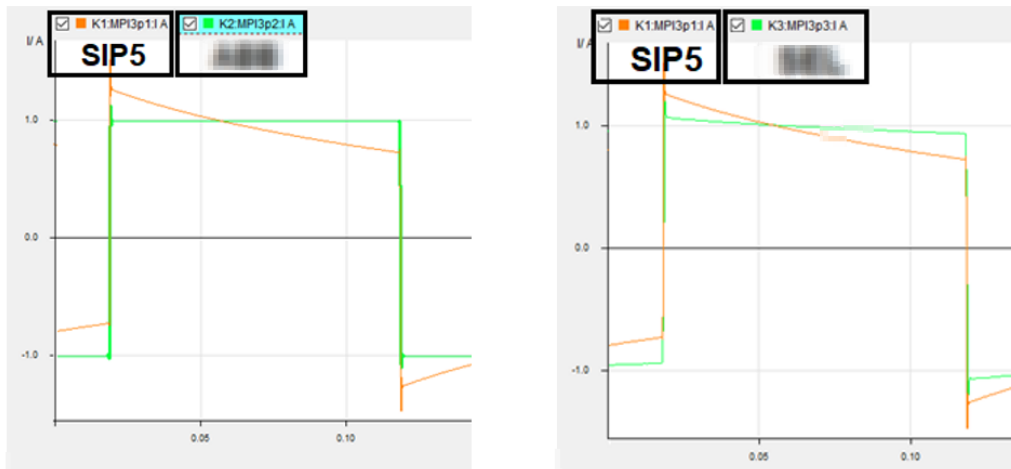


Figure 24: Reaction to a current 5 Hz square wave signal of a SIPROTEC 5 MU compared with 2 different 3rd party MUs

Any IED however requires for its reliable and correct function, a standardized process bus data input. This especially applies for protection functions, which are expecting frequency spectra within certain admissible deviations.

For achieving compatibility of process bus components, the standard IEC 61850-9-2 edition 2.1 defines these admissible deviations by defining additional parameters. This means, both Merging Units (in combination with specific LPIT) and IEDs must fulfill this standard.

The correct function of a process bus component as per standard IEC 61850-9-2 edition 2.1 can be certified e.g., by the KEMA organization or any other comparable institutes. SIPROTEC 5 process bus components implement the standard and are certified by KEMA. Hence all 3rd party devices used together with the IO240 and the SIPROTEC 5 Merging unit should also be compliant to IEC 61850 Edition 2.1 and have an adequate certificate.

IEC 61850-9-2 edition 2.0 standard and earlier do not provide those parameters that are required for compatibility. More details can be found in chapter '2.1.6 9-2 Client Instrument Transformer Settings Editor' of process bus manual (link in the beginning of this section). Hence a compatibility test of the relay in combination with Merging Unit is mandatory if one or both components do not comply to IEC 61850-9-2 edition 2.1. This compatibility tests have to verify that the protection function is guaranteed in all operating conditions of the substation.

7.4 Functional test with 3rd party IEDs

The SIPROTEC 5 Merging Unit with IO240 combined with the Siemens Energy GIS LPIT was designed in a way that the frequency spectrum is identical to the conventional instrument transformer inputs as provided e.g., by a stand-alone SIPROTEC 5 Merging Unit with IO202.

This means that functional tests with 3rd party devices using a 6MU85 with IO202 having 1A/100A inputs are also valid for a 6MU85 with IO240 and LPIT inputs.

8 Point on Wave Switching

Controlled switching of shunt reactors, capacitor banks and power transformers is possible using the SIPROTEC 5 Point-on-Wave Switching function, see also [SIPROTEC 5 Point-on-Wave Switching - Manual - ID: 109772210 - Industry Support Siemens](#).

This function **must** be configured locally in the SIPROTEC 5 device where the IO240 is installed.

9 Circuit Breaker Monitoring

The SIPROTEC 5 function Circuit breaker wear monitoring provides functions like

- recording of the wear of the circuit breaker main contacts (I^2t).
- warning messages when the wear reaches a specified limit.

Refer to the relevant chapter in the the SIPROTEC 5 device manuals.

Further Circuit Breaker Monitoring functions (e.g., trip coil current supervision) can be provided by combining SIPROTEC 5 with Siemens Energy's CBM solutions.

10 IO240 Supervision Functions

10.1 Measuring Circuit Supervision Functions

Please find in below tables details and recommendations for Measuring Circuit Supervision applicable for IO240.

Measuring Circuit Supervision for Currents (designation in DIGSI 5)	Configurable in IED with IO240 (*)	Configurable in subscriber (*)	Detects a broken wire	Applicable IO240	Consequence	Reference in 6MU85 manual V9.30
Broken Wire Detection ($di/dt \gg 0, I < 0,06 I_n$)	Yes (***)	Yes	Yes	In preparation	- MU stream remains valid - Protection blocked	9.3.11 Broken-Wire Detection
Supervision Balance Current	Yes (***)	Yes	Yes	Yes	- Failure indication typically in 500ms - MU stream remains valid	9.3.8 Current-Balance Supervision
Supervision Sum Current (only applicable in SAMU with I 3ph+IN)	No	No	No	No (no I neutral)	- Failure indication typically in 500ms - MU stream remains valid	9.3.9 Current-Sum Supervision
Supervision Phase Sequence Current	Yes (***)	Yes	No	Yes	- MU stream remains valid - Failure indication typically in 500ms => Check wiring	9.3.10 Current Phase-Rotation Supervision
Supervision ADC sum Current (only applicable in SAMU with I 3ph+IN)	No	No	No	No (no I neutral)	- MU SMV stream invalid (applies only for SAMU) - Protection blocked in 2ms	9.4.2 Analog-Channel Supervision via Fast Current-Sum
ADC supervision (Comparison measurement and measuring point LP-PT – exists on IO240)	---	---	No	Yes	- MU SMV stream invalid - Protection blocked in 2ms	Implemented per default in IO240
Differential Current Supervision of 7SS85 BBP (**)	No	Yes	Yes	Yes	No trip of BBP in case of a broken wire; reaction of BBP can be parametrized (blocking or warning)	7SS85 BBP (V8.60) 6.2.13, 8.3.5

Table 2: Measuring Circuit Supervision for Current Instrument Transformers

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Measuring Circuit Supervision for Voltages (designation in DIGSI 5)	Configurable in IED with IO240 (*)	Configurable in subscriber (*)	Detects a broken wire	Applicable IO240	Consequence	Reference in 6MU85 manual V9.30
Measuring Voltage Failure Detection	Yes (***)	Yes	Yes	Yes	- MU stream remains valid - Protection blocked in approx. 10ms	9.3.2.3 Unbalanced Measuring-Voltage Failure
						9.3.2.4 3-Phase Measuring-Voltage Failure
						9.3.2.5 Switching onto a 3-Phase Measuring-Voltage Failure, Low Load
Supervision Balance Voltage	Yes (***)	Yes	Yes	Yes	- Failure indication typically in 500ms - MU stream remains valid	9.3.5 Voltage-Balance Supervision
Supervision Phase Sequence Voltage	Yes (***)	Yes	No	Yes	- Failure indication typically in 500ms => Check wiring - MU stream remains valid	9.3.7 Voltage Phase-Rotation Supervision
Supervision Sum Voltage	Yes (***)	Yes	No	No (no U neutral)	- Failure indication typically in 500ms - MU stream remains valid	9.3.6 Voltage-Sum Supervision
VT miniature Circuit Breaker	Yes	Yes	No	No (No MCB)	- MU stream invalid - Protection blocked	9.3.4 Voltage-Transformer Circuit Breaker

Table 3: Measuring Circuit Supervision for Voltage Instrument Transformers

Other Circuit Supervision functions	Configurable in IED with IO240	Configurable in subscriber	Detects a broken wire	Comment
Temperature sensor measuring circuit supervision	Yes	Yes (receives temperature value via GOOSE)	Yes	- When a temperature sensor wire is broken a temperature measurement failure will be indicated. - CFC logic can be implemented for analyzing the temperature measurement in MU or in PB client, which generates a failure indication in case of a temperature measurement failure. - The failure indication can be used for protection blocking but it is slow (measurement cycle 200 ms).

Table 4: Other Circuit Supervision functions

(*) It is recommended to enable the supervision function in the device, in which the protection function is located

(**) According to the recommended parametrization the busbar protection trips only when the differential current exceeds 1.4 times the maximum rated feeder current. This is done to avoid false trips due to broken CT wires. Furthermore, the function "Differential current supervision" detects such a defect after 2s. The reaction of the busbar protection can be parametrized (blocking or warning)

(***) Only operational when a protection function is configured. Currently not in all protection devices all supervision functions are configurable, for example a 7UT device currently does not offer Broken wire detection.

10.2 Process Bus Status Bits

The SIPROTEC 5 Merging Unit has self-monitoring functions implemented, which are permanently active. In case a failure is detected in the measurement processing, this is indicated by a quality bit array of 10-bit length, which is included in the SMV stream for each measuring point LP-MS. When self-monitoring results are OK, all bits are set to value '0'. Quality bit setting for the various error cases are listed in below table. For a description of the general implementation principles of status & quality bits in a SMV stream please refer to the relevant Merging Unit manuals and to IEC 61850-7-3 standard documents.

Detected malfunction in the Merging Unit	Validity Status (2 bits)	Detail quality bits status (8 bits)	For each measuring point LP-MS separate	Comment / Trouble shooting
Clipping detected (SMV exceeds ADC maximum)	Questionable 11	Out of Range 0100 0000	Yes	
ADC CheckSum Error (comparison of protection + measuring point LP-MS)	Invalid 10	failure 0000 1000	Yes	<ul style="list-style-type: none"> • Check Diagnosis log und Operational Log • Contact support
Firmware – Fast current supervision in Bay Unit	Invalid 10	failure 0000 1000	No – all 3 current channels with failure bit	<ul style="list-style-type: none"> • Check Diagnosis log und Operational Log • Contact support
Firmware – DC offset of SMV exceeds allowed level	Questionable 11	inaccurate 0000 0001	Yes	<ul style="list-style-type: none"> • Check Diagnosis log und Operational Log • Contact support
Firmware – calibration failure	Questionable 11	inaccurate 0000 0001	No – all 3 measurements of measuring point	<ul style="list-style-type: none"> • Check Diagnosis log und Operational Log • Contact support
Firmware – VT MCB Supervision	Invalid 10	failure 0000 1000	No – all 3 voltage channels with failure bit	Not applicable to IO240
FPGA failure	Invalid 10	failure 0000 1000	No – all measuring point LP-MSs	<ul style="list-style-type: none"> • Check Diagnosis log und Operational Log • Contact support

Table 5: Quality Bit setting in SMV telegrams of a Merging Unit with IO240 module

Handling of the quality information contained in the SV Stream in the subscribing protection IED or Bay Controller is shown in next table (table is taken from section 1.4 of SIPROTEC 5 Process Bus manual V9.30)

Merging Unit		Health of Protection Function	Device Display
Validity	Detailed Quality		
Good (00)	All	OK	Value
Questionable (11)	No error	OK	Value
	Overflow	OK	Value
	OutOfRange	Depends on function	> Value
	BadReference	OK	Value
	Oscillatory	OK	Value
	Failure	OK	Value
	OldData	OK	Value
	Inconsistent	OK	Value
Invalid (01 and 10)	All	Alarm	Failure
	Inaccurate	Depends on function	~ Value

Table 6: Processing of Quality Information in subscribing SIPROTEC 5 IED

On invalid measurements the subscribing devices reacts always with an Alarm and blocking of the protection functions, which are based on this invalid measurement data. For the 'Questionable cases' please refer to the relevant SIPROTEC 5 manuals.

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11 Commissioning and Testing

11.1 IO240 commissioning checklist

After primary tests are completed as described above ensure that below checklist is verified:

Action item	Resource
Check that the LPITs from the three GIS poles are connected to the right IO240 terminals according to pole-phase assignment	Project specific SLD
Check that the terminal connectors have all required Voltage-Terminal Cross-Connector (bridges).	IO240 HW Manal, supplementary note
Make sure that you have entered the correct LPIT type and serial numbers.	Siemens Energy Commissioning report
Make sure that you have entered the correct cable length as actually installed (+-2m)	Siemens Energy Commissioning report
Make sure that you have parametrized the correct pole to phase assignment as actually connected	Project specific SLD, Siemens Energy Commissioning report
Make sure that the correct temperature coefficients are entered in DIGSI (\geq V8.40): 8VN1 / 8DN8-6 LPVT: 252 ppm / °C, LPCT: 23 ppm/°C 8DN8-5 LPVT: 260 ppm / °C, LPCT: 32 ppm/°C	

11.2 Control & Protection commissioning test

Here a short overview on testing principles applicable for the two different IO240 configurations:

11.2.1 Protection IEDs and BCU subscribing SMVs from MU

The control & protection functions of the IEDs that are subscribing SMV are tested with testing tools that inject SMVs in the process bus (refer to figure below).

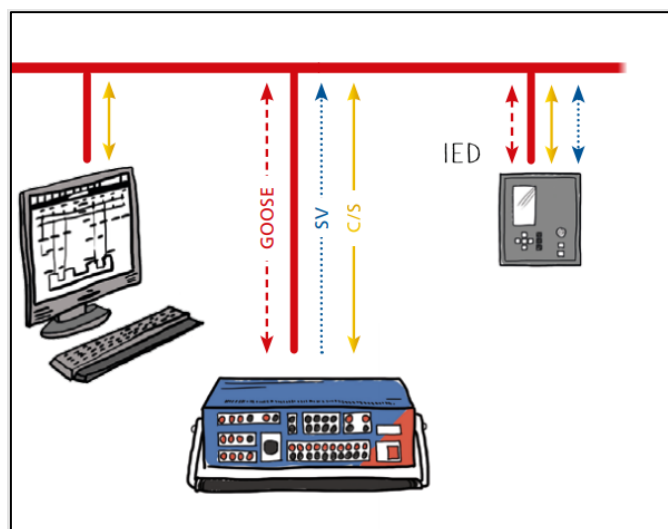


Figure 25: Example SMV injection test set-up using an Omicron device

11.2.2 SIPROTEC 5 Protection IEDs and BCUs with direct LPIT interface

The C&P function tests can be executed by following methods:

1. Testing with Reverse injection functionality by using SMV injection as shown in the figure above. With a dedicated function key the device under test is set into a temporary 'Reverse Injection Testing Mode' by redirecting the LPIT input signals to SMV input signals. After test completion the device is set back to normal operational mode.
A short configuration instruction of this functionality contains section '*13 Configuration for Reverse Injection*'.
Note: At the moment this testing principle is not applicable for protection functions which are assigned in to a circuit breaker object, refer to more details in '*13 Configuration for Reverse Injection*'. This restriction might not be applicable any more with DIGSI 5 and firmware version later than V09.50 – check the release notes!
2. By temporary reconfiguration of IEDs only for testing purpose and using SMV injections as shown on the figure above. For this method the device must have an ETH-BD-2FO module installed. The LPIT IO240 measuring point LP-MSs are temporary redirected to the process bus channels.
3. By temporary redirection (reconfiguration of the measuring points) of the measuring point LP-MSs to the conventional instrument transformers of the IED; the tests can be executed by using 1A, $100V/\sqrt{3}$. For this method the device must have conventional instrument transformer inputs installed.
4. By using dedicated secondary injections test devices from Megger with IO240 compatible outputs (in preparation)
5. By using a standard secondary injections test device and a Test adapter from SecuControl (in preparation)

To make the analog secondary injection test (4. and 5.) convenient SecuControl and Phoenix-Contact provide LPIT compatible test blocks and plugs. They are typically installed inside the GIS instrument transformer terminal box of the LCC front dox. They can be ordered together with the GIS at Siemens-Energy (in preparation).

Attention:

Do **not use a conventional test device** and feed 1A, $100V/\sqrt{3}$ signals into the IO240. The IO240 will be destroyed!

12 Cable Assembly and Hardware connection

12.1 Cable connection to IO240 module

For connecting the LPIT cable to the IO240 please refer to the following documents.

Chapter 3.2.20 "Input and Output Module IO240" in the SIPROTEC 5 Hardware Manual:

[SIPROTEC 5 Hardware - Manual - ID: 109742193 - Industry Support Siemens](#)

Supplementary note on IO240 connection:

[SIPROTEC 5 IO240 Connections of GIS-LPIT Sensors – Supplementary Note - ID: 109801262 - Industry Support Siemens](#)

The following figure gives an overview. Please don't forget the Voltage-Terminal Cross-Connector (bridges).

SIPROTEC 5 Application

Configuration Rules for Protection Systems with IO240 and LPITs

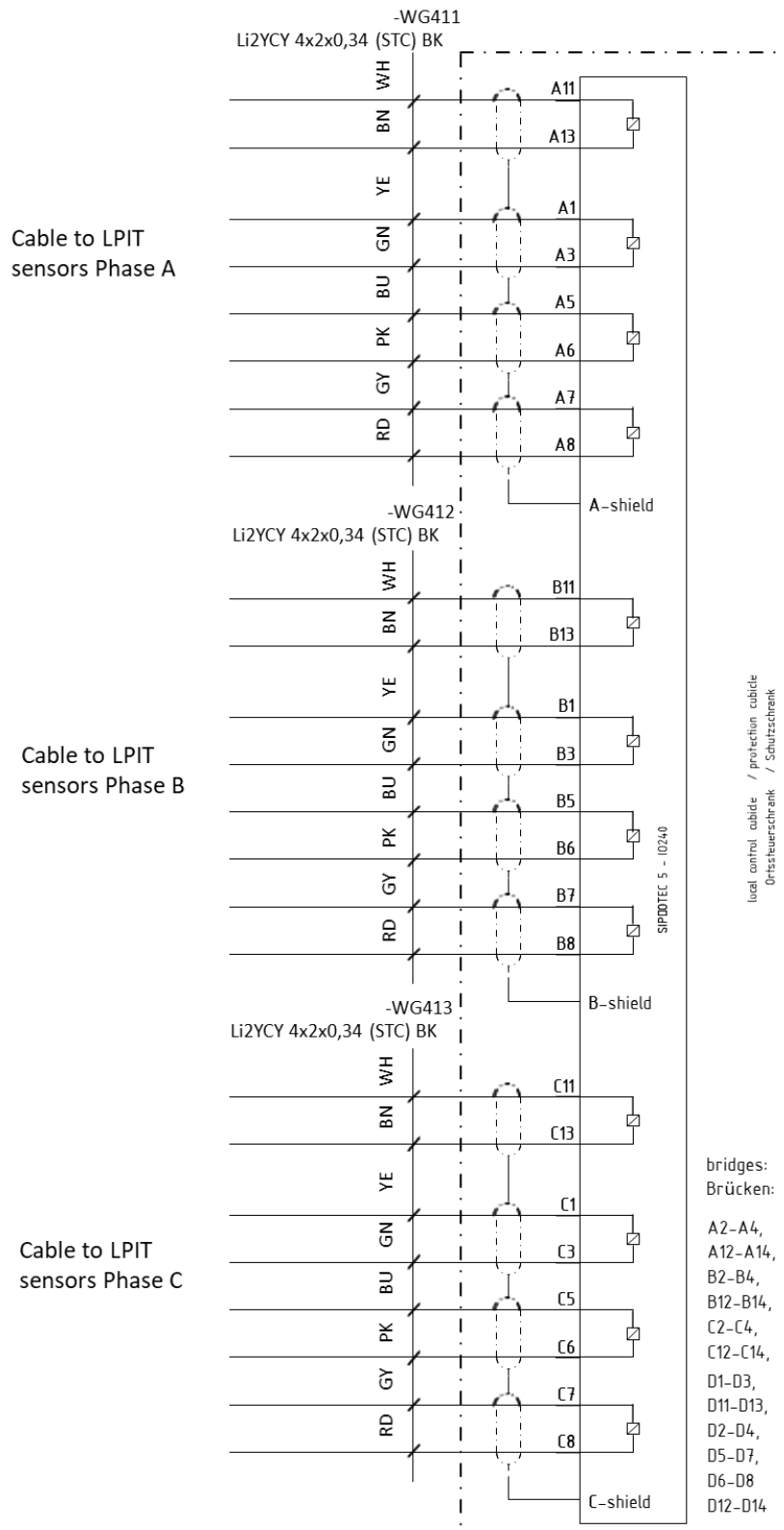
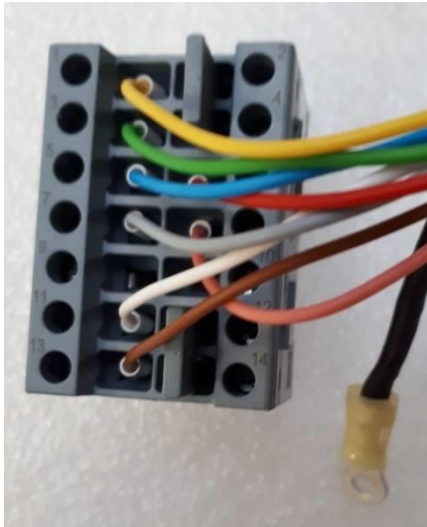


Figure 26: Connection of the LPIT partition to the IO240



- 1 = Yellow
- 2 = Bridge to 4
- 3 = Green
- 4 = Bridge to 2
- 5 = Blue
- 6 = Red
- 7 = Gray
- 8 = Pink
- 9 = Free
- 10 = Free
- 11 = White
- 12 = Bridge to 14
- 13 = Brown
- 14 = Bridge to 12



Figure 27: The assembled LPIT connector for one phase

12.2 Cable Assembly

12.2.1 Material required





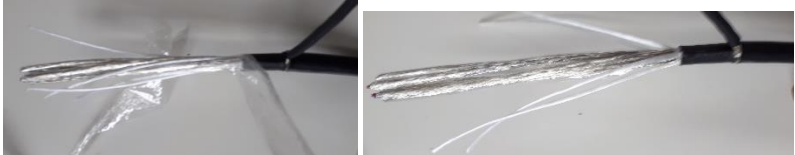

- LPIT-cables Leoni LI2Y C11Y 4X2X0.34 (STC) BK - halogen-free version - L45551-P 42-B 8 or LPIT-cables Leoni LI2Y CY 4X2X0.34 (STC) - halogen-version - L45551-P 42-B 5
The cable can be ordered at Leoni or small quantities at Aktiv-Kabel, Buschkrugallee 103, 12359 Berlin, [Aktiv-Kabel GmbH - Berlin - Home](#)
- **Attention: no other cable types of suppliers are allowed!**
- Heat shrink tubes HIS 6,4/3,2, black
- Heat shrink tubes HIS 12,7/6,4, black
- Ferulles DIN 46228 E0.34-10-turquoise
- Ferulles DIN 46228 E0.75-10-gray
- Cable lugs AMP 35108 for M4

12.2.2 Cable Assembly at the LPIT connection box

No	Work step	Remark	Drawing / Photo
1.	Strip the black cable jacket 130 mm (+/- 5mm) at the end of the cable	Do not damage the shield.	
2.	Unbraid the cable shield	The shield must be completely unbraided (up to the cable jacket)	




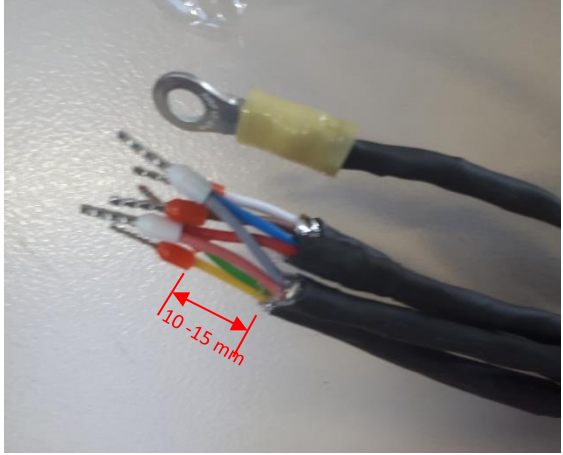
SIPROTEC 5 Application

Configuration Rules for Protection Systems with IO240 and LPITs

3.	Twist the shield	As even as possible	
4.	Cut a heat-shrink-tube (size 12.7/6.4) to 20 mm length and pull it over the cores with the foil-layer.	The foil-layer must be under the shrink-tube	
5.	Shrink the heat-shrink-tube with a hot air gun at 290°C	The shrink-tube must be as close as possible to the twisted outer shield	
6.	Cut a heat-shrink-tube (size 6.4/3.2) to 80 mm length and pull it over the twisted out shield. Shrink it with a hot air gun at 290°C .	The shrink-tube must be as close as possible to the jacket.	
7.	Remove the protective foil up to the shrink sleeve		
8.	Cut off the white support structures	Do not damage the insulation of the signal wires	

SIPROTEC 5 Application











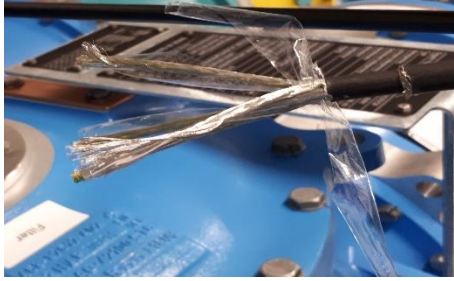
Configuration Rules for Protection Systems with IO240 and LPITs

9.	Cut 4 heat-shrink-tubes (size 6.4/3.2) to 80 mm length and pull them over the wire pairs (with foil and shield) Shrink it with a hot air gun at 290°C .	To easily insert the wires into the shrink tube, fix them together	
10.	Cut all foils and shields back to the shrink-tube.	As close as possible to the shrink-tube.	
11.	Cut a heat-shrink-tube (size 12.7/6.4) to a length of 60 mm and pull it over the wire pairs and the shield. Shrink it with a hot air gun at 290°C	The shrink tube has to be applied centrally so that the outer jacket and the foil of the cores are covered.	
12.	The wire ends are fitted to 0.34 mm² ferrules, The wires with the colors red and pink, as well as blue and gray are fitted together in a 0.75 mm² ferrule. The end of the shield is fitted to a ring-cable-lug for 6 mm² cable and a hole for M4 screws.	Make sure that the distance of 10 to 15 mm as shown in the picture is maintained	

SIPROTEC 5 Application

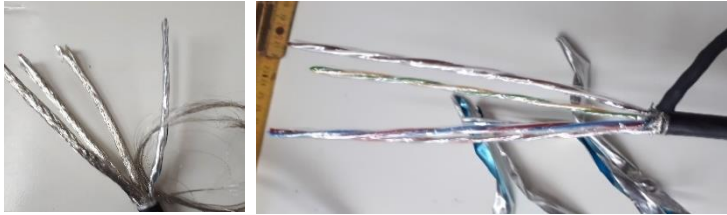

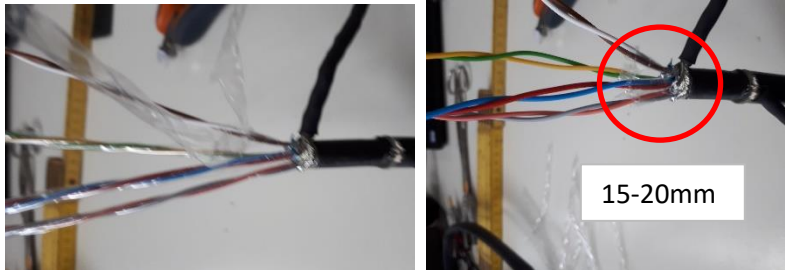

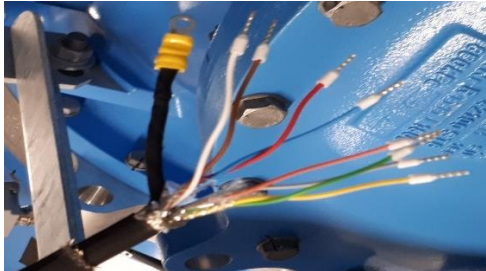
Configuration Rules for Protection Systems with IO240 and LPITs

12.2.3 Cable Assembly at the IO240

No	Work step	Remark	Drawing / Photo
1.	Strip 150 mm (+/- 5mm) of the black cable jacket at the end of the cable	Do not damage the shield	 
2.	Unbraid the shield and cut it flush with the cable jacket		 
3.	Cut a heat-shrink-tube (size 12.7/6.4) to 20 mm length and pull it over the cores with the foil-layer.	The foil-layer must be under the heat-shrink-tube	 
4.	Shrink the tube with a hot air dryer at 290°C	The shrink tube must be as close to the shield as possible	
5.	Remove the protective film up to the shrink sleeve		 
6.	Cut off the white support structures	Do not damage the insulation of the signal wires	
7.	Remove the foil from the shield of the single wire pairs		

SIPROTEC 5 Application

Configuration Rules for Protection Systems with IO240 and LPITs

8.	Remove the shield from the twisted wire pairs. Cut back the shield foil to the shrink tube	Cut off as close as possible to the shrink-tube	
9.	To twist the shield, first twist the individual shields and then twist the individual shields into a common twisted braid. Cut the heat-shrink-tube (size 6.4/3.2) to a length of 100 mm , run it over the shield and shrink it at 290°C using a hot air gun.	The shrink tube must be as close as possible to the shrink tube of point 3.	
10.	Remove the foil from the wire pairs and leave 15-20 mm to the heat-shrink-tube.	Too short insulation leads to lower dielectric strength	
11.	Cut heat-shrink-tube (size 12.7/6.4) to a length of 60 mm and run it over the cores and the shield and shrink it on with a hot air gun at 290°C .	The shrink tube must be applied centrally so that the outer jacket of the cable and the foil of the cores are covered.	
12.	The wire ends are fitted to 0.34 mm² ferrules. The end of the shield is fitted to a ring-cable-lug for 6 mm² cable and a hole for M4 screws.		



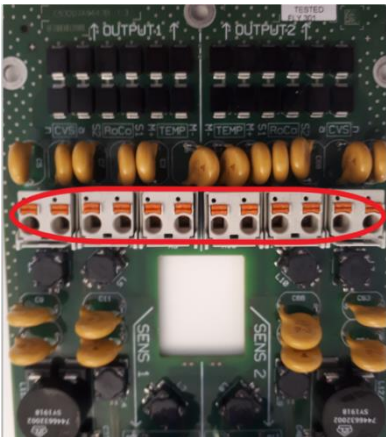
SIPROTEC 5 Application

Configuration Rules for Protection Systems with IO240 and LPITs

12.2.4 Cable connection to the LPIT connection box

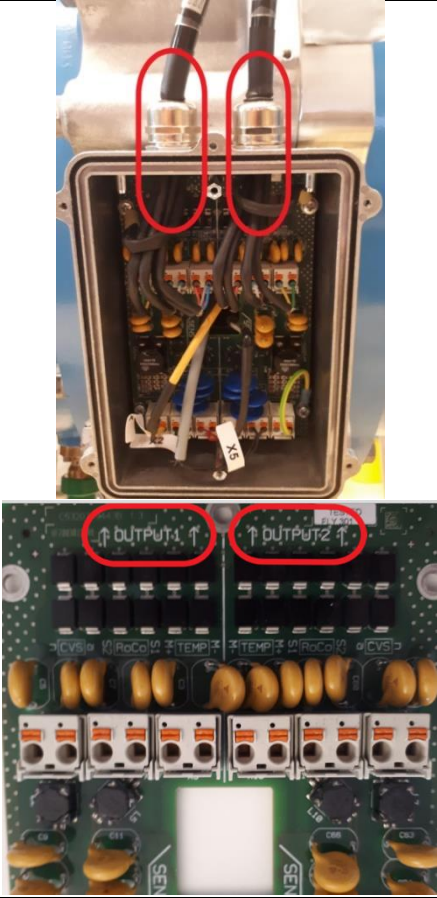
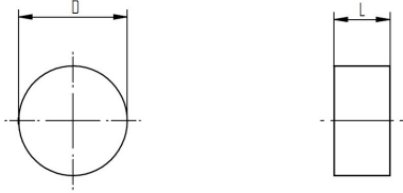
Material required:

- 3 x 6 PicoMax plug connectors
- For LPITs connected only to one IO240: M25 Sealing plug (cap)

No	Work step	Remark	Drawing / Photo
1.	Open the cover of the LPIT connection box		
2.	Remove the shielding plate		
3.	Plug the six PicoMax connectors into the printed circuit board	Caution! Socket base (locking) is fragile!	

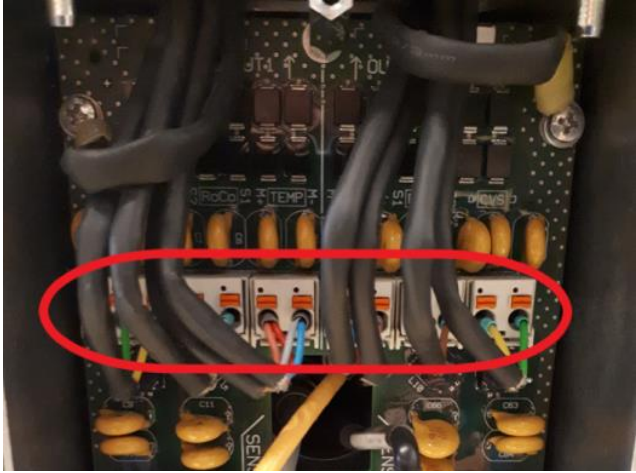

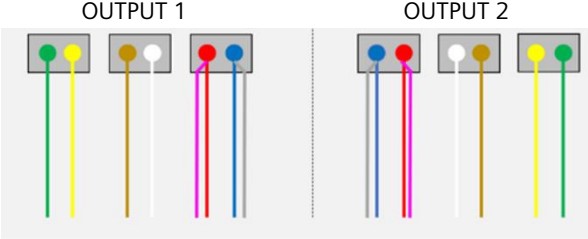

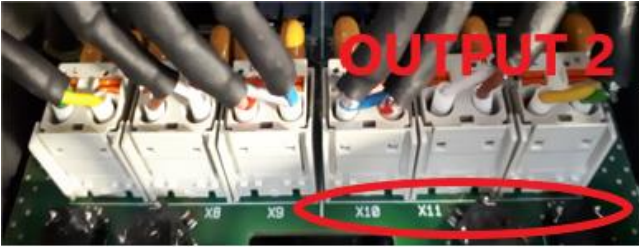
SIPROTEC 5 Application

Configuration Rules for Protection Systems with IO240 and LPITs

<p>4.</p>	<p>Insert assembled LPIT cables through cable glands into LPIT connection box. Pay attention to use the right gland for the right cable. The IO240 using Channel 1 ist connected to OUTPU 1, the IO240 using channel 2 to OUTPUT 2.</p>	<p>If there is only one IO240, connect the cable to OUTPUT 1!</p>											
<p>5.</p>	<p>If there is only one LPIT cable, seal the cable gland of OUTPUT 2 using an M25 sealing plug.</p>	<p>Pay attention not to confuse OUTPUT 1 and OUTPUT 2</p>	 <table border="1" data-bbox="855 1503 1469 1543"> <thead> <tr> <th>Größe</th> <th>ØD (mm)</th> <th>L (mm)</th> <th>Werkstoff</th> <th>Temperaturbereich</th> </tr> </thead> <tbody> <tr> <td>M25x1,5</td> <td>17,2</td> <td>9,5</td> <td>CR</td> <td>-30°C bis +100°C</td> </tr> </tbody> </table>	Größe	ØD (mm)	L (mm)	Werkstoff	Temperaturbereich	M25x1,5	17,2	9,5	CR	-30°C bis +100°C
Größe	ØD (mm)	L (mm)	Werkstoff	Temperaturbereich									
M25x1,5	17,2	9,5	CR	-30°C bis +100°C									

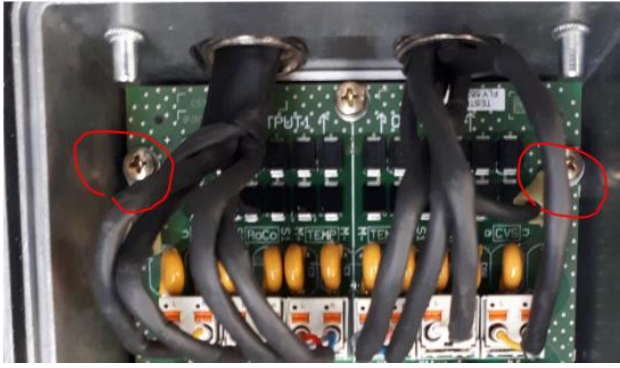
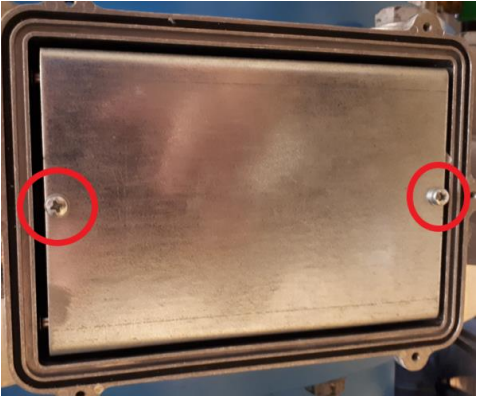

SIPROTEC 5 Application

Configuration Rules for Protection Systems with IO240 and LPITs

<p>6.</p>	<p>Plug the wires of the LPIT cables into the PicoMax connectors according to the wiring diagram X7 - X12</p>	<p>Caution! Socket base (locking) is fragile!</p>	
<p>7.</p>	<p>OUTPUT 1 (from outside to inside) X7 = Green/Yellow X8 = Brown/White X9 = Red+Pink/Gray+Blue</p>	<p>Pay attention to the right sequence!</p>	 
<p>8.</p>	<p>Connect ground. Fix the cable-lug M4 to the PCB using the screw behind the cable entry for OUTPUT 1.</p>	<p>Observe maximal torque for screw!</p>	
<p>9.</p>	<p>OUTPUT 2 (from inside to outside) X10 = Gray+Blue/ Red+Pink X11 = White / Brown X12 = Yellow / Green</p>	<p>Pay attention to the right sequence!</p>	

SIPROTEC 5 Application

Configuration Rules for Protection Systems with IO240 and LPITs

10.	Connect ground. Fix the cable-lug M4 to the PCB using the screw behind the cable entry for OUTPUT 2.	Observe maximal torque for screw!	
11.	Reattach the shielding plate	Observe maximal torque for screw!	
12.	Mount the cover of the LPIT connection box	Observe maximal torque for screw!	

12.2.1 Insulation test

To test the proper assembly of the cable a voltage withstand test shall be performed:

- All eight sensor wires of the cable are connected together. A test voltage of 3kVAC or 4,25kV DC is applied between the sensor wires and ground / cabel shield.
- A test voltage of 250VDC is applied between inner and outer cabel shield.
- This is repeated for cables.

SIPROTEC 5 Application


Configuration Rules for Protection Systems with IO240 and LPITs

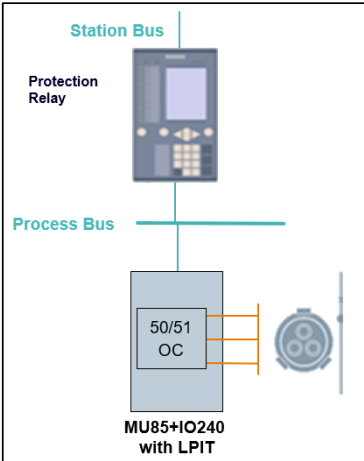
13 Configuration for Reverse Injection

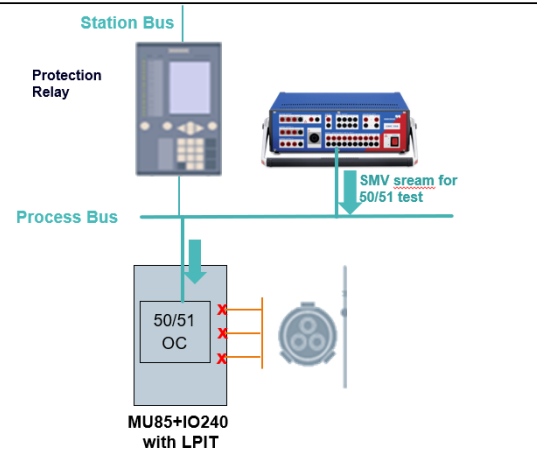
Reverse Injection Solution for LPIT Testing

MU with 50/51 Backup protection using LPIT

Challenge: How to test 50/51 on MU without a primary / LPIT injection kit?








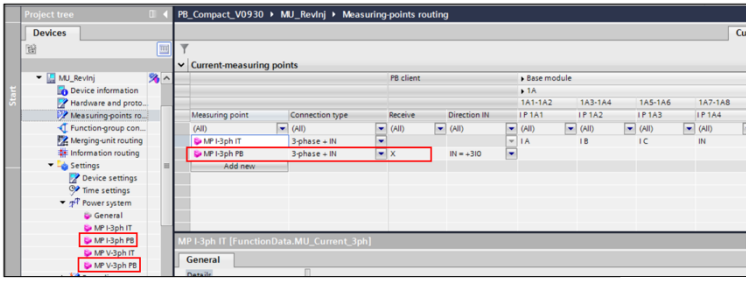
Solution: Setting the MU in 'Reverse Injection Mode' and test 50/51 with SMV injection!

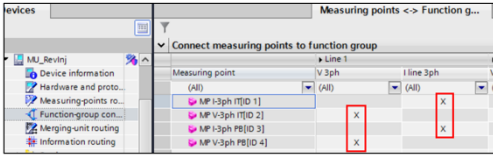
Reverse Injection Solution for LPIT Testing

Basic Settings

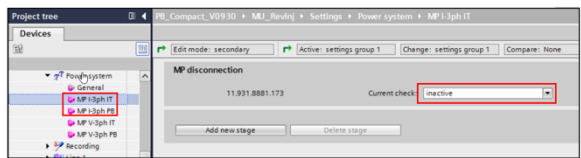


- 1) Create additional Measuring Points for Voltage and Currents with process bus as source





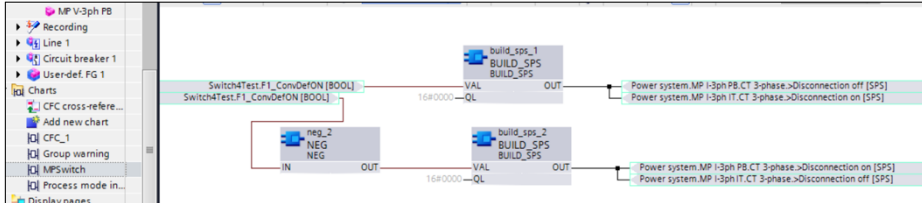
- 2) Assign the MPs to the Functions Group
- 3) IMPORTANT: Set for both Currents MPs the **MP disconnection** to **inactive**



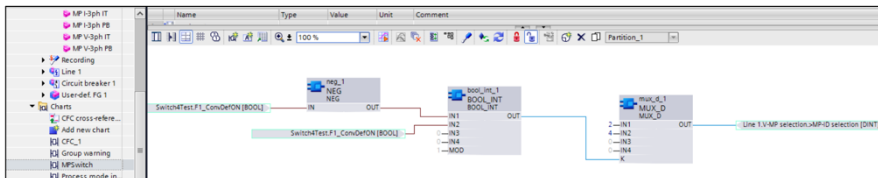
Reverse Injection Solution for LPIT Testing CFC Logic



CFC logic for swapping Current MPs with F1 key



CFC Logic for swapping voltage MPs (as known from VT selection APN)

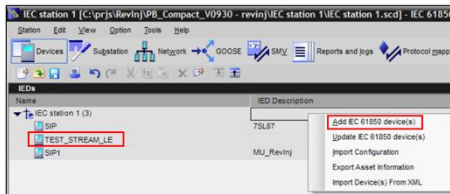


Reverse Injection Solution for LPIT Testing IEC 61850 System Configurator



1) Add the test stream (injected from CMC) to the IEC 61850 station via 'Add IEC 61850 device'

2) Assign test stream to the MU



Source	DDC	Description	Def...	Destination	Description
IEC station 1					
TEST_STREAM_LEMo2_MU2LN0PhsMeas1 (1...					
TEST_STREAM_LEMo2_MU2LN0ATCTR1Iamp...	SAV	UDEFICT 1/Sampled...		SIP1Pow5_MeasPoint3...	PowS_MP I-3ph PB/CT 1/Sampled val. current
TEST_STREAM_LEMo2_MU2LN0ATCTR1Iamp...	SAV	UDEFICT 2/Sampled...		SIP1Pow5_MeasPoint3...	PowS_MP I-3ph PB/CT 2/Sampled val. current
TEST_STREAM_LEMo2_MU2LN0BTCTR2Iamp...	SAV	UDEFICT 3/Sampled...		SIP1Pow5_MeasPoint3...	PowS_MP I-3ph PB/CT 3/Sampled val. current
TEST_STREAM_LEMo2_MU2LN0CTCTR3Iam...	SAV	UDEFICT 4/Sampled...		SIP1Pow5_MeasPoint3...	PowS_MP I-3ph PB/CT 4/Sampled val. current
TEST_STREAM_LEMo2_MU2LN0INTCTR4am...	SAV	UDEFICT 1/Sampled...		SIP1Pow5_MeasPointv...	PowS_MP V-3ph PB/VT 1/Sampled val. voltage
TEST_STREAM_LEMo2_MU2LN0INTCTR4am...	SAV	UDEFICT 2/Sampled...		SIP1Pow5_MeasPointv...	PowS_MP V-3ph PB/VT 2/Sampled val. voltage
TEST_STREAM_LEMo2_MU2LN0IBTVR2Voi5v...	SAV	UDEFIVT 3/Sampled...		SIP1Pow5_MeasPointv...	PowS_MP V-3ph PB/VT 3/Sampled val. voltage
TEST_STREAM_LEMo2_MU2LN0IBTVR2Voi5v...	SAV	UDEFIVT 4/Sampled...		SIP1Pow5_MeasPointv...	PowS_MP V-3ph PB/VT 4/Sampled val. voltage

Reverse Injection Solution for LPIT Testing Summary



How to use (in brief):

- 1) Set MU in 'Reverse Injection Mode'
- 2) Connect CMC to process bus injection point
- 3) Load same IID file as imported in the IEC 61850 Station Configurator in CMC and start SMV injection (when injected with Sim Bit, the you have also to set MU in Sim Mode)

Summary

- This principle can only be applied for measuring points connected to a 'Line object'
- On 'CB objects' this dynamic assignment is not possible
=> Synch Check, 50 Breaker Failure, etc. cannot be tested with this method
- Also applicable for conventional Instrument Transformers
- In the most cases the 'Reverse Injection Mode' will always be parallely activated with Test Mode in the Merging Unit under Test
- When MU does not have Function Keys, activation with GOOSE or MMS is also possible (Test mode to be considered for this approach)

14 Support in case of technical problems

In the following a short trouble shooting guide for various problems that may happen during configuring and commissioning of protection systems with LPITs and IO240 interface module is given.

The guide contains only measures to fix a root cause which is on the IO240 / LPIT side. Kindly check other possible root causes in the secondary system as well.

To solve the root cause start always with the analysis as per the bottom up principle ‘from the source’, this means use the information given by the WebUI or the display of the SIPROTEC5 device, to which the LPIT is connected to.

General information on the available supervision functions can be found in the chapter 8 of the relevant device manual (for example [SIPROTEC 5 7SA87, 7SD87, 7SL87 LineProt 1-/3-pol - Manual - ID: 109742440 - Industry Support Siemens](#)).

Details on error responses and possible corrective measures are contained in sub chapter 8.8. chapter (numbering may vary from device to device).

Problem	Measure
LPIT Production ID not found at DIGIS 5	<ul style="list-style-type: none"> ▪ Check online connection to internet. You may do this in you office, if you have not internet-access at site. ▪ Make sure that the ProductionID you’re entering ends with the right channel ‘CH1 or CH2’ ▪ Check, if selected ‘LPIT type’ is correct, refer to section ‘3.2 LPIT Hardware Parameters’
Voltage measurements at different bays are inconsistent	<ul style="list-style-type: none"> ▪ Check wiring and correct IO240 setting (LPIT Production ID, Pole to Phase assignment, cable length)
Displacement between the three phases differs from 120°	<ul style="list-style-type: none"> ▪ Check wiring, at least at one phase polarity is swapped
Current measurement has wrong polarity	<ul style="list-style-type: none"> ▪ Check wiring ▪ Check that the LPIT was build in in the right orientation P1/P2 <p>Note: As a corrective measure polarity can also be changed in the IO240 settings.</p>
“Measuring Circuit Supervision” shows error message	<ul style="list-style-type: none"> • Check wiring • Check Diagnosis log and Operational Log for further details and contact support if necessary
Unrealistic temperature reading / temperature alarm	<ul style="list-style-type: none"> • Check wiring • Check Diagnosis log and Operational Log for further details and contact support if necessary
Measured values are “invalid” or “questionable”	<ul style="list-style-type: none"> • Refer to ‘10.2 Process Bus Status Bits’ and the chapter on error responses and corrective measures in the relevant device manual

When above listed countermeasures could not solve the problem please contact ask for support:

- In case of technical problems related to LPIT please contact your local Siemens Energy representative
- In case of technical problems with SIPROTEC 5 including the IO240 please please contact your local Siemens EA representative; alternatively open a service request at the Siemens EA Customer Support by phone or e-mail.

When required the support will recommend a replacement of faulty hardware and arrange and help during the replacement procedure.

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upon in the concluded contract.

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This product includes software developed by the OpenSSL
Project for use in the OpenSSL Toolkit.
(<http://www.openssl.org/>)
This product includes cryptographic software written by
Eric Young (eay@cryptsoft.com)
This product includes software developed by Bodo Moeller.