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Protection Data Interface Application

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SIPROTEC 5 Application

Protection Data Interface Application

APN-005, Edition 2

Content

1 Protection Data Interface Application

1.1 Introduction

The transfer of signals and measurement values between substations becomes more and more important. State of breakers, measurement values and other information will become more important in Smart Grid solutions where devices are communicating between each other's or with decentralized data concentrators. Traditionally this is done with special tele protection equipment or with expanded functions existing in line differential relays. Use of external equipment require additional wiring, testing and causes additional cost. If the devices can be interfaced directly to fibre optical links or communication networks the integration becomes much easier. This direct integration can be done by so called protection interfaces.

Each SIPROTEC 5 device can be equipped with one or two protection interfaces. The protection interface (PI – interface) allows a data exchange between different devices over serial point to point data connections from 64 kBit/s up to 2 MBit/s. Direct fibre optical links over different distances can be used or communication links over communication networks (e.g. SDH – network). Furthermore pilot wires can be used together with an external communication converter.

Devices connected over this links can be assigned to a communication topology with 2 – 6 devices inside such a topology. This topology can be a closed ring a chain structure. Within a topology the physical connection between the devices can have different baud rates. Depending on the available bandwidth and the applications going through this interface a certain amount of data objects can be transferred between the devices belonging to one topology. The connection with the lowest bandwidth limits the number of possible information objects. These objects can be assigned with DIGSI 5 to the PI-interfaces with a communication mapping. How this is done will be explained in the application.

The following services are available, transferred and supervised:

- Topology data for establishing and permanent supervision of connections. A ring topology can switch over to a chain topology and carry on its operation. Reason may a loss of connection or a logged out of a device due to maintenance reason.
- Protection data like differential protection, teleprotection signals and binary signals and measurement values. Some measurements are transferred with their amount and phase.
- Time synchronization: One device of the topology can time sync. the other devices with a high accuracy.
- The connection will be supervised for data disturbances; loss of connection and the delay time over the links is measured and supervised permanent. If the devices are time synchronized with a high accurate second pulse on each end the delay time can be calculated independent for the transmit and receive direction. Indications and supervision values are available permanent.
- Remote devices can be interrogated with DIGSI 5 over the PI-link. In this case the channel is used for DIGSI 5 communication exclusively and the Protection Data communication will be switched OFF. This allow e.g. to change settings of remote devices without moving to the remote location.

The PI – interface is available with two types. Type 1 is used for devices with a differential protection function (7SD8x and SL8x). The other type 2 is used for all other devices and allows transferring a huge amount of binary signals and measurements between the devices even if a low bandwidth connection with 64 kBit/s is available.

This application focus on a two-terminal configuration with two devices communicating over a PI-interface.

1.2 Offline Setting

1.2.1 Communication topology

For a two terminal configuration each device must be equipped with a PI - interface. Module position F is used and an 820 nm fiber optical USART – module realize the direct fiber optical connection. Only one channel of this module is necessary

for a two terminal PI – connection. Channel 2 may be used as spare channel or for a serial connection to a substation automation system using e.g. IEC 60870-5-103 protocol.

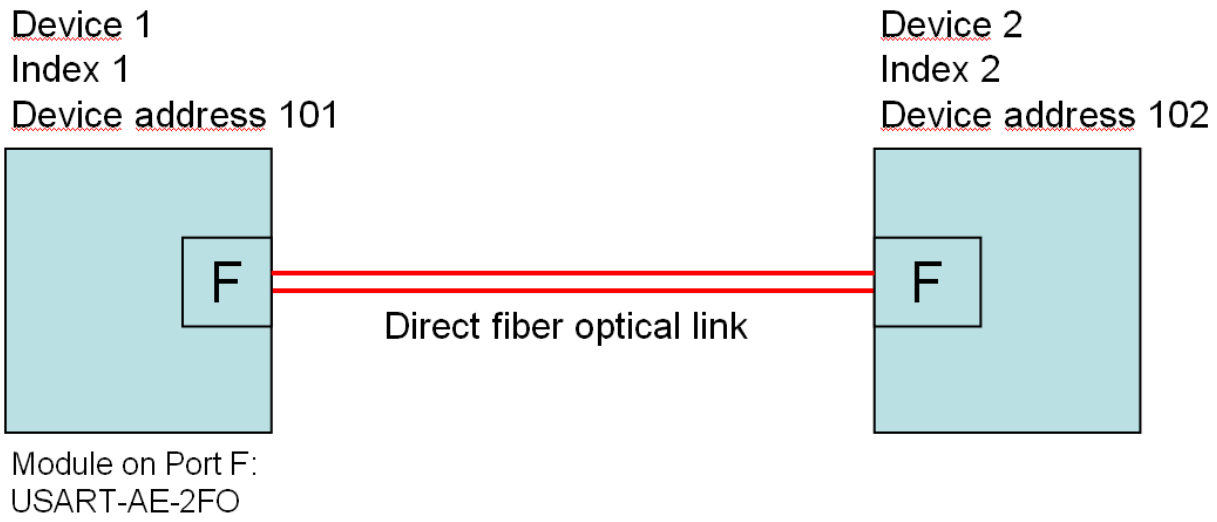

Figure 1: Example of a Protection Interface configuration with direct fiber optical link

1.2.2 Configuration assignment of device 1 in DIGSI 5

The communication module configured later with a PI - interface is taken from the hardware catalogue (right side) and assigned to module location F. Different fiber optical interfaces can be used as PI – interface. For short connections or a connection to a communication converter the USART-AD-1FO or USART-AE-2FO will be used. For direct fiber optical connection over single or multimode fiber connections other type of interfaces with 1300 nm or 1550 nm wavelength are available. Best choice for a PI – interface is a direct fiber optical connection. This offers a high bandwidth connection, immunity against external disturbances and no significant delay time for the signal transfer. But also communication networks can be used for the transfer. All properties for transfer over communication networks are considered in the design of the PI – interface like delay time measurement and the permanent supervision of the quality of the data connection.

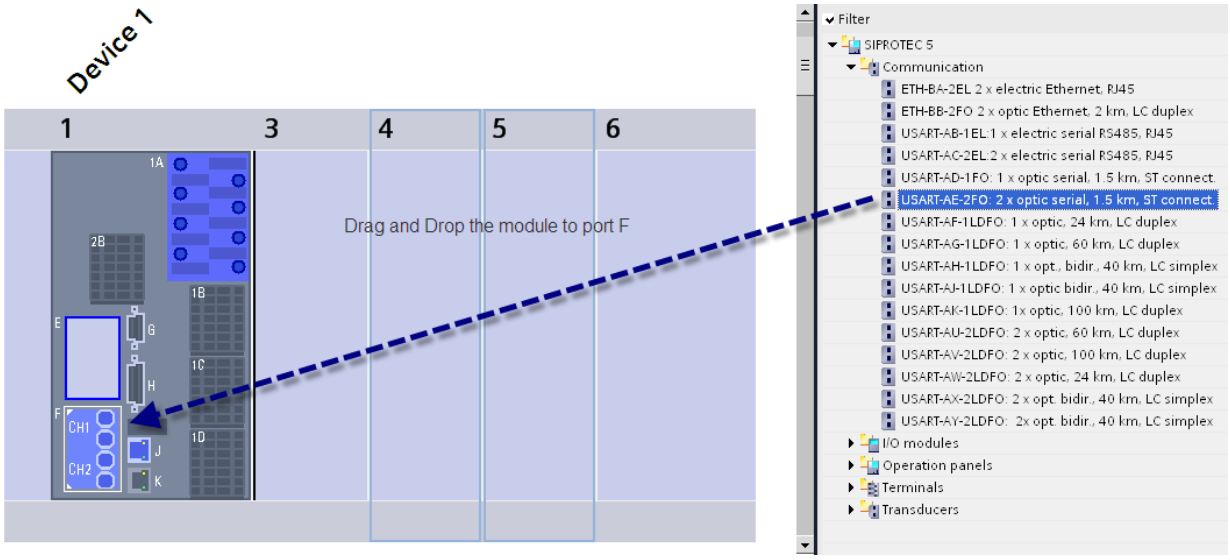

Figure 2: Assignment for module location F for the PI – interface

The settings for the first PI-interface are shown in Figure 3. The PI – interface is handled like a communication protocol which must be assigned to one channel (here channel 1) of the serial communication module (USART – module). For multi terminal (>2) connections two PI-interfaces or two channels of one communication module are required.

After this assignment of the PI-protocol the settings for the PI – interface appear. Detailed explanation for these settings is given in the manual of the devices using the PI – interface (e.g. the line protection devices 7SL8x, 7SD8x and 7SA8x).

The constellation determines how much devices are communicating with each other. Up to six are possible. Each device in a constellation must have a unique address between 1 and 65535. Here device 1 has address number 101 and device 2 number 102. Device 1 is the local device. Important is the ´Lowest appearing bitrate´. This is the slowest data connection in a device constellation and determines the number of data objects which can be transferred between the devices of a constellation. For a direct fiber optical connection it's 2048 kBit/s and therefore the highest value. Limiting value is a 64 kBit/s connection between two devices of a constellation. Especially for a differential protection function running parallel the number of additional data objects is limited. How much data objects are possible will be described for type 1 and type 2 PI-interface in the manual.

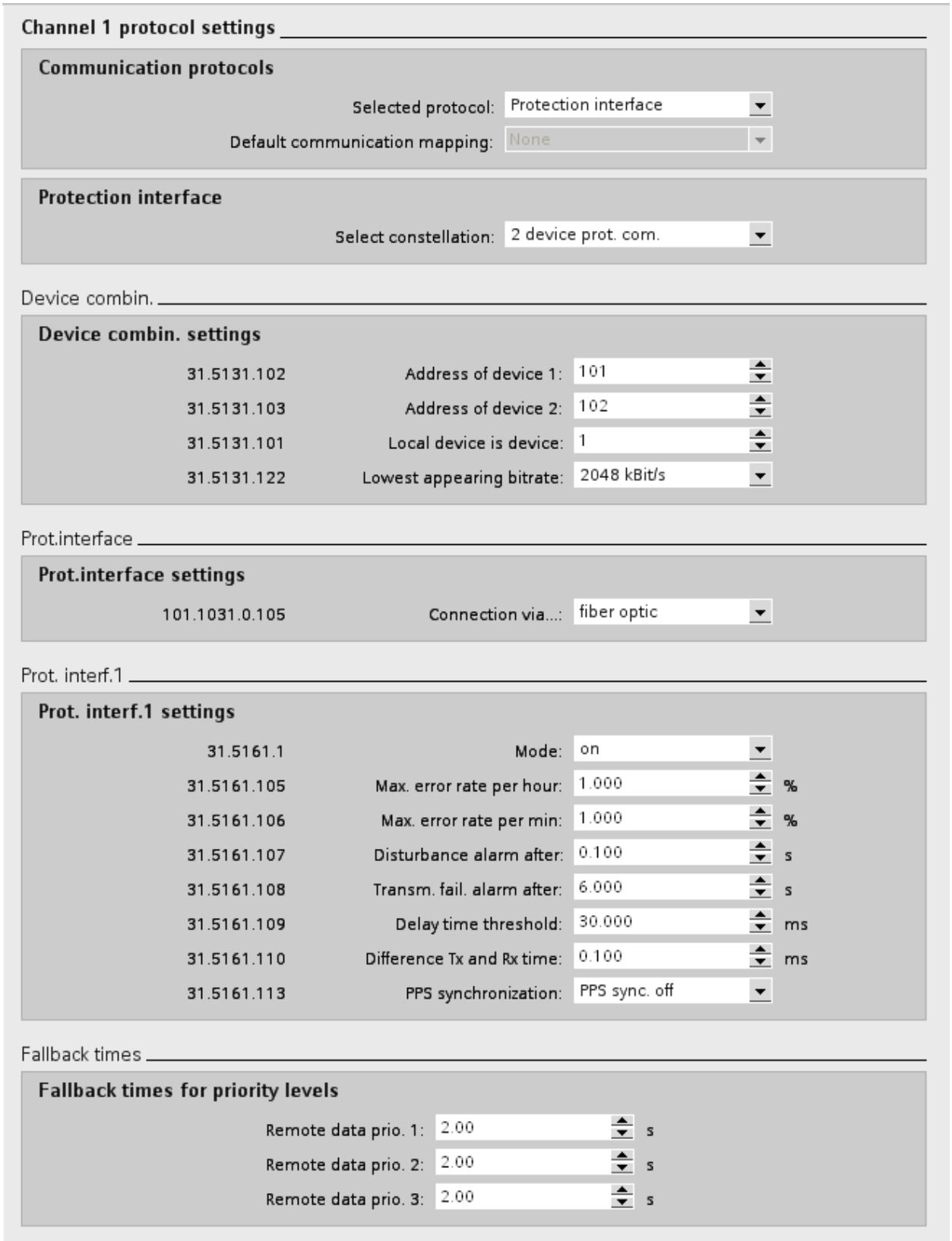

Figure 3: Settings for the PI-interface on module location F for device 1

1.2.3 Configuration of device 2 in DIGSI 5

In device 2 we are using the same module and the same settings except one value. Fig. 4 show the difference in the settings for the PI – interface for device 2.

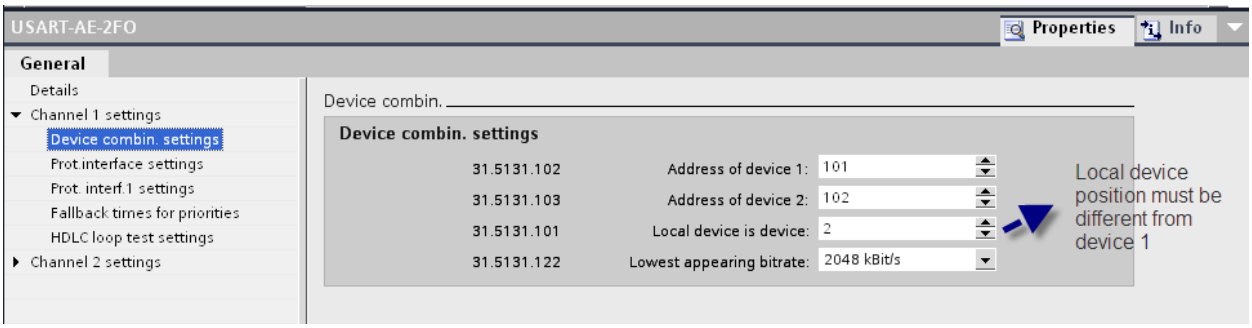

Figure 4: Settings for the PI-interface on module location F for device 2

1.2.4 Principle of the data transfer via the protection interface

Depending on the available bit rate between the devices and the type of the interface (differential (type 1) or non-differential (type 2)) signals and measurements can be freely assigned in DIGSI 5 in a communication mapping editor. These values are transferred between devices belonging to a constellation with a common communication topology.

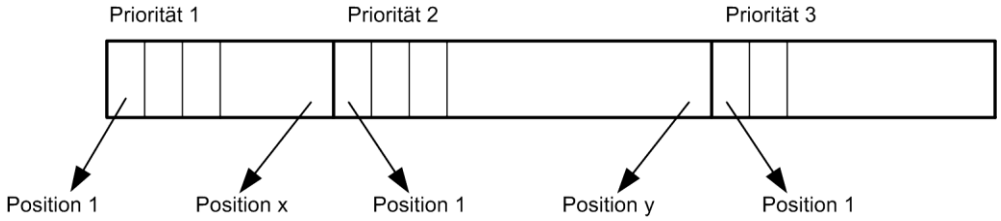

Figure 5: Principle of the data transfer via the protection data interface

The signals (data objects) can be assigned in different priority levels. The amount of signals for each level is limited by the ´Lowest appearing bitrate´ and checked by DIGSI 5 according to this setting. Please be sure this setting is valid from beginning and equal in each device of a constellation. If this setting is wrong the values in the communication matrix cannot be transferred over the physical connection between the devices if the bandwidth is not available for one connection.

Signals assigned with priority 1 are send with every telegram (5 – 10 ms). Signals and measurements with priority 2 are send with every 2. telegram (10 – 20 ms). Signals and measurements with priority level 3 are send latest every 100 ms. Each signal or measurement must be assigned to a specific position inside a priority level. If e.g. a trip signal from device 1 (single point indication) is assigned to priority 1 and position 1 the other device can read the information from this position (see Fig. 5). Device 2 may assign a trip signal to priority 1 and position 2, but not to position 1, because this position is already used by device 1. So all devices share this bit – strip which is always transferred between the devices and updated by the devices. A single point indication covers one bit (position). A double point indication 2 bits and a measurement 32 bits. Important to know is that at the receiving device a data object from the same type must be configured for the reception of this data object. Normally this is a preconfigured blocking input or a user defined signal.

Because devices connected over PI-interfaces are located in different substations and different DIGSI 5 projects there are no plausibility checks for the data objects configured to the PI-interface. It's under the responsibility of the user to configure for a send data object inside a priority the same type of data object for the receiving device on the same bit – position.

Fig. 3 shows settings for the fallback times for each priority which are valid for all received data objects assigned to this priority. If a loss of communication is detected by the receiving device after this time the value of the data object can be set to a safe state (e.g. a blocking signal with state ´1´ can be set to ´0´).

1.2.5 Assignment of signals to the PI - communication mapping

Existing signals from integrated functions (e.g. protection functions or control functions) or user defined signals can be assigned to the PI – interface in the mapping editor.

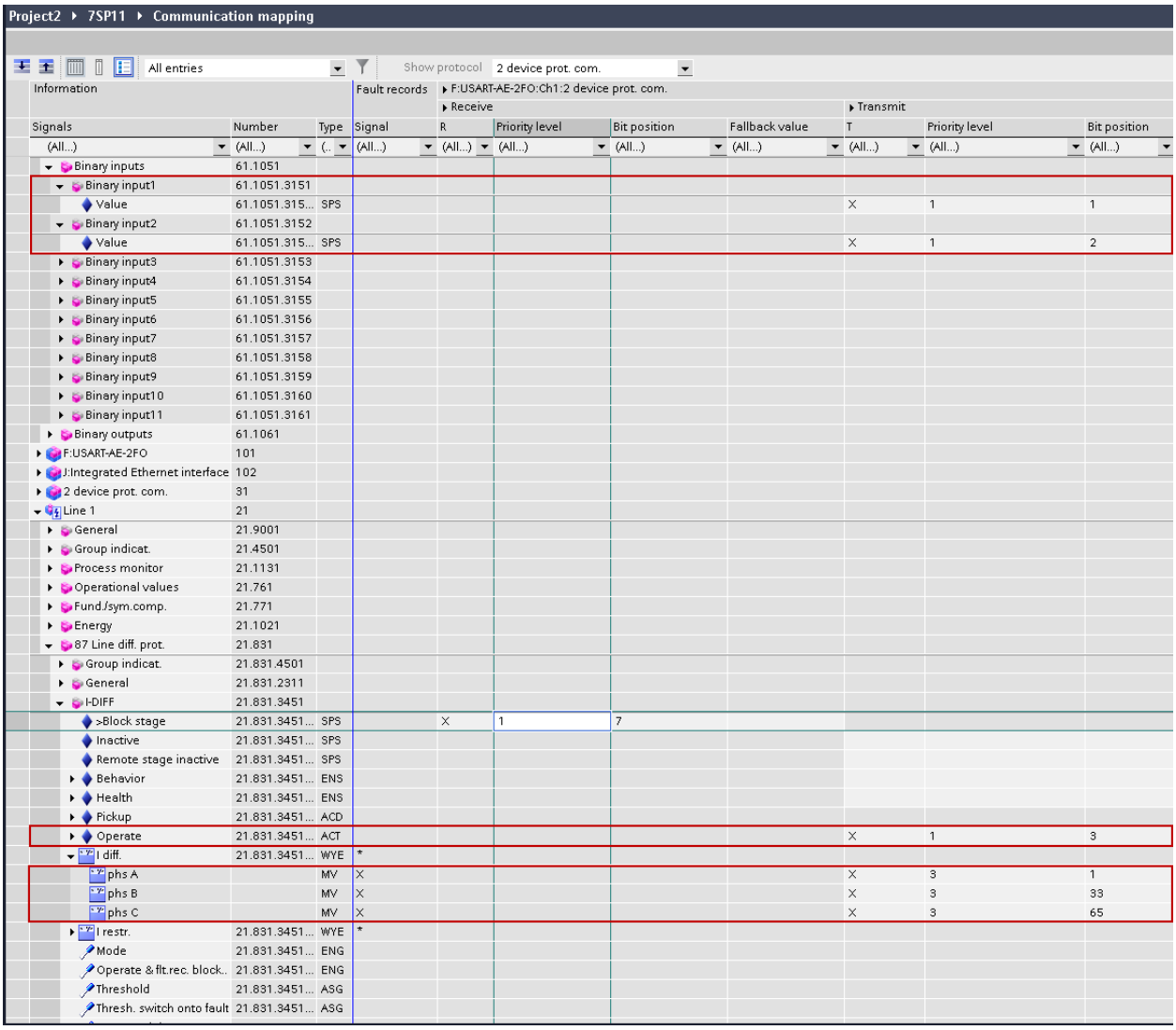

Figure 6: Assignment of data objects to the PI – interface in a communication mapping

Figure 6 shows an example for device 1. The value of binary input (BI) 1 and 2 of device 1 is assigned to priority level 1 (high) and Bit position 1 and 2. Because a BI is a Single Point Signal (Type - SPS) two bit positions are necessary for two BI-inputs. In device 2 the state of the binary inputs must received from position 1 and 2 if it shall be assigned e.g. to a trip contact or used in other applications as an input (e.g. for blocking or intertripping). Furthermore the Operate (trip) signals of the differential protection shall be transferred. This device supports single pole tripping and the Operate signal from type ACT include the three pole trip and phase selected trip signals (4 single point indications). Therefore bit positions 3 – 6 is required. As an alternative only selected trip signals could be transferred (e.g. only 3pole tripping). With priority level 3 (slow) the differential measurement values (MV) are transferred.

A measurement value needs 32 Bits (e.g. value 1 bit 1 – 32). Furthermore a signal is received on priority level 1 and bit position 7 coming from device 2. Note, that position 1 – 6 is used by device 1 for transmitting its own signals. Device 2 starts with position 7 in this example and send e.g. a SPS (trip) to device 1 which blocks the differential protection. As an option a fall back value can be set for each received signal if the communication link fails and no data are received. If no fallback value is assigned the actual value before loss of connection will be kept.

This is an example to show the principle of the assignment of data objects in the communication mapping. In this example priority level 2 is not used. The communication mapping offers a very flexible way to transfer existing and user defined signals between 2 – 6 devices between substations or inside a substation.

1.3 Test features and online supervision

1.3.1 Topology view in DIGSI 5

Once the communication is established between the two devices an editor show all relevant values of the PI – interface in DIGSI 5.

With the topology information you can check if the topology is complete and all devices are communicating with each others. Furthermore you can check if a device is logged OFF and therefore temporally out of service. The device with the lowest device address works as a timing master and can synchronize the time in the other devices of the constellation. This timing master can be checked under the topology information (last entry).

Under device information the local interface values are shown. Under ´Line´ you see if the breaker is closed or open. The value depends if the breaker position is monitored by current values only or with a feedback from the breakers auxiliary contacts or both. Also the delay time between device 1 and 2 is shown. For a short fiber optical link it's nearly to zero. Over a communication network a significant value of several milliseconds may appear. If a 1 s pulse from a GPS – clock is used the delay time in send and receive direction can be measured independent for each direction.

Also the availability of the connection is monitored. It shall be near to 100% otherwise the communication connection shall be checked. There is also an alarm threshold as a setting (see figure 3). If such an alarm appears as a failure indication you can check the value here.

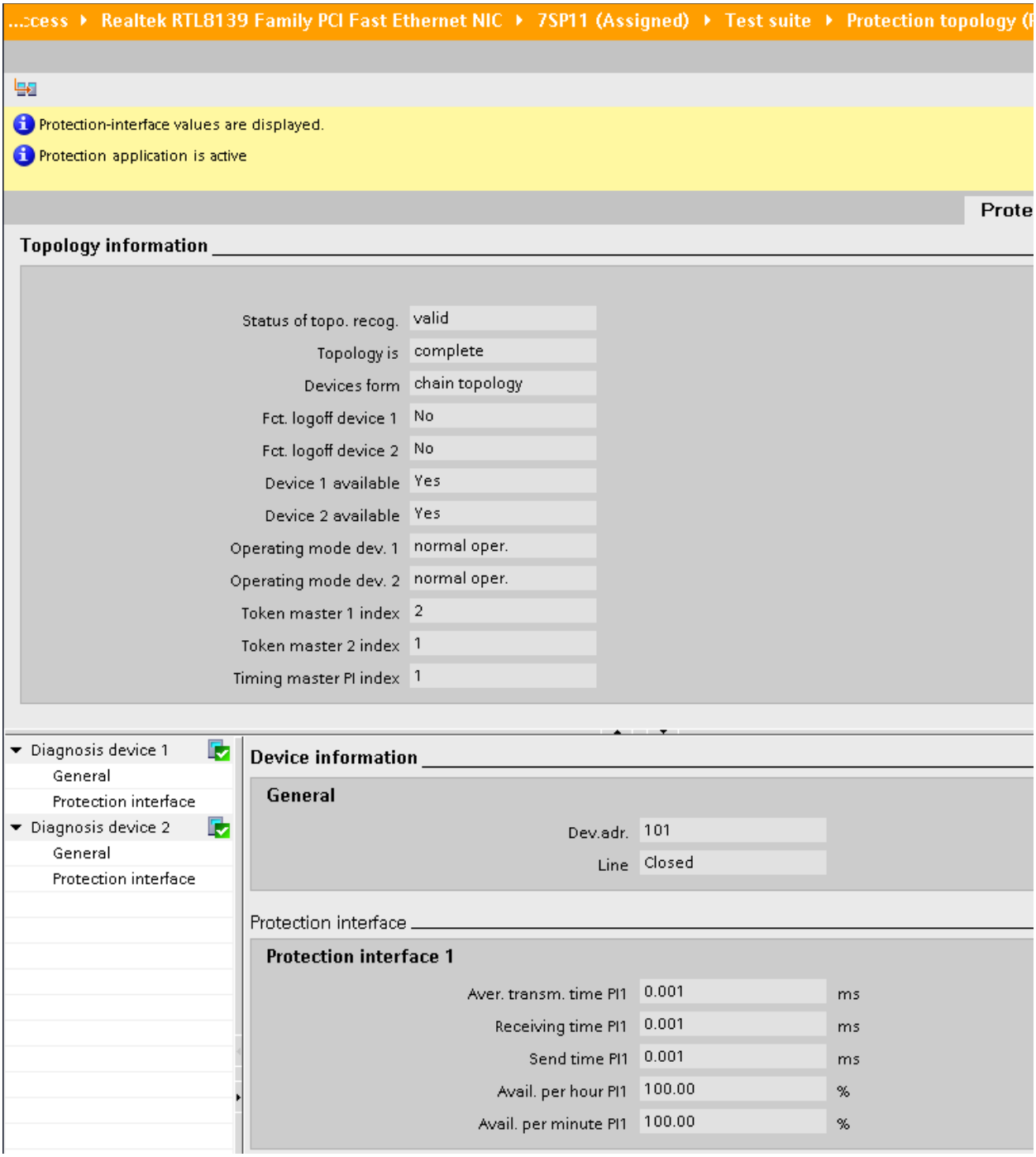

Figure 7: Test monitor for the PI – interface in the device

1.3.2 View of local and remote measurement values

If a PI-interface is configured in a Function Group Line (FG Line per default for Line protection) voltage and current values are measured by each device with their amount and their angle. This gives a complete description of the three phase system and helps to control the analogue inputs and e.g. stability of the differential protection with measured primary values.

For a device constellation connected via PI – interfaces the local and remote voltage and current values and the angles are shown in a test editor. A complete overview of the three phase system of devices in different substation is provided by

this feature. E.g. the line angle of a long line can be checked because the devices connected via PI – interfaces are exactly time synchronized with an accuracy of 10 µs.

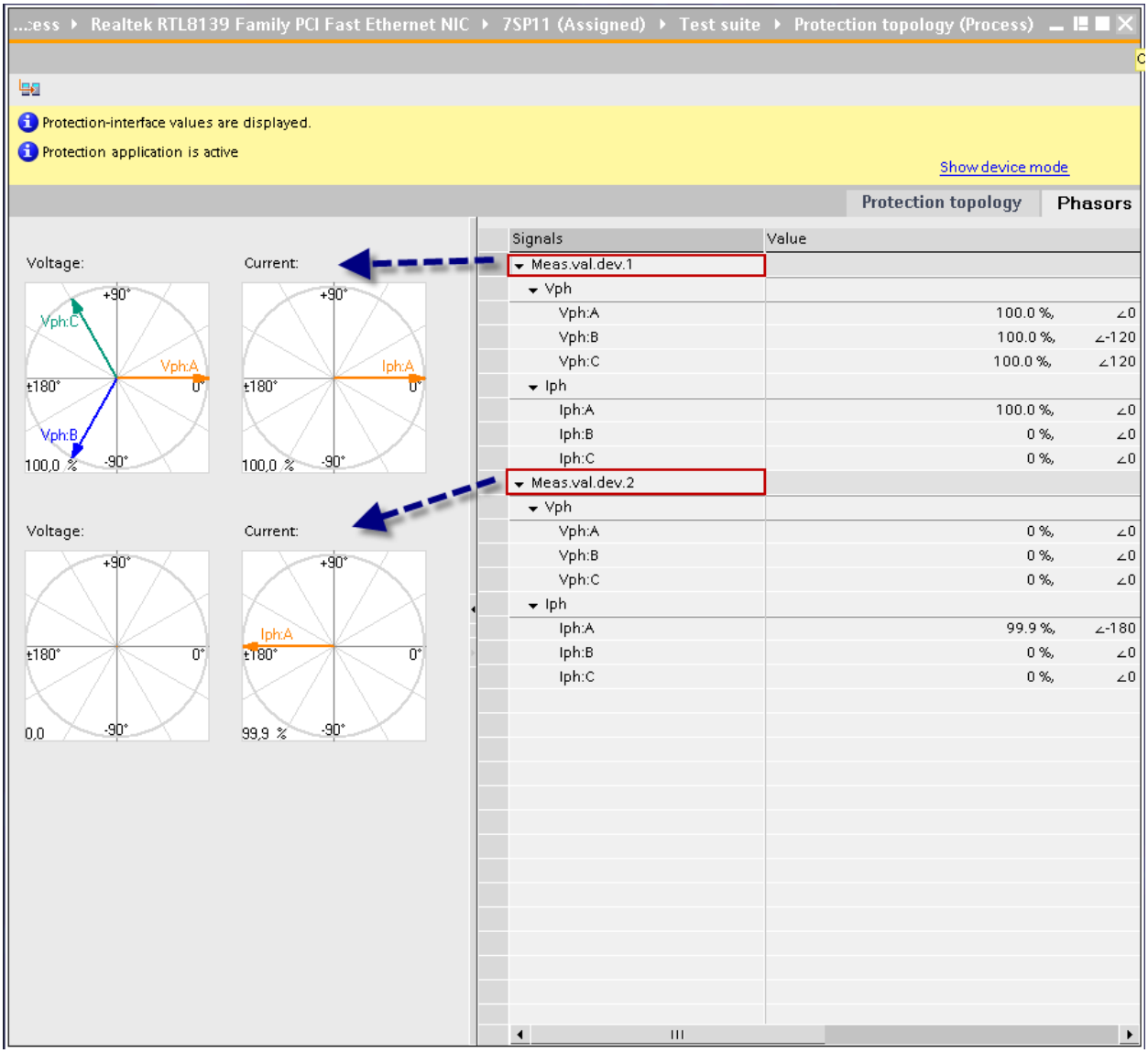

Figure 8: Test editor for voltage and currents of a device constellation connected via PI - interfaces

1.3.3 Communication diagnostic editor

For a detailed check of the communication modules with there configured channels (e.g. PI – interface) a communication diagnostic editor is available in DIGSI 5. For experts a detailed report is available which can be used to find out problems with an interface.

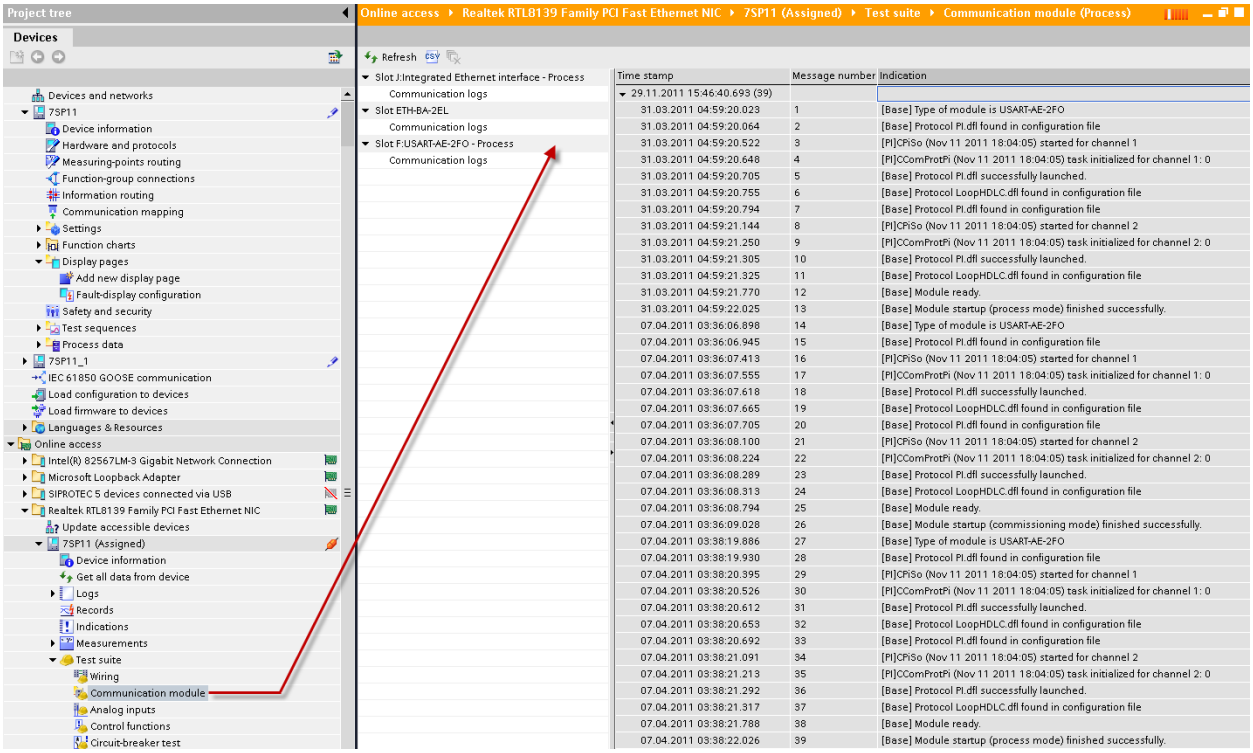

Figure 9: Communication diagnosis editor in DIGSI 5 with a detailed PI-interface report

1.4 Summary

Powerful integrated PI – interfaces can be used in communication applications for a fast exchange of binary data and measurements between devices. The concept of different priority levels and a guarantied number of signals and transfer time within a priority level offers a deterministic communication approach. Signals received over a PI-interface may be distributed inside the substation over an IEC 61850 Ethernet network with GOOSE – messages. Parallel wiring required between devices e.g. for tele protection applications can be done over communication links over long distances. Because signals can be freely assigned by the user applications can be adopted and replace inflexible hard wired traditional solutions.

Function integrated in external communication equipment can be used now with internal interfaces. Short and long connection fiber optical links are possible and also a communication over communication network by use of communication converters. Comprehensive supervision functions help to commissioning the system and to supervise it during operation. Failures and communication interruption are indicated immediately by the devices.

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Siemens AG 2016
Energy Management Division
Digital Grid
Automation Products
Humboldtstr. 59

90459 Nuremberg, Germany

www.siemens.com/siprotec

For more information,

please contact our

Customer Support Center.

Tel.: +49 180 524 70 00

Fax: +49 180 524 24 71

(Charges depending on provider)

Email: support.energy@siemens.com