synaptec
powered by Megger

Product manual

Distributed Electrical Sensing Interrogator

DES Interrogator Version: 1.0

Document: TD-002 Rev.04

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1. Introduction

1.1 Chapter overview

This chapter provides some general information about the technical manual and an introduction to the device(s) described in this technical manual.

This chapter contains the following sections:

- Chapter overview
- Foreword
- Product scope
- Features and functions
- Compliance
- Functional overview

1.2 Foreword

This technical manual provides a functional and technical description of Synaptec's Interrogator 3.0, as well as a comprehensive set of instructions for using the device. The level at which this manual is written assumes that you are already familiar with power systems instrumentation and have experience in this discipline. The description of principles and theory is limited to that which is necessary to understand the product.

We have attempted to make this manual as accurate, comprehensive and user-friendly as possible. However, we cannot guarantee that it is free from errors. Nor can we state that it cannot be improved. We would therefore be very pleased to hear from you if you discover any errors or opportunities for improvement. Our policy is to provide the information necessary to help you safely specify, engineer, install, commission, maintain and eventually dispose of this product.

We consider that this manual provides the necessary information, but if you consider that more details are needed, please contact us.

All feedback should be sent to us via info@synapt.ec.

1.2.1 Target audience

This manual is aimed towards all professionals charged with installing, commissioning, maintaining, troubleshooting or operating any of the products within the specified product range. This includes installation and commissioning personnel as well as engineers who will be responsible for operating the product.

The level at which this manual is written assumes that installation and commissioning engineers have knowledge of handling electronic equipment and fibre optics.

1.2.2 Nomenclature

Due to the technical nature of this manual, many special terms, abbreviations and acronyms are used throughout. Some of these terms are well-known industry-specific terms, while others may be special product-specific terms used by Synaptec. The first instance of any acronym or term used in a particular chapter is explained.

British English is used throughout this manual. The term 'Earth' used throughout this manual is the direct equivalent of the North American term 'Ground'.

1.3 Product scope

The Interrogator is the core component of all Synaptec sensor network installations. The device is responsible for performing centralised, light-speed interrogation of every sensor in the deployed array. Modular and scalable, the Interrogator fully supports any mix of Synaptec's electrical and mechanical sensors and is capable of both serving measurements or triggers to legacy IED devices (e.g. protection relays) and performing real-time analysis on the leveraged measurements to evaluate the performance and condition of power networks.

The Interrogator synchronously monitors up to 30 sensors over 60 km of standard single-mode optical fibre, processing and streaming Continuous Point-on- Wave (CPOW) data in real-time with industry-leading latency and detail.

The Interrogator hardware is identical for most applications (with some customisation possible for specific applications). Configuration of the device is necessary to tailor the device operation to specific applications, e.g. serving of Sampled Value (SV) data to a Process Bus or Auto-Reclose (AR) blocking on mixed circuits

1.4 Features and functions

1.4.1 Measurement functions

Function	Description
CPOW	Continuous Point-on-Wave measurement of all sensors in the optical network
Communications protocols	IEC 61850-9-2 "LE" IEC 61869-9 ISC 61850-8-1 (GOOSE)
Supported sampling rates	4 kHz 4.8 kHz 14.4 kHz
Ethernet interface	SFP (user selectable interface type)

1.4.2 Control functions

Function	Description
Watchdog contacts	Normally-open (NO) and normally-closed (NC) dry contacts available
AR block	Normally-open (NO) and normally-closed (NC) dry contacts available

1.4.3 Synthesis®

Additional visualisation and analysis functions are enabled by using the Interrogator with Synaptec's Synthesis® software.

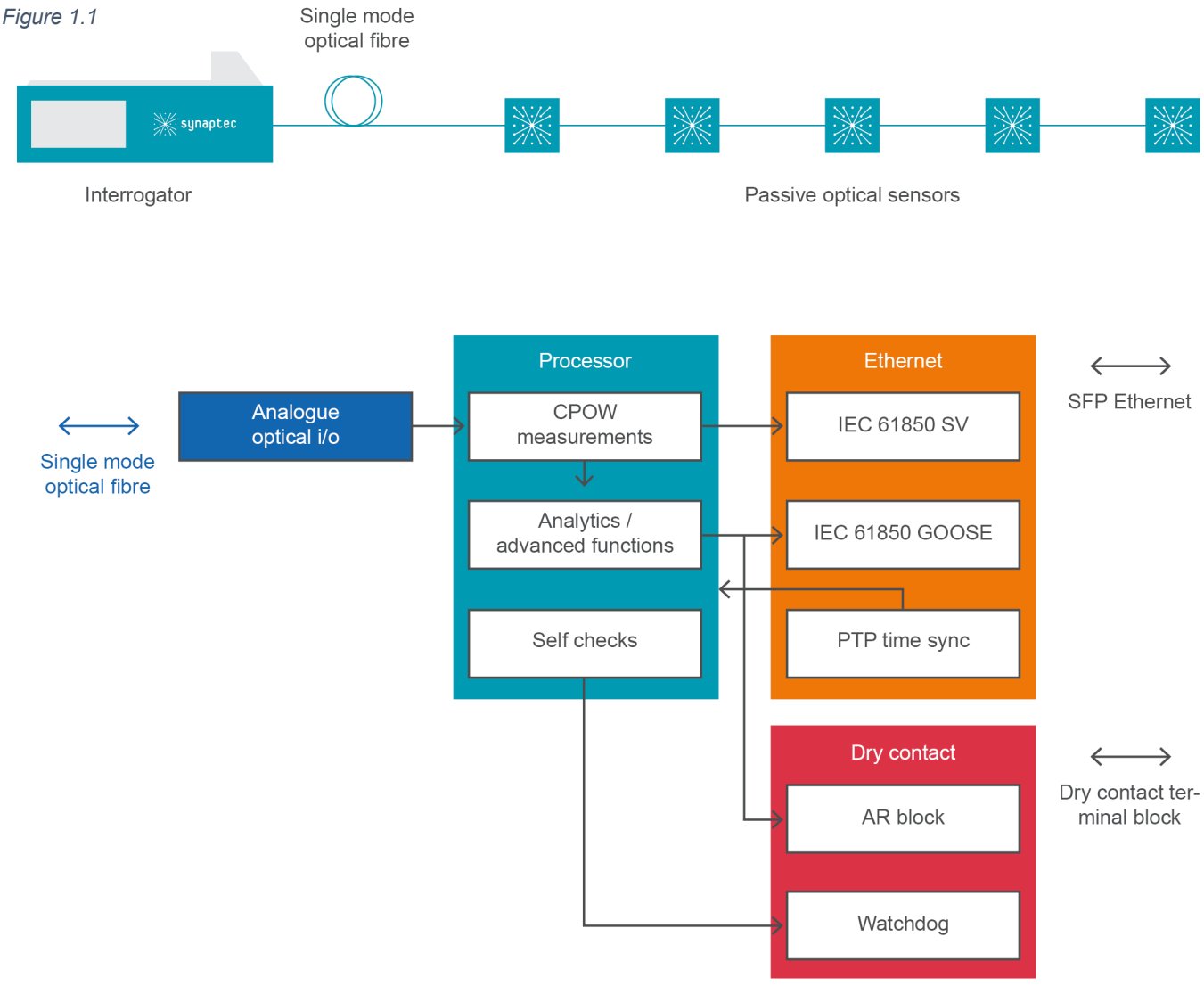
1.5 Compliance

The device has undergone a range of extensive testing and certification processes to ensure and prove compatibility with the target markets. A detailed description of these criteria can be found in Chapter 7.

1.6 Functional overview

A schematic and simplified block diagram of the Interrogator functionality is provided below.

Figure 1.1



2. Safety instructions

2.1 Chapter overview

This chapter provides information about safe handling and use of the equipment. The equipment must be properly installed and handled in order to maintain it in a safe condition and to keep personnel safe at all times. You must be familiar with the information in this chapter before unpacking, installing, commissioning or servicing the equipment.

This chapter contains the following sections:

- Chapter overview
- Health and safety
- Symbols
- Safety instructions

2.2 Health and safety

Personnel installing or using this equipment must be familiar with the contents of this Safety Instructions section.

When electrical equipment is in operation, dangerous voltages may be present in certain parts of the equipment. When the equipment is active, laser light is broadcast down the connected single-mode fibre. Improper use of the equipment and failure to observe warning notices will endanger personnel.

Only qualified personnel may work on or operate the equipment. Qualified personnel are individuals who are:

- Familiar with the installation, commissioning and operation of the equipment and the system to which it is being connected;
- Familiar with accepted safety engineering practises and are authorised to energise and de-energise equipment in the correct manner;
- Trained in the care and use of safety apparatus in accordance with safety engineering practises; and
- Trained in emergency procedures (first aid).

This manual provides instructions for installing, commissioning and operating the equipment. It cannot, however, cover all conceivable circumstances. In the event of questions or problems, do not take any action without proper authorisation. Please contact Synaptec and request the necessary information.

2.3 Symbols

This manual employs the following symbols. These may also be found labelled on parts of the equipment.

CAUTION: Refer to equipment documentation. Failure to do so could result in damage to the equipment.

WARNING: Risk of electric shock

WARNING: Risk of damage to eyesight

2.4 Safety instructions

2.4.1 Handling

Caution

Care should be taken when handling the Merger V3 system due to its size, weight and sharp corners.

Two-person handling is recommended. Please ensure that the system is not subjected to excessive vibrations or shocks during transportation or installation.

2.4.2 Hot surfaces

Caution

Areas of the rear of the system, particularly the fan exhaust and heatsink, are intended to become warm and should not be touched while the system is in operation. When the system is switched off, allow time for the rear surfaces to cool before handling.

2.4.3 Laser safety

Warning

Laser radiation can cause damage to eyes and skin and all safety precautions and instructions in this user manual must be followed to mitigate these risks.

The system operates using high-power 1550 nm near-IR laser technology which, by design, is constrained to optical fibres. The laser is a Class 3B product.

Laser output is provided via SC/APC connectors on the rear panel which incorporate a shutter to avoid stray laser light exiting when the external fibre is disconnected. At 1550 nm, the emitted light is invisible to human eyes. Under no circumstances should the user look directly into the SC/APC connector or attempt to open the shutter mechanism manually.

The system should not be switched on until all fibre optic connections to the equipment have been made. If any fibre connections are required to be disconnected, the equipment should first be switched off.

2.4.4 High voltages

Warning

The system is capable of operating from a supply voltage of up to 264 VAC and 370 VDC, connected to input terminals on the rear panel. When installing and servicing the system, ex-treme care should be taken to protect against shock.

Installation, service and repair of the system must only be performed by trained and author-ised personnel. The input power supply must be switched off and the system isolated before opening the top cover.

3. Product overview

3.1 Overview

- This chapter provides information about the product's purpose and design.
- This chapter contains the following sections:
- Chapter overview
- Product purpose and use cases
- Hardware architecture
- Mechanical implementation

3.2 Product purposes and use cases

The Interrogator is the core component of all Synaptec sensor network installations. The device is responsible for performing centralised, light-speed interrogation of every sensor in the deployed array. Modular and scalable, the Interrogator fully supports any mix of Synaptec's electrical and mechanical sensors and is capable of both serving measurements or triggers to legacy IED devices (e.g. protection relays) and performing real-time analysis on the leveraged measurements to evaluate the performance and condition of power networks.

The Interrogator synchronously monitors up to 30 sensors over 60 km of standard single-mode optical fibre, processing and streaming Continuous Point-on- Wave (CPOW) data in real-time with industry-leading latency and detail.

The Interrogator natively supports communication with digital and conventional electromechanical protection equipment. It is designed to be digital-ready, streaming live data in industry standard formats including IEC 61850 Sampled Values and GOOSE, and supporting custom data formats upon request. All measurements are time-synchronised, accurately time-stamped to within a microsecond, and published at rates of up to 14.4 kHz, enabling the system to support a combination of protection, metering and condition monitoring applications.

The uniquely powerful and flexible nature of the Interrogator makes Synaptec's systems ideal for long-range, multi-point protection, automation and control applications that demand high quality, speed, and flexibility of measurements. Streaming data from the DES Interrogator may be integrated with Synaptec's Synthesis® visualisation and analytics software to provide live system condition visualisation, configurable alarms, performance insights and decision support for asset managers.

3.3 Hardware architecture

The main components of the Interrogator are as follows:

- The housing, consisting of a front panel and connections at the rear
- Fibre optic components for illumination of and receiving of signals from an array of passive fibre optic sensors
- A processor module consisting of the main CPU (Central Processing Unit), memory and an interface to the front panel Human-Machine Interface (HMI)
- Data output and communications via Small Form-factor Pluggable (SFP) array

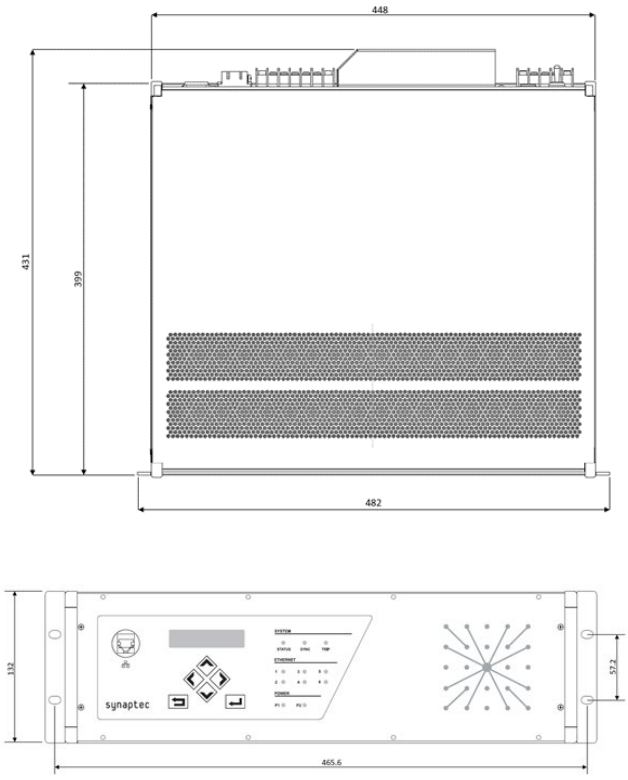
3.4 Mechanical implementation

The hardware consists of the following main parts:

- Case and terminals
- Front and rear panels
- Upper panel with ventilation grille
- Internal fibre optic and electrical modules

The case comprises the housing metal-work and terminal blocks and communications interfaces at the rear. Figure 3.1 shows a typical view of the product. The diagram shown does not necessarily represent exactly the product de-scribed in this manual.

Figure 3.1



4. Connections and interfaces

4.1 Chapter overview

This chapter provides information about the product's purpose and design.

This chapter contains the following sections:

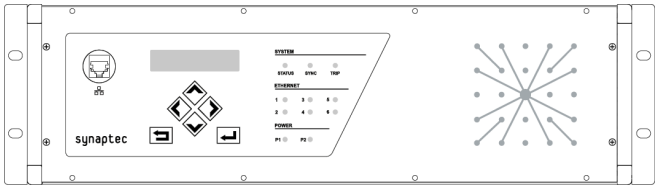
- Chapter overview
- Front panel interfaces
- Rear panel interfaces

4.2 Front panel interfaces

4.2.1 Front panel

Figure 4.1 shows the front panel of a typical Interrogator unit.

Figure 4.1



The front panel houses the following interfaces:

- HMI panel with LCD display
- Keypad
- RJ45 Ethernet port
- Fixed-function LEDs

Front membrane panel

The front membrane panel of a typical Interrogator unit is shown in Figure 4.2, with numbered items specified in Table 4.1 on the following page.

LCD Display and keypad

The keypad provides access to device functionality using a range of menu options. The in-formation is displayed on the LCD. The LCD is a high-resolution display with 16 characters by 2 lines and a controllable back light.

Ethernet port

The Ethernet port is situated on the front panel and is used to communicate with a locally connected PC. It is used for configuration and commissioning of the device.

This port is intended for temporary connection during testing, installation and commissioning. It is not intended to be used for permanent communications.

Figure 4.2

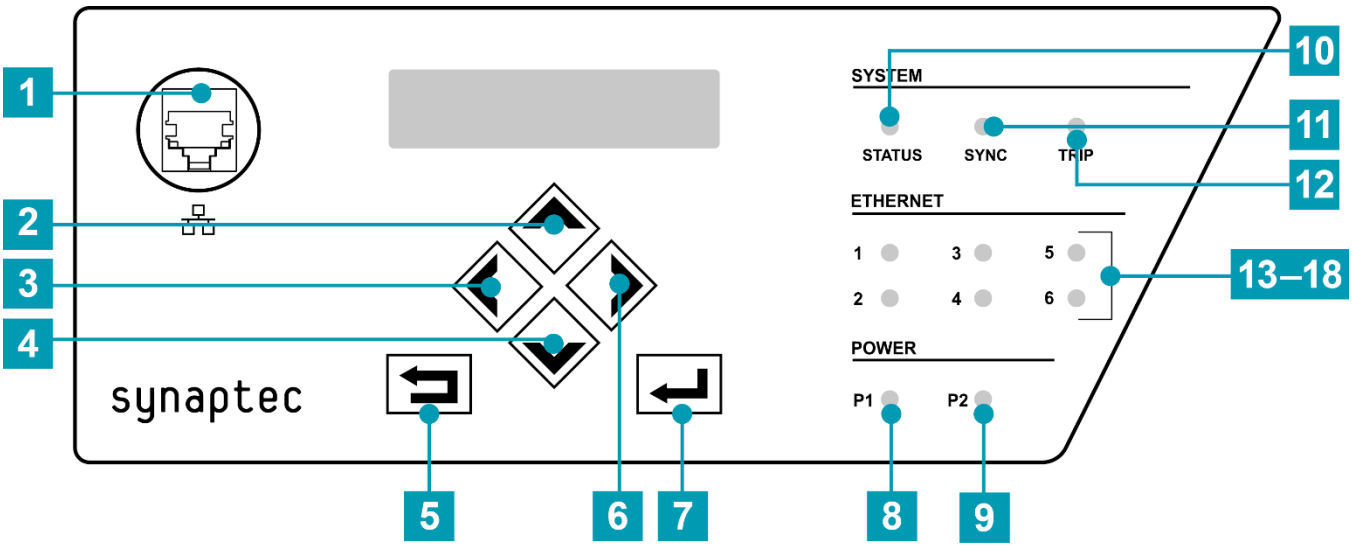


Table 4.1: Front membrane panel items.

Item	Description	Function	Specifications
1	Ethernet Port	1Gbps Ethernet	RJ45, 10/100/1000BASE-T IEEE 802.3 compliant
2	Menu navigation button	Up	
3	Menu navigation button	Left	
4	Menu navigation button	Down	
5	Menu navigation button	Back	
6	Menu navigation button	Right	
7	Menu navigation button	Enter	
8	Indicator LED	Power P1 - Indicates unit is powered on (with redundant PSU 1) / indicate PSU 1 failure	Green / Amber LED
9	Indicator LED	Power P2 - Indicates unit is powered on (with redundant PSU 2) / indicates PSU 2 failure	Green / Amber LED
10	Indicator LED	Status - Indicates system has started up correctly and is in normal state / indicates malfunction or measurement flag raised	Green / Amber LED
11	Indicator LED	Sync - Indicates time synchronisation has been established	Green LED
12	Indicator LED	Trip - Indicates tripping of protection system (if deployed)	Red LED
13	Indicator LED	Ethernet 1 - Indicates Ethernet 1 interface connected	Green LED
14	Indicator LED	Ethernet 2 - Indicates Ethernet 2 interface connected	Green LED
15	Indicator LED	Ethernet 3 - Indicates Ethernet 3 interface connected	Green LED
16	Indicator LED	Ethernet 4 - Indicates Ethernet 4 interface connected	Green LED
17	Indicator LED	Ethernet 5 - Indicates Ethernet 5 interface connected	Green LED
18	Indicator LED	Ethernet 6 - Indicates Ethernet 6 interface connected	Green LED

Fixed-function LEDs

Eleven fixed-function LEDs are present on the front panel, grouped under the following headings:

System:

- STATUS LED switches Green when the Interrogator is operating normally and Red when an alarm or malfunction condition is encountered. It is reset to Green when this condition is cleared and normal operation has resumed.
- SYNC LED switches Green when the Interrogator has acquired an external time synchronisation signal and Red when in free-running mode.
- TRIP LED switches Red when the Interrogator issues a trip signal. Conditions for trip may be configured or the function disabled via the HMI or software.

Ethernet:

- LEDs 1-6 switch ON (Green) to indicate on which SFP Ethernet ports communications are active.

Power:

- LEDs P1 and/or P2 switch ON (Green) to indicate which of the dual redundant power supplies are currently active.

4.3 Rear panel interfaces

4.3.1 Rear panel

The rear panel of a typical Interrogator unit is shown in Figure 4.3, with numbered items specified in Table 4.2.

Figure 4.3

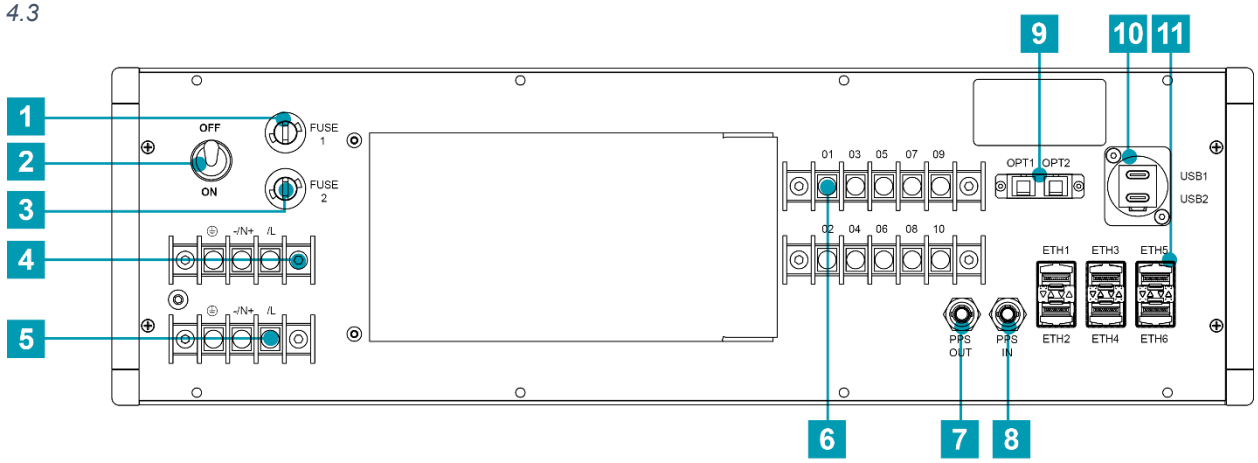


Table 4.2: Rear panel items.

Item	Description	Function	Specifications
1	Power Supply Fuse 1	Fuse for power module 1	8A Fast 250V 1.5kA breaking
2	Power Supply Switch	4-Pole switch to control the power input.	
3	Power Supply Fuse 2	Fuse for power module 2	8A Fast 250V 1.5kA breaking
4	Power Supply Terminals 2	Connection point for power supply to module 2	Power Module UL, CSA, CE certified Input Range Single phase, 85 to 264 VAC, 80 to 370 VDC AC Frequency 50/60 Hz (47 to 450 Hz)
5	Power Supply Terminals 1	Connection point for power supply to module 1	Power Module UL, CSA, CE certified Input Range Single phase, 85 to 264 VAC, 80 to 370 VDC AC Frequency 50/60 Hz (47 to 450 Hz)
6	Relay Interface	NO and NC relay contacts	Relay 2kV coil to contact and contact to contact 2kV isolation to case 8A 250VAC Resistive capacity
7	Optical Timing Interface (Output)	LED output, fibre interface	-7dBm max output at 820nm, ST fibre compatible

Table 4.2 (continued)

Item	Description	Function	Specifications
8	Optical Timing Interface (Input)	Photodiode input, fibre interface	-7dBm max input, ST fibre compatible
9	Optical Measurement Interface	Fibre ports for measurements, laser output	SC duplex fibre port, shuttered
10	Engineering Interface	USB interfaces for test and development	USB compliant interfaces
11	Network Interface	SFP module cages for Ethernet interfaces	Dependent on module fitted

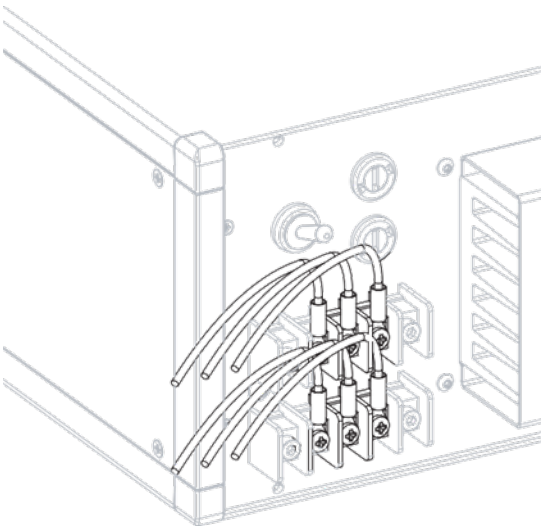
The rear panel houses the following interfaces:

- Power supply terminals and power switch
- Relay interface
- Optical measurement interface
- Optical timing interfaces (PPS)
- Network interface

Power supply terminals

Dual redundant power supplies are available inside the Interrogator chassis. Two independent terminal blocks are provided on the rear panel for additional redundancy, labelled appropriately for connection of external AC or DC supplies. Should a single supply be available externally, this should be wired up to both terminal blocks in parallel. Should two supplies be available, these may be wired up separately to each terminal block. Power supply wiring should be terminated in suitable ring lugs for connection to the M4 screw terminals. Per the diagram in Figure 4.4, to ensure clearance for the mounting bracket the power wires should enter the terminal connections from above.

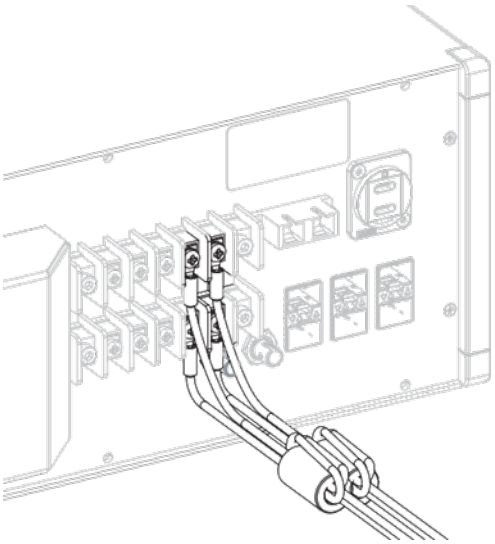
Figure 4.4



Relay interference

The relay interface provides dry contacts for both normally-open (NO) and normally-closed (NC) operation. Wiring for connection to an external device (e.g. watchdog device or protection relay) should be terminated in suitable ring lugs for connection to the M4 screw terminals. Connections to the relay terminals may be made from the top or bottom to best suit cable routing. The individual pairs of relay cables must be installed with a Wirth 74270053 ferrite bead with wires looped around per the diagram in Figure 4.5.

Figure 4.5



Optical measurement interface

The Interrogator is designed for monitoring of Synaptec's passive optical sensors via standard single- mode optical fibre. At the Interrogator, connection to the external optical sensor network should be made via an appropriate single-mode fibre optic patch cable terminated in an SC/APC connector.

PPS time synchronisation ports

The Interrogator may be time-synchronised via either IEEE 1588 Precision Time Protocol (PTP) or Pulse-Per-Second (PPS). In the case of PPS synchronisation, two ST fibre ports are present for synchronisation to and re-broadcast of a PPS signal.

Ethernet communication ports

Six multi-purpose SFP module cages are provided for interface with external devices.

5. Installation and commissioning

5.1 Chapter overview

This chapter provides information about installing and commissioning the product.

This chapter contains the following sections:

- Chapter overview
- Handling
- Mechanical installation
- Cables and connectors

5.2 Handling

Synaptec's products are of robust construction but require careful handling and treatment until installation is complete. This section discusses requirements for receiving and unpacking the goods, as well as associated considerations regarding product care and user safety.

Caution

Before lifting or moving the equipment you should be familiar with the Safety Instructions chapter of this manual.

5.2.1 Receipt

On receipt, confirm the correct product has been delivered. Unpack the product immediately to ensure there has been no external damage in transit. If the product has been damaged, make a claim to the transport contractor and notify Synaptec promptly.

If the product is not intended for immediate installation, repack it in its original delivery packaging.

5.2.2 Unpacking

When unpacking and installing the product, take care not to damage any of the parts and make sure that additional components are not accidentally left in the packaging or lost. Do not discard any technical documentation. These should accompany the product to its installation destination and be stored in a dedicated safe location.

The site should be well-lit to aid inspection, and should be clean, dry and reasonably free from dust and excessive vibration. This particularly applies where installation is being carried out at the same time as construction work.

5.2.3 Storage

If the product is not intended for immediate installation, store it in a place free from dust and moisture in its original packaging.

On subsequent unpacking, make sure that any dust on the carton does not fall inside. Avoid storing in locations of high humidity. The device can be stored between -25 °C to +70 °C (see technical specifications).

5.3 Mechanical installation

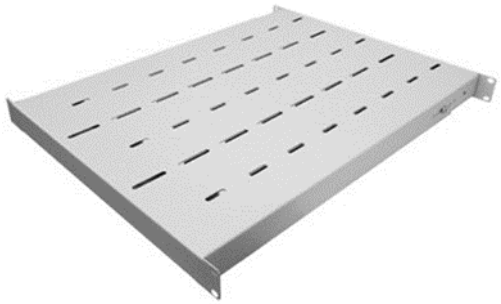
The product is dispatched either individually or as part of a rack assembly. The product is ultimately designed to be compatible with a 19" (483 mm) rack with 3U height.

5.3.1 Rack mounting

The Interrogator device occupies a rack height of 3U (three rack units). However, a space of 1U must be provided above the Interrogator to allow for adequate ventilation.

Installation in the rack will vary depending on the rack design. To ensure long-term, reliable operation, it is required that the device is located on a shelf system with minimum static load-bearing capacity of 15 kg, fixed at both the front and rear of the cabinet. An example of a suitable shelf is shown in the image below:

Figure 5.1



The Interrogator must be secured at the front of the rack using the four standard rack mounting bolt positions. Bolts compatible with the rack system must be used (generally M6), and must be of sufficient length to pass through the Interrogator flange, shelf flange, rack upright and cage nut. The four bolts should be tightened to the torque specified by the rack manufacturer.

Installation of the Interrogator and rear panel brackets for connection to the shelf are shown in Figure 5.2 and Figure 5.3. The following instructions refer to the numbered items in Figure 5.3.

At the rear, the Interrogator should be secured to the installed shelf using the two mounting brackets (**3**) suppled. Install the two brackets to the rear of the Interrogator using the supplied M2.5 x 20 screws (**6**) and washers (**7**) and tighten to a torque of 1.0 Nm.

When the Interrogator is installed and seated correctly on the shelf, use the supplied M6 x 25 screws (**1**), washers (**2,4**) and nylon-insert nuts (**5**) to attach the two brackets to the shelf. The screws should be tightened to a torque of 8 Nm.

Depending on the shelf design, it may be necessary to drill suitable locating holes in the shelf to enable retention of the brackets.

Caution

Sufficient space should be left above the upper panel to ensure air flow to the ventilation grille. It is recommended that minimum ½U of rack space is left open above the Interrogator for this purpose.

Figure 5.2

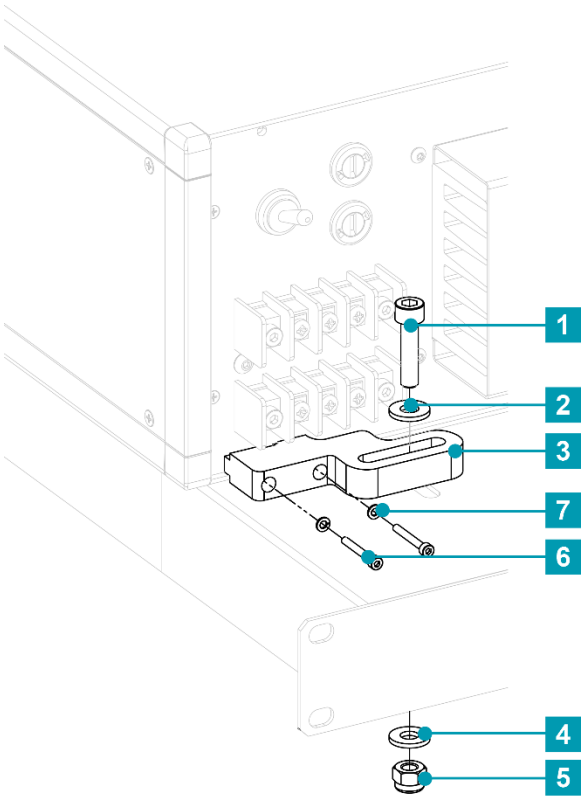
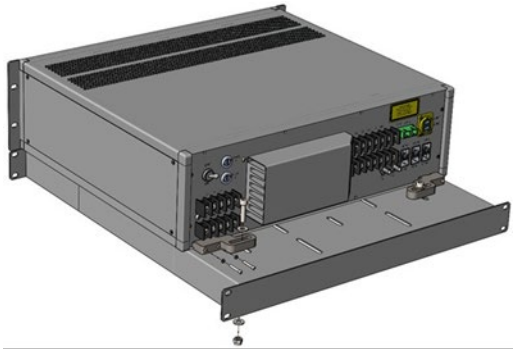
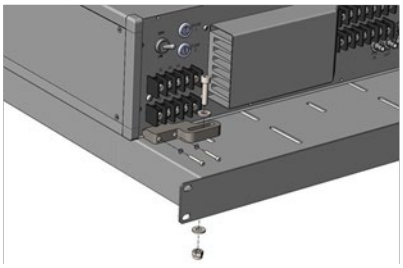


Figure 5.3





5.4 Cables and connectors

5.4.1 Electrical connections

Appropriately rated cables should be used for all electrical connections. These should be chosen by the installer with reference to the power supply ratings provided in Table 4.2.

5.4.2 Fibre optic connections

The optical measurement interface should be connected to the sensor network using telecoms standard OS2 single-mode fibre patch cables, terminated in an SC/APC connector.

If PPS time synchronisation is being used, the optical timing interface should be connected to the time source using telecoms standard multi-mode fibre patch cables, terminated in an ST connector.

5.4.3 Comms connections

The Interrogator is supplied with six small form-factor pluggable (SFP) network connections on the rear panel. A suitable SFP transceiver should be chosen by the installer for interface between the Interrogator and any external network or devices.

5.5 Commissioning

5.5.1 General guidelines

Synaptec's Interrogator performs self-checks during start-up and will raise an alarm in the unlikely event of a failure.

To commission the devices, the commissioning engineer is not required to test every function. It is only necessary to verify that the hardware is functioning correctly and that the application-specific software settings have been applied. Synaptec engineers will be able to confirm settings and system functionality should this be required at the commissioning stage.

Caution

Before carrying out any work on the equipment you should be familiar with the Safety Instructions chapter of this manual.

Warning

Do not disassemble the device during commissioning.

Warning

If a fibre optic connection is made to the optical measurement interface on the rear panel of the unit, do not power the system on until all fibre connections are safely made.

Commissioning will typically follow installation of a series of Synaptec passive optical sensors and connection of the single-mode fibre network to the Interrogator during its installation. Commissioning is then required to confirm that the system is operating as designed and within agreed limits.

Commissioning activities may vary depending on the application and user policy. This chapter covers only the minimum commissioning requirements necessary to confirm operation of the Interrogator. Further commissioning activities shall be agreed with Synaptec during project specification.

5.5.2 Commissioning equipment

As an absolute minimum, the following equipment is required:

- Hardware or software packet inspection tool (e.g. Wireshark network packet analyser, https://www.wireshark.org/)
- Ethernet cable
- Label maker
- Optical time-domain reflectometer (OTDR)
- Fibre end cleaner
- Fibre optic test kit (source and optical power meter)

5.5.3 Visual inspection

Carefully examine the Interrogator to check that no physical damage has occurred since installation.

Ensure that the case earthing connections at the rear panel power supply terminals are used to connect the unit to a local equipment earth.

5.5.4 External wiring

Caution

Check that any external wiring is correct according to the installation scheme agreed with Synaptec.

Electrical connections to external equipment (power supplies, dry contacts) are the responsibility of the installer.

5.5.5 Power supply

The Interrogator can be operated from a DC or AC supply. The incoming voltage must be within the operating ranges stated in the device specifications.

Caution

Only energise the Interrogator if the auxiliary supply is within the specified operating ranges.

Warning

The Interrogator outputs near-IR laser light. Do not energise the Interrogator if open fibre optic connections are present in the optical sensor network. Ensure all connections are made before energising the device.

5.5.6 Power-on self-test (POST)

On energisation of the Interrogator, the device will run a series of self-checks to ensure it is operating correctly. If completed successfully, the front panel LCD screen will indicate 'System Ready' per the example below:

Should any issues arise during the POST process, an alarm will be raised by the system and Synaptec engineers should be contacted for assistance.

5.5.7 *Fibre optic connections*

With the system energised and POST passed, the Interrogator will perform further checks to determine whether all optical sensors in the specified network can be detected via the connected single-mode fibre. Should there be any issues, an alarm will be raised by the system.

This type of problem is typically a result of improper or faulty fibre connections external to the Interrogator in the sensor array. An OTDR device should be used to examine the sensor array from the point of connection to the Interrogator and identify any locations of high optical losses. The telecoms contractor responsible for fibre connections should then repair any affected fibres or connections until the Interrogator alarm is resolved. It may also be required to clean the connectors of any fibre patch cables using a fibre end cleaner.

Following verification of the fibre network, it should be ensured that all fibres used for the system are labelled adjacent to the Interrogator with their use or allocation as appropriate.

5.5.8 *Sampled value output*

The Interrogator is typically configured to output measured values from the sensor array in IEC 61850 Sampled Value (SV) format over Ethernet via the network interfaces on the rear panel. Following successful installation, visual checks, POST, and confirmation of fibre optic connections, the presence of the SV stream(s) on the network can be verified using a hardware or software packet inspection tool. For example, Wireshark (https://www.wireshark.org/) can be installed on a suitable computer connected to the SV Ethernet network interface (or connected via a network switch).

6. User operation and software configuration

6.1 Chapter overview

This chapter provides information about operation of the product and software configuration.

This chapter contains the following sections:

Chapter overview

User operation

Software configuration

6.2 User operation

This section explains the operation of the user-facing aspects of the Interrogator.

6.2.1 *Basic operation and front-panel indicators*

After completing the installation and commissioning process (see Chapter 5), the Interrogator can be powered. The POST process will begin, which will check the internal subsystems and configuration of the Interrogator and the connected sensor array.

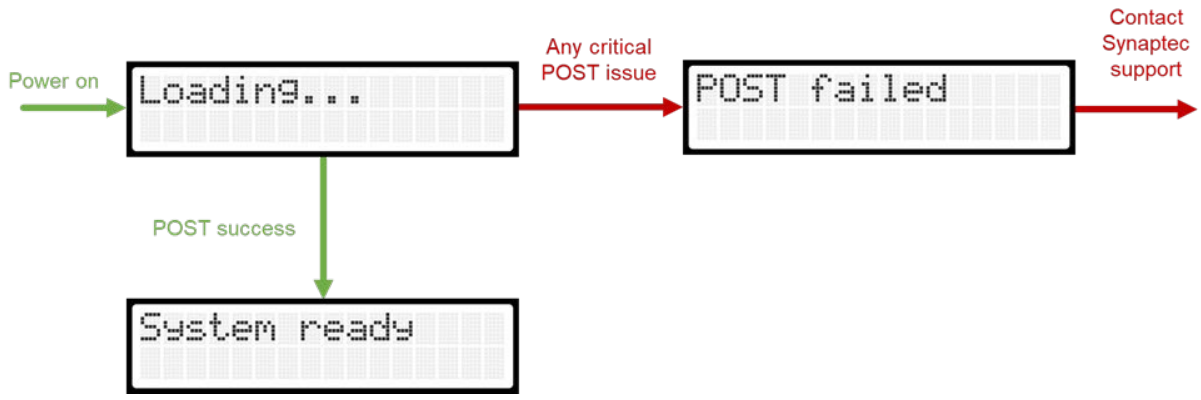
During this process, the front-panel LCD will display the “Loading...” message. After the POST process completes, the LCD will display the “System ready” message. If a critical POST issue is detected, then “POST failed” message is displayed and Synaptec support should be contacted. This sequence is summarised in Figure 6.1 on the following page. The POST process typically takes 2-3 minutes to complete. Note that if the sensor array is misconfigured, such as due to the sensor optical fibre not being connected, the POST process will take longer to complete.

LEDs for the appropriate subsystems in use, such as rear Ethernet ports and PTP time synchronisation, will be illuminated (see Chapter 4 for the full description of the front panel indicators).

6.2.2 *Front-Panel HMI Input Buttons*

At present, the front-panel HMI input buttons are not used.

Figure 6.1: LCD message flow chart.



6.2.3 Front-Panel Ethernet Port

At present, the front-panel Ethernet port is not used.

6.3 Software configuration

This section describes how the Interrogator can be configured to perform multiple functions and applications.

6.3.1 System settings

At present, system settings are configured by Synaptec at the factory. Table 6.1 describes the available settings.

Table 6.1: System settings.

Setting	Possible values
Nominal system frequency	50 Hz or 60 Hz

6.3.2 Network interface settings

At present, network interfaces are configured by Synaptec at the factory, and will be tailored for each application's requirements. For example, this may include PTP time synchronisation, SV output streams, and GOOSE trip commands. Six Gigabit network interfaces are available, supporting both optical and electrical SFPs, allowing a high level of flexibility and customisability for real-time applications.

6.3.3 IEC 61850 Configuration

Information relating to the IEC 61850 data model definition, SV/GOOSE services, and related parameters will be provided in an IED Capability Description (ICD) file. This will enable interoperability and distributed functionality with other IEC 61850 devices.

Synaptec will provide an ICD file, where required, for use in system installation and commissioning.

6.3.4 Protection settings

At present, all protection settings are configured by Synaptec at the factory, and correct system operation will normally be demonstrated during a Factory Acceptance Test (FAT).

Current differential protection overview

Current Differential Protection is used to enable Mixed Circuit Protection (MCP) and Busbar Protection applications. Two-ended differential schemes are the common case, but the function can also readily be configured to support multi-ended zones. The protection operates independently on a per-phase basis. For MCP applications, a "trip" is equivalent to an AR block command.

The processing chain calculates high-fidelity current phasors from waveform samples at the full sensor sampling rate (typically 4 or 4.8 kHz). The phasor calculation is designed to be highly resilient to disturbances such as noise, harmonics, DC component phase-steps, and off-nominal frequency. The performance is also tuned to enable fast measurement response and therefore to ensure sub-cycle tripping for low-impedance faults.

Due to the nature of interrogating remote CTs, potentially over long distances, at the speed of light, Synaptec's line current differential protection solution can operate significantly faster than conventional approaches which rely upon communications networks, which can add delay and jitter. Another advantage is that all measurements performed by each Interrogator are inherently synchronised to a common time reference, so current differential protection can be executed without requiring external time synchronisation (or can operate continuously even if the time synchronisation source is lost).

Current differential protection settings

The current differential protection scheme uses dual-slope characteristic as illustrated in Figure 6.2. The protection settings will be defined in collaboration with the customer and the specific application requirements.

Figure 6.2: Current differential protection characteristic.

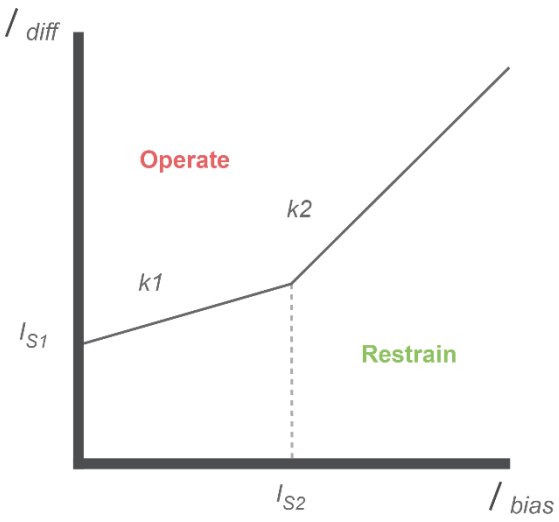


Table 6.2 describes the settings available for current differential protection schemes. Note that setting ***k1 = k2*** creates a single slope characteristic, if desired.

Table 6.2: Protection settings.

Setting	Possible values
I_{S1}	Minimum operating/ pickup current
I_{S2}	Bias slope breakpoint threshold
k1	Gradient of first slope
k2	Time required for continuous trip state before actual trip is issued

Idiff is calculated as the **vector sum** of the input current phasors. It should equal 0 A in a perfect, non-fault scenario (although there are sources of error which make it non-zero).

Ibias is the bias (or restraining or spill) current, and is the **sum of the magnitudes** of the current input phasors, divided by 2. This is used to make the protection less sensitive during high currents, which may be due to CT saturation or external (“through”) faults.

Operate means that a genuine fault has been detected inside the protected zone. In MCP applications, AR should be blocked.

Restrain means that the measurements are from non-fault conditions, or from an external fault. In MCP applications, AR should not be blocked.

Protection trip outputs

Trip outputs are typically assigned to a normally-open or a normally-closed dry contact output (see Chapter 4 for details). Dry contact trip outputs are configured to latch for at least 1 second from fault detection. If a fault condition is no longer present after 1 second, the dry contact output will revert to its inactive state.

Trip outputs and other information can also be published using fast-responding IEC 61850-8-1 GOOSE messaging. This configuration is presently performed by Synaptec engineers.

Dry contact outputs can also be configured by Synaptec to provide a system watchdog function.

CT polarity

During system commissioning, Synaptec engineers can reverse the polarity of individual CTs within the Interrogator system software, to correct for improperly installed CTs.

6.3.5 Software updates

At present, only Synaptec-qualified engineers can perform Interrogator software updates.

7. Technical data

7.1 Chapter overview

This chapter describes the technical specifications of the product.

This chapter contains the following sections:

- Chapter Overview
- Mechanical Specifications
- Environmental Conditions
- Regulatory Compliance

7.2 Mechanical specifications

7.2.1 Physical parameters

Table 7.1

Item	Specification
Dimensions (main body only)	W: 448 mm, H: 132 mm, D: 399 mm
Dimensions (including mounting and rear panel components	W: 482 mm, H: 132 mm, D: 431 mm
Weight	8.3 kg

7.2.2 Enclosure protection

Table 7.2

Item	Specification
Enclosure protection	IP2X (IEC 60529)

7.2.3 Mechanical robustness

Table 7.3

Item	Specification
Vibration test per IEC 60255-21-1	Class 1
Shock and bump test per IEC 60255-21-2	Class 1
Seismic test per IEC 60255-21-3	Class 1

7.3 Environmental conditions

7.3.1 Ambient temperature range

Table 7.4

Item	Specification
Compliance	IEC 60255-27
Test method	IEC 60068-2-1 and IEC 60068-2-2
Operating temperature range	-25 °C to +55 °C (continuous)
Storage temperature range	-25 °C to +70 °C (continuous)

7.3.2 *Ambient humidity range*

Table 7.5

Item	Specification
Compliance	IEC 60068-2-78
Durability	93% at +40°C

7.3.3 *Altitude*

Table 7.6

Item	Specification
Operating altitude	Below 2,000 m

7.4 Regulatory compliance

The Interrogator complies with the general requirements of IEC 60255-1:2009, including:

- Product safety — IEC 60255-27
- Electromagnetic compatibility — IEC 60255-26 (Zone A)
- Climatic — IEC 60068-2
- Mechanical — IEC 60255-21 (Class 1)
- Laser safety — IEC 60825-1