

APPLICATION GUIDE

Line differential communication and binary signal transmission

PROTECTA HUNGARY

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PROTECTION, AUTOMATION AND CONTROL FOR POWER INDUSTRY

VERSION INFORMATION

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1 Introduction

This application guide is intended to explain different line differential protection communication methods with EuroProt+ devices.

Basically, the line differential protection is carried out either on 100Base-Fx fiber channel or on a serial HDLC-based channel. The communication protocol and the frame structure in Ethernet case is relies on the IEC61850-9-2LE specification but the required bandwidth is approximately 1.5Mbit/s and some proprietary frame fields were introduced. The data communication layer utilizes VLANs as identification.

1.1 Setting of the VLAN parameters

During user parametrization of the sending and receiving VLANs, VLAN priority and multicast address need to be set. The priority parameter matters only in case of telecom network with managed switches/routers are between the devices. Priority handling in the switch ensures time critical frames to be sent In time to its final destination. Direct fiber link application does not care about this parameter.

2 Peer-to-peer communication

2.1 Direct link

In case dark fiber is available between two substations, peer-to-peer communication mode is recommended with the following properties:

- Short-haul applications limited to 2km: multimode fiber,
- Short-haul application up to 27dB line attenuation (50km in practice): single mode fiber
- Long-haul applications up to 35dB line attenuation (100-120km in practice): single mode 1550nm fiber.

"COM1Dir: 1Dir. Communication module" (previously "CPUEth: CPU LDC module") and "DIFF87L" functions must be in the configuration.
CPU labels are seen below are samples only. Other types of CPU modules can also be used.

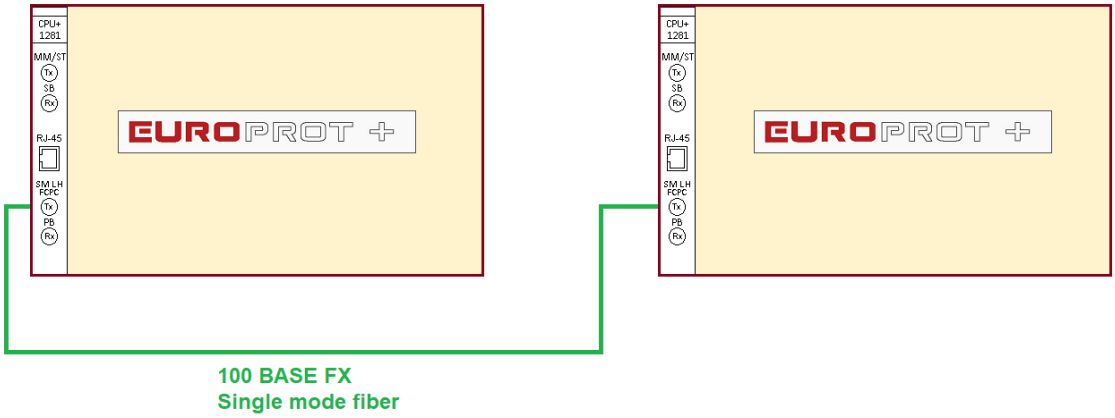


Figure 2-1 Schema of the Direct link communication

Table 2-1 Communication parameters of Direct link communication

COMMUNICATION PARAMETERS	COMMENT
Tx VLAN (1-4096)	Transmit VLAN ID Default values are: device 1:1 device 2:2
Rx VLAN	Receive VLAN ID Default values are: device 1:2 device 2:1
Priority (0-7)	VLAN priority (Default value is 4)
Multicast address (0 - 65535)	VLAN multicast address (Default value is 1)

2.2 Via LAN/Telecom network

"COM1Dir: 1Dir. Communication module" (previously "CPUEth: CPU LDC module") and "DIFF87L" functions must be in the configuration.
CPU labels are seen below are samples only. Other types of CPU modules can also be used.

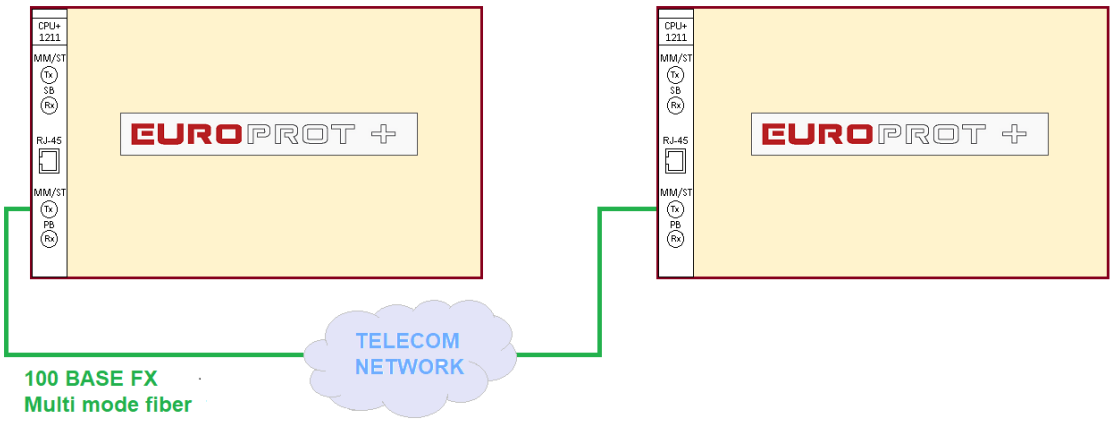


Figure 2-2 Schema of the communication via LAN/Telecom network

Table 2-2 Communication parameters of the communication via LAN/Telecom network

COMMUNICATION PARAMETERS	COMMENT
Tx VLAN (1-4096)	Transmit VLAN ID Default values are: device 1:1 device 2:2
Rx VLAN	Receive VLAN ID Default values are: device 1:2 device 2:1
Priority (0-7)	VLAN priority (Default value is 4)
Multicast address (0 - 65535)	VLAN multicast address (Default value is 1)

3 Pilot wire application

Pilot wire application allows protection devices to communicate with each other via traditional copper wire. The xDSL technology supports high speed and reliable communication channel establishment via 2-8 wire copper lines. The EuroProt+ is connected to an industrial grade Ethernet/SHDSL MODEM via an Ethernet 100Base-Fx interface.

“COM1Dir: 1Dir. Communication module” (previously “CPUEth: CPU LDC module”) and “DIFF87L” functions must be in the configuration.
CPU labels are seen below are samples only. Other types of CPU modules can also be used.

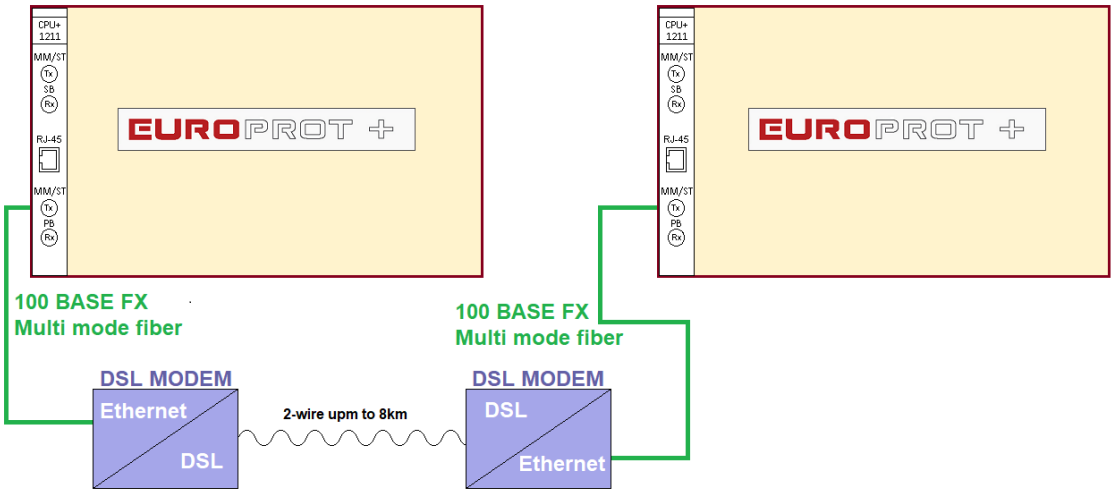


Figure 3-1 Schema of Pilot wire application

Table 3-1 Communication parameters of Pilot wire application

COMMUNICATION PARAMETERS	COMMENT
Tx VLAN (1-4096)	Transmit VLAN ID Default values are: device 1:1 device 2:2
Rx VLAN	Receive VLAN ID Default values are: device 1:2 device 2:1
Priority (0-7)	VLAN priority (Default value is 4)
Multicast address (0 - 65535)	VLAN multicast address (Default value is 1)

Table 3-2 SHDSL interface specification

Specification	ITU-T G.991.2-G.shdsl, ITU-T G.991.2-G.shdsl.bis
Line Code	TC-PAM16/32, Extended: TC-PAM4/8/64/128
Impedance	135Ω
Transmit Power	13.5 (Annex A) or 14.5 (Annex B) dBm @ 135Ω
Number of Pairs	1,2 or 4
Bit Rate	192 to 5704kbit/s, Extended: 128 to 15232kbit/s
Distance	Max. 8km @ 0.8mm (AWG-20) wire Max. 6km @ 0.6mm (AWG-23) wire Max. 4km @ 0.4mm (AWG-26) wire
Connector Type	RJ-45, 8 pin
Overvoltage Protection	ITU-T Rec. K.20/K.21
Wetting Current	2-4mA @ 47VDC

Table 3-3 Ethernet interface specification

Standard:	IEEE-802.3, VLAN IEEE-802.1Q, QoS IEEE-802.1P
Data Rate	100Base-TX, Full/Half Duplex
Interface/connector Type @ EuroProt+ side	Multi-mode 1310nm, ST connector
Interface/connector Type @ MODEM side	SFP multi-mode 1310nm, LC connector

4 Line differential communication via telecom networks

4.1 Communication via G.703 64kbit/s co-directional interface (E0)

The EuroProt+ device supports line differential communication via telecom networks using G.703.1 64kbit/s co-directional interface type, that is synchronized to the network (timing slave). This type of communication is performed via 2*2 wire isolated galvanic type interface. The protection device is connected to a multiplexer or gateway which is responsible for protocol/speed conversion.

"G70364k: G703 module" and "DIFF87L" functions must be in the configuration.

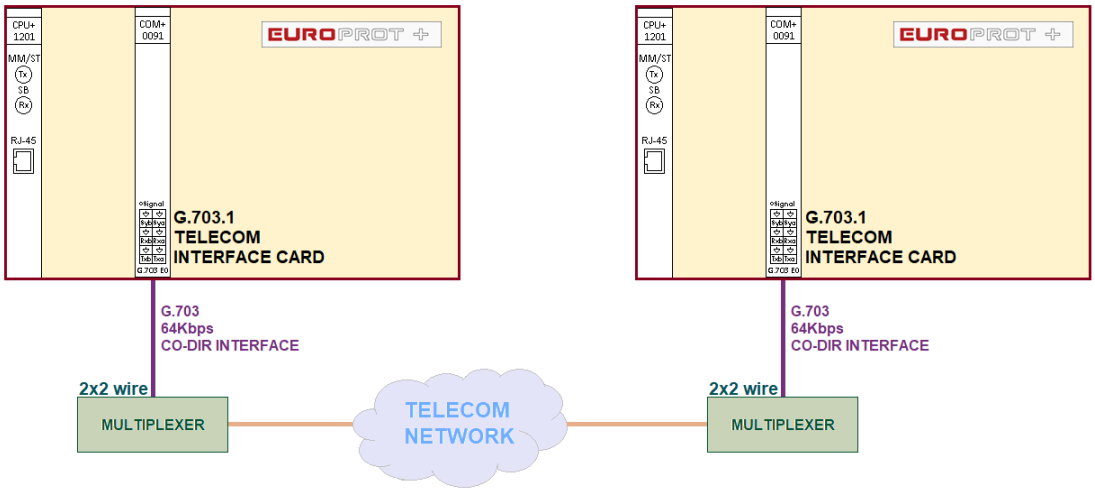


Figure 4-1 Schema of communication via G.703 64kbit/s co-directional interface

Table 4-1 Communication via G.703/64kbit/s communication parameters

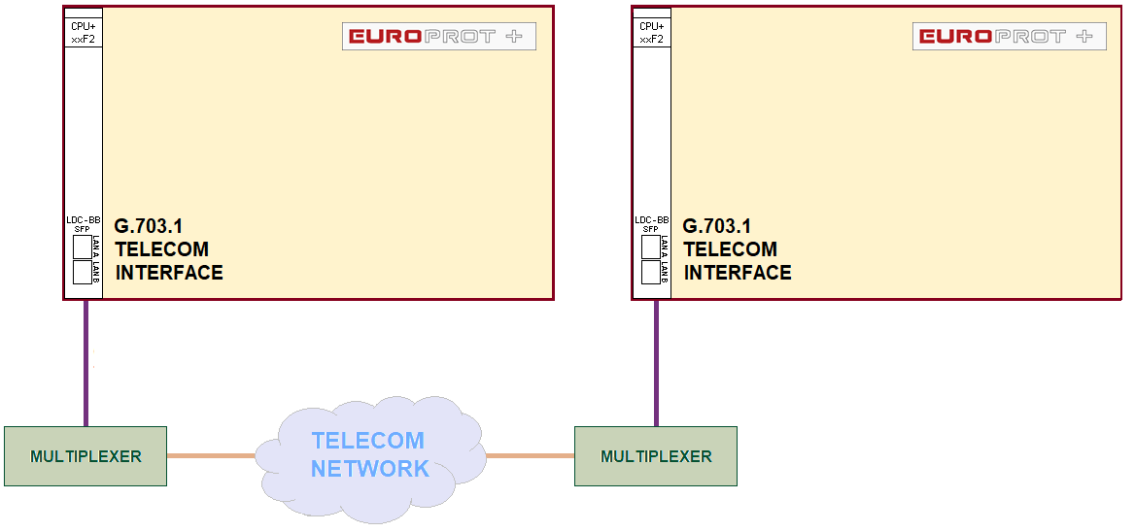
COMMUNICATION PARAMETERS	COMMENT
HDLC Adress (1-63)	Default value is: 1

4.2 Communication via 2.048Mbit/s (E1/T1) Nx64kbit/s interface

EuroProt+ device supports line differential communication via telecom networks with G703/704 2.048Mbit/s interface (E1). Besides, E1 in European networks the T1 interface (1.54Mbit/s) in America also available.

“G703E1: G703 module” function and “DIFF87L” functions must be in the configuration.

CPU module with LDC – BB SFP interface with dedicated SFP module (MiRICi-E1/T1 (Intelligent Miniature Ethernet to E1/T1) by RAD) is mandatory hardware for this option.



LDP – BB: Proprietary Process Bus for Line differential or Busbar communication

SFP: Small Form-factor Pluggable connector

Figure 4-2 Schema of communication via 2.048Mbit/s (E1/T1) Nx64kbit/s interface

Table 4-2 Communication via 2.048Mbit/s (E1/T1) Nx64kbit/s interface communication parameters

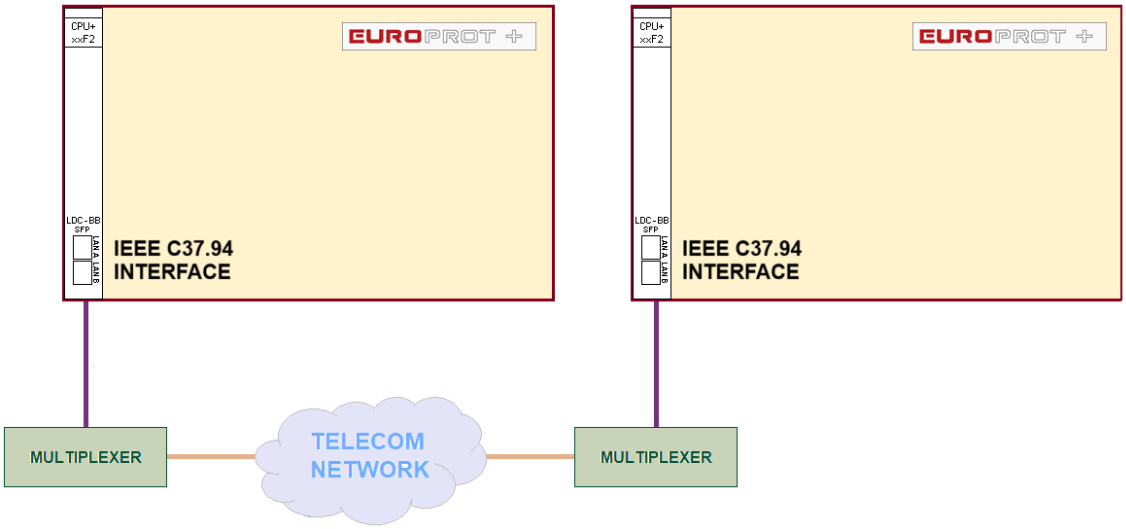
COMMUNICATION PARAMETERS	COMMENT
HDLC Adress (1-63)	Default value is: 1
HDLC Speed (n x 64kbit/s, n: 1-31)	Default value: 31
Start Timeslot (1-31)	Default value: 1

4.3 Communication via IEEE C37.94 interface

The EuroProt+ device supports line differential communication via telecom networks with standard IEEE C37.94 interface.

"COM1Dir: 1Dir. Communication module" (previously "CPUEth: CPU LDC module") and "DIFF87L" functions must be in the configuration.

CPU module with LDC – BB SFP interface with dedicated MM/LC SFP module (***LM28-A3C-TI-N-EC*** or ***CM85-2MF-3C-TI-L***) is mandatory hardware for this option.



LDP – BB: Proprietary Process Bus for Line differential or Busbar communication

SFP: Small Form-factor Pluggable connector

Figure 4-3 Schema of communication via IEEE C37.94 interface

The device detects if C37.94-capable SFP is plugged in Port 3 and makes options visible for each port where it is there. In the following example, only Port 3B is used (the lowermost connector) for C37.94 in both devices.

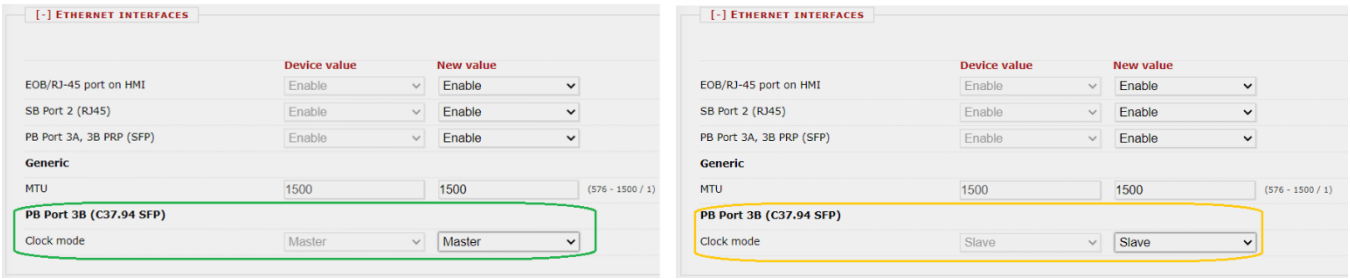


Figure 4-4 Options in the System settings menu for Port 3B for device #1 and #2

The *Clock mode* setting must be 'Master' in one device and 'Slave'!

Checking the C37.94 communication status in detail is possible under the Advanced → Maintenance menu where an additional bracket appears for this application, see the picture below:

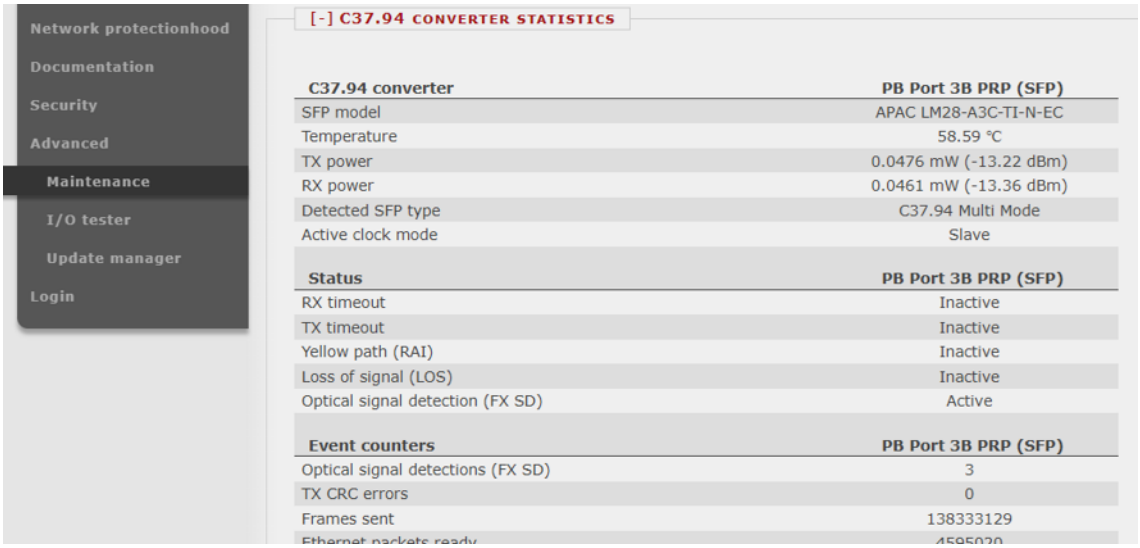


Figure 4-5 Additional bracket for C37.94 communication diagnostics

5 Redundant line differential communication

The data interchange over the two communication channels is carried out in parallel way which enables hot standby operation. In case of single point of failure in one of the links, the algorithm processes the data from the other link without switchover time.

5.1 G.703 and 100Base-FX redundancy

For availability please contact: sales@protecta.hu

Redundant communication also supported by EuroProt+. The high speed 100Base-FX link is used as main channel and G.703.1 leased or dedicated line as backup link. An extra COM+1091 or COM+8091 card needs to be added to the configuration for this kind of redundancy.

“G70364k: G703 module” and “DIFF87L3” functions must be in the configuration.

Module labels on the are samples only; other types of COM modules can also be used.
The operation parameter of Line differential function must be “On Redu 2ends”.

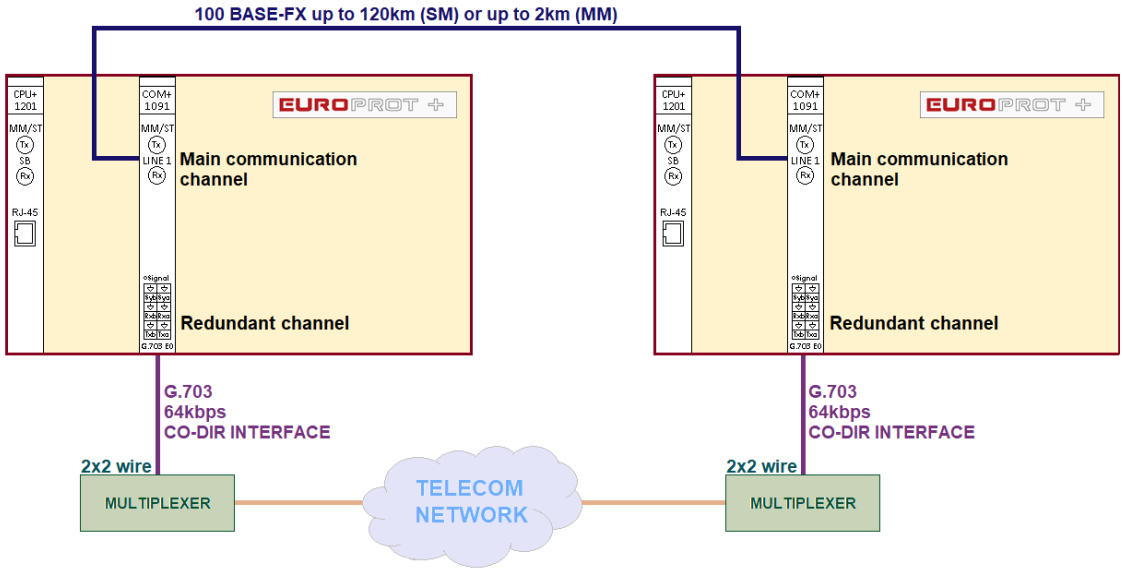


Figure 5-1 Schema of the communication via G.703 and 100Base-FX redundancy

Table 5-1 G.703 and 100Base-FX redundancy communication parameters

COMMUNICATION PARAMETERS	COMMENT
Main communication parameters	
Tx VLAN	Default values are: device 1: 2 device 2: 1
Rx VLAN	Default values are: device 1: 2 device 2: 1
Priority	VLAN priority (Default value is 4)
Mcast Addr	VLAN multicast address (Default value is 1)
Redundant communication parameters	
HDLC Address (1-63)	Default value is: 1

5.2 100Base-FX redundancy

Both communication links are Ethernet 100Base-FX type and the connection type can be direct link (dark fiber) and/or a service from a telecom operator. An extra COM+1101 or COM+8801 or COM+9901 card needs to be added to the configuration for this kind of redundancy.

"COM2Dir: 2Dir. LD communication module" (previously "COM1101: COM1101 module") and "DIFF87L3: Line Differential" functions must be in the configuration.
Module labels on the are samples only; other types of COM modules can also be used.
The operation parameter of Line differential function must be "On Redu 2ends".

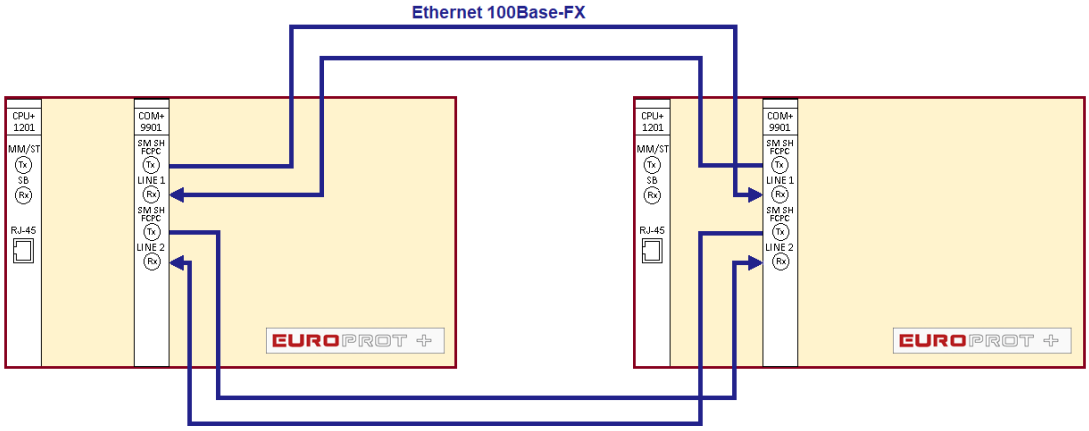


Figure 5-2 Schema of the communication via fiber optic cable with 100Base-FX redundancy

Table 5-2 100Base-FX redundancy communication parameters

COMMUNICATION PARAMETERS	COMMENT	VALUES
Tx VLAN Line1	Transmit VLAN ID for Line1	device1: 1 device2: 2
Rx VLAN Line1	Receive VLAN ID for Line1	device1: 2 device2: 1
Priority Line1	Line1 VLAN priority	4
Multicast Address Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	device1: 3 device2: 4
Rx VLAN Line2	Receive VLAN ID for Line2	device1: 4 device2: 3
Priority Line2	Line2 VLAN priority	4
Multicast Address Line2	Line2 VLAN multicast address	1

6 Three terminal line differential communication

With an additional communication card, the EuroProt+ device allows three terminal line differential communication between protections. The communication channel in this case is Ethernet 100Base-Fx. The three terminal line differential protection scheme can tolerate the link failure of one of the three communication channels between the devices.

"COM2Dir: 2Dir. LD communication module" (previously "COM1101: COM1101 module") and "DIFF87L3: Line Differential" functions must be in the configuration.
Module labels on the picture are samples only; other types of COM modules can also be used.
The operation parameter of Line differential function have to be "On 3ends.

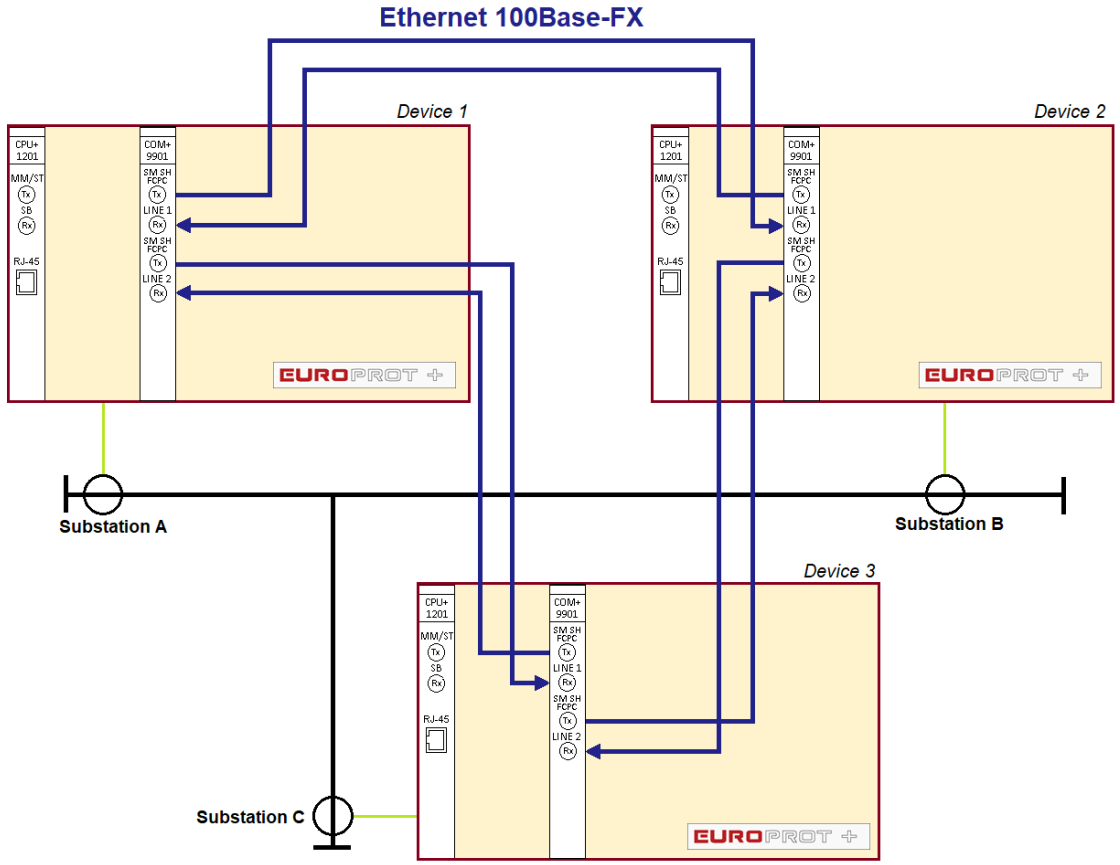


Figure 6-1 Schema of three line diff. communication

Table 6-1 Parameters of device 1

COMMUNICATION PARAMETERS	COMMENT	VALUES
Tx VLAN Line1	Transmit VLAN ID for Line1	1
Rx VLAN Line1	Receive VLAN ID for Line1	2
Priority Line1	Line1 VLAN priority	4
Multicast Address Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	1
Rx VLAN Line2	Receive VLAN ID for Line2	3
Priority Line2	Line2 VLAN priority	4
Multicast Address Line2	Line2 VLAN multicast address	1

Table 6-2 Parameters of device 2

COMMUNICATION PARAMETERS	COMMENT	VALUES
Tx VLAN Line1	Transmit VLAN ID for Line1	2
Rx VLAN Line1	Receive VLAN ID for Line1	1
Priority Line1	Line1 VLAN priority	4
Multicast Address Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	2
Rx VLAN Line2	Receive VLAN ID for Line2	3
Priority Line2	Line2 VLAN priority	4
Multicast Address Line2	Line2 VLAN multicast address	1

Table 6-3 Parameters of device 3

COMMUNICATION PARAMETERS	COMMENT	VALUES
Tx VLAN Line1	Transmit VLAN ID for Line1	3
Rx VLAN Line1	Receive VLAN ID for Line1	1
Priority Line1	Line1 VLAN priority	4
Multicast Address Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	3
Rx VLAN Line2	Receive VLAN ID for Line2	2
Priority Line2	Line2 VLAN priority	4
Multicast Address Line2	Line2 VLAN multicast address	1

7 2-ends line differential communication with three terminals

Normally there are three terminals in T-branch topology.
If one of three circuit breakers is switched off and the terminal in that bay is working, the customer/user does not need to do anything.
If one of three circuit breakers is switched off and the terminal in that bay is not working, the “Map L2 to L1” must be chosen in some cases. This setting depends on the fiber optic connection of terminals. Mapping means redirecting measured analogue values from Connector2 to Connector1 in communication module. This behavior is necessary for the correct calculation of differential current in line differential function.
You can see the different situations below.

“COM2Dir: 2Dir. LD communication module” (previously “COM1101: COM1101 module”) and “DIFF87L3: Line Differential” functions must be in the configuration
COM module labels are on the picture are samples only, other COM modules can also be used.
The operation parameter of Line differential function must be “On 2ends”.

7.1 Variant 1

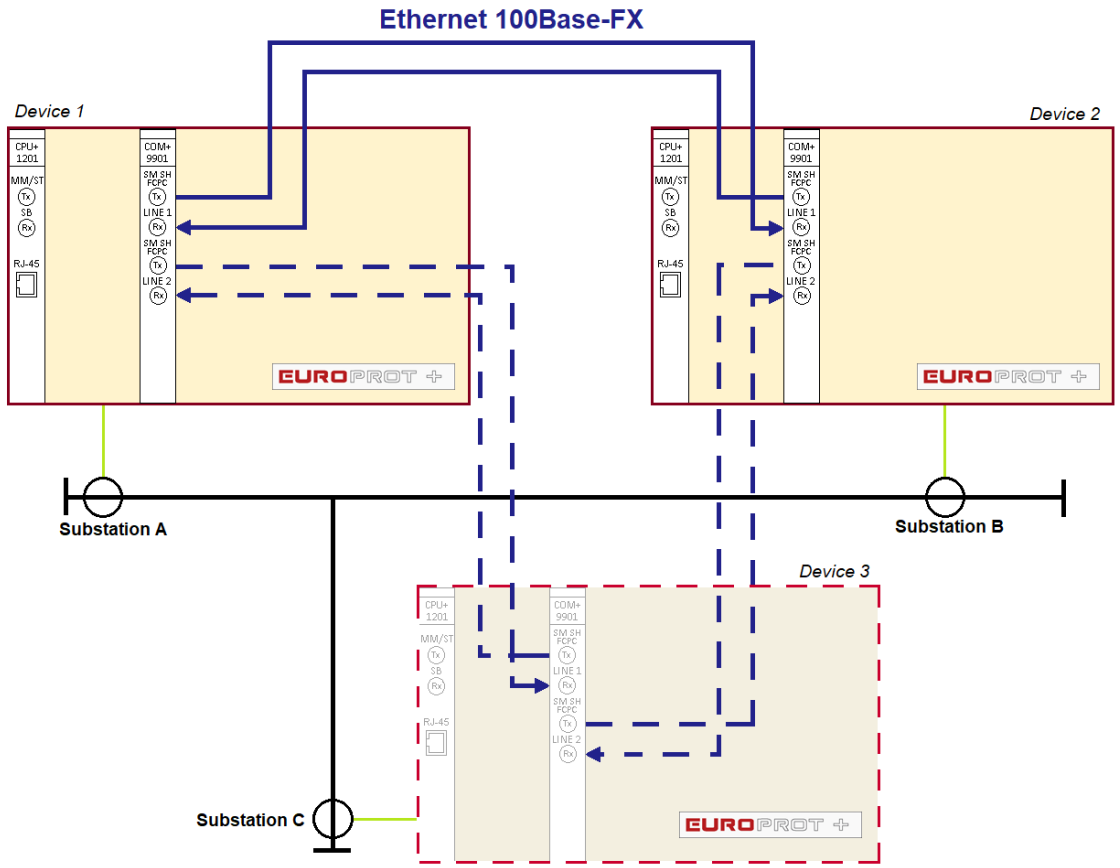


Figure 7-1 Schema of 2 ends line diff. communication with three terminals, variant 1

Table 7-1 Parameters of device 1

COMMUNICATION PARAMETERS	COMMENT	VALUES
Tx VLAN Line1	Transmit VLAN ID for Line1	1
Rx VLAN Line1	Receive VLAN ID for Line1	2
Priority Line1	Line1 VLAN priority	4
Mcast Addr Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	1
Rx VLAN Line2	Receive VLAN ID for Line2	3
Priority Line2	Line2 VLAN priority	4
Mcast Addr Line2	Line2 VLAN multicast address	1
Map L2 to L1	Mapping the analogue values	No

Table 7-2 Parameters of device 2

COMMUNICATION PARAMETERS	COMMENT	VALUES
Tx VLAN Line1	Transmit VLAN ID for Line1	1
Rx VLAN Line1	Receive VLAN ID for Line1	2
Priority Line1	Line1 VLAN priority	4
Mcast Addr Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	2
Rx VLAN Line2	Receive VLAN ID for Line2	3
Priority Line2	Line2 VLAN priority	4
Mcast Addr Line2	Line2 VLAN multicast address	1
Map L2 to L1	Mapping the analogue values	No

7.2 Variant 2

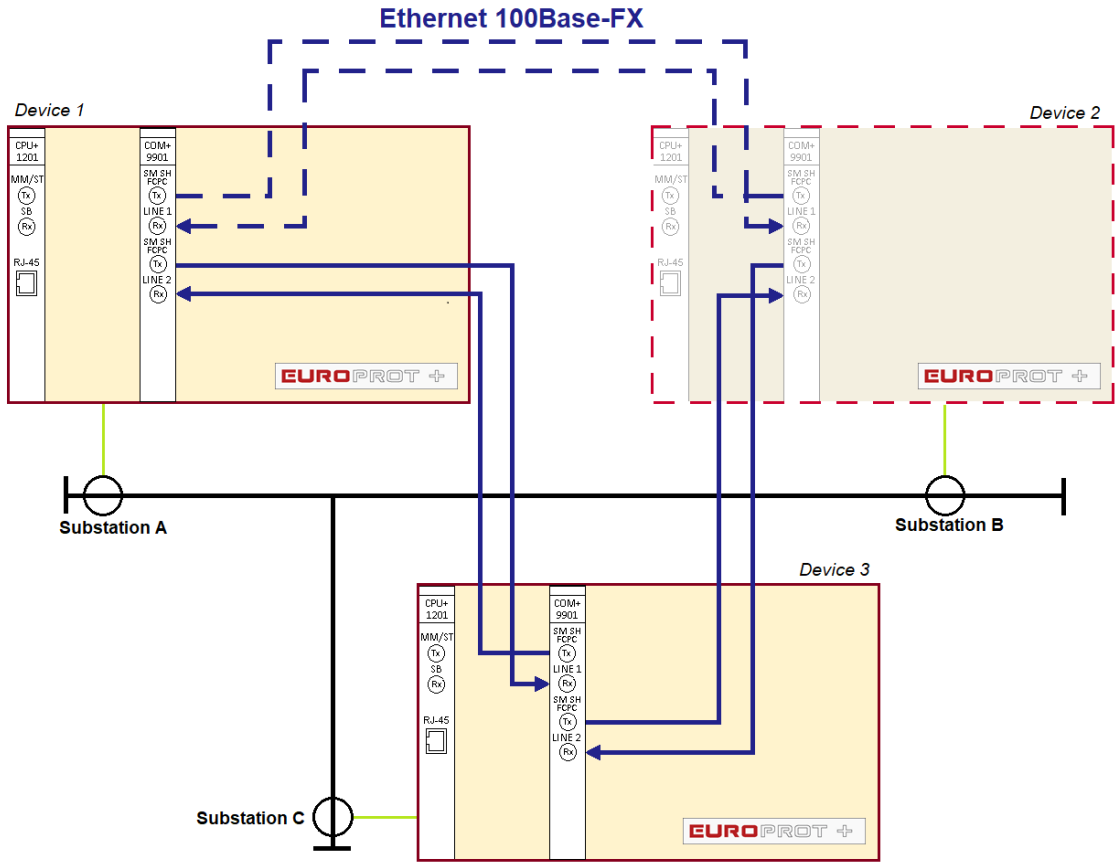


Figure 7-2 Schema of 2 ends line diff. communication with three terminals, variant 2

Table 7-3 Parameters of device 1

COMMUNICATION PARAMETERS	COMMENT	VALUES
Tx VLAN Line1	Transmit VLAN ID for Line1	1
Rx VLAN Line1	Receive VLAN ID for Line1	2
Priority Line1	Line1 VLAN priority	4
Mcast Addr Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	1
Rx VLAN Line2	Receive VLAN ID for Line2	3
Priority Line2	Line2 VLAN priority	4
Mcast Addr Line2	Line2 VLAN multicast address	1
Map L2 to L1	Mapping the analogue values	Yes

Table 7-4 Parameters of device 3

COMMUNICATION PARAMETERS	COMMENT	VALUES
Tx VLAN Line1	Transmit VLAN ID for Line1	3
Rx VLAN Line1	Receive VLAN ID for Line1	1
Priority Line1	Line1 VLAN priority	4

Mcast Addr Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	3
Rx VLAN Line2	Receive VLAN ID for Line2	2
Priority Line2	Line2 VLAN priority	4
Mcast Addr Line2	Line2 VLAN multicast address	1
Map L2 to L1	Mapping the analogue values	No

7.3 Variant 3

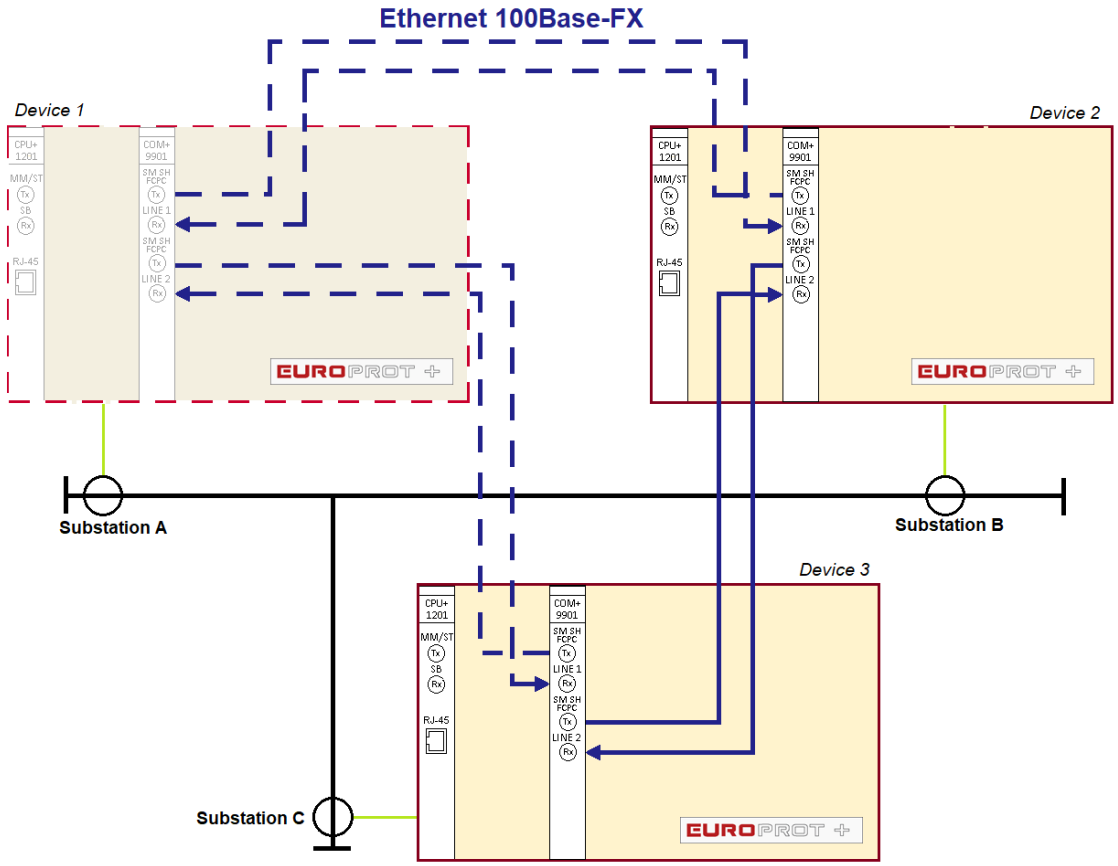


Figure 7-3 Schema of 2 ends line diff. communication with three terminals, variant 3

Table 7-5 Parameters of device 2

COMMUNICATION PARAMETERS	COMMENT	VALUES
Tx VLAN Line1	Transmit VLAN ID for Line1	2
Rx VLAN Line1	Receive VLAN ID for Line1	1
Priority Line1	Line1 VLAN priority	4
Mcast Addr Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	2
Rx VLAN Line2	Receive VLAN ID for Line2	3
Priority Line2	Line2 VLAN priority	4
Mcast Addr Line2	Line2 VLAN multicast address	1
Map L2 to L1	Mapping the analogue values	Yes

Table 7-6 Parameters of device 3

COMMUNICATION PARAMETERS	COMMENT	VALUES
Tx VLAN Line1	Transmit VLAN ID for Line1	3
Rx VLAN Line1	Receive VLAN ID for Line1	1
Priority Line1	Line1 VLAN priority	4
Mcast Addr Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	3
Rx VLAN Line2	Receive VLAN ID for Line2	2
Priority Line2	Line2 VLAN priority	4
Mcast Addr Line2	Line2 VLAN multicast address	1
Map L2 to L1	Mapping the analogue values	Yes

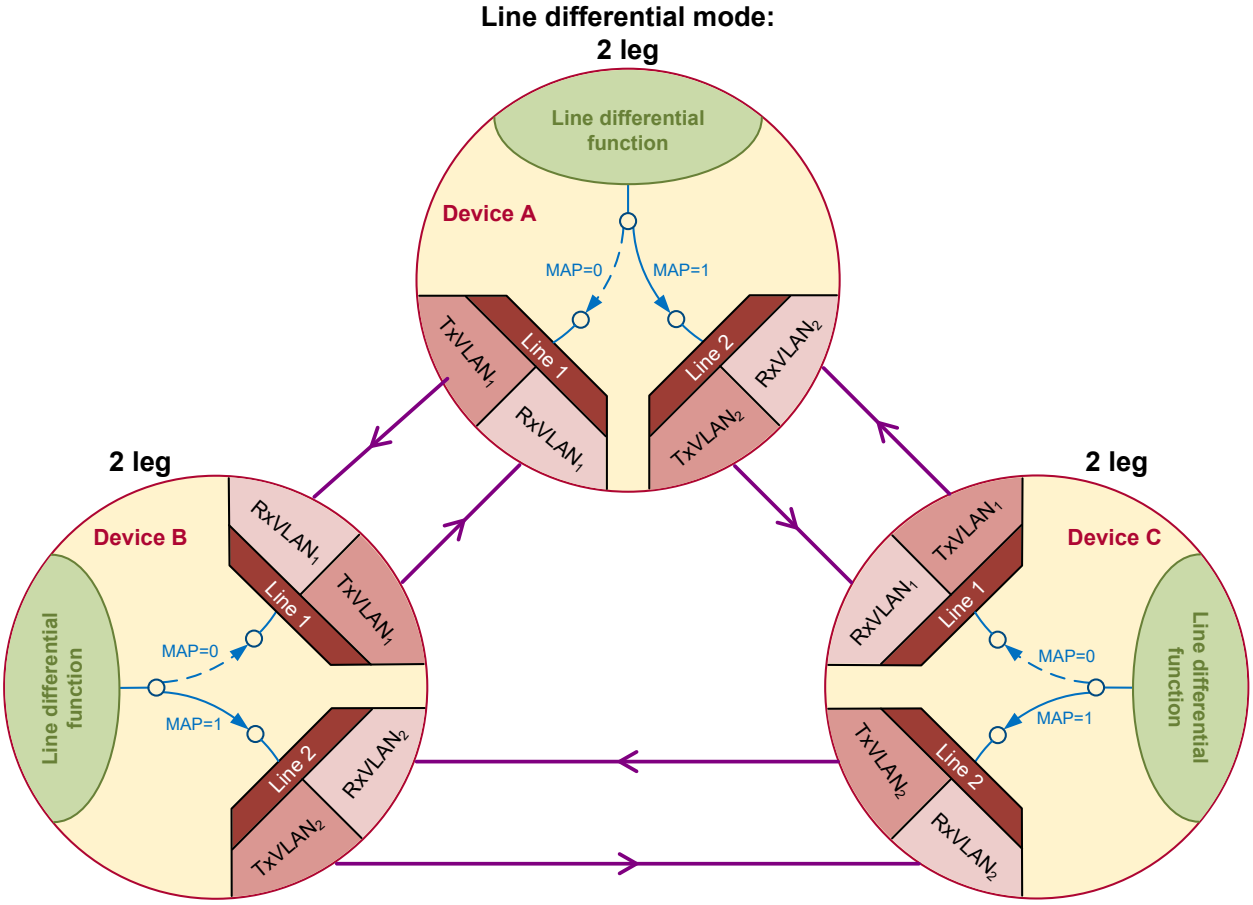


Figure 7-4 Communication schema of 2 ends line diff. used on 3 terminals

8 Remote binary signal transmission

8.1 Direct link communication

In case of a dark fiber is available between two substations or between two devices at the substation the peer-to-peer communication mode is recommended. For short-haul applications, that is limited to 2km the multi-mode fiber or up to 50km single mode 1550nm fiber can be used. Long-haul applications up to 35dB line attenuation, that is 100-120km in practice, the single mode 1550nm fiber can be used.

“COM1Dir: 1Dir. Communication module” (previously “CPUEth: CPU LDC module”) and “REMBIN1: 16Ch Binary signal transmission” functions must be in the configuration.

The “REMBIN1: 16Ch Binary signal transmission” function block can send and receive 16 signals which is to be configured in the Logic Editor of the EuroCAP tool.
If more than 16 signals transmission is needed, one „REMBIN1_16Add: 16Ch additional binary signal transm.” function block can be used in the configuration. This shall be added to the user logic as well.
Maximum number of transferable signals is 32.

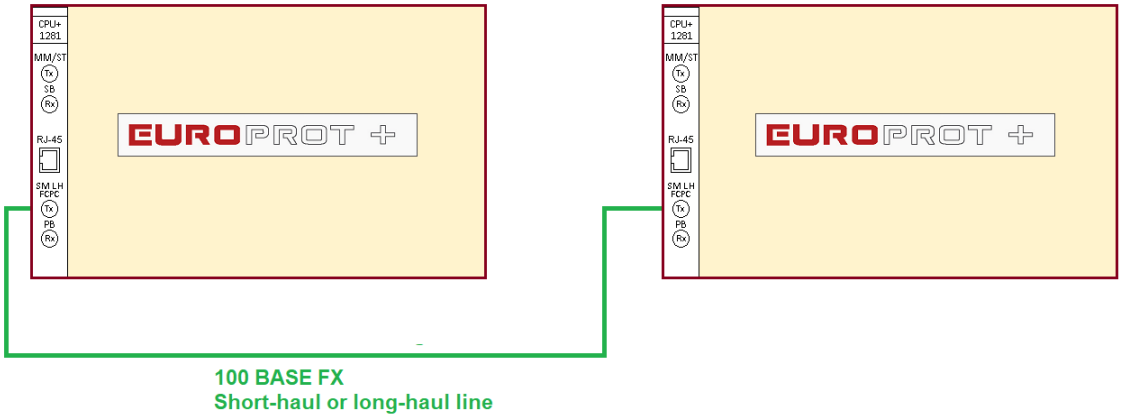


Figure 8-1 Schema of the direct link communication for rem. bin. transmission

Table 8-1 Communication parameters of direct link communication for rem. bin. transmission

COMMUNICATION PARAMETERS	COMMENT
Tx VLAN (1-4096)	Transmit VLAN ID Default values are: device 1:1 device 2:2
Rx VLAN	Receive VLAN ID Default values are: device 1:2 device 2:1
Priority (0-7)	VLAN priority (Default value is 4)
Multicast (0 - 65535)	VLAN multicast address (Default value is 1)

8.2 Three or more terminals binary signal transmission

In some special applications, signals are to be transferred among many devices either in ring or in meshed network topology within or between substations. A four devices example is below.

"COM3Dir: 2 or 3Dir. bin. signal transm. module" and "REMBIN3: 3Dir. binary signal transmission" functions must be in the configuration.
In case of 2 directional use (e.g. if COM+/9902 is used), all GrI statuses of third direction shall be hidden and all I/Os of third direction shall be deleted from FB in configuration. TX, RX parameters of Line 3 shall be set to different values than other communications (e.g. 3127) and hidden in COMM3Dir function block.
The "REMBIN3" function block can send and receive in 3 directions 10-10-9 signals which can be configured in the Logic Editor of EuroCAP tool.

The COM module labels on the picture are samples only, other types of COM modules also can be used.

Note that the third connector/direction of communication module in Device 1 and Device 4 has no connection to anywhere, communication failure in direction 3 is generated in this case.
These two devices (1 and 4) can connect if binary signal transmission is necessary between them.
Topology can be expanded with additional devices which can connected to Device 1, Device 4 or both in this example.

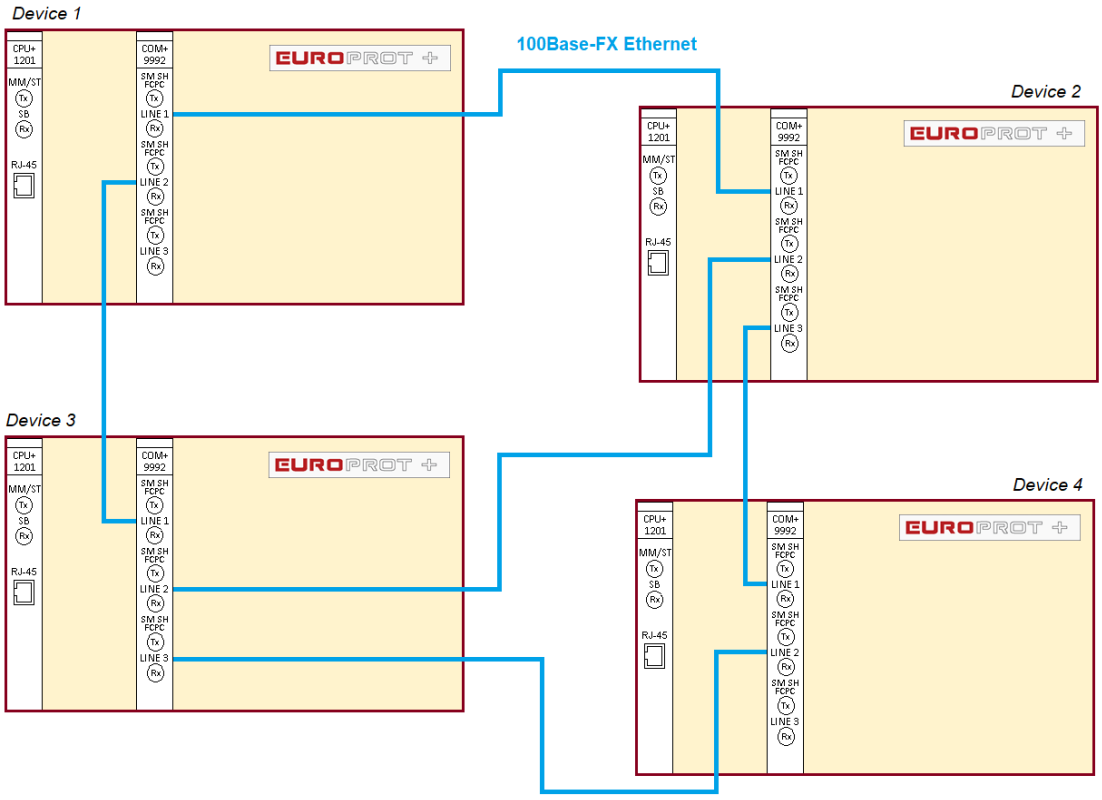


Figure 8-2 Schema of the multi-terminal communication for rem. bin. transmission

Table 8-2 Communication parameters of Device 1

COMMUNICATION PARAMETERS	COMMENT	VALUES
Priority	VLAN priority	4
Tx VLAN Line1	Transmit VLAN ID for Line1	1
Rx VLAN Line1	Receive VLAN ID for Line1	2
Mcast Addr Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	1
Rx VLAN Line2	Receive VLAN ID for Line2	3
Mcast Addr Line2	Line2 VLAN multicast address	1
Parameters of Line 3 are hidden if COM+/9902 is used		
Tx VLAN Line3	Transmit VLAN ID for Line3	1
Rx VLAN Line3	Receive VLAN ID for Line3	Different than other parameters in every devices
Mcast Addr Line3	Line3 VLAN multicast address	1

Table 8-3 Communication parameters of Device 2

COMMUNICATION PARAMETERS	COMMENT	VALUES
Priority	VLAN priority	4
Tx VLAN Line1	Transmit VLAN ID for Line1	2
Rx VLAN Line1	Receive VLAN ID for Line1	1
Mcast Addr Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	2
Rx VLAN Line2	Receive VLAN ID for Line2	3
Mcast Addr Line2	Line2 VLAN multicast address	1
Tx VLAN Line3	Transmit VLAN ID for Line3	2
Rx VLAN Line3	Receive VLAN ID for Line3	4
Mcast Addr Line3	Line3 VLAN multicast address	1

Table 8-4 Communication parameters of Device 3

COMMUNICATION PARAMETERS	COMMENT	VALUES
Priority	VLAN priority	4
Tx VLAN Line1	Transmit VLAN ID for Line1	3
Rx VLAN Line1	Receive VLAN ID for Line1	1
Mcast Addr Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	3
Rx VLAN Line2	Receive VLAN ID for Line2	2
Mcast Addr Line2	Line2 VLAN multicast address	1
Tx VLAN Line3	Transmit VLAN ID for Line3	3
Rx VLAN Line3	Receive VLAN ID for Line3	4
Mcast Addr Line3	Line3 VLAN multicast address	1

Table 8-5 Communication parameters of Device 4

COMMUNICATION PARAMETERS	COMMENT	VALUES
Priority	VLAN priority	4
Tx VLAN Line1	Transmit VLAN ID for Line1	4
Rx VLAN Line1	Receive VLAN ID for Line1	2
Mcast Addr Line1	Line1 VLAN multicast address	1
Tx VLAN Line2	Transmit VLAN ID for Line2	4
Rx VLAN Line2	Receive VLAN ID for Line2	3
Mcast Addr Line2	Line2 VLAN multicast address	1
Parameters of Line 3 are hidden if COM+/9902 is used		
Tx VLAN Line3	Transmit VLAN ID for Line3	4
Rx VLAN Line3	Receive VLAN ID for Line3	Different than other parameters in every device
Mcast Addr Line3	Line3 VLAN multicast address	1

9 Communication interface characteristics

9.1 Ethernet multi-mode transmitter and receiver

This interface is for applications up to approximately 2 km.

Table 9-1 Parameters of the Transmitter

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Optical Output Power 62.5/125 µm, NA=0.275 fiber	P_0	-19 -20		-14	dBm avg
Optical Output Power 50/125 µm, NA=0.20 fiber	P_0	-22.5 -23.5		-14	dBm avg
Optical Extinction Ratio				10 -10	% dB
Center Wavelength	λ_c	1270	1308	1380	nm

The receiver sensitivity is measured with $2^{23} – 1$ PRBS pattern within BER = 2.5×10^{-10}.

Table 9-2 Parameters of the Receiver

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Signal Detect – Asserted	P_a			-33	dBm avg.
Signal Detect - Deasserted	P_d				dBm avg.
Signal Detect - Hysteresis	P_a-P_d				dB
Signal Detect Assert Time (off to on)	AS_Max		2	100	µs
Signal Detect Deassert Time (on to off)	ANS_Max		8	350	µs

9.2 Ethernet single mode transmitter and receiver

9.2.1 Long haul single mode transceiver

This interface is for applications up to approximately 120 km, with max. 32 dB link attenuation.

Table 9-3 Parameters of the Transmitter

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Optical Output Power (avg.)	P_0	-6		0	dBm
Extinction Ratio	ER	8.3			dB
Optical Wavelength	λ_c	1490	1550	1610	Nm

Table 9-4 Parameters of the Receiver

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Optical Input Sensitivity (avg.)	P_{in}		-38	-35	dBm
Saturation	P_{sat}	-3	0		dBm
Optical Wavelength	λ	1100		1600	nm
Signal Detect Asserted (avg.)	P_a			-35	dBm
Signal Detected Deasserted (avg.)	P_d	-45			dBm
Hysteresis	P_{hys}		3		dB

9.2.2 Short haul single mode transceiver

This interface is for applications up to approximately 120 km, with max. 32 dB link attenuation.

Table 9-5 Parameters of the Transmitter

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Optical Output Power (avg.)	P_0	-12		-6	dBm
Extinction Ratio	ER	8.3			dB
Optical Wavelength	Λ_c	1490	1550	1610	Nm

Table 9-6 Parameters of the Receiver

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Optical Input Sensitivity (avg.)	P_{in}		-38	-35	dBm
Saturation	P_{sat}	-3	0		dBm
Optical Wavelength	λ	1100		1600	nm
Signal Detect Asserted (avg.)	P_a			-35	dBm
Signal Detected Deasserted (avg.)	P_d	-45			dBm
Hysteresis	P_{hys}		3		dB

9.3 G.703 64kbit/s co-directional interface (E0)

Interface type: G.703.1 64 kbit/s (E0) co-directional, selectable grounding, with optional external clock input.

Connector type

Receptacle	Weidmüller S2L 3.50/12/90 F
Plug	Weidmüller B2L 3.50/12/180 F

Impedance	120 Ω
Cable length	50 m

Receiver

Loss of Signal Alarm Level	±1.5 dB Difference Between Alarm-on and Alarm-off
Dynamic Range	10 dB Maximum Cable Loss Range

Transmitter

Pair for each direction	One symmetric pair
Test load impedance	120 Ω resistive
Nominal peak voltage of a „mark” (pulse)	1.0 V
Peak voltage of a „space” (no pulse)	0 V ± 0.10 V
Nominal pulse width	3.9 ms
Ratio of the amplitudes of positive and negative pulses at the center of the pulses interval	0.95 to 1.05
Ratio of the widths of positive and negative pulses at the nominal half amplitude	0.95 to 1.05
Maximum peak-to-peak jitter at the output port	Refer to clause 2/G.823

9.4 2.048Mbit/s (E1/T1) Nx64kbit/s interface

MiRICi E1 interface

Number of Ports	1
Compliance	G.703, G.704, G.775, G.823
Data Rate	2.048 Mbps
Line Code	HDB3, AMI
Framing	Framed (G.732.N, G.732.N CRC), unframed
Line Impedance	120W, balanced
Cable Length	Up to 2500m (8202 ft) for AWG 22 cable
Connector	RJ-45