X20ET8819

1 General information

Analyzing POWERLINK

POWERLINK has proven itself in the field for years and rarely has problems during commissioning and production. Nonetheless, it is still possible for communication disturbances to occur due to damaged or poor quality cables. If an error occurs, localizing and correcting it is usually very easy thanks to the heterogeneous structure of this flat network type (all data is always visible throughout the network). What's problematic are errors that occur sporadically. This is where tools such as Omnipeek or Wireshark come in.

These tools (or more likely the standard PC technology being used) reach their limits, however, when dealing with machines that have short network cycles. Either not all frames can be recorded, or some telegrams are lost altogether. In these cases, what's needed is a special hardware tool that can work very quickly, record and save every bit of traffic and then pass it on to a laptop.

Ethernet analysis tool X20ET8819

This module provides different operating modes. For example, it can work passively on the network, in which case the real-time behavior remains unchanged. The device listens in and selectively takes in data when certain defined trigger conditions are met. It can read all of the data, mark it with a timestamp, store it temporarily and ultimately pass it on to a PC. The data is then analyzed in the familiar PC environment.

- NetTime time stamp has a resolution of 20 ns
- Recording and analysis of CRC and frame errors
- Triggers can also be activated using external digital signals
- Analysis of both half-duplex and full-duplex networks
- Able to record two networks simultaneously

2 Order data

Model number	Short description	Figure
	X20 hub system	
X20ET8819	X20 Ethernet analysis tool, can be expanded with active hub modules, 2x RJ45	
	Required accessories	
	System modules for bus controllers	
X20BB80	X20 bus base, for X20 base module (BC, HB, etc.) and X20 power supply module, X20 end cover plates (left and right) X20AC0SL1/X20AC0SR1 included	
X20PS9400	X20 power supply module, for bus controller and internal I/O power supply X2X Link power supply	
	System modules for expandable bus controllers	
X20BB81	X20 bus base, for X20 base module (BC, HB, etc.) and X20 power supply module, with one expansion slot for an X20 add-on module (IF, HB, etc.), X20 locking plates (left and right) X20AC0SL1/X20AC0SR1 included	
X20BB82	X20 bus base, for X20 base module (BC, HB, etc.) and X20 power supply module, with 2 expansion slots for 2 X20 add-on modules (IF, HB, etc.), X20 end cover plates (left and right) X20AC0SL1/X20AC0SR1 included	
	Terminal blocks	
X20TB12	X20 terminal block, 12-pin, 24 VDC keyed	
	Optional accessories	
	Bus modules	
X20BM11	X20 bus module, 24 VDC keyed, internal I/O supply continuous	
X20BM15	X20 bus module, with node number switch, 24 VDC keyed, internal I/O supply continuous	
	Digital inputs	
X20DI9371	X20 digital input module, 12 inputs, 24 VDC, sink, configurable input filter, 1-wire connections	
	Digital outputs	
X20DO9322	X20 digital output module, 12 outputs, 24 VDC, 0.5 A, source, 1-wire connections	
	System modules for the X20 hub system	
X20HB2880	X20 hub expansion module, integrated 2-port hub, 2x RJ45	
X20HB2881	X20 hub expansion module, integrated 2-port hub, for fiber optic cable	

Table 1: X20ET8819 - Order data

3 Technical data

Model number	X20ET8819
Short description	
Ethernet analysis tool	Ethernet analysis tool with up to 2 slots for hub expansion modules
General information	
Status indicators	Module status, bus function
Diagnostics	
Module status	Yes, using status LED and software
Bus function	Yes, using status LED and software
Power consumption	2 W
Certifications	
CE	Yes
ATEX	Zone 2, II 3G Ex nA nC IIA T5 Gc IP20, Ta (see X20 user's manual) FTZÚ 09 ATEX 0083X
UL	cULus E115267 Industrial control equipment
HazLoc	cCSAus 244665 Process control equipment for hazardous locations Class I, Division 2, Groups ABCD, T5
EAC	Yes
KC	Yes
Interfaces	
Type	Ethernet analysis tool
Variant	2x shielded RJ45
Cable length	Max. 100 m between 2 stations (segment length)
Transfer rate	100 Mbit/s
Transfer	
Physical layer	100BASE-TX
Half-duplex	Yes
Full-duplex	Yes
Autonegotiation	Yes
Auto-MDI/MDIX	Yes
Electrical properties	
Electrical isolation	POWERLINK (IF1, IF2) isolated from power supply
Operating conditions	
Mounting orientation	
Horizontal	Yes
Vertical	Yes
Installation elevation above sea level	
0 to 2000 m	No limitations
>2000 m	Reduction of ambient temperature by 0.5°C per 100 m
Degree of protection per EN 60529	IP20
Ambient conditions	
Temperature	
Operation	
Horizontal mounting orientation	-25 to 60°C
Vertical mounting orientation	-25 to 50°C
Derating	-
Storage	-40 to 85°C
Transport	-40 to 85°C
Relative humidity	
Operation	5 to 95%, non-condensing
Storage	5 to 95%, non-condensing
Transport	5 to 95%, non-condensing
Mechanical properties	
Note	Order 1x X20TB12 terminal block separately Order 1x X20PS9400 power supply module separately Order 1x X20BB8x bus base separately
Pitch [1]	
X20BB80	37.5 $^{+0.2}$ mm
X20BB81	62.5 $^{+0.2}$ mm
X20BB82	87.5 $^{+0.2}$ mm

Table 2: X20ET8819 - Technical data

1)   Spacing is based on the width of the X20BB80 bus base. Up to two X20HB2880 or X20HB2881 hub expansion modules and one X20PS9400 power supply module are also always required for the Ethernet analysis tool.

4 LED status indicators

Figure	LED	Color	Status	Description
	S/E[1]	Green/red		Status/Error LED. The statuses of this LED are described in section "S/E LED" on page 4.
	L/A IF1	Green	On	A link to the remote station has been established.
			Blinking	A link to the remote station has been established. Indicates Ethernet activity is taking place on the bus
	L/A IF2	Green	On	A link to the remote station has been established.
			Blinking	A link to the remote station has been established. Indicates Ethernet activity is taking place on the bus

1)   The Status/Error LED is a green/red dual LED.

5 S/E LED

The Status/Error LED is a green and red dual LED.

Red - Error	Description
On	This error can occur only in Analysis mode. If packets are lost when in Analysis mode, the red Status LED lights up. Remedy: Use the "MODE" switch to reduce the number of bytes in the received packets (see "Analysis mode" on page 10). As soon as no packets are lost for longer than 1 s, it switches back to green.

Table 3: Status/error LED is red: LED indicates error

Green - Status	Description
Off	The Ethernet analysis tool is either booting or not receiving power.
Green flickering (approx. 10 Hz)	The analysis tool is in Service mode: Analysis tool disabled, go to website to update firmware (see "Firmware update" on page 9)
Single flash (approx. 1 Hz)	The external trigger is active. No data is currently being recorded. No data has been recorded since turned on.
Double flash (approx. 1 Hz)	The external trigger is active. No data is currently being recorded. However, the analysis tool has recorded data at least once. This means that the trigger has been triggered at least once.
On	The analysis tool is active, and is recording all received packets.

Table 4: Status/error LED is green: LED indicates operation

System failure error codes

Incorrect node number or defective hardware can cause a system failure error. The error code is indicated by the red error LED using four switch-on phases. The switch-on phases have a duration of either 150 ms or 600 ms. Error code output is repeated cyclically after 2 seconds.
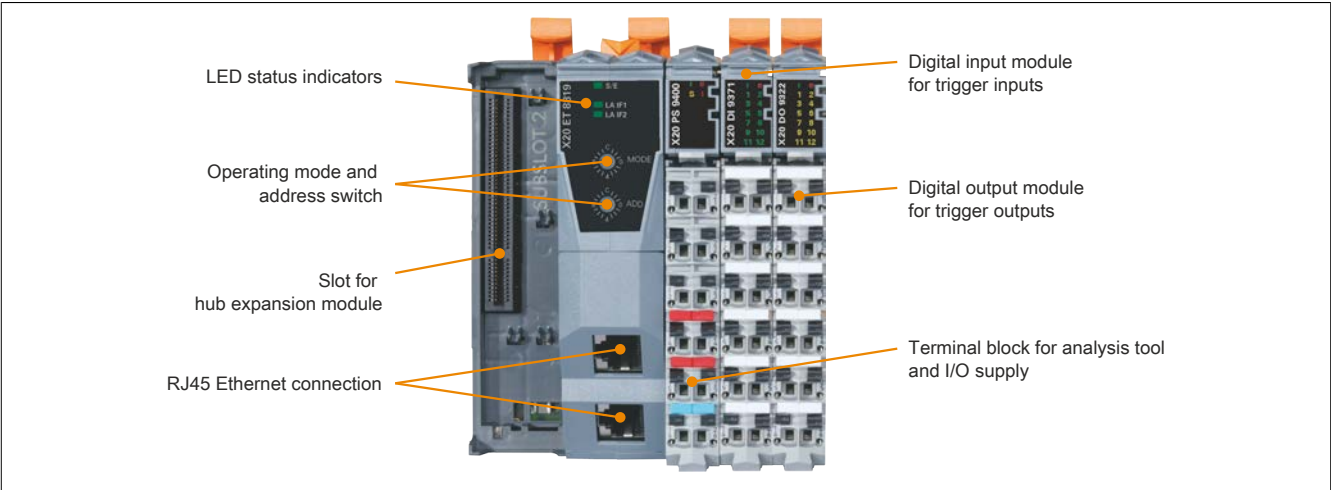
Key: • ... 150 ms
         − ... 600 ms
         Pause ... 2 sec. delay

Error description	Error code indicated by red status LED									
RAM error: The module is defective and must be replaced.	•	•	•	−	Pause	•	•	•	−	Pause
Wrong node number	•	−	−	−	Pause	•	−	−	−	Pause
Hardware errors: The module or a system component is defective and must be replaced.	−	•	•	−	Pause	−	•	•	−	Pause

Table 5: Status/Error LED as Error LED - System failure error codes

6 Operating and connection elements

LED status indicators

Operating mode and address switch

Slot for hub expansion module

RJ45 Ethernet connection

Digital input module for trigger inputs

Digital output module for trigger outputs
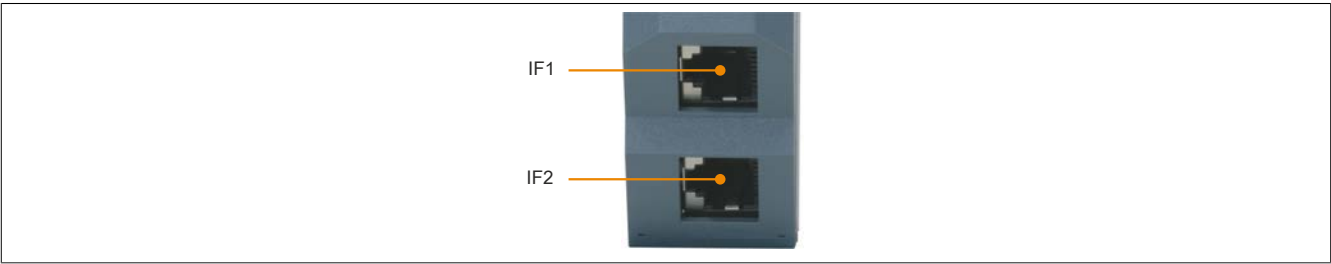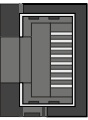
Terminal block for analysis tool and I/O supply

7 Operating mode and address switch

switches	Description
MODE	Specifies the mode in which the analysis tool is run (see "Analysis mode" on page 10)
ADD	The following addresses are derived from the position of the ADD switch: • Own IP address (192.168.0.ADD) • Analysis mode: Destination MAC (01:00:5 e: 00:00: ADD) • Analysis mode: MulticastIP 239.0.0.ADD Note: Position 0 is not permitted

8 Ethernet interface

For information about wiring X20 modules with an Ethernet interface, see section "Mechanical and electrical configuration - Wiring guidelines for X20 modules with Ethernet cables" in the X20 user's manual.

IF1

IF2

Interface	Pinout		
	Pin	Ethernet	
	1	RXD	Receive data
	2	RXD\	Receive data\
	3	TXD	Transmit data
	4	Termination	
	5	Termination	
	6	TXD\	Transmit data\
	7	Termination	
	8	Termination	
Shielded RJ45			

9 Hardware configuration 1

If the Ethernet analysis tool is run without additional hub expansion modules, then recording is only possible on port T0. The analysis tool must be connected to an available hub port in the system.

Information:

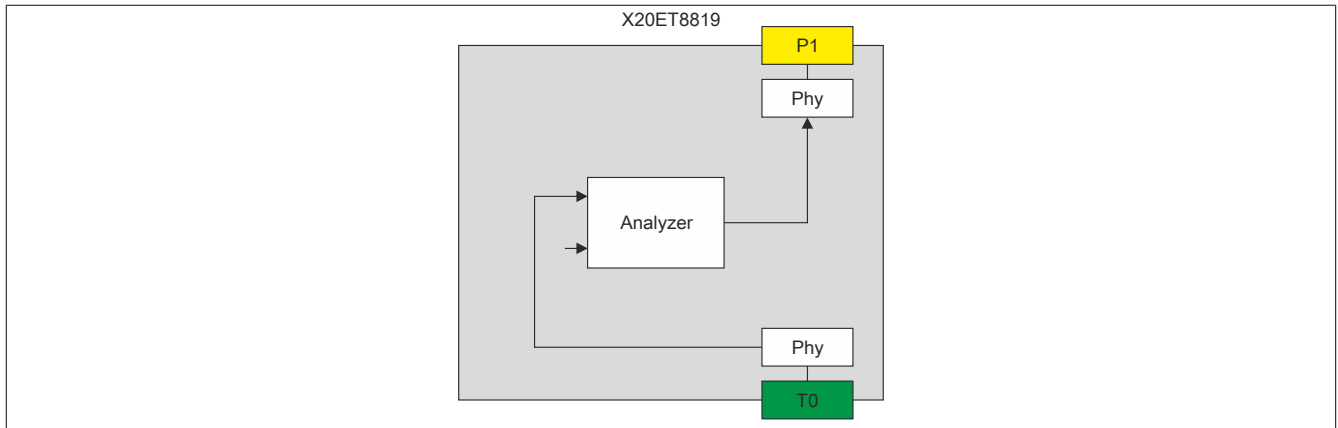**An X20HB288x module is not permitted in this hardware configuration.**

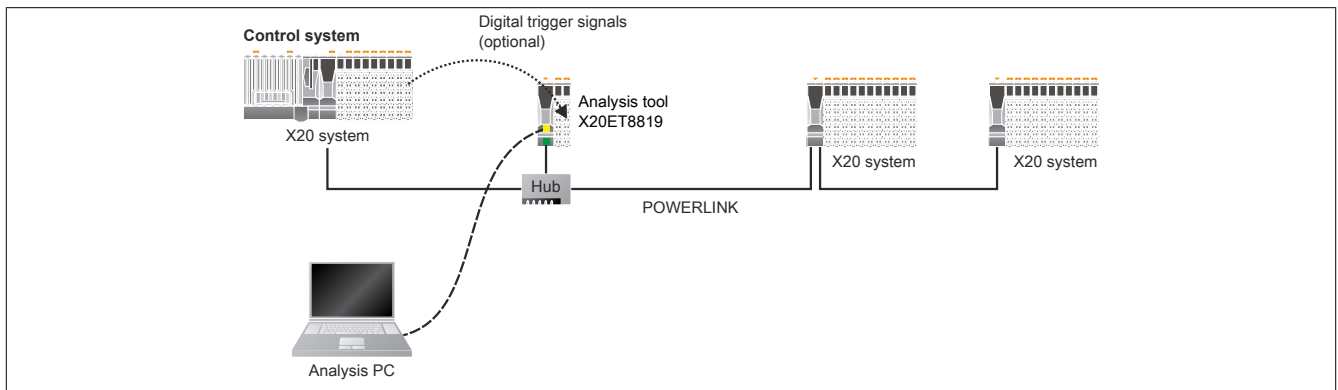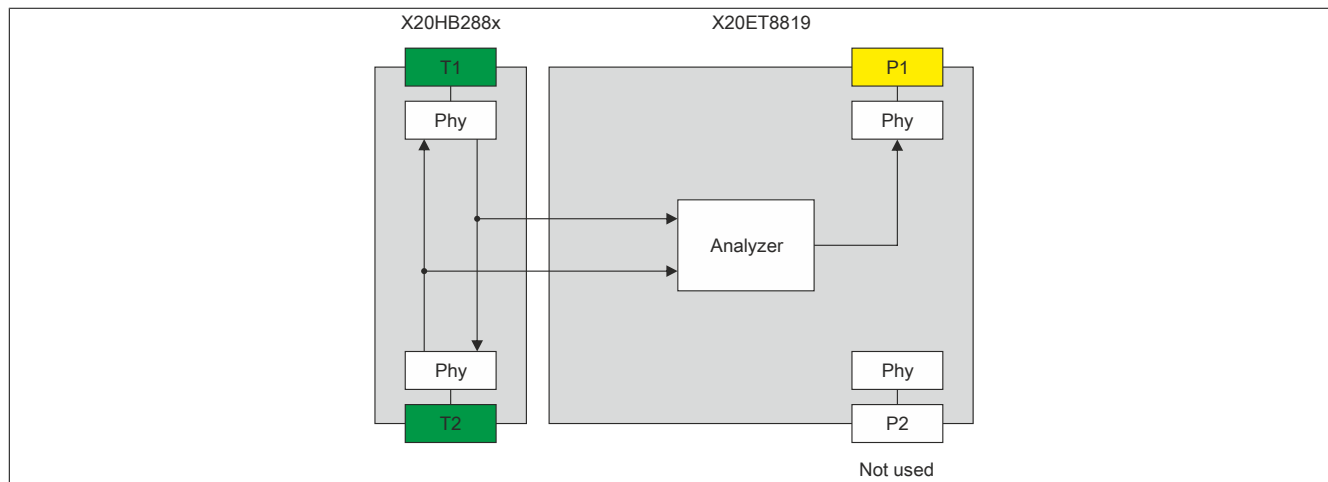Figure 1: Diagram of hardware configuration 1

Figure 2: Example application of hardware configuration 1

10 Hardware configuration 2

Extending the Ethernet analysis tool with an X20HB2880 or X20HB2881 allows even full-duplex lines to be recorded as well. In this case ports T1 and T2 are analyzed.

Information:

Only the required X20HB288x module is permitted in this hardware configuration. A second X20HB288x module would produce different behavior (see Hardware configuration 3).

Figure 3: Diagram of hardware configuration 2
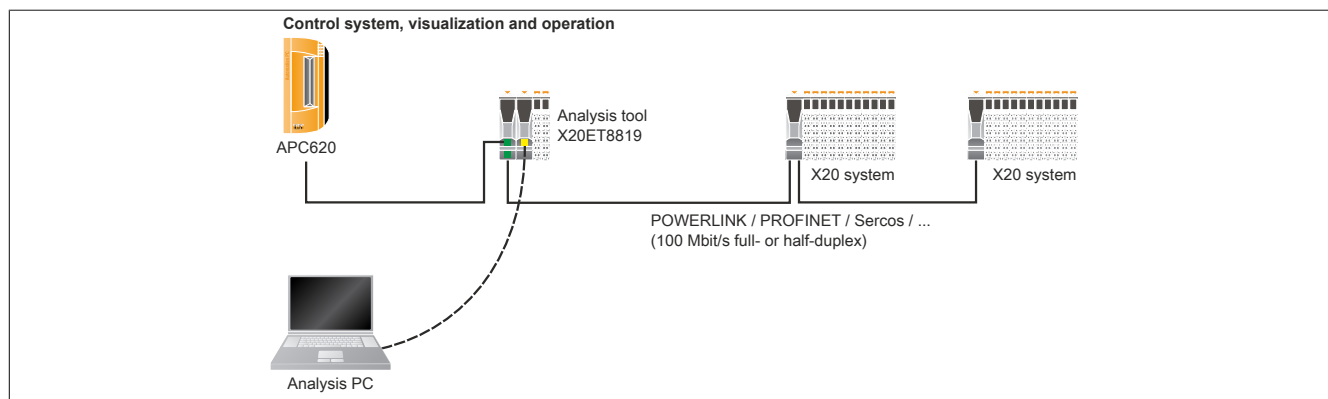
Figure 4: Example application of hardware configuration 2

11 Hardware configuration 3a

Simultaneous data recording at two locations in the network is possible by using two X20HB2880 or X20HB2881. **Only** data from T1 and T3 is analyzed.
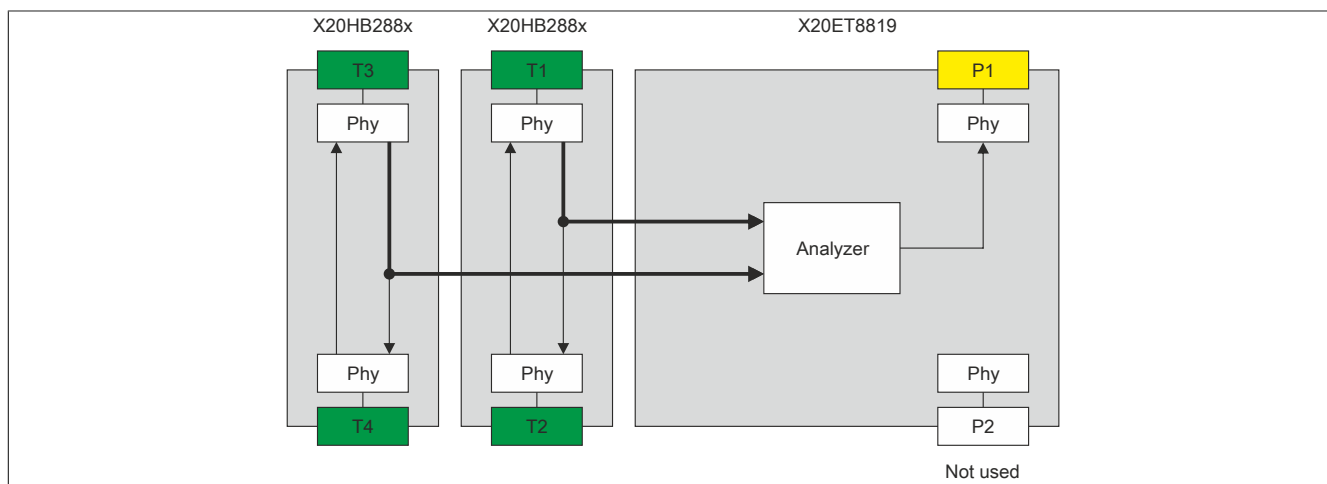
Figure 5: Diagram of hardware configuration 3a

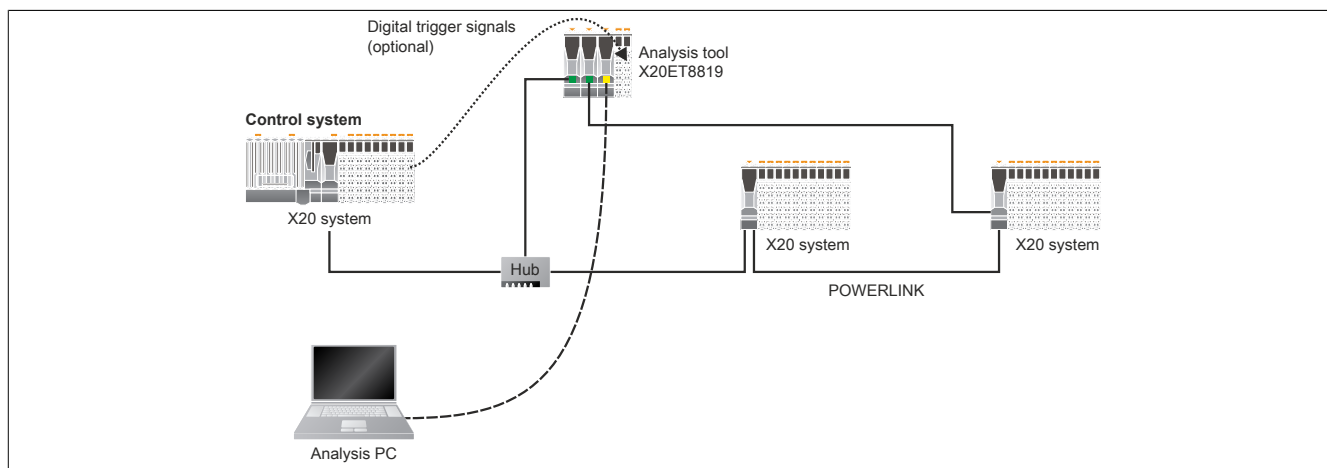Example application 1 shows data being recorded simultaneously from two hubs.

Figure 6: Example application 1 of hardware configuration 3, connection via hubs

The two hub expansion modules can also be inserted in series in the network. It should be noted that in this case data recording is only possible in one direction at a time.
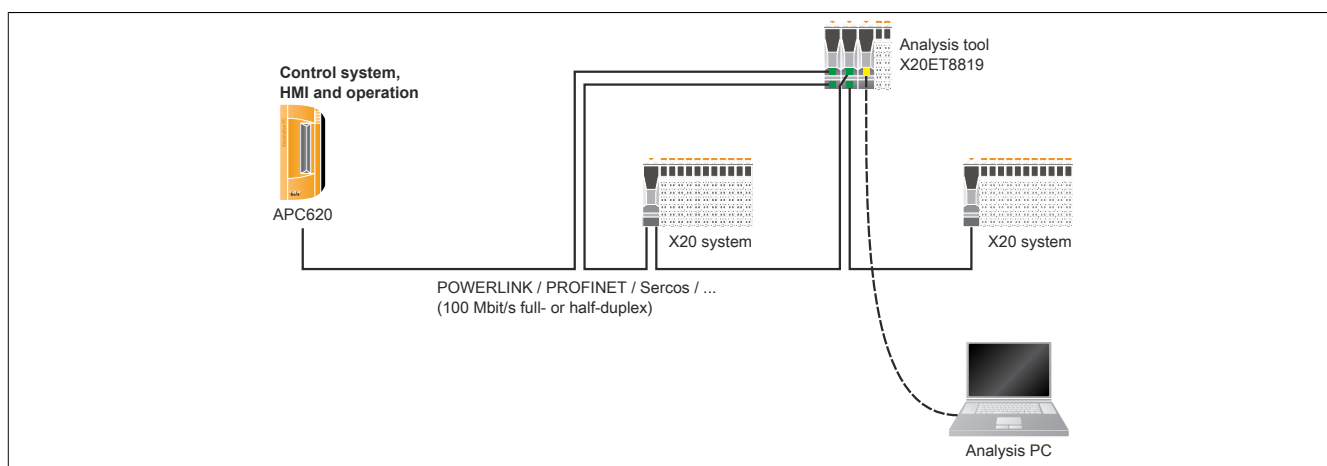

Figure 7: Example application 2 of hardware configuration 3, connection in line

12 Hardware configuration 3b

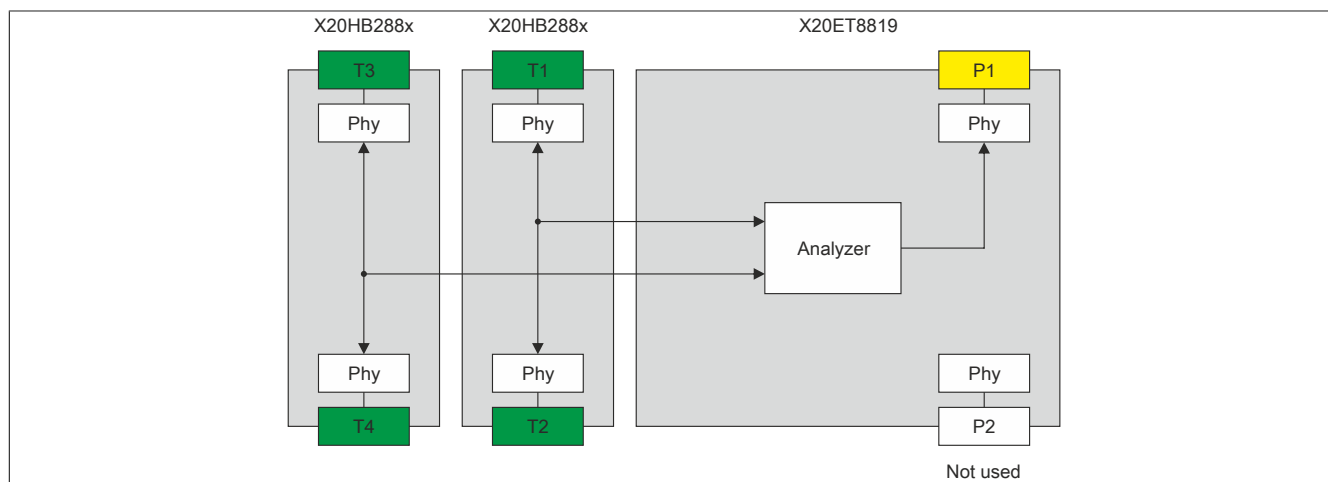With firmware V 1.03 and higher, data traffic in half-duplex networks (e.g. POWERLINK) is recorded in both directions.

Figure 8: Diagram of hardware configuration 3b

13 Firmware update

To update the firmware, the webpage of the X20ET8819 module must be opened when in service mode. To do this, set the MODE switch to 0 and ADD to a value between 0x1 and 0xF. When the hardware is restarted now, the module will enter service mode. A connection can be established to the webpage using a web browser via the interface IF1 (P1) and the IP address 192.168.0.ADD. The update is started by selecting "Firmware Download".
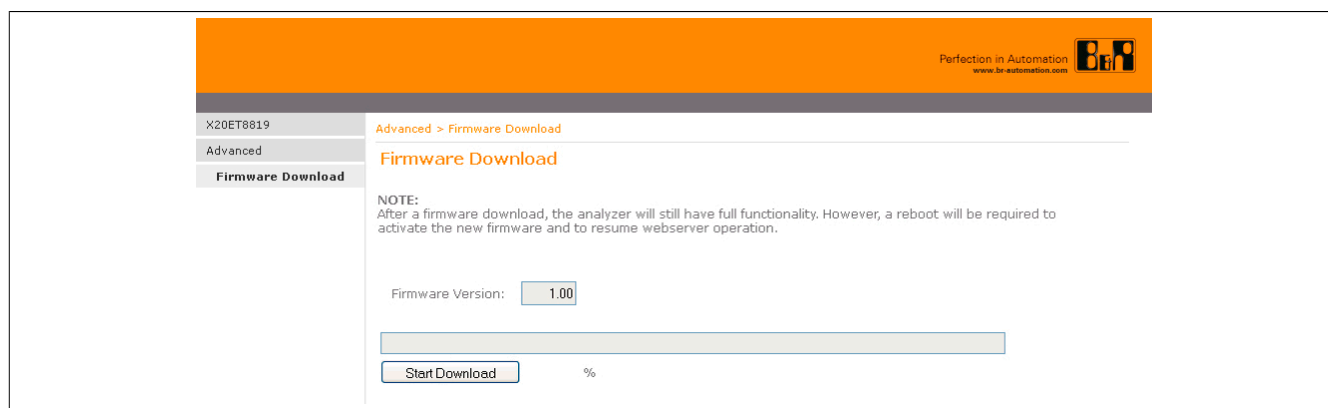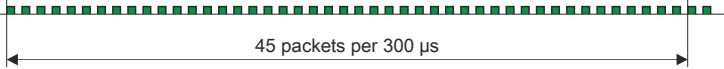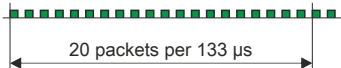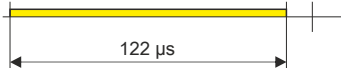

Figure 9: Start firmware update

14 Analysis mode

Each time an incoming packet is analyzed, (see hardware configurations 1 to 3), the analysis tool saves the reception timestamp, various flags and the first 'n' bytes of data from the received packet in capture frames. These frames are sent via IF 1 (P1).

The number of recorded data bytes, 'n', is set with the operating mode switch MODE. This defines the number of packets that are sent for each capture frame.

MODE	n	p/s	Description
0	-	-	Service mode
1	24	148800	45 packets fit in a capture frame: (1514-64) / (24+8) = 45 packets Network to be analyzed (worst case = 64 bytes/packet, packet interval of 6.7 μs) 45 packets per 300 μs Capture frame from Ethernet analysis tool to PC 122 μs
2	40	148800	30 packets per 200 μs Capture frame from Ethernet analysis tool to PC 122 μs
3	64	148800	This is the first setting at which complete packets fit in the capture frame (minimum packet with 60 byte payload). 20 packets can fit in one capture frame, however this setting could cause problems on the analysis PC because there is not much idle time between the capture frames. 20 packets per 133 μs 122 μs
4	80	128000	
5	120	88000	
6	196	56000	
7	280	40000	
8	716	16000	2 packets fit in a capture frame: (716+8)*2 + 64 = 1512 bytes A setting 'n' > 716 has the disadvantage that a network with full capacity would not be able to be analyzed.
9	24 to 1440	-	The analysis tool selects the largest possible value for 'n' itself due to the packet volume of the last capture frame that was sent. This means that each capture frame can be assigned a different 'n' value. 'n' is always a multiple of 4 and can assume values between 24 and 1440.
A	-	-	Up to a size of 1440 bytes every packet is recorded in its original size.
B - F	-	-	Reserved

Note:

- A change in the position of the MODE switch from 1 to A will be applied online during operation.
- If the "S/E" LED is red, then the number of bytes to be recorded should be reduced.

15 Using trigger inputs

The Ethernet analysis tool launches the first connected I/O module in the standard function model. The X2X link is configured with a fixed cycle of 1 ms. If this configuration contains digital input data (digital input module X20DI9371), the first 4 digital inputs will be included in the packet header.

15.1 Background

When looking for very complicated errors, it is usually not possible to find a trigger condition on the network. It is often difficult to discern whether the cause of the problem is even associated with the Ethernet communication or somewhere else. The fact that such errors are extremely rare makes finding them that much harder.
A permanent record of network frames through the module X20ET8819 would exceed storage capabilities of the recording software due to the large amount of data. The trigger inputs on the X20ET8819 offer an additional way to circumvent this problem. Analysis of the network can be started or stopped when a specific event occurs.

In most cases, the problem can be indicated using a digital signal. The CPU can detect errors or irregularities (e.g. failure of a network slave), for example, and then set a digital output on the local I/O bus. If this signal is connected to a digital input on the Ethernet analysis tool, then the module is able to evaluate this information and trigger a response such as pausing an active recording.

15.2 Evaluation of the inputs on the analysis tool X20ET8819

Input 1 - 4

The first 4 inputs will be inserted only in the packet header by the X20ET8819. The recording software from B&R (OmniPeek full version and plugin) can determine how the signals are interpreted.

Input 5 - 7

If the recording software is unable to evaluate the first 4 inputs (Wireshark, OmniPeek, various other capture tools), then inputs 5 - 7 are used to control the Ethernet analysis tool X20ET8819 directly.

Input	Name	Description
5	ExternActivate	Recording will not start automatically if this input is set to HIGH when the analysis tool is turned on. The module waits for a positive edge on input 6.
6	ExternStart	Recording begins when a positive edge occurs on this input. The value in 'captureId', offset 49 in the capture frame header is incremented to indicate to the receiving tool that a new recording has been started. When recording using the recording software from B&R, this information can be used to switch to a new ring buffer and to store the last one.
7	ExternStop	Recording stops when a negative edge occurs on this input.
8 - 12	-	Reserved

Table 6: Evaluation of inputs 5 - 7 on the analysis tool

Example 1

A drive is started one time each minute. After 10 to 30 hours, a problem arises on a network station shortly after starting the drive. To analyze the error, the Ethernet communication is recorded between when the start command is issued and when the error occurs.

Problems:

Due to the large amount of data it is not possible to record the entire 30 hours. Someone would have to stay on the analysis PC the whole time to stop recording when the error occurs.

Solution:

Input	Description
ExternActivate	Input permanently wired to 24 VDC = Activates the external trigger function
ExternStart / ExternStop	Connect both inputs to the same digital output that the master uses to notify the X20ET8819 when to start and stop recording. The master can, for example, always set the output before the drive start command and reset it as soon as the startup has been completed. When the master detects an error, it only has stop setting the output. This would mean that after 30 hours the recording is certain to contain the time period in which the error occurred and as well as a few prior recordings of proper startups for comparison.

Table 7: Function of the inputs in Example 1

Example 2

A system containing multiple X20 I/O systems on the POWERLINK network is experiencing sporadic failures. An I/O slave suddenly fails for no apparent reason after running properly for a long time. To analyze whether the failure is network related, the time before the failure must be recorded.

Problems:

The master has no indication as to when and why the problem occurs. That means there is no start condition for the recording. Someone would have to stay on the analysis PC the whole time to stop recording when the error occurs.

Solution:

Input	Description
ExternActivate	Input permanently wired to 24 VDC = Activates the external trigger function
ExternStart	Input permanently wired to 24 VDC = Ensures that the recording starts immediately when the X20ET8819 is turned on
ExternStop	Connect input to a digital output on the affected I/O slave, which is permanently set to 1 by the program. As soon as the slave fails the first time and resets the digital outputs, recording is stopped by the negative edge on ExternStop and is not started again.

Table 8: Function of the inputs in Example 2

16 Using trigger outputs

Output	Name	Description
1	FrameError	As soon as a frame error (CRC, Oversize, Preamble, Noise or Alignment) occurs, this output is set for 10 ms.
2 - 12	-	Reserved

Table 9: Using trigger outputs in the event of an error

17 B&R recording software

The following tools for analysis can be downloaded in the Downloads section on the B&R website (https://www.br-automation.com):

- Recording plug-in for Wireshark to decode the captured frames