SIEMENS

Application Notes

SIPROTEC 5 Application

SIP5-APN-028:
Time synchronization via IEEE 1588

SIPROTEC 5 - Application:
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Content:

1 Time synchronization via IEEE 1588

1.1 Introduction

IEEE1588 is standardized and contains the precision time protocol (PTP), which allows time synchronization of local networks with a very high precision over an Ethernet connection. Precise time synchronization is needed to permit the accurate reconstruction of an event from device Logs, created by different devices.

PTP uses always one grandmaster clock, if more than one device in the network is capable of being grandmaster clock the best master clock (BMC) is chosen, as defined by the standard. PTP has multiple possible configurations, which have to be supported over the whole network.

Time synchronization can be done in “Two-Step” or “One-Step”. Both times the clock sends a “SYNC-Message” (SYNC). For the synchronization it is needed to know when this SYNC was send. One way is to send another package with this information (Two-Step) or to write this information in the last possible moment in the SYNC.

To calculate the offset to the grandmaster clock the package runtime has to be determined. Possible is the “End-to-End” (E2E) communication, in which every slave exchange packages with the grandmaster clock or the “Peer-to-Peer” (P2P) communication, where only packages between the neighbouring switches (All switches has to support these function) are exchanged.

For an interference-free integration in an already existing network topology, a new virtual local area network (VLAN) is created, which works independent of the rest of the system.

This paper describes how the internal time of a SIPROTEC device can be synchronized with the IEEE1588 network protocol on a simplified example.

1.2 Example of Set-Up

The example set-up as shown below exists of a grand master clock, a switch and a SIPROTEC 5 device (Firmware and Configuration at least V6). They are connected over Ethernet. Also a Computer is connected to the Set-up to ensure a easy way to configure the parts of the network and get feedback from them.

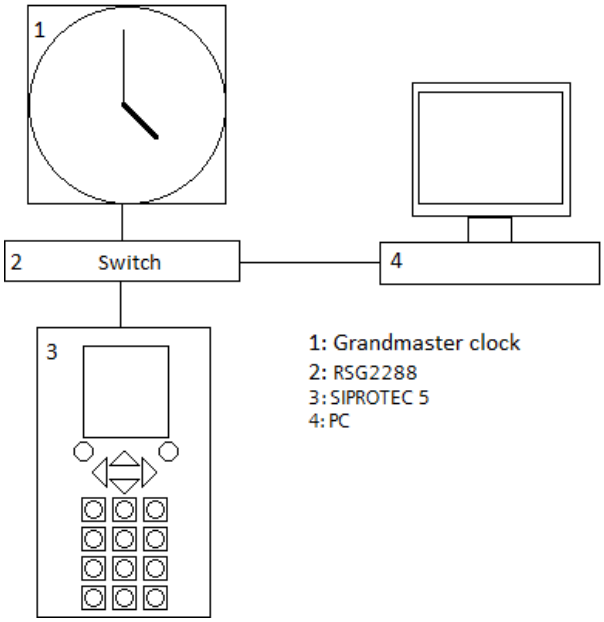

Figure 1: Configuration

1.2.1 Hardware

The following Hardware was used in the example set-up:

Device: SIPROTEC 5 device with one Ethernet module (ETH-BA-2EL)

Switch: RUGGEDCOM RuggedSwitch RSG2288

Clocks:

- Meinberg M400
- OMICRON OTMC 100p Grandmaster Clock
- RUGGEDCOM RuggedSwitch RSG2288

1.2.2 Device configuration

For using the IEEE 1588 protocol, it has to be enabled on the Ethernet modul (As shown in Figure 2). No further settings are necessary, but activating the homepage can provide useful information. For active time synchronization the IEEE protocol has to be chosen as the active time source (As shown in Figure 3). In this example we configure the Device to show the UTC.

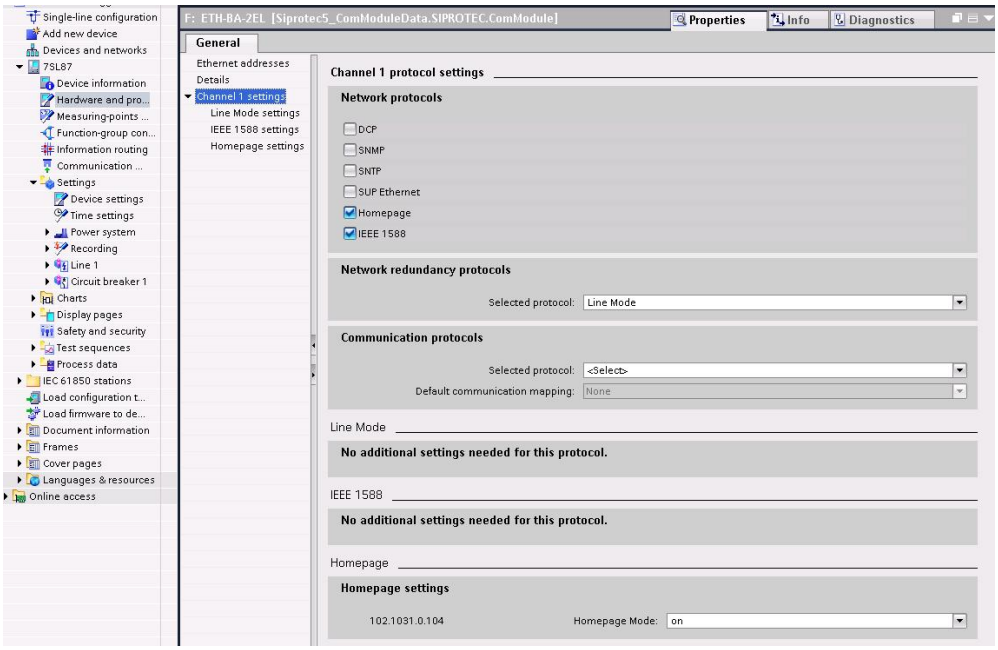

Figure 2: Hardware and protocol

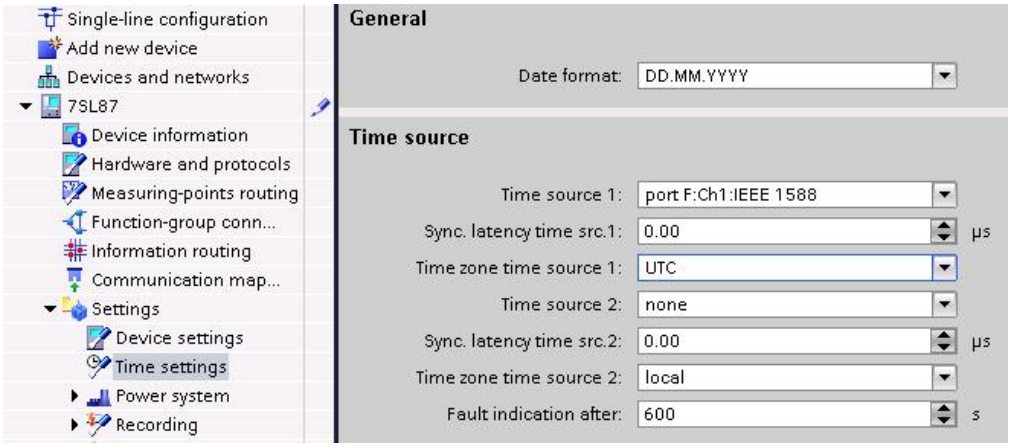

Figure 3: Time settings

1.2.3 RUGGEDCOM Configuration

This Switch could work as a grandmaster clock, but in this example it will be used simply to transmit the ptp-packages.

On the RUGGEDCOM a new Static VLAN (used is VLAN-ID 4) has to be configured:

VID	VLAN Name	Forbidden Ports	IGMP	MSTI
4	VLAN4	None	Off	0

Figure 4: Static VLAN

The next step is to configure the Port VLAN Parameters. We change the ports used for the Set-up to Trunk ports. In this example Port 1, 2, 3 and 4 (See Figure 5). On port 1 the ptp-signal of the Clock is connected, on port 2 the Ethernet port of the Clock (for configuration purpose), on port 3 the ETH-BA-2EL module of the SIPROTEC Device and on port 4 a Computer.

Port VLAN Parameters

Port(s)	Type	PVID	PVID Format	GVRP
1	Trunk	1	Untagged	Disabled
2	Trunk	1	Untagged	Disabled
3	Trunk	1	Untagged	Disabled
4	Trunk	1	Untagged	Disabled
5	Edge	1	Untagged	Disabled
6	Edge	1	Untagged	Disabled
7	Edge	1	Untagged	Disabled
8	Edge	1	Untagged	Disabled
11	Edge	1	Untagged	Disabled

Figure 5: Port VLAN Parameters

With this configuration the used Ports should be tagged Ports in the VLAN 4, as can be seen in the VLAN Summary and Figure 6.

VLAN Summary

VID	Untagged Ports	Tagged Ports
1	All	None
4	None	1-4

Figure 6: Port VLAN Summary

If you change the PVID of the used port to VLAN 4, then the system will work, but the VLAN-Tag will be lost.

To configure PVID to 4 and the PVID Format to tagged won´t result in the same behavior of the system.

Also if you enable PTP on the Switch, you have to especially enable the VLAN of the PTP-packets.

1.2.1 Grand master clock configuration in IEEE 1588 networks

1.2.1.1 Grand master clock configuration Meinberg M400

For the Grand master clock the PTP profile has to be set to Power profile, also the clock has to be not in slave-only state. In our example we use Peer-to-Peer communication. These Settings can be changed over the Homepage of the Meinberg clock in the menu PTP, in the file: ptp2_global_conf_0.
Note: Meinberg M400 supports only the two step mode.

```
#------------------------
#     PTP2 Global
#  Configuration File
#------------------------
# 0=Multicast (MC), 1=Unicast (UC), 2=MulticastAuto (MA)
PTP Mode                                [NUM]:0
# Force PTP to act as slave-only system
PTP is slave                            [BOOL]:0
# 0=End-to-End, 1=Peer-to-Peer
PTP Delay Mechanism                     [0,1]:1
# only for certain slaves, see Standard
PTP V1 Hardware Compatibility           [0,1]:0
# A PTP domain is a logical group of PTP devices
PTP Domain Number                   [NUM,0:3]:0
# 1=UDP/IPv4 (L3), 3=IEEE 802.3 (L2)
PTP Network Protocol                [NUM,1,3]:3
# 0=ARB, 1=PTP (default)
PTP Timescale                       [NUM,0:1]:1
# Debug only, leave set to 0
PTP clockClass: REF sync, cold      [6:255]:6
# Debug only, leave set to 0
PTP clockClass: REF sync, warm      [6:255]:6
# Debug only, leave set to 0
PTP clockClass: REF not sync, cold [6:255]:52
# Debug only, leave set to 0
PTP clockClass: REF not sync, warm [6:255]:7
# Priority 1 as used in BMCA (GM only)
PTP priority1                     [NUM:0:255]:128
# Priority 2 as used in BMCA (GM only)
PTP priority2                     [NUM:0:255]:128
# used in MC Master or UC Slave mode
PTP Sync Interval                       [2^x]:0
# used in MC Master or UC Slave mode
PTP Announce Interval                   [2^x]:0
# used in MC Master or UC Slave mode
PTP DelayRequest Interval               [2^x]:0
# Requested duration until timeout/renewal
PTP Unicast interval duration [s]     [NUM]:60
# Unicast Clock ID: FF:FF:FF:FF:FF:FF:FF:FF
PTP Unicast clockid of master    [ASCII,50]:FF:FF:FF:FF:FF:FF:FF:FF
# Unicast: IP address of Grandmaster
PTP Unicast IP address of master       [IP]:172.29.9.236
# 1:Power Profile  2:Telecom Profile
Feature Presets                         [NUM]:1
# User defined value 3 - 254
Power Profile Grandmaster ID            [NUM]:0
# accumulated time inaccuracy in worst network path
Power Profile Network Inaccuracy [ns][NUM]:0
# Fix Offset from RefTime in Master Mode
User defined Fix Offset [ns]            [NUM]:0
# Optimized filter for high load/jitter
HQ Filter active                       [BOOL]:0
# estimated accuracy of HQ Filter
HQ Filter estimated accuracy [ns]     [NUM]:5000
# Optimize filter for frequency (1) or time (0)
HQ Filter optimized for frequency    [BOOL]:0
# Path Delay Step Compensation (Filter on)
PDSC active                            [BOOL]:0
# 0=DRRDP, 1=Power, 2=Telecom, 3=P2PDP, 4=Exp
Selected Profile                        [NUM]:1
# used in Multicast Master mode
PTP Announce Receipt Timeout            [2^x]:2
# used in all PTP modes
PTP one step active                    [BOOL]:1
# general PTPv2 Management Messages
PTP Management Messages disabled     [BOOL]:0
# Update interval for checking all PTP nodes
PTP Client Management Interval [s]    [NUM]:0
```

Figure 7: General clock settings

In addition the PTP-Port of the Clock has to be configured (in the File ptp2_network_conf_0) to the used VLAN 4, as can seen in Figure 8.

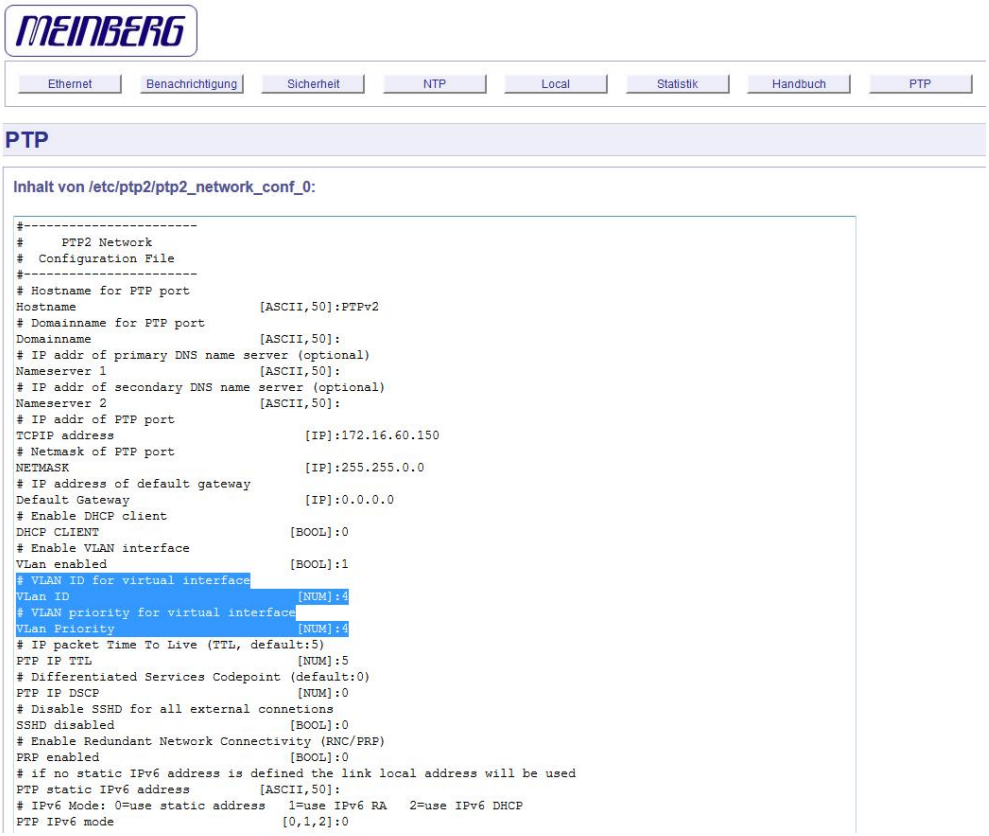

Figure 8: VLAN of the Clock

1.2.1.2 Grand master clock configuration Omicron

For the Grand master clock the PTP profile has to be set to Power systems, the operational mode can be One Step or Two steps, see Figure 9. Both works in our example.

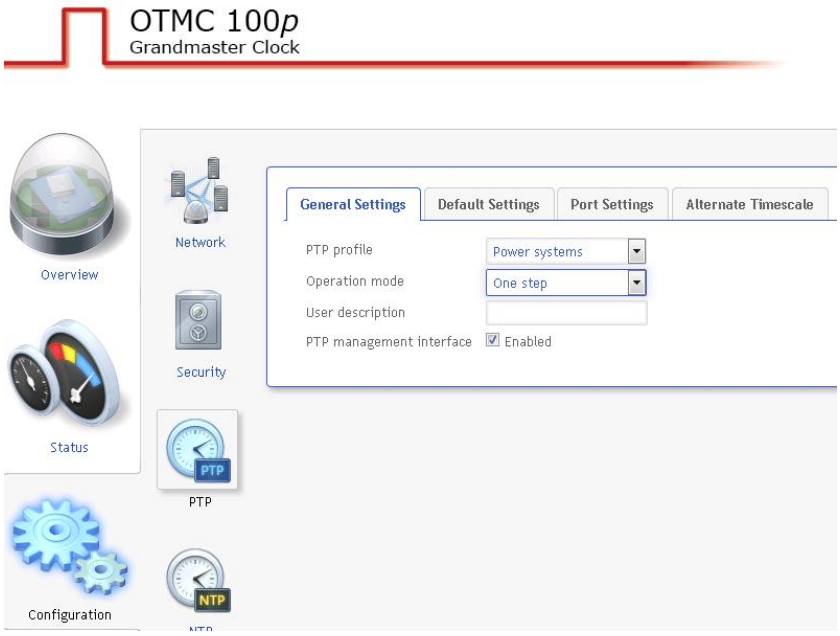

Figure 9: General Clock settings

In addition the Port of the Clock has to be configured to the used VLAN 4, as can be seen in Figure 10.

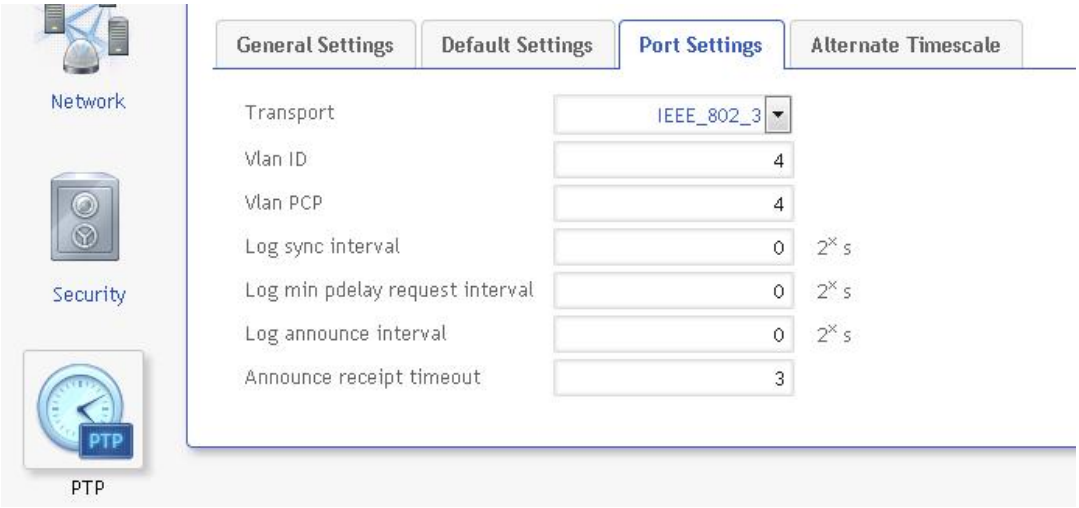

Figure 10: VLAN of the Clock

Additional Note:

The power supply of the Omicron clock takes place with power over Ethernet (PoE), therefore the switch has to support this functionality. In a more complex network compared to this set-up, it could happen, that more than one switch tries to supply the power for the clock. In this case the switch, which has no direct connection to the clock does not work properly, because there is no consumer of the provided power. The power supply function on the port of this switch has to be disabled in order to solve this problem.

1.2.1.3 Grand master clock configuration RUGGEDCOM RSG2288

It is possible to configure the Switch to work as a clock source (see Figure 11).

Figure 11: PTP-Settings

In the global parameters we enable the PTP, configure the VLAN tags with the PTP-packets are send. As the Clock Type we choose OC and P2P TClock. This means that the Switch works only as clock, if no other clock is available.

Figure 12: Console Global Parameters

In the clock parameters it is important to set “Slave Only” to no (see figure 13). It could be necessary to change the path delay mechanism to “End-to-End”, if not all switches in the network support PTP. But in this case the accuracy will be reduced.

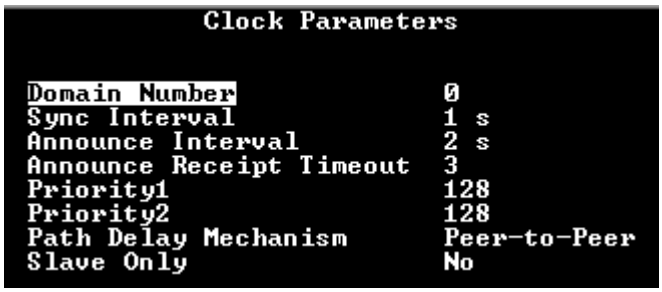

Figure 13: Console Clock Parameters

1.3 Verification of Configuration

There are multiple ways to verify the configuration.

First you can use the homepage of the Device. Type the configured IP of the Ethernet module into a browser, in the Application Diagnostic> IEEE 1588 you can verify that the time synchronization is completed (see figure 9).

Figure 14: Homepage

A second way to verify that the SIPROTEC device was synchronized is to use the information routing in DIGSI to indicate on an LED that the time source is active (see Figure 10).

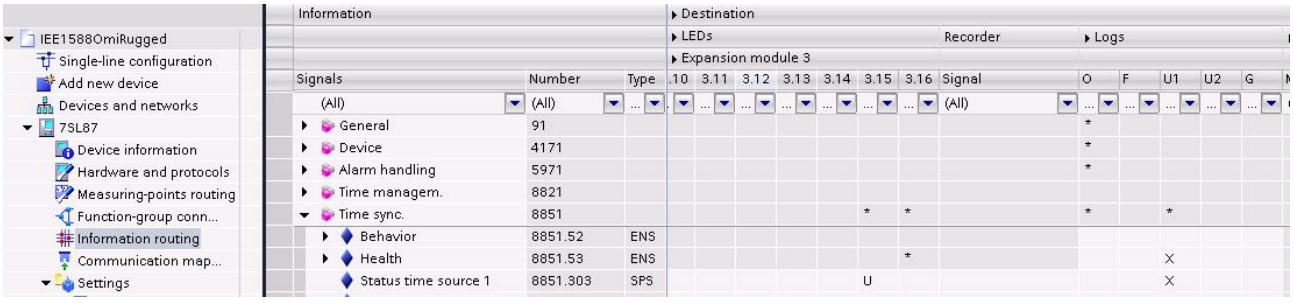

Figure 15: Information routing

A way to verify the traffic of the network is to use Wireshark on the Computer. It is assumed that VLAN tags are supported by the network interface card. With an applied Filter for the ptp-protocol, Wireshark should show similar view like in figure 11. Note that the source of the message depends on the used grandmaster clock. The “Follow_up Message” will also not be present in single step mode.

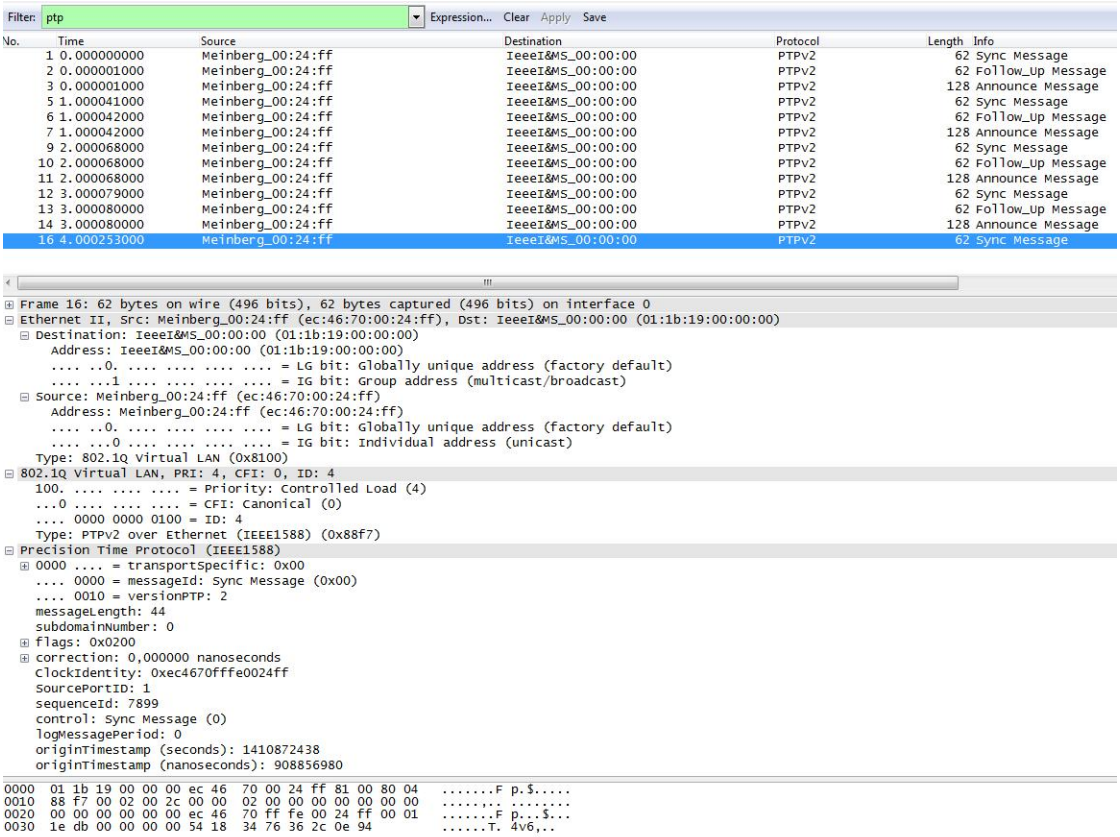

Figure 16: Wireshark trace

1.4 Summary

IEEE1588 is standardized and contains the precision time protocol (PTP), which allows time synchronization of local networks with a very high precision over an Ethernet connection. Precise time synchronization is needed to permit the accurate reconstruction of an event from device Logs, created by different devices.

For using the IEEE 1588 protocol, it has to be enabled on the Ethernet module and for active time synchronization the IEEE protocol has to be chosen as the active time source. No further settings are necessary, but we recommend activating the homepage which provides useful information for verification.

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Siemens AG

Infrastructure & Cities Sector

Smart Grid Division

Humboldtstr. 59

90459 Nuremberg, Germany

Siemens AG

Infrastructure & Cities Sector

Smart Grid Division

Energy Automation

Humboldtstr. 59

90459 Nuremberg, Germany

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