SIEMENS

Ingenuity for life

Time synchronization via IEE 1588

www.siemens.com/siprotec5

SIPROTEC 5 Application

Time synchronization via IEE 1588

APN-028, Edition 2

Content

1 Time synchronization via IEE 1588

1.1 Introduction

IEEE1588 is standardized and contains the precision time protocol (PTP). It is a network protocol which secure the synchronism of the time settings of all devices within a network with the focus on high accuracy in a local defined network. The precise time synchronization is necessary to permit the accurate reconstruction of an event from operational logs of different devices or for high-precision applications like the process bus.

A PTP network consists of communicating clocks. It will be determined with the best master clock algorithm (BMCA) which device has the time with the highest accuracy. This device is then the according reference clock and will be called as the Grandmaster clock. It there are changes in the network topology, the BMC algorithm will be undertaken again. Due to the continuous measuring of the delay times between the partners in the network, IEEE 155 is much more precise than the SNTP.

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 Grandmaster clock, a switch and a SIPROTEC 5 device (≥V6). They are connected over Ethernet. Also a Computer is connected to the Set-up to ensure an easy way to configure the parts of the network and to get the necessary data for analysis.

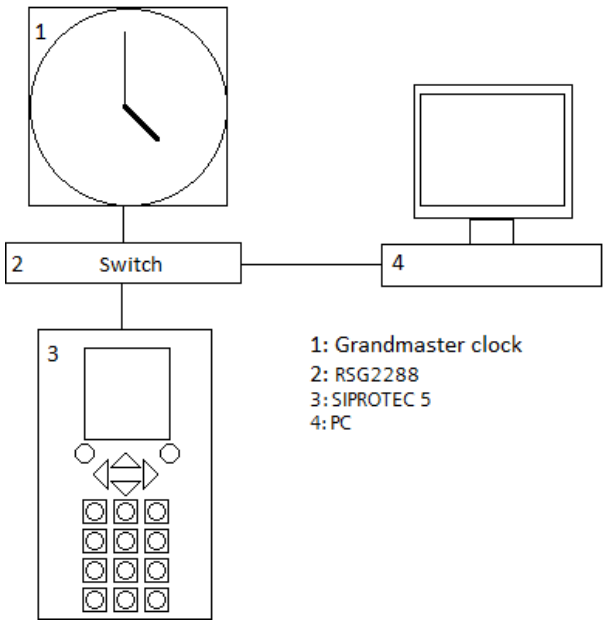


Figure 1: Configuration

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 Lab OTMC 100p Grandmaster Clock
- RUGGEDCOM RuggedSwitch RSG2288

1.2.2 Device configuration

For using the IEEE 1588 protocol, it has to be activated on the Ethernet module (as shown in Figure 2). No further settings are required, but activating the homepage can provide useful information for evaluation. The IEEE 1588 protocol must be selected as time source in order to evaluate the synch telegram from the Grandmaster Clock and for the use for synchronization. The Device to show the UTC, fig.2 and 3.

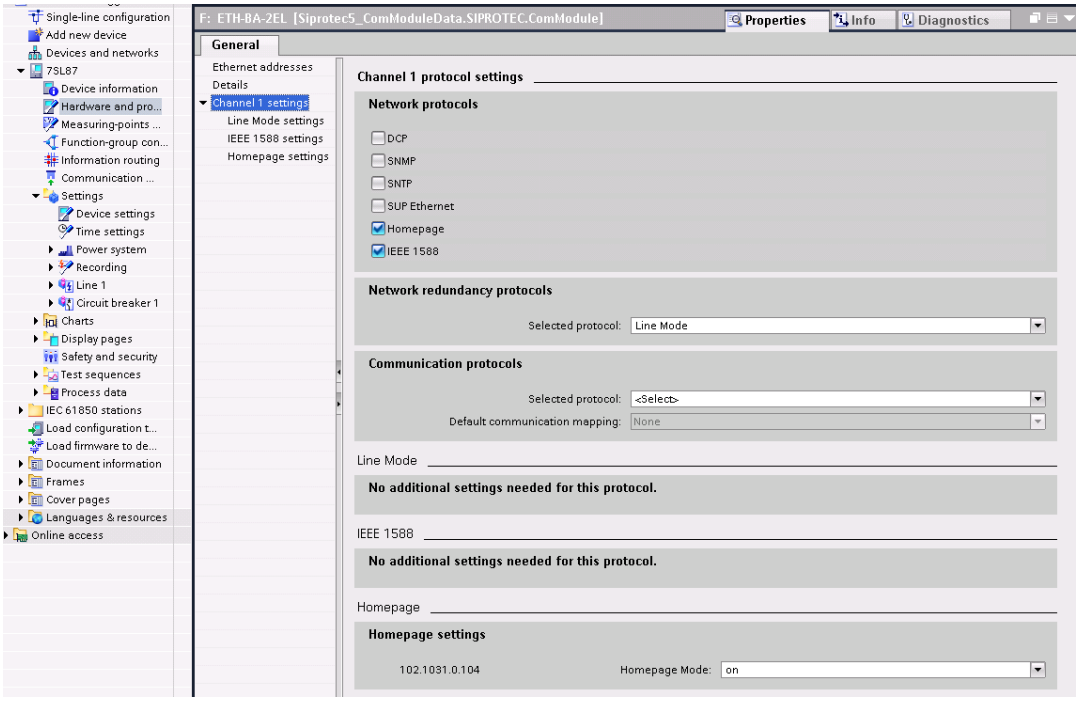


Figure 2: Hardware and protocol

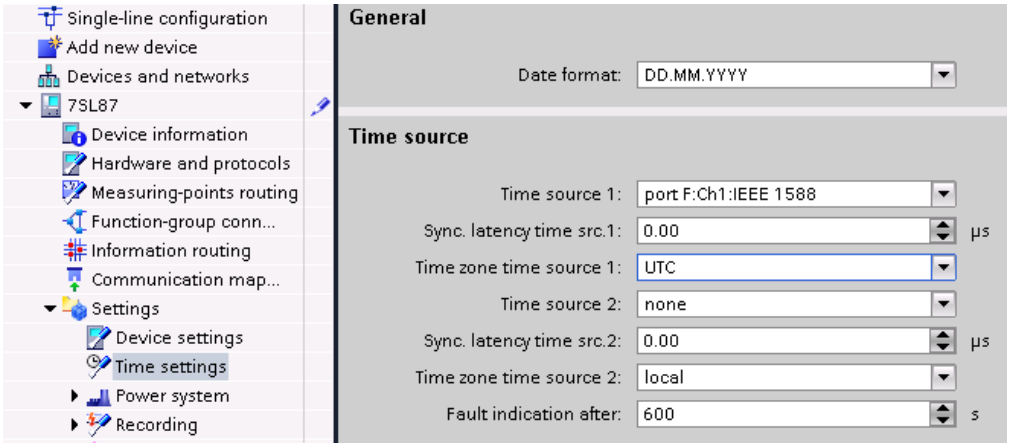


Figure 3: Time settings

1.2.3 RUGGEDCOM Configuration

This Switch could work as a grandmaster clock, but in this example it will be used only to transmit the PTP-packages. But, the switch takes active part in the measuring of the operating time in the network, because the switch supports IEEE 1588.

All ports of the switch which support IEEE 1588 are configured in a new static VLAN-ID 4 (virtual LAN). RUGGEDCOM configured in a new Static VLAN (used is VLAN-ID 4):

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

Figure 4: Static VLAN

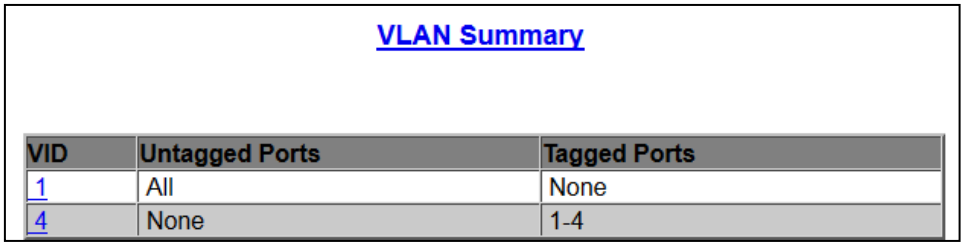
The next step is to configure the Port VLAN Parameters. Port 1,2,3 and 4 are configured as type = “trunk”, see Figure 5. On port 1 the PTP-signal of the clock is connected, on port 2 the Ethernet port of the clock (for configuration purpose), on port 3 the ETH-BA-2EL module of the SIPROTEC Device and on port 4 the PC.

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

After the configuration the used ports should be tagged Ports in the VLAN 4, see VLAN Summary in fig. 6.



VLAN Summary

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

Figure 6: Port VLAN Summary

If th PVID of the used ports are changed to VLAN 4, the system works, but the VLAN-Tag will be lost → The system behavior will be changed!

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

1.2.4 Grandmaster Clock configuration in IEEE 1588 networks

1.2.4.1 Grandmaster Clock Meinberg M400

The Power Profile is a specific IEEE 1588 profile for the applications in switchgears standardized by IEEE. All participants wihtin the networks must support this profile. The practical experience indicates that different IEEE 1588 profiles exist which are not compatible to each other.

For the Grand master clock the PTP profile has to be set to Power profile, also the clock has to be **not** in slave-mode. In our example we use Peer-to-Peer communication.

These settings can be changed in the menu PTP, in the file: ptp2_global_conf_0. On the homepage of the Meinberg clock.

```
#-----------------------
#     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

Note: IEEE 1588 time synchronization can be executed in “Two-Step” or “One-Step”.
Meinberg M400 supports only the two step mode.

Additionally, the PTP-Port of the Clock has to be configured (in the File ptp2_network_conf_0) to the used VLAN 4, see figure 8.

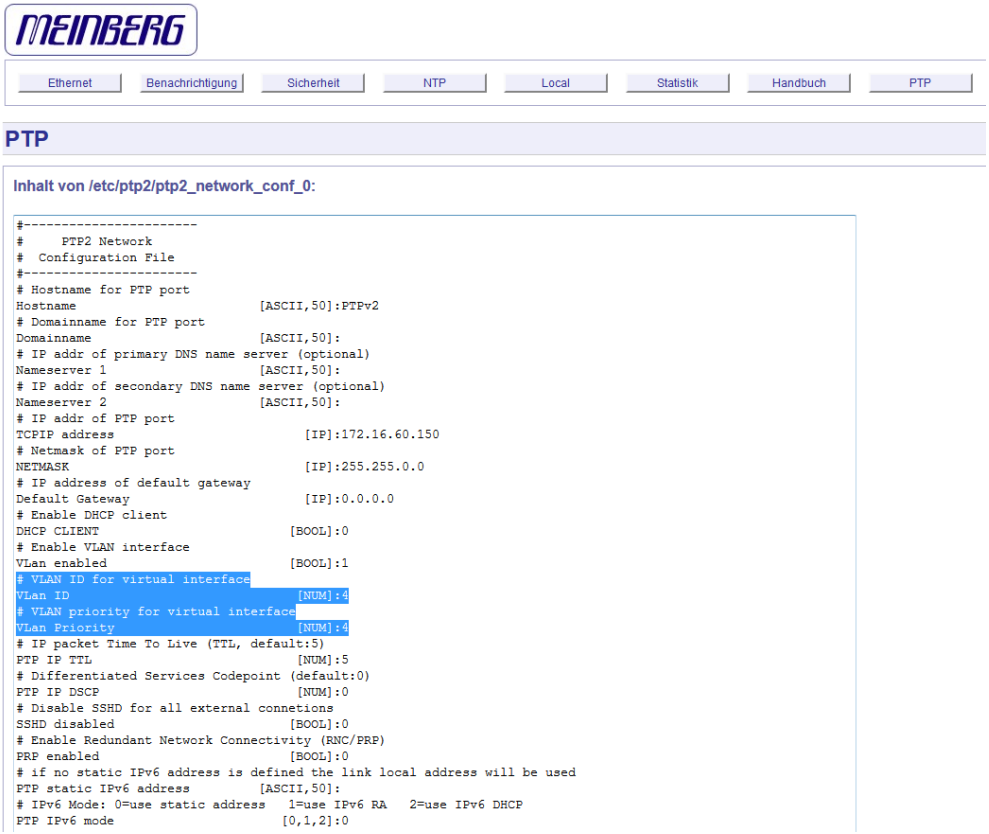


Figure 8: VLAN of the Clock

1.2.4.2 Grandmaster Clock OMICRON Lab OTMC 100p

For the Grandmaster Clock the PTP profile has to be set to Power systems, the operational mode can be One Step or Two step modes, see Figure 9.

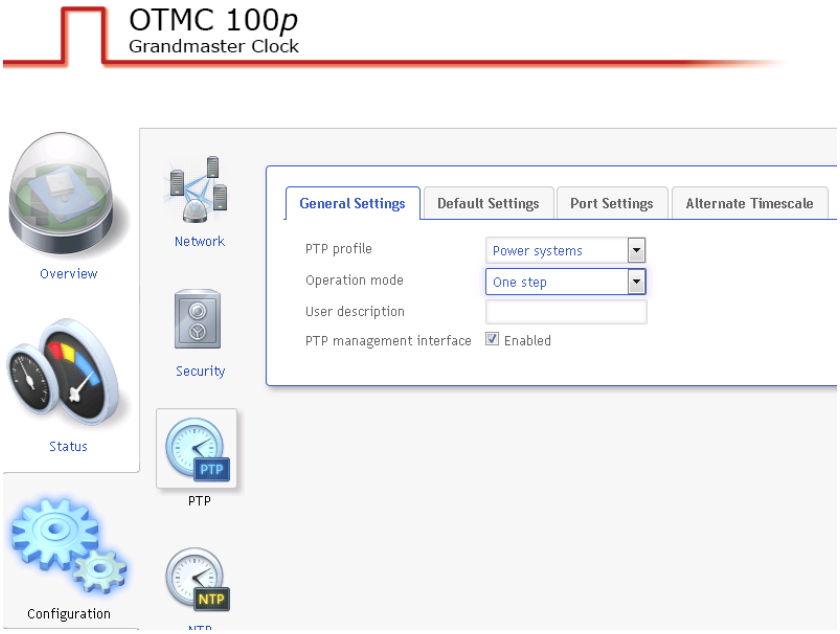


Figure 9: General Clock settings

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

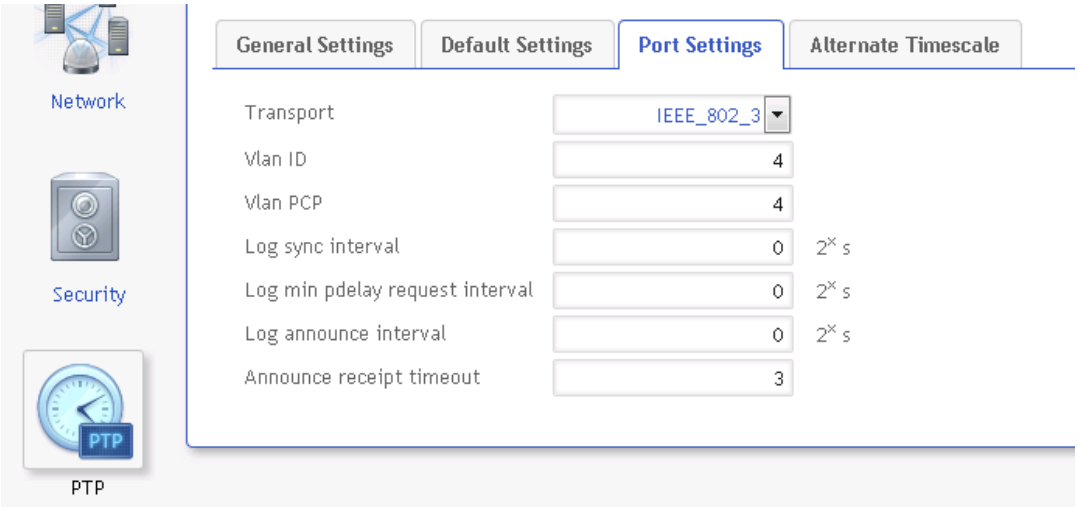


Figure 10: Settings of the VLAN ID of the OMICRON Lab OTMC 100p

Hint: The PTP port in the port settings must be configured for the VLAN 4 also.

1.2.4.3 Grandmaster Clock RUGGEDCOM RSG2288

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

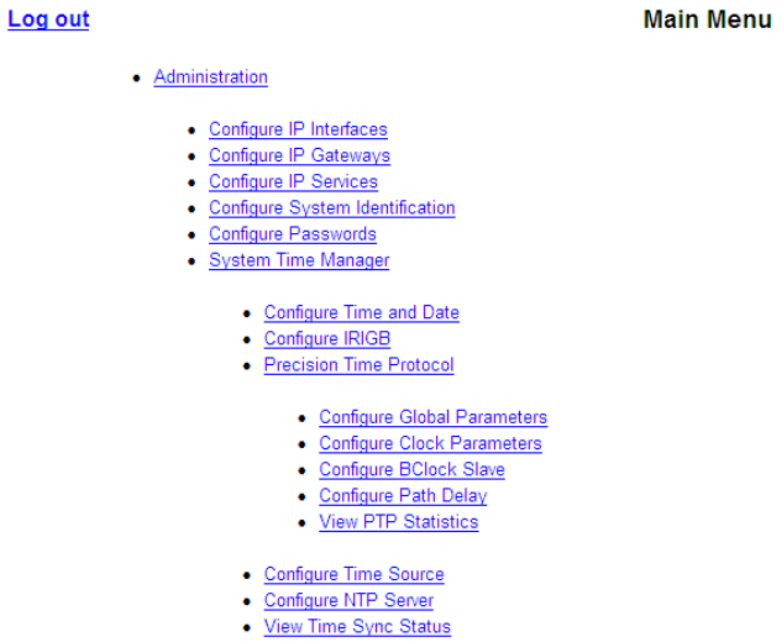


Figure 11: PTP-Settings

In the general settings activate PTP and configure the PTP telegrams as VLAN = 4. Conf. Select "OC and P2P TClock" for the clock type, that means the switch works only as a clock in case no further clocks are available.

Figure 12: Console Global Parameters

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

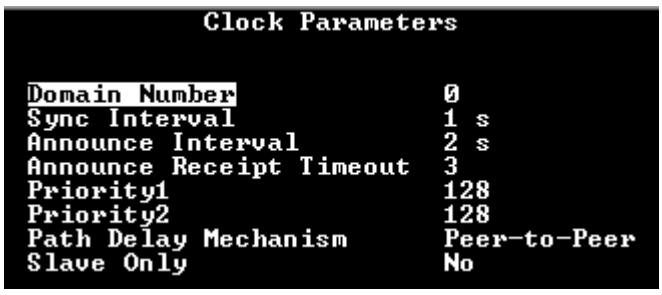


Figure 13: Console Clock Parameters

1.3 Verification of the configuration

There are multiple ways to verify the configuration.

First you can use the homepage of the device, for this type the configured IP-address of the Ethernet module into a browser (e.g.: http:{{192.168.1.2). In the Application Diagnostic > IEEE 1588 you can verify that the time synchronization is completed (see figure 14).

Application Diagnostic-> IEEE 1588 zeigt das die Zeitsynchronisierung vollständig ist, siehe Bild 14.

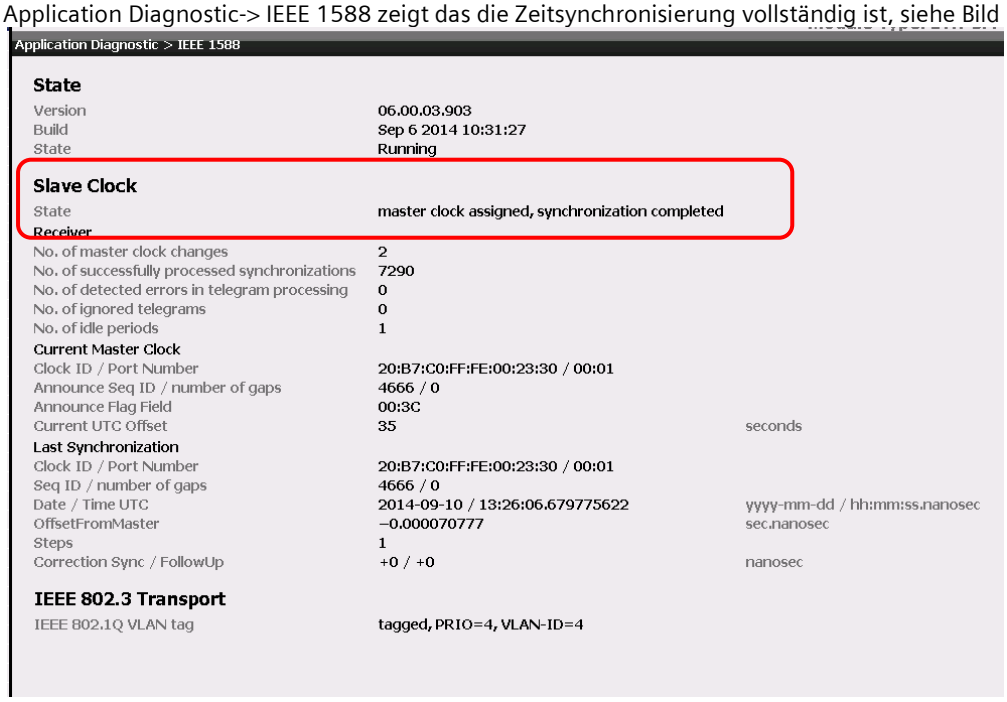


Bild 14: Homepage SIPROTEC 5

The Clock ID must correspondent to the master clock. This can be checked on the web interface of the OTMC 100p: Status/PTP/Default.

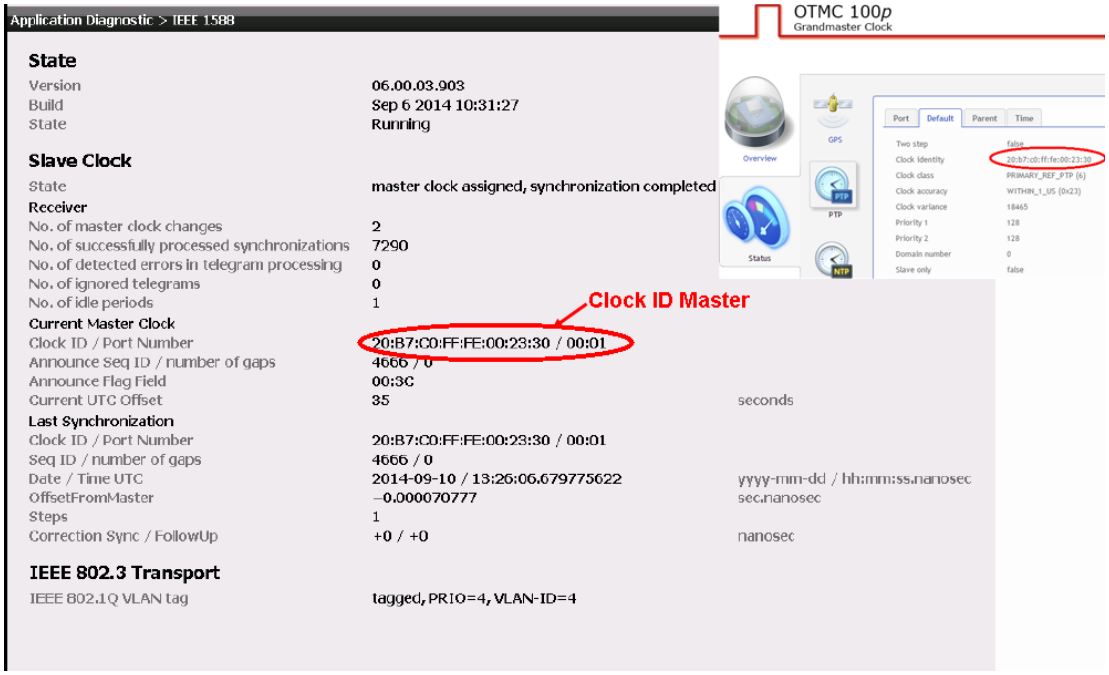


Figure 15: Homepage of the SIPROTEC 5 device and the web interface on OTMC 100p.

A further 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. The information must be configured in the information matrix towards a LED (see Figure 16).

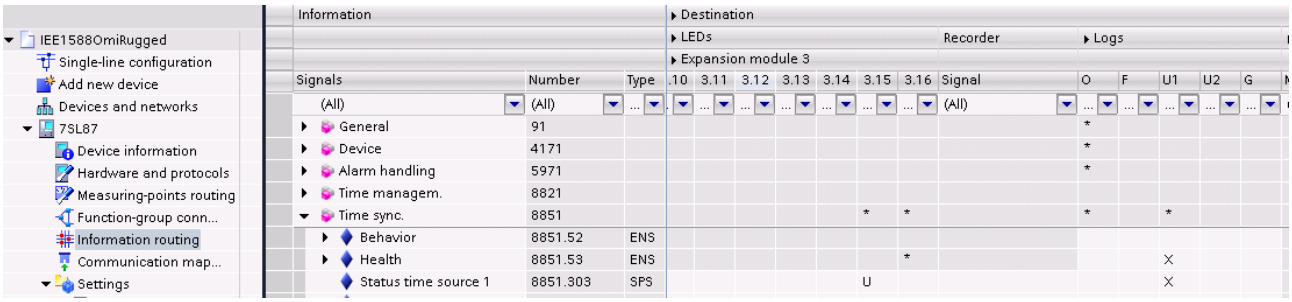


Figure 16: Information routing

The load and the data exchange of the network is checked by Wirkeshark installed on the PC. The network card of the PC must support VLAN tags. In the filter view for “PTP protocols” a trace can be created, see fig. 17.

Note: TAhe source depends on the selected Grandmaster Clock. In the modus “single step” certainly no indication “follow up message” occur.

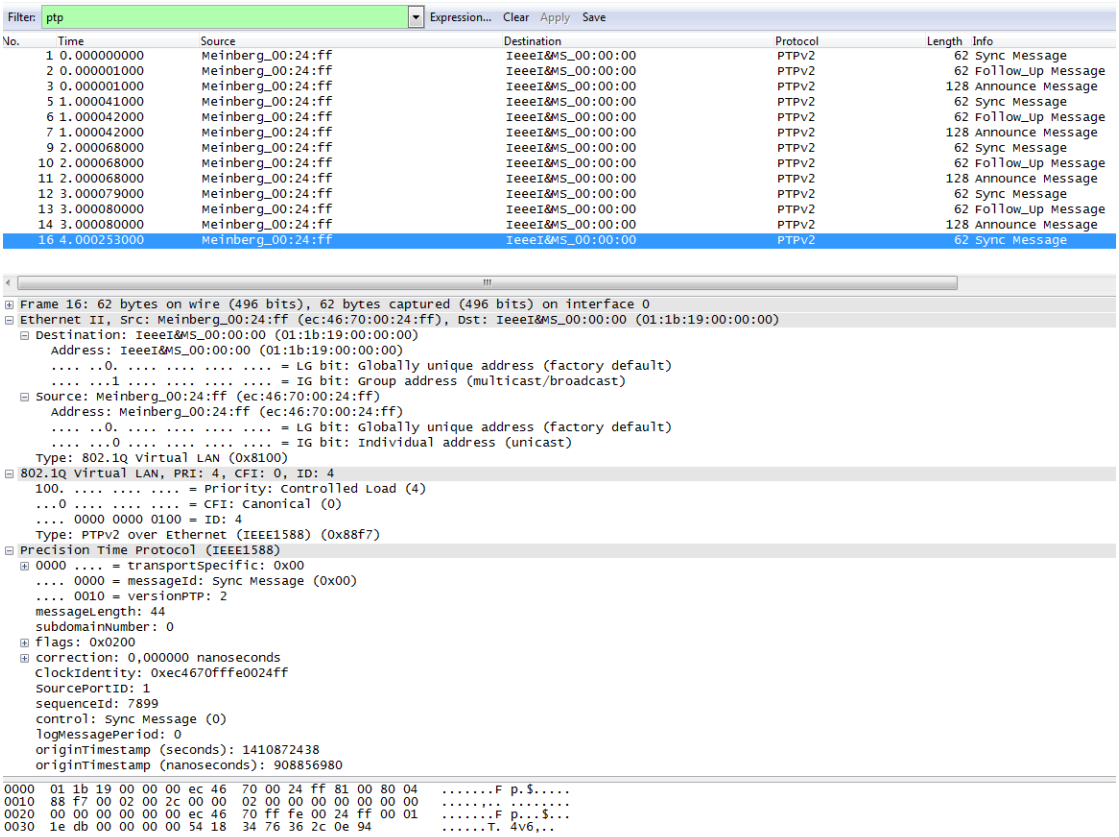


Figure 17: Wireshark trace

1.4 Summary

IEEE1588 is standardized and contains the precision time protocol (PTP). It is a network protocol which secure the synchronism of the time settings of all devices within a network with the focus on high accuracy in a local defined network. The precise time synchronization is necessary to permit the accurate reconstruction of an event from operational logs of 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 beside activating the homepage which provides useful information for verification.

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

90459 Nuremberg, Germany

www.siemens.com/siprotec

For more information,

please contact our

Customer Support Center.

Tel.: +49 180 524 70 00

Fax: +49 180 524 24 71

(Charges depending on provider)

Email: support.energy@siemens.com