



Application Notes

# SIPROTEC 5 Application

SIP5-APN-028: Time synchronization via IEEE 1588

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## SIPROTEC 5 - Application: Time synchronization via IEE 1588

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## 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

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### 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.

T Single-line configuration	F: ETH-BA-2EL [Siprote	c5_ComModuleData.SIPROTEC.ComModule]	S Properties	i Info 🛛 Diagnosti	cs 🗖 🗏 🤉
Add new device	General				
Devices and networks     Jack Control of the second s	Ethernet addresses Details	Channel 1 protocol settings			
<ul> <li>Hardware and pro</li> <li>Measuring-points</li> <li>Function-group com</li> <li>Information routing</li> <li>Communication</li> <li>Settings</li> <li>Device settings</li> <li>Three settings</li> <li>Power system</li> <li>Securition</li> </ul>	✓ Channel 1. settings Line Mode settings IEEE 1588 settings Homepage settings	Network protocols DCP SNMP SNTP SUP Ethemet Homepage VIEEE 1588			
Get uning     Get Line 1     Get Circuit breaker 1     Get Charts     Disclaw pages		Network redundancy protocols Selected protocol:	Line Mode		•
Constant pages     Constant pages     Constant pages     Constant pages     Constant pages     Constant page     Constant page     Constant page     Constant page     Constant page		Communication protocols Selected protocol: Default communication mapping:	<select></select>		•
💝 Load firmware to de ) 🌆 Document information		Line Mode			
Ell Frames     Ell Cover pages     Cover pages     Cover pages		No additional settings needed for this pro	tocol.		
Doline access		IEEE 1588			
		No additional settings needed for this pro	tocol.		
		Homepage			
		Homepage settings			
		102.1031.0.104 F	lomepage Mode: on		•



🕂 Single-line configuration		General			
💕 Add new device					
晶 Devices and networks		Date format:	DD.MM.YYYY	•	
🕶 🌆 7SL87	1				
🚮 Device information		Time source			
Mardware and protocols					
🂯 Measuring-points routing		Time source 1:	port F:Ch1:IEEE 1588	-	
🕂 Function-group conn		Sync. latency time src.1:	0.00		ЦS
🗰 Information routing			Luto		- F.S.
📮 Communication map		Time zone time source 1:			
🕶 👆 Settings		Time source 2:	none	•	
📝 Device settings		Sync. latency time src.2:	0.00	•	μs
🥍 Time settings		Time zone time source 2	local	-	
🕨 🚚 Power system					
🕨 🚧 Recording		Fault indication after:	600	Ţ	5

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:

V	ID	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)	Туре	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.

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#### **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 slaveonly 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 ŧ ‡ Configuration File ±-# 0=Multicast (MC), 1=Unicast (UC), 2=MulticastAuto (MA) [NUM] : 0 PTP Mode Force PTP to act as slave-only system [BOC 0=End-to-End, 1=Peer-to-Peer (0.11:1 PTP Delay Mechanism ‡ 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) [NUM, 1, 3]:3 PTP Network Protocol # 0=ARB, 1=PTP (default) [NUM, 0:11:1 PTP Timescale # 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 [21x1:0 ‡ 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 ‡ Unicast: IP address of Grandmaster PTP Unicast IP address of master [IP]:172.29.9.236 2:Telecom Profile [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 [BOOL]:0 HQ Filter active # 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 [BOOL1:0 # Path Delay Step Compensation (Filter on) PDSC active [BOOL]:0 # 0=DRRDP, 1=Power, 2=Telecom, 3=P2PDP, 4=Exp [NUM]:1 Selected Profile ‡ 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 [5] [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.

Ethernet Benachrichtigung	Sicherheit NTP Local Statistik Handbuch P	TP
ТР		
nhalt von /etc/ptp2/ptp2_netwo	rk_conf_0:	
<b></b>		
PTP2 Network		
Configuration File		
Hostname for PTP port		
lostname	[ASCI1, 50]:PTPv2	
Domainname for PTP port		
Domainname	[ASCI1,50]:	
IP addr of primary DNS name	server (optional)	
Nameserver 1	[ASCI1, 50]:	
IP addr of secondary DNS nam	me server (optional)	
Nameserver 2	[ASCII, 50]:	
IP addr of PTP port		
CPIP address	[IP]:172.16.60.150	
Netmask of PTP port		
TETMASK	[IP]:255.255.0.0	
IP address of default gatewa	ay and a second s	
Default Gateway	[IP]:0.0.0.0	
Enable DHCP client		
HCP CLIENT	[BOOL]:0	
Enable VLAN interface		
/Lan enabled	[BOOL]:1	
	[NUM]: 4	
	nterface	
/Lan Priority	[NUM]:4	
IP packet Time To Live (TTL,	, default:5)	
TP IP TTL	[NUM] : 5	
Differentiated Services Code	epoint (default:0)	
PTP IP DSCP	[NUM] : 0	
Disable SSHD for all externation	al connetions	
SHD disabled	BOOT : 0	
F Enable Redundant Network Cor	nnectivity (RNC/FRF)	
PRF enabled	[BOOT]:0	
f if no static IPv6 address is	s defined the link local address will be used	
FTF static IPv6 address	[ASCI1, 50]:	



#### 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.

Time synchronization via IEEE 1588

	)TMC 10 randmaster C	0 <i>p</i> lock			
		General Settings	Default Settings	Port Settings	Alternate Timescale
Overview	Network	PTP profile Operation mode User description PTP management i	Power sys One step	tems 💌	
Status	Security				
i	PTP				
Configuration					

#### 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.

		12	
work	Transport	IEEE_802_3 💌	
	Vlan ID	4	
	Vlan PCP	4	
	Log sync interval	0	2 <sup>×</sup> s
urity	Log min pdelay request interval	0	2 <sup>×</sup> s
	Log announce interval	0	2 <sup>×</sup> s
	Announce receipt timeout	3	

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).

#### Log out

#### Main Menu

- Administration
  - Configure IP Interfaces
  - Configure IP Gateways
  - <u>Configure IP Services</u>
  - <u>Configure System Identification</u>
  - <u>Configure Passwords</u>
  - System Time Manager
    - Configure Time and Date
    - <u>Configure IRIGB</u>
    - Precision Time Protocol
      - Configure Global Parameters
      - <u>Configure Clock Parameters</u>
      - <u>Configure BClock Slave</u>
      - Configure Path Delay
      - <u>View PTP Statistics</u>
    - <u>Configure Time Source</u>
    - <u>Configure NTP Server</u>
    - <u>View Time Sync Status</u>

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.

Global Par	ameters
PTP Enable	Yes
Clock Type	OC and P2P TClock
PTP Profile	Default P2P Profile
Ethernet Ports	All
ULAN ID	4
Class Of Service	Disable
Transport Protocol	Layer 2 Multicast
Startup Wait	10 s
Desired Clock Accuracy	1 us

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. <u>But</u> in this case the accuracy will be reduced.

Clock Paramete	ers
Domain Number	0
Sync Interval	1 s
Announce Interval	2 s
Announce Receipt Timeout	3
Priority1	128
Priority2	128
Path Delay Mechanism	Peer-to-Peer

Figure 13: Console Clock Parameters

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### 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).

Version	06.00.03.903	
Build	Sep 6 2014 10:31:27	
State	Running	
Slave Clock		
State	master clock assigned, synchronization completed	
Receiver		
No. of master clock changes	2	
No. of successfully processed synchronizations	7290	
No. of detected errors in telegram processing	0	
No. of ignored telegrams	0	
No. of idle periods	1	
Current Master Clock		
Clock ID / Port Number	20:B7:C0:FF:FE:00:23:30 / 00:01	
Announce Seq ID / number of gaps	4666 / 0	
Announce Flag Field	00:3C	
Current UTC Offset	35	seconds
Last Synchronization		
Clock ID / Port Number	20:B7:C0:FF:FE:00:23:30 / 00:01	
Seq ID / number of gaps	4666 / 0	
Date / Time UTC	2014-09-10 / 13:26:06.679775622	yyyy-mm-dd / hh:mm:ss.nanos
OffsetFromMaster	-0.000070777	secinanosec
Steps	1	
Correction Sync / FollowUp	+0 / +0	nanosec
IEEE 802.3 Transport		
IEEE 802,10 VLAN tag	tagged, PRIO=4, VLAN-ID=4	

#### 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).

	Information			Destination						
✓ ☐ IEE15880miRugged				▶ LEDs			Recorder	▶ Logs		
🕂 Single-line configuration				▶ Expansio	on module 3	1				
💕 Add new device	Signals	Number	Туре	.10 3.11	3.12 3.13	3.14 3.15	3.16 Signal	O F	U1 U2	G I
h Devices and networks	(All)	🕶 (All)	•] 💌	. 💌 💌	💌 💌	• 💌 💌	💌 (All)	💌 💌	. 💌 💌 🔽	n 💽
▼ 🔚 7SL87	🕨 🦻 General	91						*		
Device information	🕨 👂 Device	4171						*		
P Hardware and protocols	🕨 😜 Alarm handling	5971						*		
📅 Measuring-points routing	🕨 😺 Time managem.	8821								
Tunction-group conn	🗢 😜 Time sync.	8851				*	*	*	*	
🗰 Information routing	🕨 🔶 Behavior	8851.52	ENS							
Communication map	🕨 🕨 Health	8851.53	ENS				*		x	
- A Settings	🔷 🔷 Status time source 1	8851.303	SPS			U			x	

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.

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Filter: ptp		Expression Clear Apply Save		
No. Time	Source	Destination	Protocol	Length Info
1 0.00000000	Meinberg_00:24:ff	Ieee1&M5_00:00:00	PTPv2	62 Sync Message
2 0.000001000	Meinberg_00:24:ff	Ieee1&M5_00:00:00	PTPv2	62 Follow_Up Message
3 0.000001000	Meinberg_00:24:ff	Ieee1&M5_00:00:00	PTPv2	128 Announce Message
5 1.000041000	Meinberg_00:24:ff	Ieee18M5_00:00:00	PTPv2	62 Sync Message
6 1,000042000	Meinberg 00:24:ff	Ieee1&M5 00:00:00	PTPv2	62 Follow Up Message
7 1.000042000	Meinberg_00:24:ff	Ieee1&M5_00:00:00	PTPv2	128 Announce Message
9 2.000068000	Meinberg_00:24:ff	Ieee18M5_00:00:00	PTPv2	62 Sync Message
10 2.000068000	Meinberg 00:24:ff	Ieee18M5 00:00:00	PTPv2	62 Follow Up Message
11 2,000068000	Meinberg 00:24:ff	TeeeT&M5_00:00:00	PTPV2	128 Announce Message
12 3 000079000	Meinberg 00:24:ff	TeeeT&M5_00:00:00	PTPv2	62 SVDC Message
13 3 000080000	Meinberg 00:24:ff	TeeeT&M5_00:00:00	PTPV2	62 Follow Un Message
14 3 000080000	Meinberg 00:24:ff	TeeeT&MS_00:00:00	PTPV2	128 Appounce Message
16 4.000253000	Meinberg_00:24:ff	Ieee1&M5_00:00:00	PTPV2	62 Sync Message
٠ [				
		y unique address (factory default) lual address (unicast) (4)		
subdomäinkumber: # flags: 0x0200 © correction: 0,000 ClockIdentity: 0) SourcePortID: 1 sequenceId: 7899 control: sync Mes logMessagePeriod: originTimestamp ( originTimestamp)	0 2000 nanoseconds kec4670fffe0024ff 5 5 5 5 5 5 5 5 5 5 5 5 5			
0000 01 1b 19 00 00 0010 88 f7 00 02 00 0020 00 00 00 00 00 0030 1e db 00 00 00	00 ec 46 70 00 24 ff 81 00 80 0 2c 00 00 02 00 00 00 00 00 00 00 00 ec 46 70 ff fe 00 24 ff 00 0 00 54 18 34 76 36 2c 0e 94	4F p.\$ 0F p.\$ 1F p\$ Τ. 4ν6,		

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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