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IEEE1588v2 PTP cost  
optimized solution for  
IEC 61850 process bus

# SIPROTEC Application

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APN-089, Edition 1

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# 1 IEEE1588v2 PTP cost optimized solution for IEC 61850 process bus

## 1.1 Introduction

This application describes a special communication network- and Precision Time Protocol (PTP) Timing solution for process bus deployments.

In view of more cost optimized solutions, one important part is to investigate on timing options providing better cost positions. With this application note a timing solution is described which, on the one hand has better cost position but also utilizes Siemens RUGGEDCOM Redboxes as part of this timing solution. The solution is based on Timing Server which has the product name OSA5401 and can be sourced from Oscilloquartz. Kindly refer to the following figure.



Figure 1: OSA 5401 SFP

The OSA5401 is a PTP grandmaster, boundary, slave clock and NTP Timing Server in the format of a SFP module which can be inserted in PTP aware Ethernet Switches for synchronization of Ethernet networks.

The OSA5401 supports Best Master Clock algorithm from SW Version SW-load 11.5.1-091 and many PTP timing profiles, NTP server, Synchronous Ethernet, and has a PPS output.

The besides PTP Telecom profiles the following PTP Power/Utility profiles are supported by OSA5401 and the SIPROTEC 5 protection relays:

- IEC/IEEE 61850-9-3 [1] PTP profile for power utility automation
- IEEE C37.238-2017 [2] IEEE Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications

For more information kindly also refer to the Brochure of OSA 5401 available from Oscilloquartz:

<https://www.oscilloquartz.com/en/resources/downloads/data-sheets/osa-5401>

Price Information can be requested from the procurement department.

## 1.2 Basic communication and synchronization concept

The following figure shows the basic concept of this timing solution which was tested for the process bus application. This basic concept of this setup is per APN 073 "Special communication network topology for small process bus and distributed busbar protection deployments", section 1.2 Basic communication and synchronization concept.

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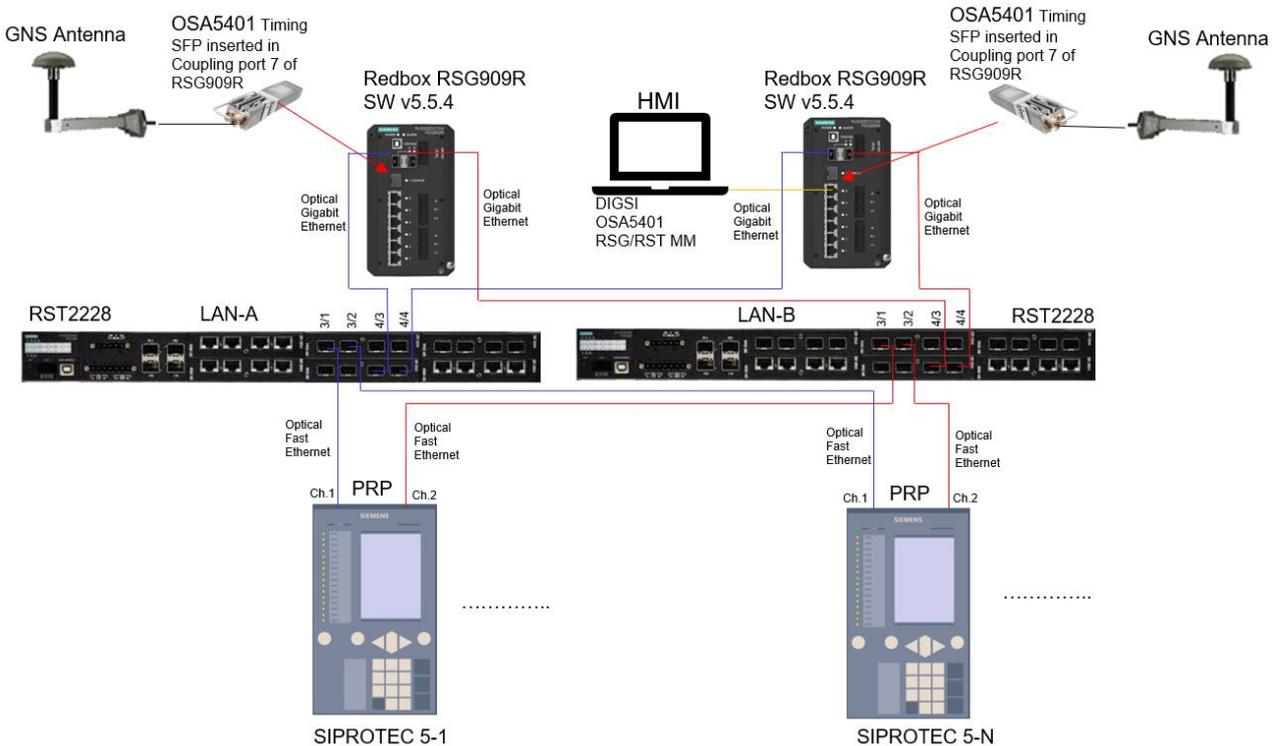


Figure 2: Basic Communication and Synchronization Concept

In the example above, the OSA5401-SFPs are inserted in the port 7 of the Siemens RuggedCom Redboxes RSG909R and are working as Grand Master Clocks [3] synchronized from GNSS. This setup deploys redundant PTP grandmaster clocks. One of them is the active and the other one the passive master. The passive master clock becomes the active one in case the previously active master has failed.

The RSG909R Redboxes send the PTP Frames from the OAS5401 SFPs via their PRP ports A and B to the RST2228 switches. These A- and B- Ports shall be optical Gigabit Ethernet Ports for the fiber connection to the RST2228 switches. For the test the RuggedCom SW version v5.5.4 was used for the Redboxes.

Parallel Redundancy Protocol (PRP) ensures hitless redundancy in the setup with the SIPROTEC5 Relays/Merging Units.

Siemens RUGGEDCOM RST2228 was selected for the LAN-A and LAN-B Segments as Transparent Clock functionality is required. LAN-A and LAN-B must not be directly interconnected to each other. Please note that in general PRP LAN A and LAN B (this means the switches of these LANs) are always mutually isolated from each other, for avoiding endless circulating frames and other undesired behavior. The Redboxes work as Double Attached Nodes (DANP) and do not forward frames from their LAN A port to LAN B port (and vice versa) for this purpose.

The Best Master Clock Algorithm BMCA of the OSA5401 MCA ensures that there is only one active master in the PTP domain or sub-domain.

### 1.2.1 OSA 5401 PTP Setup Parameters

In the example above the OSA 5401 SFPs are set up as following:

- PTP Profile IEC/IEEE 61850-9-3 as master.
- Priority1: Both OSA5401 SFPs are set to `priority1= 1`.
- Priority2: OSA5401 SFP1 is set to `priority2= 2` and OSA SFP2 is set to `priority2= 3`.

The OSA 5401 SFP is recognized by the RSG909R Redboxes as an optical 1000SX1000LX1000CX SFP Type. Kindly refer to the following figure showing the port status of the RSG909R Redbox. The red arrow indicates how the RSG909R recognizes the OSA 5401 SFP.

Port	Link	Speed	Duplex	Media	Name
1	Down	---	----	1000T	Port 1
2	Down	---	----	1000T	Port 2
3	Down	---	----	1000T	Port 3
4	Down	---	----	1000T	Port 4
5	Up	100M	Full	1000T	Port 5
6	Up	100M	Full	1000T	Port 6
7	Up	1G	Full	SFP 1000SX1000LX1000CX L.C Length	Port 7
RNA/A	Up	1G	Full	SFP 1000LX SM L.C Length(SMF km)	Port 8
RNA/B	Up	1G	Full	SFP 1000LX SM L.C Length(SMF km)	Port 9

Figure 3: OSA 5401 port status in RSG909R

### 1.2.2 RSG909R Redbox Settings

The RSG909R Redboxes loaded with latest SW version 5.5.4 are setup with PTP “Utility Profile Level 1” (in RuggedCom Configuration manual referred as profile IEC/IEEE 61850-9-3 Ed.1) and as clock type “OC and P2P TClock” Please refer to the following figure. Red arrow indicating important settings:

**Global Parameters**

PTP Enable: No:  Yes:

Clock Type: OC and P2P TClock

PTP Profile: Utility Profile Level 1

Ethernet Ports: All

VLAN ID: Disable

Class Of Service: Disable

Transport Protocol: Layer 2 Multicast

Startup Wait: 10 s

Desired Clock Accuracy: 1 us

Network Class: IEEE1588 network:  Non-IEEE1588 network:

Apply Reload

Figure 4: RSG909R PTP Global Parameters

The path delay mechanism shall be set to Peer-to-Peer

**Clock Parameters**

Domain Number: 0

Sync Interval: 1 s

Announce Interval: 1 s

Announce Receipt Timeout: 3

Priority1: 255

Priority2: 255

Path Delay Mechanism: Peer-to-Peer

Slave Only: No:  Yes:

Apply Reload

Figure 5: RSG909R Clock Parameters

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The RSG909R PRP A- and B- Ports shall be equipped with optical Gigabit Ethernet SFPs for the fiber connection to the RST2228 switches. Please refer to the following figure. Red darts indicating the PRP ports.

Port	Link	Speed	Duplex	Media	Name
1	Down	---	----	1000T	Port 1
2	Down	---	----	1000T	Port 2
3	Down	---	----	1000T	Port 3
4	Down	---	----	1000T	Port 4
5	Up	100M	Full	1000T	Port 5
6	Up	100M	Full	1000T	Port 6
7	Up	1G	Full	SFP 1000SX1000LX1000CX LC Lengt	Port 7
RNA/A	Up	1G	Full	SFP 1000LX SM LC Length(SMF km)	Port 8
RNA/B	Up	1G	Full	SFP 1000LX SM LC Length(SMF km)	Port 9

Figure 6: PRP Ports of the RedBoxes

The RSG909R is set to Redundancy Mode PRP Redbox and Switch Interlink Mode is set to VDAN. This sets all switch port to VDANP.

**RedBox ID:** 0 GET

Redundancy Mode: PRP RedBox

Switch Interlink Mode: VDAN

Switch Interlink Port: RNA

Second Interlink Mode: None

Second Interlink Port: 1

Net ID: 1

Life Check Interval: 2 s

Node Forget Time: 60 s

Proxy Node Forget Time: 60 s

Entry Forget Time: 40 ms

Max Proxy Node Entries: 128

Apply Reload

Figure 7: PRP Ports of the RedBoxes

### 1.2.3 RST2228 Switch settings

Both RST2228 must be set to set to Utility Profile Level1 and Clock Type "P2P TClock" which corresponds to peer-to-peer transparent clock.

PTP Enable:  No:  Yes:

Clock Type: P2P TClock

PTP Profile: Utility Profile Level 1

Ethernet Ports: All

VLAN ID: Disable

Class Of Service: Disable

Transport Protocol: Layer 2 Multicast:  Layer 3 Multicast:

Startup Wait: 10 s

Desired Clock Accuracy: 1 us

Network Class: IEEE1588 network:  Non-IEEE1588 network:

1 Step Master Clock: No:  Yes:

Apply Reload

Figure 8: RST2228 Global Parameters

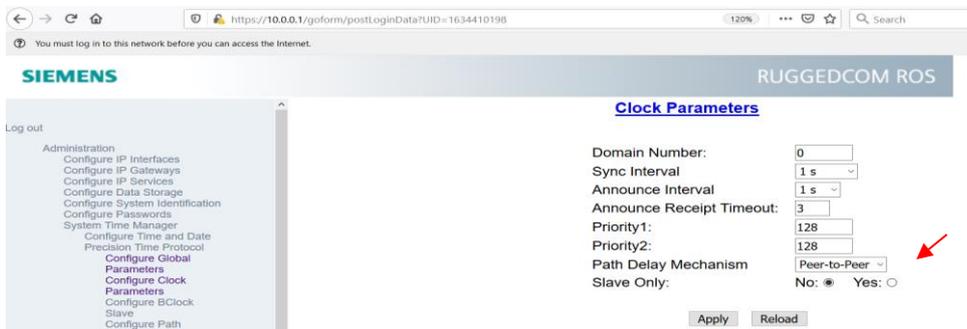


Figure 9: RST2228 Clock Parameters

### 1.3 OSA5401 Configuration Handling

The OSA 5401 SFP is managed via a SSH connection. In our example the HMI is connected via the RSG909R Redbox to the Network. The HMI can reach the LAN e.g., VLAN1 where the OSA 5401 SFPs operate. The HMI can then setup a putty SSH connection to the OSA 5401 SFPs. The default pre-configured IP-address of the SFP is 192.168.0.2. (In case of two OSA5401 are in the network this default IP-address can be changed).

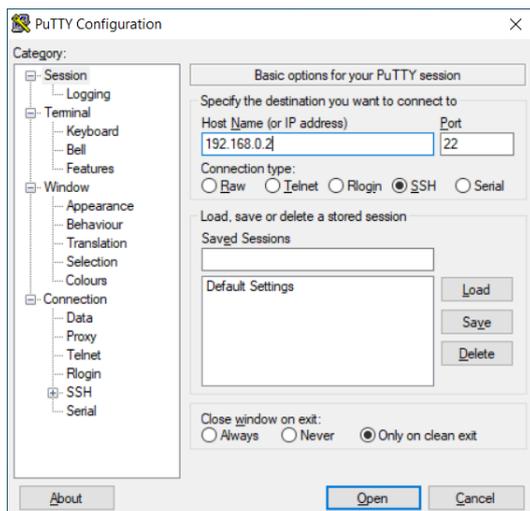
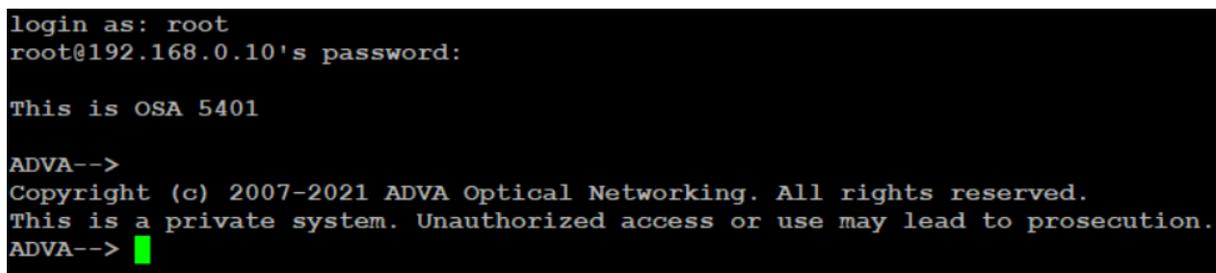


Figure 10: Putty setting

Then the CMD Windows opens, and the configuration can start. The standard login is "root" and the password is "ChgMeNOW"



In the following section the basic principle of OSA5401 CLI configuration is described.

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With the command "configure" the configuration menu is opened where "interface", "clock", "management", "port" or "system" configuration menus can be accessed.

```
ADVA--> configure
configure [ interface | clock | management | port | system ]
ADVA:configure-->
```

### 1.3.1 Configure clock profile of OSA5401

The configuration of the OSA5401 SFP is based on CLI. The following figure shows the working principle how e.g., the PTP profile "iec-61850-9-3" is setup in the OSA 5401.

After the login type:

"configure" ↵

Then type "clock" ↵

Then type "l2-profiles" ↵

Then type "master" ↵

Then type "profile" ↵

Then type the profile "iec-61850-9-3" ↵

Then do not forget to type "save" ↵ to save the configuration.

To climb the menu tree back you can use the symbol "<" on the keyboard.

In the same way you reach the settings for "priority1", "priority2", "domain-number", ...

```
ADVA--> configure
configure [ interface | clock | management | port | system ]
ADVA:configure--> clock
configure clock [ l2-profiles | l3-profiles | gns | ntp | type | syncjack | references | h
oldover-timeout | show status ]
ADVA:configure-clock--> l2-profiles
configure clock l2-profiles [ port-delay-asymmetry | master | slave | tlv | show status ]
ADVA:configure-clock-l2-profiles--> master
configure clock l2-profiles master [ [no] shutdown | domain-number | profile | mac | priori
ty1 | priority2 | rate | type | interface | show status ]
; default=no shutdown
Currently in use: no shutdown

ADVA:configure-clock-l2-profiles-master--> profile
configure clock l2-profiles master profile [ g8275.1 | 1588_2008_annex_f | iec-61850-9-3 |
c37.238-2011 | c37.238-2017 | 802.1as-2011 ] ; default=g8275.1
ADVA:configure-clock-l2-profiles-master-profile--> iec-61850-9-3
configure clock l2-profiles master profile iec-61850-9-3
Done

ADVA:configure-clock-l2-profiles--> save

Wait for five seconds, configuration will be
Saved

ADVA:configure-clock-l2-profiles-->
```

Figure 11: CMD Config Window

### 1.3.2 Configure the Best Master Clock Algorithm BMCA

The OSA5401 supports Best Master Clock algorithm from SW Version SW-load 11.5.1-091. Per default it is enabled. Nevertheless, It can also be disabled/enabled. When the BMCA is disabled then two active masters are in the domain. The following command tree shows how the BMCA can be disabled or enabled again:

```

"configure" ↵
  "clock" ↵
    "l2-profiles" ↵
      "master" ↵
        "bmca" ↵
          "disable" or "enable" ↵
  
```

To save the setting insert: "save" ↵

```

ADVA:configure-clock-l2-profiles-master-> bmca
configure clock l2-profiles master bmca [ disable | enable ] ; default=enable
  
```

### 1.3.3 Configuration Summary of OSA5401 SFPs

The following tables summarize the Configuration setting of the OSA5401 SFPs used in the test.

<pre> SFP OSA5401-1  ADVA→ show running-config  . . ipv4-address      : 192.168.0.10/24 . . clock l2-profiles   master multicast: enabled   interface       : ptp1   domain-number  : 0   profile         : iec-61850-9-3   mac            : 01-1B-19-00-00-00   rate announce  : 1 pps   rate sync      : 1 pps   rate dresp     : 1 pps   priority1      : 1   priority2      : 2   type           : two-step           </pre>	<pre> SFP OSA5401-2  ADVA→ show running-config  . . ipv4-address      : 192.168.0.20/24 . . clock l2-profiles   master multicast: enabled   interface       : ptp1   domain-number  : 0   profile         : iec-61850-9-3   mac            : 01-1B-19-00-00-00   rate announce  : 1 pps   rate sync      : 1 pps   rate dresp     : 1 pps   priority1      : 1   priority2      : 3   type           : two-step           </pre>
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Figure 12: OSA5401 Configuration Summary

## 1.4 Conclusion

The OSA5401 SFP in combination with Siemens RuggedCom Redboxes is a cost-efficient solution for process bus applications. The configuration of the SFP is based on CLI but is easy to learn and straight forward. The SFP has the functionalities for Process Bus Application but also has furthermore features like NTP, PPS which are useful for our solutions.

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This product includes software written  
by Tim Hudson ([tjh@cryptsoft.com](mailto:tjh@cryptsoft.com))

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