APPLICATION NOTE

Configuring the RAPTOR® as a Grandmaster clock using the OSA 5401 SFP

INTRODUCTION

With an increasing level of operational sophistication, greater timing accuracy is needed in power grid monitoring and localization of faults. Substations require nanosecond/microsecond accuracy with phasor measurement units as well as sampled value merging units.

The power industry has adopted Precision Timing Protocol (PTP) as defined by IEEE 1588 for its significant advantages compared to the existing packet-based synchronization protocols such as NTP. PTP can be implemented with physical hardware timestamping to minimize delay and achieve the very high accuracy required by these essential substation systems.

iS5 Communications has optimized the current design by integrating the OSA5401 with its RAPTOR platform. The 5401 is a very compact, zero-footprint, SFP-based grandmaster clock with a GNSS receiver that will reduce space and power consumption.

OSA 5401

The OSA 5401 SyncPlug™ small form factor pluggable (SFP) is a powerful and versatile time server with a built-in GNSS receiver and the smallest footprint and most compact design on the market. It enables accurate phase and frequency synchronization using PTP, Sync-E, and NTP at the network edge with zero-added footprint. Its small form factor and rich feature set enable a versatile range of deployment options for enhanced synchronization network performance.

The OSA 5401 can be used as a PTP Grandmaster clock and as an NTP server to synchronize the substation devices.

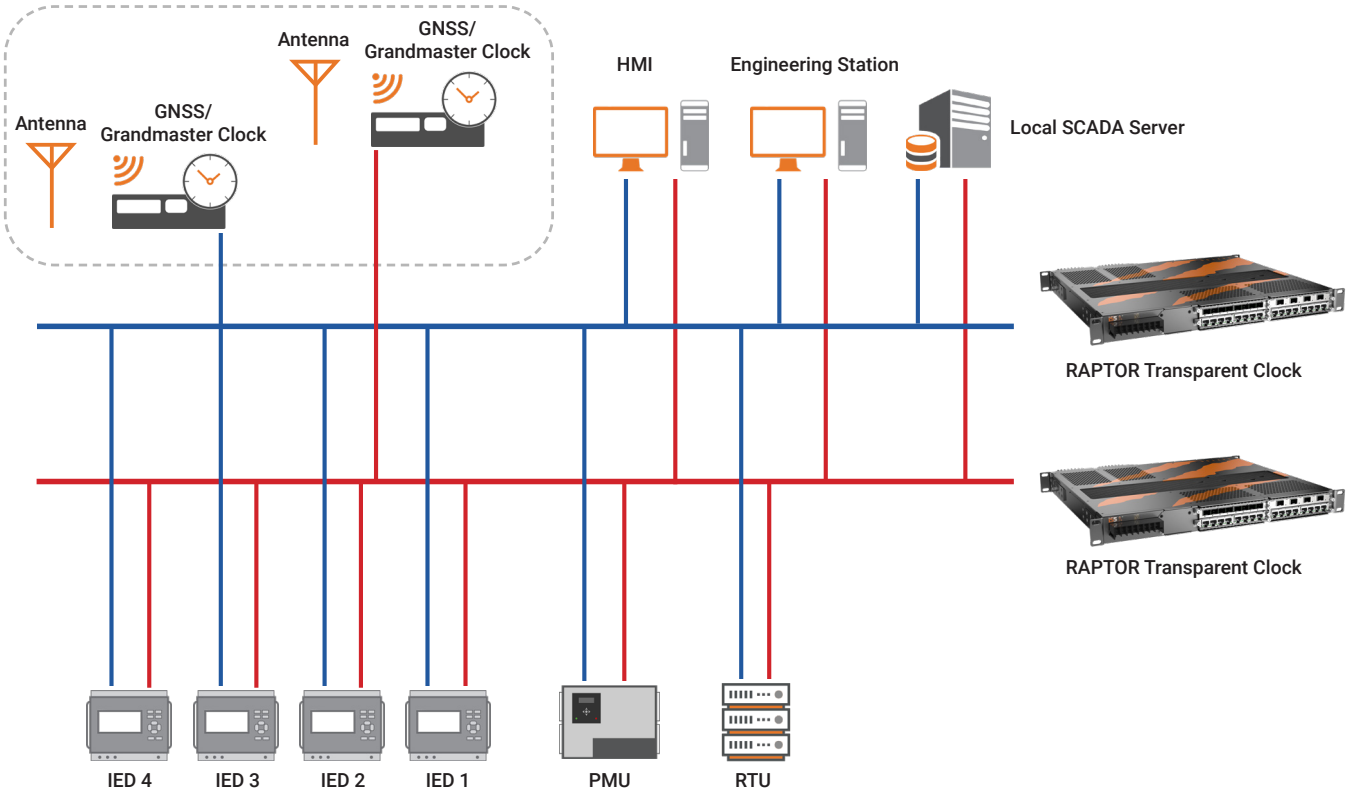
SUBSTATION NETWORK DESIGN WITH PTP

A typical substation design relies heavily on PTP to synchronize devices that require high accuracy, such as phasor measurement units and merging units. Two Grandmaster clocks are used to provide redundancy and maintain the edge devices synchronization during an outage or a device failure.

The Grandmaster clock cabling will depend on the topology and the redundancy protocol used, such as RSTP, HSR, or PRP. Switches with PTP transparent clock support are required to maintain an accuracy below 1 microsecond as per the PTP power profile.

Figure 1 represents a typical substation network with two Grandmaster clocks connected each to a different network to provide redundancy.

Figure 1 - *Substation network with Grandmaster Clocks*



SUBSTATION NETWORK DESIGN WITH OSA5401 AND RAPTOR

The OSA 5401 is an SFP with a built-in GNSS receiver. This can be used as a PTP Grandmaster clock with various Layer 2 and Layer 3 PTP profiles, including power profile and supports NTP Server operation.

A GPS antenna should be installed and connected to the GNSS input connector prior to inserting the SFP in the RAPTOR.

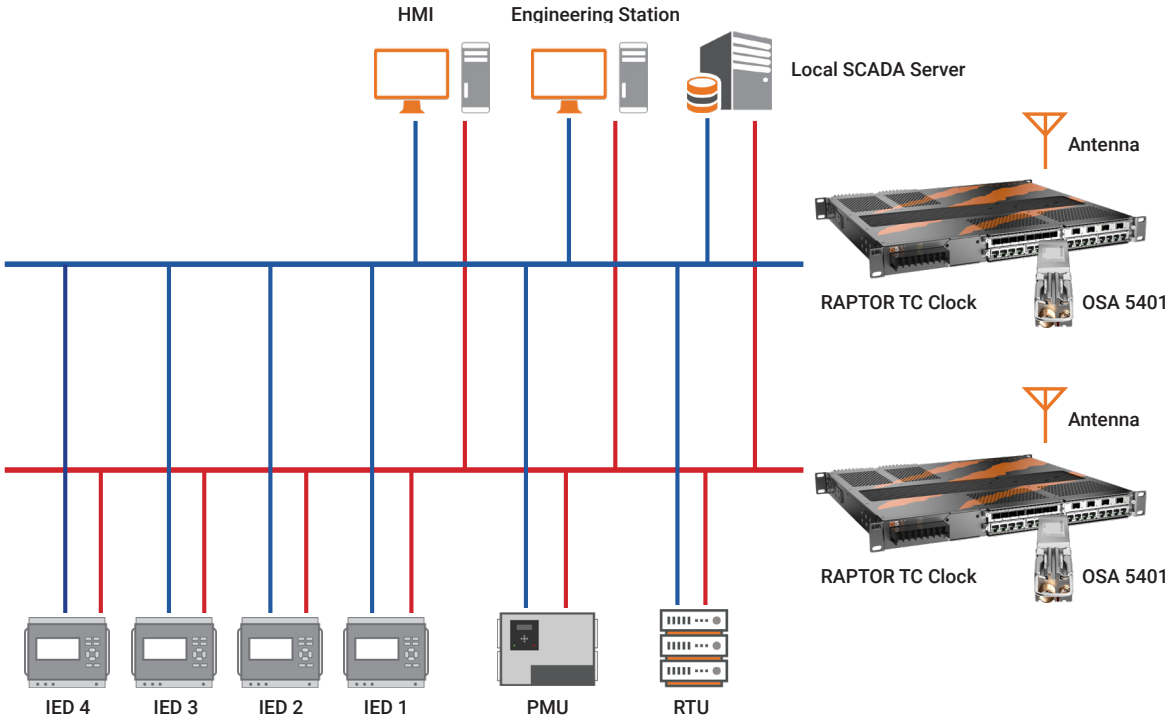
The OSA 5401 SFP will be powered by the RAPTOR, but it will act as an independent device. It has a dedicated IP address for management and sync messages. It can be accessed through CLI and can be monitored from a network management system with SNMP.

This solution provides various advantages:

- A considerable space reduction is achieved in space-restrictive locations
- A lower power consumption
- Lower cost
- Eliminates the need for power and network cabling since the OSA SFP is directly plugged in the RAPTOR

Figure 2 represents a substation network with two OSA5401 SFPs acting as PTP Grandmaster Clocks and NTP server.

Figure 2 - *Substation network with OSA 5401 SFP for PTP GM clock and NTP server*

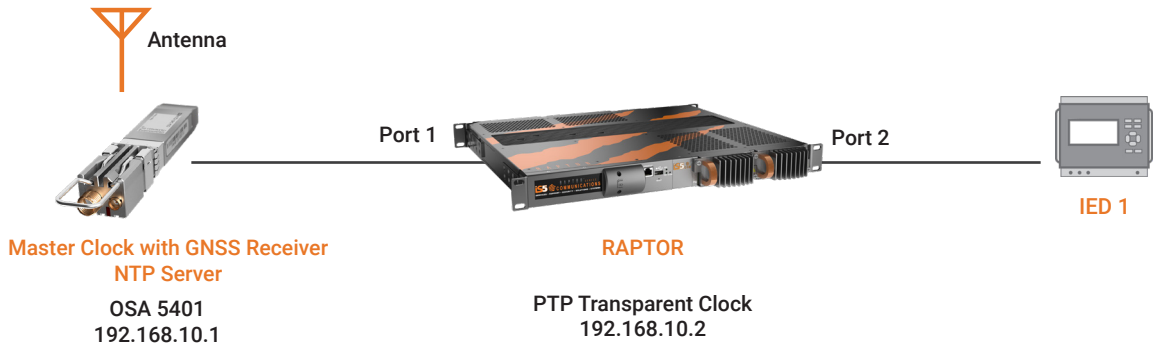


Configuration steps

This section describes the configuration steps required to configure the RAPTOR as a PTP transparent clock and the OSA5401 as a PTP Grandmaster clock and an NTP server.

The configuration details are defined in figure 3.

Figure 3 - *Configuration details*



RAPTOR Configuration

1. **Enable PTP globally in the switch**

   iS5comm# configure terminal

   iS5comm (config)# no shutdown ptp

2. **Select PowerProfileV2 as the PTP profile**

   iS5comm(config)# ptp profile PowerProfileV2

3. **Select PowerProfileV2 as the PTP profile**

   iS5comm(config)# int gi 0/1

   iS5comm(config-if)# ptp enable

   iS5comm(config-if)# exit

   iS5comm(config)# int gi 0/2

   iS5comm(config-if)# ptp enable

   iS5comm(config-if)# end

Figure 4 - *RAPTOR Configuration*

```
iS5comm#
iS5comm# configure terminal
iS5comm(config)# no shutdown ptp
iS5comm(config)# ptp profile PowerProfileV2
iS5comm(config)# int gi 0/1
iS5comm(config-if)# ptp enable
iS5comm(config-if)# exit
iS5comm(config)# int gi 0/2
iS5comm(config-if)# ptp enable
iS5comm(config-if)# end
iS5comm#
```

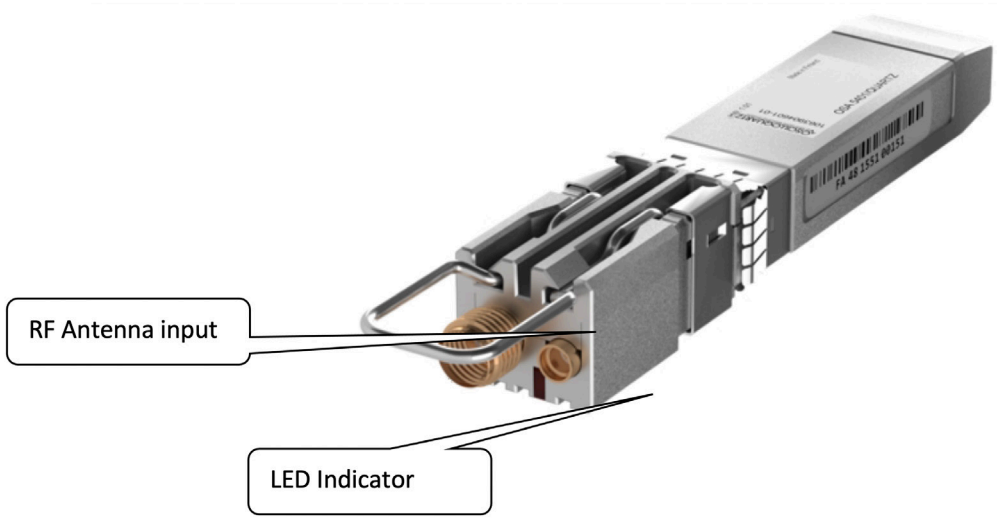
OSA5401 INSTALLATION AND CONFIGURATION

OSA 5401 Installation

OSA 5401 Syncplug™ is installed by plugging the device into an SFP socket of the RAPTOR.

Connect the cable from the antenna to the GNSS input connector on the front panel of the OSA 5401 Device.

Figure 5 - *OSA5401 RF antenna input and LED indicator location*



OSA 5401 Installation

The OSA5401 configuration requires three steps.

1. **Change the default IP address.**

   To connect to the OSA 5401 unit, open a terminal emulation window on a PC that supports either Telnet or SSH client, such as TeraTerm or PuTTY

   The default IP address is 192.168.0.2

   The default username and passphrase is set as:

   Username: root

   Passphrase: ChgMeNOW

   Use the commands below to change the IP address to 192.168.10.1

   configure interface mgmt+ptp1 ip-address ipv4 192.168.10.1/24

   save-and-reconfig

2. **Verify that the GNSS receiver is locked.**

   With the command below verify that the GNSS tracking is locked and the receiver can receive signals from multiple satellites.

   configure clock gnss show status

Figure 6 - *Output of the command "configure clock gnss show status"*

```
ADVA--> configure clock gnss show status
configure clock gnss show status

Administrative Status  : Up
Operational Status     : Up
Mode                   : gps
Antenna-delay          : 0

Tracking               : GNSS - Locked

Location Mode          : survey-in
Minimum SNR            : 9 dBHz
Minimum Elevation      : 5 deg
```

Figure 7 - *Output of the command "configure clock gnss show status"*

```
Satellite Status:
------------------------------
   Num SNR Hlth Used Azim Elev
------------------------------
 G   2  39    Y    Y   327   74
 G   4  23    Y    Y    40   11
 G   5  32    Y    Y   211   22
 G   6  35    Y    Y    56   53
 G   9  29    Y    Y    73   23
 G  11   0    N    N   341   77
 G  12  34    Y    Y   259   49
 G  17   0    Y    N   125   10
 G  19  27    Y    Y   120   31
 G  20  26    Y    Y   205   58
 G  25  20    Y    Y   299   32
 G  29   0    Y    N   306    6
------------------------------
```

3. **Configure the Grandmaster Clock**

   - Change the PTP profile to power profile

     configure clock l2-profiles profile c37.238-2017

   - Active the master clock type under l2 profiles

     configure clock l2-profiles master no shutdown

   - Change the domain number to 254

     configure clock l2-profiles master domain-number 254

   - Change the multicast MAC address used to 01-1B-19-00-00-00

     configure clock l2-profiles master mac 01-1B-19-00-00-00

   - Verify that the Master clock is enabled and that Sync messages are send and that PDelay request/response messages are sent and received.

```
configure clock l2-profiles show status
Master:
  multicast:                enabled
   rate announce:           1 pps
   rate sync:               1 pps
   rate dresp:              1 pps
   type:                    one-step
  Tx clockClass:            6
  Dynamic slaves:           1

  Active GM Clock ID:       00:80:EA:FF:FE:86:AD:13
  Time Source:              GPS
  Freq/Time Traceable:      TRUE/TRUE
  UTC Offset:               37
Slave:                      disabled

 Press <enter> to continue

ADVA:configure-clock-l2-profiles-show-status-->
configure clock l2-profiles show status

 Counters:     Received        Sent
  Sync:               0       19487
  FollowUp:           0           0
  DelayReq:           0           0
  DelayResp:          0           0
  PDelayReq:      18246       19027
  PDelayRsp:      17807       18246
  PDRespFup:          0           0
  Announce:           0       19487
```

4. **Configure the NTP Server**
   - Enable the NTP server

     configure clock ntp server no shutdown
   - Verify that the NTP server is running

     configure clock ntp show status
   - Save the configuration

     save-and-reconfig

```
configure clock ntp show status
  ntp server       : enabled

 Counters:     Received        Sent
  NTP:                1           1

ADVA:configure-clock-ntp--> 
```

CONCLUSION

The power industry selected the PTP protocol to synchronize applications requiring high time accuracy, such as sampled values and synchrophasors. PTP is an ethernet-based protocol and can be used with the same communication medium as the control and protection traffic, eliminating the need for dedicated cabling for the synchronization traffic.
iS5 Communications optimizes the current design by integrating the OSA5401 to its RAPTOR platform. The OSA5401 is a small form factor pluggable with a GNSS receiver that can be used as a PTP Grandmaster Clock or an NTP server. The OSA5401 supports various layer 2 and layer 3 profiles, including Power Profile and Utility Profile.

ABOUT iS5 COMMUNICATIONS INC.

iS5 Communications Inc. (“iS5Com”) is a global provider of integrated services and solutions, and manufacturer of intelligent Industrial Ethernet products. Our products are designed to meet the stringent demand requirements of utility sub-stations, roadside transportation, rail, and industrial applications. iS5Com’s services and products are key enablers of advanced technology implementation such as the Smart Grid, Intelligent Transportation Systems, Intelligent Oil Field, and Internet of Things. All products have the ability to transmit data efficiently without the loss of any packets under harsh environments and EMI conditions.

iS5 COMMUNICATIONS

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