



Qg 2 Multi-Sync Gateway

USER GUIDE

SJC-DEV7250-HR REV. 1.19



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4.5.2	Replaced PTP::Clock tab figure – Clock Accuracy has added text
4.5.9	Replaced PTP::dataset screenshots to show updated text
4.8	Added note for security enhancement with support for TLSv1.2 and not prior versions
4.9	Replaced System Tab figure with an updated one
5.7	Date command enhancement to include optional clock quality parameters
5.10	Hidden webui command to enable/disable Web interface for security reasons
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4.3	Added explanation for Time Source = HAND SET

4.5.2	Clock class, accuracy and variance are RO
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7.1.2/3	Removed references to ARB timescale (only PTP timescale supported)
7.3.2	
7.3.2	Fixed to say GNSS only or GNSS Primary and PTP Secondary
8.2.8	Fixed typo – it should say SMPTE profile and not Power Utility profile
9.8.1	Fixed typo in Avago SFP part number
10	New dedicated chapter for Software Upgrade including SWM interaction
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4.4.3	Added important note on GNSS Clock Class mapping and removed note for Galileo workaround as the issue is fixed
4.9	Important NOTE on downgrading of software version
5.0	Updated all CLI command screenshots as prompt has been changed to “Sync>”
7.1.3	Change “Mode 1” to “Mode GNSS Only”
9.3.2	Updated note to not to do another reset after a long push button reset for factory default
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Section	Changes since previous revision
4.3	Label “Applying configuration and starting the engine - please wait!!” displays while engine is being started
4.4.3	Interface::GNSS page: change “1PPS IN - Cable Delay” to “Antenna Delay (ns)”
4.5.8	New tab for configuring Qg 2 as an SNTP server
4.9	System Tab: added descriptions of Mac Address, Serial Number and System Uptime
5.3	Changed “Inventory commands” to “System commands”
5.3.2	New CLI command to restore system configuration
5.8	New CLI command to start performance monitoring feed
7.8	Added SNTP section
9.3.2	IMPORTANT note: do not power cycle Qg 2 until long push button reset is complete
Changes in Rev 1.15	
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All	Copyright changed from 2020 to 2021
4.3	Support for eEEC bandwidth for Option-1 and Option-2, and full on-path network type
4.4.2	IMPORTANT note on Galileo constellation selection
4.5.4	Added support for mixed and both port modes of operation for PTP::Unicast
4.5.7 & 4.9	Replace “Super OCXO” with “OCXO” for 8 hour holdover oscillator
7.4.5	Support for port unicast-both mode of operation
7.4.6	Support for port mixed mode of operation
7.7.4	Support for full on-path option for network type
7.7.6	Description of SyncE status on PTP::Port webpage
8.0	New chapter – Network Architecture and Deployment Considerations, 5G, ORAN
8.2	New Section - Description of PTP profiles

Changes in Rev 1.14	
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1.6	GNSS constellation selection is user configurable
4.3	Removed obsoleted note on DST, addition of SMPTE profile in the drop-down menu
4.5.3	Selection option for G.8275.1 L2 multicast DA. Also removed an obsolete note on L2/IPv6.
4.9, 5.3.3	FTP option for image upgrade is deprecated.
4.10	Fixed typo – SNMPv3, and not SNMPv2
9	End User License Agreement (EULA)
12	Updated Contacts information
Changes in Rev 1.13	
Section	Changes since previous revision
1.1, 1.2	Updated Qg 2 images with latest
4.3	Added Operating Mode PTP-only, GNSS debug (experimental, Qulsar internal use only) Added Note to indicate that SyncE feature is supported for PTP Only and GNSS Only operating modes
4.10	Updated SNMP tab webpage to include SNMP v3
5.1.2, 5.4.3	Update CLI network ping command as it takes an extra parameter now
5.6	New “date” command in CLI
6.1	Changed start-up time from 2 minutes to 4 minutes in Troubleshooting section
8.7	Fixed typo - 1PPS output is 3.3V
8.8	Cleaned up documentation on RJ45 and SFP port speeds
8.8.1	New section on SFP and SFP+ modules
Changes in Rev 1.12	
Section	Changes since previous revision
2.5.1	Added “IMPORTANT NOTE” on usage of Qg 2 power supplies
4.9	Added “IMPORTANT NOTE on Upgrade”
Changes in Rev 1.11	
Section	Changes since previous revision
3.3.3	More details on PTPBASE MIB and download link
4.3	Support for Full on-path support in Home::Network Type configuration
4.4.3	New configuration field for GNSS constellation selection
8.9.1	Updated LED description for more clarity
9.0	Updated to latest Part Numbers and product offering
Changes in Rev 1.10	
Section	Changes since previous revision
2.8	Minor update to documentation on applying power to Qg 2
4.3	Synchronous Ethernet dropdown menu options on Home webpage
4.4.1	Auto-negotiation configuration for PTP ports on Interfaces::PTP webpage
4.5.3	Update to PTP::Port webpage for SyncE support

7.7	New section on SyncE application
Changes in Rev 1.9	
Section	Changes since previous revision
1.5	Mention of product SKU for slave capacity documentation
4.8	Security tab webpage (https) added
5.2.1	Fig 27 – Alarms table formatting correction
5.3.1	Fig 29 – Updated “system info” to reflect the latest
5.5	Added documentation for “HTTPS Restore” command
8.3	Hard Reset Button – more documentation
Changes in Rev 1.8	
Section	Changes since previous revision
4.3	Home page - reflect new layout and doc to support PTP profiles
4.4.3	Interface::GNSS - updated webpage capture to show footnote
4.4.4	Table 6 - Fixed 1PPS OUT Period to indicate minimum setting is 1 second
4.5.1	Updated Fig 13 PTP::Config - "Network Type" configuration is now in Home webpage
4.5.2	Updated Fig 14 PTP::Clock - All fields are now read/write (configurable)
4.5.5	Updated Fig 17 PTP::Unicast Nodes - from latest software
4.5.6	Replaced Parent Dataset page with Dataset page - now displays all dataset information
4.7	Alarms/Events page updated to show the new alarms that are now supported
4.8	Systems Tab page - screen capture updated to reflect latest
5.2.1	Show Alarms CLI command output updated to reflect latest
7.6.7	Profile guidelines section removed since profile configuration is supported in SW now
Changes in Rev 1.7	
Section	Changes since previous revision
4.4.1	Updated Interface::PTP Timing Ports – added IPv6 address
4.5.3	Updated PTP::Port – adding IPv6 option to Network Protocol
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4.3	Updated Home Webpage to include Daylight Savings Time configuration
4.5.3	Updated PTP::Port Webpage to include Network Asymmetry configuration
8.9.1	Updated LED power description to indicate SW upgrade
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Section	Changes since previous revision
all	Updated screen captures to reflect the later versions of software
4..4.3	Support GNSS Visible Satellite Information feature
4.4.5	Support for SFP (optical module) information for PTP ports
4.7	GUI tab changed from Alarms to Alarms/Events
Changes in Rev 1.4	
Section	Changes since previous revision

4.3	Updated Home Webpage to include Local Time Zone configuration
4.4.1	Updated Interface::PTP Timing Ports Webpage to include Passthrough configuration
4.5.3	Updated PTP::Port Webpage to include DSCP configuration
Changes in Rev 1.3	
Section	Changes since previous revision
4.1	Updated Login Webpage
4.2	Added Change Password Webpage
4.5.1	Removed Minimize Frequency Change from PTP::Config Webpage
5.4.1	Updated “network config” CLI entry
Changes in Rev 1.2	
Section	Changes since previous revision
4.3	Add configuring Clock Class Mapping to GNSS webpage
4.3.4	Add configuring time zones to ToD/1PPS output webpage
4.4.5	Add ClockID for unicast master node list
4.4.6	Add Parent Node webpage to PTP webpages section
Changes in Rev 1.1	
Section	Changes since previous revision
All	Moved to new document template
Changes in Rev 1.0	
Section	Changes since previous revision
All	First version

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1 Introduction

1.1 Functional Overview

The Qg 2 is a small form factor, highly accurate Multi-Sync Gateway that provides IEEE 1588-2008 PTP Grand Master and Boundary Clock functionality. IEEE 1588-2008 PTP is also known as PTP Version 2.



Figure 1 The Qg 2

Qg 2 gets its time from the built-in GNSS receiver or 1PPS/ToD input or IEEE 1588-2008 PTP as input references. PTP algorithms are leveraged to deliver stringent timing for frequency and phase profiles. Outputs include IEEE 1588-2008 PTP, selectable FREQ Out, 1PPS, and Time of Day (ToD). Qg 2 will provide holdover depending on the chosen built-in oscillator.

Remote control and monitoring are provided over SSH, Web Interface and SNMP (v2, v3).

1.2 Interfaces

Qg 2 Interfaces are shown in Figure 2 and Figure 3 along with a brief description of them in the tables below them. Detailed description of the interfaces is provided in the REF section of this User Guide

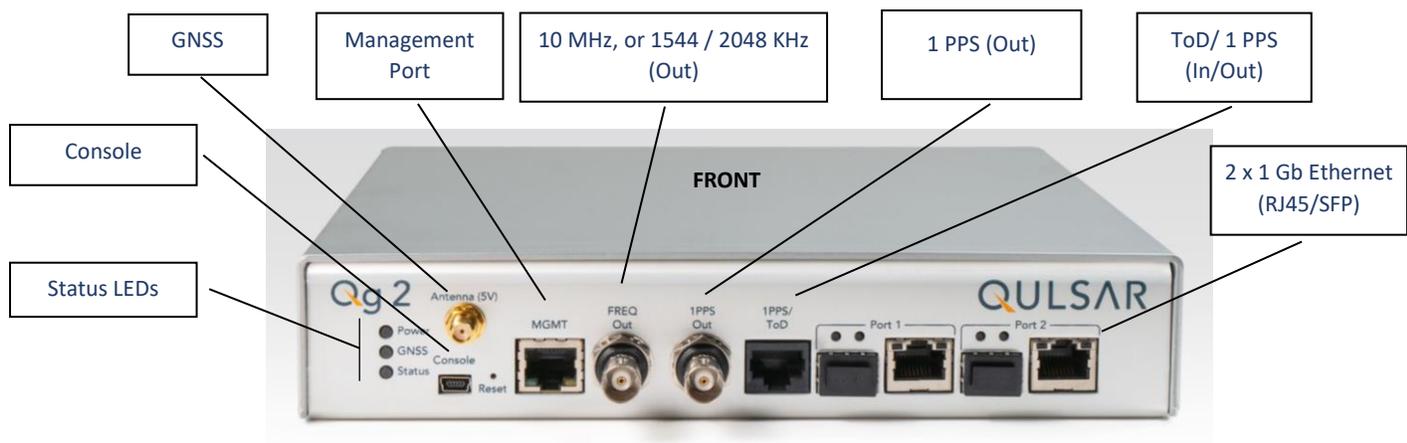


Figure 2 The Qg 2 Front Panel

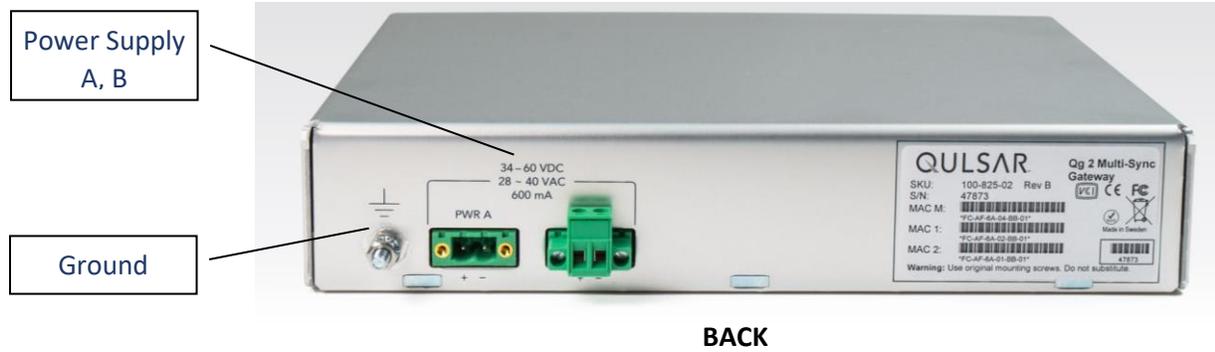


Figure 3 The Qg 2 Rear Panel

Rear Panel Description
Ground connector
Primary power plug, 34 – 60 VDC / 28 – 40 VAC
Secondary power plug, 34 – 60 VDC / 28 – 40 VAC

Table 1 Qg 2 Rear Panel Interfaces

1.3 Typical Applications

Qg 2 is a small form factor IEEE-1588-2008 PTP Edge Grand Master and Boundary Clock that can be used for smart grid transmission and distribution substations. This Multi-Sync Gateway platform is designed for small cell clusters, C-RAN, and edge applications. For more information about PTP, see [1].

1.4 Oscillator Options

Standard: OCXO oscillator, 4-hour holdover for 1.5 μ sec accuracy.

Superior: Super OCXO oscillator, 8-hour holdover for 1.5 μ sec accuracy.

1.5 PTP Slave Capacity

The Qg 2 has variants that can support different unicast slave capacity (32, 128, 256, ..) slaves at up to 128 sync / delay packets per second when the MCE is operated as a master clock depending on the product SKU. The variants are configured at the factory and cannot be field upgraded at present. Contact information for ordering the Qg 2 with the supportable slave capacities is presented in the Contact Section of this User Guide on page 107. Section 10 of this User Guide presents all the variants available.

1.6 Components Block Diagram

The following block diagram defines the main components of the Qg 2 system along with the physical connections to each component.

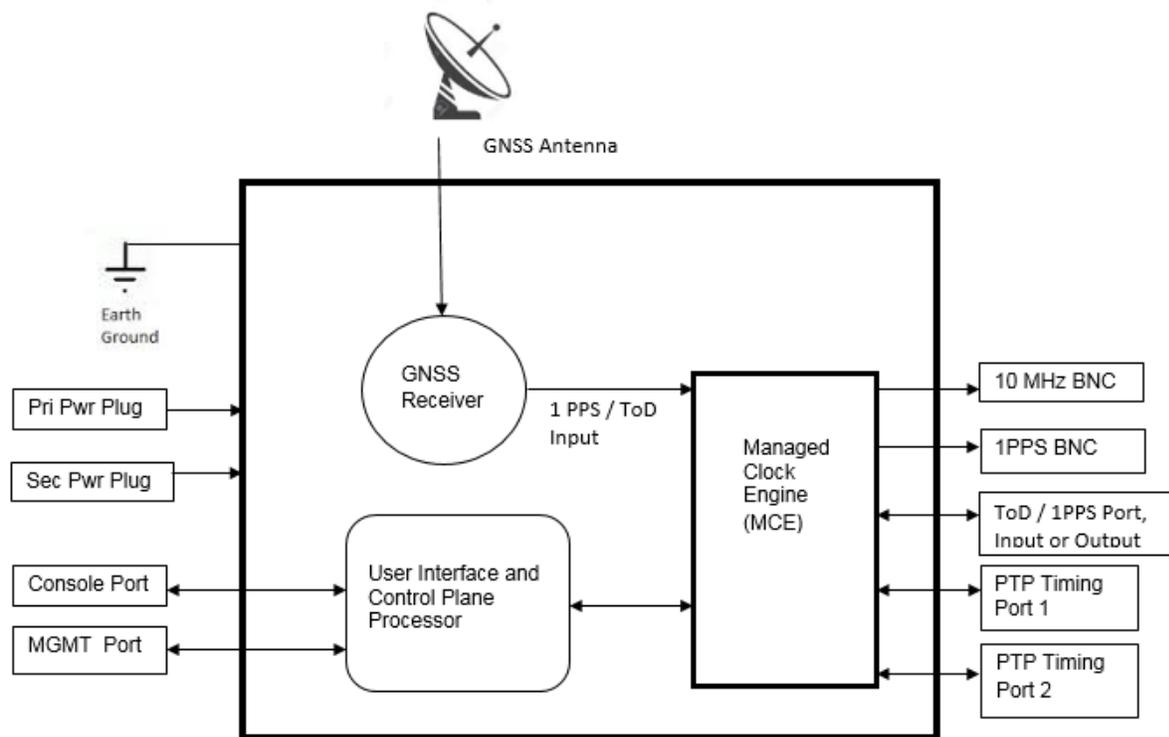


Figure 4 Qg 2 Components Block Diagram

- Managed Clock Engine (MCE) is a full packet network-based synchronization engine supporting IEEE 1588-2008 Precise Time Protocol. The MCE is where IEEE 1588-2008 PTP packet communication processing runs, and port / BNC provisioning is applied. GNSS signals and User Interface Processor (UIP) commands are sent to the MCE.
- User Interface and Control Plane Processor, which supports all the user access and connectivity to the entire system. The Processor supports DHCP, HTTP webpage/CLI access, SSH, SFTP, XML and SNMP (v2, v3).
- GNSS Receiver – GPS Receiver combined with either a Beidou or Glonass or Galileo Receiver with external antenna input. The selection of the constellation is user configurable.

2 Installation

Before the Qg 2 is installed, review the information in this section. If difficulties are encountered during the installation process, contact Qulsar Customer Support, with the contact information provided in the Contact Section of this User Guide.

2.1 Security Recommendations

The Qg 2 Management port and PTP Timing ports should be installed behind the company's firewall to prevent public access. Additionally, the PTP Timing ports should be connected to a Local Area Network (LAN) or Wide Area Network (WAN) dedicated to transporting PTP timing messages.

2.2 Environmental Requirements

The Qg 2 operating temperature is 0°C to 50° C (-32°F to 122° F). Use only shielded cable for all signal wiring, including I/O, clocks and Ethernet. Use the Ground connector to appropriately ground the Qg 2 to earth ground.

2.3 Packaging List and Unpacking

The Qg 2 box contains the following:

- The Qg 2 Multi-Sync Gateway
- 48V DC power adapter

GNSS antenna, mounting bracket and console cable can optionally be supplied by the local distributor.

The Qg 2 is packaged to be protected from normal shock, vibration, and handling damage during shipment. Unpack and inspect the box contents as follows:

1. Wear a properly grounded protective wrist strap or suitable ESD protection.
2. Inspect the shipping box for signs of damage. If the box appears to be damaged, notify both the carrier and your Qulsar distributor. Retain the shipping box and packaging material for the carrier to inspect.
3. Open the box, being careful to cut only the packaging tape.
4. Locate and save the printed packaging list and paperwork that is included in the box.
5. Remove the Qg 2 from the box and place the unit on an anti-static surface.
6. Locate and set aside additional parts which may be contained in the box.
7. Remove and dispose of the anti-static packaging from the Qg 2 and parts.
8. Verify that the model and serial number shown on the packaging list agrees with the model and serial number on the Qg 2. The model number can be found on a label affixed on the back of Qg 2. Contact your Qulsar distributor if the model or serial number do not match.

2.4 Rack Mounting the Qg 2

The Qg 2 is half of a 19-inch rack, and occupies 1.75 in (4.5 cm, 1RU) of vertical rack space. An optional mounting bracket can be provided by the local distributor.

Warning: When rack mounting the Qg 2, use the original mounting screws provided with the mounting bracket so that the Qg 2 case will not be damaged. Do not substitute other mounting screws.

2.5 Power and Ground Connections

2.5.1 Power

The Qg 2 uses two VDC power sources, primary and backup. One or both power sources can be used. The power source can be 34 – 60 VDC. The VDC power connector uses two power feed lines, PWR A and PWR B. Qg 2 comes equipped with 2 Phoenix connectors to supply PWR A and PWR B and the user needs to connect the two terminals of it to their DC +/- supplies. The Qg 2 can also be powered by two VAC power sources, with 28 – 40 VAC supply.

IMPORTANT NOTE:

All operation, test and performance references and specifications that Qulsar, Inc. makes in its Qg 2 customer documents, and on its label, and to certification authorities are based on actual measurements ONLY when operated with the power supplies that Qulsar provides or offers as an optional accessory. If operated with other brands and/or different specifications of power supplies, Qulsar, Inc. will NOT guarantee Qg 2's proper operation, functionality or its compliance with the stated standards!

2.5.2 Ground

The Qg 2 ground is a 4 mm ground stud and is identified with the international ground marking as shown on Figure 3. This ground wire should be routed to earth ground.

2.6 Input / Output Signal Connections

2.6.1 Management

Using a standard CAT5 cable, connect the cable to the port labelled MGMT of the front panel to your network. The data rate is 10/100 Base-T shielded RJ45 receptacle. The Management port supports both forms of IP address assignment, static or DHCP.

2.6.2 Console

A mini-USB connector labelled Console is available for Qg 2 to have a serial connection to a PC or laptop. The user can connect to Qg 2 console via terminal emulation applications on PC like Tera Term, PuTTY, minicom or Procomm to access the CLI over the serial port.

2.6.3 FREQ Out

BNC connector to port labelled FREQ Out to provide syntonized selectable frequencies output from Qg 2. The FREQ Out is DC Blocked.

2.6.4 Timing outputs, 1PPS

A configurable 1PPS is provided on a BNC connector, labelled 1PPS. Connect the 1PPS signal output to a frequency counter or any other measuring device.

2.6.5 Timing inputs/outputs, ToD / 1PPS

An RJ45 port is provided, labelled ToD / 1PPS. These ports are configurable to provide input or output for ToD / 1PPS. Both, the ToD format and the 1PPS signal are configurable. Refer to [2] for details of the timing ports physical/electrical characteristics.

2.6.6 PTP Port 1 and Port 2

One shielded RJ45 copper port and one SFP port is provided in parallel for Port 1. Likewise, one shielded RJ45 copper port and one SFP port is provided in parallel for Port 2. These ports provide PTP protocol messages to the timing network. See Gateway and Boundary clock Section of this User Guide for information on how the PTP Port 1 and Port 2 perform when the Clock Type Mode is configured as Gateway or Boundary clock. Selecting the Clock Type Mode is described in PTP :: Clock Section of this User Guide.

2.7 Connecting GNSS Antenna

Connect a suitable GNSS antenna, making sure the antenna has a clear view of the sky. When the GNSS receiver has good reception, the GNSS LED will be green. Qg 2 provides 5.0 VDC bias to power remote active antennas.

The GNSS antenna connector is a female SMA with external threads. Once the GNSS antenna is connected to Qg 2 antenna port, the GNSS operation can be configured and monitored in the Interface :: GNSS Section of this User Guide.

2.8 Applying Power

Qg 2 does not have a power switch, so power should not be applied until the Ground connector is installed and connected to earth ground. To avoid accidental power up of the Qg 2, please re-check and ensure all connections are made including the Ground connector, before enabling external power to Qg 2.

IMPORTANT NOTE:

When using the 48 V power supply 99-905-04 for the Japanese and China markets on a 100 - 120 V mains voltage, the included power supply needs to *first* be connected to the wall socket and then to the Qg 2 for proper operation.

3 Getting Started

This chapter describes on how the user can start using Qg 2 system after installing Qg 2 device and making the necessary connections to the various hardware interfaces.

3.1 Logging in with the console

Log into Qg 2 using the mini-USB console. Default set-up is 115200 baud, 8 bits, no parity, and one stop bit. Login is admin and password are admin. Terminal emulation software like Tera Term, PuTTY, minicom and Procomm can be used for this purpose.

3.2 Set up IP address

The Management port IP address assigned to the Qg 2 can be viewed using the mini-USB console.

At the factory, the Qg 2 Management port IP is statically assigned to 192.168.2.100 with netmask of 255.255.255.0. This static IP address will be set after doing a restore to factory default configuration. To configure the Management port IP address for customer network:

1. Connect the Qg 2 mini-USB console port to a PC and run a terminal emulator application (Tera Term, PuTTY, minicom, Procomm, etc.) to login to the Qg 2. Login credentials are provided in the Qg 2 Basic Commands section. Use the “network configure” command to configure the Management port IP parameters. The Network Configure Command section provides CLI command details for setting the Management port IP address, subnet mask and Gateway IP.
2. With the Management port IP address configured successfully, the IP address can be entered into a browser URL field to access the Qg 2 Login page, with login credentials (admin/admin).

3.3 Remote Network Access to Qg 2

Qg 2 can be accessed remotely over IP network via the Management IP Interface. These are some of the methods to access Qg 2 remotely:

3.3.1 HTTP/Web access

Qg 2 can be accessed over the web from any standard browser (IE, Chrome, Firefox, Safari, etc.). This provides a Graphical User Interface (GUI) for the user to configure or monitor Qg 2 operations.

The following web browsers / versions are supported by the Qg 2 HTTP server:

- Internet Explorer / v11.0.31
- Chrome / v63.0.3239.132
- Firefox / v56.0
- Safari / v11.0.3

3.3.2 Secure Shell (SSH) access

SSH offers a secure shell for users to do remote login to Qg 2 using terminal emulation software. After login, the user can use Qg 2 CLI to send commands. Note that only SSH and not Telnet access is allowed for remote shell login.

3.3.3 SNMP (v2, v3)

Qg 2 can be one of many managed devices on the network with an Element Management System (EMS) or Network Management System (NMS) as the centralized server. Currently, only SNMP is supported for PTPBASE-MIB specification from Timing Over IP Connections and Transfer of Clock (TICTOC) Working

Group. The text format of PTPBASE-MIB can be downloaded from <https://qulsar.com/support/downloads/PTPBASE-MIB.zip>

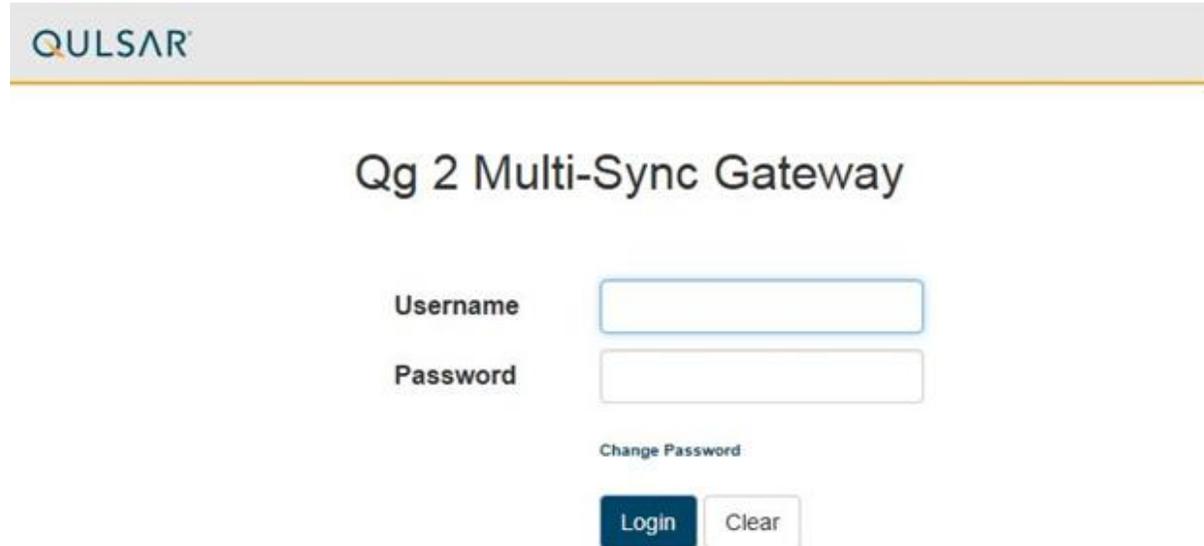
3.3.4 XML API

Applications using XML interface can access Qg 2 system via its XML API's. Support for this will be added in future release.

4 Web Interface

This chapter deals with the Web Interface of Qg 2. A topic for each page in the web interface is provided, with an explanation of each tab, button and selection on each page. The Login Webpage and Home Webpage are presented as a starting point for accessing the Web Interface.

4.1 Login Webpage



The screenshot shows the login interface for the Qg 2 Multi-Sync Gateway. It includes the QULSAR logo, the title 'Qg 2 Multi-Sync Gateway', and a form with 'Username' and 'Password' fields, a 'Change Password' link, and 'Login' and 'Clear' buttons.

Figure 5 Login Webpage

The Login webpage contains the following entries and buttons:

- Username (Factory default: “admin”)
- Password (Factory default: “admin”)
- Change Password hyperlink, selects Change Password webpage
- Login button – Apply Username and Password to login
- Clear button – Clear Username and Password

4.2 Change Password Webpage

QULSAR

Qg 2 Multi-Sync Gateway

Please change your old password and click "Submit" to continue signing in

Old Password

New Password

Confirm New Password

[Cancel Change Password](#)

Figure 6 Change Password Webpage

The Change Password webpage contains the following entries and buttons:

- Old Password – Enter current password.
- New Password – Enter new password.
- Confirm New Password – Re-enter new password.
- Cancel Change Password hyperlink, selects Login webpage.
- Submit button – Apply New Password
- Clear button – Clear all entries

In the case of a forgotten or lost password, the Qg 2 can be reset to factory defaults to recover the default password. The Hard Reset Button section of this User Guide describes how to reset the Qg 2 to factory defaults. When the Qg 2 completes the reboot, the password will be reset back to “admin”. Prior to doing a Hard Reset, saving the current configuration of the Qg 2 is recommended, and then reloading the configuration after reboot has completed.

4.3 Home Webpage

The screenshot shows the Qulsar Home Webpage. At the top, there is a navigation bar with 'QULSAR' on the left and 'Home', 'Interface', 'PTP', 'Configuration', 'Alarms/Events', 'System', and 'SNMPv2' on the right. The version 'Qg 2 Version: 12.1.16' is displayed in the top right corner. The main content area is titled 'Home' and contains a configuration box for the Timing Engine. This box includes dropdown menus for 'Profile' (Default profile(1588_V2)), 'Clock Type' (Ordinary Clock), 'EEC Option' (Option-1), 'Operating Mode' (GNSS Only), 'Network Type' (Unmanaged), and 'Synchronous Ethernet' (Off). Below this box is a 'Stop Engine' button. The configuration details are listed below: Clock ID (FC AF 6A FF FE 2 85 4F), Time Source (GNSS), PTP Sync (Locked/Synchronizing), GNSS Status (1PPS Stable/ToD Stable), UTC Time (2019-05-19 07:13:56), PTP Time (2019-05-19 07:14:33.366563184), Local Time (2019-05-19 07:13:56 GMT), and Local TZ ((GMT +0:00) UTC, GM1). There is also a section for 'Daylight Saving' with an 'Enable DayLight Saving' checkbox and a table for setting start and end times. The table has columns for Month, Week, Day, Hour, and Min. The start time is set to Jan, Last, Sun, 00, 00 and the end time is also set to Jan, Last, Sun, 00, 00. 'Apply' and 'Clear' buttons are at the bottom.

Figure 7 Home Webpage

Prior to starting the Timing Engine, some basic configurations are needed to define the clock, the mode of operation and user deployment scenario. These basic configurations are provided inside the box at the top of the Home page.

(PTP) Profile dropdown selections

- Default profile (1588_V2)
- Telecom profile
 - G8275.1 (frequency + phase, L2 multicast, requires full on-path timing network support)
 - G8275.2 (frequency + phase, L3 unicast, for partial timing network)
 - G8265.1 (frequency only from packet network)
- Power profile
 - Power_V1 (IEEE C37.238-2011)
 - Power_V2 (IEEE C37.238-2017)
 - Power Utility (IEC61850-9-3:2016)
- SMPTE profile
 - ST 2059-2:2015 - SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications

Operating Mode dropdown selections

- PTP Only
- GNSS Only
- GNSS Primary, PTP Secondary
- PTP Primary, GNSS Secondary
- PTP only, GNSS debug (experimental, for Qulsar internal use ONLY!)

Qg 2 Operating Modes are described in detail and can be managed as described in the Qg 2 Engine Modes Section of this User Guide.

Clock Type dropdown selections

- Ordinary Clock (Grandmaster, Master, Slave)
- Boundary Clock (one port is Slave, and the other port is Master)

Network Type dropdown selections (to optimize for user network conditions)

- Unmanaged (networks with unknown packet delay variation)
- Managed (networks with distinct floor of minimum packet delay variation)
- Full on-path (networks as specified in G.8275.1 to comply with G.8273.2 for frequency response specification. NOTE: The slave Start and Main Time Constant values will be optimized to 100 and 1 when Full on-path support is configured)

EEC Option dropdown menu (EEC = Ethernet Equipment Clock, with accuracy within ± 4.6 ppm)

- Option-1 (for 2048 kbps network hierarchy, min BW = 1Hz, max BW = 10Hz, Europe)
- Option-2 (for 1544 kbps network hierarchy, min BW = none, max BW = 0.1Hz, N America)
- eEEC Option-1 (enhanced EEC bandwidth with Option-1)
- eEEC Option-2 (enhanced EEC bandwidth with Option-2)

Note: eEEC bandwidth option that can be combined with Option-1 (Europe) or Option-2 (N America).

Synchronous Ethernet dropdown menu

- OFF (Synchronous Ethernet is disabled, no clock recovery from either port, no ESMC processing or transmit, only PTP operation)
- GM – GNSS Source (no clock recovery from ports, ref frequency from 1PPS used for SyncE out (Ethernet Tx clock, ESMC/QL out on both ports), plus PTP operation)
- BC – Ref input port-1 (SyncE in (recovered clock, input ESMC/QL) from port-1, SyncE out on port-2, plus PTP operation. For G8275.2 profile, SyncE out is disabled)
- BC – Ref input port-2 (SyncE in (recovered clock, input ESMC/QL) from port-2, SyncE out on port-1, plus PTP operation. For G8275.2 profile, SyncE out is disabled)

NOTE:

1. The above configurations that are encapsulated in the box on Home webpage need to be configured BEFORE starting the timing engine. These configuration parameters in the box defines the basic mode of operation in customizing for customer deployment and application.
2. Once the engine is stopped to change the profile or other configuration within this box, some of the timing engine related configuration may get reset to default values.
3. Synchronous Ethernet is supported only for the following Operating Modes:
 - a. PTP Only, and
 - b. GNSS Only

Start Engine/Stop Engine

Click the button to start Clock Engine if engine is stopped or stop it if it is already running. While the engine start is in progress, a label will display “Applying configuration and starting the engine - please wait!!!” at the top of the screen.

Clock ID

- This is this Qg 2 node's PTP Clock-Id.

Time Source

- GNSS
- PTP
- HAND SET

Soon after booting up, Qg 2's timing engine will be configured with the build time of the software instead of it being unknown or arbitrary. This will be updated once it finds a time reference (GNSS or PTP)

PTP Sync (Status / State)

- Status can be "Locked" or "Unlocked".
- State can be:
 - Free Running – no reference clock source, using internal oscillator.
 - Syntonizing – 1PPS reference but no reference ToD source, frequency only
 - Synchronizing – (1PPS + ToD) or PTP reference source, timing synchronized to that.
 - Holdover – Lost reference source, timing continues with earlier reference.

Qg 2 Sync States are described in detail in the Qg 2 Clock Sync States Section of this User Guide.

GNSS Status (1PPS / ToD)

- Stable
- Unstable
- N/A if the operating mode is PTP-only as there is no GNSS reference

UTC Time

- Format YYYY-MM-DD HH:MM:SS
- This is also known as Greenwich Mean Time (GMT) or Zulu time.

PTP Time

- Format YYYY-MM-DD HH:MM:SS:<fraction of a second>

Local Time

- Format YYYY-MM-DD HH:MM:SS <xxT>
- Can be customized to local time zone using "Local TZ" configuration
- Default setting is the same as UTC Time (i.e.. "GMT")

Local TZ (time zone)

User can select one of many pull-down options to select the appropriate time-zone for the local time.

- (GMT +0:00) UTC, GMT, WET
- (GMT -11:00) MIT
- (GMT -10:00) HST
- :
- :
- (GMT +11:00) SST

- (GMT +12:00) NST

Daylight Saving

- Enable Daylight Saving
- Start Time: Month [Jan-Dec], Week [1..4, last], Day [Sun – Sat], Hour [0-23], Min [0, 15, 30, 45]
- End Time: Month [Jan-Dec], Week [1..4, last], Day [Sun – Sat], Hour [0-23], Min [0, 15, 30, 45]

Logout Button – Logs the user out of the Qg 2 Web server.

4.4 Interface Webpage Tab

Interface Dropdown selections

- PTP Timing Ports
- MGMT Port
- GNSS
- ToD/1PPS Output

4.4.1 Interface :: PTP Timing Ports

The screenshot shows the QULSAR web interface for configuring PTP Timing Ports. The top navigation bar includes 'Home', 'Interface', 'PTP', 'Configuration', 'Alarms/Events', 'Security', 'System', and 'SNMP'. The left sidebar lists 'PTP Timing Ports', 'MGMT Port', 'GNSS', 'ToD/1PPS output', and 'SFP Info'. The main content area is divided into two columns for 'Port 1' and 'Port 2'. Port 1 is configured with DHCP enabled, IPv4 address 10.0.1.168, subnet mask 255.255.255.0, gateway IP 10.0.1.1, auto negotiation on, link state 1000M/Full, IPv6 address fe80:0000:0000:0000:feaf:6aff:fe06:67b8, and MAC fc:af:6a:05:67:b8. Port 2 is currently N/A. There are 'Apply' and 'Clear' buttons for each port's configuration. A 'DOWN' status indicator is visible for Port 2. The bottom of the configuration area has an 'Apply' button.

Figure 8 Interface :: PTP Timing Ports

The PTP Timing Ports webpage contains the following displays, selections, entries, and buttons:

PTP Timing Ports		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
PTP Timing Ports – Port 1		
DHCP	RW	Enable / Disable DHCP for dynamic IP assignment
Ipv4 Address	RW	Four dot separated octets (0 – 255) for static IP assignment
Subnet Mask	RW	Four dot separated octets (0 – 255) for static IP assignment
Gateway IP	RW	Four dot separated octets (0 – 255) for static IP assignment
Auto Negotiation	RW	Drop down menu for IEEE 802.3 Ethernet link auto-negotiation. Drop down menu options: On 1000 Full Duplex 1000 Half Duplex 100 Full Duplex 100 Half Duplex 10 Full Duplex 10 Half Duplex NOTE: Synchronous Ethernet is supported only for 1000 Full Duplex ports
Link State	RO	Link Up / Link Down Status with Mbps Data Rate and Full Duplex I/O
IPv6 Address	RO	(Link local) IPv6 address used when PTP::Port::Network Protocol is IPv6
MAC	RO	Six colon separated hexadecimal MAC address display
PTP Timing Ports – Port 2		
DHCP		N/A (DHCP supported only for Port 1)
Ipv4 Address	RW	Four dot separated octets (0 – 255)
Subnet Mask	RW	Four dot separated octets (0 – 255)
Gateway IP	RW	Four dot separated octets (0 – 255)
Link State	RO	Link Up / Link Down Status with Mbps Data Rate and Full Duplex I/O
IPv6 Address	RO	(Link local) IPv6 address used when PTP::Port::Network Protocol is IPv6
MAC	RO	Six colon separated hexadecimals
Apply / Clear		
Apply Button	WO	Click for selection and Timing Port settings to be applied to Qg 2
Clear Button	WO	Click to clear the recent changes
IPv6 Address Configuration		
IPv6 Address	RW	128-bit IPv6 address. It can be one of the popular formats as shown: <ul style="list-style-type: none"> x:x:x:x:x:x (x is a 16-bit hex value), 2023:130F:0:0:0:09C0:080F:130B (omitting leading zeroes) 2023:130F::09C0:080F:130B (double colon suppressing zero values)
Prefix Length	RW	Number of bits for prefix - value in the 1 thru 128 range
Gateway IPv6	RW	128-bit IPv6 address of the Gateway
Apply / Clear		
Apply Button	WO	Click for selection and Timing Port settings to be applied to Qg 2
Clear Button	WO	Click to clear the recent changes
VLAN Configuration – Port 1		

Type	RW	Select Off / None / VLAN Off – Send and receive untagged frames only. None – Send untagged frames, receive untagged frames and priority tagged frames. VLAN – With Priority 0, send priority tagged frames, receive untagged and priority tagged frames. VLAN – With VLAN ID and Priority 1 to 7, send and receive VLAN-tagged frames only
VLAN ID (0-4094)	RW	Set VLAN ID
Priority (0-7)	RW	Set VLAN Priority
VLAN Configuration – Port 2		
Type	RW	Select Off / None / VLAN Off – Send and receive untagged frames only. None – Send untagged frames, receive untagged frames and priority tagged frames. VLAN – With Priority 0, send priority tagged frames, receive untagged and priority tagged frames. VLAN – With VLAN ID and Priority 1 to 7, send and receive VLAN-tagged frames only
VLAN ID (0-4094)	RW	Set VLAN ID
Priority (0-7)	RW	Set VLAN Priority
Apply / Clear		
Apply Button	WO	Click for selection and VLAN settings to be applied to Qg 2
Clear Button	WO	Click to clear recent changes
Forwarding		
PassThrough	RW	Enable: All packets (including user data) received on the PTP port(s) that is not destined for this Qg 2 will be forwarded from one PTP port to another PTP port. Disable: Only (PTP) traffic destined for this Qg 2 will be processed. All other traffic will not be forwarded to the other port and will be dropped/terminated.
Ping		
IP Address	RW	Four dot separated octets (0 – 255) IP to ping
Ping Button	WO	Click to ping to the entered IPv4 address (support for IPv6 in a future release)

Table 2 PTP Timing Ports Options

4.4.2 Interface :: MGMT Port

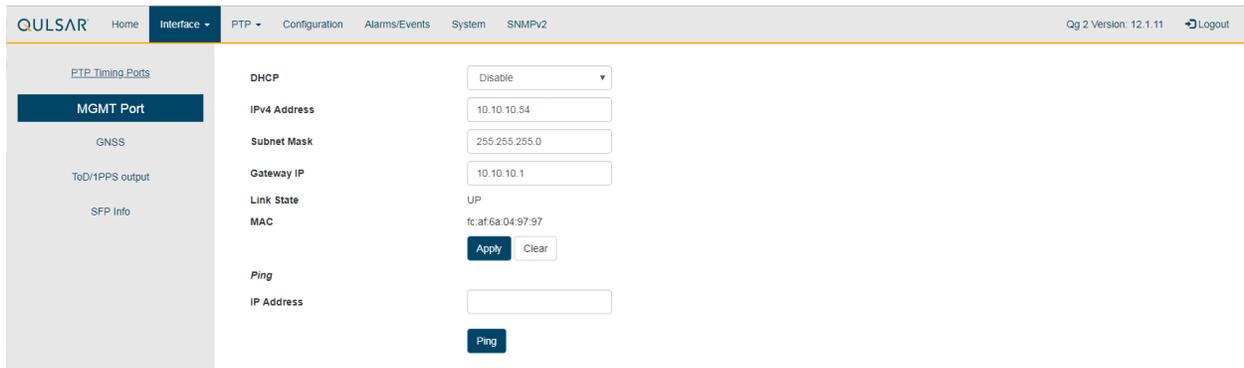


Figure 9 MGMT Port Webpage

The MGMT Port webpage contains the following displays, selections, entries, and buttons:

Interface :: MGMT Port		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
MGMT Port		
DHCP	RW	Enable / Disable DHCP for dynamic IP assignment
Ipv4 Address	RW	Four dot separated octets (0 – 255) for static IP assignment
Subnet Mask	RW	Four dot separated octets (0 – 255) for static IP assignment
Gateway IP	RW	Four dot separated octets (0 – 255) for static IP assignment
Link State	RO	Link UP / Link DOWN Status
MAC	RO	Six colon separated hexadecimal MAC address display
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2 MGMT port
Clear Button	WO	Click to clear the latest changes
Ping		
IP Address	RW	Four dot separated octets (0 – 255) IP to ping
Ping Button	WO	Click to Ping to the entered IP address

Table 3 Management Port Options

4.4.3 Interface :: GNSS

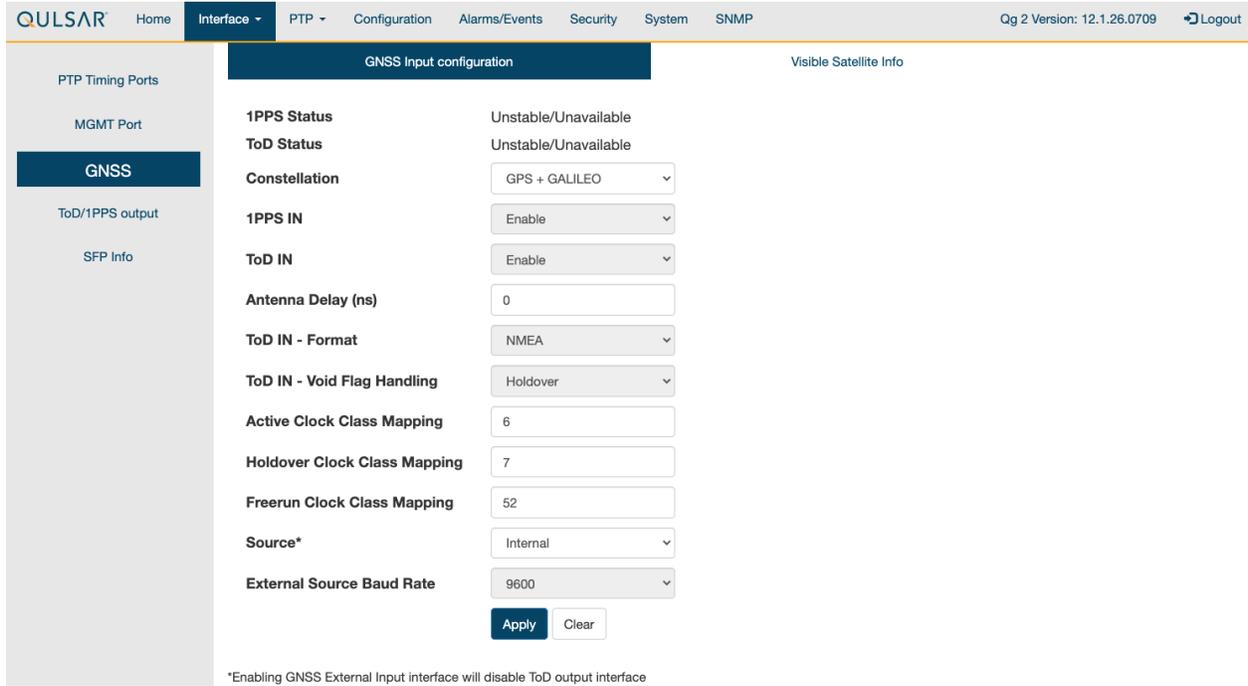


Figure 10 Interface :: GNSS :: GNSS Input Configuration

The GNSS webpage contains the following displays, selections, entries, and buttons:

Interface :: GNSS		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
GNSS		
1PPS Status	RO	1 pulse per second (1PPS) Stable or Unstable
ToD Status	RO	Time of Day (ToD) Stable or Unstable
Constellation	RW	Selection of one GNSS constellation option: <ul style="list-style-type: none"> • GPS-only • GPS + Glonass • GPS + Beidou • GPS + Galileo
1PPS IN	RW	Enable/Disable of 1PPS from external GNSS Receiver
ToD IN	RW	Enable/Disable of ToD from external GNSS Receiver
Antenna Delay (ns)	RW	Calibration for cable delay in nano-seconds. Range [0 – 2147483647]
ToD IN - Format	RW	Format of ToD message – NMEA, ASCII, or China Mobile
ToD IN – Void Flag Handling	RW	Option for handling Void (V) flag in RMC data in GNSS message. Options are: Ignore: Ignore the Void flag in RMC and treat as Active (A) Syntonize: Do not ignore but accept 1PPS only as valid. Holdover: Do not ignore Void flag and treat as not Active

Active Clock Class Mapping	RW	GNSS Active (A) clock class. The allowed Clock Class settings are defined in IEEE Std 1588-2008, section 7.6.2.4 and Table 5.
Holdover Clock Class Mapping	RW	GNSS Holdover clock class. The allowed Clock Class settings are defined in IEEE Std 1588-2008, section 7.6.2.4 and Table 5.
Freerun Clock Class Mapping	RW	GNSS Freerun clock class. The allowed Clock Class settings are defined in IEEE Std 1588-2008, section 7.6.2.4 and Table 5.
Source	RW	GNSS ToD/1PPS source: Internal or External Note: Selecting External will disable ToD and 1PPS outputs as the same interface is used for both, input and output.
External Source Baud Rate	RW	GNSS ToD Baud Rate: 4800 or 9600
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes

Table 4 GNSS Options

IMPORTANT NOTE on GNSS Clock Class mapping:

By default, Qg 2 software will set the default configuration of GNSS Clock Class Mapping as: 6 for Active, 7 for Holdover, and 52 for Freerun. This is correct when the Engine Operating Mode (on the Home webpage) is set to GNSS-Only.

Please follow this table in setting up the GNSS Clock Class Mapping for the different Engine Operating Modes. This is important, to ensure proper operation of the timing engine in different operating modes.

Operating Mode	Clock Class Mapping			Comment
	Active	Holdover	Freerun	
PTP Only	6	7	52	Don't care – use default
GNSS Only	6	7	52	Use default
GNSS Primary, PTP Secondary	6	7	187	Freerun => 187
PTP Primary, GNSS Secondary	6	7	187	Freerun => 187
PTP only, GNSS debug	6	7	52	Use default

Table 5 GNSS Clock Class Mapping configuration

Interface::GNSS Visible Satellite Info

Informational parameters of all the visible satellites are displayed on selecting this tab. Also, the physical geographical location & fix quality is displayed.

PRN	Constellation	Used	Elevation	Azimuth	SNR
19	GPS	*	76	15	17
24	GPS	*	51	298	26
6	GPS	*	49	144	21
17	GPS	*	48	42	32
2	GPS	-	25	184	0
28	GPS	*	25	88	17
12	GPS	*	21	296	36
15	GPS	*	15	245	22
13	GPS	*	14	209	17
30	GPS	-	2	147	0
46	GPS	-	0	0	0

Figure 11 Interface :: GNSS :: Visible Satellite Info

NOTE :

- The Visible Satellite Info field will get updated as constellations/satellites come into view. If user configures a different new constellation at run-time, some of the old stale information may still be displayed. This will be cleared on a reboot.

4.4.4 Interface :: ToD/1PPS Output

Figure 12 Interface :: ToD / 1PPS Output

The ToD / 1PPS Output webpage contains the following selections, entries, and buttons:

Interface :: ToD / 1PPS Output

Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
GNSS		
1PPS State	RW	Stop/Start control of 1PPS output
1PPS Period (us)	RW	1PPS pulse period in micro-seconds. Typically, one second but can be configured to be different. Range: 1000000 to 4294967295 (or ~ 1hour)
1PPS Pulse Width (us)	RW	1PPS pulse width in micro-seconds. Range: 250 to (1PPS Period minus 250)
1PPS Mode	RW	1PPS Mode options : Sync, Holdover, Always
1PPS Error Tolerance (ns)	RW	1PPS Error Tolerance Range: 0 to 4294967295 <ul style="list-style-type: none"> If the 1PPS mode is Always, the Error Tolerance is simply ignored. For Sync and Holdover modes, the error tolerance has the following effects: <ul style="list-style-type: none"> If the Error Tolerance is zero, then the ToD/1PPS signal is started/stopped as soon as the MCE enters/leaves corresponding Sync/Holdover states. If the Error Tolerance is non-zero, and the MCE is in the Holdover state, the ToD/1PPS signal is stopped as soon as either the estimated error becomes larger than the Error Tolerance or the MCE exits the Holdover state.
1PPS Auto Restart	RW	1PPS Auto Restart ON/OFF control
1PPS Delay (ns)	RW	Delay between 1PPS and the following ToD message string to be put out Range: 0 to 2147483647
ToD Format	RW	Format of ToD to be output. The options are: NMEA, ASCII, China Mobile
ToD Subformat (NMEA Only)	RW	ToD Subformat options are: RMC, ZDA, Both
ToD Void Flag Handling	RW	Void Flag generation in RMC message when: Never, Free-run, Holdover,
NMEA Timezone	RW	The Timezone options for ToD output are: None, TZ, TZ + DST

TOD OUT Baud Rate	RW	Select TOD OUT Baud Rate: 4800, 9600, 14400, 19200, 28800, 38400, 57600, or 115200
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes

Table 6 ToD/1PPS Output Options

4.4.5 SFP Info

SFP Information page displays PTP ports optical module transceiver details as provided by the module vendor. Note that depending on specific SFP or vendor, some or all information may not be displayed.

The screenshot shows the QULSAR web interface. The top navigation bar includes 'Home', 'Interface', 'PTP', 'Configuration', 'Alarms/Events', 'System', and 'SNMPv2'. The right side of the header shows 'Qg 2 Version: 12.1.11' and a 'Logout' button. On the left, a sidebar menu lists 'PTP Timing Ports', 'MGMT Port', 'GNSS', 'ToD/1PPS output', and 'SFP Info' (which is highlighted). The main content area is divided into two columns: 'PTP Port 1 SFP' and 'PTP Port 2 SFP'. Under 'PTP Port 1 SFP', a box contains the following details: Connector: LC, Compliance: 1000BASE-SX, Medium: Multimode OM2 fiber, 850 nm, Link length: 150 m, Vendor name: Intel Corp., Vendor OUI: 00:02:b3, Vendor P/N: TXN3115D100000, Vendor rev: AZ6P6217H3MB, Module temp: 50.3 C / 122.5 F, Module voltage: 3.260 V, Laser current: 7 mA, Laser TX power: 0.351 mW / -4.55 dBm, and Laser RX power: 0.219 mW / -6.60 dBm. Under 'PTP Port 2 SFP', a box displays 'SFP Not present'.

Figure 13 Interface :: SFP Info

4.5 PTP Webpage Tab

PTP Dropdown selections

- Config
- Clock
- Port
- Unicast
- Unicast Nodes
- Time
- SNTP

4.5.1 PTP :: Config

Figure 14 PTP :: Config

The Config webpage contains the following selections, entries, and buttons:

PTP :: Config		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
PTP Config		
Main Time Constant (s)	RW	The main Time Constant used for the PTP servo after the servo has synchronized. Range: 1 to 2147483647
Startup Time Constant (s)	RW	The startup Time Constant used for the PTP servo before the servo has synchronized. Range: 1 to 2147483647
Quality Threshold(ns)	RW	Maximum variation allowed in the sync and delay request direction, respectively, before packets are ignored.
Timing Output		
Frequency Out	RW	Select Timing Frequency Output: 1544 kHz, 2048 kHz, and 10 MHz.
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes

Table 7 PTP Configuration Options

A description of the selections and settings for each entry on the PTP::Config web page is presented in the PTP (Slave)Servo Configuration Parameters Section of this User Guide.

4.5.2 PTP :: Clock

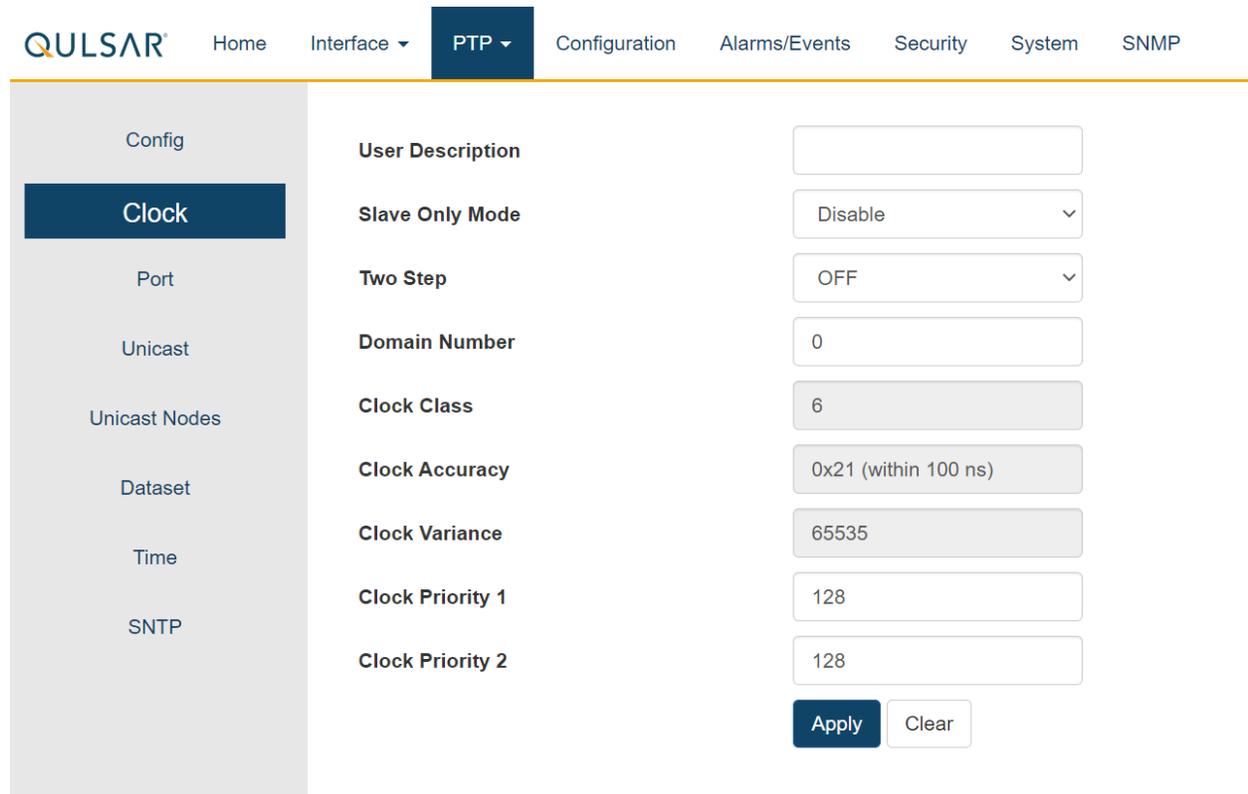


Figure 15 PTP :: Clock Webpage

The Clock Webpage contains the following selections, entries, and buttons:

PTP :: Clock		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
Clock		
User Description	RW	Optionally the user can provide a user description to identify this Qg 2's clock. Normal ASCII characters can be used – letters, numbers, and special characters. Note, the following characters are not allowed: ; (semi-colon), (space), and \$.
Clock Type Mode	RW	Selection of PTP clock for this Qg 2 device. The options are: Ordinary Clock, Boundary Clock
Slave Only Mode	RW	Disable/Enable control for PTP Slave-only mode. In this mode, the PTP ports will always remain in Slave or Listening mode.
Two Step	RW	ON/OFF control of PTP two-step mode.
Clock Class	RW	PTP Clock class
Clock Accuracy	RO	PTP Clock accuracy

Clock Variance	RO	PTP Clock variance
Clock Priority 1	RO	PTP Clock priority 1
Clock Priority 2	RW	PTP Clock priority 2
Domain Number	RW	Configure the PTP Clock domain number
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes

Table 8 PTP Clock Options

In addition, there are additional PTP profile specific parameters or options that will be selectively shown. More information is provided in the [section](#) describing PTP profiles

4.5.3 PTP :: Port

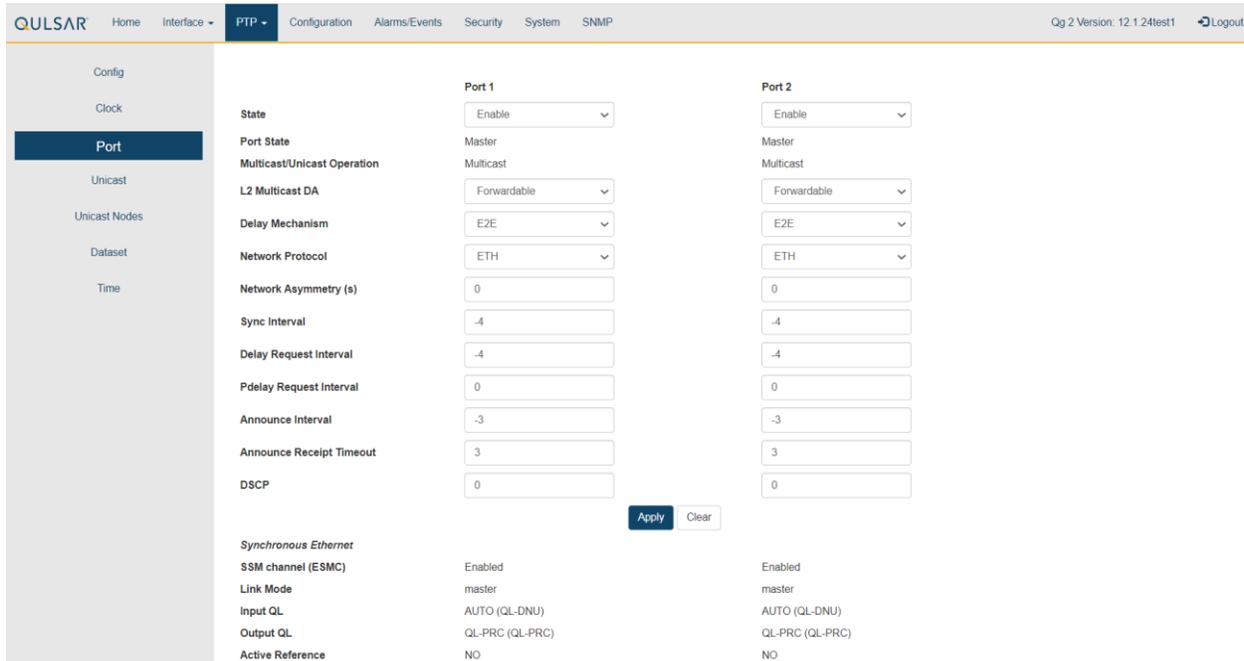


Figure 16 PTP :: Port Webpage

The Port Webpage contains the following displays, selections, entries, and buttons for Ports 1 and 2:

PTP :: Port		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
Port 1 and Port 2		
State	RW	Select PTP port operational state: Disable / Enable
Port State	RO	PTP port state. The Clock Engine maintains the following states, and the port can be in one of these states. The states are {Undefined, Initializing, Faulty, Disabled, Listening, Pre Master, Master, Passive, Uncalibrated, Slave}
L2 Multicast DA	RW	G8275.1 L2 multicast DA for PTP messages selection options: Forwardable, Non-forwardable,

		<p>Forwardable only, and Non-forwardable only</p> <p>The table show more details for each of these options:</p> <table border="1"> <thead> <tr> <th>Selection</th> <th>Send</th> <th>Receive</th> </tr> </thead> <tbody> <tr> <td>Forwardable</td> <td>Announce/sync/delay to FW address pdelay to NF</td> <td>Both FW and NF</td> </tr> <tr> <td>Non-forwardable</td> <td>Send all messages to NF</td> <td>Both FW and NF</td> </tr> <tr> <td>Forwardable only</td> <td>Send all messages to FW</td> <td>Only FW</td> </tr> <tr> <td>Non-forwardable only</td> <td>Send all messages to NF</td> <td>Only NF</td> </tr> <tr> <td colspan="3">FW = Forwardable DA (MAC Address: 01-1B-19-00-00-00)</td> </tr> <tr> <td colspan="3">NF = Non-Forwardable DA (MAC Address: 01-80-C2-00-00-0E)</td> </tr> </tbody> </table>	Selection	Send	Receive	Forwardable	Announce/sync/delay to FW address pdelay to NF	Both FW and NF	Non-forwardable	Send all messages to NF	Both FW and NF	Forwardable only	Send all messages to FW	Only FW	Non-forwardable only	Send all messages to NF	Only NF	FW = Forwardable DA (MAC Address: 01-1B-19-00-00-00)			NF = Non-Forwardable DA (MAC Address: 01-80-C2-00-00-0E)		
Selection	Send	Receive																					
Forwardable	Announce/sync/delay to FW address pdelay to NF	Both FW and NF																					
Non-forwardable	Send all messages to NF	Both FW and NF																					
Forwardable only	Send all messages to FW	Only FW																					
Non-forwardable only	Send all messages to NF	Only NF																					
FW = Forwardable DA (MAC Address: 01-1B-19-00-00-00)																							
NF = Non-Forwardable DA (MAC Address: 01-80-C2-00-00-0E)																							
Multicast/Unicast Operation	RO	PTP port operational mode status – Unicast or Multicast																					
Delay Mechanism	RW	Configuration of PTP delay mechanism: End-to-End (E2E) or Peer-to-Peer (P2P)																					
Network Protocol	RW	Configure PTP's underlying network protocol. The options are: IPv4 (PTP over UDP/IPv4), IPv6 (PTP over UDP(6)/IPv6), ETH (PTP over L2 Ethernet)																					
Network Asymmetry (s)	RW	Configure Network Asymmetry delay to compensate for difference between the forward and return paths from this PTP slave port to PTP master as it may not be same or symmetric. The units are in seconds and can be configured as decimal. For e.g., to configure +1 usec asymmetry, this field should be set to 0.000001 seconds.																					
Sync Interval	RW	Configure the PTP Sync packet interval. The unit is in log to the base 2. For example, value = -5 is 32 packets/second, or value = 0 is 1 packet /second, or value = 2 is 1 packet in 4 seconds The range is -8 to +2																					
Delay Request Interval	RW	Configure PTP Delay Request interval. The unit is in log to the base 2. For example, value = -5 is 32 packets/second, or value = 0 is 1 packet /second, or value = 2 is 1 packet in 4 seconds Range is -7 to +7																					
Pdelay Request Interval	RW	Configure PTP Peer Delay Request Interval. The unit is in log to the base 2. For example, value = -5 is 32 packets/second, or value = 0 is 1 packet /second, or value = 2 is 1 packet in 4 seconds The range is -7 to +7																					
Announce Interval	RW	Configure PTP Announce Interval. The unit is in log to the base 2. For example, value = -4 is 16 packets/second, or value = 0 is 1 packet /second, or																					

		value = 2 is 1 packet in 4 seconds The range is -4 to +5
Announce Receipt Timeout	RW	Configure Announce Receipt Timeout in seconds. The range is +2 to +10
DSCP	RW	Differentiated Service Code Point (DSCP) settings for PTP frames for network-wise QoS treatment
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes
Synchronous Ethernet		
SSM Channel (ESMC)	RO	ESMC channel is enabled or disabled
Link Mode	RO	IEEE 802.3 link mode: Master or Slave or none
Input QL	RO	Input QL on Rx ESMC message on this port
Output QL	RO	Output QL on Tx ESMC message on this port
Active Reference	RO	Following an active reference clock (frequency)

Table 9 PTP Port Options

Note: The above configurations are per PTP port.

4.5.4 PTP :: Unicast

Figure 17 PTP :: Unicast Webpage

The Unicast Settings Webpage for Port 1 / Port 2 contains the following displays, selections, entries, and buttons:

PTP :: Unicast		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
Port 1 and Port 2		
Unicast Operation	RW	Control of Unicast operation. The options are: DISABLED, MASTER, SLAVE, BOTH, MIXED
Negotiation	RW	Control for unicast negotiation, ON / OFF
Transmission Duration (s)	RW	Unicast transmission duration The range is 60 – 3600 seconds
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes
MIXED Mode		
PDelay	RW	Auto: pDelay responses will be multicast or unicast depending on pDelayReq Unicast: pDelay request and responses are always unicast
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes
Add Unicast Peer Address		
Peer Address	RW	Unicast peer address to use for peer delay mechanism
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes
Delete Unicast Peer Address		
Peer Address	RW	Remove Unicast peer address to add a different one
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes
Add Master Node		
Network Address	WO	IPv4 address of Master node to be added, four dot separate octets (0- 255) or Ethernet address, six dash separated double hexadecimal numbers (NN-NN-NN-NN-NN-NN)
ClockID [optional]	WO	Master Clock ID – optional field. Enter eight colon separated double hexadecimal numbers (NN:NN:NN:NN:NN:NN:NN:NN).
Clock Priority	WO	Clock priority Range is 0 – 255
Sync Interval	WO	Configure the PTP Sync packet interval. The unit is in log to the base 2. For example, value = -5 is 32 packets/second, or value = 0 is 1 packet /second, or

		value = 2 is 1 packet in 4 seconds The range is -8 to +2
Delay Request Interval	WO	Configure PTP Delay Request interval. The unit is in log to the base 2. For example, value = -5 is 32 packets/second, or value = 0 is 1 packet /second, or value = 2 is 1 packet in 4 seconds Range is -7 to +7
Add Master Node Button	WO	Click for selection and settings to be applied to the Qg 2
Delete Master Node		
Network Address	WO	IPv4 address of Master node to be deleted, four dot separate octets (0- 255) or Ethernet address, six dash separated double hexadecimal numbers (NN-NN-NN-NN-NN-NN)
Delete Master Node Button	WO	Click for selection and settings to be applied to the Qg 2

Table 10 PTP Unicast Options

Note: The Sync Interval and Delay Request Interval are expressed in exponents of 2, with the Webpage entries being converted to intervals between messages in seconds or fractions of seconds.

Examples:

1. an entry of 0 represents an interval of 1 second between messages.
2. an entry of -5 represents an interval of 1/32 seconds between messages or 32 messages per second.

4.5.5 PTP :: Unicast Nodes

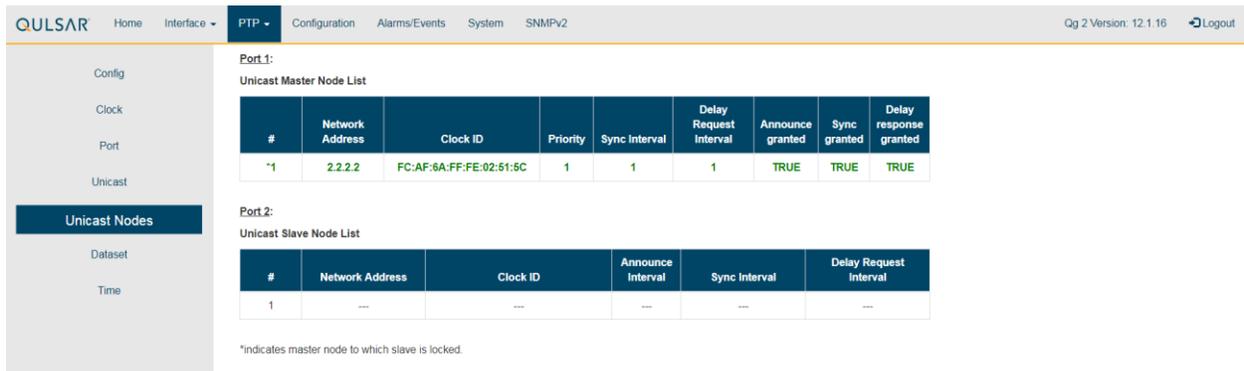


Figure 18 PTP :: Unicast Nodes Webpage

The Unicast Nodes Webpage contains the following selections, entries, and buttons:

PTP :: Unicast Nodes		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
Port 1 and Port 2		
Unicast Master Node List	RO	Display Master Node List in a table format with the following information:

		Table Entry Number, Network Address, Clock ID, Priority, Sync Interval, Delay Request Interval, Announce granted state, Sync granted state, Delay response granted state.
Unicast Slave Node List	RO	Display Slave Node List in a table format with the following information: Table Entry Number, Network Address, Clock ID, Announce Interval, Sync Interval, Delay Request Interval

Table 11 PTP Unicast Node Options

4.5.6 PTP :: Dataset

There are two sub-tabs on this webpage:

1. PTP profile dataset

This tab provides profile specific information as shown below (G8275.2 profile, for example).

This information will be different based on what PTP profile has been chosen.

The screenshot displays the QULSAR web interface for the PTP profile dataset configuration. The navigation menu includes Home, Interface, PTP, Configuration, Alarms/Events, Security, System, and SNMP. The left sidebar lists options: Config, Clock, Port, Unicast, Unicast Nodes, Dataset (highlighted), Time, and SNTP. The main content area shows the 'PTP profile dataset' configuration for 'Default (1588 v2)'. The parameters are as follows:

Two step clock	FALSE
Clock identity	FC-AF-6A-FF-FE-2-BB-3E
Number of ports	2
Clock quality	
Clock class	6
Clock accuracy	0x21 (within 100 ns)
Offset scaled log	65535
Priority 1	128
Priority 2	128
Domain number	0
Slave only	FALSE

Figure 19 PTP::Dataset::PTP profile dataset (for G8275.2)

2. PTP (non-profile) dataset

PTP (non-profile) dataset

Default dataset

Two step clock	FALSE
Clock identity	FC-AF-6A-FF-FE-2-BB-3E
Number of ports	2
Clock quality	
Clock class	6
Clock accuracy	0x21 (within 100 ns)
Offset scaled log	65535
Priority 1	128
Priority 2	128
Domain number	0
Slave only	FALSE

Current dataset

Steps removed	0
Offset from master	sec: 0 nsec: 000000000
Mean path delay	sec: 0 nsec: 000000000

Parent dataset

Parent Port Identity:	
Clock Identity	FC-AF-6A-FF-FE-2-BB-3E*
Port number	0
Parent Stats	False
Observed parent offset scaled log variance	65535
Observed parent clock phase change rate	2147483647
Grandmaster identity	FC-AF-6A-FF-FE-2-BB-3E*
Grandmaster clock quality	
Clock class	248
Clock accuracy	0xFE (Unknown)
Offset scaled log variance	65535
Grandmaster priority1	128
Grandmaster priority2	128

* Indicates own clock-id

PTP profile dataset

Time properties dataset

Current UTC offset	37
Current UTC offset valid	TRUE
Leap 59	FALSE
Leap 61	FALSE
Time traceable	FALSE
Frequency traceable	FALSE
PTP timescale	TRUE
Time source	Hand-set

Port dataset

Port identity:

Clock identity	FC AF 6A FF FE 2 BB 3E
Port number	1
Port state	PTP2_STATE_PASSIVE
Log min delay req interval	0
Peer mean path delay	sec: 0 nsec: 000000000
Log announce interval	1
Announce receipt timeout	3
Log sync interval	0
Delay mechanism	E2E
Log min pdelay req interval	0
Version number	2

Port identity:

Clock identity	FC AF 6A FF FE 2 BB 3E
Port number	2
Port state	PTP2_STATE_INITIALIZING
Log min delay req interval	0
Peer mean path delay	sec: 0 nsec: 000000000
Log announce interval	1
Announce receipt timeout	3
Log sync interval	0
Delay mechanism	E2E
Log min pdelay req interval	0
Version number	2

Figure 20 PTP :: Dataset::PTP (non-profile) dataset

4.5.7 PTP :: Time

QULSAR Home Interface PTP Configuration Alarms/Events System SNMPv2 Qg 2 Version: 12.1.11 Logout

UTC Time 2019-01-15 23:08:40

UTC Offset 37

Holdover Limits (us)

On Board Oscillator OCXO 8 hrs

Holdover duration (based on above HO limit) 0.28 hrs

Figure 21 PTP :: Time Webpage

The Time Webpage for setting UTC time values contains the following displays, entries, and buttons:

PTP :: Time		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
Time		
UTC Time	RO	Display UTC time in the following format: YYYY-MM-DD HH:MM:SS
UTC Offset	RO	UTC offset in seconds.

Holdover Limits (us)	RW	Set the holdover limits. This time limit is used to determine the Holdover Duration Spec Achieved. The time limit value is the Qg 2 user's maximum allowed error above the Quality Threshold setting on the PTP :: Config web page for the Qg 2 to remain in Holdover.
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes
On-board Oscillator		
On Board Oscillator	RO	Display OCXO and specified holdover duration
Holdover Duration Specs Achieved with Current XO and Holdover Limit Settings	RO	Display holdover duration based on the Holdover Limits (us) setting

Table 12 PTP Time Options

4.5.8 PTP :: SNTP

The SNTP webpage is for setting up a Simple Network Time Protocol version 4 server. SNTP is a subset of Network Time Protocol used to synchronize computer systems in the network. SNTP synchronizes clients time with the server, that has already been synchronized by a source such as a from GNSS, PTP master or manually set, using date command using connectionless User Datagram Protocol in IP networks. This requires that there be an IP address configured on both the PTP ports before enabling SNTP.

The screenshot shows the QULSAR web interface for configuring SNTP. The navigation menu includes Home, Interface, PTP (selected), Configuration, Alarms/Events, Security, System, and SNMP. The left sidebar lists various configuration options: Config, Clock, Port, Unicast, Unicast Nodes, Dataset, Time, and a highlighted SNTP button. The main content area is titled 'SNTP Server' and contains the following settings:

- Operating Mode:** A dropdown menu set to 'Broadcast'.
- Broadcast Interval (log):** A text input field containing the value '4'.
- Broadcast TTL:** A text input field containing the value '255'.

At the bottom of the configuration area, there are two buttons: 'Apply' (in a dark blue box) and 'Clear' (in a light blue box).

Enabling SNTP will make it operational on both the PTP ports. The SNTP Webpage for setting server contains the following displays, entries, and buttons:

PTP :: SNTP		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
Time		
Operating Mode	RW	<p>Stopped – To stop / disable SNTP server</p> <p>Unicast – To operate in unicast mode. Only IP unicast requests are answered</p> <p>Manycast – To operate in Manycast mode. IP unicast & multicast (224.0.1.1) requests are answered</p> <p>Broadcast – Periodic SNTP replies are broadcasted (224.0.1.1)</p> <p>Mixed - This is combination of Manycast and Broadcast</p>
Broadcast Interval (log)	RW	<p>Configure the Broadcast packet interval. The unit is in log to base 2. For example,</p> <p>value = 0 is 1 packet /second, or</p> <p>value = 3 is 1 packet in 8 seconds</p> <p>The range is 0 to 16</p>
Time To Live	RW	<p>Configure ttl value in broadcast packets. By default, the value is set to 1.</p> <p>The range is 1 to 255</p>
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes

Table 13 SNTP Options

4.6 Configuration Webpage Tab

Configuration Tab supports the following:

- Restore Default Configuration
- Download Configuration
- Upload Configuration

The Configuration selections are described in the Configuration Webpage Tab Section of this User Guide.

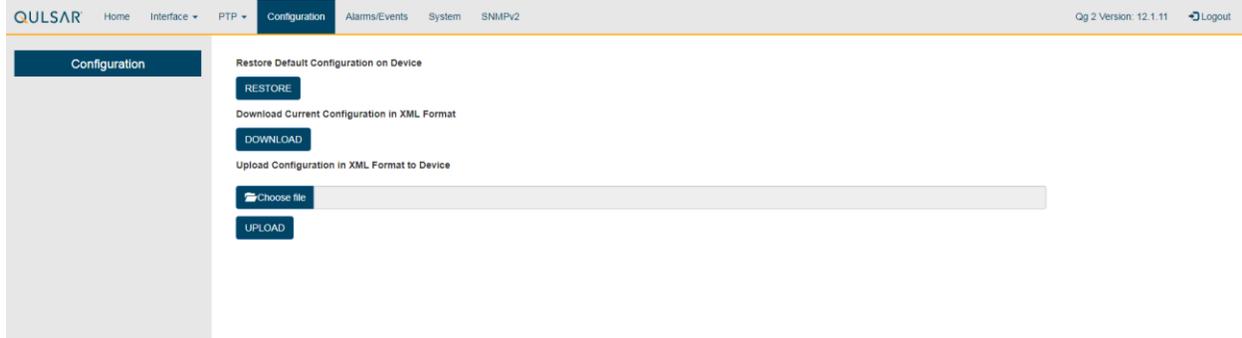


Figure 22 Configuration Webpage

The Configuration Webpage for Restoring and Downloading the Qg 2 operational configuration contains the following displays, entries, and buttons:

Configuration		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
Restore Default Configuration on Device		
RESTORE button	WO	Click to restore Qg 2 Factory Default configuration.
Download Current Configuration in XML Format		
DOWNLOAD button	WO	Download current Qg 2 configuration into browser's default download folder. Downloaded in XML format.
Upload Configuration in XML Format to Device		
Choose file button	WO	Browser button to navigate through the Host PC where the browser is running to select previously saved Qg 2 file to upload.
UPLOAD button	WO	Click to start the upload configuration option

Table 14 Configuration Options

4.7 Alarms/Events Tab

Alarms/Events Tab – Provides hardware alarm states and an event log generated by the Qg 2 software.

The screenshot shows the 'Alarms/Events' section of the Qg 2 web interface. At the top, there is a navigation bar with 'QULSAR' and menu items like 'Home', 'Interface', 'PTP', 'Configuration', 'Alarms/Events', 'System', and 'SNMPv2'. The main content area features a table with the following data:

Alarm Name	Current Status	Last Failure	Failure Count
System/Internal Error	Not Active	Not Occurred	0
GNSS Lock/Unlock	Locked	Not Occurred	0
PTP Sync Lock	Locked	05/19/2019 03:23:32	1
PTP Sync State	Synchronizing	Not Occurred	0
PTP Port 1 Link	Up	Not Occurred	0
PTP Port 2 Link	Down	Not Occurred	0

Below the table is a 'Clear Alarms' button. Underneath, the 'Event Log' section shows a list of system events with timestamps, such as 'May 19 08:42:00 Clock status: Synchronized' and 'May 19 08:42:00 Clock status: Not synchronized'. The current UTC time is displayed as '2019-05-19 08:59:21'.

Figure 23 Alarms Webpage

The Alarms section will list all the Qg 2 Alarms and their current status. The following is a list of the Qg 2 Alarms.

Alarm	Detection Reason
System Internal Error	Any power or hardware component error detected
GNSS Lock/Unlock	When GNSS goes from Lock to Unlock state
PTP Sync Lock	When PTP engine goes from Lock to Unlock state
PTP Sync State	When PTP engine state goes out of Synchronizing
PTP Port 1 Link	Link goes from UP to DOWN
PTP Port 2 Link	Link goes from UP to DOWN

Table 15 Alarm Detection Reason

Each Alarm entry will have the Alarm's Name, the Alarm's Current Status, the Alarm's Last Occurrence and the number of times the Alarm has occurred since Qg 2 startup. The timestamp of last occurrence is UTC time.

The Clear Alarms button will clear Alarms that are no longer in a fault state, and the "Last Cleared At" time (in UTC) will be displayed on the page.

The Events section will display the event Log that is maintained by Qg 2 software. The information it maintains include operations like configuration changes, reboot, software upgrade, as well as any asynchronous events detected from hardware or operation like link loss, synchronization status change, etc.. For each event, a timestamp is also shown. The timestamps in the log are based on the Qg 2 generated UTC time.

4.8 Security Tab

Security Tab – Currently, this page provides control for https – secure way of accessing Qg 2 over the web. The web access or GUI for Qg 2 is over http protocol which can be either:

non-secure (http): Mainly for inside customers' secure or internal network – does not need SSL certificate.

secure (https): For improved security, or in public network – encrypted with or without a proper Secure Sockets Layer (SSL) certificate issued or signed from a public certified authority (CA) for authentication against man-in-the-middle or similar security risks.

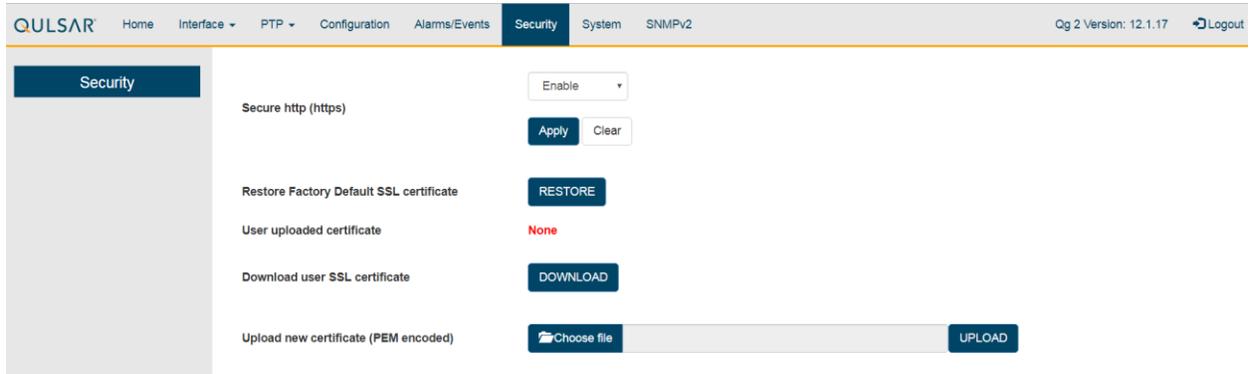


Figure 24 Security Webpage

Security		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
Security		
Secure http (https)	RW	Enable/Disable HTTPS
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes
Restore Factory Default SSL certificate		
Restore Factory Default SSL certificate	WO	Restore Qulsar’s self-signed SSL certificate
User uploaded certificate		
User uploaded certificate	RO	File name of the user specific SSL certificate (PEM format)
Downloaded user SSL certificate		
Downloaded user SSL certificate	RO	Download user specific SSL certificate that was uploaded previously
Upload new certificate (PEM encoded)		
Upload new certificate (PEM encoded)	WO	Upload a user specific SSL certificate. This may be a proper public certificate signed by a valid Certificate Authority (CA)

Table 16 Security Options

Without proper authentication, the client or browser accessing Qg 2 may warn the user that the access is “not secure” since the SSL certificate has not been authenticated. With https, all web transactions are encrypted regardless of SSL certificate is authenticated or not.



Figure 25 Browser "Not secure" indication

NOTE:

- If an incorrect file or wrongly formatted user SSL certificate is uploaded and the web access to Qg 2 stops working, then the user can restore to factory default https configuration from CLI using the "HTTPS Restore" command.
- With HTTPS, there is a security vulnerability with older cipher suites. This may be flagged by many 3rd party security scan software as they deem this to be a major security vulnerability. With 12.2.2 version onwards, this security vulnerability has been addressed by allowing only TLS version 1.2

4.9 System Tab

System Tab – Provides Qg 2 hardware and software information like version, Oscillator type, GNSS Receiver type and entries, upgrade and logs.

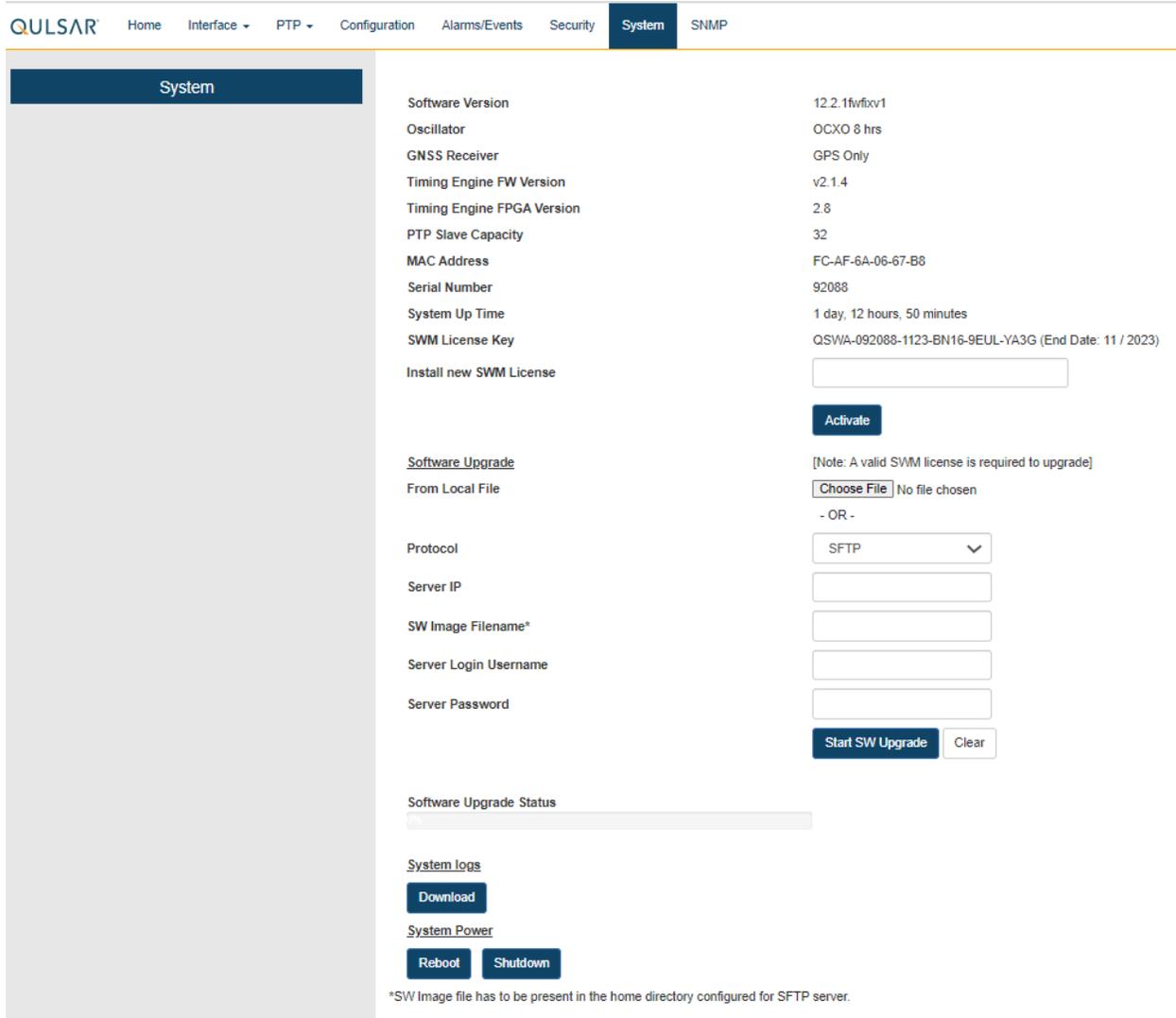


Figure 26 System Webpage

The System Webpage for Qg 2 system and firmware information contains the following displays, entries, and buttons:

System		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
System		
Software Version	RO	Version of Qg 2 software
Oscillator	RO	OCXO 4 hours or OCXO 8 hours
GNSS Receiver	RO	GNSS Receiver information
Timing Engine FW Version	RO	Version of firmware that is running on the Qulsar’s internal Managed Clock Engine
Timing Engine FPGA Version	RO	Version of FPGA that is running on the Qulsar’s internal Managed Clock Engine
MAC Address	RO	MAC address of port 1

Serial Number	RO	Serial number
System Up Time	RO	Time since last reboot
SWM License Key	RO	Installed Software and Support Maintenance (SWM) License key
Install new SWM License	RW	Enter new SWM license key retrieved from Qulsar Support portal for this Qg 2 unit
Activate button	WO	To install the new SWM license key
Software Upgrade		
From Local File button	RW	Browser button to navigate through the Host PC where the browser is running to select previously downloaded Qg 2 software
Protocol pull-down option	RW	Only SFTP option is supported. Note, the image file is expected to be in the home directory on SFTP server
Server IP	RW	IPv4 address of SFTP server
SW Image Filename	RW	Software file to be used for the upgrade
Server Login Username	RW	Login credentials for SFTP server
Server Password	RW	Login credentials for SFTP server
Start SW Upgrade button	WO	Clicking the button initiates upgrade process
Clear button	WO	Click to clear the latest changes
Software Upgrade Status	RO	Display bar to show the upgrade progress
System Logs		
Download	WO	Download the Qg 2 MCE Event Log to the Host PC. The log file is encrypted and is solely for Qulsar internal use for debug.
System Power		
Reboot button	WO	Reboot the Qg 2 system
Shutdown button	WO	Shutdown of the Qg 2 in controlled and sequential steps that will protect the Qg 2 memory storage. Using this button is recommended prior to disconnecting physical power to the Qg 2.

Table 17 System Options

IMPORTANT NOTE ON Qg 2 SOFTWARE UPGRADE:

Due to a software issue that was discovered later and fixed in 12.1.20 version, please follow this procedure for doing Qg 2 software upgrades:

- Stop the Engine before doing the software upgrade (for all versions as a safe measure)
- To upgrade from a version prior to 12.1.20 to another version:
 - Reboot Qg 2 from Systems webpage
 - Do **NOT** change any configuration after Qg 2 software comes up
 - Upgrade to new Qg 2 software version of choice

IMPORTANT NOTE ON Qg 2 SOFTWARE DOWNGRADE:

Due to incompatibility, downgrading from a version that is 12.1.25 or higher, to a version that is lower than 12.1.25 is NOT supported. Doing so will have undesirable effects and should be avoided.

IMPORTANT NOTE ON Qg 2 SOFTWARE UPGRADE AND SWM:

With 12.2.1 release, Qulsar has enabled a license key mechanism for Software and Support Maintenance (SWM). Without a valid license, the user would not be able to upgrade from 12.2.1 to a higher version.

They are free to use all the previously released versions including 12.2.1 release without renewing the license but to use any new features or enhancements or fixes that has been put in a later than 12.2.1 release, a valid license will be required. Qulsar’s technical support will also be restricted in future to 12.2.x versions. For any questions, please contact support@qulsar.com or sales@qulsar.com.

4.10 SNMP Tab

SNMP Tab – Provides SNMP (v2, v3) Management Server configuration.

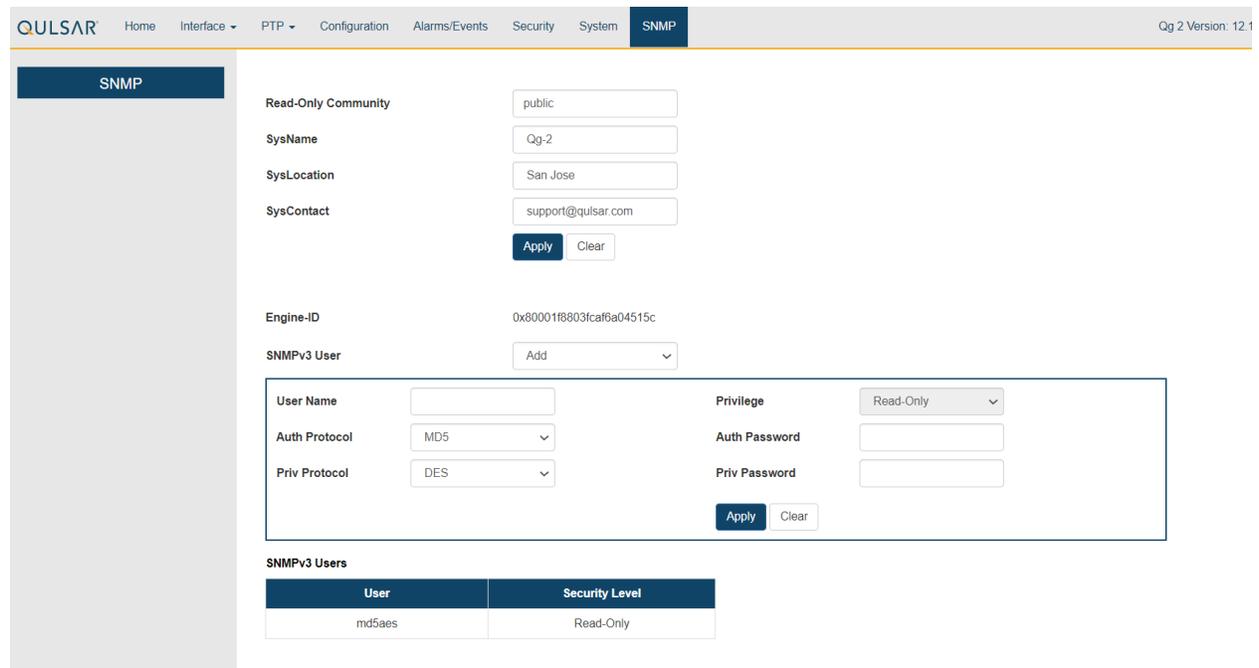


Figure 27 SNMP Webpage

The SNMP Webpage for the SNMP configuration contains the following entries, and buttons:

SNMPv2		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
SNMPv2		
Read-Only Community	RW	Community string – usually ‘public’ or ‘private’
SysName	RW	Administratively assigned name for this Qg 2 node in the network
SysLocation	RW	Location of this Qg 2 node
SysContact	RW	Contact information for support for this Qg 2 node

Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes

Table 18 SNMPv2 Options

Qg 2 supports SNMP v3 as well and the table below shows the related parameters.

SNMPv3		
Legend: RO = Read Only, RW = Read/Write, WO = Write Only		
Labels	Access	Description
SNMPv3		
Engine-Id	RO	Unique Engine-Id specific to a Qg 2 unit
SNMP v3 user	RW	Add/Delete SNMP users
User Name	RW	User name to be added (or deleted)
Privilege	RO	Read-Only (as specified in PTPMIB)
Auth Protocol	RW	Selection of authorization protocol: MD5 or SHA (applicable only when adding a new user)
Auth Password	WO	Authorization password – should be at least 8 characters. (applicable only when adding a new user)
Priv Protocol	RW	Selection of privacy protocol: MD5 or SHA (applicable only when adding a new user)
Priv Password	WO	Privacy password – should be at least 8 characters. (applicable only when adding a new user)
Apply / Clear		
Apply Button	WO	Click for selection and settings to be applied to the Qg 2
Clear Button	WO	Click to clear the latest changes

Table 19 SNMPv3 Options

Qg 2 maintains the list of active SNMPv3 users with the user name and their security level at the bottom of the webpage.

5 Command Reference

5.1 Qg 2 Basic Commands

The login credentials for accessing Qg 2 CLI shell is admin/admin. This is a list of the available commands related to the control and monitoring of the Qg 2. The CLI commands are case insensitive.

5.1.1 Help Command

After logging in, the user can enter “help” to get a list of commands and descriptions to be displayed on the command terminal.

```

File Edit Setup Control Window Help
-----
Sync> help
Commands available:
  help          Show available commands
  quit         Disconnect
  history      Show a list of previously run commands
  show alarms  Show Alarms
  show status  Show Sync Status
  clear alarms Clear Alarms
  system info  Show Version Information
  system Restore Restore Default Config
  system Upgrade_Status Software Upgrade status
  system Upgrade_Start Software Upgrade start
  license(swm) status Support and Software Maintenance SWM Lic Key Status
  license(swm) install Support and Software Maintenance SWM Lic Key Install
  network configure Configure the MGMT Port
  network status MGMT Port Status
  network ping  Ping Remote IP Address
  HTTPS Restore Restore factory default certificate
  date         Display/Set current date & time
  reboot      Reboot the System
  shutdown    Shutdown the System
  monitoring log Display current monitoring dataset

Sync> □

```

Figure 28 Help Command

5.1.2 History Command

To view the history of previously entered commands, enter “history”.

```

File Edit Setup Control Window Help
-----
Sync> history
Command history:
  0. help
  1. show alarms
  2. show status

Sync>
Sync>

```

Figure 29 History Command

5.1.3 Quit Command

To terminate the command session and log out, enter “quit”. Note that, pressing Control-C will have the same effect as “quit” command.

5.2 Show commands

The “show” command can be used to show alarms or clock status.

5.2.1 Show Alarms Command

This command will display any active Qg 2 alarms. If no alarms are present, the Alarm Name and State columns will be blank.

```

File Edit Setup Control Window Help
Sync> show alarms

```

Alarm Name	Current Status	Last Failure	Failure count
System/Internal Error*	Not Active	Not Occurred	0
GNSS Lock/Unlock	Locked	Not Occurred	0
PTP Sync Lock	Locked	10/29/2021 06:48:25	1
PTP Sync state	SYNCHRONIZING	Not Occurred	0
PTP Port1 Link	Up	Not Occurred	0
PTP Port2 Link	Down	Not Occurred	0

```

*Internal hardware error
Sync>

```

Figure 30 Show Alarms Command

5.2.2 Show Status Command

This command shows the Managed Clock Engine's Sync information – Qg 2 Sync Status and Qg 2 Sync State.

- Qg 2 Sync Status can be either LOCKED or UNLOCKED.
- Qg 2 Sync State can be one of the following: FREE RUNNING, SYNTONIZING, SYNCHRONIZING, or HOLDOVER.
- GNSS 1PPS Status can be either Stable or Unstable.
- GNSS ToD Status can be either Stable or Unstable.

```

File Edit Setup Control Window Help
Sync> show status
PTP Sync Status      : LOCKED
PTP Sync State       : SYNCHRONIZING
GNSS 1PPS Status     : Stable
GNSS ToD Status      : Stable
Sync>

```

Figure 31 Show Status Command

5.3 System commands

These are system-level commands.

5.3.1 System Info Command

This command displays the basic system information – Qg 2 firmware version, on-board oscillator type, Managed Clock Engine Firmware version, number of PTP slaves supported and GNSS module type.

```
File Edit Setup Control Window Help
-----
Sync> system info
FW Version: 12.1.27
XO: OCKO 4 hrs
Timing Engine FW Version: v2.1.3
Timing Engine FPGA Version: 2.8
PTP Slave Capacity: MAX
GNSS Receiver: GPS Only
Sync>
```

Figure 32 System Info Command

5.3.2 System Restore Command

The Qg2 System Restore command will restore factory default configuration.

```
File Edit Setup Control Window Help
-----
Sync> system restore
Restore default config. Are you sure ? (y/n)
```

Figure 33 System Restore Command

5.3.3 System Upgrade Status Command

The Qg 2 System Firmware Upgrade Status will be displayed if the upgrade was initiated previously from either CLI or through Web User Interface.

```
File Edit Setup Control Window Help
-----
Sync>
Sync> system Upgrade_Status
FW upgrade not yet initiated
Sync>
```

Figure 34 System Upgrade Status Command

5.3.4 System Upgrade Start Command

The Qg 2 System Upgrade Start command will perform firmware upgrade when the following inputs are provided:

- File transfer protocol, 1 or 2 (for FTP or SFTP).
Note: Option 1 (FTP) has been deprecated and is not available anymore
- Hostname, as either IP address or DNS name
- File name containing the upgrade FW

```

File Edit Setup Control Window Help
-----
Sync>
Sync> system Upgrade_Start
Usage:
system Upgrade_Start <protocol:<1:FTP, 2:SFTP>> <hostname> <file name>
Sync> █

```

Figure 35 System Upgrade Start Command

5.3.5 SWM License Install command

5.4 SWM License commands

The following two commands are related to the Software and Support Maintenance (SWM) license key operations.

5.4.1 SWM License Status command

The actual syntax of the command is “license (swm) status”. This command returns the current SWM license information.

```

Sync> license<swm> status
SWM-License Key Status: QSWA-059612-1023-EDLN-MLXE-HABG <End Date: 10 / 2023>
Sync> □

```

Figure 36 SWM License Status command

5.4.2 SWM License Install command

The actual syntax of the command is “license (swm) install”. A new SWM license key can be entered using this command.

```

Sync> license<swm> install
Usage:
license<swm> install ? or license<swm> install help
license<swm> install LLLL-LLLLLL-LLLL-LLLL-LLLL-LLLL
Sync> license<swm> install QSWA-059612-1023-EDLN-MLXE-HABG
SWM-License Installed successfully
Sync> □

```

5.5 Network Commands

The Network Command operate on the Management port. The user can set up the network parameters like enable/disable DHCP, static IPv4 address, netmask, and gateway addresses and display the current setting of it. By factory default, the Management port network parameters are set statically as follows:

- DHCP: Disabled
- IP Address: 192.168.2.100
- Netmask: 255.255.255.0
- Gateway: 0.0.0.0

5.5.1 Network Configure Command

This command lets the user configure Qg 2 Management port network parameters.

```

File Edit Setup Control Window Help
-----
Sync>
Sync> network config
Usage:
network configure dhcp
network configure ip <ip_addr> mask <netmask> gateway <gateway>
Sync>

```

Figure 37 Network Configure Command

5.5.2 Network Status Command

Get network status for the Management Port, PTP Timing Port-1, and PTP Timing Port-2.

```

File Edit Setup Control Window Help
-----
Sync> network status

MGMT Port
  DHCP      : DISABLED
  IPv4 Addr : 10.10.10.130
  NetMask   : 255.255.255.0
  Gateway   : 10.10.10.1
  MAC       : fc:af:6a:04:bb:b0
  Link      : UP

PTP Timing Port-1
  IPv4 Addr : 10.10.10.65
  NetMask   : 255.255.255.0
  Gateway   : 10.10.10.1
  IPv6 Addr : fe80:0000:0000:0000:feaf:6aff:fe02:bbb0
  MAC       : fc:af:6a:02:bb:b0
  Link      : 1000M/Full

PTP Timing Port-2
  IPv4 Addr : 10.10.10.140
  NetMask   : 255.255.255.0
  Gateway   : 10.10.10.1
  IPv6 Addr : fe80:0000:0000:0000:feaf:6aff:fe01:bbb0
  MAC       : fc:af:6a:01:bb:b0
  Link      : Down

```

Figure 38 Network Status Command

5.5.3 Network Ping Command

Send a ping message to a device on the network to test reachability. The results of the ping operation are displayed as “Ping Success” or “Ping Failed”.

The ping command takes an additional parameter “mgmt” or “ptp” to specify from which port the ping request needs to go out.

```

File Edit Setup Control Window Help
-----
Sync> network ping 10.0.1.1
Usage:
network ping mgmt <ip_addr>
network ping ptp <ip_addr>

Sync> network ping mgmt 10.0.1.1
Ping Success

Sync> network ping ptp 10.10.10.132
Ping Success

```

Figure 39 Network Ping Command

5.6 HTTPS Restore command

This command is provided in case of user uploading an incorrect file or wrongly formatted SSL certificate (PEM format) file via Qg 2 GUI. Executing this command gives the user to option to reset to factory default – removing the user uploaded SSL certificate file and restoring Qulsar’s self-signed certificate. This is needed if wrong user file got uploaded and user is unable to access Qg 2 from their browser.

```

File Edit Setup Control Window Help
-----
Sync> HTTPS Restore
User certificate, if any, will be removed & default certificate will be restored
Do you want to continue? [Y/N] : n
Abort.

Sync>

```

Figure 40 HTTPS Restore command

5.7 Date command

This command is provided mainly for initial customer lab bring-up or for those deployments where there is no timing reference (like GNSS) but need Qg 2 to act as a Grandmaster to propagate time and synchronization over PTP to slave units. This command enables the user to set the date and time (ToD) on Qg 2 manually. The user can enter the wall-clock time for the present date and time with this command with the “set” option. The date command without any parameters will display the current ToD.

```

Sync> date set
Usage:
date
date set yyyy-mm-dd-hh-mm-ss [clock class] [clock accuracy] [clock variance]
Date entered will be taken as UTC Time
Clock class, accuracy and variance are optional parameters

Sync> date
UTC time: 2023-01-30 08:17:45 <+37 sec>
Clock: class = 52, Accuracy = 0xfe, Variance = 65535

```

Figure 41 Date command

NOTE: If there is a proper timing reference available (like GNSS time or a remote PTP master), then the time set by this command will be overwritten by the actual ToD received from the timing reference. This command is not needed for normal operation with a good timing reference.

In addition, when setting the ToD with the date command, the PTP clock quality (class, accuracy and variance) can be optionally forced to specific values. Again, this is provided as a way to assist with lab testing instead of the default values in the timing engine (which can be displayed using the date command). Ideally, these values should reflect the clock quality of the reference clock source – for example, with GNSS lock, the clock class = 6, losing GNSS lock and going into holdover, the clock class = 7, and so on.

It should be noted that after setting the date command manually, if GNSS or PTP master reference is available, then the clock quality parameters will be automatically updated as per the reference. The variance parameter is “sticky” in the sense that it will be set to whatever was provided with the date command earlier.

5.8 Reboot command

The Reboot command is to provide for user initiated manual reboot of Qg 2 system. Note that a firmware upgrade will automatically initiate reboot of the system.

5.9 Monitoring log command

This command will start a log of the Managed Clock Engine’s Sync information in PTP only and PTP primary and GNSS secondary mode. The data points are: Qg2 Sync Status, Qg2 Sync State, Steps removed, Offset from master (in ns), Mean path delay (in ns) and the timestamp.

The log will be printed out on the console every 10 to 13 seconds. To stop the log, the user will have to press “Ctrl + c”. Once “Ctrl + c” is pressed the console will print “Stopping the monitoring log” and a new command line will appear.

- Qg 2 Sync Status can be either LOCKED or UNLOCKED.
- Qg 2 Sync State can be one of the following: FREE RUNNING, SYNTONIZING, SYNCHRONIZING, or HOLDOVER.

```

File Edit Setup Control Window Help
-----
Sync>
Sync> monitoring log
Sync Status: locked
Sync State: Synchronizing
Steps Removed: 1
Offset From Master: sec: 0 nsec: 000000046
Mean Path Delay: sec: 0 nsec: 000002892
Timestamp 1635822032

Sync Status: locked
Sync State: Synchronizing
Steps Removed: 1
Offset From Master: sec: 0 nsec: 000000050
Mean Path Delay: sec: 0 nsec: 000002937
Timestamp 1635822044

^C
Stopping the monitoring log
Sync>

```

Figure 42 Monitoring log command

5.10 webui [hidden] command

This “webui” command is provided for those customers who are concerned about security vulnerabilities when the Qg 2 unit can be accessed over the web in deployment. This is for added security on top of secure HTTP and TLSv1.2 cipher mechanism that are used by default on Qg 2.

This command takes one additional parameter: on/off. By default, web UI is enabled (or webui is ON) which allows http/https web access to the Qg 2 unit. That can be turned off with the “webui off” command.

```
Sync> webui off
```

Disabling Web UI...

```
Sync> webui on
```

Enabling Web UI...

6 Troubleshooting and Safety Considerations

This section provides some Qg 2 Troubleshooting and Safety Considerations. References are provided on how to get technical or sales assistance and how to obtain manual updates.

6.1 Troubleshooting

This section provides some Qg 2 Troubleshooting practices and the indicators for when a problem may be present in the Qg 2 operation. Some of the indicators of Qg 2 problems are Front Panel LED states, Interface and PTP Webpage statuses and the Alarms/Events Tab Webpage.

Symptom	Probable Cause	Recommended Action																	
Power LED is Red	User Interface and Control Plane Processor has not completed its boot up process.	Wait for a few seconds for it to turn orange and then finally green when all of software has been brought up. It takes approximately 4 minutes for the LED to turn green when system is ready for operation.																	
	Power supply does not meet Qg 2 requirements.	<p>Verify that the voltage from the Qg 2 power source meets the specifications of the</p> <p>6.1.1 Management Port</p> <table border="1"> <thead> <tr> <th>Mgmt Port LEDs state</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>Both off</td> <td>No Link</td> </tr> <tr> <td>Yellow only</td> <td>10M link</td> </tr> <tr> <td>Green</td> <td>100M link</td> </tr> <tr> <td>Yellow blinking</td> <td>Traffic</td> </tr> </tbody> </table> <p>6.1.2 PTP Port 1/2</p> <table border="1"> <thead> <tr> <th>PTP Port LED state</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>Both off</td> <td>No link</td> </tr> <tr> <td>Green only</td> <td>100M link, blinking if traffic</td> </tr> <tr> <td>Yellow only</td> <td>1000M link, blinking if traffic</td> </tr> </tbody> </table>	Mgmt Port LEDs state	Description	Both off	No Link	Yellow only	10M link	Green	100M link	Yellow blinking	Traffic	PTP Port LED state	Description	Both off	No link	Green only	100M link, blinking if traffic	Yellow only
Mgmt Port LEDs state	Description																		
Both off	No Link																		
Yellow only	10M link																		
Green	100M link																		
Yellow blinking	Traffic																		
PTP Port LED state	Description																		
Both off	No link																		
Green only	100M link, blinking if traffic																		
Yellow only	1000M link, blinking if traffic																		

		Both on	10M link, blinking if traffic
		Power Section.	
	Qg 2 Alarm condition is affecting power.	Check the Alarms/Events Tab Webpage for information about any Qg 2 alarms that might affect power.	

Symptom	Probable Cause	Recommended Action
GNSS LED is Off	Qg 2 has not completed its boot up process.	Wait approximately 4 minutes for software to complete booting.
	MCE running in PTP Only mode.	None. The LED is off when MCE is in PTP Only mode.

Symptom	Probable Cause	Recommended Action
GNSS LED is Red	1 PPS Input Error on Front Panel RJ45 port	Verify that the input RJ45 connector is securely inserted in the port. Verify that the 1 PPS source is outputting a 1 PPS signal.
	ToD Input Error on Front Panel RJ45 port	Verify that the input RJ45 connector is securely inserted in the port. Verify that the ToD source is outputting a ToD signal.
	GNSS input signal from Antenna and cable is missing or weak.	Verify that the GNSS Antenna coax is securely plugged into the SMA port. Verify that the GNSS Antenna signal is present.
	Qg 2 Alarm condition is affecting 1 PPS or ToD Input.	Check the Alarms/Events Tab Webpage for information about any Qg 2 alarms that might affect 1 PPS or ToD Input.

Symptom	Probable Cause	Recommended Action
---------	----------------	--------------------

Sync Status LED is Off	MCE Processor has not completed its boot up process.	Wait approximately 4 minutes for the MCE processor to complete booting.
------------------------	--	---

Symptom	Probable Cause	Recommended Action
Sync Status LED is Red	MCE is operating in GNSS Only mode and is not receiving the GNSS inputs.	Verify that the GNSS LED is Green.
	MCE is operating in PTP Only mode and is not receiving PTP Grand Master timing messages.	Verify that the PTP Port 1 or Port 2 is connected to a PTP Grand Master time source through the RJ45 or SFP connectors. Verify that the PTP Grand Master is providing PTP Timing messages.
	MCE is operating in GNSS Primary / PTP Secondary mode, or in PTP Primary / GNSS Secondary mode and is not receiving timing signals from either source.	Verify that the GNSS LED is Green. Verify that the PTP Port 1 or Port 2 is connected to a PTP Grand Master time source through the RJ45 or SFP connectors. Verify that the PTP Grand Master is providing PTP Timing messages.
	The user has selected external 1PPS / ToD inputs but has not connected the input sources.	On the Qg 2 Front Panel, connect the 1PPS / ToD RJ45 input source. On the Interface :: GNSS web page, Enable 1PPS In and ToD In.
	Qg 2 Alarm condition is affecting inputs from the GNSS or the PTP Grand Master.	Check the Alarms/Events Tab Webpage for information about any Qg 2 alarms that might affect timing input signals.

Symptom	Probable Cause	Recommended Action
Sync Status LED is Amber	MCE is operating in GNSS Only mode and is not synchronized to the GNSS input.	Verify that the GNSS LED is Green.

	MCE is operating in PTP Only mode and is not synchronized to the PTP Grand Master.	Verify that the PTP Port 1 or Port 2 is connected to a PTP Grand Master time source through the RJ45 or SFP connectors. Verify that the PTP Grand Master is providing PTP Timing messages
	MCE synchronization loop control system has not converged to the input timing source.	Wait 2 to 15 minutes for the MCE to converge and synchronize to the input timing source.
	Qg 2 Alarm condition is affecting MCE synchronization.	Check the Alarms/Events Tab Webpage for information about any Qg 2 alarms that might affect MCE synchronization.

Symptom	Probable Cause	Recommended Action
Home Webpage – GNSS 1 PPS Status Unstable/Unavailable	GNSS input signal from Antenna and cable is missing or weak.	Verify that the GNSS Antenna coax is securely plugged into the SMA port. Verify that the GNSS Antenna signal is present.
	GNSS Antenna / cable configuration does not meet requirements of the Antenna input Section.	Verify that the GNSS Antenna / cable meets requirements of the Antenna input Section.
	Qg 2 Alarm condition is affecting inputs from the GNSS.	Check the Alarms/Events Tab Webpage for information about any Qg 2 alarms that might affect GNSS input signals.

Symptom	Probable Cause	Recommended Action
Home Webpage – GNSS ToD Status Unstable/Unavailable	GNSS input signal from Antenna and cable is missing or weak.	Wait approximately 2 minutes for the MCE processor to complete booting.
	GNSS Antenna / cable configuration does not meet requirements of the Antenna input Section.	Verify that the GNSS Antenna / cable meets requirements of the Antenna input Section.

	The user has selected external 1PPS / ToD inputs but has not connected the input sources.	On the Qg 2 Front Panel, connect the 1PPS / ToD RJ45 input source. On the Interface :: GNSS web page, Enable 1PPS In and ToD In.
	Qg 2 Alarm condition is affecting inputs from the GNSS.	Check the Alarms/Events Tab Webpage for information about any Qg 2 alarms that might affect GNSS input signals.

Symptom	Probable Cause	Recommended Action
Interface :: PTP Timing Ports Webpage – Link State not up	PTP Timing Port 1 or Port 2 IP address configuration is incorrect.	Verify that IP configuration for Port 1 and Port 2 is correct on the Interface :: PTP Timing Ports Webpage. Verify that the network routers/switches/hubs between the Qg 2 Port 1 and Port 2 and the timing network are properly connected.
	Port 1 and Port 2 are in the same network / subnet as the MGMT port.	Make sure that the IP addresses of Port 1, Port 2 and MGMT port are on different networks/subnets.
	Qg 2 Alarm condition is affecting Timing Ports Link State.	Check the Alarms/Events Tab Webpage for information about any Qg 2 alarms that might affect Timing Ports Link State.

Symptom	Probable Cause	Recommended Action
Interface::MGMT Port Webpage – Link State not up	MGMT Port IP address configuration is incorrect.	Verify that IP configuration for MGMT Port is correct on the Interface :: MGMT Port Webpage. Verify that the network routers/switches/hubs between the Qg 2 MGMT Port and the management network are properly connected.
	MGMT Port is on the same network / subnet as the timing ports.	Make sure that the IP address of the MGMT port and the addresses of Port 1 and Port 2

		are on different networks/subnets.
	Qg 2 Alarm condition is affecting MGMT Port Link State.	Check the Alarms/Events Tab Webpage for information about any Qg 2 alarms that might affect MGMT Port Link State.

6.2 Safety Considerations

The following safety consideration should be used when handling and installing the Qg 2.

- When installing or working on the Qg 2 equipment, ESD wrist straps should be worn.
- Use the specified power supply and ground for the Qg 2 equipment as stated in the Power and Ground Connections section.
- Refer to the Applying Power section when applying power to the Qg 2 equipment.
- When rack mounting the Qg 2 equipment, use the original mounting screws provided with the mounting bracket so that the Qg 2 case will not be damaged. Do not substitute other mounting screws.
- Only authorized personnel should open the Qg 2 equipment enclosure. Unauthorized access to the Qg 2 equipment could result in equipment damage and voiding the Qg 2 warranty.
- Use caution when installing the GNSS antenna near, under, or around high voltage lines. The GNSS antenna should be equipped with proper external lightning protection/grounding to avoid equipment damage should the antenna receive a lightning strike.
- If the Qg 2 is rack mounted, 1RU above the Qg 2 enclosure must be left unoccupied for heat dissipation.

7 Managed Clock Engine Overview

7.1 Qg 2 Engine Modes

The Qg 2 Managed Clock Engine can operate in four different modes. The operational mode defines the functionality supported by the engine, Qg 2 clock behavior and its properties in different operating conditions. The operational mode is specified upon startup and can only be changed by restarting the engine on the Home Webpage.

- PTP Only
- GNSS Only
- GNSS Primary, PTP Secondary
- PTP Primary, GNSS Secondary.

In addition to these four modes, a Slave Only mode is supported. The clock can be switched to the Slave Only mode and back at any time and from any of above operational modes. The Slave Only mode is selected on the PTP :: Clock Webpage.

There is also the PTP Only, GNSS debug mode for internal Qulsar use.

7.1.1 PTP Only mode

This is an ordinary PTP master-slave mode. The GNSS interface is disabled. In this mode, the clock normally acts as a PTP slave, but may also become a PTP master if no better clock exists on the network based on the Best Master Clock Algorithm (BMCA).

The clock class is initialized to value of DEFAULT (248).

7.1.2 GNSS Only mode

In this mode, the clock is a GNSS-clock and the GNSS is the only source of synchronization. The clock can never become a slave to another clock regardless of its clock class.

In this mode, the clock class is automatically controlled by the engine. The clock is initialized with class of DEFAULT (248), and when it locks to a stable GNSS signal it raises the class to PRC_SYNC (6). If the ToD-input signal is available as well, then the timescale is automatically switched to PTP and the clock class is PRC_SYNC (6).

Later, if the GNSS-signal is lost, the clock switches to the holdover mode and lowers its class to PRC_HOLDOVER (7). If after the holdover period, the GNSS-signal is still not available the clock downgrades its class PRC_DEGRADATION_A (52) and stays as the PTP master in the free running mode. If a better clock exists on the network based on BMCA, the clock will switch to the PTP passive state.

7.1.3 GNSS Primary, PTP Secondary mode

This mode is almost the same as the previous mode, Mode GNSS Only, but after the holdover duration the clock degrades its class to PRC_DEGRADATION_B (187), so clock can potentially become a PTP slave if a better clock appears on the network.

This mode means that the Qg 2 clock has the GNSS-signal as its primary source of synchronization and the PTP as a backup source, i.e. when no GNSS-signal present.

7.1.4 PTP Primary, GNSS Secondary Mode

This mode is designed for unstable GNSS-reception environments, where the node having a better signal reception becomes a PTP master and all others become PTP slaves, even if they have their own GNSS-signal.

The clock is initialized with class DEFAULT (248) and the class is not changed by the engine while operating. Instead after detecting the stable GNSS-signal the engine increases the priority2 member of the Default Dataset (lowers its value) by some small margin, which might depend on the reception quality. That clock which has a higher priority2 (better GNSS signal reception) becomes the PTP master on the network and all others synchronize with it.

7.2 GNSS Interface

The Qg 2 supports GNSS L1 input signals from a GNSS antenna. Signal frequency is 1575.42 MHz for GPS; 1561.098 MHz for Beidou; and 1602.0 MHz for Glonass. The status and configuration of GNSS interface can be accessed via the Interface :: GNSS Webpage.

7.3 Qg 2 Clock Sync States

Qg 2 clock at any instance of time can be in one of four following sync states:

- FREE RUNNING
- SYNTONIZING
- SYNCHRONIZING
- HOLDOVER
- UNKNOWN/ERROR

7.3.1 FREE RUNNING State

The Qg 2 clock comes into this state upon initialization. The Qg 2 clock time is not set, the clock class is DEFAULT (248), clock accuracy is UNKNOWN (0xFE).

The timescale is PTP, the UTC offset is initially set to 37 secs, leap flags are FALSE. In Free Running state, the clock frequency comes from the on-board oscillator.

7.3.2 SYNTONIZING State

This state is only possible when the 1PPS-input signal from the GNSS interface is available, but not the ToD-input signal and the clock become a PTP master.

When the Qg 2 engine is running in GNSS Only mode or GNSS Primary PTP Secondary mode, the clock class is automatically changed to PRC_SYNC (6) and the clock accuracy is set to WITHIN_100_NS. In GNSS Primary, PTP Secondary mode, the clock class remains unchanged.

Note that the frequency can be traced, but not the time in this state. Once the ToD-input signal becomes available the clock switches to SYNCHRONIZING state.

7.3.3 SYNCHRONIZING State

The Qg 2 clock enters this state when it starts to synchronize its time and frequency with either a PTP or GNSS source. If the synchronization source is the GNSS, then both time and frequency are present and traceable. The timescale is changed to PTP, the clock class is changed to PRC_SYNC (6) and the clock accuracy is set to WITHIN_100_NS.

If the ToD-input signal becomes unavailable, while the 1PPS-input is still present, the Qg 2 clock switches to SYNTONIZED state.

If the synchronization source is a PTP master, then the clock quality remains unchanged. The timescale is set according to what is distributed by the PTP master. If the timescale distributed is PTP then the UTC offset (if valid) and leap flags are also set to master's values and the time source is set to PTP.

7.3.4 HOLDOVER State

The Qg 2 clock enters this state when the synchronization source is lost. If the clock was synchronized with PTP master its clock class remains unchanged. Otherwise, the clock class is modified according to the engine's operational mode and the clock accuracy is changed based on the time spent in the holdover state.

There is a static parameter which defines the clock stability. Currently it is fixed to 1 ns/s for a temperature-stable environment. During the holdover state an estimated error value is calculated and the clock accuracy is set according to that value.

The maximum time the clock stays in holdover state is defined by the holdover duration. By default, this value is set to 1000 seconds which gives about 1 microsecond error at the end of holdover duration. After holdover duration, the clock switches to the FREE RUNNING state, and its accuracy is reset to UNKNOWN (0xFE).

7.3.5 UNKNOWN/ERROR State

The Qg 2 clock has entered a failed or error condition and the sync state is unknown.

7.4 Unicast Operations

By default, unicast operations are disabled and the Qg 2 port operates in multicast mode. After unicast mode is enabled no multicast communications are possible.

The PTP port can be switched to unicast operations and back at any time using the PTP :: Port and PTP :: Unicast Sections of this User Guide.

7.4.1 Unicast Master

A Qg 2 port in unicast master state can support:

- Slave nodes which dynamically request unicast message transmission services from the master using the unicast negotiation mechanism.
- Slave nodes which do not support the unicast negotiation and simply rely on the reception of unicast messages from the master.

To accept unicast negotiation requests from slave nodes the master needs to be configured as follows:

- Unicast negotiation must be enabled.
- Slave acceptance filter must be populated. Note that in the current design, the slave acceptance filter is not user configurable and it is set to accept all slaves.

To provide message transmission services to slave nodes which do not support the unicast negotiation the master needs to be manually configured with the list of static slave nodes.

7.4.2 Enabling Master Unicast Negotiation

The unicast negotiation state is controlled by the PTP :: Unicast Section of this User Guide.

When unicast negotiation is enabled the master accepts unicast transmission requests from negotiation-capable nodes. If a node is allowed by the acceptance filter and if enough resources are available the master grants message transmission services to that node.

If unicast negotiation is disabled no new requests are accepted, but all existing grants remain serviced until they are either expired or cancelled.

7.4.3 Maintaining Master's Slave Acceptance Filter

Note: In the current implementation, the slave acceptance filter is not user configurable and it is set to accept all slaves. In that respect, the following documentation on slave acceptance filter is only for academic purpose.

The slave acceptance filter is a mechanism to control which slave nodes may obtain unicast services from the master. If the filter table is empty no services will be granted to any node. The PTP :: Unicast Section of this User Guide is used to manipulate the slave acceptance filter.

As the result of the filter table modification, if a node becomes unacceptable or message rates of any active grants becomes beyond the newly configured limits, all affected grants will be cancelled.

7.4.4 Maintaining Master's List Of Static Slaves

Note: In the current implementation, this is not supported. To provide unicast services to slaves which do not support the unicast negotiation the master maintains a list of static slave nodes.

When a node is in this list the master can send Announce and Sync messages to that node and can reply to Delay Request messages received from that node.

PTP :: Unicast Section of this User Guide is used to monitor and manipulate the static slave node list.

7.4.5 Unicast BOTH mode of operation

The PTP port on Qg 2 can be configured to automatically assume either the role of a unicast Master or an unicast Slave when the port mode is unicast BOTH. For example, if a port is in unicast Master mode and has GNSS reference and if the GNSS reference is lost, it can switch over to unicast Slave to another GM in the network. It is important to note that it is mutually exclusive, and cannot assume both, unicast Master and unicast Slave role at the same time as the case would be in a single-armed boundary clock.

7.4.6 Unicast MIXED mode of operation

The MIXED mode of operation is also referred to as PTP hybrid mode. In this mode, the Announce and Sync messages are sent as a multicast, but the delay mechanism is in unicast mode. The advantage of doing so is two-fold in a network of single master and many slaves that are being serviced by that Master:

- The Master does not have to replicate the Announce and Sync (and Follow-up) messages for each slave in its time domain or in the network,
- Each slave does not have to receive, process and drop DelayReq and DelayResponse messages from other slaves in the network.

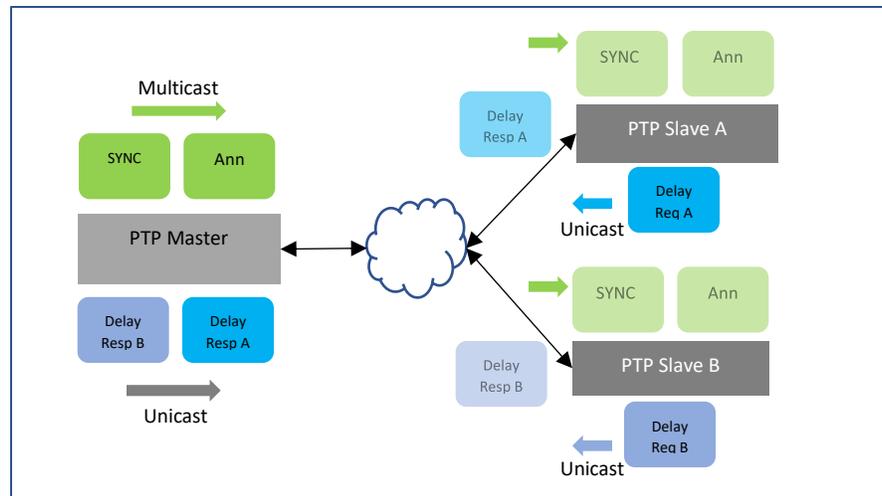


Figure 43 MIXED mode of operation

The delay mechanism can be end-to-end (E2E) as show in the figure or can be peer-to-peer (P2P). In P2P, typically the peer delay mechanism (i.e., sending a Peer Delay Request and getting a Peer Delay Mechanism) is typically over multicast. But, in the case of MIXED mode and with P2P delay mechanism enabled, then the peer unicast addresses may be used and need to be statically configured.

The MIXED mode of operation is used in the broadcast industry with SMPTE profile.

7.4.7 Monitoring Unicast Operations

Monitoring the status of master unicast operations can be done on the PTP :: Unicast Nodes and PTP :: Dataset Sections of this User Guide.

7.5 PTP Clocks

IEEE 1588 v2 standard specifies different types of clocks that are used to propagate timing and synchronization. The grandmaster, master and slave (or subordinate) clocks are generally grouped as ordinary clocks. Intermediate switches and routers in the network can either be a Transparent Clock (TC) or Boundary Clock (BC). BCs are preferable to TCs as they provide more accuracy and can easily scale in large networks. Using a hierarchical architecture and using divide and conquer principle, a single grandmaster does not have to serve large number of slaves.

PTP Clocks – GM, BC, TC, SC

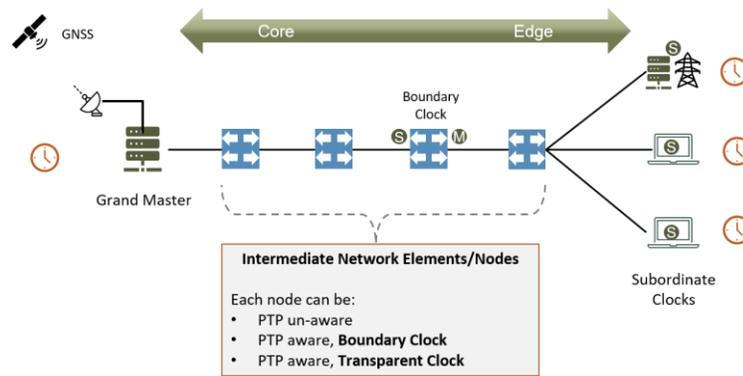


Figure 44 PTP Clocks

7.6 Gateway and Boundary clock

The Qg 2 Multi-Sync Gateway has the capability of using both of its Ethernet ports (Port 1 and Port 2) as PTP ports. This opens the possibility of using the Qg 2 as a two-port gateway or boundary clock. For more information about Gateway and Boundary Clocks, see [1].

7.6.1 The Gateway Clock

The Gateway Clock (GC) can be considered as an Ordinary Clock (OC) with two ports, with one port configured as a master and the other port configured as a slave.

Another capability of the Qg 2 is for both ports to be configured as master ports. In that configuration, each port would have its own IP address and be associated with different subnets. However, both ports would have the same PTP Clock Identity. With each port connected to different subnets, the ports can serve as GM for the slaves on the two different subnets. The slaves on the two separate subnets would then use the BMCA to select the best GM from which to recover the PTP time messages.

7.6.2 The Boundary Clock

The Boundary Clock (BC) has one port defined as a master port and the second port as a slave port receiving PTP messages from an external Grand Master (GM) Clock. The PTP Clock Webpage is used to set the Qg 2 clock as a boundary clock, described in PTP :: Clock Section of this User Guide.

The following figure illustrates the difference between a Gateway Clock and a Boundary Clock. The slaves connected to a Gateway Clock will only recognize the Gateway Clock as a Grand Master and not any other upstream masters. In the following figure, the slaves connected to the Gateway Clock will not recognize the Clock 1 (GM). The slaves that are connected to the Boundary Clock will recognize Clock 1 (GM) as the Grand Master.

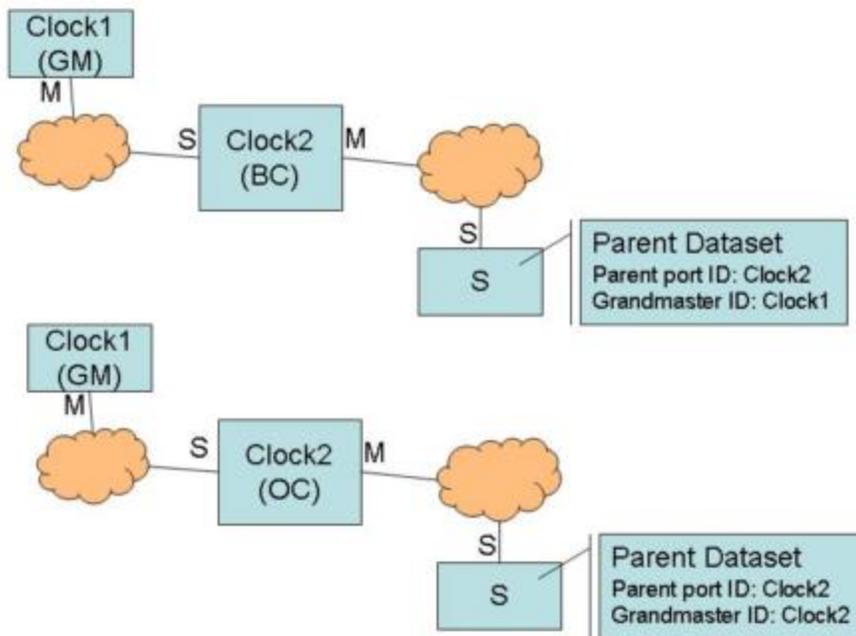


Figure 45 Gateway Clock (GC) vs. Boundary Clock (BC)

7.7 PTP (Slave) Servo Configuration Parameters

7.7.1 Main Time Constant

The main time constant used by the PTP Servo (slave) algorithm, in seconds. A longer time constant makes the oscillator frequency change more slowly and less responsive to changes in a network environment, such as the temperature or the network delays. For networks with low packet delay variation a short time constant (e.g., 30 sec) can be used. For networks with unknown or high traffic load, a longer time constant (e.g., 300 sec) would be a better setting. A longer time constant requires a more stable oscillator to be effective. For example, a time constant above 500 sec requires the Qg 2 super OCXO. The default value is 100 sec.

7.7.2 Startup Time Constant

The time constant used during the period of obtaining a preliminary synchronization (startup phase), in seconds. If this field is set to 0 the main time constant will be used. This parameter can help to shorten the synchronization time when a long main time constant is required. But values that are too short may lead to unwanted oscillations which increase the total time required to synchronize and eliminate any positive effects of shorter startup time constant. The default value is 0.

7.7.3 Quality Threshold

Defines the maximum allowed time variation in nanoseconds before the slave goes into holdover. The time variation is based on a statistical measurement of time error between the source input time and the slave's formulated time, where the source input time is the GNSS or ToD + 1PPS input. The default value is 1500 nsec.

7.7.4 Network Type

The Network Type selection is used to adjust the loop control algorithm behavior according to the underlying network characteristics. There are three types of networks currently supported: Unmanaged, Managed and Full on-path.

“Unmanaged” selection is used for a network with unknown or unspecified packet delay and delay variation or with packet delay distribution that may dramatically change its characteristics over time.

“Managed” selection is used for a network where the packet delay and delay variation distribution are specified and that always has a distinct “floor”. That “floor” may vary over the time, but the distribution limitations provided by the “floor” should still be present.

“Full on-path” selection is used along with G.8275.1 profile, where all network elements in the network participate in PTP protocol.

7.7.5 Frequency Out

The synchronized frequency that will be output on the FREQ Out port on the Qg 2 Front Panel. The valid options are 10MHz (default), 1.544MHz (T1 frequency) and 2.048 MHz (E1 frequency).

7.8 SNTP

Besides PTP timing protocol, Qg 2 supports SNTP (Simple Network Time Protocol) for those applications where very high precision (i.e., sub-microsecond accuracy) synchronization is not a requirement. Many client devices and their operating systems synchronize to a NTP server. Qg 2 can operate as a Stratum-1 NTP server to provide of this time. In this regard, Stratum-1 NTP server is the same as SNTP server.

Qg 2 can operate as a PTP grandmaster or as a NTP Stratum-1 server, by getting time reference from GNSS and distributing that over the network to PTP slaves or NTP clients. If SNTP is enabled, then Qg 2 can service both, PTP slaves as well as NTP clients.

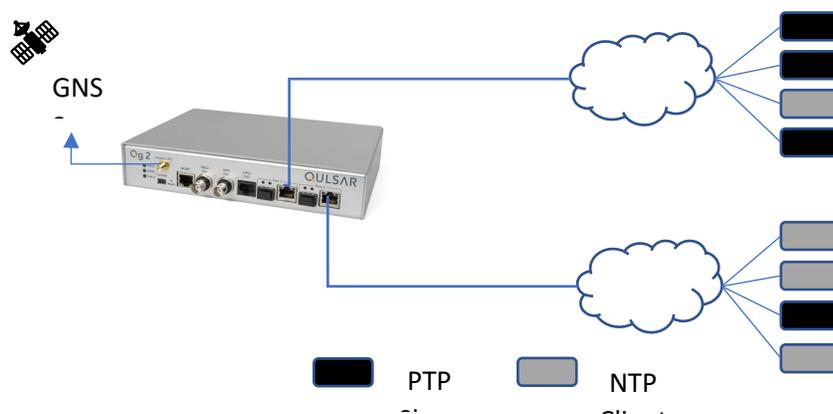


Figure Support of PTP slaves and NTP clients

SNTP server implementation of Qg 2 as per the specification in RFC 4330 - Simple Network Time Protocol (SNTP) Version 4 for IPv4, IPv6 and OSI.

7.9 PTP over IPv6

Internet Protocol version 6 (IPv6) expands the number of network address bits from 32 bits (in IPv4) to 128 bits, which provides more than enough globally unique IP addresses.

- IPv6 Address:

The IPv6 128-bit addresses are represented as a series of eight 16-bit hexadecimal fields separated by colons in the format: n:n:n:n:n:n:n:n. For example,
2023:0000:130F:0000:0000:09C0:080F:130B

For easier implementation, leading zeros in each field are optional. This is the same address without leading zeros:

2023:0:130F:0:0:9C0:80F:130B

One can also use two colons (::) to represent successive hexadecimal fields of zeros, but this short version can be used only once in each address:

2023:0:130F::09C0:080F:130B

- IPv6 Prefix:

An IPv6 address prefix represents a block of address space or a network. The prefix is a combination of an IPv6 prefix (address) and a prefix length. It takes the form ipv6-prefix/prefix-length.

IPv6 addresses can be broken into prefixes of varying length. The prefix length is a decimal value that specifies the number of the leftmost bits in the address that make up the prefix. The prefix length follows a forward slash and, in most cases, identifies the portion of the address owned by an organization. All remaining bits (up to the right-most bit) represent individual nodes or interfaces.

For example, 2023:db8:0000:0000:250:af:34ff:fe26/64 has a prefix length of 64.

The first 64 bits of this address (2023:db8:0000:0000) are the prefix. The rest (250:af:34ff:fe26) identify the interface.

From Qg 2 SW release version 12.2.2 onwards, additional configuration support is available to support PTP over IPv6 for the 2 PTP Timing Ports. Prior to 12.2.2 release, only a fixed link local IPv6 address derived from PTP port MAC address was supported.

With version 12.2.2 (and onwards), the IPv6 stack on Qg 2 embedded system has been enhanced to support configurable 128 bit IPv6 addresses in different address notations that are commonly used, along with setting the prefix length (1 – 128 bits), and the gateway address. Both, with PTP over IPv6 both, multicast and unicast IPv6 addresses are supported

The configuration of the IPv6 related address parameters can be configured from Interface::PTP Timing Ports webpage. This is a per port configuration.

The selection of PTP over IPv6 is done by setting it on PTP::Port::Network Protocol configuration parameter. This is a per port configuration.

As prior to 12.2.2 release, IPv6 link local address continues to be supported.

Please note that dynamic assignment of IPv6 address for the PTP timing ports (via DHCP6) is not supported currently.

8 Network Architecture and Deployment Considerations

8.1 Network Operator’s or Carrier’s perspective

The diagram below shows the carrier’s perspective of the network with a view of the synchronization requirements. The left side of the drawing is more on the customer/applications side which require synchronization while the core of the network is on the right. Traditionally, from TDM world to packet world, the synchronization flow is hierarchical, starting from the core and propagating down to the endpoints.

Network topology – Synchronization Overview

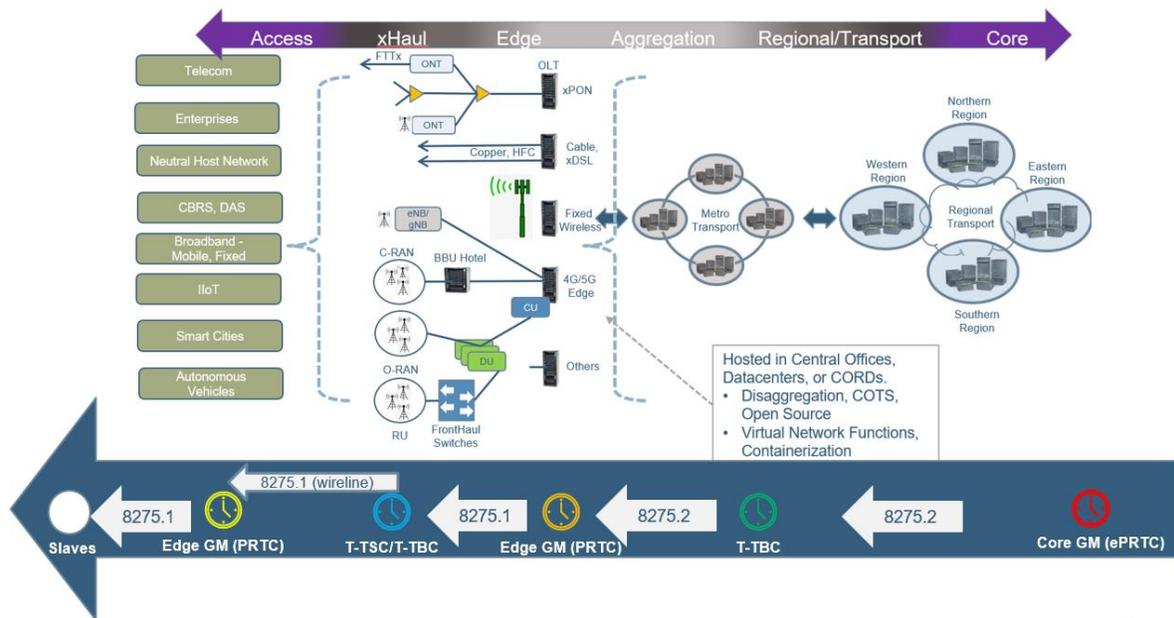
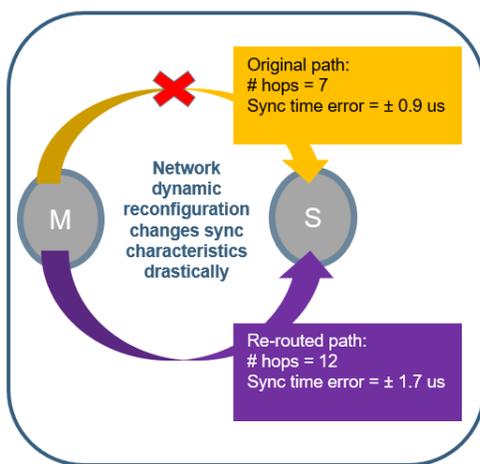


Figure 46 Network Topology - Synchronization Overview



For tighter precision, this method of propagation is changing with more Grandmasters put in the network path and the Grandmasters are moving to the edge. Timing and synchronization over large segments of network has its challenges, especially when higher layer protocols and traffic engineering (TE) methods can dynamically re-route traffic based on network conditions.

With less hops, a good accuracy and precision can be maintained. Conceptually, this is like how low-latency applications require caching or mirroring of data locally on-site or at the edge. The figure shows how network dynamic reconfiguration could impact the sync characteristics at the endpoint (PTP slave).

8.2 PTP Profiles

Qg 2 provides the flexibility and ease for customers to select one of the many PTP profiles provided to set the Qg 2 timing engine mode of operation. In the current release, both ports will be set to the same profile and not independently.

There are many different PTP profiles that have been specified based on specific industries like Telecom, Power, Broadcasting, Enterprise, etc. while a few others are being created. These profiles will put some restrictions on some of the configuration parameters that are part of the IEEE 1588 to make it simpler and targeted towards specific industry and deployment. Typically, the profile dictates the PTP domain value range, PTP over L2 (Ethernet) or IP/UDP, multicast or unicast or mixed mode, message rates, announce timeout, delay mechanism, datasets, etc. are customized per profile. This covers most of it but for some of the profiles some additional parameters also need to be specified.

With Qg 2, the user can select one of these PTP profiles for the timing engine to operate in. To make it user friendly, once the profile is selected, internally Qg 2 software will set up the most of the PTP profile specific parameters to default values for that profile and it is up to the customer if they want to customize it further (like a power user).

Below is the list of PTP profiles that Qg 2 currently supports. More profiles will be added in future releases and this documentation will be updated accordingly.

8.2.1 IEEE 1588 Default Profile

This is the profile that is specified by IEEE 1588 Standard itself. It uses domain 0, PTP over IPv4/UDP and multicast mode of operation.

8.2.2 G.8275.1 Telecom Profile

This is one of the Telecom profiles specified by ITU-T and is recommended for new deployment or green-field networks comprising switches. It is expected that every node or element in the network is PTP-aware, or in other words, the network has full on-path support. This is used in conjunction with Synchronous Ethernet (SyncE) which provides the physical layer frequency synchronization. G.8275.1 uses L2 (Ethernet) multicast as PTP transport layer. This is a better option as using the physical layer assist for frequency and phase/time from PTP over packet network as it gives the best of both worlds.

With G.8275.1 profile and SyncE, a slave or the network is congruent if the PTP source and SyncE source is traced back to the same Grandmaster. If they are not, then it is said to be non-congruent. In either case, the SyncE frequency reference that is used by the slave should be traceable as specified in the Quality Level (QL) value in the ESMC messages.

The figure below shows the details of G.8275.1 telecom profile.

PTP Profiles: G.8275.1 with full on-path support

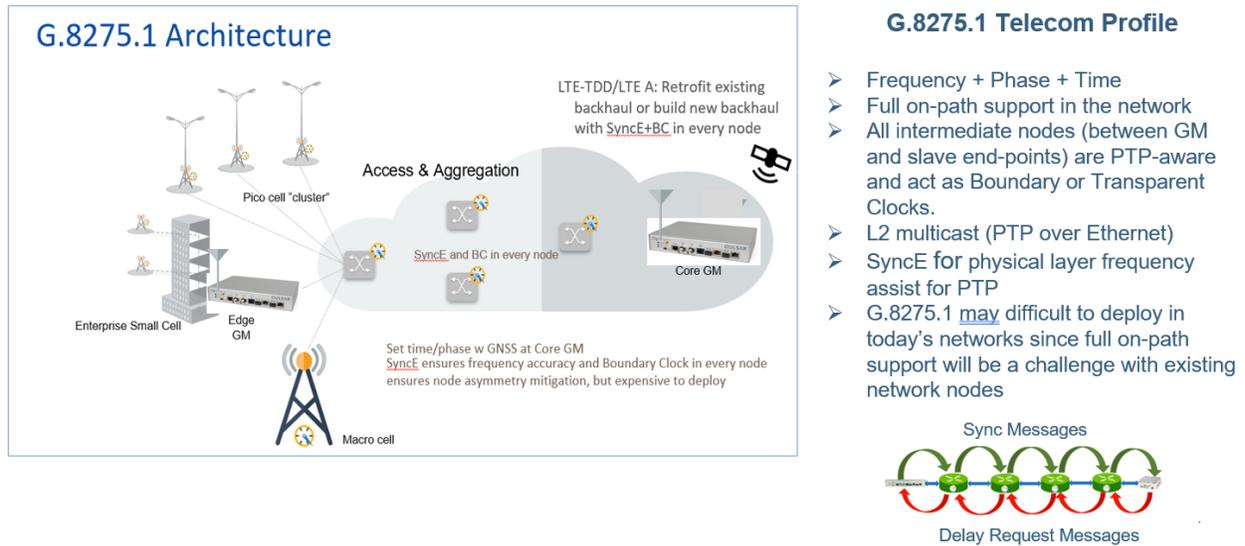


Figure 47 G.8275.1 PTP profile

In PTP::Clock page, additional configuration parameters are provided that are specific to G.8275.1 profile as shown below.

<u>G8275.1 Profile</u>	
Clock Local Priority	<input type="text" value="1"/>
Max Steps Removed	<input type="text" value="255"/>
PTP Ports Priority	<input type="text" value="1"/>
Master Only	<input type="text" value="Disable"/>
<input type="button" value="Apply"/> <input type="button" value="Clear"/>	

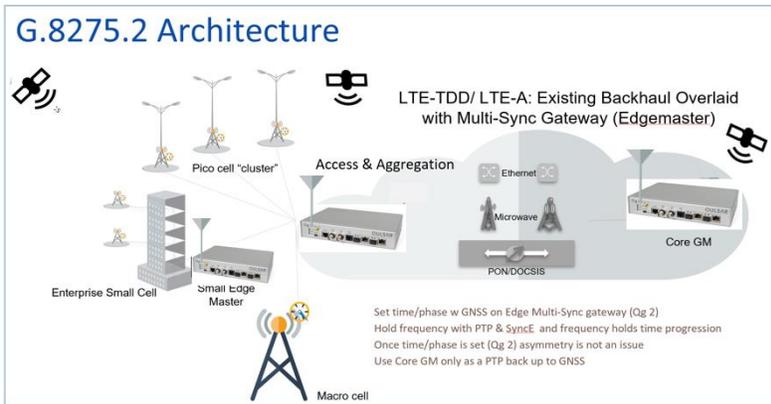
Figure 48 G.8275.1 profile - additional configuration parameters

8.2.3 G.8275.2 Telecom Profile

This is another Telecom profile specified for legacy (brownfield) networks that work in conjunction with the older networks which can comprise switches and routers. This profile is used where there are network elements which are not PTP-aware and do not participate in PTP protocol processing. They act as pass-through elements but introduce additional delays which the endpoints or slaves need to compensate for, to maintain timing precision. Since the sync path traverses over routers, this profile specifies PTP over UDP/IPv4 or UDP/IPv6 and unicast mode of operation.

The figure below shows the details of G.8275.2 telecom profile.

PTP Profiles: G.8275.2 with partial timing support



G.8275.2 Telecom Profile

- L3 (UDP/IPV4) Unicast
- Partial on-path support (some network elements are PTP unaware) and just propagate PTP traffic
- PTP aware nodes can act as Boundary Clock (BC) or End-to-End Transparent Clock (TC)
- End-to-End (E2E) Delay measurement
- This is realistic in today's network, but the challenge is GNSS signal availability at the edge masters

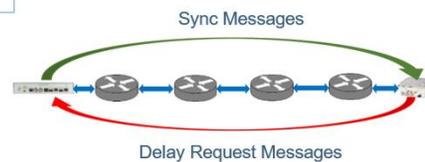


Figure 49 G.8275.2 PTP Profile

In PTP::Clock page, additional configuration parameters are provided that are specific to G.8275.2 profile as shown below.

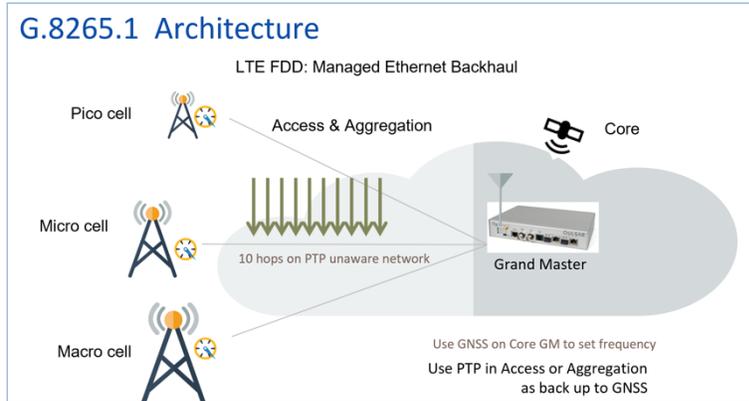
G8275.2 Profile

Clock Local Priority	<input type="text" value="1"/>
Max Steps Removed	<input type="text" value="255"/>
PTP Ports Priority	<input type="text" value="1"/>
Master Only	<input type="text" value="Disable"/>

Figure 50 G.8275.2 profile - additional configuration parameters

8.2.4 G.8265.1 Telecom Profile

This is yet another Telecom profile from ITU-T for providing frequency-only synchronization (or syntonization) over packet network. This was specified to support legacy TDM networks like (SONET/SDH, etc.). It does not provide time/phase synchronization.



G.8265.1 Telecom Profile

- ITU-T G.8265.1 Frequency Profile over packet network
- Both, one-way and two-way supported since it is frequency only
- One-step and two-step modes supported
- Restricted to unicast mode of operation with unicast negotiation (over UDP/IP)

Figure 51 G.8265.1 PTP Profile

8.2.5 Power version-1 profile

This profile is specified for the power industry mainly in power system protection, control, automation, and data communication applications. This specific Power V1 is according to the IEEE C37.238-2011 standard. It uses PTP over L2 multicast, P2P delay mechanism and one of the salient features of this profile is that it uses priority tagging for VLAN (i.e., VLAN-id = 0, priority = 4).

In PTP::Clock page, additional configuration parameters are provided that are specific to Power Profile v1 as shown below.

POWER-V1 Profile

GrandMaster ID	<input type="text" value="3"/>
GM Inaccuracy (ns)	<input type="text" value="0"/>
Network Inaccuracy (ns)	<input type="text" value="0"/>
	<input type="button" value="Apply"/> <input type="button" value="Clear"/>

Figure 52 Power Profile v1 - additional configuration parameters

8.2.6 Power version-2 profile

This is version 2, 2017 edition of the power industry standards, IEEE C37.238-2017. One of the main differences from the 2011 edition is that there is no restriction on VLAN priority tagging on the PTP ports.

In PTP::Clock page, additional configuration parameters are provided that are specific to Power Profile v2 as shown below.

POWER-V2 Profile

GrandMaster ID	<input type="text" value="0"/>
GM Inaccuracy (ns)	<input type="text" value="0"/>
Network Inaccuracy (ns)	<input type="text" value="0"/>
	<input type="button" value="Apply"/> <input type="button" value="Clear"/>

Figure 53 Power Profile v2 - additional configuration parameters

8.2.7 Power Utility Profile

This profile is specified as in Power Utility (IEC/IEEE 61850-9-3:2016) standard: Communication networks and systems for power utility automation – Part 9-3: Precision time protocol profile for power utility automation. In many aspects, this is very similar to Power v2 profile mentioned earlier.

In PTP::Clock page, additional configuration parameters are provided that are specific to Power Utility profile as shown below.

Power Utility:

POWER-UTILITY Profile

GrandMaster ID	<input type="text" value="0"/>
GM Inaccuracy (ns)	<input type="text" value="0"/>
Network Inaccuracy (ns)	<input type="text" value="0"/>
	<input type="button" value="Apply"/> <input type="button" value="Clear"/>

Figure 54 Power Utility Profile - additional configuration parameters

8.2.8 SMPTE Profile

SMPTE 2059 is a standard from the Society of Motion Picture and Television Engineers (SMPTE) that describes how to synchronize video equipment over an IP network. The standard is based on IEEE 1588-2008. SMPTE 2059 is published in two parts on 9 April 2015:

- SMPTE 2059-1 – Defines signal generation based on time information delivered by the IEEE 1588 protocol.
- SMPTE 2059-2 – Defines an operating profile for the IEEE protocol optimized to the needs of media synchronization.

The new television standard as specified by ATSC 3.0 uses SMPTE and for synchronization via IEEE 1588 v2. ATSC 3.0, also known by the moniker NextGen TV, is a major version of the ATSC standards for television broadcasting created by the Advanced Television Systems Committee (ATSC).

In PTP::Clock page, additional configuration parameters are provided that are specific to SMPTE profile as shown below.

SMPTE Profile

System Frame Rate (Base)	<input type="text" value="0"/>
Frame Rate Frac	<input type="text" value="Disable (Divisor 1.0)"/>
Time Code Drop	<input type="text" value="Off"/>
Time Code Color	<input type="text" value="Off"/>
Jam Event	<input type="text" value="None"/>
Jam Event Time*	<input type="text"/>

Figure 55 SMPTE Profile - additional configuration parameters

8.3 Synchronous Ethernet (SyncE)

8.3.1 What is Synchronous Ethernet?

Synchronous Ethernet feature is to help in providing frequency synchronization over packet based networks using Ethernet. It provides a mechanism to distribute frequency from Ethernet packet network to Time Division Multiplexed(TDM) circuits and nodes. For this, the (natively asynchronous) Ethernet physical layer is utilized in a fashion like (natively synchronous) SONET/SDH networks, with clock recovery and the assist of a new IEEE 802.3 slow-protocol packet called Ethernet Synchronization Messaging Channel (ESMC). This ESMC message is to convey the reference clock quality and traceability information in the form of Quality Level (QL). The SyncE feature is considered a physical layer characteristic unlike PTP which is in higher-layer software.

In current and next generation networks, there is need for time and not just frequency synchronization. That is, a combination of frequency, phase and time-of-day synchronization is required and expected to be delivered in a reliable and resilient fashion. Synchronous Ethernet can provide a stable frequency and can also be used as a local short-term holdover clock for maintaining time.

The Synchronous Ethernet standard is specified in ITU-T G.8262 and ESMC message in ITU-T G.8264.

8.3.2 SyncE feature in Qg 2

Synchronous Ethernet feature is a configurable option on Qg 2 that can be enabled or disabled from the Home webpage, depending on the customer use-case and deployment. There are 4 main modes of operation in which SyncE feature can be deployed as described below. The PHY's used in Qg 2 support SyncE in terms of supporting clock recovery on Ethernet Rx and being able to provide 125MHz clock externally for Ethernet Tx. This is supported with native RJ45 (1000BASE-T) PTP port interfaces and with optical 1GE SFP modules. SyncE is currently not supported on Copper SFPs.

8.3.3 SyncE in OFF mode

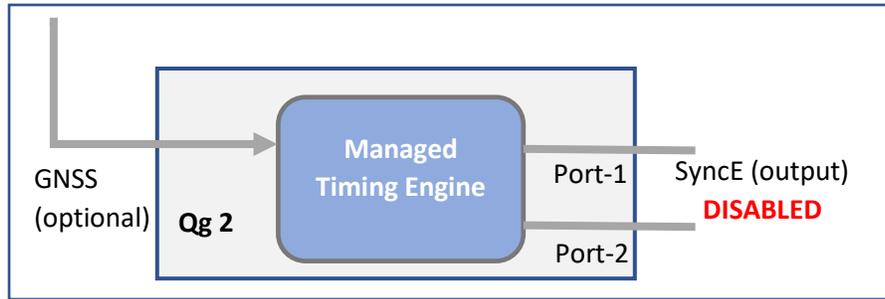


Figure 56 SyncE OFF

In this mode of operation, Synchronous Ethernet feature is turned off completely. Any incoming ESMC packets will be ignored and not processed, and no generation of outgoing ESMC packets. No clock recovery is done on Ethernet Rx. Frequency, along with phase and time are extracted from GNSS or PTP. This applies to both PTP ports.

8.3.4 SyncE in Master mode

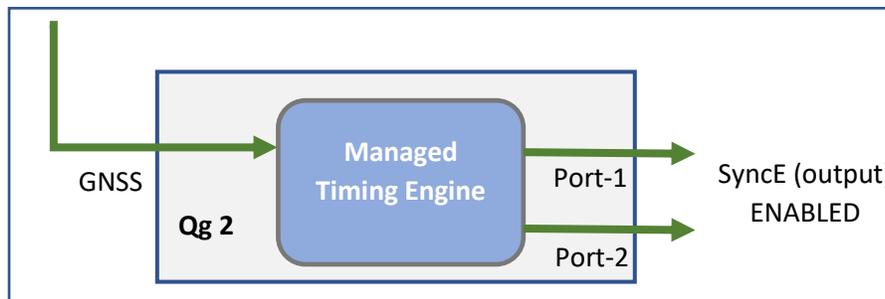


Figure 57 SyncE in Master Mode

In this mode of operation, Qg 2 is in GNSS-only operating mode where it gets 1PPS and ToD signals from a GNSS receiver (internal or external to Qg 2), which was originally extracted from GNSS L1 signal. In this mode, the frequency, phase and time references are extracted from GNSS signal, and SyncE is output on both ports for frequency with ESMC/QL message distribution to next downstream L2 network node. The outgoing QL enumeration is PRC (for EEC Option-1) or PRS (for EEC Option-2) when locked to GNSS.

8.3.5 SyncE in Boundary Clock Mode

In Boundary Clock mode, SyncE feature can be enabled when engine is operating in PTP-only mode. In this mode, one of the PTP ports operates as a PTP-slave synchronizing to a PTP master upstream, while the other PTP port operates as a PTP-master distributing time and sync downstream to other PTP slaves.

There are some differences that should be noted when using L2 (Ethernet multicast) based PTP profile like G8275.1 and L3 based PTP profile like G8275.2. More details to follow in the sections below.

8.3.5.1 SyncE in Boundary Clock Mode for G8275.1 Telecom Profile

G8275.1 profile is specified for PTP clock distribution in a Layer-2 Ethernet multicast network. This network is expected to have full on-path support, i.e.. every node is PTP-aware and participates in the PTP protocol. When Qg 2 is put in Boundary Clock mode in this network, the input SyncE from upstream is used as frequency reference and used directly for SyncE distribution on downstream port, after getting cleaned up by the internal PLL in the clock engine.

On Qg 2 Home webpage, the SyncE selection provides the flexibility of specifying upstream port (PTP slave + SyncE reference input) and downstream port (PTP slave + SyncE output) and as shown in the figures below.

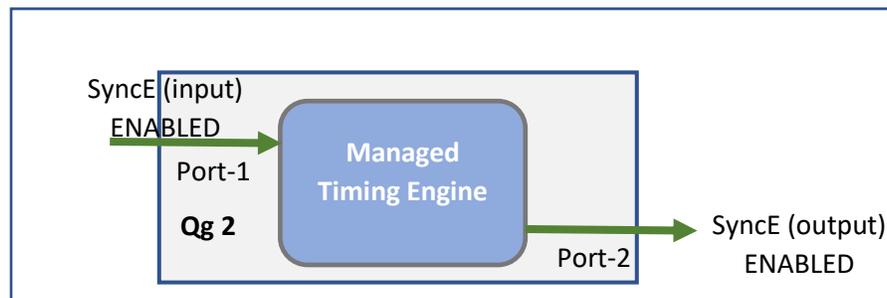


Figure 58 SyncE in BC mode for G8275.1, ref input on Port-1

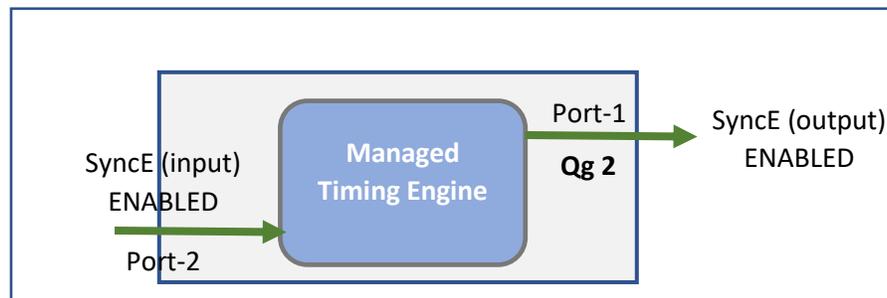


Figure 59 SyncE in BC mode for G8275.1, ref input on Port-2

8.3.5.2 SyncE in Boundary Clock Mode for G8275.2 Telecom Profile

G8275.2 profile is specified for L3 unicast network and is based on partial timing support from the network. This means that not all network nodes may participate in PTP protocol. In this mode, SyncE input frequency reference can be used as a frequency-assist for PTP. The physical layer (i.e.. frequency) output is controlled by both, the input (from SyncE) and PTP engine. Unlike in G8275.1, here the physical layer output is NOT directly from input reference and hence not traceable and cannot be used for SyncE output distribution. SyncE output is disabled in this case.

The figures below show the flexibility of specifying the ports for operation in this mode.

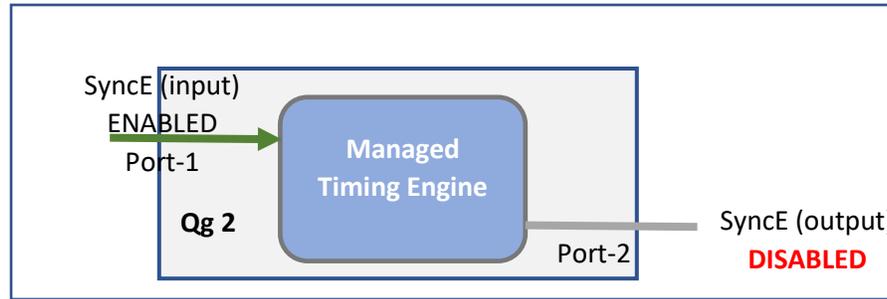


Figure 60 SyncE in BC mode for G8275.2, ref input on Port-1

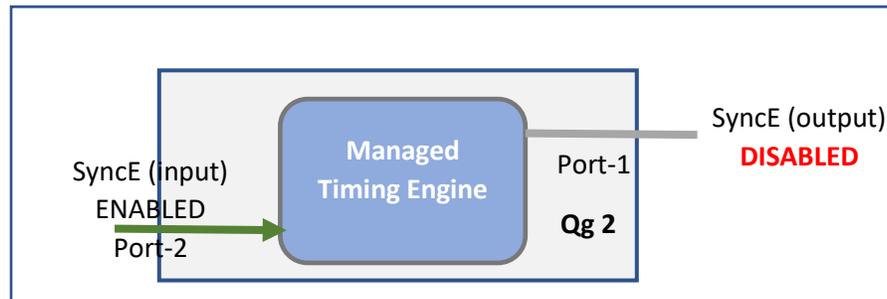


Figure 61 SyncE in BC mode for G8275.2, ref input on Port-2

8.3.6 SyncE status

The SyncE status is displayed at the bottom of PTP::Port webpage.

8.3.6.1 SyncE Status in GM mode

	Port 1	Port 2
<i>Synchronous Ethernet</i>		
SSM channel (ESMC)	Enabled	Enabled
Link Mode	master	none
Input QL	AUTO (QL-DNU)	AUTO (QL-FAILED)
Output QL	QL-PRC (QL-PRC)	QL-PRC (QL-DNU)
Active Reference	NO	NO

Figure 62 GM SyncE status output on PTP::Port webpage

The above figure is a sample status when Qg 2 is operating as a GM and Port1 is connected to a SyncE slave and Port2 is not connected to a link partner (link down condition). The following describes the different fields in this use case:

- SSM channel (ESMC) – it is enabled for both ports.
- Link Mode – This is applicable only for Copper/RJ45. This is as per 802.3 standard which specifies the physical media and the working characteristics of Ethernet. To work in conjunction with SyncE, link mode on Qg 2 ports will be (forced) set to master clock and 1000 Mbps full-duplex

and auto-negotiation turned off. In the example above, there is a link on port-1 and its Link Mode set to “master”, while for port-2 there is no link, it shows as “none”.

- Input QL – This is the Quality level in the ESMC message received on that port (from its link partner).
 - For Port1, it indicates AUTO (QL-DNU), and
 - For Port2, it indicates AUTO (QL-FAILED)

In GM mode, the input QL processing in Qg 2 is set to AUTO to take the input from the port and feed it into the PLL as one of the inputs. What is shown in the parentheses is the actual value received.

- Port1, receives QL-DNU (DNU = do not use) from its link partner.
- Port2, since the link is down, it shows QL-FAILED.
- Output QL – In this use case, the frequency reference is coming from GNSS (or 1PPS) and not from either of the two Ethernet ports. The quality level for that is PRC (or PRS). This QL is what should be propagated downstream as the Qg 2 is a Grand Master.
 - For Port1, the link is up and so the actual QL that is put in the outgoing ESMC message is QL-PRC as shown in the parentheses.
 - For Port2, not that it matters since the link is down, the value that will be put in the ESMC message will be QL-DNU.
- Active Reference – this will indicate YES or NO to indicate the recovery of frequency on that Ethernet port. The YES would mean that the frequency is recovered from this port. In a BC clock mode of operation with SyncE enabled, it will indicate YES on the slave port where we get the frequency reference and NO on the other (master) port. In our sample use case of GM, it will show NO on both pots as the active reference is from GNSS (1PPS) and not from the Ethernet ports.

8.3.6.2 SyncE Status in BC mode

	Port 1	Port 2
<i>Synchronous Ethernet</i>		
SSM channel (ESMC)	Enabled	Enabled
Link Mode	slave	master-slave
Input QL	AUTO (QL-PRC)	QL-DNU (QL-DNU)
Output QL	QL-DNU (QL-DNU)	AUTO (QL-PRC)
Active Reference	YES	NO

Figure 63 BC SyncE status output on PTP::Port webpage

The above figure is a sample status of SyncE when Qg 2 is operating as a BC, getting the SyncE reference from Port1 and propagating it on Port2. Here, on port-2 a SFP optical module is used instead of the native RJ45 Copper port. The following explains the different fields for this use case:

- SSM channel (ESMC) – it is enabled for both ports. On Port1 it is recovered and on Port2 it is transmitted.
- Link Mode – this is as per 802.3 standard as mentioned in the previous GM use case.
 - Port1: The link mode is in alignment with SyncE as this is a SyncE slave port and getting the frequency reference from its link partner.

- Port2: The link mode does not matter as it is not copper but is SFP optical. It is displayed as “master-slave”. If it had been Copper/RJ45, then it would have displayed as “master”.
- Input QL – This is the Quality level received on that port (from its link partner).
 - For Port1, it indicates AUTO (QL-PRC) indicating that incoming SyncE ESMC has QL-PRC. This is used as SyncE reference.
 - For Port2, it indicates AUTO (QL-DNU) indicating that incoming SyncE ESMC has QL-DNU.
- Output QL – This is the Quality level transmitted out on the port.
 - For Port1, QL-DNU is sent out. This is required on the port that is being used as SyncE reference to avoid any clock loops
 - For Port2, the AUTO indicates that we are transmitting QL that was received as reference. The actual value is QL-PRC, the frequency propagated from Port1 input.
- Active Reference - This will indicate YES or NO and pertains to recovery of frequency on a specific Ethernet port
 - For Pot1, it is YES since the reference frequency is recovered here
 - For Port2, it is NO since the recovered frequency is not used as reference

8.3.7 SyncE – some additional notes

Some additional notes regarding SyncE feature in Qg 2:

1. Synchronous Ethernet is supported only for 1GE interface speed. If user had configured previously on Interfaces::PTP webpage for a different Auto-Negotiation and speed parameters, they will be reset to 1000Mbps Full-duplex.
2. For other profiles besides G8275.1 and G8275.2, the SyncE operation will depend on whether the profile is specified for L2-multicast or L3-unicast. If L2-multicast, then it will follow G8275.1 operation, and if L3-multicast, it will follow G8275.2 operation.
3. SyncE operation is valid only in association with Operating Modes, GNSS-only and PTP-only. Synchronous Ethernet field should be set to off for other operating modes.

8.4 5G and Synchronization

As the reader may be aware, in 5G the base stations is decomposed into remote radio unit (RRU), distribution unit (DU), and the control unit (CU). For the proper functioning and getting optimal performance from RU, DU and CU in 5G RAN, precise timing and synchronization plays a crucial role. Not only just from RAN perspective, but also from an end-to-end network perspective for new applications and services like network slicing that run on 5G network.

For 5G RAN, the typical sync and time error budget is +/-1.5us from the core to RAN over the air (OTA) interface. For specific deployments and network operation use case scenarios, a higher precision or sync accuracy may be required. For Time Alignment Error (TAE) within a cluster of RUs, , all of which synchronizing from the same DU, it is +/-130ns. It should be noted that this budget is specified for synchronization and not latency.

8.4.1 Open RAN, ORAN deployment scenarios

Qg 2 is a simple yet powerful and flexible stand-alone timing and synchronization solution for today's and next generation networks. Specifically with the advent of commercial off the shelf hardware (COTS), open source software and disaggregation concepts and technologies into Radio Access Network (RAN).

Below shows the RAN Architecture evolution. Prior to 5G, the RAN architecture was such that the base stations are co-located with the Radio tower and all the layer 1 (or PHY or Radio) including analog/digital conversions at or near the radio. In 5G, with massive MIMO, millimeter wave with shorter range radios, and more end applications, there will be more radios (small cells, and towers). This is needed to provide the necessary coverage. The radios need to be small, economical and efficient and located remotely for 5G. Centralized RAN, virtualized RAN and Open RAN are some of the new architectures that are gaining traction in this regard.

RAN Architecture Evolution

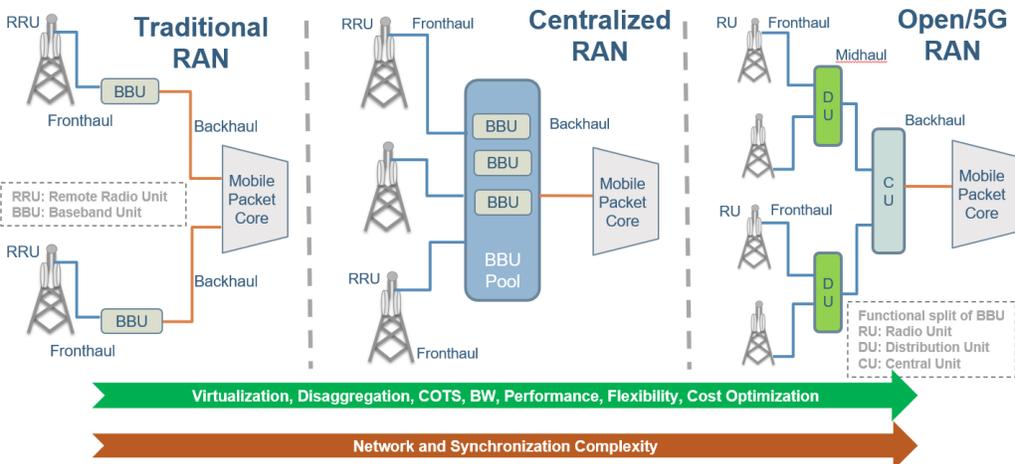


Figure 64 5G RAN Architecture evolution

8.5 Qg 2 for 5G deployment

There is a lot of activity currently going on in 5G as the ecosystem evolves. There are legacy vendors (Ericsson, Huawei, Nokia, etc.) working with the carriers in building and deploying a single-vendor solution. Besides these legacy vendors and providers, a new host of companies have entered the 5G ecosystem. The basic driving factor for new players is that 5G is seen as a new technology that requires products from multi-vendors to be interoperable and there is no single vendor “lock-in”. Most of the hardware is off-the-shelf and the software is open source which empowers smaller players to enter this market. Regardless of whether the network operator deploys a disaggregated multi-vendor or the legacy single-vendor infrastructure, precise timing and synchronization is critical.

Shown below is how Qg 2 can be deployed for the different configurations as specified in Synchronization plane (or S-plane) of ORAN Workgroup-4. The configurations are specified as LLS-C1 through LLS-C4, where LLS = low-level split. The recommendation by ORAN is to use G.8275.1 profile along with SyncE.

Versatile Qg 2 solution for 5G RAN (ORAN S-Plane)

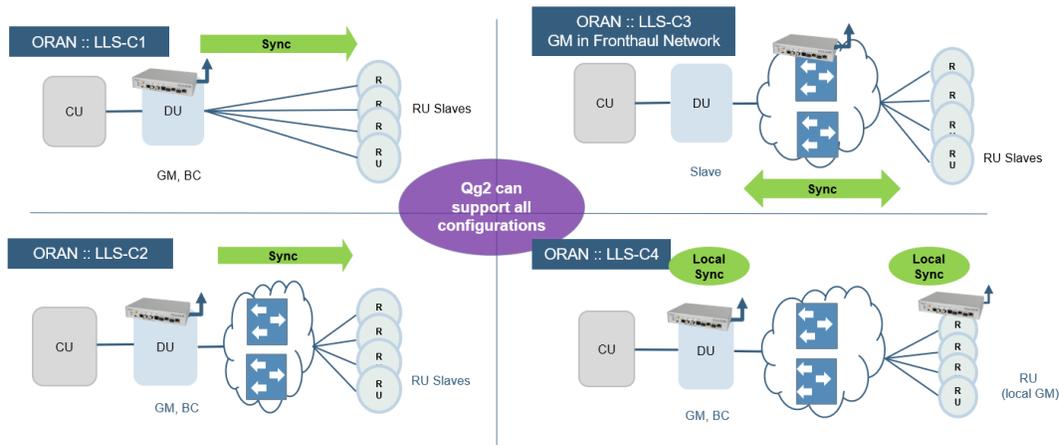


Figure 65 Qg 2 solution for ORAN S-plane

The figure below shows other deployment scenarios – for 5G using legacy network architecture for synchronization.

Versatile Qg 2 solution for 5G RAN (legacy sync)

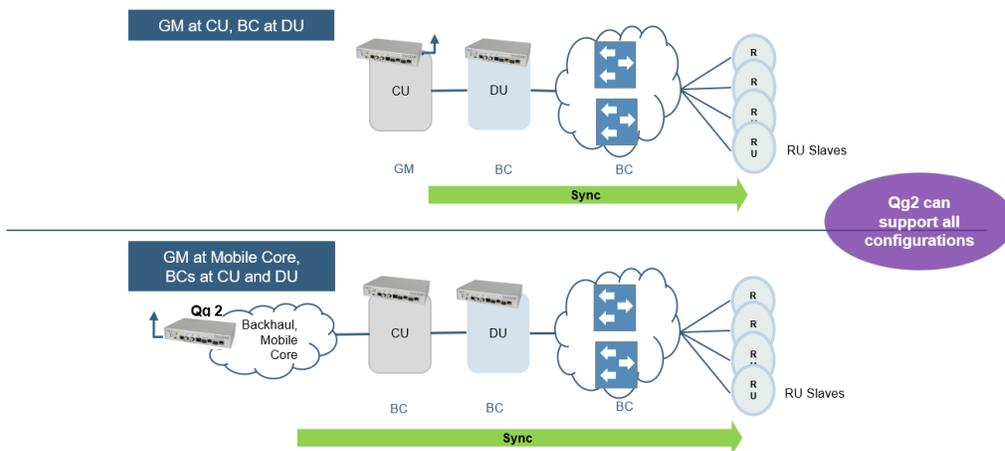


Figure 66 Qg 2 solution for 5G RAN (legacy sync)

8.5.1 Integrated sync solutions from Qulsar (Qg-iNT)

Qg 2 as a stand-alone is a flexible solution for different deployments. In addition, Qulsar can provide customized solution that can be integrated into DU/CU white box server (Qg-i), or into the switch (Qg-iS) or into the radio unit (Qg-iR). These solutions use the hardened, performance proven Qg 2 architecture and design as the reference model and can be easily customized for a PoC trial. The obvious advantage of this is to have a small footprint, less devices to manage and be part of vendor offering of complete

solution. Precise timing and synchronization, especially to meet the requirements of 5G is complex requires expertise for an optimal solution.

The figure below shows Qulsar solution for the different components of 5G RAN.

Qg iNT Sync Family with QSync™ for 5G RAN

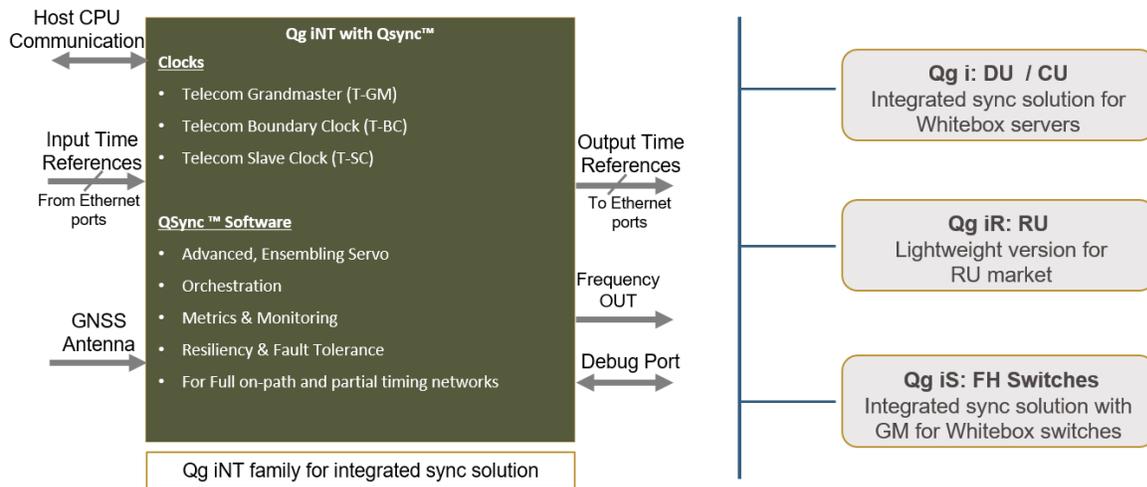


Figure 67 Qg iNT solution

If interested, please contact Qulsar for more details on Qg-iNT.

9 Physical Interfaces

9.1 Antenna input

SMA 50 ohm. Protected for shorted antenna. The Qg 2 provides 5.0 VDC bias to power remote active antennas that provide 40 dB gain. The antenna system supports cable length up to 50 meters with RG59/RG58 and 50 to 100 meters with LMR500/LMR600.

9.2 Console

The console port uses mini-USB serial terminal protocol. The connector is on the front panel and the default settings are as follows:

- Baud = 115.2K
- Data Bits = 8 bits
- Parity = None
- Stop Bits = 1
- Flow Control = None

9.3 Hard Reset Button

The Hard Reset Button provides 2 different functionalities depending on how it is used or pushed. These are described below.

Note: It should be noted that using the Hard Reset Button should be a last resort consideration as it is abrupt and not a graceful way.

9.3.1 Hard Reset Button – Quick Push for Reboot

When Hard Reset Button is pushed and held for a short duration (approx. 1 or 2 seconds), it will reboot the unit. The current configuration of Qg 2 is preserved.

9.3.2 Hard Reset Button – Long Push for Factory Reset

When Hard Reset Button is pushed and held for a longer duration (at least 10 seconds), it will do a factory reset of the unit followed by a reboot. The current configuration of Qg 2 will NOT be preserved and the user should save and restore their configuration as needed.

Important Note: Do NOT power cycle or do another reset of the Qg 2 until the long push button reset is finished and the system comes back in normal operation mode. This is indicated by the power LED turning green or Qg 2 log on Alarms/Events page indicates that it is ready for operation. Prematurely cutting off power or doing another reset after a long push button reset could potentially make the unit non-operational permanently and cannot be fixed in the field or customer site.

9.4 Management interface

Management port is 10/100BaseT RJ45. The Management port supports DHCP, HTTP Webpages, XML, SNMP (v2,v3), and SSH remote login.

9.5 Frequency Out port

BNC 50 ohm. 3.3V TTL DC blocked. Frequency Out selectable on the PTP :: Config Webpage.

9.6 1PPS timing output

BNC 50 ohm. 3.3V TTL output.

9.7 Time-of-Day / 1PPS input/output

ToD / 1PPS port is RJ45, input/output. The pin-outs for this RJ45 connector are defined in ITU-T G.703 Transmission Systems and Media, Digital Systems and Networks, Section 19. For more information about ITU-T G.703, see[2].

The Time-of-Day Input format is selectable on the Interface :: GNSS Webpage and the Time-of-Day Output format is selectable on the Interface :: ToD/1PPS Output Webpage. The selections for both input and output are NMEA, ASCII text and China Mobile.

9.8 PTP interface, Port 1 and Port 2

Two Electrical RJ45 ports and two SFP ports. Each RJ45 port can support triple-speed (10/100/1000 Mbps) and each SFP port can support 1GE.

For Port 1, the same PTP messages/packets will be present in both the RJ45 and SFP connections, but the data rates may be different depending on the speed of the network to which they are connected.

For Port 2, the same PTP messages/packets will be present in both the RJ45 and SFP connections, but the data rates may be different depending on the speed of the network to which they are connected.

9.8.1 SFP (and SFP+) optical modules for PTP Port 1 and 2

SFP optical modules can be plugged into the PTP ports for Ethernet connectivity instead of the electrical RJ45 ports. These ports have been designed for standard SFP 1GE modules and dual-rate SFP+ modules operating at 1GE speed.

Qulsar has verified the operation with modules from leading vendors as shown below:

Finisar: FTRJ8519P1BNL, FCLF-8521-3

Intel: AFBR709DMZ-IN3

Avago: AFBR-709DMZ

Ubiquity: UF-MM-1G

FiberStore (FS): H3C SFP-10GSR-85 (SFP+ dual-rate configured for 1GE)

NOTE: SFP Copper modules are also available and will work with Qg 2. The user should be aware that in that case, the PHY is inside the SFP Copper and in most cases will not fully support Synchronous Ethernet feature. In that case, we recommend using the native electrical RJ45 ports on Qg 2.

9.9 LED Description

The Qg 2 has 3 LEDs on the front panel which communicates the status of the Power, GNSS Signal and Sync Status. In addition, there are LEDs on the management and PTP network ports.

9.9.1 Power

Power LED state	Description
Red	Any of the internal voltages are in alarm state. On power-on, this LED is red for 15-20 seconds before changing to amber color
Amber/Orange	Initial boot and OS load completed successfully. Loading Applications.
Green	HW and SW Applications loaded and ready for normal operation
Green - blinking	Qg 2 software upgrade in progress – do NOT reboot or turn power off! Qg2 System webui tab or from CLI system Upgrade Status command

	will indicate the progress of the upgrade and if the upgrade failed then a reboot may be required.
Red - blinking	Previous attempt to upgrade software on Qg 2 failed

9.9.2 GNSS

GNSS LED state	Description
Off	MCE not running or MCE running in PTP only mode or software upgrade in progress
Red	1PPS Input Error or ToD Input Error
Green	Signal acquired, 1PPS Input or ToD Input Available

9.9.3 Sync Status

Sync Status LED state	Description
Off	MCE not running or software upgrade in progress
Red	MCE running, Not Synchronized and engine state is FREE RUNNING
Amber	MCE running, Not Synchronized and engine state is SYNCHRONIZING, SYNTONIZING or HOLDOVER
Green	MCE running, Locked / Synchronized

9.9.4 Management Port

Mgmt Port LEDs state	Description
Both off	No Link
Yellow only	10M link
Green	100M link
Yellow blinking	Traffic

9.9.5 PTP Port 1/2

PTP Port LED state	Description
Both off	No link
Green only	100M link, blinking if traffic
Yellow only	1000M link, blinking if traffic
Both on	10M link, blinking if traffic

9.10 Power

The options are -48 VDC, (-34 to -60 VDC supply) or 28 – 40 VAC. 17-25W power consumption, depending on oscillator option.

Estimated Power Consumption based on Oscillator Option	
Oscillator Option	Power Consumption
OCXO	17 watts
Super OCXO	25 watts

9.11 Physical dimensions

Size: 218 (W) x 160 (D) x 43 (H) mm excluding connectors

Weight: 1.01 kg

9.12 MTBF

The reliability prediction of the Qg 2 has been in accordance with the Telcordia Technologies Special Report SR-332, issue 2:

- MTBF (hours): 162k

Environmental conditions: Ground, Benign and ambient temperature 40 °C.

10 Software Upgrade

10.1 Software Releases

Qulsar provides updated software to the customers on a regular basis in the form of software image releases. These images would typically include new features, enhancements and fixes for issues found. When a new software is released it includes:

- New Release Notes for that specific version
- Updated User Guide document (as needed)

Email notifications will go out to all the customers about the availability of the new release and the related collaterals (Release Notes, User Guide). They are also made available on Qulsar Support portal (https://qulsar.com/Support/Online_Resources/System_SW_Download.html) for registered users to be able to access and download it.

The image is in an encrypted, binary format, which after downloading, is installed on the Qg 2 unit. The specifics of the mechanism will be addressed in the next section.

10.2 Software Upgrade Mechanism

The new version of Qg 2 software can be installed by one of the following methods. After successful installation (takes about 3 – 4 minutes), Qg 2 will automatically reboot and start a new session with the new software.

NOTE: It is very important that during the upgrade process, the unit should not be powered down or restarted as it might lead to undesirable results. If the installation encounters any error, appropriate notification will be made to the user and a reboot may be necessary in that case.

10.2.1 Software Upgrade via WebUI and SFTP (Secure FTP)

The software image should be placed on a server on the same network as Qg 2 management port. The image (or a soft link to it) should be in the /home/<user> folder if it is a Linux server.

From Qg 2 System webpage, the IP address of the SFTP server, the user credentials and the image filename should be provided and followed by pressing the Start SW Upgrade button. It is as shown below:

Software Upgrade [Note: A valid SWM license is required to upgrade]

From Local File No file chosen

- OR -

Protocol

Server IP

SW Image Filename*

Server Login Username

Server Password

Software Upgrade Status

Figure 68 System webpage - SW upgrade via SFTP

The Software Update Status bar at the bottom will show the progress of the upgrade.

10.2.2 Software Upgrade via WebUI and local disk

There is another option besides SFTP to install the new image from the webpage. If the release image is downloaded on a PC, and with the browser connected to Qg 2 unit over the network, then the installation can be easily accomplished. The image download from the local PC to remote Qg2 is done over HTTP(s). By clicking the “Browse” button and navigating to the location of the image and selecting it and then pressing the Start SW Upgrade button will start the installation.

The Software Update Status bar at the bottom will show the progress of the upgrade.

10.2.3 Software Upgrade via CLI

Using the CLI shell, the new software can be installed, as shown below. The option “2” provided in the command line of system Upgrade_Start tells Qg 2 software to use SFTP. That is the only option available from CLI. Option 1 is for FTP which has been deprecated and is not supported any longer.

```

File Edit Setup Control Window Help
-----
Last login: Tue Dec 13 02:38:39 2022 from 10.0.8.2
Sync> system Upgrade_Start 2 10.0.1.61 Qg2v12.1.77new19.fw
Enter user name for FTP/SFTP server:johndoe
Enter Password for FTP/SFTP server(max 20 char):

```

Figure 69 Software Upgrade via CLI

Qg 2 will check the login credentials on the remote server for SFTP before it starts downloading the image for installation. The progress of it can be monitored by using another CLI command,

system Upgrade_Status

10.3 Software Upgrade and SWM

With the release of 12.2.1 software, Qulsar introduced the Software and Support Maintenance (SWM) license key mechanism. The license key is valid for a year and can be renewed by contacting support@qulsar.com and/or sales@qulsar.com. The SWM license key for a specific Qg 2 unit can be obtained by registered users on our support portal.

When a new software image is released(12.2.2 onwards), Qg 2 will first check if there is a valid SWM license key installed. If there is no license key or if the key has expired prior to this new release date, then it will prompt the user to renew the license and enter a new, valid SWM license key. Without which, the upgrade will not proceed.

The following sections show how to retrieve the information and install a new and valid SWM license key.

10.3.1 SWM on System webpage

The figure below shows the current license key (when installed) and an option to enter a new license key in case the previous one has expired.

Serial Number	59612
System Up Time	24 minutes
SWM License Key	QSWA-059612-1023-EDLN-MLXE-HABG (End Date: 10 / 2023)
Install new SWM Lic	<input type="text"/>
	<input type="button" value="Activate"/>

Figure 70 SWM license on System webpage

10.3.2 SWM license on CLI

The SWM license information can also be obtained and a new license key can be installed from CLI.

```
Sync> license<swm> status
SWM-License Key Status: QSWA-059612-1023-EDLN-MLXE-HABG <End Date: 10 / 2023>

Sync> license<swm> install QSWA-059612-1023-EDLN-MLXE-HABG
SWM-License Installed successfully

Sync> □
```

11 End User License Agreement (2022 - 2023)

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Qulsar, Inc.
90 Great Oaks Blvd, #204
San Jose, CA 95119
U. S. A.

Qulsar Sweden AB
Torshamnsgatan 35
SE-164 40 Kista
Sweden

12 Part Numbers

Qg 2 P/N	Description
100-825-02	Qulsar Qg 2, 32 slaves, configurable GNSS, 4 hours holdover
100-825-03	Qulsar Qg 2, 32 slaves, configurable GNSS, 8 hours holdover
100-827-02	Qulsar Qg 2, 128 slaves, configurable GNSS, 4 hours holdover
100-827-03	Qulsar Qg 2, 128 slaves, configurable GNSS, 8 hours holdover
100-828-03	Qulsar Qg 2, 256 slaves, configurable GNSS, 8 hours holdover
100-829-03	Qulsar Qg 2, 450 slaves, configurable GNSS, 8 hours holdover
Please visit https://qulsar.com/Products/Overview/Product_Part_Numbers.html for up-to-date information	

13 Glossary

Acronyms and Abbreviations	
1PPS	Pulse Per Second
1RU	1 Rack Unit, 1.75 inches or 44.45 millimeters
API	Application Program Interface
ASCII	American Standard Code for Information Interchange
BaseT	Megabits / second Transferred over CAT5 cable
BC	Boundary Clock
BMCA	Best Master Clock Algorithm
BNC	Bayonet Neill-Concelman connector
CAT5	Category 5 cable
CLI	Command Line Interface
C-RAN	Cloud-Radio Access Network
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name Server
DST	Daylight Savings Time
E2E	End to End delay measurement mechanism
ESD	Electrostatic Discharge
ETH	Layer 2 network communication for PTP messages
FTP	File Transfer Protocol
FW	Firmware
GC	Gateway Clock
GM	Grand Master
GNSS	Global Navigation Satellite System
GPS	Global Position System
HMI	Human Machine Interface
HTTP	HyperText Transfer Protocol
IEEE	Institute of Electrical and Electronics Engineers
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
LAN	Local Area Network
LED	Light-emitting Diode
MAC	Media Access Control address
Mbps	Megabits per second
MGMT Port	Management Port
MHz	Megahertz Frequency
Mini-USB	Mini Universal Serial Bus
MCE	Managed Clock Engine
NMEA	National Marine Electronics Association
NV	Nonvolatile Memory
OC	Ordinary Clock
OEXO	Oven Controlled Crystal Oscillator
P2P	Peer to Peer delay measurement mechanism
PLL	Phase Locked Loop

PoE	Power over Ethernet
PTP	Precise Time Protocol
PWR	Power
RF	Radio Frequency
RU	Rack Unit
RMC	Recommended Minimum data for GPS, Sentence C from NMEA
SFP	Small Form-Factor Pluggable transceiver
SFTP	SSH File Transfer Protocol or Secure File Transfer Protocol
SMA	SubMiniature version A connector
SNMP	Simple Network Management Protocol
SSH	Secure Shell cryptographic network protocol
ToD	Time of Day
TTL	Transistor-transistor Logic
TZ	Time Zone
UDP	User Datagram Protocol, IPv4. Layer 3 network communication
UDP6	User Datagram Protocol, IPv6. Layer 3 network communication
UIP	User Interface Processor
UTC	Coordinated Universal Time
VAC	Voltage Alternating Current
VDC	Voltage Direct Current
WAN	Wide Area Network
XML	eXtensible Markup Language
ZDA	Data and Time from GPS, NMEA standard

14 References

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15 Contact

Qulsar Headquarters	Qulsar Sweden AB
90 Great Oaks Blvd, #204 San Jose, CA 95119 U. S. A.	Torshamnsgatan 35 SE-164 40 Kista Sweden
Sales Support	
Phone: +1 (408) 715-1098	Phone: +46 8 750 7850 Fax: +46 8 750 7851
Email: sales@qulsar.com	
Technical Support	
Phone: +1 785-727-1263 (+1 QULSAR-1263)	Phone: +46 8 750 7850
Email: support@qulsar.com	