

Global Navigation Satellite Systems

The Global Navigation Satellite System (GNSS) is a positioning, navigation, and timing (PNT) service. It facilitates:

- network synchronization planning,
- enhances flexibility, and
- strengthens resilience in managing synchronization challenges within hierarchical networks.

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Global Navigation Satellite Systems for network synchronization

Time synchronization with GNSS in industrial networks

The router timing module has a built-in GNSS receiver that enables the router to:

- determine its own location, and
- obtain an accurate time from a satellite constellation.

Industrial automation and control systems, utility networks, and military networks require a large number of devices to maintain an accurate and synchronized sense of time.

GNSS signaling

The GNSS receiver acquires satellites and provides timing signals to the host system in two ways.

- Self-survey mode
- Overdetermined clock mode

Summary

GNSS signaling calculates and stores position data to establish a stable reference and then delivers precise timing signals for reliable network synchronization. This is achieved through the Self-Survey and Overdetermined clock modes.

Workflow

Table 1: GNSS receiver modes

Mode	Description
Self-survey	This mode automates position calculation, result storage, and faster transitions to operational modes: • After a reset, the GNSS receiver enters self-survey mode. • It calculates a 3D position after locking onto at least four satellites. • Around 2,000 positions are calculated over 35 minutes. • Once complete, it generates timing signals and switches to the Normal (Locked to GPS) mode. • The Self-survey mode results are saved to the receiver's flash memory, enabling quicker transitions to Overdetermined clock mode. • Each new self-survey overwrites the previous results in flash memory. • You can manually restart the self-survey using the **gnss self-survey restart** command.
Overdetermined clock	The device enters Overdetermined clock mode after completing the self-survey and storing position data in non-volatile memory. In this mode, the GNSS receiver provides timing information based on the satellite positions stored during the self-survey Cisco IOS collects PPS signals only in Overdetermined clock mode, as timing signals during self-survey mode can have an error of up to 20 seconds. The GNSS receiver stays in Overdetermined clock mode and can restart the self-survey in these scenarios: • automatically, if the antenna is moved more than 100m, and • manually, using the **gnss self-survey restart** command.

After locking onto a satellite system, the GNSS receiver sends a 10-ms-wide PPS (Pulse Per Second) pulse and the current time and date to the Cisco IOS time service.

Restrictions for GNSS timing source

Use these guidelines when employing GNSS as a timing source and monitoring related events.

- GNSS is available as a timing source only for the default PTP and power profiles.

- GNSS can be used as a PTP timing source only in GMC-BC mode.
- The supported syslog messages for GNSS events are:
  - entering self-survey mode,
  - reaching the OD mode, and
  - firmware upgrade status—start, complete, or fail.
- When the router loses the antenna signal while acting as the PTP GMC:
  - clock quality degrades and
  - a GMC switchover occurs.
- GPS antenna alarms do not trigger external relay alarms.
- To configure GNSS Auto, verify that a minimum of eight satellites are tracked for each enabled major GNSS, such as GPS, or Global Navigation Satellite System (GLONASS).
- The Antenna Open alarm may activate without a hardware issue. In such situations, configure the constellation AUTO to GPS or another available constellation.

GNSS receiver functionality

The router uses a GNSS receiver to deliver precise frequency and phase output for the host system. When connected to an external GNSS antenna, the receiver automatically:

- delivers an accurate one pulse-per-second (PPS) signal.
- offers a stable 10 MHz frequency output.
- acquires GNSS satellite signals.
- tracks up to 32 satellites.
- calculates location, speed, heading, and time.

For more information on the GNSS receiver and its timing signals, see GNSS signaling.

Note It is recommended to use the GPS LRM-400 cable for GNSS to verify that you can monitor all GNSS alarms. For details on supported antennas and cables, see the *Cisco Catalyst IR8340 Rugged Series Router Hardware Installation Guide*.

The GNSS supports these frequency bands:

- AUTO—GPS, QZSS, and GLONASS (default)
- GPS
- GLONASS
- BeiDou
- Galileo

GNSS features

This table lists the GNSS features of the router.

Table 2: GNSS features of Cisco Catalyst IR8340 Rugged Series Router

Feature	Description
Time mode	A receiver mode where the position of receiver is fixed, and only the time is calculated using all available satellites.
survey-in	A procedure performed before enabling time mode. It determines the position of a stationary receiver by averaging all valid 3D position solutions over time. The receiver: • computes the average position over time until it achieves a predefined standard deviation, • ensures the minimum observation time has passed, • switches to fixed mode, and • activates the timing features automatically.
survey-in and fixed-position navigation	• reduces timing jitter, even at low signal levels, and • maintains synchronization with a single satellite in view
Time pulse accuracy	• clear sky—20 ns • indoor—500 ns.

Feature	Description
Per second activity	Once the receiver locks onto the signal, the router performs these tasks every second: • reads the updated time and date. • retrieves the PPS timestamp from the hardware. • sends the time, date, and PPS timestamp to the GNSS virtual clock or servo. The GNSS virtual clock then drives the PTP output.

Use the **constellation** command to select between these constellations (Global Positioning System (GPS) and Global Navigation Satellite System (GLONASS)). Changing the constellation restarts the survey-in process to lock onto the new constellation. For more details, see Configure the satellite constellation for GNSS, on page 6.

Default time of day format for GNSS

The default Time of Day (TOD) format is UBX, and a one PPS output is available when GNSS is locked (Example: PRTC mode).

To achieve a lock at a one-Hertz frequency, you can configure these commands.

- **network-clock synchronization automatic**
- **network-clock synchronization mode QL-enabled**
- **network-clock quality-level rx QL-PRC External R0 1hz**
- **network-clock input-source 1 External R0 1hz**
- **network-clock wait-to-restore 10 global**

GNSS LED

The GNSS LED (labeled 'GPS' on both the cable side and power supply side) shows the GNSS status. This table shows LED colors and their meaning.

Table 3: GNSS LED

Color	Status
Blinking green	Attempt to acquire satellite fix.
Solid green	GNSS has valid signal or fix.
Blinking amber	Antenna fault.
Off	GNSS not configured.

Primary Reference Time Clock mode with GNSS

Primary Reference Time Clock (PRTC) mode with GNSS provides a precise and reliable timing source for synchronization in high-precision networks like telecommunications and industrial systems.

The router operates in Primary Reference Time Clock (PRTC) mode with these characteristics:

- It functions in PRTC mode when GNSS is locked, and telecom profiles are not configured.
- In this mode, it outputs Time of Day (TOD) in UBX format along with a one PPS signal.
- Ordinary clocks and transparent clocks under LAN profiles are not supported while in PRTC mode.
- All boundary clocks in LAN profiles operate exclusively in Grandmaster Clock-Boundary Clock mode (GMC-BC mode) using GNSS input for timestamps and grandmaster clock details.
- In GMC-BC mode, the clock quality values:

```
Clock Quality:
            Class: 6                        //----GNSS CLASS
            Accuracy: Within 250ns          //----GNSS Accuracy
            Offset (log variance): 20061    //----GNSS Variance
```

- PRTC mode is supported on default PTP profile and power profile. The conversion to this mode takes place automatically when GNSS moves to a locked state.
- GNSS cannot be configured if any of these modes or options are configured:
  - 802.1AS (Time-Sensitive Networking Standard)
  - PTP Transparent Clock (TC) mode
  - GMC-BC options

Configure the satellite constellation for GNSS

Perform these steps to configure the satellite constellation for Global Navigation Satellite System (GNSS).

Procedure

Step 1 Use the **configure terminal** to enter the configuration mode.

Example:

```
Router# configure terminal
```

Enter global configuration mode.

Step 2 Use the **gnss** command to enable GNSS.

Example:

```
Router(config)# gnss
```

When GNSS is enabled, it collects PPS timestamp information.

When GNSS is disabled: The chip functions normally, but no software process collects timestamp or PPS information.

Step 3 Use the **constellation** command to configure the GNSS constellation.

Example:

```
Router(config-gnss)# constellation gps
```

(Optional) Configure the GNSS constellation. The default is auto (GPS+GLONASS+QZSS). Only one constellation is active at any given time.

The syntax of the command: **[no] constellation** { **auto** | **galileo** | **gps** | **glonass** | **beidou**}

Table 4: Syntax description

Keyword	Description
no	Clears the configuration.
constellation	sets the active GNSS constellation policy.
auto	Automatically selects the best available constellation.
galileo	Uses the European Union's global navigation satellite system constellation.
gps	Uses the GPS constellation.
glonass	Uses the Russian Federation's global navigation satellite system constellation.
beidou	Uses the China's global navigation satellite system constellation.

Step 4 Use the **exit** command to exit the GNSS configuration mode.

Example:

```
Router(config-gnss)# exit
```

Step 5 (Optional) Use the **show gnss status** command to view the GNSS status. This action is possible after the GNSS receiver has completed self-survey mode and is providing timing information from the satellite system.

Example:

```
Router# show gnss status
  GNSS status:
  GNSS status: Enable
  Clock Progress: Locked (GnssFixOK)
  GNSS Fix Type: time only fix
  Constellation: GLONASS
  Satellite count: 9
  PDOP: 99.989998  TDOP: 0.350000
  HDOP: 99.989998  VDOP: 99.989998
  Major Alarm: False
  Minor Alarm: False
```

This table shows the possible values for the GNSS and its receiver status.

Table 5: The possible values

Status values	Receiver values	
• Enable • Disable	Receiver Status	• auto—Auto mode for 2D/3D • 1SV—Single satellite • 2SV—Horizontal (2D) • 3SV—Full position (3D) • OD—Overdetermined
	Alarm	• Antenna open • Antenna shorted • Not tracking satellites • Survey-in progress • No stored position • Leap second pending
	Survey progress	This field shows the progress of the survey as a percentage of fixes collected so far. The self-survey is complete when the self-survey progress reaches one hundred percent.
	Positioning	• PDOP—Position Dilution of Precision • HDOP—Horizontal Dilution of Precision • VDOP—Vertical Dilution of Precision • TDOP—Time Dilution of Precision

Note
If any GNSS alarm conditions are present, the switch may not be providing timing information from the satellite system.

The alarm clears automatically.

Step 6 (Optional) Use the **show gnss satellite** command to view the GNSS-tracked satellite status.

Example:

```
Router# show gnss satellite all
All Satellites Info:

SV ID  Channel  Eph Flag  SV Used  CNR  Azimuth  Elevation  Health  Quality

--------------------------------------------------------------------------------
   19        6         1        -   24      260          1       1        4
   18        6         1        -   31      219          2       1        7
   15        6         1     Used   46      223         42       1        7
   14        6         1     Used   44      340         73       1        7
   13        6         1     Used   36       22         20       1        7
    4        6         1     Used   48      349         27       1        7
```

```
    3        6         1     Used   48       53         51       1        7
    2        6         1     Used   45      114         24       1        7
```

The syntax of the command: **show gnss satellite { all | satellite-number }**

Carrier-to-Noise Density, abbreviated as (C/N0) displays signal strength. The signal strength unit is dB-Hz and refers to the ratio of the carrier power and the noise power (dB) *per unit bandwidth* (Hz). Received satellite signal power varies with user antenna gain, satellite elevation angle, and satellite age. Typical C/N0 range is from 35 dB-H to 55 dB-Hz.

Step 7 (Optional) Use the **show gnss time** command to monitor the GNSS time.

Example:

```
Router## show gnss time
  Current GNSS Time:
  Time: 2021/12/09  07:11:59 UTC
```

Step 8 (Optional) Use the **show gnss location** command to view the GNSS location.

Example:

```
Router## show gnss location
  Current GNSS Location:
  LOC: 12:56.187572 N  77:41.742096 E  832.44 m
```

Step 9 (Optional) Use the **show gnss device** command to monitor the GNSS device information.

Example:

```
Router# show gnss device
  GNSS device:
  Model: NEO-M8T-0
  Software version: EXT CORE 3.01 (111141)
  Hardware version: 00080000
  Protocol version: 22.00
  Firmware version: TIM 1.10
  Unique Chip ID: 311652325097
  Major GNSS Satellites supported: GPS;GLO;GAL;BDS
```

Step 10 (Optional) Use the **show network-clocks synchronization** command to view the network clock synchronization status.

Example:

```
Router# show network-clocks synchronization
Symbols:     En - Enable, Dis - Disable, Adis - Admin Disable
             NA - Not Applicable
             *  - Synchronization source selected
             #  - Synchronization source force selected
             &  - Synchronization source manually switched
Automatic selection process : Enable
Equipment Clock : 2048 (EEC-Option1)
Clock Mode : QL-Enable
ESMC : Enabled
SSM Option : 1
T0 : External R0 1hz
Hold-off (global) : 300 ms
Wait-to-restore (global) : 10 sec
Tsm Delay : 180 ms
Revertive : No
Nominated Interfaces
 Interface            SigType     Mode/QL      Prio  QL_IN  ESMC Tx  ESMC Rx
 Internal             NA          NA/Dis       251   QL-SEC    NA        NA
```

```
*External R0          1HZ         NA/Dis       1     QL-PRC    NA        NA
```

Step 11 (Optional) Use the **show platform hardware network-clocks** command to view the available network clocks in the hardware.

Example:

```
Router# show platform hardware network-clocks
DPLL1 Status:
-------------
Bandwidth: 0.001 Hz
Phase Slope Limit: 885 ns/s
Current PLL1 Mode: MANUAL NORMAL
Current Input Selected: REF4 (CLK_PPS_GPS_PLL)
Current PLL1 Holdover Status: OFF
Current PLL1 Lock Status: ON
DPLL2 Status:
-------------
Bandwidth: 0.001 Hz
Phase Slope Limit: 885 ns/s
Current PLL2 Mode: MANUAL NORMAL
Current Input Selected: REF4 (CLK_PPS_GPS_PLL)
Current PLL2 Holdover Status: OFF
Current PLL2 Lock Status: ON

Router# show platform hardware network-clocks
  Current Input Status:
  REF0 (CLK_LOOPBACK1)   : OK
  REF1 (CLK_LOOPBACK2)   : OK
  REF2 ((TDM_SYNC_MB_PLL) : FAIL (SCM, CFM, GST, PFM failed)
  REF3 (RSV_2_M_PLL)      : FAIL (SCM, CFM, GST, PFM failed)
  REF4 (CLK_PPS_GPS_PLL)  : OK
  REF5 (CLK_PPS_MB_PLL)   : FAIL (SCM, CFM, GST, PFM failed)
  REF6 (CLK_REC_25M_WAN1) : FAIL (SCM, CFM, GST, PFM failed)
  REF7 (CLK_REC_25M_WAN2) : FAIL (SCM, CFM, GST, PFM failed)
  REF8 (CLK20M_OCXO)      : OK
  REF9 (RSV_1_MB_PLL)     : FAIL (SCM, CFM, GST, PFM failed)

DCO Frequency:
  Current_DCO_Freq_Offset: -0.033687
```