

Global Navigation Satellite System (GNSS)

A global navigation satellite system (GNSS) is a satellite-based positioning and timing system that

- provides precise timing signals for synchronization,
- allows receivers to determine their position by decoding signals from multiple satellites, and
- enables direct access to accurate timing in distributed networks.

A GNSS receiver obtains signals from several satellites and determines its distance from each one. This information lets the receiver calculate its position and recover accurate clock timing. Telecommunications networks traditionally synchronize by distributing a stratum-1 clock in a hierarchy. GNSS removes this hierarchy so access networks can take timing directly from satellites using onboard chips.

For accurate operation, make sure all systems use a common time scale. If your system detects timing mismatches, your GNSS receiver may only use one satellite constellation. More satellites provide better coverage and reliability. This approach makes network synchronization planning more flexible and resilient. Cisco IOS XR routers now include support for onboard GNSS receivers to recover accurate timing.

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GNSS Modules and Operations

A GNSS module is a hardware component that

- acquires and tracks satellite signals to determine precise geographic location
- provides accurate timing signals (including 1-PPS and 10 MHz frequency outputs) to synchronize network devices, and
- supports multiple operating modes (self-survey and over-determined clock) to ensure stable time and position reference for routers.

You can find the GNSS module on the front panel of the Route Processor (RP) module and order it separately. You do not need a license to enable the GNSS module.

When connected to an external antenna, the module can acquire satellite signals, track up to 32 GNSS satellites, and compute location, speed, heading, and time. GNSS provides an accurate one pulse-per-second (PPS), a stable 10 MHz frequency output for synchronizing wireless, aggregation, and pre-aggregation routers, and an accurate time-of-day (ToD).

By default, anti-jamming is enabled on the GNSS module.

A router with a GNSS module can maintain highly accurate network timing for broadband services even after a power cycle, resuming normal operation in over-determined clock mode using stored positional data.

Modes of GNSS module operation

Summary

A GNSS module operates in one of these modes. Both modes acquire and provide timing signals to Cisco 8000 routers.

Workflow

1. **Self-survey mode** - When the router is reset, the GNSS module comes up in self-survey mode.It tries to lock on to a minimum of four satellites. It computes approximately 2,000 different satellite positions to obtain a three-dimensional location (latitude, longitude, and height) of its current position. This operation takes about 35 to 40 minutes. During this stage, the module generates accurate timing signals and achieves a normal or phase-locked state.
2. **Over-determined clock mode** - The router switches to over-determined (OD) mode when self-survey mode is complete and the position information is stored in non-volatile memory. In this mode, the module only processes the timing information based on satellite positions captured in self-survey mode.

Best practice: Do not configure multiple time sources

Do not configure both the front panel (10M, 1PPS, and ToD) input configuration and the GNSS input configuration. Configuring multiple time sources can lead to synchronization issues.

Conditions for GNSS mode transitions

The Global Navigation Satellite System (GNSS) module operates in over-determined (OD) mode until you trigger one of these conditions:

- If you relocate the antenna by more than 100 meters, the system automatically restarts the self-survey mode.
- If you restart the self-survey mode manually.
- If you delete the stored reference position.
- If you consider a worst-case recovery scenario after a jamming-detection condition that you cannot resolve with other methods.

The router stores the tracking data. The tracking data remains available even after the router restarts. If you want to change the tracking data, use the **no shutdown** command to set the GNSS interface to its default value.

GNSS module default states and reboot behavior

The GNSS module operates in these ways:

- Configure the module to track any satellite constellation automatically or use a specific constellation. The module uses the configured satellites only in OD mode.



Note You cannot enable GLONASS and BeiDou satellites together.

- After you reload the router, the GNSS module switches to OD mode unless one of these conditions applies:
  - You reload the router during a self-survey operation.
  - If you move the router by more than 100 meters from its previous position.
- If you restart the self-survey using the default **gnss slot R0/R1** command in configuration mode, the 10 MHz, 1 PPS, and ToD signals stay up and do not change.



Note You can access the R1 slot only on modules that support dual RP.

GNSS Prerequisites

To ensure proper GNSS operation:

- Configure 1PPS, 10 MHz, and ToD to enable network synchronization and precision time protocol.
- Make sure your antenna has a clear view of the sky.
- Lock at least 4 satellites for accurate timing.

Restrictions for GNSS

- You must configure the GNSS module using commands; SNMP does not support GNSS module configuration.
- After the GNSS module has maintained lock for 12 hours, its holdover performance remains within 1 microsecond over a 2-hour holdover period.
- The GNSS FPD displays the current version and automatically executes necessary firmware upgrades during the boot sequence.

- Manual runtime upgrades or downgrades for GNSS FPD are not supported.

PRTC Mode with GNSS

A Primary Reference Time Clock (PRTC) mode with GNSS is a timing synchronization method for Cisco 8000 routers that

- requires GNSS lock and the absence of telecom profiles,
- provides ToD + 1PPS outputs in UBX format, and
- forces all boundary clocks into GMC-BC mode based on GNSS input.
- When you enable PRTC mode, the router disables ordinary and transparent clocks in LAN profiles. Boundary clocks operate in GMC-BC mode and retrieve timestamps from the GNSS input.
- Clock quality values provided by the GMS-BC master clock include:

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

- PRTC mode is supported on PTP Default and Power profiles, and conversion occurs automatically when GNSS moves to locked state.

Note GNSS cannot be configured if any of the following are present:

- 802.1AS
- PTP TC mode
- GMC-BC options

Class Support Matrix

Use this table to check which GNSS class is supported on Cisco 8000 series routers and line cards.

Table 1: GNSS Class Support Matrix

Hardware Module	Supported GNSS Class	Cisco IOS XR Release
8711-28H8F-M	PRTC-B	Release 26.3.1
8711-48Z-M	PRTC-B	Release 25.4.1
8011-12G12X4Y-A/D	PRTC-B	Release 25.4.1
8011-32Y8L2H2FH	PRTC-B	Release 25.4.1

Hardware Module	Supported GNSS Class	Cisco IOS XR Release
8011-4G24Y4H-I	PRTC-B	Release 25.1.1
8712-MOD-M	PRTC-B	Release 24.4.1
8711-32FH-M	PRTC-B	Release 24.3.1

Configure GNSS

Enable Global Navigation Satellite System (GNSS) reception and synchronization features to provide accurate timing and location information on your router.

Use this task to configure GNSS on supported router models so the device can synchronize its system clock with secure satellite sources. GNSS enables applications to use precise time and geographic data..

Before you begin

- Ensure the router model supports GNSS.
- Make sure you have administrative (privileged EXEC) access to the router.
- Find the correct slot and location to install the GNSS receiver module.

Follow these steps to configure GNSS on your router:

Procedure

Step 1 Enable the GNSS receiver and enter GNSS configuration submode:

At the router prompt, run:

```
Router(config)# gnss-receiver 0 location 0/0/CPU0
```

Step 2 Enable frequency synchronization for the receiver:

In GNSS configuration submode, run:

```
Router(config-gnss)# frequency synchronization
```

Step 3 Select the input source for frequency synchronization:

In frequency synchronization submode, run:

```
Router(config-gnss-freqsync)# selection input
```

Step 4 (Optional) Customize GNSS receiver settings as needed:

Example:

```
gnss-receiver 0 location 0/RP0/CPU0
frequency synchronization
  selection input
  priority 1
  wait-to-restore 0
  quality receive exact itu-t option 1 PRC
```

```
 !
!
```

```
Router(config)# gnss-receiver 0 location 0/0/CPU0
```

- Disable anti-jam protection.

  ```
  Router(config-gnss)# anti-jam disable
  ```

- Specify a constellation such as GPS.

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

- Adjust the signal-to-noise threshold.

  ```
  Router(config-gnss)# snr threshold 10
  ```

- Set the receiver priority and wait-to-restore values.

  ```
  Router(config-gnss-freqsync)# priority 5
  Router(config-gnss-freqsync)# wait-to-restore 0
  ```

Step 5 Verify GNSS receiver status and operation:

Example:

```
Router# show gnss-receiver
GNSS-receiver 0 location 0/RP0/CPU0
    Status: Available, Up
    Position: 741:12.12 N 4451:39.60 E 0.827km
    Time: 2019:01:17 14:43:08 (UTC offset: 18s)
    Firmware version: 1.4
    Lock Status: Phase Locked, Receiver Mode: 3D-fix
    Survey Progress: 100, Holdover Duration: 0
    Major Alarm: Not used
    Minor Alarm: Not used
    Anti-jam: Enabled, Cable-delay compensation: 0
    1PPS polarity: Positive
    PDOP: 6.000, HDOP: 0.000, VDOP: 0.000, TDOP: 1.000
    Constellation: GPS, Satellite Count: 10
```

Example:

```
Router# show gnss-receiver
Fri Jan 17 07:27:34.804 UTC
GNSS-receiver 0 location 0/RP0/CPU0
    Status: Available, Up
    Position: 12:56.18 N 77:41.77 E 0.823km
    Time: 2020:01:17 07:31:41 (UTC offset: 0s)
    Locked at: 2020:01:15 17:15:28
    Firmware version: TIM 1.10
    Lock Status: Phase Locked, Receiver Mode: Time fix only
    Survey Progress: 100, Holdover Duration: Unknown
    Major Alarms: Unknown
    Minor Alarms: Unknown
    Anti-jam: Enabled, Cable-delay compensation: 0
    1PPS polarity: Positive
    PDOP: 99.990, HDOP: 99.990, VDOP: 99.990, TDOP: 0.240
    Constellation: GPS, Satellite Count: 17
    Satellite Thresholds:
        SNR - 0 dB-Hz, Elevation - 0 degrees, PDOP - 0, TRAIM - 0 us
    Satellite Info:
        CHN: Channel, AQUN: Aquisition, EPH: Ephemeris
        PRN   CHN   AQUN   EPH    SV           Signal
        No.   No.   Flag   Flag   Type         Strength   Elevat'n   Azimuth
        ---   ---   ----   ----   -----------  --------   --------   --------
```

```
  1   n/a   On     On     GPS             44.000     19.000    220.000
  3   n/a   On     On     GPS             48.000     62.000    299.000
  4   n/a   On     On     GPS             46.000     30.000    338.000
  7   n/a   On     On     GPS             47.000      9.000    261.000
  8   n/a   On     On     GPS             41.000     17.000    172.000
  9   n/a   On     On     GPS             44.000      7.000    317.000
 11   n/a   On     On     GPS             42.000     10.000    202.000
 14   n/a   On     On     GPS             42.000     22.000     90.000
 16   n/a   On     On     GPS             46.000     66.000     59.000
 22   n/a   On     On     GPS             47.000     71.000    238.000
 23   n/a   On     On     GPS             46.000     27.000    332.000
 26   n/a   On     On     GPS             48.000     40.000     40.000
```

- Use the following command to display GNSS status and receiver details:

```
Router# show gnss-receiver
```

- Review information, including receiver status, position, time, firmware version, lock status, satellite count, and constellation type.

You have configured and activated the GNSS receiver. The router synchronizes its system clock and location information using the selected satellite constellation. You can verify correct operation using the **show gnss-receiver** command.

What to do next

- Monitor GNSS receiver status regularly for alarms or synchronization issues.
- Use the **show gnss-receiver** command as needed to confirm continued service availability.