Global Navigation Satellite System for IE 5000

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Information About GNSS

Industrial automation and control, utilities, and military networks require large numbers of devices in their networks to have an accurate and synchronized view of time. Cisco Industrial Ethernet switches are capable of accurate time distribution using PTP or IRIG-B, but previously relied on an external source (Grand Master Clock) to provide accurate time. The IE 5000 switch has a built-in Global Navigation Satellite System (GNSS) receiver that enables the switch to determine its own location and get an accurate time from a satellite constellation. The switch can then become the source (Grand Master Clock) for time distribution in the network. GNSS capability simplifies network synchronization planning and provides flexibility and resilience in resolving network synchronization issues in a hierarchical network.

GNSS Hardware

The IE 5000 uses a GNSS receiver with precise frequency and phase outputs for the host system. When connected to an external GNSS antenna, the receiver contains all the circuitry necessary to automatically acquire GNSS satellite signals, track up to 32 GNSS satellites, and compute location, speed, heading, and time. It provides an accurate one pulse-per-second (PPS) and stable 10 MHz frequency output. For more information, see GNSS Signaling, on page 2

The GNSS chip supports the following frequency bands:

- GPS/NAVSTAR - Global Positioning System – USA: L1
- GLONASS – Global’naya Navigatsionnaya Sputnikovaya Sistema – Russia: L1/G1
- BeiDou – China: (including B1-2)

Note

The Galileo satellite system is not currently supported in the released software.

Software

The GNSS feature is available for all feature sets (lanbase, ipservices). GNSS software performs the following functions:

- Configures the GNSS receiver.
- After the receiver has gained lock, software performs the following functions once per second:
  - Reads the new time/date.
  - Reads the corresponding PPS timestamp from the hardware.
  - Feeds time/date and PPS timestamp into the Time Services SW Virtual Clock/Servo for GNSS.

The GNSS SW Virtual Clock time can then be used to drive PTP output.

GNSS Signaling

There are two stages in the process for the GNSS receiver to acquire satellites and provide timing signals to the host system:
• Self-Survey Mode: On reset, the GNSS receiver comes up in self-survey mode and attempts to lock on to a minimum of four different satellites to obtain a 3-D fix on its current position. It computes nearly 2000 different positions for these satellites, which takes about 35 minutes. Also during this stage, the GNSS receiver is able to generate accurate timing signals and achieve “Normal (Locked to GPS)” state. Note that the timing signal obtained during self-survey mode can be off by 20 seconds; therefore, Cisco IOS collects PPS only during OD mode.

After the self-survey is complete, the results are saved to the GNSS receiver flash, which speeds up the transition to OD mode the next time the self-survey runs. You can manually restart the self-survey process with the `gnss self-survey restart` Cisco IOS command. After self-survey mode completes again, the results in the GNSS receiver flash are overwritten with the updated results.

• Over-determined (OD) clock mode: The device transitions to OD mode when self-survey mode is completed and the position information is stored in non-volatile memory on the device. In this mode, the GNSS receiver outputs timing information based on satellite positions obtained in self-survey mode.

The GNSS receiver remains in OD mode until there is a reason to leave it, such as:

• Detection of a position relocation of the antenna of more than 100m, which triggers an automatic restart of the self-survey.

• Manual restart of the self-survey using the `gnss self-survey restart` command.

After the GNSS receiver locks on to a satellite system, it sends a 10ms wide PPS pulse and the current time/date according to the satellite system to the Cisco IOS time service.

**GNSS LED**

The GNSS LED (labeled "GPS" on the cable side and power supply side LEDs) indicates the GNSS status. The following table shows LED colors and their meaning.

<table>
<thead>
<tr>
<th>Color</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flashing Green</td>
<td>• GNSS is in self-survey mode.</td>
</tr>
<tr>
<td></td>
<td>• The signal is lost.</td>
</tr>
<tr>
<td>Solid Green</td>
<td>• GNSS is in normal state and self-survey is complete.</td>
</tr>
<tr>
<td></td>
<td>• GNSS has valid signal/fix.</td>
</tr>
<tr>
<td>Amber</td>
<td>• GNSS receiver firmware upgrade is in process.</td>
</tr>
<tr>
<td></td>
<td>After the GNSS receiver firmware upgrade is complete,</td>
</tr>
<tr>
<td></td>
<td>GNSS is reset and the LED flashes green as self-survey starts after reset.</td>
</tr>
<tr>
<td></td>
<td>• A GNSS error occurred, such as antenna open, antenna shorted, no tracking satellite, etc.</td>
</tr>
<tr>
<td></td>
<td>See <code>show gnss status</code> command for details.</td>
</tr>
</tbody>
</table>
Guidelines and Limitations

- GNSS is supported only on IE 5000 switches with SKUs that have Version ID (VID) v05 or higher. The `show version` command output includes the VID:

  Switch# show version
  .
  .
  Version ID : V05

- The GNSS feature is supported only on IE 5000 switches that have GNSS receiver firmware version 1.04. To verify the GNSS firmware version, use the `show version` command:

  Switch# show version
  .
  .
  GNSS firmware version : 1.04

- A GNSS license is not required. The GNSS feature is available for all feature sets (lanbase, ipservices).

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

- GNSS is available as a timing source for PTP only when PTP is in GMC-BC mode.

- Syslog messages are sent when the following GNSS events occur:
  - GNSS is in self-survey mode.
  - GNSS reaches OD mode.
  - GNSS firmware upgrade is in progress, complete, or failed.

- If the switch is the PTP grandmaster clock and it loses the antenna signal, the clock quality will degrade, resulting in a grandmaster clock switchover.

- The GPS antenna alarm will not trigger an external relay alarm.

Default Settings

GNSS is disabled by default.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>cable-delay</td>
<td>Amount of time to compensate for cable delay in nanoseconds.</td>
<td>0</td>
</tr>
<tr>
<td>antenna power</td>
<td>Antenna power input voltage.</td>
<td>5</td>
</tr>
<tr>
<td>constellation</td>
<td>Satellite constellation that GNSS detects and locks to.</td>
<td>gps</td>
</tr>
</tbody>
</table>
### Configuring GNSS

Perform these steps to configure GNSS. To disable GNSS after it is enabled or to remove a GNSS parameter configuration, use the `no` form of the commands shown in the steps below. Configuring GNSS parameters is optional if you use the defaults.

#### Before you begin

Refer to the documentation for your GNSS antenna to determine the antenna’s power input voltage.

#### Procedure

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Step 1** | Enter global configuration mode:  
`Switch# configure terminal` |
| **Step 2** | Enable GNSS:  
`Switch(config)# gnss`  
When GNSS is enabled, the GNSS process will run to collect GNSS pulse-per-second (PPS) timestamp information.  
When GNSS is disabled, the chip operates normally, but there is no software process running to collect GNSS timestamp and PPS information. |
| **Step 3** | (Optional) Enter a value in nanoseconds to compensate for antenna cable delay:  
`Switch(config-gnss)# [no] antenna cable-delay cable-delay-in-nanoseconds`  
_cable-delay-in-nanoseconds:_ A number from -100,000,000 to 100,000,000 nanoseconds.  
A negative value means that PPS is output earlier to compensate for cable delay. By default, no cable delay is configured. The default value is 0.  
It is recommended to compensate 5 nanoseconds per meter of cable. |
| **Step 4** | (Optional) Configure the antenna power input voltage:  
`Switch(config-gnss)# [no] antenna power {3.3 | 5}`  
The default antenna power input voltage is 5 volts. |
| **Step 5** | (Optional) Configure the GNSS constellation:  
`Switch(config-gnss)# [no] constellation {gps | glonass | beidou}` |
• gps: Enables detection and locking to the GPS constellation.
• glonass: Enables detection and locking to the GLONASS constellation.
• beidou: Enables detection and locking to the BeiDou constellation.

The default is gps.

Only one constellation is active at any given time.

**Step 6**  
(Optional) Disable or enable anti-jam for GNSS:

Switch(config-gnss)# [no] anti-jam

- **Enabled:** A minimum of two satellites is required for a fix in over-determined clock mode, and three satellites are required for the first fix in self-survey mode.
- **Disabled:** Only one satellite is required for a valid timing fix.

By default, anti-jam is enabled.

**Step 7**  
(Optional) Restart the self-survey process:

Switch# gnss self-survey restart

This command deletes the stored reference position and restarts the self-survey process. After self-survey mode is complete, the new reference position is saved to the GNSS chip flash.

Use this command when the switch is moved to another location.

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### Configuring GNSS as Time Source for PTP

Follow these steps to select the time source for PTP. The `ptp mode gmc-bc` command to select the time source is available for both the PTP default profile and the PTP power profile.

When this command is configured and the clock is active and GNSS is in normal state, the GNSS PPS and timestamp string are used as input to PTP.

**Before you begin**

Ensure that the PTP clock is active and GNSS is enabled and in normal state. For more information about PTP configuration, see *Precision Time Protocol Software Configuration Guide for IE 4000, IE 4010, and IE 5000 Switches*.

**Procedure**

**Step 1**  
Enter global configuration mode:

Switch# configure terminal

**Step 2**  
Configure the switch for grandmaster-boundary clock mode:

Switch(config)# ptp mode gmc-bc
**Example**

```
Switch(config)# ptp mode gmc-bc
Switch(config)# exit
Switch# show ptp clock  → Verify PTP

PTP CLOCK INFO
PTP Device Type: Grand Master clock - Boundary clock  → Verify GMC-BC mode
PTP Device Profile: Default Profile
Clock Identity: 0x34:C0:F9:FF:FE:59:11:80
Clock Domain: 0
Number of PTP ports: 28
Time Transfer: Linear Filter
Priority1: 128
Priority2: 128
Clock Quality:
  Class: 6
  Accuracy: Within 250ns
  Offset (log variance): N/A
Offset From Master(ns): 0
Mean Path Delay(ns): 0
Steps Removed: 0  → Verify this node is the master. 0 step away from master.
Local clock time: 15:46:42 UTC May 26 2017

Switch# show ptp time-property

PTP CLOCK TIME PROPERTY
Current UTC offset valid: TRUE
Current UTC offset: 37
Leap 59: FALSE
Leap 61: FALSE
Time Traceable: TRUE
Frequency Traceable: TRUE
PTP Timescale: TRUE
Time Source: GNSS  → Verify GNSS is the time source
```

**Verifying Configuration**

<table>
<thead>
<tr>
<th>Command</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>show gnss status</td>
<td>Display the GNSS status.</td>
</tr>
<tr>
<td></td>
<td>See example output with field descriptions below.</td>
</tr>
<tr>
<td>show gnss satellite {all</td>
<td>satellite-number}</td>
</tr>
<tr>
<td></td>
<td>The signal strength is displayed in the form carrier-to-noise density (C/N0). 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 35–55 dB-Hz.</td>
</tr>
<tr>
<td>show gnss time</td>
<td>Display GNSS time.</td>
</tr>
<tr>
<td>show gnss location</td>
<td>Display GNSS location.</td>
</tr>
<tr>
<td>Command</td>
<td>Purpose</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>show platform gnss</td>
<td>Display GNSS hardware chip. If applicable, display firmware upgrade progress (the remainder of bytes to be sent/total image size).</td>
</tr>
<tr>
<td>show version</td>
<td>Display GNSS firmware version.</td>
</tr>
<tr>
<td>debug gnss {configuration</td>
<td>driver</td>
</tr>
</tbody>
</table>

The following shows example output for `show gnss status` after the GNSS receiver has completed self-survey mode and is providing timing information from the satellite system:

```
# show gnss status
GNSS status: Enable
Constellation: GPS
Receiver Status: OD
Survey progress: 100
Satellite count: 7
PDOP: 1.00  TDOP: 1.00
HDOP: 0.00  VDOP: 0.00
Alarm: None
```

Status fields and possible values are:

- **GNSS status**
  - Enable
  - Disable

- **Receiver Status**
  - Auto—Auto mode for 2D/3D
  - 1SV—Single satellite
  - 2SV—Horizontal (2D)
  - 3SV—Full position (3D)
  - OD—Over-determined

- **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 100%.

- **PDOP**—Position dilution of precision
- **HDOP**—Horizontal dilution of precision
- **VDOP**—Vertical dilution of precision
- **TDOP**—Time dilution of precision
- **Alarm**
  - Antenna open
• Antenna shorted
• Not tracking satellites
• Survey-in progress
• No stored position
• Leap second pending

**Note**

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

The alarm will clear automatically.

The following shows example output for `show gnss satellite`:

```
Switch# show gnss satellite all
SV Type Codes: 0 - GPS, 1 - GLONASS, 2 - Beidou

All Satellites Info:
SV PRN No Channel No Acq Flg Ephemeris Flg SV Type Sig Strength
--------------------------------- --------------------------------- --------------------------------- --------------------------------- --------------------------------- --------------------------------- ---------------------------------  
5 0 1 1 1 0 44
2 1 1 1 1 0 46
29 2 1 1 1 0 49
18 3 1 1 1 0 43
25 4 1 1 1 0 44
21 5 1 1 1 0 44
20 6 1 1 1 0 45
12 7 1 1 1 0 47
15 8 1 1 1 0 47
13 9 1 1 1 0 46
```

This example shows output for `show gnss time` and `show gnss location`:

```
Switch# show gnss time
Current GNSS Time:
Time: 2017/09/18 19:29:58 UTC Offset: 18

Switch# show gnss location
Current GNSS Location:
LOC: 30.26.045678699 N 97.45.036946399 W 266.1928 m
```

**Related Documents**

• [Cisco Industrial Ethernet 5000 Series Switches](#)
• [Cisco IE 5000 Hardened Aggregator Hardware Installation Guide](#)
• [Precision Time Protocol Software Configuration Guide for IE 4000, IE 4010, and IE 5000 Switches](#)
### Feature History

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Release</th>
<th>Feature Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Navigation Satellite System (GNSS)</td>
<td>Cisco IOS Release 15.2(6)E0a</td>
<td>Initial support on IE 5000.</td>
</tr>
</tbody>
</table>
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