Frequency Synchronization

Frequency Synchronization is used to distribute precision frequency around a network. Frequency is synchronized accurately using Synchronized Ethernet (SyncE) in devices connected by Ethernet in a network.

This module describes the tasks required to configure frequency synchronization on Cisco IOS XR software.

Using Synchronous Ethernet for Frequency Synchronization

Frequency or timing synchronization is the ability to distribute precision frequency around a network. In this context, timing refers to precision frequency, not an accurate time of day. Precision frequency is required in next generation networks for applications such as circuit emulation.

To achieve compliance to ITU specifications for TDM, differential method circuit emulation is used that requires a known, common precision frequency reference at each end of the emulated circuit. The incumbent example of frequency synchronization is provided by SDH equipment. This is used in conjunction with an external timing technology to provide precise synchronization across the network.

SDH equipments are widely replaced by Ethernet equipments and synchronized frequency is required over such Ethernet ports. Synchronized Ethernet (SyncE) is used to accurately synchronize frequency in devices connected by Ethernet in a network. SyncE provides level frequency distribution of known common precision frequency references to a physical layer Ethernet network.

To maintain SyncE links, a set of operational messages are required. These messages ensure that a node is always deriving timing information from the most reliable source and then transfers the timing source quality information to clock the SyncE link. In SDH networks, these are known as Synchronization Status Messages (SSMs). SyncE uses Ethernet Synchronization Message Channel (ESMC) to provide transport for SSMs.

SyncE is supported on Cisco NCS 5001 and Cisco NCS 5002 Routers on 100G, 40G, and 10G interfaces in LAN mode.

> **Note**
> - Cisco NCS 5001 and NCS 5002 Routers do not support Global Positioning System (GPS).
> - Cisco NCS 5011 Router neither supports SyncE nor GPS.

Source and Selection Points

Frequency Synchronization implementation involves Sources and Selection Points.

A Source inputs frequency signals into a system or transmits them out of a system. There are two types of sources:

- Line interfaces: This includes SyncE interfaces.

- Internal oscillator: This is a free-running internal oscillator chip.

Each source has a Quality Level (QL) associated with it which gives the accuracy of the clock. This QL information is transmitted across the network using ESMC or SSMs contained in the SDH frames. This provides information about the best available source the devices in the system can synchronize to. To define a predefined network synchronization flow and prevent timing loops, you can assign priority values to the sources on each router. The combination of QL information and user-assigned priority levels allow each router to choose a source to synchronize its SyncE or SDH interfaces, as described in the ITU standard G.781.

A Selection Point is any point where a choice is made between several frequency signals and possibly one or many of them are selected. Selection points form a graph representing the flow of timing signals between different cards in a router running Cisco IOS XR software. For example, there can be one or many selection points between different Synchronous Ethernet inputs available on a single line card. This information is forwarded to a selection point on the RSP, to choose between the selected source from each card.

Note   The output of a selection point can be used to drive the signals sent out of a set of interfaces.

Restrictions

This section lists a few restrictions in configuring frequency synchronization and SyncE. They are:

- SyncE is supported only on Cisco NCS 5001 and NCS 5002 Routers.

- Cisco NCS 50xx Series Routers do not support GPS TOD Input/Output.

- SyncE is supported only on the Hub-and-Spoke topology.

Configuring Frequency Synchronization

- To enable Frequency Synchronization on the router, use **frequency synchronization** command in the configuration mode.

- To display the Quality Level (QL) of the Router, use **quality itu-t** command in the frequency synchronization configuration mode.

  - **option 1**: Includes PRC, SSU-A, SSU-B, SEC, and DNU. This is the default option.
  - **option 2 generation 1**: Includes PRS, STU, ST2, ST3, SMC, ST4, RES, and DUS.
  - **option 2 generation 2**: Includes PRS, STU, ST2, ST3, TNC, ST3E, SMC, ST4, PROV, and DUS.

> **Note** The **quality option** configured here must match the **quality option** specified in the quality receive and quality transmit commands in the interface frequency synchronization configuration mode.

- To enable logging of frequency synchronization selections, use **log selection** command in the frequency synchronization configuration mode.

  - **changes**: Logs errors and every time there is a change to the selected source.
  - **errors**: Logs only when there are no available frequency sources or when the only available frequency source is an internal oscillator.

Configuration Example

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# frequency synchronization
RP/0/RP0/CPU0:router(config-freqsync)# quality itu-t option 2 generation 1
RP/0/RP0/CPU0:router(config-freqsync)# log selection changes
RP/0/RP0/CPU0:router(config-freqsync)# commit
```

Running Configuration

```
/* Quality Level (QL) of the router */
frequency synchronization
 quality itu-t option 2 generation 1
!

/* Logging Frequency Synchronization Selections */
frequency synchronization
 log selection changes
!
```

Verification

To display the frequency synchronization selection, use **show frequency synchronization selection** command.

```
RP/0/RP0/CPU0:router# show frequency synchronization selection

Fri Apr 7 15:06:24.123 UTC
Node 0/RP0/CPU0:
==============
Selection point: T0-SEL-B (1 inputs, 1 selected)
  Last programmed 4d03h ago, and selection made 2d23h ago
  Next selection points
    SPA scoped    : None
    Node scoped   : None
    Chassis scoped: NCS5K_BCM_TX_SELECT
    Router scoped : None
  Uses frequency selection
  Used for local line interface output
  S  Input                    Last Selection Point       QL   Pri Status
  == ======================== ======================== ===== === ==========
  1  Internal0 [0/RP0/CPU0]   n/a                        ST3  255 Available

Selection point: T4-SEL-A (0 inputs, 0 selected)
```

```
     Last programmed 4w0d ago, and selection made 2d23h ago
     Next selection points
       SPA scoped    : None
       Node scoped   : None
       Chassis scoped: None
       Router scoped : None
     Uses frequency selection

   Selection point: T4-SEL-C (0 inputs, 0 selected)
     Last programmed 4w0d ago, and selection made 2d23h ago
     Next selection points
       SPA scoped    : None
       Node scoped   : None
       Chassis scoped: None
       Router scoped : None
     Uses frequency selection

   Selection point: CHASSIS-TOD-SEL (0 inputs, 0 selected)
     Last programmed 4w0d ago, and selection made 4w0d ago
     Next selection points
       SPA scoped    : None
       Node scoped   : None
       Chassis scoped: None
       Router scoped : None
     Uses time-of-day selection

   Selection point: NCS5K_ETH_RXMUX (0 inputs, 0 selected)
     Last programmed 4d03h ago, and selection made 4d03h ago
     Next selection points
       SPA scoped    : None
       Node scoped   : T0-SEL-B
       Chassis scoped: None
       Router scoped : None
     Uses frequency selection
```

To display a summary of the frequency synchronization configuration, use **show frequency synchronization summary** command.

```
RP/0/RP0/CPU0:router# show frequency synchronization summary

Fri Apr 7 15:06:24.123 UTC
Frequency
=========
Internal0 [0/RP0/CPU0] is driving frequency on:
  0 Clock-interfaces
  4 Ethernet interfaces
  0 SONET interfaces

Time-of-Day
=========
```

Configuring Frequency Synchronization on an Interface

To configure Frequency Synchronization on an Interface, use the following procedure:

✎

Note   By default, there is no Frequency Synchronization on a line Interface. Frequency Synchronization must be enabled globally on the router prior to configuring Frequency Synchronization on an interface.

1. Enter the global configuration mode and configure the interface.

```
RP/0/RP0/CPU0:router# configure
RP/0/RP0/CPU0:router(config)# interface TenGigE0/0/0/8
```

2. Configure Frequency Synchronization on this interface.

```
RP/0/RP0/CPU0:router(config-if)# frequency synchronization
```

Note By default, frequency signal chosen by the system is used for clocking transmission. However, this does not enable the use of the interface as an input.

3. Configure the interface to be used as a timing source by the selection algorithm.

```
RP/0/RP0/CPU0:router(config-if-freqsync)# selection input
```

4. Configure priority of the frequency source on a controller or an interface by specifying a value in the range 1 (highest priority) to 254 (lowest priority). The default value is 100. The priority value set is used by the clock-selection algorithm to choose between two sources that have the same quality level (QL) and lower priority values are usually preferred.

```
RP/0/RP0/CPU0:router(config-if-freqsync)# priority 101
```

5. Configure the time (in minutes) to wait after the interface is up, before it can be used for frequency synchronization by specifying a value in the range 0 to 12. The default value is 5.

```
RP/0/RP0/CPU0:router(config-if-freqsync)# wait-to-restore 300
```

6. Disable the Synchronization Status Messages (SSMs) on the interface to stop sending the packets and ignore the received packets. For SyncE interfaces. sending or receiving ESMC packets is disabled.

```
RP/0/RP0/CPU0:router(config-if-freqsync)# ssm disable
```

7. Adjust the QL transmitted by specifying one of the following **quality transmit** options:

- **exact**: Exact QL to be sent. DNU is sent if the exact *ql value* is not specified.

- **highest**: Upper limit on the QL to be sent. QL value specified here is sent, if the QL value of the selected source is higher than the QL value specified here.

- **lowest**: Lower limit on the QL to be sent. DNU is sent, if the QL value of the selected source is lesser than the QL value specified here.

```
RP/0/RP0/CPU0:router(config-if-freqsync)# quality transmit highest itu-t option 1 PRC
```

8. Adjust the QL received by specifying one of the following **quality receive** options before the value can be used in the selection algorithm:

- **exact**: Exact QL received unless the received value is DNU.

- **highest**: Upper limit on the received QL. QL value specified here is used, if the received QL value is higher than the QL value specified here.

- **lowest**: Lower limit on the received QL. DNU is used, if the received QL value is lesser than the QL value specified here.

```
RP/0/RP0/CPU0:router(config-if-freqsync)# quality receive highest itu-t option 1 PRC
```

Note The **quality option** configured here must match the globally configured **quality option** specified in the **quality itu-t option** command.

9. Exit to the global configuration mode and commit your configuration.

```
RP/0/RP0/CPU0:router(config-if-freqsync)# commit
```

Verification

To verify the configured interfaces, use **show frequency synchronization interfaces** command.

```
RP/0/RP0/CPU0:router# show frequency synchronization interfaces tenGigE 0/0/0/8

Fri Apr 7 15:06:24.123 UTC
Interface TenGigE0/0/0/8 (down)
  Assigned as input for selection
  Wait-to-restore time 0 minutes
  SSM Enabled
  Input:
    Down
    Last received QL: Failed
    Effective QL: Failed, Priority: 100
    Supports frequency
  Output:
    Selected source: Internal0 [0/RP0/CPU0]
    Selected source QL: Opt-II,1/ST3
    Effective QL: Opt-II,1/ST3
  Next selection points: NCS5K_ETH_RXMUX
```

To verify the configurations on all line interfaces with frequency synchronization, use **show frequency synchronization interfaces brief** command.

```
RP/0/RP0/CPU0:router# show frequency synchronization interfaces brief

Flags: > - Up            D - Down            S - Assigned for selection
       d - SSM Disabled  x - Peer timed out  i - Init state

Fl   Interface           QLrcv QLuse Pri QLsnt Source
===  ==================  ===== ===== === ===== ================
>Sx  GigabitEthernet0/2/0/0  Fail  Fail  100 DNU   None
Dd   GigabitEthernet0/2/0/1  n/a   Fail  100 n/a   None
```

Sources configured as inputs is indicated by *S* in the Flags column.

Note Internal oscillators are always eligible as inputs.

To verify each configured interface separately, use **show frequency synchronization interfaces** *node-id* command.

```
RP/0/RP0/CPU0:router# show frequency synchronization interfaces TenGigE0/0/0/8

Interface TenGigE0/0/0/8 (shutdown)
  Assigned as input for selection
  SSM Enabled
  Input:
    Down
    Last received QL: Failed
    Effective QL: Failed, Priority: 100
  Output:
    Selected source: Internal0 [0/RP0/CPU0]
    Selected source QL: Opt-II,1/ST3
    Effective QL: Opt-II,1/ST3
  Next selection points: NCS5K_ETH_RXMUX
```