Configuring 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.

This module contains the following topics:

Overview

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 must be used, which 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 synchronization of precision timing across the network.

SDH equipments are widely replaced by Ethernet equipments and synchronized frequency is required over such Ethernet ports. Synchronous 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.

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 four types of sources:

- Line interfaces. This includes SyncE interfaces and SONET interfaces.

- Clock interfaces. These are external connectors for connecting other timing signals, such as BITS, UTI and GPS.
- PTP clock. If IEEE 1588 version 2 is configured on the router, a PTP clock may be available to frequency synchronization as a source of the time-of-day and frequency.
- 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.

The input signals to the selection points can be:

- Received directly from a source.
- Received as the output from another selection point on the same card.
- Received as the output from a selection point on a different card.

The output of a selection point can be used in a number of ways, like:

- To drive the signals sent out of a set of interfaces.
- As input into another selection point on a card.
- As input into a selection point on an another card.

Use **show frequency synchronization selection** command to see a detailed view of the different selection points within the system.

SyncE Hardware Support Matrix

This table provides details on the harware that supportes SyncE:

Note The table also contains support details of upcoming releases. You can read this table in context of the current release and see relevant *Release Notes* for more information on supported features and hardware.

Hardware Variant	Cisco IOS XR	Cisco IOS XR 64 bit
A9K-8X100GE-L-SE/TR (10GE and 100GE)	5.3.0	6.1.1
A9K-RSP880-SE/TR	5.3.0	6.1.1

Hardware Variant	Cisco IOS XR	Cisco IOS XR 64 bit
A9K-8X100GE-L-SE/TR (40-GE)	6.0.1	6.1.1
A9K-4X100GE-SE/TR A9K-8X100GE-SE/TR	5.3.2 (100G LAN only) 6.0.1	6.1.1
A9K-MOD400-SE/TR A9K-MOD200-SE/TR with MPA 20x10GE and Legacy MPAs	6.0.1	6.2.2
A9K-MOD400-SE/TR A9K-MOD200-SE/TR with MPAs 2x100 and 1x100	6.1.3	6.2.2
A9K-400G-DWDM-TR	5.3.3 6.0.1	
A9K-24X10GE-1G-SE/TR A9K-48X10GE-1G-SE/TR	6.2.1	6.3.2
A99-RSP-SE/TR (Cisco ASR 9910 Series Routers)	6.1.4	6.3.2
A99-12X100GE	6.3.2	6.3.2
RSP880-LT-SE/TR	6.2.2	6.4.1
A9K-RSP440-TR/SE Enhanced Ethernet Linecards A99-RP-SE	4.3.4	
A99-RP2-TR/SE	5.3.0	6.3.2 6.4.1
Cisco ASR 9001 Series Routers	4.3.4	
Cisco ASR 9901 Series Routers	NA	6.4.1
A99-RSP-SE/TR (Cisco ASR 9906 Series Routers)	6.3.1	6.3.2
A9K-RSP5-SE/TR	NA	6.5.15
A99-RP3-SE/TR	NA	6.5.15
A9K-8X100GE-X-TR	NA	6.5.15
A9K-16X100GE-TR	NA	6.5.15
A9K-32X100GE-TR	NA	6.5.15

Configuring Frequency Synchronization

Enabling Frequency Synchronization on the Router

This task describes the router-level configuration required to enable frequency synchronization.

SUMMARY STEPS

1. **configure**
2. **frequency synchronization**
3. **clock-interface timing-mode** {**independent** | **system**
4. **quality itu-t option** {**1** | **2 generation** {**1** | **2**}}
5. **log selection** {**changes** | **errors**}
6. Use one of these commands:
   - **end**
   - **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**frequency synchronization** **Example:** `RP/0/RSP0/CPU0:router(config)# frequency synchronization`	Enables frequency synchronization on the router.
Step 3	**clock-interface timing-mode** {**independent**	**system** **Example:** `RP/0/RSP0/CPU0:router(config-freqsync)# clock-interface timing-mode system`	(Optional) Configures the type of timing sources that can be used to drive the output from a clock interface. If this command is not used, the default quality mode is used. In the default mode, the clock interface output is driven only by input from line interfaces and the internal oscillator; it is never driven by input from another clock interface. In addition, some heuristic tests are run to detect if the signal being sent out of one clock interface can be looped back by some external box and sent back in via the same, or another clock interface. • **independent**—Specifies that the output of clock interfaces is driven only by the line interfaces (SyncE and SONET/SDH), as in the default mode. Loopback detection is disabled. • **system**—Specifies that the output of a clock interface is driven by the system-selected timing source (the source used to drive all SyncE and SONET/SDH

	Command or Action	Purpose
		interfaces), including clock interfaces. Loopback detection is disabled.

Step 4	**quality itu-t option** {**1** | **2 generation** {**1** | **2**}}
	Example:
	`RP/0/RSP0/CPU0:router(config-freqsync)# quality itu-t`
	`option 2 generation 1`
		(Optional) Specifies the quality level for the router. The default is **option 1**.
		• **option 1**—Includes PRC, SSU-A, SSU-B, SEC and DNU.
		• **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 interface frequency synchronization configuration mode.

Step 5	**log selection** {**changes** | **errors**} **Example:** `RP/0/RSP0/CPU0:router(config-freqsync)# log selection changes`	Enables logging to frequency synchronization. • **changes**—Logs every time there is a change to the selected source, in addition to errors. • **errors**—Logs only when there are no available frequency sources, or when the only available frequency source is the internal oscillator.

Step 6	Use one of these commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-freqsync)# end`
	or
	`RP/0/RSP0/CPU0:router(config-freqsync)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file, and remain within the configuration session.

What to do next

Configure frequency synchronization on any interfaces that should participate in frequency synchronization.

Configuring Frequency Synchronization on an Interface

By default, there is no frequency synchronization on line interfaces. Use this task to configure an interface to participate in frequency synchronization.

Before you begin

You must enable frequency synchronization globally on the router.

SUMMARY STEPS

1. **configure**
2. **interface** *type interface-path-id*
3. **frequency synchronization**
4. **selection input**
5. **priority** *priority-value*
6. **wait-to-restore** *minutes*
7. **ssm disable**
8. **time-of-day-priority** *priority*
9. **quality transmit** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option*
10. **quality receive** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option*
11. Use one of these commands:
    - **end**
    - **commit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**interface** *type interface-path-id* **Example:** `RP/0/RSP0/CPU0:router(config)# interface GigabitEthernet0/1/1/0`	Enters interface configuration mode.
Step 3	**frequency synchronization** **Example:** `RP/0/RSP0/CPU0:router(config-if)# frequency synchronization`	Enables frequency synchronization on the interface and enters interface frequency synchronization mode to configure the various options. By default, this causes the system selected frequency signal to be used for clocking transmission, but does not enable the use of the interface as an input.
Step 4	**selection input** **Example:**	(Optional) Specifies the interface as a timing source to be passed to the selection algorithm.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-if-freqsync)# selection input`	
Step 5	**priority** *priority-value* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# priority 100`	(Optional) Configures the priority of the frequency source on a controller or an interface. Values can range from 1 (highest priority) to 254 (lowest priority). The default value is 100. This command is used to set the priority for an interface or clock interface. The priority is used in the clock-selection algorithm to choose between two sources that have the same quality level (QL). Lower priority values are preferred.
Step 6	**wait-to-restore** *minutes* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# wait-to-restore 300`	(Optional) Configures the wait-to-restore time, in minutes, for frequency synchronization on an interface. This is the amount of time after the interface comes up before it is used for synchronization. Values can range from 0 to 12. The default value is 5.
Step 7	**ssm disable** **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# ssm disable`	(Optional) Disables Synchronization Status Messages (SSMs) on the interface. • For SyncE interfaces, this disables sending ESMC packets, and ignores any received ESMC packets. • For SONET and clock interfaces, this causes DNUs to be sent, and ignores any received QL value.
Step 8	**time-of-day-priority** *priority* **Example:** `RP/0/RSP0/CPU0:router(config-if-freqsync)# time-of-day-priority 50`	(Optional) Specifies the priority of this time source as the time-of-day (ToD) source. The priority is used as the first criterion when selecting between sources for a time-of-day selection point. Values can range from 1 (highest priority) to 254 (lowest priority); the default value is 100.
Step 9	**quality transmit** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option* **Example:** `RP/0/RSP0/CPU0:router(config-clk-freqsync)# quality transmit highest itu-t option 1 prc`	(Optional) Adjusts the QL that is transmitted in SSMs. • **exact** *ql*—Specifies the exact QL to send, unless DNU would otherwise be sent. • **highest** *ql*—Specifies an upper limit on the QL to be sent. If the selected source has a higher QL than the QL specified here, this QL is sent instead. • **lowest** *ql*—Specifies a lower limit on the QL to be sent. If the selected source has a lower QL than the QL specified here, DNU is sent instead. The quality option specified in this command must match the globally-configured quality option in the **quality itu-t option** command.

	Command or Action	Purpose
		Note For clock interfaces that do not support SSM, only the lowest QL can be specified. In this case, rather than sending DNU, the output is squelched, and no signal is sent.
Step 10	**quality receive** {**exact** | **highest** | **lowest**} **itu-t option** *ql-option* **Example:** `RP/0/RSP0/CPU0:router(config-clk-freqsync)# quality receive highest itu-t option 1 prc`	(Optional) Adjusts the QL value that is received in SSMs, before it is used in the selection algorithm. • **exact** *ql*—Specifies the exact QL regardless of the value received, unless the received value is DNU. • **highest** *ql*—Specifies an upper limit on the received QL. If the received value is higher than this specified QL, this QL is used instead. • **lowest** *ql*—Specifies a lower limit on the received QL. If the received value is lower than this specified QL, DNU is used instead. The quality option specified in this command must match the globally-configured quality option in the **quality itu-t option** command. **Note** For clock interfaces that do not support SSM, only the exact QL can be specified.

Step 11	Use one of these commands:
	• **end**
	• **commit**
	Example:
	`RP/0/RSP0/CPU0:router(config-if-freqsync)# end`
	or
	`RP/0/RSP0/CPU0:router(config-if-freqsync)# commit`
		Saves configuration changes.
		• When you issue the **end** command, the system prompts you to commit changes:
		`Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]:`
		• Entering **yes** saves configuration changes to the running configuration file, exits the configuration session, and returns the router to EXEC mode.
		• Entering **no** exits the configuration session and returns the router to EXEC mode without committing the configuration changes.
		• Entering **cancel** leaves the router in the current configuration session without exiting or committing the configuration changes.
		• Use the **commit** command to save the configuration changes to the running configuration file, and remain within the configuration session.

Verifying the Frequency Synchronization Configuration

After performing the frequency synchronization configuration tasks, use this task to check for configuration errors and verify the configuration.

SUMMARY STEPS

1. **show frequency synchronization configuration-errors**
2. **show frequency synchronization interfaces brief**
3. **show frequency synchronization interfaces** *node-id*
4. **show processes fsyncmgr location** *node-id*

DETAILED STEPS

Step 1 show frequency synchronization configuration-errors

Example:

```
RP/0/RSP0/CPU0:router# show frequency synchronization configuration-errors

Node 0/2/CPU0:
==============
  interface GigabitEthernet0/2/0/0 frequency synchronization
    * Frequency synchronization is enabled on this interface, but isn't enabled globally.

  interface GigabitEthernet0/2/0/0 frequency synchronization quality transmit exact itu-t option 2
generation 1 PRS
    * The QL that is configured is from a different QL option set than is configured globally.
```

Displays any errors that are caused by inconsistencies between shared-plane (global) and local-plane (interface) configurations. There are two possible errors that can be displayed:

- Frequency Synchronization is configured on an interface (line interface or clock-interface), but is not configured globally. Refer to Enabling Frequency Synchronization on the Router, on page 4
- The QL option configured on some interface does not match the global QL option. Under an interface (line interface or clock interface), the QL option is specified using the **quality transmit** and **quality receive** commands. The value specified must match the value configured in the global **quality itu-t option** command, or match the default (option 1) if the global **quality itu-t option** command is not configured.

Once all the errors have been resolved, meaning there is no output from the command, continue to the next step.

Step 2 show frequency synchronization interfaces brief

Example:

```
RP/0/RSP0/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
```

```
RP/0/RSP0/CPU0:router# show frequency synchronization clock-interfaces brief

Flags:  > - Up                D - Down              S - Assigned for selection
        d - SSM Disabled      s - Output squelched  L - Looped back

Node 0/0/CPU0:
==============
  Fl    Clock Interface     QLrcv  QLuse  Pri QLsnd  Source
  ===== ================== ====== ====== === ====== ======================
  >S    Sync0               PRC    Fail   100 SSU-B  Internal0 [0/0/CPU0]
  >     Sync1               SSU-A  Fail   100 SSU-B  Internal0 [0/0/CPU0]
  >S    Internal0           n/a    SSU-B  255 n/a    None

Node 0/1/CPU0:
==============
  Fl    Clock Interface     QLrcv  QLuse  Pri QLsnd  Source
  ===== ================== ====== ====== === ====== ======================
  D     Sync0               None   Fail   100 SSU-B  Internal0 [0/1/CPU0]
  D     Sync1               None   Fail   100 SSU-B  Internal0 [0/1/CPU0]
  >S    Internal0           n/a    SSU-B  255 n/a    None
```

Verifies the configuration. Note the following points:

- All line interface that have frequency synchronization configured are displayed.
- All clock interfaces and internal oscillators are displayed.
- Sources that have been nominated as inputs (in other words, have **selection input** configured) have ‘S’ in the Flags column; sources that have not been nominated as inputs do not have ‘S’ displayed.

  Note Internal oscillators are always eligible as inputs.

- ‘>’ or ‘D’ is displayed in the flags field as appropriate.

If any of these items are not true, continue to the next step.

Step 3 **show frequency synchronization interfaces** *node-id*

Example:

```
RP/0/RSP0/CPU0:router# show frequency synchronization interfaces GigabitEthernet0/2/0/2

Interface GigabitEthernet0/2/0/2 (shutdown)
  Assigned as input for selection
  SSM Enabled
  Input:
    Down
    Last received QL: Failed
    Effective QL:     Failed, Priority: 100
  Output:
    Selected source:    Sync0 [0/0/CPU0]
    Selected source QL: Opt-I/PRC
    Effective QL:       Opt-I/PRC
  Next selection points: LC_INGRESS

RP/0/RSP0/CPU0:router# show frequency synchronization clock-interfaces location 0/1/CPU0

Node 0/1/CPU0:
==============
  Clock interface Sync0 (Down: mode not configured)
```

```
  SSM supported and enabled
  Input:
    Down
    Last received QL: Opt-I/PRC
    Effective QL:     Failed, Priority: 100
  Output:
    Selected source:    Internal0 [0/1/CPU0]
    Selected source QL: Opt-I/SSU-B
    Effective QL:       Opt-I/SSU-B
Next selection points: RP_SYSTEM

Clock interface Sync1 (Down: mode not configured)
  SSM supported and enabled
  Input:
    Down
    Last received QL: Opt-I/PRC
    Effective QL:     Failed, Priority: 100
  Output:
    Selected source:    Internal0 [0/1/CPU0]
    Selected source QL: Opt-I/SSU-B
    Effective QL:       Opt-I/SSU-B
Next selection points: RP_SYSTEM

Clock interface Internal0 (Up)
  Assigned as input for selection
  Input:
    Default QL:   Opt-I/SSU-B
    Effective QL: Opt-I/SSU-B, Priority: 255
Next selection points: RP_SYSTEM RP_CLOCK_INTF
```

Investigates issues within individual interfaces. If the clock interface is down, a reason is displayed. This may be because there is missing or conflicting platform configuration on the clock interface.

Step 4 **show processes fsyncmgr location** *node-id*

Example:

```
RP/0/RSP0/CPU0:router# show processes fsyncmgr location 0/0/CPU0

                  Job Id: 134
                     PID: 30202
        Executable path: /pkg/bin/fsyncmgr
             Instance #: 1
             Version ID: 00.00.0000
                Respawn: ON
          Respawn count: 1
  Max. spawns per minute: 12
           Last started: Mon Mar  9 16:30:43 2009
          Process state: Run
          Package state: Normal
      Started on config: cfg/gl/freqsync/g/a/enable
                   core: MAINMEM
              Max. core: 0
              Placement: None
           startup_path: /pkg/startup/fsyncmgr.startup
                  Ready: 0.133s
       Process cpu time: 1730768.741 user, -133848.-361 kernel, 1596920.380 total
  ------------------------------------------------------------------------------
```

Verifies that the fsyncmgr process is running on the appropriate nodes.