



Synchronous Ethernet (SyncE)

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About Synchronous Ethernet (SyncE)

With Ethernet equipment gradually replacing Synchronous Optical Networking (SONET) and Synchronous Digital Hierarchy (SDH) equipment in service-provider networks, frequency synchronization is required to provide high-quality clock synchronization over Ethernet ports. 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.

Synchronous Ethernet (SyncE), described in ITU G.781, provides the required synchronization at the physical level. In SyncE, Ethernet links are synchronized by timing their bit clocks from high-quality, stratum-1-traceable clock signals in the same manner as SONET/SDH.

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 SONET/SDH networks, these are known as Synchronization Status Messages (SSMs). SyncE uses Ethernet Synchronization Message Channel (ESMC) to provide transport for SSMs.

Customers using a packet network find it difficult to provide timing to multiple remote network elements (NEs) through an external time division multiplexed (TDM) circuit. The SyncE feature helps to overcome this problem by providing effective timing to the remote NEs through a packet network. SyncE synchronizes clock frequency over an Ethernet port, leveraging the physical layer of the Ethernet to transmit frequency to the remote sites. SyncE's functionality and accuracy resemble the SONET/SDH network because of its physical layer characteristic.

SONET/SDH use 4 bits from the two S bytes in the SONET/SDH overhead frame for message transmission. Ethernet relies on ESMC that is based on an IEEE 802.3 organization-specific slow protocol for message transmission. Each NE along the synchronization path supports SyncE, and SyncE effectively delivers frequency in the path. SyncE does not support relative time (for example, phase alignment) or absolute time (Time of Day).

SyncE provides the Ethernet physical layer network (ETY) level frequency distribution of known common precision frequency references. Clocks for use in SyncE are compatible with the clocks used in the SONET/SDH

synchronization network. To achieve network synchronization, synchronization information is transmitted through the network via synchronous network connections with performance of egress clock.

ESMC carries a Quality Level (QL) identifier that identifies the timing quality of the synchronization trail. QL values in QL-TLV are the same as QL values defined for SONET and SDH SSM. Information provided by SSM QLs during the network transmission helps a node derive timing from the most reliable source and prevents timing loops. ESMC is used with the synchronization selection algorithms. Because Ethernet networks are not required to be synchronous on all links or in all locations, the ESMC channel provides this service. ESMC, described in G.8264, is composed of the standard Ethernet header for an organization-specific slow protocol; the ITU-T OUI, a specific ITU-T subtype; an ESMC-specific header; a flag field; and a type, length, value (TLV) structure. The use of flags and TLVs improves the management of SyncE links and the associated timing change.

Sources and Selection Points

A 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, including SyncE 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 an associated Quality Level (QL), which specifies the accuracy of the clock. This QL information is transmitted across the network using SSMs carried by ESMC. The QL information is used to determine the best available source to which the devices in the system can synchronize.

To define a predefined network synchronization flow and to prevent timing loops, you can assign priority values to each source on the switch. When more than one source has the same QL, the user-assigned priority value determines the relative preference among the sources.

A selection point is the process within the switch where a choice is made between several available frequency signals. The combination of QL information and user-assigned priority levels allows each switch to choose a source to synchronize its SyncE interfaces, as described in the ITU standard G.781.

Guidelines and Limitations for SyncE

SyncE has the following configuration guidelines and limitations:

- SyncE is supported on the N9K-C93180TC-FX3.
- SyncE can be enabled only on downstream front panel ports. The interface can be switched, routed, or a subinterface.
- SyncE is not supported on the fabric ports.
- We do not recommend configuring SyncE on a non-fabric port that is connected to another leaf.

- Local distribution of SyncE is supported. This is the case in which both the reference source and the client are on the same leaf switch. The leaf can be within a pod or a remote leaf.
- SyncE distribution over peer-link between two remote leaf switches is not supported.
- Hybrid mode with PTP is supported for telecom profile ITU-T G8275.1.
- The switch can monitor a maximum of four downlink SyncE sources. The switch can lock to one of these sources.
- Each quad port group on the PHY provides one reference clock. For example, a leaf switch can monitor and lock to one source when interfaces 1/1 to 1/4 are connected to four different sources.
- Extended SSM or Extended QL TLV format are not supported.
- GPS and GNSS are not supported.
- SyncE is supported on all qualified optics with the exception of copper Gigabit Ethernet SFPs.

Configuring Synchronous Ethernet

To enable SyncE on a leaf switch, you must create two levels of policy:

- A node level policy enables the SyncE process on the leaf or remote leaf switch. This policy specifies the global Quality Level (QL) option configuration for the SyncE node.
- An interface level policy configures SyncE properties on the interface. This policy can also enable QL level override specific to an interface. The QL option in the interface policy should match the QL option in the node level policy.

Creating a Synchronous Ethernet Node Policy

This procedure creates a node level configuration policy for SyncE.

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- Step 1** On the menu bar, choose **Fabric > Access Policies**.
- Step 2** In the Navigation pane, choose **Policies > Switch > Synchronous Ethernet Node**.
- Step 3** Right-click **Synchronous Ethernet Node** and choose **Create Synchronous Ethernet Node Policy**.
- Step 4** In the **Create Synchronous Ethernet Node Policy** dialog box, complete the following steps:
- a) Enter a **Name** for the policy.
 - b) Enter a **Description** of the policy.
 - c) In the **Quality Level Option** drop-down list, select the quality level.

Choose one of the following ITU-T Quality Level (QL) options:

- **Option 1:** Includes DNU, EEC1, PRC, PRTC, SEC, SSU-A, SSU-B, eEEC and ePRTC.
- **Option 2 generation 1:** Includes DUS, EEC2, PRS, PRTC, RES, SMC, ST2, ST3, ST4, STU, eEEC and ePRTC.
- **Option 2 generation 2:** Includes DUS, EEC2, PROV, PRS, PRTC, SMC, ST2, ST3, ST3E, ST4, STU, TNC, eEEC and ePRTC.

Note Extended SSM QL options PRTC, eEEEC, and ePRTC are not supported.
Stratum 4 freerun (ST4) is not supported on Ethernet line interfaces.

For details of QL mapping for these options, see [QL Mapping with ACI Configuration Options, on page 6](#).

Note The **Quality Level Option** is typically configured here instead of at the interface level. If configured at the interface level, the QL option there must match the QL selected here.

- d) Set the **Admin State** control to either **Enabled** to activate the policy or **Disabled** (default) to deactivate the policy.
- e) Click **Submit**.

What to do next

Add the policy to an Access Switch Policy Group at **Fabric > Access Policies > Switches > Leaf Switches > Policy Groups**.

Creating a Synchronous Ethernet Interface Policy

This procedure creates an interface level configuration policy for Synchronous Ethernet (SyncE).

A SyncE interface policy allows you to configure an Ethernet interface as a frequency synchronization input and output. Configuring an interface as an input (using **Selection Input**) allows the interface to be passed to the selection algorithm to be considered as a timing source for frequency synchronization.

If the interface is locked to an input, the interface will always transmit synchronized to the selected frequency signal.

Step 1 On the menu bar, choose **Fabric > Access Policies**.

Step 2 In the Navigation pane, choose **Policies > Interface > Synchronous Ethernet Interface**.

Step 3 Right-click **Synchronous Ethernet Interface** and choose **Create Synchronous Ethernet Interface Policy**.

Step 4 In the **Create Synchronous Ethernet Interface Policy** dialog box, complete the following steps:

- a) Enter a **Name** for the policy.
- b) Enter a **Description** of the policy.
- c) Set the **Admin State** control to either **Enabled** to activate the policy or **Disabled** (default) to deactivate the policy.
- d) Check or uncheck the **Synchronization Status Message** checkbox.
If unchecked, disables sending ESMC packets and also ignores any received ESMC packets. This checkbox is checked by default.
- e) Check or uncheck the **Selection Input** checkbox.
If checked, assigns the interface as a timing source to be passed to the selection algorithm. This checkbox is unchecked by default.
- f) Click the up or down controls to set the **Source Priority**.

The priority of the frequency source on an interface. This value is used in the clock-selection algorithm to choose between two sources that have the same QL. Values can range from 1 (highest priority) to 254 (lowest priority). The default value is 100.

Note This setting is active only if **Selection Input** is checked.

- g) Click the up or down controls to set the **Wait-To-Restore** time in minutes.

The wait-to-restore time, in minutes, is the amount of time after the interface comes up before it is used for frequency synchronization on an interface. Values can range from 0 to 12 minutes. The default value is 5.

Note This setting is active only if **Selection Input** is checked.

- h) In the **Quality Level Option** drop-down list, select the quality level (QL).

This setting allows you to specify or override the Quality Level (QL) received or transmitted at the interface level. The ITU-T Quality Level options are:

- **No Quality Level configured:** (Default) The QL received from the connected source via ESMC is used for frequency synchronization.
- **Option 1:** Includes DNU, EEC1, PRC, PRTC, SEC, SSU-A, SSU-B, eEEEC and ePRTC.
- **Option 2 generation 1:** Includes DUS, EEC2, PRS, PRTC, RES, SMC, ST2, ST3, ST4, STU, eEEEC and ePRTC.
- **Option 2 generation 2:** Includes DUS, EEC2, PROV, PRS, PRTC, SMC, ST2, ST3, ST3E, ST4, STU, TNC, eEEEC and ePRTC.

Note Extended SSM QL options PRTC, eEEEC, and ePRTC are not supported.

Stratum 4 freerun (ST4) is not supported on Ethernet line interfaces.

For details of QL mapping for these options, see [QL Mapping with ACI Configuration Options](#), on page 6.

- i) If you selected a **Quality Level Option**, you can configure either or both of the **Quality Receive** and **Quality Transmit** values.

The Quality Receive values allow you to override the received QL value in the SSM messages, which is used in the selection algorithm. The choices are as follows:

- **Exact Value:** Use the exact QL, regardless of the value received, unless the received value is Do Not Use (DNU).
- **Highest Value:** Sets an upper limit on the received QL. If the received value is higher than this specified QL, this QL is used instead.
- **Lowest Value:** Sets a lower limit on the received QL. If the received value is lower than this specified QL, DNU is used instead.

The Quality Transmit values allow you to override the QL value to be transmitted in the SSM messages. The choices are as follows:

- **Exact Value:** Use the exact QL unless Do Not Use (DNU) would otherwise be sent.
- **Highest Value:** Sets 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 Value:** Sets 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.

Note The quality options specified in these settings must match the configured QL option in the Synchronous Ethernet Node Policy for the switch.

Step 5 Click **Submit**.

What to do next

Add the policy to a Leaf Access Port Policy Group at **Fabric > Access Policies > Interfaces > Leaf Interfaces > Policy Groups > Leaf Access Port**.

QL Mapping with ACI Configuration Options

The following tables list the clock-source quality level (QL) value selections in the synchronous Ethernet policy configuration.

For details about these QL options, see *ITU-T G.781, Synchronization layer functions for frequency synchronization based on the physical layer*.

ITU-T Option 1

| Quality Transmit/Receive Value | Quality Level |
|---|---|
| This signal should not be used for synchronization | QL-DNU |
| Quality common failed | QL-FAILED (see Notes) |
| Quality common invalid | QL-INVx (see Notes) |
| Quality common none | (see Notes) |
| ITU-T Option 1: Ethernet equipment clock | QL-SEC/QL-EEC1 |
| ITU-T Option 1: Enhanced Ethernet equipment clock | QL-eEEC not supported Translated to QL-SEC/QL-EEC1 (see Notes) |
| ITU-T Option 1: Enhanced primary reference timing clock | QL-ePRTC not supported Translated to QL-PRC (see Notes) |
| ITU-T Option 1: Primary reference clock | QL-PRC |
| ITU-T Option 1: Primary reference timing clock | QL-PRTC not supported Translated to QL-PRC (see Notes) |
| ITU-T Option 1: SONET equipment clock | QL-SEC |

| Quality Transmit/Receive Value | Quality Level |
|---|---------------|
| ITU-T Option 1: Type I or V slave clock | QL-SSU-A |
| ITU-T Option 1: Type IV slave clock | QL-SSU-B |

ITU-T Option 2, Generation 1

| Quality Transmit/Receive Value | Quality Level |
|---|---|
| This signal should not be used for synchronization | QL-DUS |
| Quality common failed | QL-FAILED (see Notes) |
| Quality common invalid | QL-INVx (see Notes) |
| Quality common none | (see Notes) |
| ITU-T Option 2, Generation 1: Ethernet equipment clock | QL-EEC2 |
| ITU-T Option 2, Generation 1: Enhanced Ethernet equipment clock | QL-eEEC not supported Translated to QL-ST3 (see Notes) |
| ITU-T Option 2, Generation 1: Enhanced primary reference timing clock | QL-ePRTC not supported Translated to QL-PRS (see Notes) |
| ITU-T Option 2, Generation 1: Primary reference source | QL-PRS |
| ITU-T Option 2, Generation 1: Primary reference timing clock | QL-PRTC not supported Translated to QL-PRS (see Notes) |
| ITU-T Option 2, Generation 1: RES | QL-RES |
| ITU-T Option 2, Generation 1: SONET clock self timed | QL-SMC |
| ITU-T Option 2, Generation 1: Stratum 2 | QL-ST2 |
| ITU-T Option 2, Generation 1: Stratum 3 | QL-ST3 |
| ITU-T Option 2, Generation 1: Stratum 4 freerun | (see Notes) |
| ITU-T Option 2, Generation 1: Synchronized - traceability unknown | QL-STU |

ITU-T Option 2, Generation 2

| Quality Transmit/Receive Value | ITU Quality Level |
|---|---|
| This signal should not be used for synchronization | QL-DUS |
| Quality common failed | QL-FAILED (see Notes) |
| Quality common invalid | QL-INVx (see Notes) |
| Quality common none | (see Notes) |
| ITU-T Option 2, Generation 2: Ethernet equipment clock | QL-EEC2 |
| ITU-T Option 2, Generation 2: Enhanced Ethernet equipment clock | QL-eEEC not supported Translated to QL-ST3 (see Notes) |
| ITU-T Option 2, Generation 2: Enhanced primary reference timing clock | QL-ePRTC not supported Translated to QL-PRS (see Notes) |
| ITU-T Option 2, Generation 2: PROV | QL-PROV |
| ITU-T Option 2, Generation 2: Primary reference source | QL-PRS |
| ITU-T Option 2, Generation 2: Primary reference timing clock | QL-PRTC not supported Translated to QL-PRS (see Notes) |
| ITU-T Option 2, Generation 2: SONET clock self timed | QL-SMC |
| ITU-T Option 2, Generation 2: Stratum 2 | QL-ST2 |
| ITU-T Option 2, Generation 2: Stratum 3 | QL-ST3 |
| ITU-T Option 2, Generation 2: Stratum 3E | QL-ST3E |
| ITU-T Option 2, Generation 2: Stratum 4 freerun | (see Notes) |
| ITU-T Option 2, Generation 2: Synchronized - traceability unknown | QL-STU |
| ITU-T Option 2, Generation 2: Transit node clock | QL-TNC |

Notes

- The "quality common none" QL is the default when no QL is configured.

- The quality levels "quality common invalid" (QL-INVx) and "quality common failed" (QL-FAILED) are internal quality levels inside the leaf or remote leaf switch and are never generated at an output port.
- ITU-T Option 2, Generation 1 and Generation 2: Stratum 4 freerun (QL-ST4) is not supported on Ethernet line interfaces.
- Extended QL TLV (type-length-value) is not supported. When an extended QL TLV is received in an ESMC frame from the connected frequency source, the leaf or remote leaf switch will process the received ESMC frame but only honor the Standard TLV, ignoring the specified Extended TLV.
- Several QL values are described by combining standard QL TLV and extended QL TLV. These values are translated on ACI leaf nodes to QL values that can be described only with standard QL TLV. The translations are shown in the following tables:

| Extended TLV | Description | Translated/Effective QL |
|-----------------------|--|-------------------------|
| ITU-T Option 1 | | |
| QL-PRTC | ITU-T Option 1: Primary reference timing clock | QL-PRC |
| QL-eEEC | ITU-T Option 1: Enhanced ethernet equipment clock | QL-SEC/QL-EEC1 |
| QL-ePRTC | ITU-T Option 1: Enhanced primary reference timing clock | QL-PRC |
| ITU-T Option 2 | | |
| QL-PRTC | ITU-T Option 2, Generation 1 and Generation 2: Primary reference timing clock | QL-PRS |
| QL-eEEC | ITU-T Option 2, Generation 1 and Generation 2: Enhanced ethernet equipment clock | QL-ST3 |
| QL-ePRTC | ITU-T Option 2, Generation 1 and Generation 2: Enhanced primary reference timing clock | QL-PRS |

