



# Configuring Synchronous Ethernet

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This chapter describes the Synchronous Ethernet features, standards, and limitations in CPT. This chapter also describes procedures to configure Synchronous Ethernet.

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## Synchronous Ethernet Overview

A separate external time-division multiplexing (TDM) circuit is required to provide synchronized timing to multiple remote network elements (NEs) for packet transport networks like Cisco Carrier Packet Transport system. The Synchronous Ethernet (SyncE) feature addresses this requirement by providing effective timing to the remote NEs through a packet network without using an external circuit for timing.

With Ethernet equipment gradually replacing existing 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. The SyncE feature provides the required synchronization at the physical level. Operation messages maintain SyncE links and ensure that a node always derives timing from the most reliable source. SyncE uses the Ethernet Synchronization Message Channel (ESMC) to enable traceability of the best clock source to correctly define the timing source and prevent a timing loop.

## Understanding SyncE

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. In SONET/SDH the communication channel for conveying clock information is SSM, and in SyncE it is the ESMC.

SyncE is a standard for distribution of frequency over Ethernet links. Other standards (IEEE Std. 1588 Precision Time Protocol [PTP], IETF Network Time Protocol [NTP], etc.) have been and are being developed or enhanced for high-quality time distribution and Adaptive Clock Recovery (ACR) requirements.

To maintain the timing chain in SONET/SDH, operators often use SSM. Information provided by SSM Quality Levels (SSM-QL) helps a node derive timing from the most reliable source and prevent timing loops. The SONET/SDH header has a QL information present in the S1 bytes of its header. Hence, the SONET/SDH does not require any specific channel for QL information exchange. As the Ethernet does not have the QL information in its header, it requires ESMC for QL information. Because Ethernet networks are not required to be synchronous on all links or in all locations, a specific channel, the ESMC channel defined in G.8264, provides this service. ESMC 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 aimed at improving the management of Synchronous Ethernet links and the associated timing change.

## SyncE Standards

- ITU-T G.8261: Timing and synchronization aspects in packet network
- ITU-T G.8262: Timing characteristics of Synchronous Ethernet equipment slave clock
- ITU-T G.8264: Distribution of timing through packet networks
- ITU-T G.781: Synchronization layer functions

These standards specify the jitter and wander tolerances, supported frequencies, clock specifications (Synchronous Ethernet Equipment Clocks [EECs] are defined to ensure compatibility with SONET/SDH clocks detailed in ITU-T G.813 and G.812 or Telcordia GR-1244-CORE), clock selection logic, possible clock quality levels, error responses, noise tolerances, noise generation and transfer limits, holdover performance, deployment scenarios, interworking requirements, clock selection process, SSM support, and a new ESMC (which allows interworking with existing SONET/SDH infrastructure by allowing the SyncE links to convey the SSM quality level as defined in ITU-T G.707, G.781, Telcordia GR-253-CORE, and ANSI T1.101).

## SyncE Support in CPT

The clock selection algorithm of SyncE runs on the controller card of the Cisco CPT. The controller card has a Digital Phase Lock Loop (DPLL) that validates the clock for OOB (Out of Bound) frequency and then based on the clock stability and Quality Level (QL) selects the appropriate clock. All the clocks selected as reference are sent to the controller card for validation and selection. However, if an appropriate clock is not found, the controller card that has an ST3 internal clock is used as a FreeRunning clock to drive the system.

CPT supports a maximum of three clock references (per node) to be configured including BITS, 10G ports on the fabric or line card, and 1G CPT-50 ports. The clock source can be configured on any of the 10G ports of the fabric, line card, and 1G ports in CPT-50. The fabric XFP port in OTN mode can also be configured as the clock source and does not require Ethernet Synchronization Message Channel (ESMC) because it derives the QL information from the OTN OTU2E RES header. The XFP ports in OTN mode transmits the SSM-QL information in OTN OTU2E RES header.

ESMC can be enabled on any port. Administrative configuration of QL is used to support non-ESMC legacy clock sources (ITU-T G.8264 /10.2) or to override a QL. CPT needs a clock to be stable for 140 seconds to use it as HoldOver.

SyncE can be used with TNC, TSC, TNC-E, and TSC-E as a controller card in CPT.

## SyncE Limitations in CPT

- SyncE is supported for all pluggables except copper GE SFPs.
- Clock source per slot supported is only one.
- Clock that is persistent for less than 140 seconds then the clock cannot go to the holdover state.
- Controller card handles up to three clock sources and selects the best of the three clock sources.
- Clock sources that are configured and the ports configured with "ESMC Enabled" must be disabled when changing the clock mode.
- SyncE phase transients fail mask during hardware reset of the TNC-E card.
- Generation 1 to Generation 2 or SDH mode to SONET mode (or vice-versa) migration requires all the clock sources and ESMC enabled ports to be deselected and the generation/clock mode, changed.

## Synchronization Status Message in Ethernet

Network clocking uses the Synchronization Status Messages (SSM) mechanism to exchange the Quality Level (QL) of the clock between the network elements. In Ethernet, Ethernet Synchronization Message Channel (ESMC) is used for SSM exchange.

### Synchronization Status Message

Network elements use SSM to inform the neighboring elements about the QL of the clock. The non-ethernet interfaces, such as optical interfaces and T1 or E1 SPA frames, use SSM. The key benefits of the SSMs are:

- Prevents timing loops.

- Provides fast recovery when a part of the network fails.
- Ensures that a node get timing from the most reliable clock source.

SSM is either Generation 1 or Generation 2. Generation 1 is the first and most widely deployed SSM message set. Generation 2 is a newer version.

The following table shows the SDH message set.

**Table 1: SDH SSM Message Set**

Message	Quality	Description
G811	1	Primary reference clock
STU	2	Sync traceability unknown
G812T	3	Transit node clock traceable
G812L	4	Local node clock traceable
SETS	5	Synchronous equipment
DUS	6	Do not use for timing synchronization

The following table shows the Generation 1 message sets for SONET.

**Table 2: SONET SSM Generation 1 Message Set**

Message	Quality	Description
PRS	1	Primary reference source-Stratum 1
STU	2	Sync traceability unknown
ST2	3	Stratum 2
ST3	4	Stratum 3
SMC	5	SONET minimum clock
ST4	6	Stratum 4
DUS	7	Do not use for timing synchronization
RES	—	Reserved; quality level set by user

The following table shows the Generation 2 message sets for SONET.

**Table 3: SONET SSM Generation 2 Message Set**

Message	Quality	Description
PRS	1	Primary reference source-Stratum 1
STU	2	Sync traceability unknown

Message	Quality	Description
ST2	3	Stratum 2
TNC	4	Transit node clock
ST3E	5	Stratum 3E
ST3	6	Stratum 3
SMC	7	SONET minimum clock
ST4	8	Stratum 4
DUS	9	Do not use for timing synchronization
RES	—	Reserved; quality level set by user

### Ethernet Synchronization Messaging Channel

In order to maintain a logical communication channel in synchronous network connections, Ethernet relies on a channel called the Ethernet Synchronization Messaging Channel (ESMC), which is based on the IEEE 802.3 Organization-Specific Slow Protocol (OSSP) standards. ESMC relays the SSM code that represents the quality level of the Ethernet Equipment Clock (EEC) in a physical layer.

ESMC carries a 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 is comprised 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.

The ESMC packets are received only for the ports configured as clock sources, and transmitted on all the SyncE interfaces in the system. These packets are then processed by the clock selection algorithm on route processors (RP) and are used to select the best clock. The Tx frame is generated based on the QL value of the selected clock source, and sent to all the enabled SyncE ports.

## DLP-J326 Set Up Timing Parameters Using CTC

<b>Purpose</b>	This procedure sets up timing parameters using CTC.
<b>Tools/Equipment</b>	None
<b>Prerequisite Procedures</b>	None
<b>Required/As Needed</b>	As needed
<b>Onsite/Remote</b>	Onsite or remote
<b>Security Level</b>	Provisioning or higher

## Procedure

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- Step 1** Complete the [NTP-J22 Log into CTC](#) procedure at a node where you want to set up timing parameters.
- Step 2** Go to the Node View.
- Step 3** Click the **Provisioning > Timing > General** tabs.
- Step 4** In Timing Standard area, Click **Change** button to change the Current Timing Standard. The "Change Timing Standard" dialog box appears.
- Step 5** Select the **SONET** or **SDH** radio button as required. Click **OK**.
- Step 6** In the General Timing section, complete the following information:
- Timing Mode—Choose External if the CPT derives its timing from a BITS source; choose Line if timing is derived from the line card that is connected to the timing node. A third option, Mixed, allows you to set both external and line timing references.
- Note** Because Mixed timing might cause timing loops, we do not recommend its use. Use this mode with care.
- SSM Message Set—Choose either Generation 1 or Generation 2 synchronization status messaging (SSM) option if the Timing Standard selected is SONET.
  - Quality of RES—Sets the timing quality for the user-defined, reserved (RES) QL value if your timing sources supports RES. Most timing sources do not use RES. If it does not support RES, choose RES=DUS (do not use for timing reference). Qualities are displayed in the descending quality order as ranges. For example, in Generation 1 SSM, ST3<RES<ST2 means that the timing reference RES is higher than a Stratum 3 (ST3) and lower than a Stratum 2 (ST2). If the Timing Standard selected is SDH, RES is not supported.
  - Revertive—Check this check box if you want the CPT to revert to a primary reference source after the conditions that caused it to switch to a secondary timing reference are corrected.
  - Reversion Time—Check this check box and choose the amount of time that the CPT system should wait before reverting to its primary timing source. The default value is 5 minutes.
- Step 7** Click **Apply**.
- Step 8** Click the **BITS Facilities** tab.
- Note** The BITS Facilities section sets the parameters for your BITS-1 and BITS-2 timing references. Many of these settings are determined by the timing source manufacturer. If equipment is timed through BITS Out, you can set timing parameters to meet the requirements of the equipment.
- Step 9** In the BITS In area, complete the following information:
- Facility Type—(TNC/TSC/TNC-E/TSC-E only) Choose the BITS signal type supported by your BITS clock, either DS1 or 64Khz+8Khz.
  - BITS In State—Set the BITS In state for BITS-1, BITS-2, or both, to IS (in service) if Timing Mode is set to External or Mixed, depending on whether one or both BITS input pin pairs are connected to the external timing source. If Timing Mode is set to Line, set the BITS In state to OOS (out of service).
- Step 10** If the BITS In state is set to OOS, continue with Step 12. If the BITS In state is set to IS, complete the following information:

- **Coding**—Choose the coding used by your BITS reference, either B8ZS (binary 8-zero substitution) or AMI (alternate mark inversion).
- **Framing**—Choose the framing used by your BITS reference, either ESF (Extended Super Frame) or SF (D4) (Super Frame).
- **Sync Messaging**—Check this check box to enable SSM. SSM is not available if framing is set to Super Frame.
- **Admin SSM**—Choose the SSM Generation 2 type from the drop-down list if the SyncE Messaging check box is unchecked. Available options are PRS (Primary reference source; Stratum 1), ST2 (Stratum 2), TNC (Transit Node Clock), ST3E (Stratum 3E), ST3 (Stratum 3), SMC (SONET minimum clock), and ST4 (Stratum 4).

**Step 11** In the BITS Out area, complete the following information, as needed:

- **Facility Type**—(TNC/TSC only) Choose the BITS Out signal type, either DS1 or 64Khz+8Khz.
- **BITS Out state**—Set the BITS Out state for BITS-1, BITS-2, or both to IS ((depending on which BITS Out pins are used for the external equipment): if the equipment is connected to the BITS output pins of the node on the backplane (ANSI) or MIC-C/T/P FMEC (ETSI); and to time the equipment from a node reference. If equipment is not attached to the BITS output pins, set the BITS Out state to OOS.

**Step 12** If the BITS Out state is set to OOS, continue with Step 12. If the BITS Out state is set to IS, complete the following information:

- **Coding**—Choose the coding used by your BITS reference, either B8ZS or AMI.
- **Framing**—Choose the framing used by your BITS reference, either ESF or SF (D4).
- **AIS Threshold**—Choose the quality level where a node sends an alarm indication signal (AIS) from the BITS 1 Out and BITS 2 Out backplane pins (ANSI) or MIC-C/T/P FMEC (ETSI), if SSM is disabled or Super Frame is used. An AIS alarm is raised when the optical source for the BITS reference falls to or below the SSM quality level defined in this field.
- **LBO**—Set the line build-out (LBO) distance between the ONS 15454 and an external device, if an external device is connected to the BITS Out pins. If an external device is connected to BITS Out, choose the distance between the device and the CPT system. Options are: 0-133 ft (default), 134-266 ft, 267-399 ft, 400-533 ft, and 534-655 ft. LBO relates to the BITS cable length. If an external device is not connected to BITS Out, leave this field set to the default.

**Step 13** Click **Apply**.

**Step 14** Return to your originating procedure (NTP).

## DLP-J330 Enable or Disable ESMC Using CTC

<b>Purpose</b>	This procedure enables or disables ESMC using CTC.
<b>Tools/Equipment</b>	None
<b>Prerequisite Procedures</b>	None

<b>Required/As Needed</b>	As needed
<b>Onsite/Remote</b>	Onsite or remote
<b>Security Level</b>	Provisioning or higher

### Procedure

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- Step 1** Complete the [NTP-J22 Log into CTC](#) procedure at a node on the network where you want to enable or disable ESMC.
- Step 2** Right-click the fabric or line card and choose **Open Packet Transport System View**.
- Step 3** The Packet Transport System View window appears. Click the **Provisioning > Timing** tabs. In the Timing Configurations area, expand the appropriate slot and check the **ESMC Enable** check box on the port where you want to enable SyncE. You can select the clock source among the ESMC enabled ports. To select the clock source among the OTN ports, do not check the **ESMC Enable** check box.
- Step 4** Click **Apply**.
- Step 5** Return to your originating procedure (NTP).
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## DLP-J328 Configure SyncE Port Using CTC

<b>Purpose</b>	This procedure configures SyncE port using CTC.
<b>Tools/Equipment</b>	None
<b>Prerequisite Procedures</b>	None
<b>Required/As Needed</b>	As needed
<b>Onsite/Remote</b>	Onsite or remote
<b>Security Level</b>	Provisioning or higher

### Procedure

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- Step 1** Complete the [NTP-J22 Log into CTC](#) procedure at a node where you want to configure the SyncE port.
- Step 2** Right-click the fabric or line card and choose **Open Packet Transport System View**.
- Step 3** The Packet Transport System View window appears. Choose the SyncE port parameters as shown in the following table.



**Table 4: SyncE Port Configuration Parameters**

Parameter	Description	Options
Port	(Display only) Displays the port number (n-n) and rate.	—
ProvidesSync	(Display only) Selects port automatically after the port is used as a clock source.	—
SyncMsgIn	Sets the EnableSync card parameter.  Enables synchronization status messages, which allow the node to choose the best timing source.	Checked or unchecked
Admin SSM In	Overrides the synchronization status message (SSM) and the synchronization traceability unknown (STU) value. If the node does not receive an SSM signal, it defaults to STU.	<ul style="list-style-type: none"> <li>• PRS-Primary Reference Source (Stratum 1)</li> <li>• ST2-Stratum 2</li> <li>• TNC-Transit node clock</li> <li>• ST3E-Stratum 3E</li> <li>• ST3-Stratum 3</li> <li>• SMC-SONET minimum clock</li> <li>• ST4-Stratum 4</li> <li>• DUS-Do not use for timing synchronization</li> <li>• RES-Reserved; quality level set by user</li> </ul>
Send DoNotUse	Sends a DUS message as the QL value, when checked.	Checked or unchecked

**Step 4** Click **Apply**.

**Step 5** Return to your originating procedure (NTP).

## Clock Selection Algorithm

The clock selection algorithm selects the best available synchronization source from the nominated sources. This algorithm exhibits nonrevertive behavior among the clock sources with the same QL value, and always

selects the signal with the best QL value. For clock option SDH, the default is revertive, and for clock option SONET, the default is nonrevertive.

## Clock Source Selection

The CPT supports the following clock source references:

### Internal Clock Source

The controller card has its own internal clock ST3 in SONET mode, and SEC in SDH mode. This clock is used during the freerunning mode. By default, the internal clock is selected as the clock reference.

### External Clock Source

BITS-IN1 and BITS-IN2 can be configured as the external clock reference and the QL can be configured as the BITS-IN clock.

### Line Card Clock Source

One SyncE clock source per line card is supported. In Cisco CPT-600, a maximum of six clock sources are available for selection excluding the BITS; In Cisco CPT-200, a maximum of two clock sources are available for selection excluding BITS.



#### Note

The CPT supports a maximum of three clock references.

For example, more than one clock source per line card (inclusive of all the Cisco CPT-50 fanout ports) cannot be selected. If a Cisco CPT-50 1G port is selected as a clock source, no other clock source from any other Cisco CPT-50 fanout from that slot (where the former CPT-50 was fanned out) nor can any port from the line card can be selected.

### Clock Source Protection in Cisco CPT-50

The Cisco CPT-50 can have one of the 44 GE ports to act as a clock source. When 1G port is selected as a clock source, the clock is preserved when bundled interlinks are added. The clock protection is also maintained on the bundled interlinks. When one of the interlinks fail, the clock momentarily moves to holdover or freerunning state, but will restore using the other interlinks.

## Clock Mode

- **Holdover Mode**—In this mode, all external or line timing references are lost and the clock uses timing data referenced while in normal operating mode to control its output signal. However, holdover frequency drifts over time until a timing reference becomes available. If the previous timing reference was available for less than 140 seconds before it was lost, TCC enters the Free-running mode when the timing reference is lost. This mode is better than the Free-running mode because it uses the average of 140 seconds of data from the last qualified timing reference to augment its internal clock. TCC remains in this mode until a reference becomes available to switch, or the drift is out of bounds. Traffic is guaranteed to be uninterrupted by a transition to the Holdover mode for the first 24 hours.

- **Free-running Mode**—This mode only references the internal clock on the TCC card. It is also the default mode when other references are lost, even when it is not specifically provisioned as a reference. Ensure that your network does not operate with the internal clock of the TCC card as the only or primary timing source.

## Timing Modes

- **External**—Only external clock can be used as a source. The external clock source can be configured as Internal, BITS-IN1, and BITS-IN2.
- **Line**—Internal controller card clock (ST3 in SONET, and SEC in SDH) or line card ports (10G ports in fabric or line card and 1G ports in CPT-50) can be selected as clock source.
- **Mixed**—Both External and Line clock sources can be configured.

## DLP-J327 Select Timing Reference Using CTC

<b>Purpose</b>	This procedure selects the timing reference using CTC.
<b>Tools/Equipment</b>	None
<b>Prerequisite Procedures</b>	None
<b>Required/As Needed</b>	As needed
<b>Onsite/Remote</b>	Onsite or remote
<b>Security Level</b>	Provisioning or higher

### Procedure

- Step 1** Complete the [NTP-J22 Log into CTC](#) procedure at a node where you want to select the timing reference.
- Step 2** Go to the Node View.
- Step 3** Click the **Provisioning > Timing > General** tabs.
- Step 4** In the Reference Lists area, complete the following information:
  - **NE Reference**—Defines three timing references (Ref 1, Ref 2, Ref 3). The node uses Reference 1 unless a failure occurs to that reference, in which case the node uses Reference 2. If Reference 2 fails, the node uses Reference 3, which is typically set to Internal Clock. Internal Clock is the Stratum 3 clock provided on the TNC/TSC/TNC-E/TSC-E card.
    - If the Timing Mode is set to External, the options are BITS-1, BITS-2, and Internal Clock.
    - If the Timing Mode is set to Line, the options are the 10G PTM, 10G PTF, and 1G, or both Cisco CPT-50 ports that are ESMC enabled. In addition, the internal clock can also be selected.

- If the Timing Mode is set to Mixed, both BITS references and the 10G PTM, 10G PTF, or 1G, Cisco CPT-50 ports are available, allowing to set a mixture of external BITS clocks and 10G PTM, 10G PTF, and 1G, or both Cisco CPT-50 ports as timing references.

- BITS-1 Out/BITS-2 Out—Sets the timing references for equipment wired to the BITS Out. BITS-1 Out and BITS-2 Out are enabled when BITS-1 Out and BITS-2 Out facilities are put in service. If Timing Mode is set to external, choose the 10G PTM, 10G PTF, and 1G, or both Cisco CPT-50 ports used to set the timing. If Timing Mode is set to Line, choose an 10G PTM, 10G PTF, or 1G Cisco CPT-50 ports or choose NE Reference to have the BITS-1 Out, BITS-2 Out, or both, follow the same timing references as the network element (NE).

**Step 5** Click **Apply**.

**Step 6** Return to your originating procedure (NTP).

## Revertive and Non-revertive Clock Switching

The switching of timing references can be made revertive or non-revertive. In non-revertive switching, a switch to an alternate reference is maintained even after the original reference has recovered from the failure that caused the switch. However, that the node should switch back to the original reference (rather than enter the Holdover) if the original reference has recovered from its failure and the alternate reference subsequently fails. The clock enters Holdover only when all references fail, regardless of the revertive setting. In revertive switching, the clock switches back to the original reference after that reference recovers from the failure, independent of the condition of the alternate reference. In CPT, support for revertive and non-revertive clock source is on a slot basis as CPT does not support more than one clock source per line card slot.

If the primary external source fails, the clock card enters holdover mode. After a few seconds, it switches over to the secondary external source. The clock card switches back to the primary external source only when it becomes available.

## DLP-J329 View Timing Status Report Using CTC

<b>Purpose</b>	This procedure views the timing status report using CTC.
<b>Tools/Equipment</b>	None
<b>Prerequisite Procedures</b>	None
<b>Required/As Needed</b>	As needed
<b>Onsite/Remote</b>	Onsite or remote
<b>Security Level</b>	Provisioning or higher

## Procedure

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- Step 1** Complete the [NTP-J22 Log into CTC](#) procedure at a node where you want to view the timing status report.
- Step 2** Go to the Node View.
- Step 3** Click the **Maintenance > Timing > Report** tabs.  
The report shows current timing information of the CPT system, including the timing mode, clock state and status, switch type, and reference data.
- Step 4** Return to your originating procedure (NTP).
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