CEM Generic Configuration Guide, Cisco IOS XE 17 (Cisco ASR 900 Series)

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CHAPTER 1

Preface

Circuit Emulation (CEM) is a technology that provides a protocol-independent transport over IP/MPLS networks. It enables proprietary or legacy applications to be carried transparently to the destination, similar to a leased line.

This guide covers CEM features, configuration, and verfication that are common for the following CEM interface modules.

- 48-Port T1 or E1 CEM interface module
- 48-Port T3 or E3 CEM interface module
- 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4-port T3/E3 CEM interface module
- 1-port OC-192 or 8-port Low rate CEM interface module
- ASR 900 Combo 8-port SFP GE and 1-port 10 GE 20G interface module

- Document Organization, on page 1
- Supported Configurations, on page 2
- Related Documentation, on page 3

Document Organization

Chapter	Description
Feature History	Lists features supported with the Cisco IOS XE release versions.
Circuit Emulation	Provides the information about CEM classes and parameters, and how to configure them.
CEM pseudowire	Provides information about CEM pseudowire modes and how to configure pseudowires on the interface module of the chassis.
Clock Recovery	Provides information about ACR and DCR for SONET and SDH on SAToP and CESoP, and describes configuration with verification steps.

Chapter	Description
BERT	Provides information about BERT modes and BERT patterns that are supported on IMs and describes how to configure BERT on SONET and SDH-supported modes.
CEM over MPLS QoS	Provides information about QoS experimental bits (EXP) matching feature and how to classify and mark network traffic using QoS EXP matching feature.

Supported Configurations

Table 1: Supported Configurations

	T1/E1	T3/E3	SONET	SDH
			STS-1 - T3 and CT3 **VT-15 – T1 and VT**	**AU-3 - CE3, CT3, E3, T3, and VC1X** **AU4 - VC3, Tug-3 E3, Tug-3 VC1x, and Tug-3 T3**
Required Circuit Emulation Configurations				
CEM Class	Yes	Yes	NA	NA
Payload Size	Yes	Yes	NA	NA
Dejitter Buffer	Yes	Yes	NA	NA
CEM Pseudowire				
Structure- Agnostic TDM over Packet (SATOP) (Framed/Unframed)	Yes	Yes	Yes	Yes
Circuit Emulation over Packet-Switched Network (CESoPSN)	NA	Yes	Yes	Yes
Circuit Emulation over Packet (CEP)	Yes	Yes	Yes	Yes
Clock Recovery Features				
Adaptive Clock Recovery	Yes	Yes	Yes	Yes
Differential Clock Recovery	Yes	Yes	Yes	Yes

	T1/E1	T3/E3	SONET	SDH
			STS-1 - T3 and CT3 **VT-15 – T1 and VT**	**AU-3 - CE3, CT3, E3, T3, and VC1X** **AU4 - VC3, Tug-3 E3, Tug-3 VC1x, and Tug-3 T3**
Network Clock	NA	NA	NA	NA
BERT Features				
BERT	Yes	Yes	Yes (only on T3 mode)	NA
BERT Error Injection	Yes	Yes	Yes	NA
CEM over MPLS QoS Support				
Classify MPLS Encapsulated Packets	Yes	Yes	Yes	Yes
Mark MPLS EXP on Imposed Labels	Yes	Yes	Yes	Yes

Related Documentation

- Alarm Configuring and Monitoring Guide
- 48-Port T1 or E1 CEM Interface Module Configuration Guide
- 48-Port T3 or E3 CEM Interface Module Configuration Guide

CHAPTER 2

Feature History

The following table lists the new and modified features supported in the CEM Generic Configuration Guide in Cisco IOS XE 17 releases.

Feature	Description
Cisco IOS XE Cupertino 17.8.1	
CAS feature to perform Super Frame to Extended Super Frame conversion	Channel Associated Signaling (CAS) is a method of signaling each traffic channel rather than having a dedicated signaling channel. CAS uses the same channel, which carries voice or data to pass control signals. This provides an advantage as the implementation of CAS is inexpensive. Supports CAS feature with "in-band" signaling type. You can configure CAS on a specific interface or under global CEM class.
Digital Signaling level zero (DS0) Loopbacks - Network and Local	DS0 loopback is used for testing and troubleshooting the T1 or E1 channel over PSN. You can configure local and remote loopback on channelized T1 or E1 controller (DS0 channel). If the PSN has several NxDS0 pseudowires that are configured at the TDM side, then the same number of NxDS0 loopbacks can be configured on the controller. This provides better TDM maintenance.
Cisco IOS XE Cupertino 17.7.1	
Increased MPLS label scale support	Starting with Cisco IOS XE Cupertino 17.7.1 release, you can further increase the MPLS label range from 32,768 to 40,950 to configure the dynamic label range.
TAP and Split TAP Support for Protected Interfaces	TAP and split TAP support for the following protected interfaces on both receive and transmit direction: • Automatic Protection Switching (APS) • Unidirectional Path Switching Ring (UPSR) • Card Protection Group (CPG) With this feature support, you can perform monitoring and debugging on these virtual protection interfaces.
Cisco IOS XE Bengaluru 17.6.1	

<table>
<tr><th>Feature</th><th>Description</th></tr>
<tr><td>Test Access Port (TAP) or Test Access Digroup (TAD)</td><td>Support for Test access port or digroup (TAP/TAD) in the following aspects:
• Non-intrusive monitoring for both receive and transmit directions.
• Split and terminate cross connection for intrusive testing in both directions. The TAP feature helps in monitoring and debugging purpose.</td></tr>
<tr><td colspan="2">Cisco IOS XE Bengaluru 17.5.1</td></tr>
<tr><td>RSP-based Non-Intrusive Monitor Ports</td><td>This feature allows you to transmit data to multiple connections from a single source using the RSP-based non-intrusive monitor port or Terminal Access Point (TAP) port. It establishes a one-way cross-connect listen connection that listens to either the source or destination of an existing cross-connect or a local connect connection. This feature is only supported on Cisco RSP3 module.
This feature is supported on the following CEM interface modules:
• 1-port OC481/ STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-Port T1/E1 + 4-Port T3/E3 CEM Interface Module
• 48-port T3/E3 CEM Interface Module (ASR 900 48-portT3/E3 Interface Module)
• 48-port T1/E1 CEM Interface Module (ASR 900 48 port T1/E1 Interface Module)
• ASR 900 Combo 8-Port SFP GE and 1-Port 10 GE 20G Interface Module (A900-IMA1Z8S-CXMS)</td></tr>
<tr><td>Support for Static MPLS Labels on Cisco RSP3 Module</td><td>This feature allows you to provision an Any Transport over Multiprotocol (AToM) label switching static pseudowire without the use of a directed control connection. In environments that do not or cannot use directed control protocols, this feature provides a means for provisioning the pseudowire parameters statically at the Cisco IOS Command-Line Interface (CLI).
This feature is supported on Cisco RSP3 module.</td></tr>
<tr><td colspan="2">Cisco IOS XE Bengaluru 17.4.1</td></tr>
<tr><td>STS1E Framed SAToP Support on IMA3G</td><td>Support on clock recovery on STS-1e controller for framed SAToP on the following modes:
• T3
• CT3
• VT-15</td></tr>
<tr><td>BERT Error Injection</td><td>BERT Error injection enables you to inject errors into the BERT stream on SONET and SDH controllers. You can introduce BERT errors in a range of 1 to 255.</td></tr>
</table>

Feature	Description
Support for all 0s and 1s BERT Patterns	Support for all 0s and 1s BERT patterns for SONET and SDH for the following interface modules: • 1-port OC-192 or 8-9ort Low Rate CEM Interface Module • 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 CEM Interface Module • ASR 900 Combo 8-Port SFP GE and 1-Port 10 GE 20G Interface Module ((A900-IMA1Z8S-CXMS)
Cisco IOS XE Amsterdam 17.3.1	
Pseudowire Scale Support	A maximum of 26,880 CEM Pseudowires are supported on the Cisco RSP3 chassis using combination of the 1-Port OC-192 or 8-Port Low Rate CEM interface module.

CHAPTER 3

Circuit Emulation

Circuit Emulation (CEM) is a technology that provides a protocol-independent transport over IP/MPLS networks. It enables proprietary or legacy applications to be carried transparently to the destination, similar to a leased line.

CEM provides a bridge between a Time-Division Multiplexing (TDM) network and a Multiprotocol Label Switching (MPLS) network. The router encapsulates the TDM data in the MPLS packets and sends the data over a CEM pseudowire to the remote Provider Edge (PE) router. As a result, CEM functions as a physical communication link across the packet network.

The router supports the pseudowire type that utilizes CEM transport: Structure-Agnostic TDM over Packet (SAToP) and Circuit Emulation Service over Packet-Switched Network (CESoPSN).

L2VPN over IP/MPLS is supported on the interface modules.

Note We recommend that you configure the controller in the administratively up mode. Configuration under the administratively down mode is not recommended and it might cause configuration errors.

Note The default behaviour of the CEM pseudowire is always UP irrespective of the controller alarms.

- Restrictions for CEM, on page 9
- How to Configure CEM, on page 10

Restrictions for CEM

- With Synchronous Transport Signal (STS) Circuit Emulation over Packet (CEP) or STS concatenated CEP mode, if you receive a B3 error, then the Remote Error Indication (REI) won't be generated. Request for Comments (RFC) reference—RFC 4842.
- Not all combinations of payload size and dejitter buffer size are supported. If you apply an incompatible payload size or dejitter buffer size configuration, the router rejects it and reverts to the previous configuration.
- The RSP switchover with physical SSO is above 50 ms as follows:
    - R0 to R1 is 5 seconds

  - R1 to R0 is 10 seconds

- CEM interface doesn't support idle-cas parameter.
- The **`cem description`** command is not supported on the CEM circuits that are created using the smart SFP.
- The speed CLI option is not supported with T1 or E1 CEM group and channel group configuration.
- The speed 56 option with DS0 circuits is not supported and by default all DS0 circuits operate at 64 kbps speed only.

How to Configure CEM

This section provides information about how to configure CEM. CEM provides a bridge between a Time Division Multiplexing (TDM) network and a packet network, MPLS. The chassis encapsulates the TDM data in the MPLS packets and sends the data over a CEM pseudowire to the remote Provider Edge (PE) chassis.

Shutting Down a CEM Channel

To shut down a CEM channel, use the **shutdown** command in CEM configuration mode. The **shutdown** command is supported only under CEM mode and not under the CEM class.

Configuring CEM Classes

A CEM class is a single step configuration of CEM parameters such as payload size and dejitter buffer that you can perform at the global configuration mode and apply this CEM class on an individual CEM interfaces.

Thus the CEM class allows you to create a single configuration template for multiple CEM pseudowires.

Follow these steps to configure a CEM class:

Note

- The CEM parameters can be configured either by using CEM class or on CEM interface directly.
- The CEM parameters at the local and remote ends of a CEM circuit must match; otherwise, the pseudowire between the local and remote PE chassis does not come up.

```
enable
configure terminal
class cem mycemclass
payload-size 512
dejitter-buffer 12
exit
interface cem 0/0/1
cem 0
cem class mycemclass
xconnect 10.10.10.10 200 encapsulation mpls
exit
```

Note Removing the global CEM class that is associated with CEM interface/CEM group will remove the configuration from all the associated CEM.

Configuring CEM Parameters

The following sections describe the parameters you can configure for CEM circuits.

Calculating Payload Sizes for T1 and E1 Interfaces

Payload size for a CEM class denotes the number of bytes encapsulated into a single IP packet and you configure the payload size using the **payload-size** command. The size argument specifies the number of bytes in the payload of each packet. The range is from 32 to 1312 bytes.

Default Payload Sizes

Default payload sizes for an unstructured CEM channel are as follows:

- T1 = 192 bytes
- E1 = 256 bytes
- DS0 = 32 bytes

Default payload sizes for a structured CEM channel depend on the number of time slots that constitute the channel. Payload size (L in bytes), number of time slots (N), and packetization delay (D in milliseconds) have the following relationship: L = 8*N*D. The default payload size is selected in such a way that the packetization delay is always 1 millisecond. For example, a structured CEM channel of 16xDS0 has a default payload size of 128 bytes.

Note Both payload-size and dejitter-buffer must be configured simultaneously.

Calculating Payload Sizes for T3 and E3 Interfaces

To specify the number of bytes encapsulated into a single IP packet, use the **payload-size** command. The size argument specifies the number of bytes in the payload of each packet.

Default payload sizes for T3/E3 interface are:

- T3/E3 clear channel= 1024 bytes
- T3/E3 channelized = 192 bytes

Default payload sizes for a structured CEM channel depend on the number of time slots that constitute the channel. Payload size (L in bytes), number of time slots (N), and packetization delay (D in milliseconds) have the following relationship: L = 8*N*D. The default payload size is selected in such a way that the packetization delay is always 1 millisecond.

Note Both payload-size and dejitter-buffer must be configured simultaneously. When you select a value of payload-size, the acceptable range of dejitter-buffer for that payload size is displayed.

Setting the Dejitter Buffer Size

Dejitter Buffer is a buffering mechanism to account for a delay variation in the CEM packet stream. The buffer size is the amount of time you allocate to compensate for the network filter. The configured dejitter-buffer size is converted from milliseconds to packets and rounded up to the next integral number of packets. To set the size of the dejitter-buffer (in milliseconds), use the **dejitter-buffer** *value* command. The value range is from 1 to 32; the default is 5.

Configuring CEM Parameter on CEM Interface

The CEM parameters can be configured directly on CEM interface. Follow these steps to configure CEM parameters:

```
enable
configure terminal
interface cem 0/0/1
cem 0

payload-size 512 dejitter-buffer 12
xconnect 10.10.10.10 200 encapsulation mpls
exit
```

Verifying the Interface Configuration

Use the following commands to verify the pseudowire configuration:

- **show cem circuit**—Displays information about the circuit state, administrative state, the CEM ID of the circuit, and the interface on which it is configured. If **xconnect** is configured under the circuit, the command output also includes information about the attachment circuit status.

```
Router# show cem circuit
 ?

  <0-504>    CEM ID
  detail     Detailed information of cem ckt(s)
  interface  CEM Interface
  summary    Display summary of CEM ckts
  |          Output modifiers
Router# show cem circuit

CEM Int.       ID   Line      Admin     Circuit         AC
--------------------------------------------------------------
CEM 0/4/0       1    UP        UP        ACTIVE          --/--
CEM 0/4/0       2    UP        UP        ACTIVE          --/--
CEM 0/4/0       3    UP        UP        ACTIVE          --/--
CEM 0/4/0       4    UP        UP        ACTIVE          --/--
CEM 0/4/0       5    UP        UP        ACTIVE          --/--
```

- **show cem circuit** *cem-id* — Displays the detailed information about that particular circuit.

```
Router# show cem circuit 0

CEM 0/4/0, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Controller state: down, T3 state: up
Idle Pattern: 0x55, Idle CAS: 0x8
Dejitter: 10 (In use: 0)
Payload Size: 1024
Framing: Unframed
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    11060                Dropped:            0
Egress Pkts:     11061                Dropped:            0

CEM Counter Details
Input Errors:    0                    Output Errors:      0
Pkts Missing:    0                    Pkts Reordered:     0
Misorder Drops:  0                    JitterBuf Underrun:  0
Error Sec:       0                    Severly Errored Sec: 0
Unavailable Sec: 0                    Failure Counts:     0
Pkts Malformed:  0                    JitterBuf Overrun:   0
```

- **show cem circuit summary**—Displays the number of circuits which are up or down for each interface.

```
Router# show cem circuit summary

CEM Int.       Total Active  Inactive
--------------------------------------
CEM 0/4/0       1     1       0
```

- **show running configuration**—The **show running configuration** command shows detail on each CEM group.

- **show cem circuit description**—Displays the CEM interface details with description.

Use the **`show cem circuit description`** command

```
Router#show cem circuit description
CEM Int.       ID   Ctrlr     Admin     Circuit    Description
 ------------------------------------------------------------------
CEM0/3/16      29   DOWN      UP        Active          cem29_description
Router#show cem circuit interface cem 0/3/16 29 description
CEM Int.       ID   Ctrlr     Admin     Circuit    Description
 ------------------------------------------------------------------
CEM0/3/16      29   DOWN      UP        Active       cem29_description

Router#show cem circuit 29 description
CEM Int.       ID   Ctrlr     Admin     Circuit    Description
 ------------------------------------------------------------------
CEM0/3/16       29    DOWN      UP        Active       cem29_description
```

CHAPTER 4

CEM Pseudowire

Cisco Pseudowire Emulation Edge-to-Edge (PWE3) allows you to transport traffic by using traditional services such as T1 over a packet-based backhaul technology such as MPLS or IP. A pseudowire (PW) consists of a connection between two provider edge (PE) chassis that connects two attachment circuits (ACs), such as T1 or T3 links.

- Overview of CEM Pseudowire, on page 15
- Modes of CEM, on page 15
- Pseudowire Scale Support, on page 16
- Structure-Agnostic TDM over Packet , on page 17
- How to Configure Pseudowire, on page 19

Overview of CEM Pseudowire

Pseudowires manage encapsulation, timing, order, and other operations in order to make it transparent to users. The pseudowire tunnel acts as an unshared link or circuit of the emulated service. CEM is a way to carry TDM circuits over packet switched network. CEM embeds the TDM circuits into packets, encapsulates them into an appropriate header, and then sends that through Packet Switched Network. The receiver side of CEM restores the TDM circuits from packets.

Modes of CEM

- **Structure Agnostic TDM over Packet (SAToP)** (RFC 4553) – SAToP mode is used to encapsulate T1/E1 or T3/E3 unstructured (unchannelized) services over packet switched networks. In SAToP mode, the bytes are sent out as they arrive on the TDM line. Bytes do not have to be aligned with any framing.

  In this mode, the interface is considered as a continuous framed bit stream. The packetization of the stream is done according to IETF RFC 4553. All signaling is carried transparently as a part of a bit stream.

- **Circuit Emulation Service over Packet (CEP)** (RFC 4842) - CEP mode is used to encapsulate SDH payload envelopes (SPEs) like VC11, VC12, VC4, or VC4-Nc over PSN. In this mode, the bytes from the corresponding SPE are sent out as they arrive on the TDM line. The interface is considered as a continuous framed bit stream. The packetization of the stream is done according to IETF RFC 4842.

Table 2: SDH CEM Channelization Modes

SDH Modes	CEM	Ports
VC4-16c	CEP	STM16
VC4-4c	CEP	STM4, STM16
VC4	CEP	STM1, STM4, STM16
TUG-3-E3	SAToP	STM1, STM4, STM16
TUG-3-T3	SAToP	STM1, STM4, STM16
TUG-2-VC11	CEP	STM1, STM4, STM16
TUG-2-VC12	CEP	STM1, STM4, STM16
TUG-2-T1	SAToP	STM1, STM4, STM16
TUG-2-E1	SAToP	STM1, STM4, STM16

Pseudowire Scale Support

Table 3: Feature History

Feature Name	Release	Description
Pseudowire Scale Support	Cisco IOS XE Gibraltar 16.12.1	A maximum of **21,504** Pseudowires are supported on the Cisco RSP3 chassis using combination of the 1-Port OC-192 or 8-Port Low Rate CEM interface module.

Effective Cisco **IOS XE 16.12.1**, the Cisco router supports,

- 21,504 CEM Pseudowire (PWs) without protection (with SONET)
- 10,752 CEM PWs with protection

Note These 21,504 CEM PWs can be achieved on the router by using the combination of the 1-port OC-192 Interface module or 8-port Low Rate Interface Module and 1-port OC148/ STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-Port T1/E1 + 4-Port T3/E3 CEM Interface Module IMs with the 48-port T3/E3 CEM Interface Module and 48-port T1/E1 CEM Interface Module (ASR 900 48-port T1/E1 Interface Module) in multiple slot combinations.

Restrictions for PW Scale

- CEM PW scale is supported in **only** in the SONET mode.
- When configured for scale beyond the maximum CEM PW scale, a syslog is generated as *Cannot allocate CEM group*, maximum CEM group exceeded, but the configurations will not be rejected.

- While performing ISSU with the specified CEM PW scales, sufficient interface-module-delay must be provided for each IM. This provision enables all PWs to program after the IM OIR. The minimum 'time for delay' in case of 1-port OC-192 Interface module or 8-port Low Rate Interface Module (ASR 900 Combo 8-port SFP GE and 1-port 10GE IM with CEM, 10G) is 1800 seconds.
- After SSO and successful bulk sync, run the **show platform software tdm-combo cem ha-stray-entries** command. If the output of this command displays no entries, then the next SSO can be performed. You must wait until **show platform software tdm-combo cem ha-stray-entries** has no entries.
- You should not perform any operations on the active node while the standby node is reloading until the sync is complete between the active and standby nodes.
- With the scale IM configuration, bootup time increases as the scale sessions have to be programmed internally to the hardware.
- With CEM scale of 10,000 and above, it is recommended to wait for 90 minutes after Standby-RSP is "standby-Hot" before performing any more SSOs on the node.

Note To configure CEM circuits (for example, T1 or VT1.5 CEP pseudowire) at a large number (for example, 10,000), we recommend you to configure the CEM circuits in a batch of 2000 CEM circuits. Use the **show platform software tdm-combo cem ha-stray-entries** command to verify that there are no pending circuits to be programmed before proceeding to the next batch of configuration. The **show platform software tdm-combo cem ha-stray-entries** command can be used only in the standby RSP3 console.

To configure CEM PWs, see the *Carrier Ethernet Configuration Guide (Cisco ASR 900 Series).*

Structure-Agnostic TDM over Packet

Structure-Agnostic TDM over Packet (SAToP) encapsulates Time Division Multiplexing (TDM) bit-streams as pseudowires over public switched networks. It disregards any structure that may be imposed on streams, in particular the structure imposed by the standard TDM framing.

The protocol used for emulation of these services does not depend on the method in which attachment circuits are delivered to the Provider Edge (PE) chassis. For example, a T1 attachment circuit is treated the same way for all delivery methods, including copper, multiplex in a T3 circuit, a virtual tributary of a SONET circuit, or unstructured Circuit Emulation Service (CES).

In SAToP mode, the interface is considered as a continuous framed bit stream. The packetization of the stream is done according to IETF RFC 4553. All signaling is carried out transparently as a part of a bit stream.

Framed Structure-Agnostic TDM over Packet (SAToP)

Framed Structure-Agnostic TDM over Packet (SAToP) is required to detect an incoming AIS alarm in the DS1 SAToP mode. An AIS alarm indicates a problem with the line that is upstream from the DS1 network element connected to the interface. Framed SAToP further helps in the detection of a packet drop.

In case of unframed mode of SAToP, data received from the Customer Edge (CE) device is transported ove the pseudowire. If the Provider Edge (PE) device receives a Loss of Frame (LOF) signal or Remote Alarm Indication (RAI) signal from a CE, the PE can only transmit the signal that is detected by the CE device. With the introduction of Framed SAToP, when the PE device receives the LOF or RAI signal, the PE device can detect the alarm for SAToP. Thus, the alarm can be detected earlier in the network. This helps in enhanced performance.

Note Framing type should be maintained same in all routers end to end.

Difference between Framed and Unframed SAToP:

1. For unframed SAToP, the incoming signal is transmitted to the far end. This signal is not analyzed by the PE device. Hence, no alarm is reported.
2. For framed SAToP, the incoming signal is analyzed but is not terminated. If a LOF or RAI signal is detected, the remote PE detects the signals and transmits towards the remote CE.

Difference between Framed SAToP and CESoP:

Table 4: Behaviour Difference between Unframed SAToP, Framed SAToP, and CESoP on LOF Alarm

Modes	Alarm Detected at PE	Controller Status at PE	Alarm Detected at CE (Remote)	Framing Bits Generationat PE (Remote)	Framing Bits Terminated at PE (Remote)
Unframed SAToP	None	Up	LOF	No	No
Framed SAToP	LOF	Down (Data path remians up)	AIS[1][2]	Yes	No
CESOP	LOF	Down (Data path remians up)	AIS	Yes	Yes

[1] AIS—Cisco IOS XE Amsterdam 17.3.1 to later releases
[2] LOF—Support until Cisco IOS XE Amsterdam 17.2.1

Table 5: Behaviour Difference between Unframed SAToP, Framed SAToP, and CESoP on RDI Alarm

Modes	Alarm Detected at PE	Controller Status at PE	Alarm Detected at CE (Remote)	Framing Bits Generation at PE (Remote)	Framing Bits Terminated at PE (Remote)
Unframed SAToP	None	Up	RDI	No	No
Framed SAToP	RDI	Down (data path remains up)	RDI	No	No
CESOP	RDI	Down (data path remains up)	RDI	M-bit is set into control word	Yes

Table 6: Behaviour Difference between Unframed SAToP, Framed SAToP, and CESoP on AIS alarm

Modes	Alarm Detected at PE	Controller Status at PE	Alarm Detected at CE (Remote)	Framing Bits Generation at PE (Remote)	Framing Bits Terminated at PE (Remote)
Unframed SAToP	AIS	Down (data path remains up)	AIS	No	No
Framed SAToP	AIS	Down (data path remains up)	AIS	No	No
CESOP	AIS	Down (data path remains up)	AIS	L-bit is set into control word	Yes

Remote Loopback from CE to PE Detection:

Framed SAToP does not detect any loopback.

	Loopback Detected at PE	Controller Status at PE (Remote)	Controller Status at CE (Remote)
Unframed SAToP	No	Not in Loopback	Loopback
Framed SAToP	No	Not in Loopback	Loopback
CESOP	Yes	Loopback	Not in loopback

How to Configure Pseudowire

The following sections describe how to configure pseudowire.

CEM Group

CEM group denotes a CEM channel that you can create for one or more time slots for T1/E1 and T3/E3 lines.

Configuring CEM Group for SAToP for T1 Interfaces

To configure a CEM group for SAToP:

```
enable
configure terminal
controller t1 0/4/0
cem-group 0 unframed
end
```

Configuring CEM Group for Framed SAToP

To configure a CEM group for Framed SAToP:

```
enable
configure terminal
```

```
controller mediatype 0/4/16
mode sonet
controller sonet 0/4/16
rate oc12
sts-1 1
mode vt-15
vtg 1 t1 1 cem-group 0 framed
end
```

Configuring VT-15 mode of STS-1 for Framed SAToP

To configure VT-15 mode of STS-1 for framed SAToP:

```
enable
configure terminal
controller mediatype 0/0/16
mode sonet
controller sonet 0/0/16
rate oc3
sts-1 1
mode vt-15
vtg 1 t1 1 cem-group 0 framed
end
```

Configuring DS1/T1 CT3 mode of STS-1 for Framed SAToP

To configure DS1/T1 CT3 mode of STS-1 for framed SAToP:

```
enable
configure terminal
controller mediatype 0/0/16
mode sonet
controller sonet 0/0/16
rate oc3
sts-1 2
mode ct3
t3 framing c-bit
t1 1 cem-group 1 framed
end
```

Configuring CEM APS for Framed SAToP

To configure unidirectional ACR (SONET Framing) for framed SAToP:

```
enable
configure terminal
controller sonet 0/4/16
rate OC3
clock source internal
aps group acr 1
aps working 1
exit
controller sonet 0/4/17
rate OC3
aps group acr 1
aps unidirectional
aps protect 1 10.7.7.7
aps revert 3
aps adm
```

```
controller sonet-acr 1
sts-1 1
mode vt-15
vtg 1 t1 1 cem-group 0 framed
end
```

To configure bi-directional ACR (SONET Framing) for Framed SAToP:

```
enable
configure terminal
controller sonet 0/4/16
rate OC3
clock source internal
aps group acr 1
aps working 1
exit
controller sonet 0/4/17
rate OC3
aps group acr 1
aps protect 1 10.7.7.7
controller sonet-acr 1
sts-1 1
mode vt-15
vtg 1 t1 1 cem-group 0 framed
end
```

Verifying SONET Configuration for Framed SAToP

To verify SONET configuration for Framed SAToP:

```
Router# show running configuration | sec 0/0/16
platform enable controller mediatype 0/0/16 oc3
controller mediatype 0/0/16
mode sonet
controller sonet 0/0/16
rate oc3
no ais-shut
alarm-report all
clock source internal
!
sts-1 1
clock source internal
mode vt-15
vtg 1 t1 1 cem-group 0 framed
!
sts-1 2
clock source internal
mode ct3
t3 framing c-bit
t3 clock source internal
t1 1 cem-group 1 framed
!
sts-1 3
clock source internal
mode ct3-e1
t3 framing c-bit
t3 clock source internal
e1 1 cem-group 2 framed
interface cem 0/0/16
no ip address
cem 0
!
cem 1
!
```

```
cem 2

#Router
```

Configuring AU-4 — TUG-3 — TUG-2 — VC-12 for Framed SAToP

Use the following commands to configure AU-4 — TUG-3 — TUG-2 — VC-12 for framed SAToP under mode VC-1x (AU-4 mapping):

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-4 1
mode tug-3
tug-3 1
mode vc1x
tug-2 3 payload vc12
e1 1 cem-group 1 framed
vc 1 overhead v5 2
end
```

Configuring AU-3 — TUG-2 — VC-11 — T1 for Framed SAToP

To configure AU-3 — TUG-2 — VC-11 — T1 for framed SAToP under mode VC-1x (AU-3 mapping):

```
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
rate stm4
au-3 1
mode vc1x
tug-2 1 payload vc11
t1 1 cem-group 0 framed
vc 1 overhead v5 2
interface cem 0/0/16
cem 100
xconnect 10.2.2.2 10 encapsulation mpls
end
```

Verifying SDH Configuration for Framed SAToP

Use **show running configuration** command to verify SDH configuration for Framed SAToP:

```
Router#show running configuration | sec 0/0/16
platform enable controller mediatype 0/0/16 oc3
controller mediatype 0/0/16
mode sdh
controller sdh 0/0/16
rate stm1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
```

```
tug-3 1
mode vc1x
tug-2 1 payload vc11
tug-2 2 payload vc12
e1 1 cem-group 1 framed
tug-2 3 payload vc11
tug-2 4 payload vc11
tug-2 5 payload vc11
tug-2 6 payload vc11
tug-2 7 payload vc11
!
interface cem 0/0/16
no ip address
cem 0
!
cem 1
!
cem 2
!
cem 3
!
Router#
```

Configuring NXDS0 Loopback

Table 7: Feature History

Feature Name	Release Information	Description
Digital Signaling level zero (DS0) Loopbacks - Network and Local	Cisco IOS XE Cupertino 17.8.1	DS0 loopback is used for testing and troubleshooting the T1 or E1 channel over PSN. You can configure local and remote loopback on channelized T1 or E1 controller (DS0 channel). If the PSN has several NxDS0 pseudowires that are configured at the TDM side, then the same number of NxDS0 loopbacks can be configured on the controller. This provides better TDM maintenance.

DS0 loopback

A DS0 connection is the basic level of communication upon which all the other Digital Signaling levels (DS1, DS2, DS3, and so on) are built. It equivalent to E0 in the E-carrier system and T0 in the T-carrier system. In this system, twenty-four (24) DS0s are multiplexed into a DS1 signal. Twenty-eight (28) DS1s are multiplexed into a DS3. A DS0 is referred to as the trunk side of a Digital Cross Connect Switch (DCCS). DS0's are used to physically connect calls between end users through a Digital Cross Connect Switch (DCCS).

DS0 defines transmission rate of 64 Kbps and can carry either a single voice channel or data. DS0 loopback local and DS0 loopback network are supported.

NxDS0 loopback is supported on channelized T1/E1 controller (DS0 channel) for the following interface modules:

- 48-port T1/E1 CEM interface module
- 48-port T3/E3 CEM interface module
- 1-port OC48/ STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-Port T1/E1 + 4-Port T3/E3 CEM interface module
- ASR 900 Combo 8-Port SFP GE and 1-Port 10 GE 20G interface module

Restrictions

- DS0 loopback remote is not supported.
- DS0 card protection is not supported.

Configuring NXDS0 Loopback on T1 Controller

To configure NXDS0 loopback on T1 controller, use the following commands:

```
controller t1 0/1/0
loopback [local | network {line}] [timeslots <range>]
```

The following example shows how to configure NXDS0 loopback on the T1 controller:

```
controller t1 0/1/0
loopback local timeslots 1-5
```

Use the **show controller t1 0/1/0** to verify the configuration:

```
T1 0/1/0 is up (Local Loopback)
  Currently in Locally Diagnostic Looped
  Applique type is A900-IMA3G-IMSG
  Cablelength is short 110
  Receiver has no alarms.
  alarm-trigger is not set
  Soaking time: 3, Clearance time: 10
  Framing is ESF, Line Code is B8ZS, Clock Source is Line.
  BER thresholds:  SF = 10e-3  SD = 10e-6
  Data in current interval (880 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 865 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs, 865 Unavail Secs
     1 Path Failures, 0 SEF/AIS Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 4 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     4 Errored Secs, 0 Bursty Err Secs, 4 Severely Err Secs, 0 Unavail Secs
     0 Path Failures
```

Configuring NXDS0 Loopback on T3 Controller

To configure NXDS0 loopback on T3 controller, use the following commands:

```
controller t3 0/2/0
loopback [local | network {line}] [timeslots <range>]
```

The following example shows how to configure NXDS0 loopback on the T3 controller:

```
controller MediaType 0/2/12
mode t3
controller T3 0/2/12
no snmp trap link-status
threshold sd-ber 6
```

```
threshold sf-ber 3
framing c-bit
cablelength short
loopback local
t1 1 cem-group 0 timeslots 1-24
t1 2 cem-group 1 timeslots 1-24
t1 1 clock source Line
t1 2 clock source Line
t1 1 loopback network line timeslots 1-24
t1 2 loopback network line timeslots 1-24
```

Use the **show controller t3 0/2/12** to verify the configuration:

```
Router#show controllers t3 0/2/12
T3 0/2/12 is down.
  Hardware is A900-IMA3G-IMSG
  Applique type is Channelized T3/T1
  Receiver has loss of signal.
  MDL transmission is disabled

  FEAC code received: No code is being received
  Framing is C-BIT Parity, Line Code is B3ZS, Cablelength Short less than 225ft
  BER thresholds:  SF = 10e-3  SD = 10e-6
  Clock Source is internal
  Equipment customer loopback
  Data in current interval (130 seconds elapsed):
   Near End
     0 Line Code Violations, 0 P-bit Coding Violation
     0 C-bit Coding Violation, 0 P-bit Err Secs
     0 P-bit Severely Err Secs, 0 Severely Err Framing Secs
     129 Unavailable Secs, 129 Line Errored Secs
     0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
     129 Severely Errored Line Secs, 0 Path Failures
     0 AIS Defect Secs, 129 LOS Defect Secs
   Far End
     0 Errored Secs, 0 Severely Errored Secs
     0 C-bit Unavailable Secs, 0 Path Failures
     0 Code Violations, 0 Service Affecting Secs
  Data in Interval 1:
   Near End
     0 Line Code Violations, 0 P-bit Coding Violation
     0 C-bit Coding Violation, 0 P-bit Err Secs
     0 P-bit Severely Err Secs, 0 Severely Err Framing Secs
     900 Unavailable Secs, 900 Line Errored Secs
     0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
     900 Severely Errored Line Secs, 1 Path Failures
     0 AIS Defect Secs, 900 LOS Defect Secs
   Far End
     0 Errored Secs, 0 Severely Errored Secs
     0 C-bit Unavailable Secs, 0 Path Failures
     0 Code Violations, 0 Service Affecting Secs
  Total Data (last 1 15 minute intervals):
   Near End
     0 Line Code Violations, 0 P-bit Coding Violation,
     0 C-bit Coding Violation, 0 P-bit Err Secs,
     0 P-bit Severely Err Secs, 0 Severely Err Framing Secs,
     900 Unavailable Secs, 900 Line Errored Secs,
     0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
     900 Severely Errored Line Secs, 1 path failures
     0 AIS Defect Secs, 900 LOS Defect Secs
   Far End
     0 Errored Secs, 0 Severely Errored Secs
     0 C-bit Unavailable Secs, 0 Path Failures
     0 Code Violations, 0 Service Affecting Secs
```

```
T3 0/2/12.1 T1 is down
timeslots: 2
FDL per AT&T 54016 spec.
Receiver is getting AIS.
Framing is ESF, Clock Source is Internal
Data in current interval (140 seconds elapsed):
 Near End
   0 Line Code Violations, 0 Path Code Violations
   0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
   0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
   139 Unavail Secs, 0 Stuffed Secs
   0 Path Failures, 0 SEF/AIS Secs
 Far End
   0 Line Code Violations, 0 Path Code Violations
   0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
   0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
   0 Unavail Secs 0 Path Failures
Data in Interval 1:
 Near End
   0 Line Code Violations, 0 Path Code Violations
   0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
   0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
   80 Unavail Secs, 0 Stuffed Secs
   1 Path Failures, 0 SEF/AIS Secs
 Far End
   0 Line Code Violations, 0 Path Code Violations
   0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
   0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
   0 Unavail Secs 0 Path Failures
Total Data (last 1 15 minute intervals):
 Near End
   0 Line Code Violations,0 Path Code Violations,
   0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
   0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
   80 Unavail Secs, 0 Stuffed Secs
   1 Path Failures, 0 SEF/AIS Secs
 Far End
   0 Line Code Violations,0 Path Code Violations
   0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
   0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
   0 Unavailable Secs, 0 Path Failures

T3 0/2/12.2 T1 is down
timeslots:
FDL per AT&T 54016 spec.
Receiver is getting AIS.
Framing is ESF, Clock Source is Internal
Data in current interval (140 seconds elapsed):
 Near End
   0 Line Code Violations, 0 Path Code Violations
   0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
   0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
   139 Unavail Secs, 0 Stuffed Secs
   0 Path Failures, 0 SEF/AIS Secs
 Far End
   0 Line Code Violations, 0 Path Code Violations
   0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
   0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
   0 Unavail Secs 0 Path Failures
Data in Interval 1:
 Near End
   0 Line Code Violations, 0 Path Code Violations
   0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
```

Configuring NXDS0 Loopback on SONET Controller

To configure NXDS0 loopback on SONET controller, use the following commands:

```
controller sonet 0/1/0
sts-1 1
 mode vt-15
  vtg 1 t1 <t1 num> loopback [local | network {line}] [timeslots <range>]
```

To following example how to configure NXDS0 loopback on SONET controller:

```
controller sonet 0/1/0
sts-1 1
 mode vt-15
 vtg 1 t1 1 loopback  local  timeslots 1-10
```

```
platform enable controller MediaType 0/4/0 oc3
controller MediaType 0/4/0
 mode sonet
controller SONET 0/4/0
 no snmp trap link-status
 rate OC3
 no ais-shut
 alarm-report all
 clock source internal
 !
 sts-1 1
  clock source internal
  mode ct3
  t3 framing c-bit
  t3 clock source internal
  t1 1 loopback local timeslots 1-2
 !
 sts-1 2
  clock source internal

 !
 sts-1 3
  clock source internal
```

Configuring NXDS0 Loopback on SDH Controller

To configure NXDS0 loopback on SDH controller, use the following commands:

```
controller sdh 0/1/0
au-4 1
 mode tug-3
 tug-3 1
 mode vc1x
 tug-2 <tug-2 num> e1 <e1 num> loopback {local | network {line} [timeslots <range>]
```

To following example how to configure NXDS0 loopback on SDH controller:

```
controller sdh 0/1/0
au-4 1
 mode tug-3
 tug-3 1
 mode vc1x
 tug-2 1 t1 1 loopback  local timeslots 1,3-5
```

NXDS0 Loopback - CE3 Mode

The following example shows how to configureNXDS0 loopback in CE3 SDH mode:

```
platform enable controller MediaType 0/4/0 oc3
controller MediaType 0/4/0
```

```
 mode sdh
controller SDH 0/4/0
 no snmp trap link-status
 rate STM1
 no ais-shut
 alarm-report all
 clock source internal
 overhead s1s0 0
 aug mapping au-4
 au-4 1
  clock source internal
  mode tug-3
  tug-3 1
   mode ce3
   e3 framing g751
   e3 clock source internal
   e1 1 loopback local timeslots 1-2
```

Use the **show controllers sdh** command to verify the configuration:

```
Router#show controllers sdh 0/4/0.1/1/1
SDH 0/4/0 is down.
 Path mode CE3

 AU-4 1, TUG-3 1, E1 1 (SDH 0/4/0.1/1/1 E1) is up
  timeslots:
  DS0: 1-2 timeslots Configured for locally looped
  No alarms detected.
  Framing is crc4, Clock Source is Internal, National bits are 0x1F.
  Data in current interval (480 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     479 Unavail Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
```

NXDS0 Loopback - CE3 Mode

The following example shows how to configureNXDS0 loopback in CE3 SDH mode:

```
platform enable controller MediaType 0/4/0 oc3
controller MediaType 0/4/0
 mode sdh
controller SDH 0/4/0
 no snmp trap link-status
 rate STM1
 no ais-shut
 alarm-report all
 clock source internal
 overhead s1s0 0
 aug mapping au-4
 au-4 1
  clock source internal
  mode tug-3
  tug-3 2
   mode ct3
   t3 framing c-bit
   t3 clock source internal
   t1 1 loopback local timeslots 1-2
```

Use the **show controllers sdh** command to verify the configuration:

```
Router#show controllers sdh 0/4/0.1/2/1
SDH 0/4/0 is down.
 Path mode CT3

 AU-4 1, TUG-3 2, T1 1 (SDH 0/4/0.1/2/1 T1) is up
  timeslots:
  FDL per AT&T 54016 spec.
  DS0: 1-2 timeslots Configured for locally looped
  No alarms detected.
  Framing is ESF, Clock Source is Internal
  Data in current interval (500 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     311 Unavail Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
```

NXDS0 Loopback - CT3 - E1 Mode

The following example shows how to configureNXDS0 loopback in CT3-E1 SDH mode:

```
platform enable controller MediaType 0/4/0 oc3
controller MediaType 0/4/0
 mode sdh
controller SDH 0/4/0
 no snmp trap link-status
 rate STM1
 no ais-shut
 alarm-report all
 clock source internal
 overhead s1s0 0
 aug mapping au-4
 au-4 1
  clock source internal
  mode tug-3
  tug-3 2
   mode ct3
   t3 framing c-bit
   t3 clock source internal
   t1 1 loopback local timeslots 1-2
```

Use the **show controllers sdh** command to verify the configuration:

```
Router#show controllers sdh 0/4/0.1/3/1
SDH 0/4/0 is down.
 Path mode CT3-E1

 AU-4 1, TUG-3 3, E1 1 (SDH 0/4/0.1/3/1 E1) is up
  timeslots:
  DS0: 1-2 timeslots Configured for locally looped
  No alarms detected.
  Framing is crc4, Clock Source is Internal, National bits are 0x1F.
  Data in current interval (510 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     101 Unavail Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
```

```
0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
0 Unavail Secs
```

BGP PIC with CEM

Feature Name	Release Information	Description
BGP-PIC with CEM	Cisco IOS XE Dublin 17.12.1	BGP PIC extends support to TDM CEM pseudowire to facilitate faster, sub-second BGP convergence and to improve fast failover.

The BGP PIC (Prefix Independent Convergence) Edge for IP and MPLS-VPN feature improves BGP convergence after a network failure. This convergence is applicable to both core and edge failures and can be used in both IP and MPLS networks. For more information on BGP-PIC, see BGP PIC Edge for IP and MPLS-VPN.

On RSP3, whenever the primary link between CEM PEs and edge nodes goes down, the BGP PIC with CEM configuration switches to secondary (alternate) path with sub second convergence, and restores the link.

You can configure BGP-PIC with CEM on the following OCx CEM interface modules with or without APS:

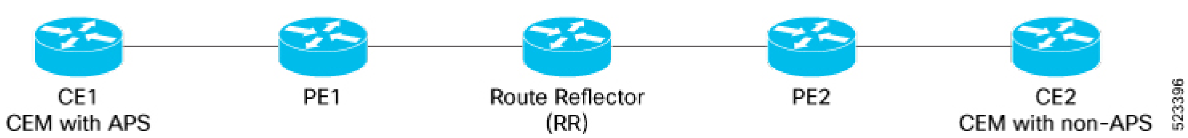
- 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4-port T3/E3 CEM interface module
- ASR 900 Combo 8-port SFP GE and 1-port 10 GE 20G interface module

Configuring BGP-PIC with CEM

The following scenarios explain configuration steps that you should perform for BGP-PIC with CEM (with or without APS) on routers.

Scenario 1 - BGP-PIC with CEM (with APS)

CEM with APS is configured on CE1, and the traffic passes through PE1 and then to route reflector and PE2. CE2 is configured only with CEM.



Before configuring CEM, ensure that you complete the BGP configurations.

To configure CEM with BGP-PIC, perform the following steps:

1. **BGP Configuration**

   Configure BGP on all nodes.

```
router bgp 100
 bgp router-id 1.1.1.1
 bgp log-neighbor-changes
 neighbor 40.0.0.2 remote-as 300
 neighbor 40.0.0.2 fall-over bfd
 neighbor 50.0.0.2 remote-as 300
 neighbor 50.0.0.2 fall-over bfd
```

```
 !
 address-family ipv4
  bgp additional-paths install
  network 1.1.1.1 mask 255.255.255.255
  redistribute connected
  neighbor 40.0.0.2 activate
  neighbor 40.0.0.2 send-label
  neighbor 50.0.0.2 activate
  neighbor 50.0.0.2 send-label
 exit-address-family
```

2. **Port Channel Configuration**

   Configure port channel.

```
interface Port-channel1
 ip address 40.0.0.1 255.255.255.0
 load-interval 30
 carrier-delay down msec 0
 no negotiation auto
 mpls ip
 mpls label protocol ldp
 mpls bgp forwarding
 port-channel bfd destination ipv4 40.0.0.2 microbfd
 lacp fast-switchover
 lacp max-bundle 1
!
interface Port-channel2
 ip address 50.0.0.1 255.255.255.0
 load-interval 30
 carrier-delay down msec 0
 no negotiation auto
 mpls ip
 mpls label protocol ldp
 mpls bgp forwarding
 port-channel bfd destination ipv4 50.0.0.2 microbfd
 lacp fast-switchover
 lacp max-bundle 1
!
```

3. **BFD Template Configuration on Gigabit Ethernet Interface**

   Configure BFD template on Gigabit Ethernet interface.

```
bfd-template single-hop bfd1
interval microseconds min-tx 3300 min-rx 3300 multiplier 3
```

4. **Multihop BFD on IBGP Sessions**

   Configure multihop BFD, IP FRR, remote IFA between PE devices for better convergence in core.

   Establish EBGP session between CE-PE and IBGP in core, for example PE1-RR-PE2.

```
bfd map ipv4  7.7.7.7/32  3.3.3.3/32 MHBFD
  bfd-template multi-hop MHBFD
  interval min-tx 50 min-rx 50 multiplier 3
  neighbor 7.7.7.7 fall-over bfd multi-hop" (under bgp)
```

5. **OSPF Configuration**

   Configure OSPF.

```
fast-reroute per-prefix enable prefix-priority low
fast-reroute per-prefix remote-lfa tunnel mpls-ldp
```

6. **MPLS Configuration**

   Configure MPLS.

```
!
mpls ldp router-id Loopback0 force
!

mpls label protocol ldp
mpls ldp nsr
multilink bundle-name authenticated
!

interface Loopback0
ip address 3.3.3.3 255.255.255.255
!

!
interface GigabitEthernet0/0/1
ip address 20.0.0.2 255.255.255.0
negotiation auto
mpls ip
mpls label protocol ldp
mpls bgp forwarding
!
interface GigabitEthernet0/0/2
ip address 50.0.0.2 255.255.255.0
negotiation auto
mpls ip
mpls label protocol ldp
mpls bgp forwarding
!

interface GigabitEthernet0/3/1
ip address 30.0.0.1 255.255.255.0
negotiation auto
mpls ip
mpls label protocol ldp
mpls bgp forwarding
!
```

7. **BFD template on Port-channel**

   Enable BFD template on port channel.

```
controller SONET-ACR 12
 !
 sts-1 1
  mode vt-15
  vtg 1 vt 1 cem-group 1 cep
  vtg 1 vt 2 cem-group 2 cep
!
!
```

8. **CEM Pseudowire Creation Using Cross Connection.**

   a. **CEM Configurations on CE1 and CE2 (with APS)**

      Configure APS on SONET

```
controller SONET 0/4/4
 no snmp trap link-status
 rate OC48
 no ais-shut
 alarm-report all
 threshold sf-ber 3
 clock source line
 aps group 12
 aps working 1
 aps group acr 12
 !
 sts-1 1
  clock source internal
 !
 sts-1 2
  clock source internal
 !
 sts-1 3
  clock source internal
!
!
transceiver type all
 monitoring
!
!
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface Loopback3
 ip address 12.12.12.12 255.255.255.255
!
interface Loopback4
 ip address 13.13.13.13 255.255.255.255
!
interface Loopback5
 ip address 14.14.14.14 255.255.255.255
!
interface Loopback6
 ip address 15.15.15.15 255.255.255.255
!
interface Loopback7
 ip address 16.16.16.16 255.255.255.255
!
interface Loopback8
 ip address 17.17.17.17 255.255.255.255
!
interface Loopback9
 ip address 18.18.18.18 255.255.255.255
!
interface Loopback10
 ip address 19.19.19.19 255.255.255.255
!
interface Loopback11
 ip address 21.21.21.21 255.255.255.255
!
interface Loopback12
 ip address 22.22.22.22 255.255.255.255
!
interface Loopback13
 ip address 23.23.23.23 255.255.255.255
!
interface Loopback14
```

```
 ip address 24.24.24.24 255.255.255.255
!
interface Loopback15
 ip address 25.25.25.25 255.255.255.255
!
```

b. Configure Pseudowire

Create CEM pseudowire.

```
interface pseudowire1
 encapsulation mpls
 neighbor 2.2.2.2 1
!
interface pseudowire2
 encapsulation mpls
 neighbor 2.2.2.2 2
!
!
!
interface GigabitEthernet0/2/1
 description PE1_0_0_1
 no ip address
 load-interval 30
 carrier-delay down msec 0
 no negotiation auto
 synchronous mode
 channel-group 1 mode active
!
interface GigabitEthernet0/2/2
 description PE2_0_0_3
 no ip address
 carrier-delay down msec 0
 no negotiation auto
 synchronous mode
 channel-group 2 mode active
!
```

c. Use L2VPN xconnect command for Cross Comection

```
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 ip address 7.19.15.19 255.255.255.0
 negotiation auto
!
interface CEM0/3/4
 no ip address
!
interface CEM0/4/4
 no ip address
!
interface CEM-ACR12
 no ip address
 cem 1
 !
 cem 2
 !
 cem 3
 !
 cem 4

!
router bgp 100
```

```
  bgp router-id 1.1.1.1
  bgp log-neighbor-changes
  neighbor 40.0.0.2 remote-as 300
  neighbor 40.0.0.2 fall-over bfd
  neighbor 50.0.0.2 remote-as 300
  neighbor 50.0.0.2 fall-over bfd
  !
  address-family ipv4
   bgp additional-paths install
   network 1.1.1.1 mask 255.255.255.255
   redistribute connected
   neighbor 40.0.0.2 activate
   neighbor 40.0.0.2 send-label
   neighbor 50.0.0.2 activate
   neighbor 50.0.0.2 send-label
  exit-address-family
 !
 ip tcp selective-ack
 ip tcp mss 1460
 ip tcp window-size 131072
 no ip http server
 no ip http ctc authentication
 no ip http secure-server
 ip forward-protocol nd
 ip ssh bulk-mode 131072
 !
 ip tftp source-interface GigabitEthernet0
 ip route vrf Mgmt-intf 0.0.0.0 0.0.0.0 7.19.0.1
 ip route vrf Mgmt-intf 7.19.0.0 255.255.0.0 7.19.0.1
 ip route vrf Mgmt-intf 202.153.144.0 255.255.255.0 7.19.0.1
 !
 logging alarm informational
 !
 l2vpn xconnect context Test1
  member pseudowire1
  member CEM-ACR12 1
 !
 l2vpn xconnect context Test10
  member pseudowire10
  member CEM-ACR12 10
 !
 l2vpn xconnect context Test100
  member pseudowire100
  member CEM-ACR12 100
 !
```

9. **Carrier Delay Configuration on Interfaces**

   Configure carrier delay on all interfaces.

```
!
interface GigabitEthernet0/2/0
 no ip address
 negotiation auto
!
interface GigabitEthernet0/2/1
 description PE1_0_0_1
 no ip address
 load-interval 30
 carrier-delay down msec 0
 no negotiation auto
 synchronous mode
 channel-group 1 mode active
```

```
!
interface GigabitEthernet0/2/2
 description PE2_0_0_3
 no ip address
 carrier-delay down msec 0
 no negotiation auto
 synchronous mode
 channel-group 2 mode active
!
```

10. **Clock Synchronization Configuration**

    Configure clock

    Use JDSU (test equipment) for internal clock and line clock for receiving ports.

    To match clock with JDSU, for CE1, use JDSU (local clock) on 0/4/4 CE1 (line) and for CE2 (internal), use JDSU (recovered clock).

    Once you start the local clock on CE1, the clock performs syncing operation on all other nodes.

```
network-clock synchronization automatic
network-clock synchronization ssm option 2 GEN1
network-clock synchronization mode QL-enabled
network-clock input-source 1 controller SONET 0/4/4
network-clock input-source 2 controller SONET 0/3/4
network-clock wait-to-restore 0 global
esmc process
```

```
Router#show running-config | sec network
network 1.1.1.1 mask 255.255.255.255
network-clock synchronization automatic
network-clock synchronization ssm option 2 GEN1
network-clock synchronization mode QL-enabled
network-clock input-source 1 controller SONET 0/4/4
network-clock wait-to-restore 0 global
esmc process
```

11. **Verify the configurations, if required.**

Scenario 2 - BGP-PIC with CEM (without APS)

CEM with APS is configured on CE1, and the traffic passes through PE1 and then to route reflector and PE2. CE2 is configured only with CEM.

Before configuring CEM, ensure that you complete the BGP configurations.

To configured CEM with BGP-PIC, perform the following steps:

1. **BGP Configuration**

    Configure BGP on all nodes.

```
router bgp 100
 bgp router-id 1.1.1.1
```

```
 bgp log-neighbor-changes
 neighbor 40.0.0.2 remote-as 300
 neighbor 40.0.0.2 fall-over bfd
 neighbor 50.0.0.2 remote-as 300
 neighbor 50.0.0.2 fall-over bfd
 !
 address-family ipv4
  bgp additional-paths install
  network 1.1.1.1 mask 255.255.255.255
  redistribute connected
  neighbor 40.0.0.2 activate
  neighbor 40.0.0.2 send-label
  neighbor 50.0.0.2 activate
  neighbor 50.0.0.2 send-label
 exit-address-family
```

2. **Port Channel Configuration**

   Configure port channel.

```
interface Port-channel1
 ip address 40.0.0.1 255.255.255.0
 load-interval 30
 carrier-delay down msec 0
 no negotiation auto
 mpls ip
 mpls label protocol ldp
 mpls bgp forwarding
 port-channel bfd destination ipv4 40.0.0.2 microbfd
 lacp fast-switchover
 lacp max-bundle 1
!
interface Port-channel2
 ip address 50.0.0.1 255.255.255.0
 load-interval 30
 carrier-delay down msec 0
 no negotiation auto
 mpls ip
 mpls label protocol ldp
 mpls bgp forwarding
 port-channel bfd destination ipv4 50.0.0.2 microbfd
 lacp fast-switchover
 lacp max-bundle 1
!
```

3. **BFD Template Configuration on Gigabit Ethernet Interface**

   Configure BFD template on Gigabit Ethernet interface.

```
bfd-template single-hop bfd1
interval microseconds min-tx 3300 min-rx 3300 multiplier 3
```

4. **Multihop BFD on IBGP Sessions**

   Configure multihop BFD, IP FRR, remote IFA between PE devices for better convergence in core.

   Establish EBGP session between CE-PE and IBGP in core, for example PE1-RR-PE2.

```
bfd map ipv4  7.7.7.7/32  3.3.3.3/32 MHBFD
  bfd-template multi-hop MHBFD
  interval min-tx 50 min-rx 50 multiplier 3
  neighbor 7.7.7.7 fall-over bfd multi-hop" (under bgp)
```

5. **OSPF Configuration**

   Configure OSPF.

```
fast-reroute per-prefix enable prefix-priority low
fast-reroute per-prefix remote-lfa tunnel mpls-ldp
```

6. **MPLS Configuration**

   Configure MPLS.

```
!
mpls ldp router-id Loopback0 force
!

mpls label protocol ldp
mpls ldp nsr
multilink bundle-name authenticated
!

interface Loopback0
ip address 3.3.3.3 255.255.255.255
!

!
interface GigabitEthernet0/0/1
ip address 20.0.0.2 255.255.255.0
negotiation auto
mpls ip
mpls label protocol ldp
mpls bgp forwarding
!
interface GigabitEthernet0/0/2
ip address 50.0.0.2 255.255.255.0
negotiation auto
mpls ip
mpls label protocol ldp
mpls bgp forwarding
!

interface GigabitEthernet0/3/1
ip address 30.0.0.1 255.255.255.0
negotiation auto
mpls ip
mpls label protocol ldp
mpls bgp forwarding
!
```

7. **BFD template on Port-channel**

   Enable BFD template on port channel.

```
controller SONET-ACR 12
 !
 sts-1 1
  mode vt-15
  vtg 1 vt 1 cem-group 1 cep
  vtg 1 vt 2 cem-group 2 cep
!
!
```

8. **CEM Pseudowire Creation Using Cross Connection.**

a. **CEM Configurations on CE1 and CE2 (without APS)**

Configure SONET controller.

```
controller SONET-ACR 12
 !
 sts-1 1
  mode vt-15
  vtg 1 vt 1 cem-group 1 cep
  vtg 1 vt 2 cem-group 2 cep
!
!
```

b. **Configure Pseudowire**

Create CEM pseudowire.

```
interface pseudowire1
 encapsulation mpls
 neighbor 2.2.2.2 1
!
interface pseudowire2
 encapsulation mpls
 neighbor 2.2.2.2 2
!
!
!
interface GigabitEthernet0/2/1
 description PE1_0_0_1
 no ip address
 load-interval 30
 carrier-delay down msec 0
 no negotiation auto
 synchronous mode
 channel-group 1 mode active
!
interface GigabitEthernet0/2/2
 description PE2_0_0_3
 no ip address
 carrier-delay down msec 0
 no negotiation auto
 synchronous mode
 channel-group 2 mode active
!
```

c. **Use L2VPN xconnect command for Cross Comection**

```
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 ip address 7.19.15.19 255.255.255.0
 negotiation auto
!
interface CEM0/3/4
 no ip address
!
interface CEM0/4/4
 no ip address
!
interface CEM-ACR12
 no ip address
 cem 1
 !
```

```
 cem 2
 !
 cem 3
 !
 cem 4

!
router bgp 100
 bgp router-id 1.1.1.1
 bgp log-neighbor-changes
 neighbor 40.0.0.2 remote-as 300
 neighbor 40.0.0.2 fall-over bfd
 neighbor 50.0.0.2 remote-as 300
 neighbor 50.0.0.2 fall-over bfd
 !
 address-family ipv4
  bgp additional-paths install
  network 1.1.1.1 mask 255.255.255.255
  redistribute connected
  neighbor 40.0.0.2 activate
  neighbor 40.0.0.2 send-label
  neighbor 50.0.0.2 activate
  neighbor 50.0.0.2 send-label
 exit-address-family
!
ip tcp selective-ack
ip tcp mss 1460
ip tcp window-size 131072
no ip http server
no ip http ctc authentication
no ip http secure-server
ip forward-protocol nd
ip ssh bulk-mode 131072
!
ip tftp source-interface GigabitEthernet0
ip route vrf Mgmt-intf 0.0.0.0 0.0.0.0 7.19.0.1
ip route vrf Mgmt-intf 7.19.0.0 255.255.0.0 7.19.0.1
ip route vrf Mgmt-intf 202.153.144.0 255.255.255.0 7.19.0.1
!
logging alarm informational
!
l2vpn xconnect context Test1
 member pseudowire1
 member CEM-ACR12 1
!
l2vpn xconnect context Test10
 member pseudowire10
 member CEM-ACR12 10
!
l2vpn xconnect context Test100
 member pseudowire100
 member CEM-ACR12 100
!
```

9. Carrier Delay Configuration on Interfaces

Configure carrier delay on all interfaces.

```
!
interface GigabitEthernet0/2/0
 no ip address
 negotiation auto
!
```

```
interface GigabitEthernet0/2/1
 description PE1_0_0_1
 no ip address
 load-interval 30
 carrier-delay down msec 0
 no negotiation auto
 synchronous mode
 channel-group 1 mode active
!
interface GigabitEthernet0/2/2
 description PE2_0_0_3
 no ip address
 carrier-delay down msec 0
 no negotiation auto
 synchronous mode
 channel-group 2 mode active
!
```

10. **Clock Synchronization Configuration**

    Configure clock

    Use JDSU (test equipment) for internal clock and line clock for receiving ports.

    To match clock with JDSU, for CE1, use JDSU (local clock) on 0/4/4 CE1 (line) and for CE2 (internal), use JDSU (recovered clock).

    Once you start the local clock on CE1, the clock performs syncing operation on all other nodes.

```
network-clock synchronization automatic
network-clock synchronization ssm option 2 GEN1
network-clock synchronization mode QL-enabled
network-clock input-source 1 controller SONET 0/4/4
network-clock input-source 2 controller SONET 0/3/4
network-clock wait-to-restore 0 global
esmc process
```

```
Router#show running-config | sec network
network 1.1.1.1 mask 255.255.255.255
network-clock synchronization automatic
network-clock synchronization ssm option 2 GEN1
network-clock synchronization mode QL-enabled
network-clock input-source 1 controller SONET 0/4/4
network-clock wait-to-restore 0 global
esmc process
```

11. **Verify the configurations, if required.**

Verifying BGP-PIC with CEM

Use the following **show** commands to verify the configurations.

- **show ip bgp summary**—Displays a summary of the status of all BGP connections.
- **show ip ospf neighbor**—Display information about OSPF neighbors. You can view the neighbor ID (router ID), priority, the functional state of the neighbor router, dead time, IP address of the interface to which this neighbor is directly connected, and the interface on which the OSPF neighbor has formed adjacency.
- **show bfd neighbor**—Displays the BFD neighbor and the routing protocols that BFD has registered.

- **show network-clock synchronization**—Displays if the system is in revertive mode or nonrevertive mode with network parameters.
- **show aps**—Displays the operational status for all configured SONET automatic protection switching (APS) groups.
- **show run | sec bfd**—Displays BFD information for a specific location.
- **show ip interface brief**—Displays the details such as IP address, interface status, and so on, for the router interface.
- **show ip cef** ***<id>***—Displays entries in the Cisco Express Forwarding Information Base (FIB).
- **show ip cef** ***<id>*** **internal**— Displays the FIB internal data structure. You can use this command to verify the BGP-PIC path.
- **show cem circuit interface cem** ***<dem-id>*** **controller** ***<cem-group-no>***—Displays information about the circuit state, administrative state, the CEM ID of the circuit, and the interface on which it’s configured.
- **show cem circuit interface cem-acr** ***<aps-no> <cem-group-no>***—Displays information about the CEM group for MSP on virtual ACR.

CHAPTER 5

Clock Recovery

Table 8: Feature History

Feature Name	Release Information	Description
ACR and DCR Scale Support	Cisco IOS XE Amsterdam 17.3.1	Adaptive Clock Recovery (ACR) and Differential Clock Recovery (DCR) are techniques used for Circuit Emulation (CEM) to recover clocks on the following Cisco RSP3 module: • ASR 900 Combo 8-Port SFP GE and 1-Port 10 GE 20G Interface Module (A900-IMA1Z8S-CXMS)

The Clock Recovery System recovers the service clock using Adaptive Clock Recovery (ACR) and Differential Clock Recovery (DCR).

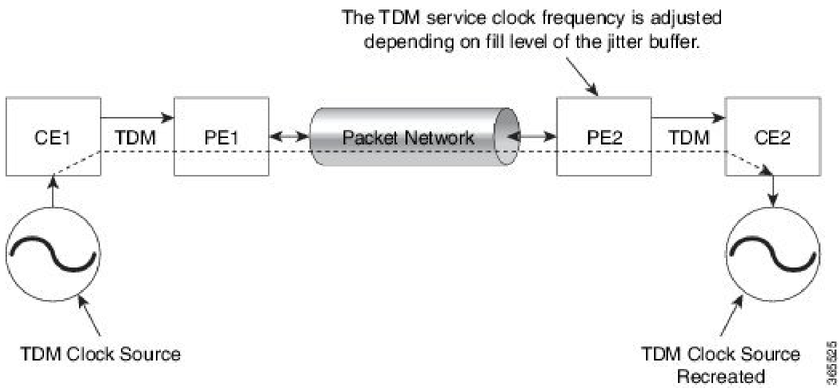
- Adaptive Clock Recovery (ACR), on page 43
- Differential Clock Recovery (DCR), on page 44
- Benefits of Clock Recovery, on page 44
- Prerequisites for Clock Recovery, on page 45
- Restrictions for Clock Recovery, on page 45
- How to Configure Clock Recovery, on page 46

Adaptive Clock Recovery (ACR)

Adaptive Clock Recovery (ACR) is an averaging process that negates the effect of random packet delay variation and captures the average rate of transmission of the original bit stream. ACR recovers the original clock for a synchronous data stream from the actual payload of the data stream. In other words, a synchronous clock is derived from an asynchronous packet stream. ACR is a technique where the clock from the TDM domain is mapped through the packet domain, but is most commonly used for Circuit Emulation (CEM). ACR is supported on unframed and framed modes of SAToP.

Note Framing type should be maintained same in all routers end to end.

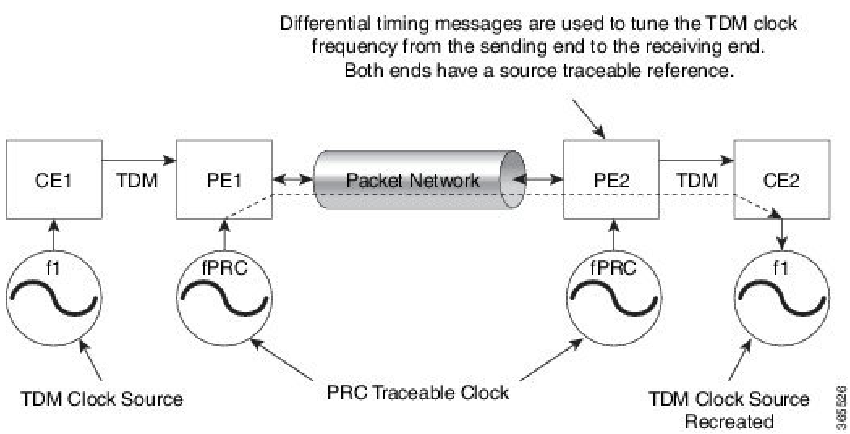
Effective Cisco IOS XE Everest 16.5.1, ACR is supported on the 8-port T1/E1 interface module.



Differential Clock Recovery (DCR)

Differential Clock Recovery (DCR) is another technique used for Circuit Emulation (CEM) to recover clocks based on the difference between PE clocks. TDM clock frequency are tuned to receive differential timing messages from the sending end to the receiving end. A traceable clock is used at each end, which ensures the recovered clock is not affected by packet transfer. DCR is supported on unframed and framed modes of SAToP.

Note Framing type should be maintained same in all routers end to end.



Benefits of Clock Recovery

- Customer-edge devices (CEs) can have different clock from that of the Provide-edge devices (PEs).

- In CESoPSN, a slave clock is supported for clock redundancy.

Scaling Information

IM Card	Pseudowires Supported (Number of Clocks Derived)
48-Port T1/E1 CEM Interface Module	48

Prerequisites for Clock Recovery

- The clock of interface modules must be used as service clock.
- CEM must be configured before configuring the global clock recovery.
- RTP must be enabled for DCR in CEM, as the differential clock information is transferred in the RTP header.

Restrictions for Clock Recovery

- The reference clock source is used and locked to a single clock.
- The clock ID should be unique for a particular interface module for ACR or DCR configuration.
- When CEM group is configured, dynamic change in clock source is not allowed.
- ACR clock configuration under each controller should be performed before configuring CEM group.
- When ACR or DCR is configured and loopback network is applied on the same PDH (T1/E1), then the ACR or DCR mode configuration is removed to enable the loopback. The ACR or DCR should be configured again after the loopback maintenance activity.

Scale Restrictions

- For the Cisco IOS XE Amsterdam 17.3.x release, a maximum of **5376** ACR and DCR session scale is supported on the Cisco 1-port OC-192 Interface module or 8-port Low Rate Interface Module (8-port SFP GE and 1-port 10GE IM with CEM, 10G). For releases before the Cisco IOS XE Amsterdam 17.3.1 release, only 2000 session are supported.

How to Configure Clock Recovery

Configuring Clock Recovery for SONET

Configuring ACR of T1/E1 Interfaces for SAToP

Before You Begin

Before configuring ACR, CEM must be configured. Below are the guidelines to configure clock recovery:

- The node (chassis) on which the DS1 is configured for ACR, must have its own clock derived from BITS/GPS/Stratum clock.
- The minimum packet size of CEM pseudowires on the network that delivers robust clock recovery is 64 bytes.

Configure the CEM Interface

```
enable
configure terminal
controller t1 0/0/1
cem-group 0 unframed
exit
```

Perform Global Configuration for Clock Recovery

To configure the clock recovery in the global configuration mode, use the following commands:

```
recovered-clock 0 0
clock recovered 1 adaptive cem 1 0
exit
```

Configure the Clock under Controller

To configure the clock recovery on T1/E1 interfaces, use the following commands:

```
enable
configure terminal
controller t1 0/0/1
clock source recovered 1
```

Note The global clock configuration must be performed before configuring the clock recovery under the controller. From the Cisco IOS XE Cupertino 17.9.1 release onwards, the above config sequence is restricted only from CLI.

To remove the clock configuration in ACR and DCR, you must remove the recovery clock configuration in global configuration mode and then remove the controller configuration.

Verifying the ACR Configuration of T1/E1 Interfaces for SAToP

Use the **show recovered-clock** command to verify the adaptive clock recovery of T1/E1 interfaces for SAToP:

```
Router# show recovered-clock

Recovered clock status for subslot 0/4
--------------------------------------
Clock     Type      Mode        CEM    Status       Frequency Offset(ppb)  Circuit-No

0         DS1       ADAPTIVE     0     ACQUIRED     n/a                    0 (Port)
```

Use the **show running-config** command to verify the configuration of adaptive clock of T1/E1 interfaces:

```
Router# show running-config | section 0/0/1
controller T1 0/0/1
 framing unframed
 clock source recovered 1
 linecode b8zs
 cablelength long 0db
  cem-group 0 unframed
interface CEM0/0/1
 no ip address
 cem 0
```

Use the **show running-config | section recovered-clock** command to verify the recovery of adaptive clock of T1/E1 interfaces:

```
Router# show running-config | section recovered-clock
recovered-clock 0 0
 clock recovered 1 adaptive cem 1 0
```

Configuring ACR of T3/E3 Interfaces for SAToP

Before You Begin

- The node (router) on which the 48-Port T3/E3 interface module is configured for ACR, must have its own clock derived from BITS/GPS/Stratum clock.
- The minimum packet size of CEM pseudowires on the network that delivers robust clock recovery is 256 bytes.

Configure the CEM Interface

```
enable
configure terminal
controller t3 0/0/1
cem-group 0 unframed
exit
```

Perform Global Configuration for Clock Recovery

To configure the clock recovery in the global configuration mode, use the following commands:

```
recovered-clock 0 0
clock recovered 1 adaptive cem 1 0
exit
```

Configure the Clock under Controller

To configure the clock recovery on T3/E3 interfaces, use the following commands:

```
enable
configure terminal
controller t3 0/0/1
clock source recovered 1
```

Note The global clock configuration must be performed before configuring the clock recovery under the controller. From the Cisco IOS XE Cupertino 17.9.1 release onwards, the above config sequence is restricted only from CLI.

Verifying Adaptive Clock Recovery Configuration of T3/E3 Interfaces for SAToP

Use the **show recovered-clock** command to verify the ACR on T3/E3 interfaces for SAToP:

```
Router# show recovered-clock

Recovered clock status for subslot 0/4
---------------------------------------
Clock    Type     Mode        CEM    Status       Frequency Offset(ppb)   Circuit-No

0        DS3      ADAPTIVE     0     ACQUIRED     n/a                     0 (Port)
```

Use the **show running-config | section** command to verify the configuration of adaptive clock of T3/E3 interfaces:

```
Router# show running-config | section 0/0/1
controller MediaType 0/0/1
 mode t3
controller T3 0/0/1
  cem-group 0 unframed
 clock source recovered 1
 cablelength 224
interface CEM0/0/1
 no ip address
 cem 0
```

Use the **show running-config | section recovered-clock** command to verify the recovery of adaptive clock of T3/E3 interfaces:

```
Router# show running-config | section recovered-clock
recovered-clock 0 0
 clock recovered 1 adaptive cem 1 0
```

Configuring ACR of Channelized T3/T1 or E3/E1 Interfaces for SAToP

Before You Begin

- The node (chassis) on which the T3/T1 or E3/E1 is configured for ACR, has to have its own clock derived from BITS/GPS/Stratum clock.
- The minimum packet size of CEM pseudowires on the network that delivers robust clock recovery is 256 bytes.

Configure the CEM Interface

```
enable
configure terminal
controller t3 0/0/1
t1 1 cem-group 0 unframed
exit
```

Perform Global Configuration for Clock Recovery

```
recovered-clock 0 0
clock recovered 1 adaptive cem 1 0
exit
```

Configure the Clock under Controller

```
enable
configure terminal
controller t3 0/0/1
clock source recovered 1
```

Note The global clock configuration must be performed before configuring the clock recovery under the controller. From the Cisco IOS XE Cupertino 17.9.1 release onwards, the above config sequence is restricted only from CLI.

To remove the clock configuration in ACR and DCR, you must remove the recovery clock configuration in global configuration mode and then remove the controller configuration.

Verifying the ACR Configuration of Channelized T3/T1 or E3/E1 Interfaces for SAToP

Use the **show recovered-clock** command to verify the ACR of T3/T1 or E3/E1 interfaces for SAToP:

```
Router# show recovered-clock

Recovered clock status for subslot 0/4
----------------------------------------

Clock     Type      Mode         CEM    Status      Frequency Offset(ppb)  Circuit-No
0         DS3-ds1   ADAPTIVE      0     ACQUIRED    n/a                    0/1 (Port/t1)
```

Use the **show running-config | section** command to verify the configuration of adaptive clock of channelized T3/T1 or E3/E1 interfaces:

```
Router# show running-config | section 0/0/1
controller MediaType 0/0/1
 mode t3
controller T3 0/0/1
 framing c-bit
 cablelength 224
 t1 1 cem-group 0 unframed
 t1 1 clock source recovered 1
interface CEM0/0/1
 no ip address
 cem 0
```

Use the **show running-config | section recovered-clock** command to verify the recovery of adaptive clock of channelized T3/T1 or E3/E1 interfaces:

```
Router# show running-config | section recovered-clock
recovered-clock 0 0
 clock recovered 1 adaptive cem 1 0
```

Configuring ACR in Mode CT3 for SAToP

You must configure ACR in mode CT3. Mode CT3 is an STS-1 carrying a DS3 signal that is divided into 28 T1s (PDH).

Configure the CEM Interface

```
controller MediaType 0/4/0
mode sonet
controller SONET 0/4/0
rate OC48
no ais-shut
framing sonet
clock source internal
!
sts-1 1

clock source internal
mode ct3
t3 framing c-bit

t1 1 framing unframed
t1 1 cem-group 1 unframed
interface CEM0/4/0
no ip address
cem 1
```

Perform Global Configuration for Clock Recovery

```
recovered-clock 0 4
clock recovered 1 adaptive cem 1 0
exit
```

Configure the Clock under Controller

```
enable
configure terminal
controller t3 0/4/0
clock source recovered 1
```

Note The global clock configuration must be performed before configuring the clock recovery under the controller. From the Cisco IOS XE Cupertino 17.9.1 release onwards, the above config sequence is restricted only from CLI.

Verifying ACR in Mode CT3 for SAToP

Verifying ACR Configuration

```
Router# show running-config | section 0/4/0

controller MediaType 0/4/0
 mode sonet
controller SONET 0/4/0
 rate OC48
 no ais-shut
 framing sonet
 clock source internal
 !
 sts-1 1
  clock source internal
  mode ct3
  t3 framing c-bit
  t1 1 clock source Recovered 10
  t1 1 framing unframed
  t1 1 cem-group 1 unframed

interface CEM0/4/0
 no ip address
 cem 1
!
```

Verifying Recovered Clock

```
show recovered-clock

Recovered clock status for subslot 0/3
----------------------------------------
Clock    Type     Mode        CEM    Status        Frequency Offset(ppb)  Circuit-No
0        OCx-ds1  ADAPTIVE     0    ACQUIRED  n/a                              0/1/1
(Port/t3/t1)
```

```
show running-config | section recovered-clock 0 4
recovered-clock 0 4
 clock recovered 10 adaptive cem 1 0
```

Configuring ACR in mode T3 for SAToP

You must configure ACR in mode T3. Mode T3 is STS-1 or AU-4/TUG3 carrying an unchannelized (clear channel) T3.

```
enable
configure terminal
recovered-clock  <bay> <slot>
clock recovered <clock-id> adaptive cem <port-no> <cem-group-no>
controller sonet <bay>/<slot>/<port>
rate OC3
sts-1 <number>
mode t3
cem-group < cem-group-no> unframed
t3 clock source recovered <clock-id>

end
```

Verifying ACR in Mode T3 for SAToP

Verifying ACR Configuration

```
Router# show run | sec recovered
recovered-clock bay/slot
clock recovered clock_id adaptive cem cem-group-no port-no
!
```

```
Router# show running-config | section 0/4/6

controller SONET 0/4/6
 rate OC3
 no ais-shut
 framing sonet
 clock source internal
 !
 sts-1 1
  clock source internal
  mode t3
  t3 clock source line
  cem-group 0 unframed
  clock source recovered 20

interface CEM0/4/6
 no ip address
 cem 0
!
```

Verifying Recovered Clock

```
Router# show recovered-clock

Recovered clock status for subslot 0/3
----------------------------------------
Clock    Type         Mode        CEM    Status        Frequency Offset(ppb)  Circuit-No
0         OCx-ds3  ADAPTIVE     0    ACQUIRED   n/a                              0/1
(Port/t3)
```

```
Router# show run | sec recovered

recovered-clock 0 4
clock recovered 20 adaptive cem 6 0
!
```

Configuring ACR in Mode VT15 for SAToP

You must configure ACR for virtual tributary groups (VTG) mode. In this mode, a single STS-1 is divided into seven VTGs. Each VTG is then divided into four VT1.5, each carrying a T1.

To configure ACR in mode VT15 for Structure-Agnostic TDM over Packet (SAToP):

```
enable
configure terminal
controller sonet <bay>/<slot>/<port>
rate OC3
sts-1 <number>
mode vt-15
vtg 1 t1 cem 0 unframed
vtg 1 t1 1 clock source recovered 1
vtg <vtg_number> t1 <t1_number> cem-group < cem-group-no> unframed
vtg <vtg_number> t1 <t1_number> clock source recovered <clock-id>
exit
```

```
recovered-clock 0 <0-15> Subslot number
end
```

Verifying ACR in Mode VT15 for SAToP

Verifying ACR Configuration

```
Router# show running-config | section 0/4/0

controller MediaType 0/4/0
 mode sonet
controller SONET 0/4/0
 rate OC48
 no ais-shut
 framing sonet
 clock source internal
 !
 sts-1 1
  clock source internal
  mode vt-15
  vtg 1 t1 1 clock source Recovered 0
  vtg 1 t1 1 framing unframed
  vtg 1 t1 1 cem-group 0 unframed

interface CEM0/4/0
 no ip address
 cem 0
!
```

Verifying Recovered Clock

```
Router# show recovered-clock

Recovered clock status for subslot 0/3
----------------------------------------
Clock    Type     Mode        CEM    Status         Frequency Offset(ppb)  Circuit-No
0        OCx-ds1  ADAPTIVE     0    ACQUIRED   n/a                              0/1/1/1
(Port/path/vtg/t1)

Router# show running-config | section recovered-clock 0 4

recovered-clock 0 4
 clock recovered 0 adaptive cem 0 0
```

Configuring ACR of T3/E3 Interfaces for CESoPSN

Before You Begin

Before configuring ACR, CEM must be configured. Below are the guidelines to configure clock recovery:

- The node (chassis) on which the DS1 is configured for ACR, must have its own clock derived from BITS/GPS/Stratum clock.
- The minimum packet size of CEM pseudowires on the network that delivers robust clock recovery is 64 bytes.

To configure the clock on T3/E3 interfaces for CESoPSN in controller mode, use the following commands:

```
enable
configure terminal
```

```
controller t3 <slot>/<bay>/<port>
t1 <t1_num>  clock source recovered <clock-id>
t1 <t1_num> cem-group < cem-group-no > timeslots <1-24>
exit
```

To configure the clock recovery on T3/E3 interfaces in global configuration mode, use the following commands:

```
recovered-clock <slot> <bay>
clock recovered <clock-id> adaptive cem <port-no> <cem-group-no>
exit
```

To remove the clock configuration in ACR and DCR, you must remove the recovery clock configuration in global configuration mode and then remove the controller configuration.

Recovering a Clock

Recovering an ACR Clock

```
enable
configure terminal
recovered-clock  <bay> <slot>
clock recovered <clock-id> adaptive cem <port-no> <cem-group-no>
end
```

Recovering a DCR Clock

```
enable
configure terminal
recovered-clock  <bay> <slot>
clock recovered <clock-id> differential cem <port-no> <cem-group-no>
end
```

Configuring DCR of T1/E1 Interfaces for SAToP

Before You Begin

Before configuring DCR, CEM must be configured. Below are the guidelines to configure Differential clock recovery:

- Before you start configuring DCR, RTP must be enabled on the CEM interface. The RTP is used to carry the differential time.
- The minimum packet size of CEM pseudowires on the network that delivers robust clock recovery is 64 bytes.

Configure the CEM Interface

```
enable
configure terminal
controller t1 0/0/1
cem-group 0 unframed
exit
```

Perform Global Configuration for Clock Recovery

To configure the clock recovery in the global configuration mode, use the following commands:

```
recovered-clock 0 0
clock recovered 1 differential cem 1 0
exit
```

Configure the Clock under Controller

To configure the clock recovery on T1/E1 interfaces, use the following commands:

```
enable
configure terminal
controller t1 0/0/1
clock source recovered 1
```

Note The global clock configuration must be performed before configuring the clock recovery under the controller. From the Cisco IOS XE Cupertino 17.9.1 release onwards, the above config sequence is restricted only from CLI.

To remove the clock configuration in ACR and DCR, you must remove the recovery clock configuration in global configuration mode and then remove the controller configuration.

Verifying the DCR Configuration of T1/E1 Interfaces for SAToP

Use the **show recovered-clock** command to verify the differential clock recovery of T1/E1 interfaces for SAToP:

```
Router# show recovered-clock

Recovered clock status for subslot 0/4
---------------------------------------
Clock     Type      Mode              CEM     Status        Frequency Offset(ppb)  Circuit-No

0         DS1       DIFFERENTIAL       0      ACQUIRED      n/a                    0 (Port)
```

Use the **show running-config | section** command to verify the configuration of differential clock of T1/E1 interfaces for SAToP:

```
Router# show running-config | section 0/0/1
controller T1 0/0/1
 framing unframed
 clock source recovered 1
 linecode b8zs
 cablelength long 0db
  cem-group 0 unframed
interface CEM 0/0/1
 no ip address
 cem 0
rtp-present
```

Use the **show running-config | section recovered-clock** command to verify the recovery of differential clock of T1/E1 interfaces:

```
Router# show running-config | section recovered-clock
recovered-clock 0 0
 clock recovered 1 differential cem 1 0
```

Configuring DCR of T3/E3 Interfaces for SAToP

Before You Begin

- Before you start configuring DCR, RTP must be enabled on the CEM interface. The RTP is used to carry the differential time.
- The minimum packet size of CEM pseudowires on the network that delivers robust clock recovery is 256 bytes.

Configure the CEM Interface

```
enable
configure terminal
controller t3 0/0/1
cem-group 0 unframed
exit
```

Perform Global Configuration for Clock Recovery

To configure the clock recovery in the global configuration mode, use the following commands:

```
recovered-clock 0 0
clock recovered 1 differential cem 1 0
exit
```

Configure the Clock under Controller

To configure the clock recovery on T3/E3 interfaces, use the following commands:

```
enable
configure terminal
controller t3 0/0/1
clock source recovered 1
```

Note The global clock configuration must be performed before configuring the clock recovery under the controller. From the Cisco IOS XE Cupertino 17.9.1 release onwards, the above config sequence is restricted only from CLI.

To remove the clock configuration in ACR and DCR, you must remove the recovery clock configuration in global configuration mode and then remove the controller configuration.

Verifying the DCR Configuration of T3/E3 Interfaces for SAToP

Use the **show recovered-clock** command to verify the DCR of T3/E3 interfaces for SAToP:

```
Router# show recovered-clock

Recovered clock status for subslot 0/4
----------------------------------------
Clock     Type      Mode             CEM    Status       Frequency Offset(ppb)  Circuit-No

0         DS3       DIFFERENTIAL      0     ACQUIRED     n/a                    0 (Port)
```

Use the **show running-config | section** command to verify the configuration of differential clock of T3/E3 interfaces for SAToP:

```
Router# show running-config | section 0/0/1
controller MediaType 0/0/1
 mode t3
controller T3 0/0/1
  cem-group 0 unframed
 clock source recovered 1
 cablelength 224
interface CEM0/0/1
 no ip address
 cem 0
  rtp-present
```

Use the **show running-config | section recovered-clock** command to verify the recovery of differential clock of T3/E3 interfaces:

```
Router# show running-config | section recovered-clock
recovered-clock 0 0
 clock recovered 1 differential cem 1 0
```

Configuring DCR of Channelized T3/T1 or E3/E1 Interfaces for SAToP

Before You Begin

- Before you start configuring DCR, RTP must be enabled on the CEM interface. The RTP is used to carry the differential time.
- The minimum packet size of CEM pseudowires on the network that delivers robust clock recovery is 256 bytes.

To configure differential clock on a channelized T3/T1 or E3/E1 interfaces under controller in controller mode, use the following commands:

```
enable
configure terminal
controller t30/0/1
t1 1 clock source recovered 1
t1 1 cem-group 0 unframed
exit
```

To configure RTP header under channelized T3/T1 or E3/E1 interfaces, use the following commands:

```
interface cem 0/0/1
cem 0
rtp-present
```

To configure recovery of differential clock of channelized T3/T1 or E3/E1 interfaces in global configuration mode, use the following commands:

```
recovered-clock 0 0
clock recovered 1 differential cem 1 0
exit
```

Note The clock configuration on controller must be done before configuring the clock recovery on global configuration mode.

Verifying the DCR Configuration of Channelized T3/T1 or E3/E1 Interfaces for SAToP

Use the **show recovered-clock** command to verify the DCR of T3/T1 or E3/E1 interfaces for SAToP:

```
Router# show recovered-clock

Recovered clock status for subslot 0/4
----------------------------------------

Clock    Type         Mode           CEM     Status     Frequency Offset(ppb) Circuit-No

0        DS3-ds1      DIFFERENTIAL   0       ACQUIRED    n/a                 0/1 (Port/t1)
```

Use the **show running-config | section** command to verify the configuration of differential clock of channelized T3/T1 or E3/E1 interfaces:

```
Router# show running-config | section 0/0/1
controller MediaType 0/0/1
 mode t3
controller T3 0/0/1
 framing c-bit
 cablelength 224
 t1 1 cem-group 0 unframed
 t1 1 clock source recovered 1
interface CEM0/0/1
 no ip address
 cem 0
  rtp-present
```

Use the **show running-config | section recovered-clock** command to verify the recovery of differential clock of channelized T3/T1 or E3/E1 interfaces:

```
Router# show running-config | section recovered-clock
recovered-clock 0 0
 clock recovered 1 differential cem 1 0
```

Configuring Clock Recovery for SONET

To configure MediaType Controller, use the following commands:

```
enable
configure terminal
controller MediaType 0/5/0
mode sonet
controller sonet 0/5/0
rate OC12
```

To configure a CEM group, use the following commands:

```
enable
configure terminal
controller sonet 0/2/1
```

```
sts-1 1
mode vt-15
vtg 1 t1 1 cem-group 0 timeslots 1
vtg 1 t1 1 cem-group 1 timeslots 2
```

To configure the clock recovery for SONET in global configuration mode, use the following commands

```
recovered-clock 0 2
clock recovered 100 adaptive cem 1 0 priority 1
clock recovered 100 adaptive cem 1 1 priority 2
exit
```

Configuring Clock Recovery on STS-1e Controller for Framed SAToP

Table 9: Feature History

Feature Name	Release Information	Description
STS1E Framed SAToP Support on IMA3G	Cisco IOS XE Bengaluru 17.4.1	Support on clock recovery on STS-1e controller for framed SAToP on the following modes: • T3 • CT3 • VT-15

Starting from Cisco IOS XE Bengaluru 17.4.1, ACR and DCR are supported on STS-1e controller for framed SAToP.

To configure the clock on STS-1e controller for framed SAToP on the T3 mode, enter the following commands:

```
enable
configure terminal
controller STS-1e slot/bay/port
sts-1 1
mode t3
t3 framing c-bit
cem-group 0 framed
t3 clock source recovered 1
```

To configure the clock on STS-1e controller for framed SAToP on the CT3 mode, enter the following commands:

```
enable
configure terminal
controller STS-1e slot/bay/port
sts-1 1
clock source internal
mode ct3
t3 framing c-bit
t1 1 cem-group 0 framed
t1 1 clock source recovered 1
```

To configure the clock on STS-1e controller for framed SAToP on the VT-15 mode, enter the following commands:

```
enable
configure terminal
controller STS-1e slot/bay/port
sts-1 1
mode vt-15
vtg 1 t1 1 cem-group 0 framed
vtg  1 t1 1 clock source recovered 2
```

The following example shows how to configure the clock on STS-1e controller for framed SAToP on the T3 mode:

```
enable
configure terminal
controller STS-1e 0/8/12
sts-1 1
mode t3
t3 framing c-bit
cem-group 0 framed
t3 clock source recovered 1
```

The following example shows how to configure the clock on STS-1e controller for framed SAToP on the CT3 mode:

```
enable
configure terminal
controller STS-1e 0/8/12
sts-1 1
clock source internal
mode ct3
t3 framing c-bit
t1 1 cem-group 0 framed
t1 1 clock source recovered 1
```

The following example shows how to configure the clock on STS-1e controller for framed SAToP on the VT-15 mode:

```
enable
configure terminal
controller STS-1e 0/8/12
sts-1 1
mode vt-15
vtg 1 t1 1 cem-group 0 framed
vtg 1t1 1 clock source recovered 2
```

Configuring DCR in Mode T3 for SAToP

```
enable
configure terminal
recovered-clock  <bay> <slot>
clock recovered <clock-id> differential cem <port-no> <cem-group-no>
controller sonet <bay>/<slot>/<port>
rate OC3
sts-1 <number>
mode t3
```

```
cem-group <cem-group-number> unframed
t3 clock source recovered <clock-id>
interface cem <bay>/<slot>/<port>
cem <cem-group-nber>
rtp-present
end
```

Verifying DCR in Mode T3 for SAToP

Verifying DCR Configuration

```
Router# show running-config | section 0/4/6

controller SONET 0/4/6
 rate OC3
 no ais-shut
 framing sonet
 clock source internal
 !
 sts-1 1
  clock source internal
  mode t3
  cem-group 0 unframed
  clock source recovered 20

interface CEM0/4/6
 no ip address
 cem 0
  rtp-present
 !
```

Verifying Recovered Clock

```
Router# show recovered-clock

Recovered clock status for subslot 0/4
----------------------------------------
Clock    Type     Mode         CEM    Status         Frequency Offset(ppb)  Circuit-No
0        OCx-ds3  Differential     0    ACQUIRED   n/a                              0/1
(Port/t3)
```

```
Router# show running-config | section recovered-clock 0 4

recovered-clock 0 4
clock recovered 20 differential cem 6 0
```

Configuring DCR in Mode CT3 for SAToP

```
enable
configure terminal
recovered-clock  <bay> <slot>
clock recovered <clock-id> differential cem <port-no> <cem-group-no>
controller sonet <bay>/<slot>/<port>
rate OC3
sts-1 <number>
mode ct3
t1 <t1_number> cem-group < cem-group-no> unframed
t1 <t1_number> clock source recovered <clock-id>
interface cem <bay>/<slot>/<port>
cem <cem-group-number>
rtp-present
end
```

Verifying DCR in Mode CT3 for SAToP

Verifying DCR Configuration

```
Router# show running-config | section 0/4/0

controller MediaType 0/4/0
 mode sonet
controller SONET 0/4/0
 rate OC48
 no ais-shut
 framing sonet
 clock source internal
 !
 sts-1 1
  clock source internal
  mode ct3
  t3 framing c-bit
  t1 1 clock source Recovered 10
  t1 1 framing unframed
  t1 1 cem-group 1 unframed


interface CEM0/4/0
 no ip address
 cem 1
  rtp-present
 !
```

Verifying Recovered Clock

```
Router# show recovered-clock

Recovered clock status for subslot 0/4
----------------------------------------
Clock    Type     Mode         CEM    Status         Frequency Offset(ppb)  Circuit-No
0        OCx-ds1  Differential     0    ACQUIRED   n/a                             0/1/1
(Port/t3/t1)
```

```
Router# show running-config | section recovered-clock 0 4
recovered-clock 0 4
 clock recovered 10 differential cem 1 0
```

Configuring DCR in Mode VT15 for SAToP

```
enable
configure terminal
recovered-clock  <bay> <slot>
clock recovered <clock-id> differential cem <port-no> <cem-group-no>
controller sonet <bay>/<slot>/<port>
rate OC3
sts-1 <number>
mode vt-15
vtg <vtg_no> t1 <t1_number> cem-group <cem-group-no> unframed
vtg <vtg_no> t1 <t1_number> clock source recovered <clock-id>
interface cem <bay>/<slot>/<port>
cem <cem-group-number>
rtp-present
end
```

Verifying DCR in Mode VT15 for SAToP

Verifying DCR Configuration

```
Router# show running-config | section 0/4/0

controller MediaType 0/4/0
 mode sonet
controller SONET 0/4/0
 rate OC48
 no ais-shut
 framing sonet
 clock source internal
 !
 sts-1 1
  clock source internal
  mode vt-15
  vtg 1 t1 1 clock source Recovered 0
  vtg 1 t1 1 framing unframed
  vtg 1 t1 1 cem-group 0 unframed


interface CEM0/4/0
 no ip address
 cem 0
  rtp-present
 !
```

Verifying Recovered Clock

```
Router# show recovered-clock

Recovered clock status for subslot 0/4
----------------------------------------
Clock    Type     Mode        CEM    Status         Frequency Offset(ppb)  Circuit-No
0        OCx-ds1  Differential     0    ACQUIRED   n/a                              0/1/1/1
 (Port/path/vtg/t1)
```

```
Router# show running-config | section recovered-clock 0 4

recovered-clock 0 4
 clock recovered 0 differential cem 0 0
```

Clock Recovery System in CESoPSN

The Clock Recovery System is able to recover the service clock using two methods, the Adaptive Clock Recovery and Differential Clock Recovery.

Configuring ACR of T1/E1 Interfaces for CESoP

To configure the clock on T1/E1 interfaces for CESoPSN in controller mode, use the following commands:

```
enable
configure terminal
controller t1 <slot>/<bay>/<port>
t1 <t1_num>  clock source recovered <clock-id>
t1 <t1_num> cem-group < cem-group-no > timeslots <1-24>
exit
```

To configure the clock recovery on T1/E1 interfaces in global configuration mode, use the following commands:

```
recovered-clock <slot> <bay>
clock recovered <clock-id> adaptive cem <port-no> <cem-group-no> prioroty <1 | 2>
exit
```

Configuring ACR of T3/E3 Interfaces for CESoP

To configure the clock on T3/E3 interfaces for CESoPSN in controller mode, use the following commands:

```
enable
configure terminal
controller t3 <slot>/<bay>/<port>
t1 <t1_num>  clock source recovered <clock-id>
t1 <t1_num> cem-group < cem-group-no > timeslots <1-24>
exit
```

To configure the clock recovery on T3/E3 interfaces in global configuration mode, use the following commands:

```
recovered-clock <slot> <bay>
clock recovered <clock-id> adaptive cem <port-no> <cem-group-no> prioroty <1 | 2>
exit
```

Configuring DCR of T1/E1 Interfaces for CESoP

To configure the clock on T1/E1 interfaces for CESoPSN in controller mode, use the following commands:

```
enable
configure terminal
controller t1 <slot>/<bay>/<port>
t1 <t1_num> clock source recovered <clock-id>
t1 <t1_num> cem-group < cem-group-no > timeslots <1-24>
exit
```

To configure RTP header on T1/E1 interfaces in global configuration mode, use the following commands:

```
interface cem 0/0/1
cem 0
rtp-present
```

To configure the clock recovery on T1/E1 interfaces in global configuration mode, use the following commands:

```
recovered-clock <slot> <bay>
clock recovered <clock-id> differential cem <port-no> <cem-group-no> prioroty <1 | 2>
exit
```

Configuring DCR of T3/E3 Interfaces for CESoP

Before You Begin

Before configuring DCR, CEM must be configured. Below are the guidelines to configure clock recovery:

- The node (chassis) on which the DS1 is configured for DCR, must have its own clock derived from BITS/GPS/Stratum clock.
- The minimum packet size of CEM pseudowires on the network that delivers robust clock recovery is 64 bytes.

To configure the clock on T3/E3 interfaces for CESoP in controller mode, use the following commands:

```
enable
configure terminal
controller t3 <slot>/<bay>/<port>
t1 <t1_num>  clock source recovered <clock-id>
t1 <t1_num> cem-group < cem-group-no > timeslots <1-24>
exit


interface cem <slot>/<bay>/<port>
cem < cem-group-no>
rtp-present
```

To configure the clock recovery on T3/E3 interfaces in global configuration mode, use the following commands:

```
recovered-clock <slot> <bay>
clock recovered <clock-id> differential cem <port-no> <cem-group-no> prioroty <1 | 2>
exit
```

Note To remove the clock configuration in ACR and DCR, perform the following steps:

- Use the **no clock source recovered** command.
- Remove the global clock.
- Remove CEM configuration, if required.

Configuring Clock Recovery for SDH

•

Configuring ACR on SDH

To configure E1 ACR:

```
enable
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 1
mode vc1x
tug-2 1 payload vc12
e1 1 cem-group 1 unframed
e1 1 clock source recovered 1
tug-2 2 payload vc11
tug-2 3 payload vc11
tug-2 4 payload vc11
end
```

To configure E3 ACR:

```
enable
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 1
mode e3
overhead c2 0
cem-group 1 unframed
e3 clock source recovered 1
```

ACR Global Configuration

```
enable
configure terminal
recovered-clock 0 4
clock recovered 1 adaptive cem 0 1
end
```

Verifying ACR Configuration on SDH

Use **show recovered clock** command to verify E1 ACR configuration:

```
#show recovered clock
Recovered clock status for subslot 0/16
----------------------------------------
Clock    Type     Mode        CEM    Status    Frequency Offset(ppb)  Circuit-No
1        STMx-E1  ADAPTIVE     1    ACQUIRED   n/a                    0/1/1/1/1
(Port/au-4/tug3/tug2/e1)
```

Use **show recovered clock** command to verify T3 ACR configuration:

```
#show recovered clock
Recovered clock status for subslot 0/16
----------------------------------------
Clock    Type     Mode        CEM    Status    Frequency Offset(ppb)  Circuit-No
1       STMx-E3  ADAPTIVE     1    ACQUIRED   n/a                   0/1/1 (Port/au-4/tug3)
```

Configuring DCR on SDH

To configure E1 DCR:

```
enable
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
```

```
tug-3 1
mode vc1x
tug-2 1 payload vc12
e1 1 cem-group 1 unframed
e1 1 clock source recovered 1
tug-2 2 payload vc11
tug-2 3 payload vc11
tug-2 4 payload vc11
end
```

To configure E3 DCR:

```
enable
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 1
mode e3
overhead c2 0
cem-group 1 unframed
e3 clock source recovered 1
```

DCR Global Configuration

```
enable
configure terminal
recovered-clock 0 4
clock recovered 1 differential cem 0 1
end
```

Verifying DCR Configuration on SDH

Use **show recovered clock** command to verify E1 DCR configuration:

```
#show recovered clockRecovered clock status for subslot 0/16
----------------------------------------
Clock    Type     Mode          CEM    Status    Frequency Offset(ppb)  Circuit-No
1        STMx-E1  DIFFERENTIAL    1    ACQUIRED   n/a                     0/1/1/1/1
(Port/au-4/tug3/tug2/e1)
```

Use **show recovered clock** command to verify T3 DCR configuration:

```
#show recovered clock
Recovered clock status for subslot 0/16
----------------------------------------
Clock    Type     Mode         CEM    Status    Frequency Offset(ppb)  Circuit-No
1        STMx-E3  DIFFERENTIAL    1    ACQUIRED   n/a                    0/1/1
(Port/au-4/tug3)
```

Configuring Network Clock

To configure a network clock, use the following commands:

```
enable
configure terminal
```

```
controller T1  0/5/0
clock source  line
cem-group  0 unframed
exit
enable
configure terminal
network-clock input-source 1 controller T1 0/5/0
exit
```

Verifying Network Clocking Configuration

Use **show run | sec network-cl** command to verify the network clocking configuration.

```
network-clock synchronization automatic
network-clock synchronization mode QL-enabled
network-clock input-source 1 controller E1 0/1/0
network-clock wait-to-restore 10 global
rtr1#sh netw synchronization
Symbols:     En - Enable, Dis - Disable, Adis - Admin Disable
             NA - Not Applicable
             *  - Synchronization source selected
             #  - Synchronization source force selected
             &  - Synchronization source manually switched

Automatic selection process : Enable
Equipment Clock : 2048 (EEC-Option1)
Clock Mode : QL-Enable
ESMC : Enabled
SSM Option : 1
T0 : E1 0/1/0
Hold-off (global) : 300 ms
Wait-to-restore (global) : 10 sec
Tsm Delay : 180 ms
Revertive : No

Nominated Interfaces

Interface            SigType     Mode/QL      Prio  QL_IN  ESMC Tx  ESMC Rx
Internal             NA          NA/Dis       251   QL-SEC    NA        NA
*E1 0/1/0             NA          NA/Dis       1     QL-SEC    NA        NA
rtr1#
```

CHAPTER 6

BERT

Bit-Error Rate Testing (BERT) is used for analyzing quality and for problem resolution of digital transmission equipment. BERT tests the quality of an interface by directly comparing a pseudorandom or repetitive test pattern with an identical locally generated test pattern.

The BERT operation is data-intensive. Regular data cannot flow on the path while the test is in progress. The path is reported to be in alarm state when BERT is in progress and restored to a normal state after BERT has been terminated.

BERT is supported in the following two directions:

- Line - Supports BERT in TDM direction.
- System - Supports BERT in PSN direction.

- BERT Restrictions, on page 69
- BERT Patterns, on page 70
- How to Configure BERT, on page 77
- BERT Error Injection, on page 79

BERT Restrictions

- BERT is not supported on the following modes:
  - T3—Framing M-13, non-channelized
  - E3—Framing G832, channelized
- When the BERT is initiated with pattern 0s and 1s from the local end and the loopback local is applied from the far end, then the BERT syncing does not happen. Since the BERT process is asserted as LOS alarms for all 0s and AIS alarms for all 1s BERT patterns. Whereas the BERT syncing behaves properly when the BERT is initiated from both the local and the far end.

  For all 1s on T3 or E3, the BERT behaviour is not asserted as AIS and the BERT syncing happens as usual.
- In the unframed mode, BERT sync is not stable and may generate alarms until Cisco IOS XE Fuji 16.9.4.

Note Framing type should be similar in all routers end to end.

- System BERT is not supported for any pattern in framed SATOP for releases earlier to Cisco IOS XE 17.13.1.
- System BERT is not configurable, without cem-group configuration.
- The default BERT pattern supported is PRBS. The QRSS pattern is supported only on T1 or E1 level and the STS-1E path level for pattern 2^20-O151.

BERT Restrictions for Cisco IOS XE Bengaluru 17.4.1 release

- When the BERT is initiated from the local end and the loopback local is applied from the far end, then BERT syncing does not happen. Since the BERT process is asserted as LOS alarms for all 0s and AIS alarms for all 1s BERT patterns. Whereas the BERT syncing behaves properly when the BERT is initiated from both the local and the far end.

BERT Patterns

The following topics explain BERT patterns supported:

BERT Patterns on T1 or E1 Interface Module

Bit error rate testing (BERT) is supported on T1 or E1 interfaces. You can run BERT tests on 16 controllers out of 48T1 or E1 controllers at a time.

Table 10: Feature History

Feature Name	Release Information	Description
Support for all 0s and 1s BERT Patterns	Cisco IOS XE Bengaluru 17.4.1	Support for all 0s and 1s BERT patterns on T1 or E1 interfaces.

The BERT patterns on the 48-port T1 or E1 interface module are :

Table 11: BERT Pattern Descriptions

Keyword	Description
All 1s [3]	Pseudo-random binary test pattern consisting of all 1's that is used to test alternating line volt and repeaters.
All 0s	Pseudo-random binary test pattern consisting of all 0's that is used for test line coding.
2^15-1 O.151	Pseudo-random O.151 test pattern consisting of a maximum of 14 consecutive zeros and 15 consecutive ones. The length of this pattern is 32,768 bits.

Keyword	Description
2^20-O.151	Pseudo-random O.151 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.
2^20-O.153	Pseudo-random O.153 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.
2^23-1 O.151	Pseudo-random 0.151 test pattern consisting of a maximum of 22 consecutive zeros and 23 consecutive ones. The length of this pattern is 8,388,607 bits.
2^9 [4]	Pseudo-random binary test pattern consisting of a maximum of eight consecutive zeros and nine consecutive ones. The length of this pattern is 511 bits.
2^11 [5]	Pseudo-random binary test pattern consisting of a maximum of ten consecutive zeros and eleven consecutive ones. The length of this pattern is 2048 bits.

3 Starting with Cisco IOS XE Bengaluru 17.4.1, All Is are supported.
4 Starting with Cisco IOS XE Gibraltar 16.12.1, 2^9 is supported on the T1 mode.
5 Starting with Cisco IOS XE Fuji 16.9.5, 2^11 is supported on the T1 mode.

Note If All 1's BERT pattern is tested on the system side, then ensure that you need to start all 1's pattern from both sides of the end points.

Configuring BERT on one side and loopback on other side of the end points is not supported. The router treats all 1's pattern as AIS alarm and BERT will not come in sync with the other side configuration of the end point.

BERT Patterns on T3/E3 Interface Module

Bit error rate testing (BERT) is supported on T3/E3 interfaces.

- You can run 16 BERTs at a time.
- The test can be either of the T1/E1 or the T3/E3 interface.

Table 12: Feature History

Feature Name	Release Information	Description
Support for all 0s and 1s BERT Patterns	Cisco IOS XE Bengaluru 17.4.1	Support for all 0s and 1s BERT patterns on T3 or E3 interfaces.

The BERT patterns on the 48-port T3/E3 interface module are:

Table 13: BERT Pattern Descriptions

Keyword	Description
All 1s [6]	Pseudo-random binary test pattern consisting of all 1's that is used to test alternating line volt and repeaters.
All 0s	Pseudo-random binary test pattern consisting of all 0's that is used for test line coding.
2^15-1 O.151	Pseudo-random O.151 test pattern consisting of a maximum of 14 consecutive zeros and 15 consecutive ones. The length of this pattern is 32,768 bits.
2^20-O.151	Pseudo-random O.151 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.
2^20-O.153	Pseudo-random O.153 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.
2^23-1 O.151	Pseudo-random 0.151 test pattern consisting of a maximum of 22 consecutive zeros and 23 consecutive ones. The length of this pattern is 8,388,607 bits.
2^9 [7]	Pseudo-random binary test pattern consisting of a maximum of eight consecutive zeros and nine consecutive ones. The length of this pattern is 511 bits.
2^11 [8]	Pseudo-random binary test pattern consisting of a maximum of ten consecutive zeros and eleven consecutive ones. The length of this pattern is 2048 bits.

[6] Starting with Cisco IOS XE Bengaluru 17.4.1, All Is are supported on all modes.
[7] Starting with Cisco IOS XE Gibraltar 16.12.1, 2^9 is supported on both T3 and T1 modes.
[8] Starting with Cisco IOS XE Fuji 16.9.5, 2^11 is supported on both T3 and T1 modes.

Note If All 1's BERT pattern is tested on the system side, then ensure that you need to start all 1's pattern from both sides of the end points.

Configuring BERT on one side and loopback on other side of the end points is not supported. The router treats all 1's pattern as AIS alarm and BERT will not come in sync with the other side configuration of the end point.

BERT Patterns on 1-Port OC-48 or 4-Port OC-12/OC-3 CEM Interface Module

Table 14: Feature History

Feature Name	Release Information	Description
Support for all 0s and 1s BERT Patterns	Cisco IOS XE Bengaluru 17.4.1	Support for all 0s and 1s BERT patterns for SONET and SDH.

The BERT patterns on the 1-Port OC-48 or 4-Port OC-12/OC-3 interface module are:

Table 15: BERT Pattern Descriptions

Keyword	Description
All 1s [9]	Pseudo-random binary test pattern consisting of all 1's that is used to test alternating line volt and repeaters.
All 0s	Pseudo-random binary test pattern consisting of all 0's that is used for test line coding.
2^15-1 O.151	Pseudo-random O.151 test pattern consisting of a maximum of 14 consecutive zeros and 15 consecutive ones. The length of this pattern is 32,768 bits.
2^20-O.151	Pseudo-random O.151 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.
2^20-O.153	Pseudo-random O.153 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.
2^23-1 O.151	Pseudo-random 0.151 test pattern consisting of a maximum of 22 consecutive zeros and 23 consecutive ones. The length of this pattern is 8,388,607 bits.
2^9 [10]	Pseudo-random binary test pattern consisting of a maximum of eight consecutive zeros and nine consecutive ones. The length of this pattern is 511 bits.
2^11 [11]	Pseudo-random binary test pattern consisting of a maximum of ten consecutive zeros and eleven consecutive ones. The length of this pattern is 2048 bits.

9 All 1s are supported only on SONET CT3, SDH AU-3 - CT3/CE3 - T1/E1, and SDH AU-3 - VC3. Starting with Cisco IOS XE Bengaluru 17.4.1, All Is are supported on all modes.

10 Starting with Cisco IOS XE Bengaluru 17.4.1, 2^9 mode is supported.

2^9 is not supported on the following modes:

- SONET—Unframed, STS-3c, STS-12c, and STS-48c.

- SDH AU-4—VC4, TUG-3-VC3, TUG-3-E3, TUG-3-T3, and TUG-3 - VC1x.
- SDH AU-3—VC3, VC4-4c, VC4-16c, and VC1x.

11 Starting with Cisco IOS XE Bengaluru 17.4.1, 2^11 mode is supported.

2^11 is not supported on the following modes:

- SONET—Unframed, STS-3c, STS-12c, and STS-48c.
- SDH AU-4—VC4 and TUG-3-VC3.
- SDH AU-3—VC3, VC4-4c, and VC4-16c.

Note If All 1's BERT pattern is tested on the system side, then ensure that you need to start all 1's pattern from both sides of the end points.

Configuring BERT on one side and loopback on other side of the end points is not supported. The router treats all 1's pattern as AIS alarm and BERT will not come in sync with the other side configuration of the end point.

BERT Patterns on 1-Port OC-192 or 8-Port Low Rate CEM Interface Module

Table 16: Feature History

Feature Name	Release Information	Description
Support for all 0s and 1s BERT Patterns	Cisco IOS XE Bengaluru 17.4.1	Support for all 0s and 1s BERT patterns for SONET and SDH.

The BERT patterns on the 1-Port OC-192 or 8-Port Low Rate CEM interface module are:

Table 17: BERT Pattern Descriptions

Keyword	Description
All 0s	Pseudo-random binary test pattern consisting of all 0's that is used for test line coding.
All 1s [12]	Pseudo-random binary test pattern consisting of all 1's that is used to test alternating line volt and repeaters.
2^15-1 O.151	Pseudo-random O.151 test pattern consisting of a maximum of 14 consecutive zeros and 15 consecutive ones. The length of this pattern is 32,768 bits.
2^20-O.151	Pseudo-random O.151 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.

Keyword	Description
2^20-O.153	Pseudo-random O.153 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.
2^23-1 O.151	Pseudo-random 0.151 test pattern consisting of a maximum of 22 consecutive zeros and 23 consecutive ones. The length of this pattern is 8,388,607 bits.
2^9-1 [13]	Pseudo-random binary test pattern consisting of a maximum of eight consecutive zeros and nine consecutive ones. The length of this pattern is 511 bits.
2^11-1 [14]	Pseudo-random binary test pattern consisting of a maximum of ten consecutive zeros and eleven consecutive ones. The length of this pattern is 2048 bits.

[12] All 1s are supported only on SONET CT3, SDH AU-3 - CT3/CE3 - T1/E1, and SDH AU-3 - VC3. Starting with Cisco IOS XE Bengaluru 17.4.1, All Is are supported on all modes.

[13] Starting with Cisco IOS XE Bengaluru 17.4.1, 2^9 mode is supported.

2^9 is not supported on the following modes:

- SONET—Unframed, STS-3c, STS-12c, and STS-48c.
- SDH AU-4—VC4, TUG-3-VC3, TUG-3-E3, TUG-3-T3, and TUG-3 - VC1x.
- SDH AU-3—VC3, VC4-4c, VC4-16c, and VC1x.

[14] Starting with Cisco IOS XE Bengaluru 17.4.1, 2^11 mode is supported.

2^11 is not supported on the following modes:

- SONET—Unframed, STS-3c, STS-12c, and STS-48c.
- SDH AU-4—VC4 and TUG-3-VC3.
- SDH AU-3—VC3, VC4-4c, and VC4-16c.

Note If All 1's BERT pattern is tested on the system side, then ensure that you need to start all 1's pattern from both sides of the end points.

Configuring BERT on one side and loopback on other side of the end points is not supported. The router treats all 1's pattern as AIS alarm and BERT will not come in sync with the other side configuration of the end point.

BERT Patterns on STS-1 Mode

The BERT patterns on the STS-1 mode are:

Table 18: BERT Pattern Descriptions

Keyword	Description
All 1s [15]	Pseudo-random binary test pattern consisting of all 1's that is used to test alternating line volt and repeaters.
All 0s [16]	Pseudo-random binary test pattern consisting of all 0's that is used for test line coding.
2^15-1 O.151	Pseudo-random O.151 test pattern consisting of a maximum of 14 consecutive zeros and 15 consecutive ones. The length of this pattern is 32,768 bits.
2^20-O.151	Pseudo-random O.151 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.
2^20-O.153	Pseudo-random O.153 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.
2^23-1 O.151	Pseudo-random 0.151 test pattern consisting of a maximum of 22 consecutive zeros and 23 consecutive ones. The length of this pattern is 8,388,607 bits.
2^9 [17]	Pseudo-random binary test pattern consisting of a maximum of eight consecutive zeros and nine consecutive ones. The length of this pattern is 511 bits.
2^11 [18]	Pseudo-random binary test pattern consisting of a maximum of ten consecutive zeros and eleven consecutive ones. The length of this pattern is 2048 bits.

15 All 1s are supported only on STS-1 CT3. Starting with Cisco IOS XE Bengaluru 17.4.1, All Is are supported on all modes.
16 Starting with Cisco IOS XE Bengaluru 17.4.1, All 0s are supported on all modes.
17 2^9 is not supported on STS-1 mode unframed, STS-1 CT3 and STS-1 VT-15.
18 2^11 not supported on STS-1 mode unframed.

Note If All 1's BERT pattern is tested on the system side, then ensure that you need to start all 1's pattern from both sides of the end points.

Configuring BERT on one side and loopback on other side of the end points is not supported. The router treats all 1's pattern as AIS alarm and BERT will not come in sync with the other side configuration of the end point.

How to Configure BERT

Configuring BERT in Modes VC-4 and VC Nc

To configure BERT in modes VC-4 and VC Nc:

```
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
mode vc4
clock source internal
bert pattern 2^15 internal 10 direction [line | system]
```

Verifying BERT Configuration in Modes VC-4 and VC Nc

Use **show controllers** command to verify BERT Configuration in Modes VC-4 and VC Nc:

```
#show controller sdh 0/0/16 | sec BERT
BERT test result (running)Test Pattern : 2^15,
Status : Sync, Sync Detected : 0Interval : 10 minute(s),
Time Remain : 00:09:47
Bit Errors (since BERT started): 0 Mbits,Bits Received (since BERT started): 0 Mbits
Bit Errors (since last sync): 1943 bits
Bits Received (since last sync): 1943 Kbits
Direction : LineRouter#
```

Configuring E1 Bert

To configure E1 Bert:

```
enable
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
rate stm4
au-3 1
mode vc1x
tug-2 1 payload vc12
e1 1 bert pattern 2^11 interval 10
end
```

Configuring T1 Bert

To configure T1 Bert:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
```

```
au-3 1
mode vc1x
tug-2 1 payload vc11
t1 1 bert pattern 2^11 interval 10
end
```

Configuring BERT in Mode T3/E3

To configure BERT in Mode T3/E3 for both AUG mapping AU-3 and AU-4:

```
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
mode tug-3
clock source internal
tug-3 1
mode t3
threshold b3-tca 0
overhead c2 0
t3 clock source internal
t3 bert pattern 2^15 internal 10 direction [line | system]
```

Verifying BERT Configuration in Mode T3 or E3

Use **show controllers** command to verify BERT configuration in mode T3 or E3:

```
show controller sdh 0/0/16 | sec BERT
BERT test result (running)Test Pattern : 2^15,
Status : Sync, Sync Detected : 0Interval : 10 minute(s),
Time Remain : 00:09:47
Bit Errors (since BERT started): 0 Mbits,
Bits Received (since BERT started): 0 Mbits
Bit Errors (since last sync): 1943 bits
Bits Received (since last sync): 1943 Kbits
Direction : Line
```

Configuring BERT in Mode VC-1x

To configure BERT in mode VC-1x for both AUG mapping AU-3 and AU-4:

```
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
mode tug-3
clock source internal
tug-3 1
mode vc-1x
```

```
tug-2 1 payload VC11
vc 1 bert pattern 2^15 internal 10 direction [line | system]
```

Verifying BERT Configuration in Mode VC-1x

Use **show controllers** command to verify BERT configuration in mode VC-1x:

```
#show controller sdh 0/0/16 | sec BERT
BERT test result (running)Test Pattern : 2^15,
Status : Sync, Sync Detected : 0Interval : 10 minute(s),
Time Remain : 00:09:47Bit Errors (since BERT started): 0 Mbits,Bits Received (since BERT
started): 0 Mbits
Bit Errors (since last sync): 1943 bits
Bits Received (since last sync): 1943 Kbits
Direction : Line
```

BERT Error Injection

Table 19: Feature History

Feature Name	Release Information	Description
BERT Error Injection	Cisco IOS XE Bengaluru 17.4.1	BERT Error injection enables you to inject errors into the BERT stream on SONET and SDH controllers. You can introduce BERT errors in a range of 1 to 255.

This feature enables you to inject a fixed number of BERT errors when a BERT pattern is running and check the same number of BERT errors to be received at the remote end. Starting with Cisco IOS XE Bengaluru 17.4.1 release, you can configure BERT error injection using the **bert errors** *count of errors* command and before configuring the errors, you must use the **bert pattern** command.

BERT Error Injection is supported on T1 and T3 for SONET and SDH controllers.

BERT Error Injection is supported in the following modes:

Table 20: Supported Modes for BERT Error Injection

Controller	Mode
SONET	• STS-1 T3 • STS-1 CT3 • VT-15 – T1 • VT-15 – VT

Controller	Mode
SDH	• AU-3 - CE3 • AU3 - CT3 • AU3 - E3 • AU3 - T3 • AU3 - VC1X • AU4 - VC3 • AU4 -Tug-3 E3 • AU4 -Tug-3 VC1x • AU4 -Tug-3 T3

Prerequisites of BERT Error Injection

- Ensure that you have set up BERT engine before injecting BERT Errors.

Restrictions of BERT Error Injection

- The BERT Error Injection once configured cannot be removed.
- BERT Error Injection is not supported on the SONET unframed mode.
- A maximum of 16 BERT engines are supported per LOTR card.
- You can configure a maximum of 255 BERT Error counts on the IM.
- BERT Error Injection is **not** supported on the following modes:
  - SONET: Unframed, STS-3C, STS-12C, STS-48C
  - SDH: VC4-4C, VC4-16C, AU3-V3, AU4-VC4

Configuring BERT Error Injection for SONET

Configuring BERT Error Injection - STS-1 T3 Mode

Ensure that you configure the STS-1 and T3 mode followed by BERT Pattern on the SONET STS-1 T3 interface.

To configure BERT Error Injection for the STS-1 mode on the T3 interface, enter the following commands:

```
config terminal
Enter configuration commands, one per line. End with CNTL/Z.
PE1(config)#controller sonet 0/4/0
PE1(config-controller)#sts-1 1
PE1(config-ctrlr-sts1)#t3 bert errors 255
Router#(config-ctrlr-sts1)#end
```

Configuring BERT Error Injection - STS-1 CT3 Mode

Ensure that you configure the STS-1 and CT3 mode followed by BERT Pattern on the SONET STS-1 CT3 interface

To configure BERT Error Injection for the STS-1 CT3 mode, enter the following commands:

```
Router#(config)#controller sonet 0/4/0
Router#(config-controller)#sts-1 1
Router#(config-ctrlr-sts1)#t1 1 bert errors 255
Router#(config-ctrlr-sts1)#end
```

Configuring BERT Error Injection - VT-15 – T1 Mode

Ensure that you configure the STS-1 VT-15 and T1 modes followed by BERT Pattern on the SONET VT-15 T1 interface.

To configure BERT Error Injection for the STS-1 VT-15 and T1 modes, enter the following commands:

```
Enter configuration commands, one per line. End with CNTL/Z.
Router# (config)#controller sonet 0/4/0
Router# (config-controller)#sts-1 1
Router# (config-ctrlr-sts1)#vtg 1 t1 1 bert errors 255
Router# (config-ctrlr-sts1)#end
```

Configuring BERT Error Injection - VT-15 – VT Mode

: Ensure that you configure the STS-1 VT-15 and VT modes followed by BERT Pattern on the SONET VT-15 VT modes.

To configure BERT Error Injection for the STS-1 VT-15 and VT modes, enter the following commands

```
config terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router#(config)#controller sonet 0/4/0
Router#(config-controller)#sts-1 1
Router#(config-ctrlr-sts1)#vtg 1 vt 1 bert errors 255
Router#(config-ctrlr-sts1)#end
```

Verifying BERT Error Injection for SONET

Verifying BERT Error Injection – STS-1 T3 Mode

To verify BERT Error Injection for the STS-1 mode on the T3 interface, use the **show-controller SONET | sec BERT** command;

```
Router# show controller sonet 0/4/0 | sec BERT
BERT test result (running)
Test Pattern : All 0's, Status : Sync, Sync Detected : 1
DSX3 BERT direction : Line
Interval : 60 minute(s), Time Remain : 00:59:00
Bit Errors (since BERT started): 255 bits,
Bits Received (since BERT started): 2697 Mbits
Bit Errors (since last sync): 255 bits
```

```
Bits Received (since last sync): 2697 Mbits
Direction    : Line
```

Verifying BERT Error Injection – STS-1 CT3 Mode

To verify BERT Error Injection for the STS-1 mode and CT3 mode, use the **show-controller SONET | sec BERT** command:

```
Router#
show controller sonet 0/4/0 | sec BERT
BERT test result (running)
Test Pattern : All 0's, Status : Sync, Sync Detected : 1
Interval : 60 minute(s), Time Remain : 00:59:01
Bit Errors (since BERT started): 255 bits,
Bits Received (since BERT started): 89 Mbits
Bit Errors (since last sync): 255 bits
Bits Received (since last sync): 89 Mbits
Direction : Line
```

Verifying BERT Error Injection – STS-1 VT-15 and T1 Modes

To verify BERT Error Injection for the STS-1 VT-15 and T1 modes, use the **show-controller SONET | sec BERT** command:

```
Router#
show controller sonet 0/4/0 | sec BERT
BERT running on timeslots 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,
BERT test result (running)
Test Pattern : All 0's, Status : Sync, Sync Detected : 1
Interval : 60 minute(s), Time Remain : 00:58:59
Bit Errors (since BERT started): 255 bits,
Bits Received (since BERT started): 92 Mbits
Bit Errors (since last sync): 255 bits
Bits Received (since last sync): 92 Mbits
Direction : Line
```

Verifying BERT Error Injection – STS-1 VT-15 and VT Modes

To verify BERT Error Injection for the STS-1 VT-15 and VT modes, use the **show-controller SONET | sec BERT** command:

```
Router#
show controller sonet 0/4/0 | sec BERT
BERT test result (running)
Test Pattern : All 0's, Status : Sync, Sync Detected : 1
Interval : 60 minute(s), Time Remain : 00:59:00
Bit Errors (since BERT started): 255 bits,
Bits Received (since BERT started): 94 Mbits
Bit Errors (since last sync): 255 bits
Bits Received (since last sync): 94 Mbits
Direction : Line
```

Configuring BERT Error Injection for SDH

Configuring BERT Error Injection – CT3-T1-AU3 Mode

Ensure that you configure the CT3-T1-AU-3 mode followed by BERT Pattern on the SDH AU-3-T1 interface.

To configure BERT Error Injection for the CT3-T1-AU3 Mode, enter the following commands:

```
config terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router#(config)#controller sdh 0/4/0
Router#(config-controller)#au-3 1
Router#(config-ctrlr-au3)#t1 1 bert errors 255
Router#(config-ctrlr-au3)#end
```

Configuring BERT Error Injection – E3-AU-3 Mode

Ensure that you configure the E3-AU-3 mode followed by BERT Pattern on the SDH E3-AU-3 interface

To configure BERT Error Injection for the E3-AU-3 Mode, enter the following commands:

```
config terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router#(config)#controller sdh 0/4/0
Router#(config-controller)#au-3 1
Router#(config-ctrlr-au3)#e3 bert errors 255
Router#(config-ctrlr-au3)#end
```

Configuring BERT Error Injection – T3-AU-3 Mode

Ensure that you configure the T3-AU3 mode followed by BERT Pattern on the SDH T3-AU-3 interface.

To configure BERT Error Injection for the T3-AU-3 Mode, enter the following commands:

```
Router# config terminal
Enter configuration commands, one per line. End with CNTL/Z.
Router#(config)#controller sdh 0/4/0
Router#(config-controller)#au-3 1
Router#(config-ctrlr-au3)#t3 bert errors 255
Router#(config-ctrlr-au3)#end
```

Verifying BERT Error Injection for SDH

Verifying BERT Error Injection – CT3-T1-AU3 Mode

To verify BERT Error Injection for the CT3-T1-AU3 Mode, use the **`show-controller SDH | sec BERT`** command

```
Router#
show controller sdh 0/4/0 | sec BERT
BERT test result (running)
Test Pattern : All 0's, Status : Sync, Sync Detected : 1
Interval : 60 minute(s), Time Remain : 00:59:00
Bit Errors (since BERT started): 255 bits,
Bits Received (since BERT started): 90 Mbits
Bit Errors (since last sync): 255 bits
Bits Received (since last sync): 90 Mbits
Direction : Line
```

Verifying BERT Error Injection – E3-AU-3 Mode

To verify BERT Error Injection for the E3-AU-3 Mode, use the **`show-controller SDH | sec BERT`** command:

```
Router# show controller sdh 0/4/0 | sec BERT
BERT test result (running)
Test Pattern : All 0's, Status : Sync, Sync Detected : 1
DSX3 BERT direction : Line
Interval : 60 minute(s), Time Remain : 00:59:00
Bit Errors (since BERT started): 255 bits,
```

```
Bits Received (since BERT started): 2046 Mbits
Bit Errors (since last sync): 255 bits
Bits Received (since last sync): 2046 Mbits
```

Verifying BERT Error Injection – T3-AU-3 Mode

To verify BERT Error Injection for the T3-AU-3 Mode, use the **show-controller SDH | sec BERT** command:

```
Router# Show controller sdh 0/4/0 | sec BERT
BERT test result (running)
Test Pattern : All 0's, Status : Sync, Sync Detected : 1
DSX3 BERT direction : Line
Interval : 60 minute(s), Time Remain : 00:59:30
Bit Errors (since BERT started): 255 bits,
Bits Received (since BERT started): 1282 Mbits
Bit Errors (since last sync): 255 bits
Bits Received (since last sync): 1282 Mbits
```

CHAPTER 7

CEM over MPLS QoS

The QoS EXP matching feature allows you to classify and mark network traffic by modifying the Multiprotocol Label Switching (MPLS) experimental bits (EXP) field in IP packets. This module contains conceptual information and the configuration tasks for classifying and marking network traffic using the MPLS EXP field.

This QoS EXP matching feature is supported on the following CEM interface modules:

- 48-Port T1 or E1 CEM interface module
- 48-Port T3 or E3 CEM interface module
- 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4-port T3/E3 CEM interface module
- 1-port OC-192 or 8-port Low rate CEM interface module
- ASR 900 Combo 8-port SFP GE and 1-port 10 GE 20G interface module

- Information About CEM over MPLS QOS, on page 85
- How to Classify and Mark MPLS EXP, on page 86
- Configuration Examples, on page 87

Information About CEM over MPLS QOS

Classifying and Marking MPLS EXP Overview

The QoS EXP matching feature allows you to organize network traffic by setting values for the MPLS EXP field in MPLS packets. By choosing different values for the MPLS EXP field, you can mark packets so that packets have the priority that they require during periods of congestion. Setting the MPLS EXP value allows you to:

- Classify traffic

  The classification process selects the traffic to be marked. Classification accomplishes this by partitioning traffic into multiple priority levels, or classes of service. Traffic classification is the primary component of class-based QoS provisioning.

- Police and mark traffic

Policing causes traffic that exceeds the configured rate to be discarded or marked to a different drop level. Marking traffic is a way to identify packet flows to differentiate them. Packet marking allows you to partition your network into multiple priority levels or classes of service.

Prerequisites for CEM over MPLS QoS

The device must be configured as an MPLS provider edge (PE) or provider (P) chassis, which can include the configuration of a valid label protocol and underlying IP routing protocols.

Restrictions for CEM over MPLS QoS

- MPLS classification and marking can only occur in an operational MPLS Network.
- MPLS EXP classification and marking is supported on the main chassis interfaces for MPLS packet switching and imposition (simple IP imposition and Ethernet over MPLS (EoMPLS) imposition) and on Ethernet virtual circuits (EVCs) or Ethernet flow points (EFPs) for EoMPLS imposition.
- MPLS EXP topmost classification is not supported for bridged MPLS packets on Ethernet virtual circuits (EVC) or Ethernet flow points (EFP).
- MPLS EXP marking in the ingress direction only.
- If a packet is classified by IP type of service (ToS) or class of service (CoS) at ingress, it cannot be reclassified by MPLS EXP at egress (imposition case). However, if a packet is classified by MPLS at ingress it can be reclassified by Quality of Service (QoS) group at egress (disposition case).
- If a packet is encapsulated in MPLS, the MPLS payload cannot be checked for other protocols such as IP for classification or marking. Only MPLS EXP marking affects packets encapsulated by MPLS.

How to Classify and Mark MPLS EXP

Classifying MPLS Encapsulated Packets

You can use the **match mpls experimental topmost** command to define traffic classes based on the packet EXP values, inside the MPLS domain. You can use these classes to define services policies to mark the EXP traffic using the **police** command.

```
enable
configure terminal
class-map [match-all | match-any] class-map-name
match mpls experimental topmost mpls-exp-value
end
```

Marking MPLS EXP on Imposed Labels

In typical configurations, marking MPLS packets at imposition is used with ingress classification on IP ToS or CoS fields. However, generic matching with the class default value is supported with other ingress attributes such as **vlan**.

Note For EVC configuration, a policy map that performs matching based on the CoS, and that sets the EXP imposition value, should be used to copy CoS values to the EXP value.

Note The **set mpls experimental imposition** command works only on packets that have new or additional MPLS labels added to them.

```
enable
configure terminal
policy-map policy-map-name
class class-map-name
set mpls experimental imposition mpls-exp-value
end
```

Classifying and Marking MPLS EXP

Note The **set mpls experimental topmost** command works only on packets that are already MPLS encapsulated.

```
enable
configure terminal
policy-map policy-map-name
class class-map-name
set mpls experimental topmost mpls-exp-value
end
```

Configuration Examples

Example: Defining an MPLS EXP Class Map

Example: Defining an MPLS EXP Class Map

The following example defines a class map named exp3 that matches packets that contains MPLS experimental value 3:

```
Router(config)# class-map exp3
Router(config-cmap)# match mpls experimental topmost 3
Router(config-cmap)# exit
```

Example: Defining a Policy Map and Applying the Policy Map to an Ingress Interface

Example: Defining a Policy Map and Applying the Policy Map to an Ingress Interface

The following example uses the class map created in the example above to define a policy map. This example also applies the policy map to a physical interface for ingress traffic.

```
Router(config)# policy-map change-exp-3-to-2
Router(config-pmap)# class exp3
Router(config-pmap-c)# set mpls experimental topmost 2
Router(config-pmap)# exit
Router(config)# interface GigabitEthernet 0/0/0
Router(config-if)# service-policy input change-exp-3-to-2
Router(config-if)# exit
```

Example: Defining a Policy Map and Applying the Policy Map to an Egress Interface

Example: Defining a Policy Map and Applying the Policy Map to an Egress Interface

The following example uses the class map created in the example above to define a policy map. This example also applies the policy map to a physical interface for egress traffic.

```
Router(config)# policy-map WAN-out
Router(config-pmap)# class exp3
Router(config-pmap-c)# shape average 10000000
Router(config-pmap-c)# exit
Router(config-pmap)# exit
Router(config)# interface GigabitEthernet 0/0/0
Router(config-if)# service-policy output WAN-out
Router(config-if)# exit
```

Example: Applying the MPLS EXP Imposition Policy Map to a Main Interface

Example: Applying the MPLS EXP Imposition Policy Map to a Main Interface

The following example applies a policy map to Gigabit Ethernet interface 0/0/0:

```
Router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# interface GigabitEthernet 0/0/0
Router(config-if)# service-policy input mark-up-exp-2
Router(config-if)# exit
```

Example: Defining an MPLS EXP Label Switched Packets Policy Map

Example: Defining an MPLS EXP Label Switched Packets Policy Map

The following example defines a policy map that sets the MPLS EXP topmost value to 2 according to the MPLS EXP value of the forwarded packet:

```
Router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# class-map exp012
Router(config-cmap)# match mpls experimental topmost 0 1 2
Router(config-cmap)# exit
Router(config-cmap)# policy-map mark-up-exp-2
Router(config-pmap)# class exp012
Router(config-pmap-c)# set mpls experimental topmost 2
Router(config-pmap-c)# exit
Router(config-pmap)# exit
```

Example: Applying the MPLS EXP Label Switched Packets Policy Map to a Main Interface

Example: Applying the MPLS EXP Label Switched Packets Policy Map to a Main Interface

The following example shows how to apply the policy map to a main interface:

```
Router# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)# interface GigabitEthernet 0/0/0
Router(config-if)# service-policy input mark-up-exp-2
Router(config-if)# exit
```

CHAPTER 8

RSP-based Non-Intrusive Monitor Ports

Table 21: Feature History

Feature Name	Release Information	Description
TAP and Split TAP Support for Protected Interfaces	Cisco IOS XE Cupertino 17.7.1	TAP and split TAP support for the following protected interfaces on both receive and transmit direction: • Automatic Protection Switching (APS) • Unidirectional Path Switching Ring (UPSR) • Card Protection Group (CPG) With this feature support, you can perform monitoring and debugging on these virtual protection interfaces.
Test Access Port (TAP) or Test Access Digroup (TAD)	Cisco IOS XE Bengaluru 17.6.1	Support for Test access port or digroup (TAP/TAD) in the following aspects: • Non-intrusive monitoring for both receive and transmit directions. • Split and terminate cross connection for intrusive testing in both directions. The TAP feature helps in monitoring and debugging purpose.

Feature Name	Release Information	Description
RSP-based Non-Intrusive Monitor Ports	Cisco IOS XE Bengaluru 17.5.1	This feature allows you to transmit data to multiple connections from a single source using the RSP-based non-intrusive monitor port TAP port. It establishes a one-way cross-connect listen connection that listens to either the source or destination of an existing cross-connect or a local connect connection. This feature is only supported on Cisco RSP3 module. This feature is supported on the following CEM interface modules: • 48-port T1/E1 CEM interface module • 48-port T3/E3 CEM interface module • 1-port OC48/ STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-Port T1/E1 + 4-Port T3/E3 CEM interface module • ASR 900 Combo 8-Port SFP GE and 1-Port 10 GE 20G interface module

Prior to Cisco IOS XE Bengaluru Release 17.5.1, it was not possible to transmit data to multiple connections from a single CEM source.

With Cisco IOS XE Bengaluru Release 17.5.1, you can transmit data to multiple connections from a single source using the RSP-based non-intrusive monitor port or Terminal Access Point (TAP) port. The destination port at which the traffic is monitored is a listen-only port. This port can only receive traffic but cannot transmit. It establishes a one-way cross-connect listen connection that listens to either the source or destination of an existing cross-connect or a local connect connection. The listen connection takes a standard cross-connect and sends the traffic to multiple 'listen only' destinations. Thus, the data can be transmitted to multiple connections from a single source. This feature is supported on Cisco RSP3 module.

This feature is supported on the following CEM interface modules:

- 48-port T1/E1 CEM interface module
- 48-port T3/E3 CEM interface module
- 1-port OC48/ STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-Port T1/E1 + 4-Port T3/E3 CEM interface module
- ASR 900 Combo 8-Port SFP GE and 1-Port 10 GE 20G interface module

Starting with Cisco IOS XE Bengaluru 17.6.1, you can enable TAP or TAD point to monitor the traffic as listen-only connections in the following directions for local connect and/or cross-connect scenarios:

- Receive direction (Rx)
- Transmit direction (Tx)

The default TAP configuration is Tx and the Tx direction support is available from Cisco IOS XE Bengaluru 17.5.1.

In addition, you can split the TAP or TAD session and monitor for intrusive testing. The original traffic is affected unlike the Tx and Rx where the traffic is replicated.

The split TAP and monitor session supports in the following directions:

- Split Receive direction (Split-Rx)
- Split Transmit direction (Split-Tx)

The directions Tx or Rx is considered with respect to the core interface in the network.

Source and destination ports can be in the same or different router.

TAP Support for Protected Interfaces

Starting with Cisco IOS XE Cupertino 17.7.1, you can enable TAP or split TAP for the following protected interfaces on both receive and transmit direction:

- Automatic Protection Switching (APS)
- Unidirectional Path Switching Ring (UPSR)
- Card Protection Group (CPG)

UPSR Protection

SONET local connect and cross connect are supported at VT-15 CEP, STS-1c, STS-3c, STS-12c, and STS-48c levels. UPSR is also supported on TDM endpoints that are mapped to a pseudowire. T1 SAToP, T3 SAToP, and CT3 are supported on an UPSR ring only with local connect mode.

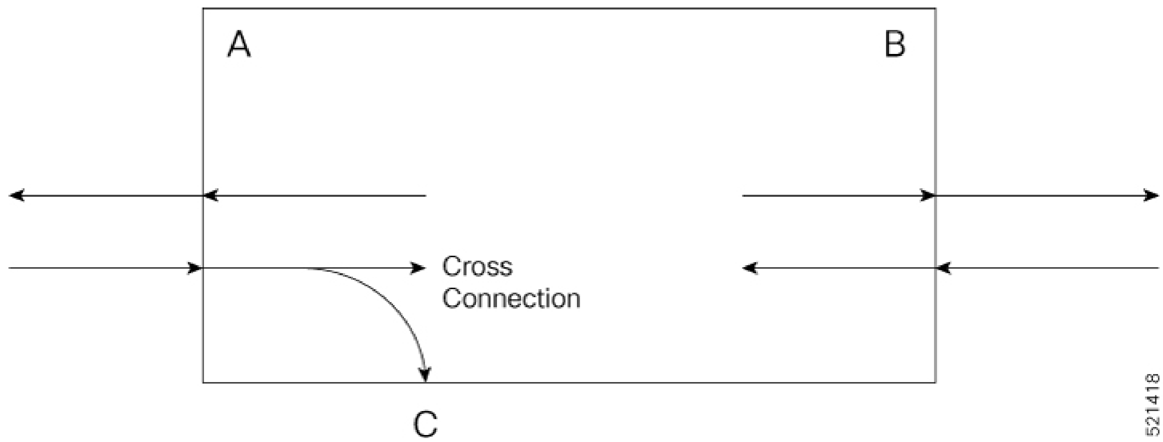
Starting with Cisco IOS XE Fuji 16.9.x, the cross connect of T1, T3, and CT3 circuits to UPSR is supported.

- Single TAP Destination, on page 93
- Multiple TAP Destinations, on page 94
- Restrictions, on page 94
- How to configure RSP-based Non-Intrusive Monitor Ports, on page 95

Single TAP Destination

In the figure below, the ingress traffic at port A is tapped at port C. Port C is a listen-only port, which can only receive the traffic but cannot transmit. Thus, the traffic is transmitted from port A to port B and from port A to port C. Port C can be present on the same IM or on different IMs of the same router as that of port A. Port C can be present on different routers (remote nodes) connected via a pseudowire.

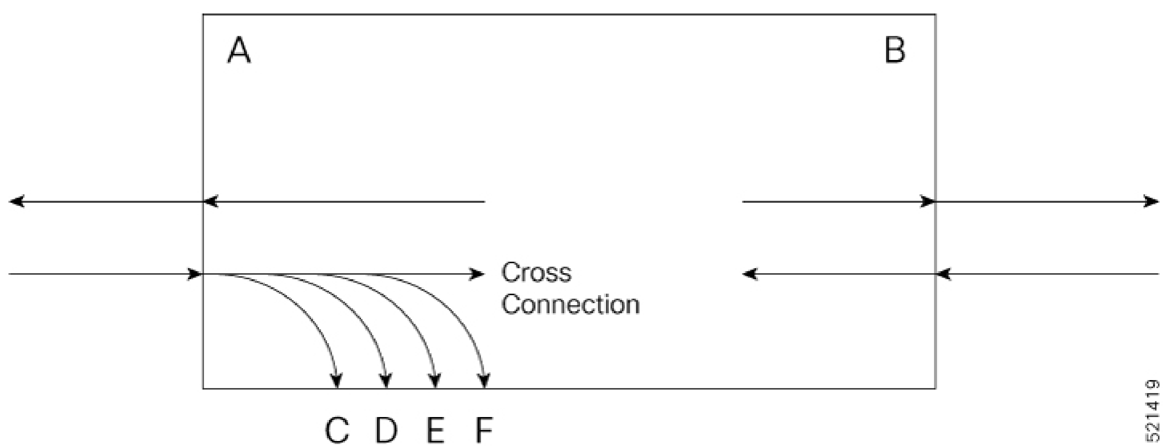
Figure 1: Single TAP Destination



Multiple TAP Destinations

In the figure below, the ingress traffic at port A is tapped at the listen-only ports C, D, E, and F. Thus, the traffic is transmitted from port A to ports B, C, D, E, and F. Ports C, D, E, and F can be present on the same IM or on different IMs of the same router as that of port A. Port C, D, E, and F can be present on different routers (remote nodes) connected via a pseudowire to port A.

Figure 2: Multiple TAP Destinations



Restrictions

- SSO is *not* supported.
- High availability is *not* supported.
- For releases prior to Cisco IOS XE Bengaluru 17.6.1, to configure TAP on an original xconnect or to create a TAP xconnect connection with more than 12 circuits, use the following command:

no cef table output-chain build indirection

You must configure the above-mentioned command before configuring TAP for L2VPN. This command increases the convergence on all existing circuits in the router on core flaps.

- The range of monitor session ID for CEM interfaces is from 16 to 1015.
- This feature is *not* supported on 1-port OC-192 Interface module or 8-port Low Rate Interface Module.
- This feature is *not* supported on circuits with protected core, FRR core, tunnel core, or with ECMP.
- TAP xconnects are *not* supported on protected core, FRR core, tunnel core, or with ECMP.
- When you first configure TAP on a circuit, there is a negligible traffic drop on the original circuit.
- Configuration under monitor is applied only after you exit the privilege mode. Hence, to apply any changes to the existing source or direction, ensure that you first unconfigure the existing source or direction before reconfiguring the feature.
- The split-Rx configuration is not supported on source interface for local connection.
- In SAToP, the loop code detection is disabled by default. Both ESF/FDL loop code and IBOC loop code are transparently sent to CPE.
- In CESoP, the loop code detection is not disabled by default. Under controller configuration, use the **rem-loop-detect-disable** command to disable loop code detection.
- If you are not using STE with unidirectional TAP (Tx/Rx), then the design consideration should be taken to handle control packets that are replicated through TAP session configuration.
- In local connect, only Tx and split-Tx configurations are supported.
- A maximum of 20 tap destinations from a single source is supported. You can tap a maximum of 50 sources. Thus, the total tap scale is 50X20=1000.
- The maximum number of split Tx or split-Rx monitor session that you can configure on a source interface is one.
- TAP is not supported when the iMSG VLAN handoff feature is enabled on the same node.
- TAP feature is supported only on RSP3 for protected interfaces. In UPSR, some of the configurations are not supported for the protected interfaces.
- The N-bits or P-bits of CEM counter keeps increasing in CEP mode of STS-1E, SONET, or SDH frame. The N-bits or P-bits adjust the placement of CEP payload in the SONET or SDH frame, but these bits do not correct the clock. The increment of these bits do not stop until CE and PE clocks are synced with proper clock configuration. This is applicable for all CEM interface modules except T1 or E1 interface module.

How to configure RSP-based Non-Intrusive Monitor Ports

Scenarios for RSP-based Non-Intrusive Monitoring or TAP Port Configuration

The following scenarios show the different configurations of RSP-based non-intrusive monitoring or TAP ports.

The following table shows the TAP monitor session direction for local and cross connections:

Table 22: TAP/TAD Support Direction for Local and Cross Connections

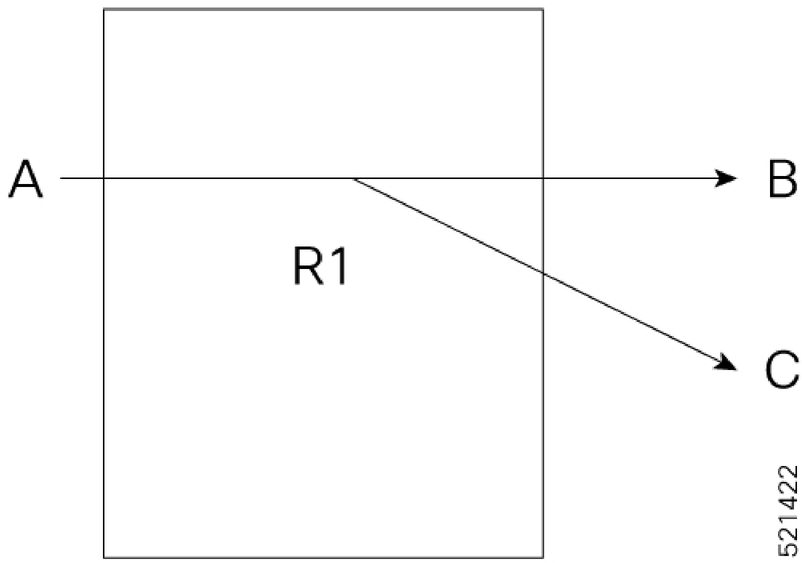
Pseudowire Type	Monitor Session Direction	Support on Monitor Session Direction
Local Connection	Tx (Passive monitor for traffic transmitted into the pseudowire)	Yes
	Rx (Passive monitor for traffic received from the pseudowire)	No
	Split-Tx (Intrusive test for TDM traffic transmitted into the pseudowire)	Yes
	Split-Rx (Intrusive test for TDM traffic received from the pseudowire)	No
Cross Connection	Tx (Passive monitor for traffic transmitted into the pseudowire)	Yes
	Rx (Passive monitor for traffic received from the pseudowire)	Yes
	Split-Tx (Intrusive test for TDM traffic transmitted into the pseudowire)	Yes
	Split-Rx (Intrusive test for TDM traffic received from the pseudowire)	Yes

Note If TAP configured with multiple modes, and to verify the correct mirror count details at ingress and egress sides, we recommend that you use the **show cem circuit interface cem** ***<bay/slot/port> <cem-group-no>*** command. For example, **show cem circuit interface cem** *0/7/0 0*.

Scenario 1: Configure Source, Destination, and TAP Port - Local Node

Consider a scenario, where the traffic originating from the CEM interface A on router R1 is transmitted to the CEM interface B via the local connect on router R1. Use the feature to tap or transmit this traffic from CEM interface A to the CEM interface C on the router R1.

Figure 3: TAP Source and Destination on Local Node



The following example shows the configuration of the tap source and destination on the local node:

1. **Configure CEM on Interface A**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 10 timeslots 1-24
```

2. **Configure CEM on Interface B**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 2
  mode vt-15
  vtg 1 t1 1 cem-group 20 timeslots 1-24
```

3. **Establish Local Connection between Interfaces A and B**

```
enable
configure terminal
connect lc cem0/5/16 10 cem0/5/16 20
```

4. **Configure CEM on Interface C**

```
enable
configure terminal
controller MediaType 0/3/16
mode sonet
controller sonet 0/3/16
```

```
rate OC3
sts-1 1
 mode vt-15
 vtg 1 t1 1 cem-group 30 timeslots 1-24
```

5. **Configure TAP Monitor Session**

```
monitor session 20 type rspan-source
no shut
source  interface cem0/5/16 10
destination pseudowire
```

6. **Configure L2VPN to Direct Traffic on Interface C**

```
l2vpn xconnect context tap20
member MONITOR 20
member cem0/3/16 30
```

Verifiy the Port Source and Destination Configuration on Local Node :

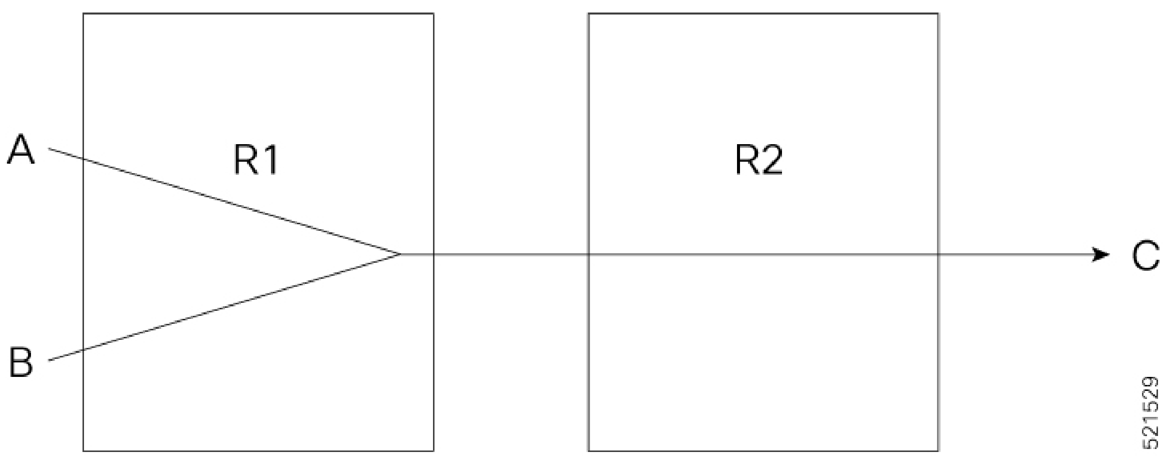
Use the **show monitor session all** command to verify the configuration:

```
Router#show monitor session all
Session 20
----------
Type                      : Remote Source Session
Status                    : Admin Enabled
Source Ports              :
     TX Only              : CE0/5/16 10
Destination Ports         : CE0/3/16 30
```

Scenario 2: Configure Source and Destination - Local Node and TAP Port - Remote Node

Consider a scenario where CEM interfaces A and B are on the local node (router R1). The traffic is mirrored or tapped from CEM interface A to the CEM interface C of the remote node (router R2).

Figure 4: Source and Destination on Local Node and TAP Port on Remote Node



The following example shows the configuration of the source and destination on local node and TAP port on remote node:

1. **Configure CEM on Interface A**

```
enable
configure terminal
```

```
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 10 timeslots 1-24
```

2. **Configure CEM on Interface B**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 2
  mode vt-15
  vtg 1 t1 1 cem-group 20 timeslots 1-24
```

3. **Establish Local Connect between Interface A and Interface B**

```
enable
configure terminal
connect lc cem0/5/16 10 cem0/5/16 20
```

4. **Configure CEM on Interface C**

```
enable
configure terminal
controller MediaType 0/3/16
mode sonet
controller sonet 0/3/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 30 timeslots 1-24
```

5. **Configure Pseudowire and L2VPN Cross Connect on Router R2**

```
interface pseudowire100
encapsulation mpls
neighbor 10.1.1.1 100
!
l2vpn xconnect context tap20
member pseudowire100
member cem0/3/16 30
!
```

6. **Configure Pseudowire on Router R1**

```
interface pseudowire100
encapsulation mpls
neighbor 10.2.2.2 100
!
```

7. **Configure TAP Monitor Session on Router R1**

```
monitor session 20 type rspan-source
no shut
source  interface cem0/5/16 10
destination pseudowire
```

8. **Configure L2VPN on Router R1 to Direct Traffic on Interface C**

```
l2vpn xconnect context tap20
member MONITOR 20
member pseudowire100
```

Verify TAP Port Configuration on Local Node

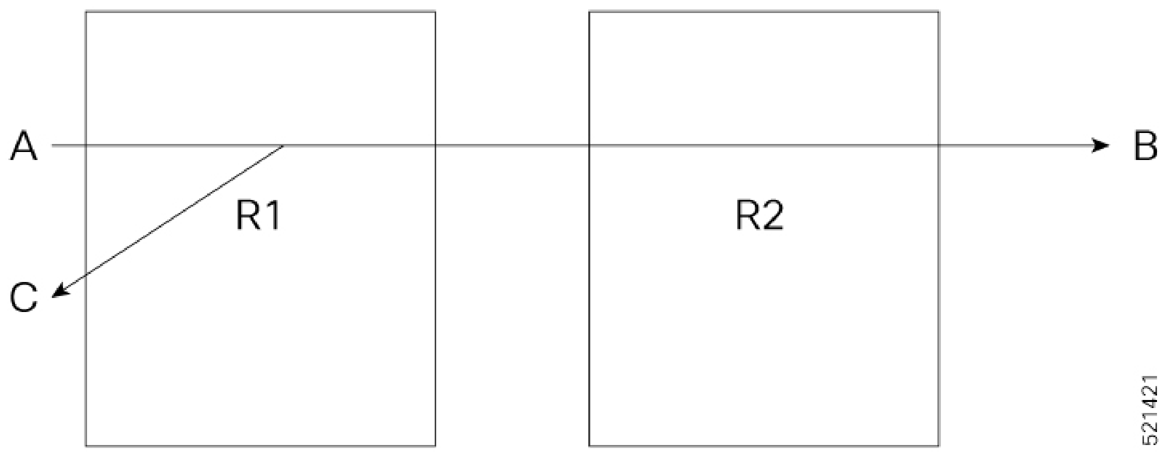
Use the **show monitor session all** command to verify the configuration:

```
Router#show monitor session all
Session 20
----------
Type                      : Remote Source Session
Status                    : Admin Enabled
Source Ports              :
    TX Only               : CE0/5/16 10
Destination Ports         : Pseudowire 100
```

Scenario 3: Configure Source and TAP Port - Local Node and Destination - Remote Node

Consider a scenario, where the traffic originating from the CEM interface A on the local node (router R1) is transmitted to the CEM interface B via the MPLS core interface on the remote node (router R2). Use the feature to tap or transmit this traffic from CEM interface A of the local node (router R1) to CEM interface C of the local node (router R1).

Figure 5: Source and TAP Port on Local Node, and Destination on Remote Node



The following example shows the configuration of source and TAP port on the local node, and destination on the remote node:

1. **Configure CEM on Interface A**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 10 timeslots 1-24
```

2. **Configure CEM on Interface B**

```
enable
configure terminal
controller MediaType 0/3/16
mode sonet
controller sonet 0/3/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 20 timeslots 1-24
```

3. **Configure Pseudowire and L2VPN Cross Connect on Router R1**

```
interface pseudowire100
encapsulation mpls
neighbor 10.2.2.2 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/5/16 10
!
```

4. **Configure Pseudowire and L2VPN Cross Connect on Router R2**

```
interface pseudowire100
encapsulation mpls
neighbor 10.1.1.1 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/3/16 20
```

5. **Configure CEM on Interface C**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 2
  mode vt-15
  vtg 1 t1 1 cem-group 20 timeslots 1-24
```

6. **Configure TAP Monitor Session on Router R1**

```
monitor session 20 type rspan-source
no shut
source  interface cem0/5/16 10
destination pseudowire
```

7. **Configure L2VPN on Router R1 to Direct Traffic on Interface C**

```
l2vpn xconnect context tap20
member MONITOR 20
member cem0/5/16 20
```

Verify TAP Port Configuration on Local Node

Use the **show monitor session all** command to verify the configuration:

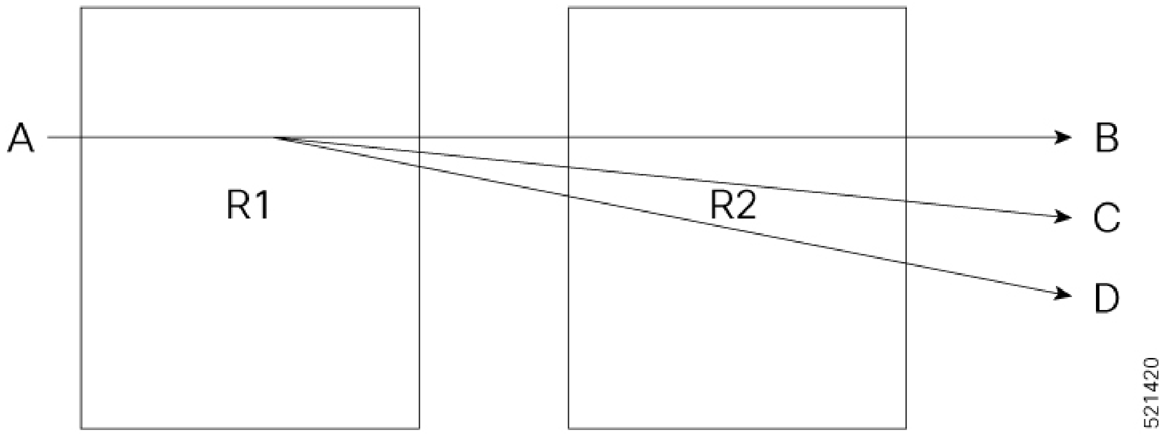
```
Router#show monitor session all
Session 20
----------
Type                      : Remote Source Session
```

```
Status                  : Admin Enabled
Source Ports            :
     TX Only            : CE0/5/16 10
Destination Ports       : CE0/5/16 20
```

Scenario 4: Configure Source - Local Node and TAP Port and Destination - Remote Node

Consider the scenario below, where the traffic originating from the CEM interface A on local node (router R1) is transmitted to the CEM interface B via the MPLS core interface on the remode node (router R2). Use the feature to tap or transmit this traffic from CEM interface A of the local node (router R1) to the CEM interface C of the remote node (router R2).

Figure 6: Source on Local Node, and TAP Port and Destination on Remote Node



The following example shows the configuration of source on the local node, and TAP port and destination on the remote node:

1. **Configure CEM on Interface A**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 10 timeslots 1-24
```

2. **Configure CEM on Interface B**

```
enable
configure terminal
controller MediaType 0/3/16
mode sonet
controller sonet 0/3/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 20 timeslots 1-24
```

3. **Configure Pseudowire and L2VPN Cross Connect on Router R1**

```
interface pseudowire100
encapsulation mpls
```

```
neighbor 10.2.2.2 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/5/16 10
!
```

4. **Configure Pseudowire and L2VPN Cross Connect on Router R2**

```
interface pseudowire100
encapsulation mpls
neighbor 10.1.1.1 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/3/16 20
!
```

5. **Configure CEM on Interface C on Router R2**

```
enable
configure terminal
controller MediaType 0/3/16
mode sonet
controller sonet 0/3/16
 rate OC3
 sts-1 2
  mode vt-15
  vtg 1 t1 1 cem-group 30 timeslots 1-24
```

6. **Configure TAP Monitor Session on Router R1**

```
monitor session 20 type rspan-source
no shut
source  interface cem0/5/16 10
destination pseudowire
```

7. **Configure Pseudowire on Router R1 for TAP**

```
interface pseudowire200
encapsulation mpls
neighbor 10.2.2.2 200
!
```

8. **Configure L2VPN on Router R1 for TAP Interface**

```
l2vpn xconnect context TAP
member pseudowire200
member monitor 20
```

9. **Configure Pseudowire on Router R2 for TAP**

```
interface pseudowire200
encapsulation mpls
neighbor 10.1.1.1 200
```

10. **Configure L2VPN on Router R2 for TAP Interface C**

```
l2vpn xconnect context TAP
member pseudowire200
member cem0/3/16 30
```

Verify TAP Port Configuration on Local Node

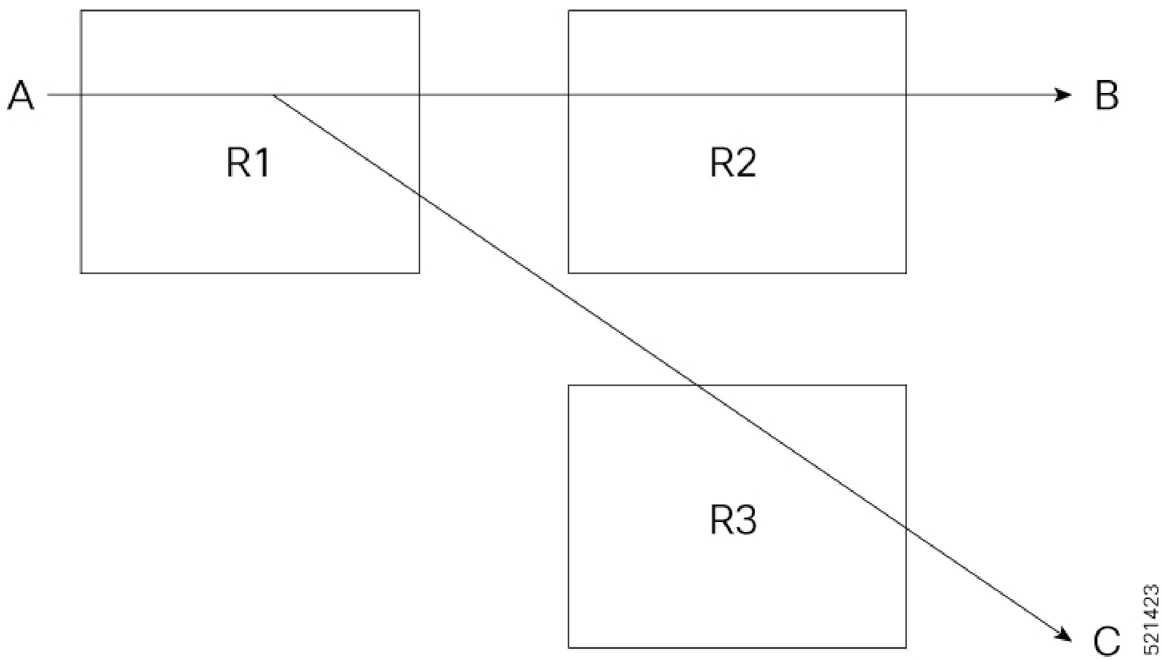
Use the **show monitor session all** command to verify the configuration:

```
Router#show monitor session all
Session 20
----------
Type                      : Remote Source Session
Status                    : Admin Enabled
Source Ports              :
    TX Only               : CE0/5/16 10
Destination Ports         : Pseudowire 200
```

Scenario 5: Configure Source - Local Node and Destination and TAP Port - Different Remote Nodes

Consider a scenario where all the source, destination, and tap interfaces are on different routers. In this scenario, the CEM interface A on the local node (router R1) and the CEM interface B on the remote node (router R2) are cross-connected. The traffic is tapped from the CEM interface A on the local node (router R1) to the CEM interface C on the different remote node (router R3).

Figure 7: Source on Local Node, and Destination and TAP Port on Different Remote Node



The following example shows the configuration of source on local node, and destination and TAP port on different remote nodes:

1. **Configure CEM on Interface A on Router R1**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 10 timeslots 1-24
```

2. **Configure CEM on Interface B on Router R2**

```
enable
configure terminal
controller MediaType 0/3/16
mode sonet
controller sonet 0/3/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 10 timeslots 1-24
```

3. **Configure Pseudowire and L2VPN Cross Connect on Router R1**

```
interface pseudowire100
encapsulation mpls
neighbor 10.2.2.2 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/5/16 10
!
```

4. **Configure Pseudowire and L2VPN Cross Connect on Router R2**

```
interface pseudowire100
encapsulation mpls
neighbor 10.1.1.1 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/3/16 10
!
```

5. **Configure CEM for Interface C on Router R3**

```
enable
configure terminal
controller MediaType 0/4/16
mode sonet
controller sonet 0/4/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 10 timeslots 1-24
```

6. **Configure TAP Monitor Session on Router R1**

```
monitor session 20 type rspan-source
no shut
source interface cem0/5/16 10
destination pseudowire
```

7. **Configure Pseudowire and L2VPN Cross Connect on Router R1 for TAP**

```
interface pseudowire200
encapsulation mpls
neighbor 10.3.3.3 200
!
l2vpn xconnect context TAP
member pseudowire200
member monitor 20
!
```

8. **Configure Pseudowire on Router R3**

```
interface pseudowire200
encapsulation mpls
neighbor 10.1.1.1 200
!
```

9. **Configure L2VPN on Router R3**

```
l2vpn xconnect context TAP
member pseudowire200
member cem0/4/16 10
```

Verify TAP Port Configuration on Local Node

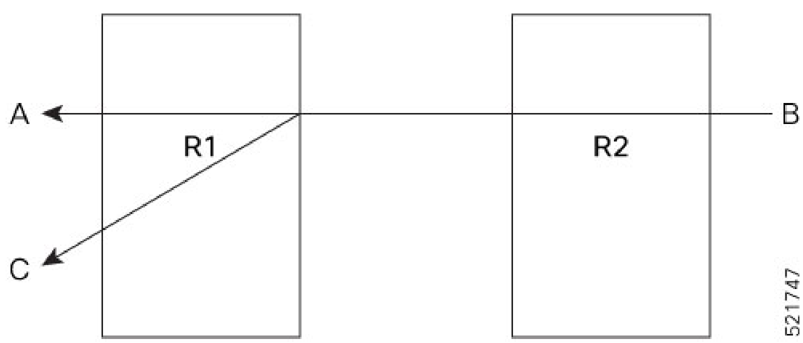
Use the **show monitor session all** command to verify the configuration:

```
Router#show monitor session all
Session 20
----------
Type                         : Remote Source Session
Status                       : Admin Enabled
Source Ports                 :
    TX Only                  : CE0/5/16 10
Destination Ports            : Pseudowire 200
```

Scenario 6 - Configure Monitor Rx

Consider a scenario, where the traffic originating from the CEM interface B on the local node (router R2) is transmitted to the CEM interface A via the MPLS core interface on the remote node (router R1). Create a TAP C on R1 to monitor the Rx traffic.

Figure 8: Monitor Rx Session



The following example shows the configuration of monitor Rx session:

1. **Configure CEM on Interface A on Router R1**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 0 timeslots 1-24
```

2. **Configure CEM on Interface B on Router R2**

```
enable
configure terminal
```

```
controller MediaType 0/2/19
mode sonet
controller sonet 0/2/19
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 0 timeslots 1-24
```

3. **Configure Pseudowire and L2VPN Cross Connect on Router R1**

```
enable
configure terminal
interface pseudowire100
encapsulation mpls
neighbor 10.2.2.2 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/5/16 0
!
```

4. **Configure Pseudowire and L2VPN Cross Connect on Router R2**

```
enable
configure terminal
interface pseudowire100
encapsulation mpls
neighbor 10.1.1.1 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/2/19 0
```

5. **Verify if the L2VPN cross connect is up on Router R1**

```
router#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                         S2
------+---------------------------------+--+---------------------------------+--
UP pri mpls 10.2.2.2:100                  UP   ac CE0/5/16:0(CESoPSN Basic)    UP
```

6. **Configure CEM on Interface C on Router R1**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 2
  mode vt-15
  vtg 1 t1 1 cem-group 20 timeslots 1-24
```

7. **Configure TAP Monitor Session on Router R1**

```
configure terminal
monitor session 20 type rspan-source
```

```
no shut
source  interface cem0/5/16 0 rx
destination pseudowire
```

8. **Configure L2VPN on Router R1 to Direct Traffic on Interface C**

```
configure terminal
l2vpn xconnect context tap20
member MONITOR 20
member cem0/5/16 20
```

9. **Verify if both the cross connections are up and running on Router R1**

```
PE1#sh xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                         S2
------+---------------------------------+--+---------------------------------+--
UP pri mpls 10.2.2.2:100                  UP   ac CE0/5/16:0(CESoPSN Basic)    UP
UP pri   ac MONITOR:20(CESoPSN Basic)    UP   ac CE0/5/16:20(CESoPSN Basic)   UP
```

Verify CEM counters on Router R1

Use the **show cem circuit detail** command to verify the CEM counters configuration:

```
Router#show cem circuit detail
CEM0/5/16, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 1, VTG: 1, T1: 1, CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 4)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    3000                 Dropped:             0
Egress Pkts:     3000                 Dropped:             0

CEM Counter Details
Input Errors:    0                    Output Errors:       0
Pkts Missing:    0                    Pkts Reordered:      0
Misorder Drops:  0                    JitterBuf Underrun:  0
Error Sec:       0                    Severly Errored Sec: 0
Unavailable Sec: 0                    Failure Counts:      0
Pkts Malformed:  0                    JitterBuf Overrun:   0
Generated Lbits: 0                    Received Lbits:      0
Generated Rbits: 0                    Received Rbits:      0
Generated Mbits: 0                    Received Mbits:      0


CEM0/5/16, ID: 20, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 2, VTG: 1, T1: 1, CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 4)
Payload Size: 192
```

```
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:     3000                 Dropped:             0
Egress Pkts:      3000                 Dropped:             0

CEM Counter Details
Input Errors:     0                    Output Errors:       0
Pkts Missing:     0                    Pkts Reordered:      0
Misorder Drops:   0                    JitterBuf Underrun:  0
Error Sec:        0                    Severly Errored Sec: 0
Unavailable Sec:  0                    Failure Counts:      0
Pkts Malformed:   0                    JitterBuf Overrun:   0
Generated Lbits:  0                    Received Lbits:      0
Generated Rbits:  0                    Received Rbits:      0
Generated Mbits:  0                    Received Mbits:      0
```

Verify TAP Port Configuration on Router R1

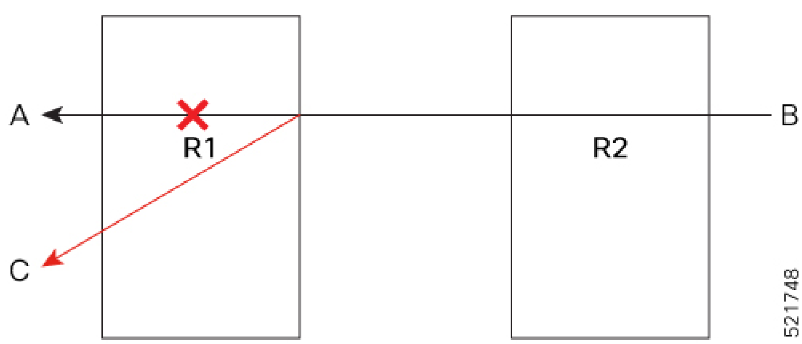
Use the **show monitor session all** to verify the configuration:

```
Router#show monitor session all
Session 20
----------
Type                      : Remote Source Session
Status                    : Admin Enabled
Source Ports              :
     RX Only              : CE0/5/16 0
Destination Ports         : CE0/5/16 20
```

Scenario 7 - Configure Monitor Split-Rx

Consider a scenario, where the traffic originating from the CEM interface B on the local node (router R2) is transmitted to the CEM interface A via the MPLS core interface on the remote node (router R1). The traffic flows from interface B to interface A. Configure split-Rx on interface C. The traffic from interface B to interface A is affected. The traffic flows from interface B to interface C.

Figure 9: Monitor Split Rx Session



The following example shows the configuration of monitor Split Rx session:

1. **Configure CEM on Interface A on Router R1**

```
enable
configure terminal
```

```
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 0 timeslots 1-24
```

2. **Configure CEM on Interface B on Router R2**

```
enable
configure terminal
controller MediaType 0/2/19
mode sonet
controller sonet 0/2/19
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 0 timeslots 1-24
```

3. **Configure Pseudowire and L2VPN Cross Connect on Router R1**

```
enable
configure terminal
interface pseudowire100
encapsulation mpls
neighbor 10.2.2.2 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/5/16 0
!
```

4. **Configure Pseudowire and L2VPN Cross Connect on Router R2**

```
enable
configure terminal
interface pseudowire100
encapsulation mpls
neighbor 10.1.1.1 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/2/19 0
```

5. **Verify that the L2VPN cross connect is Up on Router R1**

```
router#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                        S1 Segment 2                         S2
------+--------------------------------+--+---------------------------------+--
UP pri mpls 10.2.2.2:100                UP   ac CE0/5/16:0(CESoPSN Basic)    UP
```

6. **Configure CEM on Interface C on Router R1**

```
enable
configure terminal
```

```
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 2
  mode vt-15
  vtg 1 t1 1 cem-group 20 timeslots 1-24
```

7. **Configure Split-TAP Monitor Session on Router R1**

```
configure terminal
monitor session 20 type rspan-source
no shut
source  interface cem0/5/16 10 split-rx
destination pseudowire
```

8. **Configure L2VPN on Router R1 to Direct Traffic on Interface C**

```
configure terminal
l2vpn xconnect context tap20
member MONITOR 20
member cem0/5/16 20
```

9. **Verify if both the cross connections are Up on Router R1**

```
router#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                         S2
------+---------------------------------+--+----------------------------------+--
UP pri mpls 10.2.2.2:100                  UP   ac CE0/5/16:0(CESoPSN Basic)    UP
UP pri   ac MONITOR:20(CESoPSN Basic)    UP   ac CE0/5/16:20(CESoPSN Basic)   UP
```

Verify CEM counters on Router R1

Use the **show cem circuit detail** command to verify the CEM counters configuration:

```
Router#show cem circuit detail
CEM0/5/16, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 1, VTG: 1, T1: 1, CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 0)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    3000                 Dropped:             0
Egress Pkts:     0                    Dropped:             0

CEM Counter Details
Input Errors:    0                    Output Errors:       0
Pkts Missing:    3000                 Pkts Reordered:      0
Misorder Drops:  0                    JitterBuf Underrun:  3000
Error Sec:       0                    Severly Errored Sec: 0
```

```
Unavailable Sec: 0                      Failure Counts:      186
Pkts Malformed:  0                      JitterBuf Overrun:   0
Generated Lbits: 0                      Received Lbits:      0
Generated Rbits: 3000                   Received Rbits:      0
Generated Mbits: 0                      Received Mbits:      0


CEM0/5/16, ID: 20, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 2, VTG: 1, T1: 1, CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 3)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    3000                   Dropped:             0
Egress Pkts:     3000                   Dropped:             0

CEM Counter Details
Input Errors:    0                      Output Errors:       0
Pkts Missing:    0                      Pkts Reordered:      0
Misorder Drops:  0                      JitterBuf Underrun:  0
Error Sec:       0                      Severly Errored Sec: 0
Unavailable Sec: 0                      Failure Counts:      0
Pkts Malformed:  0                      JitterBuf Overrun:   0
Generated Lbits: 0                      Received Lbits:      0
Generated Rbits: 0                      Received Rbits:      0
Generated Mbits: 0                      Received Mbits:      0
```

Verify TAP Port Configuration on Router R1

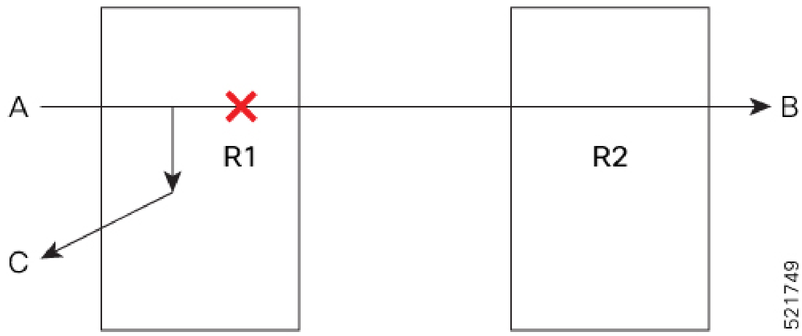
Use the **show monitor session** *<session-id>* or **show monitor session all** to verify the configuration:

```
Router#show monitor session 20
Session 20
----------
Type                     : Remote Source Session [SPLIT]
Status                   : Admin Enabled
Source Ports             :
     RX Only             : CE0/5/16 0
Destination Ports        : CE0/5/16 20
```

Scenario 8 - Configure Monitor Split-Tx

Consider a scenario, where the traffic originating from the CEM interface A on the local node (router R1) is transmitted to the CEM interface B via the MPLS core interface on the remote node (router R2). The traffic flows from interface A to interface B. Configure split-Tx on interface C. The traffic from interface A to interface B is affected. The traffic flows from interface A to interface C.

Figure 10: Monitor Split Tx Session



The following example shows the configuration of monitor Split Tx session:

1. **Configure CEM on Interface A on Router R1**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 0 timeslots 1-24
```

2. **Configure CEM on Interface B on Router R2**

```
enable
configure terminal
controller MediaType 0/2/19
mode sonet
controller sonet 0/2/19
 rate OC3
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 0 timeslots 1-24
```

3. **Configure Pseudowire and L2VPN Cross Connect on Router R1**

```
enable
configure terminal
interface pseudowire100
encapsulation mpls
neighbor 10.2.2.2 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/5/16 0
!
```

4. **Configure Pseudowire and L2VPN Cross Connect on Router R2**

```
enable
configure terminal
interface pseudowire100
encapsulation mpls
neighbor 10.1.1.1 100
```

```
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/2/19 0
```

5. **Verify that the L2VPN cross connect is Up on Router R1**

```
router#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                         S2
------+---------------------------------+--+---------------------------------+--
UP pri mpls 10.2.2.2:100                  UP   ac CE0/5/16:0(CESoPSN Basic)    UP
```

6. **Configure CEM on Interface C**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC3
 sts-1 2
  mode vt-15
  vtg 1 t1 1 cem-group 20 timeslots 1-24
```

7. **Configure Split-TAP Monitor Session on Router R1**

```
configure terminal
monitor session 20 type rspan-source
no shut
source  interface cem0/5/16 0 split-tx
destination pseudowire
```

8. **Configure L2VPN on Router R1 to Direct Traffic on Interface C**

```
configure terminal
l2vpn xconnect context tap20
member MONITOR 20
member cem0/5/16 20
```

9. **Verify if both the cross connections are Up on Router R1**

```
router#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                         S2
------+---------------------------------+--+---------------------------------+--
UP pri mpls 10.2.2.2:100                  UP   ac CE0/5/16:0(CESoPSN Basic)    UP
UP pri   ac MONITOR:20(CESoPSN Basic)    UP   ac CE0/5/16:20(CESoPSN Basic)   UP
```

Verify CEM counters on R1

Use the **show cem circuit detail** command to verify the CEM counters configuration:

```
Router#show cem circuit detail
CEM0/5/16, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 1, VTG: 1, T1: 1, CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 4)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    3000                Dropped:            0
Egress Pkts:     3000                Dropped:            0

CEM Counter Details
Input Errors:    0                   Output Errors:      0
Pkts Missing:    0                   Pkts Reordered:     0
Misorder Drops:  0                   JitterBuf Underrun:  0
Error Sec:       0                   Severly Errored Sec: 0
Unavailable Sec: 0                   Failure Counts:     0
Pkts Malformed:  0                   JitterBuf Overrun:   0
Generated Lbits: 0                   Received Lbits:     0
Generated Rbits: 0                   Received Rbits:     0
Generated Mbits: 0                   Received Mbits:     0


CEM0/5/16, ID: 20, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 2, VTG: 1, T1: 1, CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 3)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    3000                Dropped:            0
Egress Pkts:     3000                Dropped:            0

CEM Counter Details
Input Errors:    0                   Output Errors:      0
Pkts Missing:    0                   Pkts Reordered:     0
Misorder Drops:  0                   JitterBuf Underrun:  0
Error Sec:       0                   Severly Errored Sec: 0
Unavailable Sec: 0                   Failure Counts:     0
Pkts Malformed:  0                   JitterBuf Overrun:   0
Generated Lbits: 0                   Received Lbits:     0
Generated Rbits: 0                   Received Rbits:     0
Generated Mbits: 0                   Received Mbits:     0
```

Verify CEM counters on Router R2

Use the **show cem circuit detail** command to verify the CEM counters configuration:

```
Router#show cem circuit detail
CEM0/2/19, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 1, VTG: 1, T1: 1, CEM Mode: T1-CESoP
```

```
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 0)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    5000                  Dropped:             0
Egress Pkts:     0                     Dropped:             0

CEM Counter Details
Input Errors:    0                     Output Errors:       0
Pkts Missing:    5000                  Pkts Reordered:      0
Misorder Drops:  0                     JitterBuf Underrun:  5000
Error Sec:       0                     Severly Errored Sec: 0
Unavailable Sec: 0                     Failure Counts:      312
Pkts Malformed:  0                     JitterBuf Overrun:   0
Generated Lbits: 0                     Received Lbits:      0
Generated Rbits: 5000                  Received Rbits:      0
Generated Mbits: 0                     Received Mbits:      0
```

Verify TAP Port Configuration on Router R1

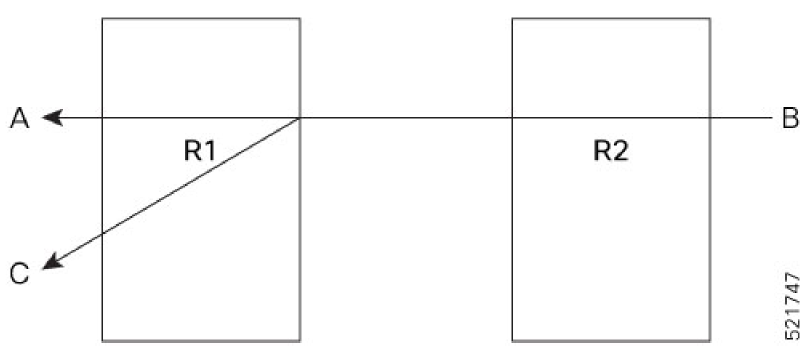
Use the **show monitor session** *<session-id>* or**show monitor session all** to verify the configuration:

```
Router#show monitor session 20
Session 20
----------
Type                      : Remote Source Session [SPLIT]
Status                    : Admin Enabled
Source Ports              :
    TX Only               : CE0/5/16 0
Destination Ports         : CE0/5/16 20
```

Scenario 9 - Configure TAP for APS Protection

Consider a scenario, where the interface A is configured with APS group on router R1 and interface B is configured without APS group on router R2. The traffic originating from the CEM interface B on the local node (router R2) is transmitted to the CEM interface A via the MPLS core interface on the remote node (router R1). Create a TAP C on R1 to monitor the Rx traffic.

Figure 11: Monitor Rx Session



The following example shows the configuration of TAP for APS:

1. **Create an APS Group (Working Controller) on Router R1**

```
enable
configure terminal
controller MediaType 0/10/18
mode sonet
controller SONET 0/10/18
no snmp trap link-status
rate OC12
no ais-shut
alarm-report all
threshold sf-ber 3
clock source internal
aps group 2
aps working 1
aps group acr 2
sts-1 1
 clock source internal
 sts-1 2
  clock source internal
interface CEM0/10/19
 no ip address
```

Note If there is no back to back connection on work or protected interfaces and to avoid alarms, we recommend that you configure loopback local on the work and protected interaces using the following command:

loopback local

2. **Create an APS Group (Protect Controller) on Router R1**

```
enable
configure terminal
controller MediaType 0/13/18
mode sonet
controller SONET 0/13/18
no snmp trap link-status
rate OC12
no ais-shut
alarm-report all
threshold sf-ber 3
clock source internal
aps group 2
aps protect 10.1.1.1
aps group acr 2
sts-1 1
 clock source internal
 sts-1 2
  clock source internal
interface CEM0/13/18
 no ip address
```

Note If there is no back to back connection on work or protected interfaces and to avoid alarms, we recommend that you configure loopback local on the work and protected interaces using the following command:

loopback local

3. **Configure Controller B on Router R2 without APS**

```
enable
configure terminal
controller MediaType 0/13/19
mode sonet
controller sonet 0/13/19
 rate OC12
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 0 unframed
```

4. **Configure CEM on Interface A on Router R1**

```
enable
configure terminal
controller sonet-acr 2
  sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 0 unframed
```

5. **Configure Pseudowire and L2VPN Cross Connect on Router R1**

```
enable
configure terminal
interface pseudowire100
encapsulation mpls
neighbor 10.2.2.2 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem-acr 2 0
!
```

6. **Configure Pseudowire and L2VPN Cross Connect on Router R2**

```
enable
configure terminal
interface pseudowire100
encapsulation mpls
neighbor 10.1.1.1 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/13/19 0
```

7. **Verify if the L2VPN cross connect is up on Router R1**

```
router#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                         S2
------+---------------------------------+--+---------------------------------+--
UP pri mpls 10.2.2.2:100                  UP   ac CE2:0(CESoPSN Basic)    UP
```

8. **Configure CEM on Interface C on Router R1**

```
enable
configure terminal
```

```
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC12
 sts-1 1
  mode vt-15
  vtg 1 t1 1 cem-group 20 unframed
```

9. **Configure TAP Monitor Session on Router R1**

```
monitor session 20 type rspan-source
no shut
source interface cem-acr 2 0 rx
destination pseudowire
```

10. **Configure L2VPN on Router R1 to Direct Traffic on Interface C**

```
configure terminal
l2vpn xconnect context tap20
member MONITOR 20
member cem0/5/16 20
```

11. **Verify if both the cross connections are up and running on Router R1**

```
PE1#sh xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                         S2
------+---------------------------------+--+---------------------------------+--
UP pri mpls 10.2.2.2:100                  UP   ac CE2:0(CESoPSN Basic)    UP
UP pri   ac MONITOR:20(CESoPSN Basic)    UP   ac CE0/5/16:20(CESoPSN Basic)   UP
```

Verify CEM counters on Router R1

Use the **show cem circuit detail** command to verify the CEM counters configuration:

```
Router#show cem circuit detail
CEM-ACR 2, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 1, VTG: 1, T1: 1, CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 4)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    3000                 Dropped:             0
Egress Pkts:     3000                 Dropped:             0

CEM Counter Details
Input Errors:    0                    Output Errors:       0
Pkts Missing:    0                    Pkts Reordered:      0
Misorder Drops:  0                    JitterBuf Underrun:  0
Error Sec:       0                    Severly Errored Sec: 0
Unavailable Sec: 0                    Failure Counts:      0
Pkts Malformed:  0                    JitterBuf Overrun:   0
```

```
Generated Lbits: 0                    Received Lbits:      0
Generated Rbits: 0                    Received Rbits:      0
Generated Mbits: 0                    Received Mbits:      0

CEM0/5/16, ID: 20, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 1, VTG: 1, T1: 1, CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 4)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    3000                 Dropped:             0
Egress Pkts:     3000                 Dropped:             0

CEM Counter Details
Input Errors:    0                    Output Errors:       0
Pkts Missing:    0                    Pkts Reordered:      0
Misorder Drops:  0                    JitterBuf Underrun:  0
Error Sec:       0                    Severly Errored Sec: 0
Unavailable Sec: 0                    Failure Counts:      0
Pkts Malformed:  0                    JitterBuf Overrun:   0
Generated Lbits: 0                    Received Lbits:      0
Generated Rbits: 0                    Received Rbits:      0
Generated Mbits: 0                    Received Mbits:      0
```

Verify CEM counters on Router R2

Use the **show cem circuit detail** command to verify the CEM counters configuration:

```
Router#show cem circuit detail
CEM0/13/19, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 1, VTG: 1, T1: 1, CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 4)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    3000                 Dropped:             0
Egress Pkts:     3000                 Dropped:             0

CEM Counter Details
Input Errors:    0                    Output Errors:       0
Pkts Missing:    0                    Pkts Reordered:      0
Misorder Drops:  0                    JitterBuf Underrun:  0
Error Sec:       0                    Severly Errored Sec: 0
Unavailable Sec: 0                    Failure Counts:      0
Pkts Malformed:  0                    JitterBuf Overrun:   0
Generated Lbits: 0                    Received Lbits:      0
Generated Rbits: 0                    Received Rbits:      0
Generated Mbits: 0                    Received Mbits:      0
```

Verify TAP Port Configuration on Router R1

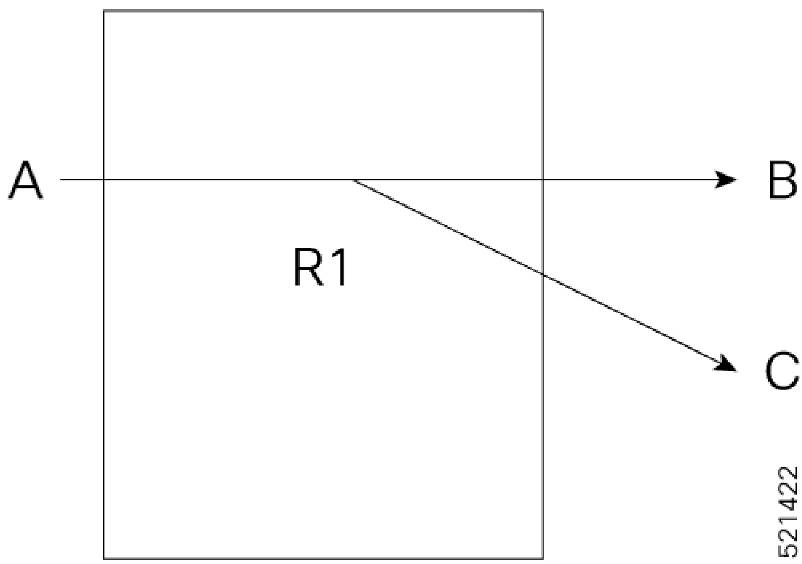
Use the **show monitor session all** to verify the configuration:

```
Router#show monitor session all
Session 20
----------
Type                     : Remote Source Session
Status                   : Admin Enabled
Source Ports             :
     RX Only             : CEM-ACR 2 0
Destination Ports        : CE0/5/16 20
```

Scenario 10 - Configure TAP for CPG Protection

Consider a scenario, where the CPG controller is configured on router R1 with CEM, and non-CPG controller is configured on the same router R1 with CEM group. Create a TAP C on R1 to monitor the Tx traffic.

Figure 12: TAP Source and Destination on Local Node



1. **Configure Card Protection Group**

```
enable
configure terminal
card-protection 4
primary slot 0 bay 0
backup slot 0 bay 5
end
```

Note (Optional) By default the card protection is non-revertive, if necessary you can change to revertive.

```
card-protection 4
revertive time [30-720]
end
```

2. **Configures CEM on T1 Controller—Source Node (Router 1)**

```
enable
configure terminal
controller t1 8/3/0
cem 0 unframed
end
```

3. **Configures CEM on non-CPG T1 controller—Destination Node on Same Router R1**

```
enable
configure terminal
controller t1 0/10/19
cem 0 unframed
end
```

4. **Configure Local Connect on CEM Interface**

```
l2vpn xconnect context lc
member  cem 8/3/0 0
member cem0/10/19 0
end
```

5. **Configure CEM on Interface C**

```
enable
configure terminal
controller t1 0/3/0
cem 0 unframed
```

6. **Configure TAP Monitor Session on T1 Controller**

```
monitor session 20 type rspan-source
no shut
source interface cem8/3/0 0 tx
destination pseudowire
```

7. **Configure L2VPN on Router R1 to Tap the Traffic on Interface C**

```
configure terminal
l2vpn xconnect context tap20
member MONITOR 20
member cem0/3/0 0
```

Verify CEM Counters on T1 Controller

Use the **show cem circuit detail** command to verify the CEM counters configuration:

```
Router#show cem circuit detail
CEM8/3/0, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Mode :Unchannelized, CEM Mode: T1-SAToP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 3)
Payload Size: 1024
Framing: Unframed
CEM Defects Set
None
```

```
Signalling: No CAS
RTP: No RTP

Ingress Pkts: 8102584 Dropped: 0
Egress Pkts: 8105758 Dropped: 0

CEM Counter Details
Input Errors: 0 Output Errors: 0
Pkts Missing: 0 Pkts Reordered: 0
Misorder Drops: 0 JitterBuf Underrun: 0
Error Sec: 0 Severly Errored Sec: 0
Unavailable Sec: 0 Failure Counts: 0
Pkts Malformed: 0 JitterBuf Overrun: 6400
Generated Lbits: 8102584 Received Lbits: 0
Generated Rbits: 0 Received Rbits: 0

CEM0/3/0, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Mode :Unchannelized, CEM Mode: T1-SAToP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 3)
Payload Size: 1024
Framing: Unframed
CEM Defects Set
None
Signalling: No CAS
RTP: No RTP
Ingress Pkts: 8102584 Dropped: 0
Egress Pkts: 8105758 Dropped: 0
CEM Counter Details
Input Errors: 0 Output Errors: 0
Pkts Missing: 0 Pkts Reordered: 0
Misorder Drops: 0 JitterBuf Underrun: 0
Error Sec: 0 Severly Errored Sec: 0
Unavailable Sec: 0 Failure Counts: 0
Pkts Malformed: 0 JitterBuf Overrun: 6400
Generated Lbits: 8102584 Received Lbits: 0
Generated Rbits: 0 Received Rbits: 0
```

Verify TAP Port Configuration

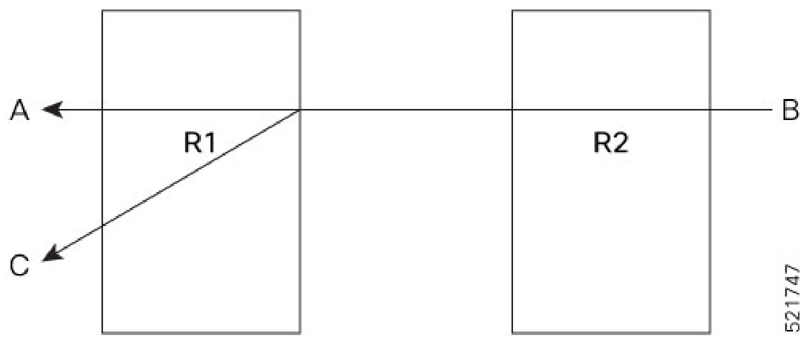
Use the show monitor session all to verify the configuration:

```
Router#show monitor session all
Session 20
----------
Type : Remote Source Session
Status : Admin Enabled
Source Ports :
TX Only : CE8/3/0 0
Destination Ports : CE0/3/0 0
```

Scenario 11 - Configure TAP for UPSR Protection

Consider a scenario, where the UPSR work and protect paths are created on router R1, and original destination is created on router R2. The traffic originating from the CEM interface B on the router R2 is transmitted to the CEM interface A via the MPLS core interface on the remote node (router R1). Create a TAP C on R1 to monitor the Rx traffic.

Figure 13: Monitor Rx Session



The following example shows the configuration of TAP for UPSR:

1. **Create UPSR on Router R1**

```
protection-group 2 type vt1.5
controller protection-group 2
type vt1.5
cem-group 16002 unframed


controller sonet 0/4/0
sts-1 1
mode vt-15
vtg 1 t1 2 protection-group 2 working


controller sonet 0/5/0
sts-1 1
mode vt-15
vtg 1 t1 2 protection-group 2 protect
```

2. **Configure CEM on Interface B on Router R2**

```
enable
configure terminal
controller MediaType 0/12/6
mode sonet
controller sonet 0/12/6
 rate OC12
 sts-1 1
  mode vt-15
  vtg 1 t1 2 cem-group 0 unframed
```

3. **Configure Pseudowire and L2VPN Cross Connect on Router R1**

```
enable
configure terminal
interface pseudowire100
encapsulation mpls
neighbor 10.2.2.2 100
!
l2vpn xconnect context original_xc
member pseudowire100
```

```
member cem-pg 2 16002
!
```

4. **Configure Pseudowire and L2VPN Cross Connect on Router R2**

```
enable
configure terminal
interface pseudowire100
encapsulation mpls
neighbor 10.1.1.1 100
!
l2vpn xconnect context original_xc
member pseudowire100
member cem0/12/6 0
```

5. **Verify if the L2VPN cross connect is up on Router R1**

```
router#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                         S2
------+---------------------------------+--+---------------------------------+--
UP pri mpls 10.2.2.2:100                 UP   ac CEM-PG 2:16002(CESoPSN Basic)    UP
```

6. **Configure CEM on Interface C on Router R1**

```
enable
configure terminal
controller MediaType 0/5/16
mode sonet
controller sonet 0/5/16
 rate OC12
 sts-1 1
  mode vt-15
  vtg 1 t1 2 cem-group 20 unframed
```

7. **Configure TAP Monitor Session on Router R1**

```
monitor session 20 type rspan-source
no shut
source interface cem-pg 2 16002 rx
destination pseudowire
```

8. **Configure L2VPN on Router R1 to Direct Traffic on Interface C**

```
configure terminal
l2vpn xconnect context tap20
member MONITOR 20
member cem0/5/16 20
```

9. **Verify if both the cross connections are up and running on Router R1**

```
PE1#sh xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                         S2
```

```
------+---------------------------------+--+---------------------------------+--
UP pri mpls 10.2.2.2:100                 UP   ac CEM-PG 2:16002(CESoPSN Basic)    UP
UP pri   ac MONITOR:20(CESoPSN Basic)    UP   ac CE0/5/16:20(CESoPSN Basic)   UP
```

Verify CEM counters on Router R1

Use the **show cem circuit detail** command to verify the CEM counters configuration:

```
Router#show cem circuit detail
CEM-PG 2, ID: 16002, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 1, VTG: 1, T1: 2, CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 4)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    3000                 Dropped:             0
Egress Pkts:     3000                 Dropped:             0

CEM Counter Details
Input Errors:    0                    Output Errors:       0
Pkts Missing:    0                    Pkts Reordered:      0
Misorder Drops:  0                    JitterBuf Underrun:  0
Error Sec:       0                    Severly Errored Sec: 0
Unavailable Sec: 0                    Failure Counts:      0
Pkts Malformed:  0                    JitterBuf Overrun:   0
Generated Lbits: 0                    Received Lbits:      0
Generated Rbits: 0                    Received Rbits:      0
Generated Mbits: 0                    Received Mbits:      0


CEM0/5/16, ID: 20, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 1, VTG: 1, T1: 2, CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8 0x8
Dejitter: 6 (In use: 4)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    3000                 Dropped:             0
Egress Pkts:     3000                 Dropped:             0

CEM Counter Details
Input Errors:    0                    Output Errors:       0
Pkts Missing:    0                    Pkts Reordered:      0
Misorder Drops:  0                    JitterBuf Underrun:  0
Error Sec:       0                    Severly Errored Sec: 0
Unavailable Sec: 0                    Failure Counts:      0
Pkts Malformed:  0                    JitterBuf Overrun:   0
Generated Lbits: 0                    Received Lbits:      0
Generated Rbits: 0                    Received Rbits:      0
```

```
Generated Mbits: 0                    Received Mbits:      0
```

Verify TAP Port Configuration on Router R1

Use the **show monitor session all** to verify the configuration:

```
Router#show monitor session all
Session 20
----------
Type                      : Remote Source Session
Status                    : Admin Enabled
Source Ports              :
     RX Only              : CEM-PG 2 16002
Destination Ports         : CE0/5/16 20
```

CHAPTER 9

Support for Static MPLS Labels on Cisco RSP3 Module

Table 23: Feature History

Feature Name	Release Information	Description
Increased MPLS label scale support	Cisco IOS XE Cupertino 17.7.1	Starting with Cisco IOS XE Cupertino 17.7.1 release, the MPLS label range is increased from 32,768 to 40,960 to configure the dynamic label range.
Support for Static MPLS Labels on Cisco RSP3 Module	Cisco IOS XE Bengaluru 17.5.1	This feature allows you to provision an Any Transport over Multiprotocol (AToM) label switching static pseudowire without the use of a directed control connection. In environments that do not or cannot use directed control protocols, this feature provides a means for provisioning the pseudowire parameters statically at the Cisco IOS Command-Line Interface (CLI). This feature is supported on Cisco RSP3 module.

Before Cisco IOS XE Bengaluru Release 17.5.1, pseudowires were dynamically provisioned using Label Distribution Protocol (LDP), or another directed control protocol such as Resource Reservation Protocol over traffic-engineered tunnels (RSVP-TE), to exchange the various parameters required for these connections.

Starting with Cisco IOS XE Bengaluru Release 17.5.1, you can provision an Any Transport over Multiprotocol (AToM) label switching static pseudowire without the use of a directed control connection. In environments that do not or cannot use directed control protocols, a means for provisioning the pseudowire parameters statically at the Cisco IOS CLI is provided by the AToM Static Pseudowire feature.

The MPLS static feature enables you to statically assign local labels to an IPv4 prefix per VRF. Also, Label Switched Paths (LSPs) can be provisioned for these static labels by specifying the next-hop information that is required to forward the packets containing static label.

Static labels are more advantageous than dynamic labels because static labels:

- Improve security because the risk of receiving unwanted labels from peers (running a compromised MPLS dynamic labeling protocol) is reduced.
- Provide you with the full control over defined LSPs.
- Utilize system resources optimally because dynamic labeling is not processed.

Static Label Pseudowire Provisioning for CEM also overcomes the restriction of limited 1400 (1-dimensional) targeted LDP sessions scale.

The feature allows you to manually configure the following parameters:

- Local Pseudowire Label
- Remote Pseudowire Label

This feature is supported on the following CEM IMs:

- 1-port OC-48 1/ STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-Port T1/E1 + 4-Port T3/E3 CEM Interface Module
- 1-port OC-192 Interface module or 8-port Low Rate Interface Module (ASR 900 Combo 8-port SFP GE and 1-port 10GE IM with CEM, 10G)
- 48-port T3/E3 CEM Interface Module
- 48-port T1/E1 CEM Interface Module

MPLS Label Range

The MPLS label range configuration helps you to configure the dynamic label range. Any label that falls outside this dynamic range is available for manually allocating as static labels. The router does not verify statically configured labels against the specified label range. Therefore, to prevent label discrepancy, ensure that you do not configure static MPLS labels that fall within the dynamic label range.

Starting with Cisco IOS XE Bengaluru Release 17.5.1, the overall range for MPLS label is from 16 through 32768. Both the static and dynamic labels must be allocated within this range. For example, if you configure the dynamic label range from 16 through 32700, you can only configure the static label range from 32701 through 32767.

The number of lookup labels or local labels that are supported in Cisco RSP3 module as of Cisco IOS XE Bengaluru Release 17.5.1 is 32k. To increase the scale value, CEM pseudowires both dynamic service labels and statics service labels must be increased. MPLS label range must be increased more than 39k to maintain a consistent configuration across the pDCS (dynamic service labels) and pADM (static service labels).

To support 13k CEM PW protection, 13440 is required for dynamic + 13440 for static + 10k global block + 2k SRLB/SRMS = 38880 total labels needed.

To support this requirement, the mpls label range is extended from 32k to 40k starting with Cisco IOS XE Cupertino Release 17.7.1.

Note Whenever the **mpls label range** command is used to modify the dynamic and static labels range, we recommend that you reload the router.

There is no increase in the overall knowledge base processor (KBP) scale that is allocated for the IPv4 Prefix and MPLS ingress labels due to this scale increase. The overall scale remains to be 163k. If 40k MPLS ingress labels are in use, then only 123k IPv4 prefixes can be used.

Note The scale increase is supported only for ingress labels with KBP. No change in scale of EoMPLS and VPLS pseudowires. Also, this change is not specific to any template, but it is applicable on all the templates.

- Configuring Static MPLS Labels on Cisco RSP3 Module, on page 131
- Verification of Static Label Pseudowire Provisioning for CEM Configuration, on page 134

Configuring Static MPLS Labels on Cisco RSP3 Module

This section shows the configuration of static MPLS labels on Cisco RSP3 module for CEM. In the figure below, the serial interfaces are configured on Customer Edge (CE) routers (CE1 and CE2). The Xconnect is configured on the Provider Edge (PE) routers (PE1 and PE2). Unlike the process where the LDP protocol assigns the MPLS labels, you can manually configure the static labels on PE1 and PE2 routers. The CEM groups are configured on PE1 and PE2 routers. The traffic originating from the CE1 router is sent to the PE2 router, where the packets are converted and are finally sent to the CE2 router.

The following configuration examples are for SONET VT-15 CEP mode.

Core Configuration:

This section shows the core configuration including the loopback, MPLS label range, OSPF, and SR configurations. You need to perform these configurations only once at the beginning.

- **For PE1**:

```
interface Loopback0
no ip address
ip address 10.1.1.1 255.0.0.0
end
l2 router-id 10.1.1.1
end
mpls label range 28032 32767 static 16 15998
mpls ldp label
allocate global prefix-list DENYALL
multilink bundle-name authenticated
end
segment-routing mpls
global-block 16000 28031
local-block 15999 15999
connected-prefix-sid-map
address-family ipv4
10.1.1.1/32 absolute 16001 range 1
exit-address-family
end
no router ospf 100
end
router ospf 100
```

```
router-id 10.1.1.1
segment-routing area 0 mpls
fast-reroute per-prefix enable prefix-priority high
fast-reroute per-prefix ti-lfa
fast-reroute keep-all-paths
network 10.1.1.1 255.0.0.0 area 0
network 192.168.1.0 255.255.0.0 area 0
end
interface Port-channel1
ip address 192.168.1.1 255.255.0.0
ip ospf network point-to-point
ip ospf mtu-ignore
end
interface Te0/11/0
no ip address
cdp enable
channel-group 1 mode active
end
network-clock input-source 1 interface Te0/11/0
network-clock synchronization automatic
network-clock synchronization mode qL-enabled
network-clock wait-to-restore 0 global
esmc process
end
```

- **For PE2**:

```
interface Loopback0
no ip address
ip address 10.2.2.2 255.0.0.0
end
l2 router-id 10.2.2.2
end
mpls label range 28032 32767 static 16 15998
mpls ldp label
allocate global prefix-list DENYALL
multilink bundle-name authenticated
end
segment-routing mpls
global-block 16000 28031
local-block 15999 15999
connected-prefix-sid-map
address-family ipv4
10.2.2.2/32 absolute 16002 range 1
exit-address-family
end
no router ospf 100
end
router ospf 100
router-id 10.2.2.2
segment-routing area 0 mpls
fast-reroute per-prefix enable prefix-priority high
fast-reroute per-prefix ti-lfa
fast-reroute keep-all-paths
network 10.2.2.2 255.0.0.0 area 0
network 192.168.1.0 255.255.0.0 area 0
end
interface Port-channel1
ip address 192.168.1.2 255.255.0.0
ip ospf network point-to-point
ip ospf mtu-ignore
end
interface Te0/4/0
no ip address
cdp enable
```

```
channel-group 1 mode active
end
network-clock synchronization automatic
network-clock synchronization mode qL-enabled
esmc process
end
```

Controller Configuration:

This section shows the controller configuration of the routers.

- **For CE 1**:

```
controller sonet 2/1/0
framing sonet
end
controller sonet 2/1/0
no shut
end
controller sonet 2/1/0
sts-1 1
mode vt-15
vtg 1 t1 1 channel-group 0 timeslots 1-24
end
interface Serial2/1/0.1/1/1:0
ip address 172.16.0.1 255.240.0.0
end
```

- **For PE1**:

```
controller mediatype 0/7/4
mode sonet
controller sonet 0/7/4
rate OC12
end
controller sonet 0/7/4
sts-1 1
mode vt-15
vtg 1 vt 1 cem-group 0 cep
end
```

- **For PE2**:

```
controller mediatype 0/3/2
mode sonet
controller sonet 0/3/2
rate OC12
end
controller sonet 0/3/2
sts-1 1
mode vt-15
vtg 1 vt 1 cem-group 0 cep
end
```

- **For CE 2**:

```
controller sonet 3/0/0
framing sonet
end
controller sonet 3/0/0
no shut
end
controller sonet 3/0/0
sts-1 1
mode vt-15
```

```
vtg 1 t1 1 channel-group 0 timeslots 1-24
end
interface Serial3/0/0.1/1/1:0
ip address 172.16.0.2 255.240.0.0
end
```

Xconnect Configuration:

This section shows the Xconnect configuration of PE1 and PE2 routers.

- **For PE1**:

```
interface cem 0/7/4
cem 0
xconnect 10.2.2.2 1 encapsulation mpls manual
mpls label 16 16
end
interface cem 0/7/4
cem 1
xconnect 10.2.2.2 2 encapsulation mpls manual
mpls label 17 17
end
```

- **For PE2**:

```
interface cem 0/3/2
cem 0
xconnect 10.1.1.1 1 encapsulation mpls manual
mpls label 16 16
end
interface cem 0/3/2
cem 1
xconnect 10.1.1.1 2 encapsulation mpls manual
mpls label 17 17
end
```

Verification of Static Label Pseudowire Provisioning for CEM Configuration

With Xconnect Configuration:

- Use the **show run | i mpls label** command to verify the MPLS label configuration:

```
Router# show  run  | i mpls label
mpls label range 16 32700 static 32701 32767

interface CEM0/4/2
no ip address
cem 0
  xconnect 10.3.3.3 1 encapsulation mpls manual
   mpls label 32702 32702
```

- Use the **show mpls l2 vc** *vc-id* **detail** command to display detailed information related to the virtual connection (VC) with the signaling protocol manual configuration:

```
Router# show mpls l2 vc 1 detail

Local interface: CE0/4/2 up, line protocol up, SATOP T1 0 up
  Destination address:10.3.3.3, VC ID:1 , VC status: up
    Output interface: Po1, imposed label stack {16005 32702}
```

```
    Preferred path: not configured
    Default path: active
    Next hop: 10.10.1.6
  Create time: 00:00:54, last status change time: 00:00:54
    Last label FSM state change time: 00:00:54
  Signaling protocol: Manual
    Status TLV support (local/remote)   : enabled/N/A
      LDP route watch                   : enabled
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: No fault
      Last local AC  circuit status sent: No fault
      Last local PW i/f circ status rcvd: No fault
      Last local LDP TLV     status sent: No status
      Last remote LDP TLV    status rcvd: Not sent
      Last remote LDP ADJ    status rcvd: No fault
    MPLS VC labels: local 32702, remote 32702 -
    Group ID: local 498, remote 498
    MTU: local 0, remote 0
  Sequencing: receive disabled, send disabled
  Control Word: On (configured: autosense)
  SSO Descriptor: 209.165.201.5/40004010, local label: 32702
  Dataplane:
    SSM segment/switch IDs: 12313/16408 (used), PWID: 2
  VC statistics:
    transit packet totals: receive 0, send 0
    transit byte totals:   receive 0, send 0
    transit packet drops:  receive 0, seq error 0, send 0
```

With L2VPN Xconnect Configuration:

- Use the **show run | sec pseudowire99** and **show run | sec l2vpn** commands to verify the MPLS label configuration with L2VPN Xconnect :

```
Router#show run | sec pseudowire99
interface pseudowire99
 encapsulation mpls
 signaling protocol none
 neighbor 10.1.1.1 1
 label 27001 27001

Router#show run | sec l2vpn
l2vpn xconnect context cem_static
 member CEM0/3/0 0
 member pseudowire99
```

- Use the **show mpls l2 vc** *vc-id* **detail** command to display detailed information related to the virtual connection (VC) with the signaling protocol manual configuration:

```
Router# show mpls l2 vc 1 detail

Local interface: CE0/3/0 up, line protocol up, SATOP T1 0 up
  Destination address: 10.1.1.1, VC ID: 1, VC status: down
    Last error: MPLS dataplane reported a fault to the nexthop
    Output interface: none, imposed label stack {}
    Preferred path: not configured
    Default path: no route
    No adjacency
  Create time: 00:04:40, last status change time: 00:04:40
    Last label FSM state change time: 00:04:40
  Signaling protocol: Manual
    Status TLV support (local/remote)   : enabled/N/A
```

```
    LDP route watch                   : enabled
    Label/status state machine        : activating, LruRruD
    Last local dataplane   status rcvd: DOWN(pw-tx-fault)
    Last BFD dataplane     status rcvd: Not sent
    Last BFD peer monitor  status rcvd: No fault
    Last local AC  circuit status rcvd: No fault
    Last local AC  circuit status sent: DOWN(pw-rx-fault)
    Last local PW i/f circ status rcvd: No fault
    Last local LDP TLV     status sent: No status
    Last remote LDP TLV    status rcvd: Not sent
    Last remote LDP ADJ    status rcvd: No fault
  MPLS VC labels: local 27001, remote 27001
  Group ID: local 94, remote 94
  MTU: local 0, remote 0
Sequencing: receive disabled, send disabled
Control Word: On (configured: autosense)
SSO Descriptor: 10.1.1.1/1, local label: 27001
Dataplane:
  SSM segment/switch IDs: 0/20492 (used), PWID: 5
VC statistics:
  transit packet totals: receive 0, send 0
  transit byte totals:   receive 0, send 0
  transit packet drops:  receive 0, seq error 0, send 0
```

CHAPTER 10

Channel Associated Signaling

Table 24: Feature History

Feature Name	Release Information	Description
CAS feature to perform Super Frame to Extended Super Frame conversion	Cisco IOS XE Cupertino 17.8.1	Channel Associated Signaling (CAS) is a method of signaling each traffic channel rather than having a dedicated signaling channel. CAS uses the same channel, which carries voice or data to pass control signals. This provides an advantage as the implementation of CAS is inexpensive. Supports CAS feature with "in-band" signaling type. You can configure CAS on a specific interface or under global CEM class.

CAS is a method of signaling each traffic channel rather than having a dedicated signaling channel (like ISDN). The most common forms of CAS signaling are loop start, ground start, Equal Access North American (EANA), and receive and transmit (E&M). In addition to receiving and placing calls, CAS signaling also processes the receipt of Dialed Number Identification Service (DNIS) and Automatic Number Identification (ANI) information, which is used to support authentication and other functions. In CAS, the least significant bit of information in a T1 signal is "robbed" in the channels that carry voice and is used to transmit framing and clocking information. This is called "in-band" signaling.

Each T1 channel carries a sequence of frames. These frames consist of 192 bits and an extra bit designated as the framing bit, for a total of 193 bits per frame. Super Frame (SF) groups twelve of these 193-bit frames and designates the framing bits of the even-numbered frames as signaling bits. Trunk can carry line events as multifrequency signaling. Digital trunks use 4-bit signaling (ABCD). The TDM frames allows 4 states (A and B), and 16 states (A, B, C, D) signaling bit options. Signaling information is sent as robbed bits in frames 6, 12, 18, and 24 when using ESF T1 framing. A D4 Super Frame only transmits 4-state signaling with A and B bits. On the E1 frame, all signaling is carried in time slot 16, and two channels of 16-state (ABCD) signaling are sent per frame.

CAS looks specifically at every sixth frame for the time slot's or channel's associated signaling information. These bits are commonly referred to as A- and B-bits. Extended Super Frame (ESF), due to grouping the frames in sets of twenty-four, has four signaling bits per channel or time slot. These occur in frames 6, 12, 18, and 24 and are called the A-, B-, C-, and D-bits respectively.

Note If the Tx Framer PDH receives CAS pattern as 0x0000, then the pattern is replaced with 0x1111 before inserting it into the 16^{th} time slot of E1 to avoid multiframe align word in the E1 frame.

- CAS Signaling Types, on page 138
- CAS Interworking, on page 139
- CAS Idle Code, on page 141
- Restrictions for CAS, on page 141
- How to Configure CAS, on page 141

CAS Signaling Types

CAS supports the following signaling types:

- Loop Start Signaling
- Ground Start Signaling
- E and M Signaling

Loop Start Signaling

Loopstart signaling is one of the simplest forms of CAS signaling. When a handset is picked up, this action closes the circuit that draws current from the telephone company Central Office (CO) and indicates a change in status, which signals the CO to provide dial tone. An incoming call is signaled from the CO to the handset by sending a signal in a standard on/off pattern, which causes the telephone to ring.

Ground Start Signaling

Groundstart signaling is similar to loopstart signaling in many regards. It works by using ground and current detectors that allow the network to indicate off-hook or seizure of an incoming call independent of the ringing signal and allow for positive recognition of connects and disconnects. For this reason, ground start signaling is typically used on trunk lines between PBXs and in businesses where call volume on loop start lines can result in glare.

The advantage of groundstart signaling over loopstart signaling is that it provides far-end disconnect supervision. Another advantage of groundstart signaling is the ability for incoming calls (network —> CPE) to seize the outgoing channel, thereby preventing a glare situation from occurring.

E and M Signaling

E&M Signaling is typically used for trunk lines. The signaling paths are known as the E-lead and the M-lead. Descriptions such as Ear and Mouth were adopted to help field personnel determine the direction of a signal in a wire. E&M connections from routers to telephone switches or to PBXs are preferable to FXS/FXO connections because E&M provides better answer and disconnect supervision.

E&M signaling has many advantages over the previous CAS signaling methods that are discussed in this document. It provides both disconnect and answers supervision and glare avoidance. E&M signaling is simple to understand and is the preferred choice when you use CAS.

CAS Interworking

In CAS interworking scenario, the SF framing is configured on one side and ESF framing is configured on the other side of the PSN. The two SF frames are sent in a single CESoP packet to align the TDM data for CAS and to match with the ESF mode.

The minimum payload size of T1 for SF or ESF should be multiples of 24. The amount of TDM data per CESoPSN packet must be constant.

The following table shows the payload sizes that are supported for T1 frames based on the time slots:

Table 25: Payload Size for T1 Frame

Time Slot	T1 Frame	Payload Size
1	4,8,12,24	5, 9, 13, 25
2	4,8,12,24	9, 17, 25, 49
3	4,8,12,24	14, 26, 38, 74
4	4,8,12,24	18, 34, 50, 98
5	4,8,12,24	23, 43, 63, 123
6	4,8,12,24	27, 51, 75, 147
7	4,8,12,24	32, 60, 88, 172
8	4,8,12,24	36, 68, 100, 196
9	4,8,12,24	41, 77, 113, 221
10	4,8,12,24	45, 85, 125, 245
11	4,8,12,24	50, 94, 138, 270
12	4,8,12,24	54, 102, 150, 294
13	4,8,12,24	59, 111, 163, 319
14	4,8,12,24	63, 119, 175, 343
15	4,8,12,24	68, 128, 188, 368
16	4,8,12,24	72, 136, 200, 392
17	4,8,12,24	77, 145, 213, 417
18	4,8,12,24	81, 153, 225, 441
19	4,8,12,24	86, 162, 238, 466
20	4,8,12,24	90, 170, 250, 490

Time Slot	T1 Frame	Payload Size
21	4,8,12,24	95, 179, 263, 515
22	4,8,12,24	99, 187, 275, 539
23	4,8,12,24	104, 196, 288, 564
24	4,8,12,24	108, 204, 300, 588

The following table shows the payload sizes that are supported for E1 frames based on the time slots:

Table 26: Payload Size for E1 Frame

Time Slot	E1 Frame	Payload Size
1	4,8,16	5, 9, 17
2	4,8,16	9, 17, 33
3	4,8,16	14, 26, 50
4	4,8,16	18, 34, 66
5	4,8,16	23, 43, 83
6	4,8,16	27, 51, 99
7	4,8,16	32, 60, 116
8	4,8,16	36, 68, 132
9	4,8,16	41, 77, 149
10	4,8,16	45, 85, 165
11	4,8,16	50, 94, 182
12	4,8,16	54, 102, 198
13	4,8,16	59, 111, 215
14	4,8,16	63, 119, 231
15	4,8,16	68, 128, 248
17	4,8,16	77, 145, 281
18	4,8,16	81, 153, 297
19	4,8,16	86, 162, 314
20	4,8,16	90, 170, 330
21	4,8,16	95, 179, 347

Time Slot	E1 Frame	Payload Size
22	4,8,16	99, 187, 363
23	4,8,16	104, 196, 380
24	4,8,16	108, 204, 396
25	4,8,16	113, 213, 413
26	4,8,16	117, 221, 429
27	4,8,16	122, 230, 446
28	4,8,16	126, 238, 462
29	4,8,16	131, 247, 479
30	4,8,16	135, 255, 495
31	4,8,16	140, 264, 512

CAS Idle Code

CEM FPGA supports two CAS idle codes, where the first code is sent for 2.5 seconds and the second code is sent for the remaining duration of fault. The default idle CAS code is 0x8, and you can configure the first and second codes from 0x0 to 0xF.

Restrictions for CAS

- CAS is not supported on the 1-Port OC-192 or 8-Port Low Rate CEM interface module.
- CAS is not supported in the 16th time slot of E1 CEM.

How to Configure CAS

Modifying Interface Module to CAS Mode

By default, the CEM interface modules are in the non-CAS mode. Before modifying the mode, ensure that you delete the iMSG-related configurations manually and use the **hw-module** *<slot/bay>* *<im-type>* **mode** *<im-mode>* command to change the CAS mode. The FPGA image is modified into the CAS mode.

To revert to the non-CAS mode, you have to remove the CAS configurations and execute the **no hw-module** *<slot/bay>* *<im-type>* **mode** *<im-mode>* command.

To modify the interface module into the CAS mode, enter the following commands:

```
Router(config)#platform hw-module configuration
```

```
Router(conf-plat-hw-conf)#hw-module <slot/bay> <im-type> mode <im-mode>
```

In the 48-Port T1 or E1 CEM interface module, the CAS and non-CAS modes are available in the same FPGA. So there is no requirement to change the IM into the CAS mode. You can add the CAS signaling configuration directly under CEM.

The interface module **<im-mode>** options that are supported are as follows:

- 48-Port T3 or E3 CEM interface module—Use the **fpga-cas** option.
- 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 CEM interface module—Use the **10g-fpga-cas** option.
- Combo 8-port SFP GE and 1-port 10 GE 20G interface module—Use the **20g-fpga-cas** option.

Note Once you change the interface module from the CAS to non-CAS mode or viceversa, the interface module restarts.

Example

To modify the 48-port T3/E3 interface module into the CAS mode, enter the following commands:

```
Router(config)#platform hw-module configuration
Router(conf-plat-hw-conf)#hw-module 0/11 A900-IMA48T-C mode fpga-cas
Router(conf-plat-hw-conf)#end
```

To modify the Combo 8-Port SFP GE and 1-Port 10GE with CEM/iMSG interface module into the CAS mode, enter the following commands:

```
Router(config)#platform hw-module configuration
Router(conf-plat-hw-conf)#hw-module 0/11 A900-IMA1Z8S-CXMS mode 20g-fpga-cas
Router(conf-plat-hw-conf)#end
```

Example

To modify the 48-port T3/E3 interface module into the CAS mode, enter the following commands:

```
Router(config)#platform hw-module configuration
Router(conf-plat-hw-conf)#hw-module 0/11 NCS4200-48T3E3-CE mode fpga-cas
Router(conf-plat-hw-conf)#end
```

To modify the Combo 8-Port SFP GE and 1-Port 10GE with CEM/iMSG interface module into the CAS mode, enter the following commands:

```
Router(config)#platform hw-module configuration
Router(conf-plat-hw-conf)#hw-module 0/11 NCS4200-1T8S-20CS mode 20g-fpga-cas
Router(conf-plat-hw-conf)#end
```

Verifying CAS Mode Configuration

Use the following **show platform hw-configuration** command to verify the CAS mode configuration:

```
Router#show platform hw-configuration
Slot   Cfg IM Type         Actual IM Type      Op State           Ad State IM Op Mode
------ ------------------- ------------------- ------------------ -------- ------------
```

```
…
0/2   -                    A900-IMA1Z8S-CXMS   N/A               N/A       20G_CAS
```

Enabling CAS

You can enable CAS on CESoP circuit in two ways:

1. On specific CEM interface
2. Under CEM class global configuration for the whole interface module

Ensure that you change the CEM interface module to the CAS mode for CESoP pseudowire configuration before proceeding to CAS configuration. By default, all the IMs are in the non-CAS mode.

Enabling CAS on CEM Interface

You can enable CAS on CEM interface using the **signaling** command on all the interface modules with the signaling type as inband CAS. The outband-cas signaling option is not supported on the CEM interface configuration.

```
Router(config)#interface CEM 0/x/y
Router(config-if-cem)#cem <cem-id>
Router(config-if-cem)#signaling inband-cas
```

Before enabling or disabling CAS on the CEM interace, you can retain the local connect or cross-connect configurations on that interface.

Enabling CAS over CEM Class Global Configuration

You can enable CAS under global CEM class using the **signaling** command.

Under the CEM interface, the configured CEM class can be mapped. One class CEM can be mapped to multiple CEM interfaces. When you enable CAS under the global class CEM, then this configuration applies to all the mapped CEM interfaces.

Create Class CEM and Enable CAS Under Global CEM Class

```
Router(config)#class cem cisco
Router(config-cem-class)#signaling inband-cas
Router(config-cem-class)#end
```

Map CEM Class to Interface

```
Router#configure terminal
Router(config)#interface cem0/3/2
Router(config-if)#cem 3
Router(config-if-cem)#cem class cisco
Router(config-if-cem)#end
```

Configuring Idle CAS Code

You can configure CAS Idle code patterns using the **idle-cas** command on a specific CEM interface or under the global CEM class.

Configuring Idle CAS Code on CEM Interface

```
Router(config)#interface CEM 0/x/y
Router(config-if-cem)#cem cem-id
Router(config-if-cem)#idle-cas 0x5 0x6
Router(config-if-cem)#end
```

Configuring Idle CAS Code Under Global CEM Class

```
Router(config)#class cem cas-code
Router(config-cem-class)#idle-cas 0xa 0xb
```

The default CAS idle code is 0x8, and you can configure one or two idle codes using the **idle-cas** CLI.

Verifying CAS Configuration

Use the **show cem circuit** command to verify the CAS configuration:

```
Router#show cem circuit int cem0/4/20
CEM0/4/20, ID: 3, Line: UP, Admin: UP, Ckt: ACTIVE
Mode: E1, CEM Mode: E1-CESoP
Controller state: down, T1/E1 state: up
Idle Pattern: 0x77, Idle CAS: 0x8 0x8
Dejitter: 8 (In use: 0)
Payload Size: 85
Framing: Framed (DS0 channels: 1-10)
CEM Defects Set
None

Signalling: In-Band CAS
RTP: No RTP

Ingress Pkts:    527521938            Dropped:             0
Egress Pkts:     527521938            Dropped:             0

CEM Counter Details
Input Errors:    0                     Output Errors:       0
Pkts Missing:    0                    Pkts Reordered:      0
Misorder Drops:  0                  JitterBuf Underrun:  0
Error Sec:       0                       Severly Errored Sec: 0
Unavailable Sec: 0                   Failure Counts:      0
Pkts Malformed:  0
```