

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.

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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 1: 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 2: 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 NCS 4200 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 3: 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 4: 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 5: 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 6: 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
- NCS 4200 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 NCS4200-3GMS
  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 NCS4200-3GMS
  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
```

DDS DS0 Remote Latching Loopback

Table 7: Feature History

Feature Name	Release Information	Description
DDS DS0 Remote Latching Loopback	Cisco IOS XE 17.15.1	DS0 loopback is used for testing and troubleshooting the T1 or E1, T3 or E3, and OCx channel over PSN. You can configure DS0 loopback on these controllers for remote devices.

For releases before Cisco IOS XE 17.14.1, the DS0 loopback is configured on the same node. From this release onwards, the DDS DS0 remote loopback supports transmission of the loopback request and monitoring confirmation of the loopback received from the remote device.

For example, when you send a packet from CE1 and perform loopback testing on PE1, the confirmation can arrive to CE1 that the loopback is performed on PE1.

Thus, this feature helps you to perform loopback testing of remote devices at the near and the far end of the network.

The supported loopback types are: DS0 data port on drop and line sides, OSU, channel, and CSU.

You can use the **loopback remote ds0 {dsu | ocu | csu | drop | line} timeslot <value>** command. To remove the peer from loopback, use the **[no]** form of the command.

You can configure DDS DS0 remote latching loopback on 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
- NCS 4200 Combo 8-Port SFP GE and 1-Port 10 GE 20G interface module

Restrictions for DDS DS0 Remote Latching Loopback

- The DS0 remote loopback isn’t supported without CEM group configuration.
- The DS0 remote loopback isn’t supported with a channel group.
- The CEM group removal isn’t allowed when the DS0 remote loopback is present.
- BERT isn’t supported on the same T1 channel when DS0 remote loopback is present and viceversa.
- DS1 loopback isn’t supported on the same T1 channel when DS0 remote loopback is present or viceversa.
- SSO isn’t supported.

Configuring DDS DS0 Remote Loopback on T1 Controller

To configure DDS DS0 remote loopback on the T1 controller with framing as ESF and dsu with time slot of 10 for router 1, enter the following commands:

Router 1

```
 controller T1 0/3/0
 framing esf
 linecode b8zs
 cablelength short 110
 loopback remote ds0 dsu timeslot 10 =====>
 no snmp trap link-status
  cem-group 0 timeslots 10
 end
```

Router 2

```
controller T1 0/4/35
 threshold sd-ber 6
 threshold sf-ber 3
 framing esf
 linecode b8zs
 cablelength short 110
 loopback network line   =========>
 no snmp trap link-status
end
```

Verifying DDS DS0 Remote Loopback on T1 Controller

To verify the configuration, use the **show controller t1 0/3/0** command:

```
Router#show controller t1 0/3/0
T1 0/3/0 is up (Far End DS0 DSU Loopback) ===>
  Currently in DS0 DSU Remotely Looped    ===>
  Applique type is NCS4200-3GMS
  Cablelength is short 110
  Receiver has loss of signal.
  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 (210 seconds elapsed):
   Near End  (Invalid)
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 210 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs, 210 Unavail Secs
     1 Path Failures, 0 SEF/AIS Secs
   Far End  (Invalid)
     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
```

Configuring DDS DS0 Remote Loopback on T3 Controller

To configure DDS DS0 remote loopback on T3 controller and loopback remote on t1 line with drop timeslot of 20, enter the following commands:

```
controller T3 0/3/12
```

```
 no snmp trap link-status
 framing c-bit
 cablelength short
 loopback local
 t1 1 cem-group 0 timeslots 20
t1 1 loopback remote ds0 drop timeslot 20   =====>
end
```

Verifying DDS DS0 Remote Loopback on T3 Controller

To verify the DDS DS0 remote loopback on T3 controller and loopback remote on t1 line with drop timeslot of 20, use the **show controller t3 0/3/12** command:

```
Router#show controller t3 0/3/12
T3 0/3/12 is up. (Configured for Locally Looped)
  Currently in Locally Looped
  Hardware is NCS4200-3GMS

  Applique type is Channelized T3/T1
  Receiver has no alarms.
  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
  Data in current interval (590 seconds elapsed):  (NE, FE Invalid)
   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
     488 Unavailable Secs, 488 Line Errored Secs
     0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
     488 Severely Errored Line Secs, 1 Path Failures
     0 AIS Defect Secs, 488 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 0/3/12.1 T1 is up
  timeslots: 20
  FDL per AT&T 54016 spec.
  Configured for DS0 Remote timeslot loop drop side       =========>
  Currently in DS0 Remote timeslot loop, drop side Looped =========>
  Receiver has no alarms.
  Framing is ESF, Clock Source is Internal
  Data in current interval (600 seconds elapsed):
   Near End  (Invalid)
     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
     21 Unavail Secs, 0 Stuffed Secs
     1 Path Failures, 0 SEF/AIS Secs
   Far End  (Invalid)
```

Configuring DDS DS0 Remote Loopback on SONET Controller

To configure DDS DS0 remote loopback on the SONET controller in the VT-15 mode, enter the following commands:

```
controller SONET 0/3/16
 no snmp trap link-status
 rate OC3
 no ais-shut
 alarm-report all
 clock source internal
 !
 sts-1 1
  clock source internal
  mode vt-15
  vtg 1 t1 1 loopback remote ds0 csu timeslot 1=====>
  vtg 1 t1 1 cem-group 0 timeslots 1
 !
 sts-1 2
  clock source internal

 !
 sts-1 3
  clock source internal
```

To configure DDS DS0 remote loopback on SONET controller in the CT-3 mode, enter the following commands:

```
controller SONET 0/3/16
 no snmp trap link-status
 rate OC3
 no ais-shut
 alarm-report all
 clock source internal
 loopback local
 !
 sts-1 1
  clock source internal
  mode vt-15
 vtg 1 t1 1 loopback remote ds0 csu timeslot 1
  vtg 1 t1 1 cem-group 0 timeslots 1
 !
 sts-1 2
  clock source internal
  mode ct3
  t3 framing c-bit
  t3 clock source internal
  t1 1 loopback remote ds0 ocu timeslot 1        ============>
  t1 1 cem-group 1 timeslots 1
 !
 sts-1 3
  clock source internal
```

Verifying DDS DS0 Remote Loopback on SONET Controller

To verify the configuration with mode VT-15, use the **show controller sonet 0/3/16 | sec T1 1** command:

```
router#show controller sonet 0/3/16 | sec T1 1
 STS-1 1, VTG 1, T1 1 (SONET 0/3/16.1/1/1 T1) is down
  timeslots: 1
  FDL per AT&T 54016 spec.
  Configured for DS0 Remote timeslot loop csu =======>
  Currently in DS0 Remote timeslot loop, csu side Looped =====>
  Receiver has no alarms.
  Framing is ESF, Clock Source is Internal
```

```
  Data in current interval (650 seconds elapsed):
   Near End  (Invalid)
     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
     33 Unavail Secs, 0 Stuffed Secs
   Far End  (Invalid)
     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
 STS-1 1, VTG 2, T1 1 (SONET 0/3/16.1/2/1 T1)
    Not configured.
 STS-1 1, VTG 3, T1 1 (SONET 0/3/16.1/3/1 T1)
    Not configured.
 STS-1 1, VTG 4, T1 1 (SONET 0/3/16.1/4/1 T1)
```

To verify the configuration with mode CT-3, use the **show controller sonet 0/3/16 | sec STS-1 2** command:

```
Router#show controller sonet 0/3/16 | sec STS-1 2
 STS-1 2, T1 1 (SONET 0/3/16.2/1 T1) is up
  timeslots: 1
  FDL per AT&T 54016 spec.
  Configured for DS0 Remote timeslot loop ocu           =======>
  Currently in DS0 Remote timeslot loop, ocu side Looped  =====>
  Receiver has no alarms.
  Framing is ESF, Clock Source is Internal
  Data in current interval (650 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 1 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     1 Errored Secs, 0 Bursty Err Secs, 1 Severely Err Secs
     0 Unavail Secs, 0 Stuffed Secs
   Far End  (Invalid)
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     2 Errored Secs, 0 Bursty Err Secs, 2 Severely Err Secs
     0 Unavail Secs
  Data in Interval 1:
   Near End  (Invalid)
     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
```

Configuring DDS DS0 Remote Loopback on SDH Controller

To configure DDS DS0 remote loopback on SDH controller in VC1x mode and loopback remote on t1 line with drop timeslot of 7, enter the following commands:

```
controller SDH 0/15/16
 no snmp trap link-status
 rate STM1
 no ais-shut
 alarm-report all
 clock source internal
 loopback local
 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
    t1 1 cem-group 0 timeslots 7
 t1 1 loopback remote ds0 csu timeslot 7
   tug-2 2 payload vc11
   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
   !
  tug-3 2
   !
  tug-3 3
   !
end
```

Verifying DDS DS0 Remote Loopback on SDH Controller

To verify the DDS DS0 remote loopback on SDH controller in VC1x mode and loopback remote on t1 line with drop timeslot of 7, enter the following commands:

```
Router#show controllers sdh 0/15/16 | sec AU-4 1
 AU-4 1, TUG-3 1, TUG-2 1, VC11 1 (SDH 0/15/16.1/1/1/1 VC11) is up
 AU-4 1, TUG-3 1, TUG-2 1, T1 1 (SDH 0/15/16.1/1/1/1 T1) is up
  timeslots: 7
  FDL per AT&T 54016 spec.
  Configured for DS0 Remote timeslot loop csu
  Currently in DS0 Remote timeslot loop, csu side Looped
  Receiver has no alarms.
  Framing is ESF, Clock Source is Internal
  Data in current interval (50 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
     0 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
  Data in Interval 1:
   Near End  (Invalid)
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
```

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:

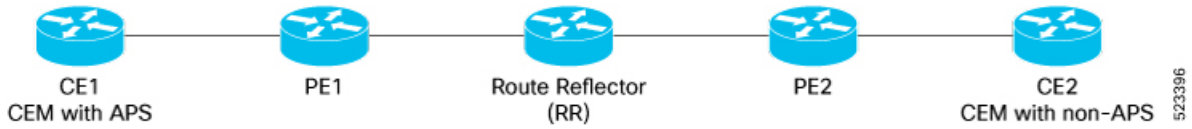
- 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4-port T3/E3 CEM interface module
- NCS 4200 Combo 8-Port SFP GE and 1-Port 10 GE 20G interface module

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.

Signal Failure and Signal Degarade Bit Error Rate Alarms

Feature Name	Release Information	Description
SD-BER and SF -BER Alarms for T1/E1 and T3/E3 services	Cisco IOS XE 17.15.1	Signal Failure-Bit Error Rate (SF-BER) and Signal Degrade-BER (SD-BER) alarms are declared when there is a signal failure or signal degradation that happens in the traffic. These alarms may be raised when the error rate of a given entity exceeds the user configured BER threshold value. This helps administrator to take corrective actions.

Services such as T1/E1 and T3/E3 links allow different bit error rates (BER). BER is determined by comparing the erroneous bits received with the total number of bits received.

Though the SD-BER and SF-BER alarms are detected in the earlier releases, the reporting of these alarms are available now only so that administrator can track and perform preemptive action.

The following topics detail on the SF-BER and SD-BER alarms:

- Signal Failure Bit Error Rate Alarms, on page 34
- Signal Degrade Bit Error Rates Alarms, on page 34

Signal Failure Bit Error Rate Alarms

A Signal Failure (SF) alarm is declared if the line bit error and Bipolar Violation (BPV) rate exceeds a user provisioned threshold (over the range of 10e-3 to 10e-9). If the BPV errors cross the SF threshold, then the link is considered unreliable and the interface changes the state to down.

The Bipolar Violation (BPV) indicates that the number of times the received signal violates the bipolar (alternating positive and negative pulses) rule; so the number of times that signals of the same polarity are consecutively received.

The SF alarm is cleared when the BPV error count remains below the configured threshold for a period of time called the Hold on Time.

Signal Degrade Bit Error Rates Alarms

A Signal Degrade (SD) alarm is declared if the line bit error Bipolar Violation (BPV) rate exceeds a user provisioned threshold (over the range of 10e-3 to 10e-9). If the BPV errors cross the SD threshold then a warning of link quality degradation will occur.

The BPV indicates that the number of times the received signal violates the bipolar (alternating positive and negative pulses) rule; so the number of times that signals of the same polarity are consecutively received.

The SD alarm is cleared when the BPV error count remains below the configured threshold for a period of time called the Hold on Time.

Restrictions for SF-BER and SD-BER Alarms

- SF-BER and SD-BER alarms are not asserted for error conditions such as CRC, FAS (framing error), C-bit, and P-bit.

Supported Interface Modules for SD-SF-BER Alarms

SF-BER, SD-BER alarm is supported on the following interface modules:

- 48-Port T1 or E1 CEM interface module
- 48-Port T3 or E3 CEM interface module

Configuring SD-BER and SF-BER Threshold on T1

Use this procedure to configure SD-BER and SF-BER threshold on the T1 controller.

Procedure

Step 1 In the T1 controller configuration mode, specify the signal fault (sf) bit error rate (ber) threshold. Range is 3 to 5. Range value is expressed exponentially as 10e-n. The default sf-ber value is 3 (10e-3).

`threshold sf-ber` *`range`*

Example

```
router(config)#controller T1 0/1/5
Router(config-controller)#threshold sf-ber 3
```

Step 2 In the T1 controller configuration mode, specify the signal degrade (sd) bit error rate (ber) threshold. Range is 5 to 8. Range value is expressed exponentially as 10e-n. The default sd-ber value is 6 (10e-6).

`threshold sf-ber` *`range`*

Example

```
router(config)#controller T1 0/1/5
Router(config-controller)#threshold sd-ber 6
```

Step 3 Save the configuration changes.

Example

```
Router(config-controller)#end
```

```
Router(config-controller)#commit
```

- When you issue the **end** command, the system prompts you to commit changes
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 4 Verify the SD-BER and SF-BER threshold configuration. The PMON counters are increment based on the line or the path errors injected.

```
Router#show controller T1 0/1/5
T1 0/1/5 is down
  Applique type is NCS4200-48T1E1-CE
  Cablelength is short 110
  Receiver has sd-ber
  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 (0 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, 0 Unavail 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
```

The SD-BER and SF-BER threshold configuration on the T1 controller is complete.

Example

The following example shows that the controller interface T1 0/1/5 is configured with a SF-BER threshold of 3 and SD-BER threshold of 6. You cam verify the BER threshold configuration using the the **show controller T1 0/1/5** command, where the BER threshold for SF is 10e-3 and SD = 10e-6.

```
Router#configure
Router(config)#controller T1 0/1/5
Router(config-controller)#threshold sf-ber 3
Router(config-controller)#threshold sd-ber 6
Router(config-controller)#end
Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]: yes
```

```
Router#show controller T1 0/1/5
T1 0/1/5 is down
  Applique type is NCS4200-48T1E1-CE
  Cablelength is short 110
  Receiver has sd-ber
  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 (0 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, 0 Unavail 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
```

Configuring SD-BER and SF-BER Threshold on T3

Use this procedure to configure SD-BER and SF-BER threshold on the T3 controller.

Procedure

Step 1 In the T3 controller configuration mode, specify the signal fault (sf) bit error rate (ber) threshold. Range is 3 to 5. Range value is expressed exponentially as 10e-n. The default sf-ber value is 3 (10e-3).

threshold sf-ber *range*

Example

```
router(config)#controller T3 0/1/5
Router(config-controller)#threshold sf-ber 3
```

Step 2 In the T3 controller configuration mode, specify the signal degrade (sd) bit error rate (ber) threshold. Range is 5 to 8. Range value is expressed exponentially as 10e-n. The default sd-ber value is 6 (10e-6).

threshold sd-ber *range*

Example

```
router(config)#controller T3 0/1/5
Router(config-controller)#threshold sd-ber 3
```

Step 3 Save the configuration changes.

Example

```
Router(config-controller)#end
```

```
Router(config-controller)#commit
```

- When you issue the **end** command, the system prompts you to commit changes
- Use the **commit** command to save the configuration changes to the running configuration file and remain within the configuration session.

Step 4 Verify the SD-BER and SF-BER threshold configuration. The PMON counters are increment based on the line or the path errors injected.

Example

```
Router#show controller T3 0/1/5
T1 0/5/15 is down
  Applique type is NCS4200-48T3E3-CE
    Applique type is Subrate T3
  Receiver has sf-ber
  Framing is Unframed, 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 (890 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
   0 Unavailable Secs, 0 Line Errored Secs
   0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
   0 Severely Errored Line Secs, 0 Path Failures
   0 AIS Defect Secs, 0 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
```

The SD-BER and SF-BER threshold configuration on the T3 controller is complete.

Example

The following example shows that the controller interface T3 0/5/15 is configured with a SF-BER threshold of 3 and SD-BER threshold of 6. You cam verify the BER threshold configuration using the the **show controller T3 0/5/15** command, where the BER threshold for SF is 10e-3 and SD = 10e-6.

```
Router#configure
Router(config)#controller T3 0/5/15
Router(config-controller)#threshold sf-ber 3
Router(config-controller)#threshold sd-ber 6
Router(config-controller)#end
Uncommitted changes found, commit them before exiting(yes/no/cancel)? [cancel]: yes
```

```
Router#show controller T3 0/5/15
T3 0/5/15 is down
  Applique type is NCS4200-48T3E3-CE
    Applique type is Subrate T3
  Receiver has sf-ber
  Framing is Unframed, 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 (890 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
     0 Unavailable Secs, 0 Line Errored Secs
     0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
     0 Severely Errored Line Secs, 0 Path Failures
     0 AIS Defect Secs, 0 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
```