Cisco Remote PHY System Configuration Guide for Cisco 1x2 / Compact Shelf RPD Software 9.x

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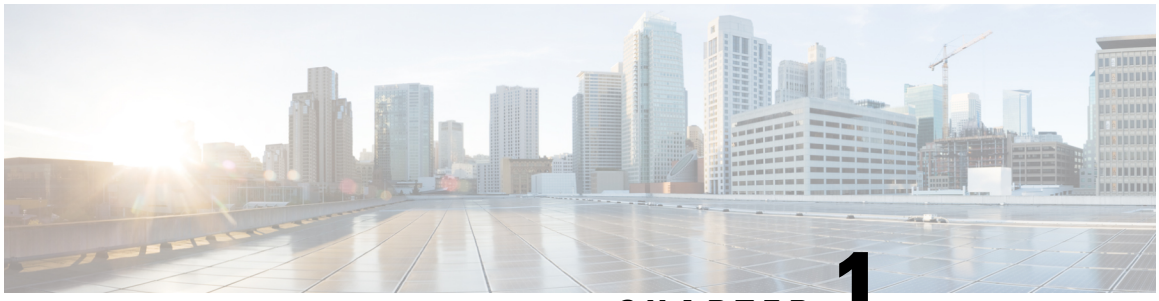


CHAPTER 1

Cisco Remote PHY Controller Profile and RPD Configuration

The Remote PHY (R-PHY) Controller Profile includes upstream controller-profile and downstream controller-profile. Upstream controller-profile is used to specify the upstream (US) channels and related parameters, which are part of a specific profile, similar to the following:

- Channel width
- DOCSIS mode
- Frequency
- Minislot size
- Modulation-profile

The downstream controller-profile is used to specify the RF channels and their RF parameters that belong to a specific profile, including the following details:

- Channel type (DOCSIS, Video Sync, Video Async)
- Frequency
- RF output
- QAM-profile (annex, modulation, inter-leaver, symbol rate, and so on)

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Use Cisco Feature Navigator to find information about the platform support and Cisco software image support. To access Cisco Feature Navigator, go to the link http://tools.cisco.com/ITDIT/CFN/. An account at the http://www.cisco.com/ site is not required.

Hardware Compatibility Matrix for Cisco Remote PHY Device

Note Unless otherwise specified, the hardware components introduced in a given Cisco Remote PHY Device Software Release are supported in all subsequent releases.

Table 1: Hardware Compatibility Matrix for the Cisco Remote PHY Device

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Node	Cisco 1x2 / Compact Shelf RPD Software 2.1 and Later Releases
Cisco GS7000 Super High Output Intelligent Node (iNode)	Cisco 1x2 / Compact Shelf RPD Software 4.1 and Later Releases Cisco Intelligent Remote PHY Device 1x2 • PID—iRPD-1X2= • PID—iRPD-1X2-PKEY=

Note The -PKEY suffix in the PID indicates units that enable the SCTE-55-2 Out-of-Band protocol support.

Controller Profile and RPD

The Controller Profile functions in a similar way to the controller integrated-cable Slot/Bay/Port (for downstream controller) or upstream-cable Slot/Bay/Port (for upstream controller) in I-CMTS. However if a Controller Profile is not associated to an RPD, physical resources cannot be allocated.

You can either unicast or multicast this profile. Multicast profile is used for DS sharing. You can multicast the same traffic to all RPDs in the multicast group, or to applications such as switched digital video (SDV) or BC video.

An R-PHY configuration consists of one principal core interface and one auxiliary core interface. The principal core specifies the DPIC interface to which the RPD connects. Auxiliary core interfaces specify the external DPIC interfaces that can be used for downstream sharing. Auxiliary core is used in this release only for video multicast and video OOB.

Configuring Controller Profile and cable RPD are the prerequisites for configuring R-PHY video.

The following table lists the DSCP value for different kinds of items.

Item	Per-Hop-Behavior (PHB)	DSCP Value
DOCSIS data (L2TP)	Best Effort	0
PTP	EF	46
GCP	CS2	0
MAP/UCD (L2TP, DOCSIS control)	EF	46
BWR and RNG-REG	EF	46
Video	CS4	32
MDD (L2TP, DOCSIS control), voice	CS5	40

Note In Cisco 1x2 / Compact Shelf RPD Software 9.3 and earlier releases, Per-Hop-Behavior for GCP is Best Effort.

RPD Configurations

Compared to the iCMTS configuration, R-PHY configuration supports the following features:

- Up to 512 RPDs per cBR-8 chassis and 64 RPDs per CBR-CCAP-LC-G2-R line card
- 128 separate service groups per cBR-8 chassis
- 32 downstream-video controllers per CBR-CCAP-LC-G2-R line card
- 32 downstream-cable controllers per CBR-CCAP-LC-G2-R line card
- 80 downstream OFDM channels and up to 1536 downstream SC-QAM channels per CBR-CCAP-LC-G2-R line card
- Up to 158 downstream SC-QAM channels (0-157) per downstream controller
- 64 upstream controllers and 128 upstream channels per CBR-CCAP-LC-G2-R line card

Note

- Cisco IOS XE Fuji 16.9.1 and later releases support 10 Gbps of upstream throughput on the CBR-CCAP-LC-G2-R line cards.
- In Cisco IOS XE Amsterdam 17.3.1 and earlier releases, each CBR-CCAP-LC-G2-R line card supports 32 downstream OFDM channels and up to 1024 downstream SC-QAM channels.

In the R-PHY configuration, the following mapping relationships are supported between the controller and the port on RPD:

- Downstream 1:N (N>= 2) mapping: one downstream controller is shared by several RPDs and one downstream controller is mapped to one downstream port of all these RPDs, that is “downstream virtual split”, all these downstream ports share the same signals from the same downstream controller.
- Downstream N:1 mapping: several downstream controllers are mapped into the same downstream port of one RPD. Notice: the downstream channels in these downstream controllers should use different rf-channel numbers.
- Downstream N:N mapping: mixed 1:N and N:1 mapping. For example: several downstream controllers are mapped into one downstream port of one RPD. But at the same time they are “virtual split” downstream controllers and are shared by several RPDs.
- Upstream 1:N(N<=8) mapping: one upstream controller can be shared by N (N<=8) upstream ports of multiple RPDs. Currently max two upstream ports are supported on one RPD, and for each upstream port, one upstream controller can be configured.

  For the two upstream ports of one RPD, the same upstream controller number can be configured.

Note Downstream 1:1 mapping is not supported under 512 RPD configuration, but still supported under smaller scale configuration.

Prerequisites for Configuring Controller Profile and RPD

The following restrictions are applicable to configuring controller profiles:

- All channels within the profiles of an RPD must be unique. Frequencies must not overlap each other.
- The principal core must contain at least one DOCSIS downstream profile
- Auxiliary core should contain only video and out-of-band profiles
- A DS controller can be associated to only one profile

Restrictions for Configuring Controller Profile and RPD

The following restrictions are applicable to configuring upstream controller profiles:

- Legacy controller configuration commands are not supported
- Legacy controller configuration cannot be shown in running-configuration

Configure Controller Profile and RPD

Configure Upstream Controller Profile

To configure the upstream controller-profile, use the cable upstream controller-profile command, as given in the following example:

```
Router#cable upstream controller-profile 4
  cable def-phy-burst 0
  us-channel 0 chan-class-id 0
  us-channel 0 channel-width 1600000 1600000
  us-channel 0 docsis-mode atdma
  us-channel 0 equalization-coefficient
  us-channel 0 frequency 50000000
  us-channel 0 hop-priority frequency modulation channel-width
  us-channel 0 ingress-noise-cancellation 100
  us-channel 0 maintain-psd
  us-channel 0 max-logical-chans 1
  us-channel 0 minislot-size 4
  us-channel 0 modulation-profile 221
  us-channel 0 power-level 0
  us-channel 0 rng-holdoff 0
  us-channel 0 shutdown
  us-channel 0 specsvl error-adaptive-profile 1
  us-channel 0 threshold cnr-profiles 25 13
  us-channel 0 threshold corr-fec 3
  us-channel 0 threshold hysteresis 3
  us-channel 0 threshold snr-profiles 25 13
  us-channel 0 threshold uncorr-fec 1
  ...
  end
```

Verify Upstream Controller Profile Configuration

To verify the Upstream controller profile configuration, use the **show cable downstream controller-profile** command or **show running-config | section upstream controller-profile** <*ID*> command, as shown in the following example:

```
Router#show cable upstream controller-profile 0
Load for five secs: 2%/0%; one minute: 3%; five minutes: 3%
Time source is NTP, 15:14:27.916 CST Fri Feb 24 2017

Upstream controller-profile 0
Description:
Upstream controller-profile 0 is being used by controller Upstream-Cable:
8/0/1,  8/0/0
  Controller Upstream-Cable
    ...
  Upstream-channel 0
    chan-class-id                  : 0x0
    channel-width                  : 1600000 1600000
    docsis-mode                    : atdma
    ...
```

Example for the **show running-config | section upstream controller-profile <ID>** command

```
Router#show running-config | s cable upstream controller-profile 0
cable upstream controller-profile 0
 us-channel 0 channel-width 1600000 1600000
 us-channel 0 docsis-mode atdma
 us-channel 0 equalization-coefficient
 us-channel 0 frequency 6000000
 us-channel 0 minislot-size 4
 us-channel 0 modulation-profile 221
 no us-channel 0 shutdown
 us-channel 1 channel-width 1600000 1600000
 us-channel 1 docsis-mode atdma
 us-channel 1 equalization-coefficient
 us-channel 1 frequency 7600000
 us-channel 1 minislot-size 4
```

```
 us-channel 1 modulation-profile 221
 no us-channel 1 shutdown
 us-channel 2 channel-width 1600000 1600000
 us-channel 2 docsis-mode atdma
 us-channel 2 equalization-coefficient
 us-channel 2 frequency 9200000
 us-channel 2 minislot-size 4
 us-channel 2 modulation-profile 221
 no us-channel 2 shutdown
 us-channel 3 channel-width 1600000 1600000
 us-channel 3 docsis-mode atdma
 us-channel 3 equalization-coefficient
 us-channel 3 frequency 10800000
 us-channel 3 minislot-size 4
 us-channel 3 modulation-profile 221
 no us-channel 3 shutdown
 us-channel 4 channel-width 1600000 1600000
 us-channel 4 docsis-mode atdma
 us-channel 4 frequency 12400000
 us-channel 4 minislot-size 4
 us-channel 4 modulation-profile 221
 no us-channel 4 shutdown
 us-channel 5 channel-width 1600000 1600000
 us-channel 5 docsis-mode atdma
 us-channel 5 frequency 14000000
 us-channel 5 minislot-size 4
 us-channel 5 modulation-profile 221
```

Configure RPD for US Controller Profile

To configure RPD for associating an upstream controller-profile, using the **rpd-ds** <*port-id*> **Upstream-Cable** <*slot/sub-slot/controller*> *[profile <id>]* command, as given in the following example:

```
Router#cable rpd 1
 identifier 0004.9f00.0743
 core-interface Te8/1/0
  principal
  rpd-us 0 upstream-cable 8/0/0 profile 0
  rpd-us 1 upstream-cable 8/0/1 profile 4
 r-dti 11
 rpd-event profile 0
 rpd-55d1-us-event profile 0
---
end
```

The Remote PHY (R-PHY) Controller Profile now provides a new summary that displays the Per RPD us port description. The summary helps distinguish between the different controllers that share the same description of us-channels.

For example, the **show cable modem rpd all summary** command displays the following information:

```
Router#show cable modem rpd all summary

Load for five secs: 5%/0%; one minute: 5%; five minutes: 5%
No time source, *15:36:49.777 UTC Thu Mar 8 2018

RPD ID: badb.ad13.417c
Interface                    Cable Modem                                  Description
          Total Reg Oper  Unreg Offline Wideband initRC initD initIO initO
C9/0/4/U0  1     0   0     1     0       0        1      0     0      0  badb.ad13.417c us
 0
C9/0/4/U1  2     0   0     2     0       0        2      0     0      0  badb.ad13.417c us
 0
```

```
C9/0/4/U3  1     0   0     1     0       0        1      0     0      0  badb.ad13.417c us
 0
C9/0/5/U0  2     0   0     2     0       0        2      0     0      0  badb.ad13.417c us
 1
C9/0/5/U1  1     0   0     1     0       0        1      0     0      0  badb.ad13.417c us
 1

RPD ID: badb.ad13.41fa
Interface                      Cable Modem                                    Description
          Total Reg   Oper  Unreg Offline Wideband initRC initD initIO initO
C9/0/2/U0  2     0     0     2     0       1        1      0     0      1  badb.ad13.41fa
us 0
C9/0/2/U1  1     0     0     1     0       0        1      0     0      0  badb.ad13.41fa
us 0
C9/0/2/U3  1     0     0     1     0       0        1      0     0      0  badb.ad13.41fa
us 0
C9/0/3/U1  1     0     0     1     0       0        1      0     0      0  badb.ad13.41fa
us 1
C9/0/3/U2  2     0     0     2     0       0        2      0     0      0  badb.ad13.41fa
us 1
C9/0/3/U3  1     0     0     1     0       0        1      0     0      0  badb.ad13.41fa
us 1
```

Note The length of configurable limitation is 20 characters while there are 80 characters reserved.

Configure Downstream Controller Profile

To configure downstream controller profile, use the following commands:

```
configure terminal
cable downstream controller-profile <profile ID>
multicast-pool <id>
rf-chan 20 47
type video <SYNC | ASYNC>
frequency 231000000
rf-output NORMAL
qam-profile <profile ID>
```

The *multicast-pool <id>* defines the DEPI multicast group. The type video <*SYNC | ASYNC*> defines synchronous or asynchronous mode.

Verify Downstream Controller Profile Configuration

To verify the Downstream controller profile configuration, use the show cable downstream controller-profile command as shown in the following example:

```
Router#show running-config | section downstream controller-profile
cable downstream controller-profile 0
 rf-chan 0 3
  type DOCSIS
  frequency 111000000
  rf-output NORMAL
  qam-profile 1
  docsis-channel-id 1
```

Configure RPD for DS Controller Profile

To configure RPD for associating a downstream controller-profile, use the following commands:

```
configure terminal
cable rpd RPD01
identifier 0004.9f31.0435
core-interface Te3/1/0
principal
rpd-ds 0 downstream-cable 3/0/0 profile 1
rpd-ds 0 downstream-cable 3/0/1 profile 2
rpd-us 0 upstream-cable 3/0/0 profile 1
core-interface te6/1/0
rpd-ds 0 downstream-cable 6/0/0 profile 2
r-dti 1
rpd-event profile 0
rpd-55d1-us-event profile 0
```

The **rpd-ds** *0* **downstream-cable** *3/0/0 profile 1* associates *controller 3/0/0* with *profile 1*, which is a DOCSIS profile.

The **rpd-ds** *0* **downstream-cable** *3/0/1 profile 2* associates *controller 3/0/1* with *profile 3*, which is a video profile.

The *core-interface te6/1/0* defines an auxiliary interface for this RPD. This auxiliary interface is used to configure downstream sharing across line cards.

Verify RPD Association with Controller Profile

To verify the downstream controller profile association with RPD, use the **show running-config | section cable rpd <ID>** command as shown in the following example:

```
Router#show running-config | section cable rpd RPD01
cable rpd toi-test1
 identifier 0000.1cbf.0000
 core-interface Te2/1/0
  principal
  rpd-ds 0 downstream-cable 2/0/9 profile 0
 rpd-event profile 0
 rpd-55d1-us-event profile 0
```

Configure Downstream Video Controller Profile

To configure a downstream video controller profile, use the following commands:

```
cable downstream controller-profile <profile ID> Video
max-carrier <RF Port Max Carrier Value>
rf-chan <Starting QAM ID> <Ending QAM ID>
  type VIDEO <SYNC | ASYNC>
  qam-profile <profile id>
  frequency 453000000
  rf-output NORMAL
```

Configure RPD for Downstream Video Controller Profile

To configure RPD for associating a downstream video controller-profile, use the following commands:

```
cable rpd RPD01
identifier 0053.ad17.5c80
```

```
core-interface Te1/1/0
  principal
  rpd-ds 0 downstream-cable 1/0/0 profile 7
  rpd-ds 0 downstream-video 1/0/0 profile 100
  rpd-us 0 upstream-cable 1/0/1 profile 3
r-dti 7
rpd-event profile 0
rpd-55d1-us-event profile 0
```

The **rpd-ds** *0* **downstream-cable** *1/0/0 profile 7* associates *controller 1/0/0* with *profile 7*, which is a DOCSIS profile.

The **rpd-ds** *0* **downstream-video** *1/0/0 profile 100* associates *controller 1/0/0* with *profile 100*, which is a video profile.

Note

- The **rpd-ds downstream-video** command is available from Cisco IOS XE Gibraltar 16.12.1 release and Cisco IOS XE Amsterdam 17.3.1x release. Using this command, you can create up to 32 separate video service groups on the Kobol-R line card.
- We recommend using **rpd-ds downstream-video** command for video channels and **rpd-ds downstream-cable** command for DOCSIS channels.
- We do not recommend using **downstream-cable** controllers for video and DOCSIS channels simultaneously. Use **downstream-video** controllers for video channels.

Configure Analog Tx/Rx Modules Alarm Threshold

To adjust the alarm threshold of the analog Tx/Rx module in RPD node, use **analog** commands as shown in the following example:

```
configure terminal
cable rpd RPD01
identifier 0004.9f31.0435
core-interface Te3/1/0
principal
rpd-ds 0 downstream-cable 3/0/0 profile 1
rpd-ds 0 downstream-cable 3/0/1 profile 2
rpd-us 0 upstream-cable 3/0/0 profile 1
r-dti 1
rpd-event profile 0
rpd-55d1-us-event profile 0
analog rx-power major-lo-th 0 minor-lo-th 50 normal-th 150 minor-hi-th 200
analog tx-power major-lo-th 0 minor-lo-th 50 normal-th 100 minor-hi-th 150
```

Verify Analog Tx/Rx Modules Alarm Threshold Configuration

To verify the analog Tx/Rx module alarm threshold configuration, use **show environment** commands in RPD as shown in the following example:

```
R-PHY#show environment table 49
sensor_id: 49
name: TX1_OPT_PWR_MON
.....
Configuration Values:
state            low             high
```

```
-----------------------------------
MAJOR-LOW          N/A              0.00
MINOR-LOW          0.00             0.59
NORMAL             0.60             1.09
MINOR-HIGH         1.10             1.59
MAJOR-HIGH         1.60             N/A
```

Configure Downstream Sharing

This configuration is optional. DS sharing is used for multicast (MC) traffic. To configure downstream sharing, use the following commands:

```
configure terminal
cable rpd RPD01
core-interface Te3/1/0
principal
rpd-ds 0 downstream-cable 3/0/1 profile 2
cable rpd RPD02
core-interface te3/1/0
principal
rpd-ds 0 downstream-cable 3/0/1 profile 2
```

Note All RDPs in the same multicast group should have the same controller and profile association.

Configure Controller in Fiber Node

To configure the controllers in fiber-node, use the **cable fiber-node** command, as given in the following example:

```
cable fiber-node 113
 downstream Downstream-Cable 8/0/0
 upstream Upstream-Cable 8/0/1
```

Verify CM RPD Association

To verify the RPD associated with the cable modem, use the **show cable modem rpd** command as shown in the following example:

```
Router# show cable modem rpd 0004.9f03.0249
Load for five secs: 4%/2%; one minute: 3%; five minutes: 4%
Time source is NTP, 10:48:11.763 CST Tue Feb 28 2017

                                                                                D
MAC Address    IP Address      I/F           MAC               Prim  RxPwr  Timing Num I
                                             State             Sid   (dBmv) Offset CPE P
0023.be5a.bb6c 10.10.10.12     C6/0/0/UB     w-online          5     0.00   862    0   N
1859.3356.8876 10.10.10.13     C6/0/0/UB     w-online          6     0.50   907    0   N
```

Display GCP Ralated Information

To display Generic Control Plane (GCP) related information of the RPD, use the command as shown in the following example:

```
Router#show cable rpd 0004.9f03.0280 Te3/1/0 gcp-state

MAC Address     IP Address       I/F       State        Role HA  Name
0004.9f03.0280  10.10.10.11      Te3/1/0   ready        Pri  Act 2

A06#show cable rpd 0004.9f03.0280 Te3/1/0 gcp-state
MAC Address     IP Address       I/F       State        Role HA  Name
0004.9f03.0280  10.10.10.11      Te3/1/0   ready        Pri  Act 2

Router#show cable rpd name node te1/1/0 gcp-session

GCP Session ID : 10
Core Address   : 10.100.10.11:8190
RPD Address    : 10.10.10.11:60656
Next Hop MAC   : 0004.9F00.0901
Session State  : Active

Packet Statistics:
========================
Rx          : 5038
Tx          : 5034
Rx Dropped : 0
Tx Dropped : 0

Message Statistics:
========================
Rx          : 5948
Tx          : 5954
Rx Dropped : 7
Tx Dropped : 0
Rx Illegal : 0
Tx Illegal : 0

Router#show cable rpd 120.102.6.7 te9/1/1 gcp-transaction
 Load for five secs: 3%/1%; one minute: 4%; five minutes: 4%
No time source, *10:22:57.158 CST Thu Mar 16 2017

RPD ID           I/F        TRANS ID   GCP MSG TYPE             RCP MSG TYPE   TIMESTAMP
---------------- ---------- ---------- ------------------------ --------------
-------------------------
0004.9f31.1007   Te9/1/1    7452       GCP_MSG_ID_EDS_RSP       TYPE_REX       2017-03-16
10:22:54.440
0004.9f31.1007   Te9/1/1    7452       GCP_MSG_ID_EDS           TYPE_REX       2017-03-16
10:22:54.415
0004.9f31.1007   Te9/1/1    7451       GCP_MSG_ID_EDS_RSP       TYPE_REX       2017-03-16
10:22:54.240
0004.9f31.1007   Te9/1/1    7451       GCP_MSG_ID_EDS           TYPE_REX       2017-03-16
10:22:54.215
0004.9f31.1007   Te9/1/1    7450       GCP_MSG_ID_EDS_RSP       TYPE_REX       2017-03-16
10:22:54.040
0004.9f31.1007   Te9/1/1    7450       GCP_MSG_ID_EDS           TYPE_REX       2017-03-16
10:22:54.015
0004.9f31.1007   Te9/1/1    7449       GCP_MSG_ID_EDS_RSP       TYPE_REX       2017-03-16
10:22:53.836
0004.9f31.1007   Te9/1/1    7449       GCP_MSG_ID_EDS           TYPE_REX       2017-03-16
10:22:53.815
0004.9f31.1007   Te9/1/1    7448       GCP_MSG_ID_EDS_RSP       TYPE_REX       2017-03-16
10:22:50.236
0004.9f31.1007   Te9/1/1    7448       GCP_MSG_ID_EDS           TYPE_REX       2017-03-16
10:22:50.215
0004.9f31.1007   Te9/1/1    7447       GCP_MSG_ID_EDS_RSP       TYPE_REX       2017-03-16
10:22:50.038
0004.9f31.1007   Te9/1/1    7447       GCP_MSG_ID_EDS           TYPE_REX       2017-03-16
10:22:50.015
```

```
0004.9f31.1007   Te9/1/1    7446       GCP_MSG_ID_EDS_RSP       TYPE_REX       2017-03-16
10:22:49.839
0004.9f31.1007   Te9/1/1    7446       GCP_MSG_ID_EDS           TYPE_REX       2017-03-16
10:22:49.815
```

Display DEPI Related Information

To display the Downstream External PHY Interface (DEPI) related information, use the command as shown in the following example:

```
Router#show cable rpd depi

DEPI Tunnel and Session Information Total tunnels 1 sessions 26
LocTunID   RemTunID   Remote Device  State  Remote Address  Sessn L2TP Class
                                                           Count
338514820  671581873  0004.9f00.0901 est    10.10.10.11     26    rphy-l2tp-gl...

LocID      RemID      Pseudowire      State  Last Chg Uniq ID    Type Mode RemSt
0x41040008 0x00000B02 US1/0/0:2(R)    est    00:34:57 21          P    PSP  UP
0x41010000 0x00000600 US1/0/0:0(D)    est    00:34:57 11          P    PSP  UP
0x00002006 0x00000405 DS1/0/0:5       est    00:34:57 6           P    PSP  UP
0x00002004 0x00000403 DS1/0/0:3       est    00:34:57 4           P    PSP  UP
0x4100000C 0x00000D03 US1/0/0:3(M)    est    00:34:57 23          P    PSP  UP
0x00002002 0x00000401 DS1/0/0:1       est    00:34:57 2           P    PSP  UP
0x00002007 0x00000406 DS1/0/0:6       est    00:34:57 7           P    PSP  UP
0x00002008 0x00000407 DS1/0/0:7       est    00:34:57 8           P    PSP  UP
0x4101000C 0x00000603 US1/0/0:3(D)    est    00:34:57 24          P    PSP  UP
0x41000004 0x00000D01 US1/0/0:1(M)    est    00:34:57 15          P    PSP  UP
0x00002001 0x00000400 DS1/0/0:0       est    00:34:57 1           P    PSP  UP
0x41080008 0x00000F02 US1/0/0:2(S)    est    00:34:57 22          P    PSP  UP
0x41010004 0x00000601 US1/0/0:1(D)    est    00:34:57 16          P    PSP  UP
0x41020000 0x00000800 US1/0/0:0(B)    est    00:34:57 12          P    PSP  UP
0x00002009 0x00000408 DS1/0/0:8       est    00:34:57 9           P    PSP  UP
0x41010008 0x00000602 US1/0/0:2(D)    est    00:34:57 20          P    PSP  UP
0x41000008 0x00000D02 US1/0/0:2(M)    est    00:34:57 19          P    PSP  UP
0x4108000C 0x00000F03 US1/0/0:3(S)    est    00:34:57 26          P    PSP  UP
0x00002003 0x00000402 DS1/0/0:2       est    00:34:57 3           P    PSP  UP
0x41080000 0x00000F00 US1/0/0:0(S)    est    00:34:57 14          P    PSP  UP
0x41040004 0x00000B01 US1/0/0:1(R)    est    00:34:57 17          P    PSP  UP
0x41080004 0x00000F01 US1/0/0:1(S)    est    00:34:57 18          P    PSP  UP
0x41000000 0x00000D00 US1/0/0:0(M)    est    00:34:56 10          P    PSP  UP
0x00002005 0x00000404 DS1/0/0:4       est    00:34:56 5           P    PSP  UP
0x4104000C 0x00000B03 US1/0/0:3(R)    est    00:34:56 25          P    PSP  UP
0x41040000 0x00000B00 US1/0/0:0(R)    est    00:34:56 13          P    PSP  UP

outer#show cable rpd 0004.9f03.0214 te7/1/0 depi tunnel

Load for five secs: 7%/2%; one minute: 6%; five minutes: 6%
No time source, *12:41:44.228 CST Mon Mar 20 2017

LocTunID   RemTunID   Remote Device  State  Remote Address  Sessn L2TP Class
                                                           Count
3388764998 1054297851 0004.9f03.0214 est    10.10.10.11     29    rphy-l2tp-gl...
```

Table 2: show cable rpd depi Field Descriptions

Field	Description
LocID	Local session ID.

Field	Description
RemID	Remote session ID.
US1/0/0:2(R)	US means UEPI session, DS means DEPI session. This string means UEPI session on line card slot 1, controller 0, rf-channel 2.
est in State	Established state.
P in Type	On primary line card.

Troubleshooting Tips

Refer to the following troubleshooting tips if configuration errors occur.

If you configure DS controller profile and cable RPD, you can check the controller status, regardless of the status of the RPD. If the channel's state is DOWN, use verbose option to view the reason.

```
Router#show controllers downstream-Cable 6/0/1 rf-channel 20 <verbose>
Chan State Admin Frequency Type       Annex Mod  srate Interleaver dcid output
20    UP    UP   231000000 VIDEO-SYNC B     256   5361  I128-J1     -   NORMAL
```

Configuration Examples

This section provides example configurations for the R-PHY Controller Profile.

Example: Controller Profile Configuration

Upstream Controller Profile Configuration

```
configure terminal
cable upstream controller-profile 2
  cable def-phy-burst 0
  us-channel 0 chan-class-id 0
  us-channel 0 channel-width 1600000 1600000
  us-channel 0 docsis-mode atdma
  us-channel 0 equalization-coefficient
  us-channel 0 frequency 50000000
  us-channel 0 hop-priority frequency modulation channel-width
  us-channel 0 ingress-noise-cancellation 100
  us-channel 0 maintain-psd
  us-channel 0 max-logical-chans 1
  us-channel 0 minislot-size 4
  us-channel 0 modulation-profile 221
  us-channel 0 power-level 0
  us-channel 0 rng-holdoff 0
  us-channel 0 shutdown
  us-channel 0 specsvl error-adaptive-profile 1
  us-channel 0 threshold cnr-profiles 25 13
  us-channel 0 threshold corr-fec 3
  us-channel 0 threshold hysteresis 3
  us-channel 0 threshold snr-profiles 25 13
  us-channel 0 threshold uncorr-fec 1
```

```
...
end
```

Downstream Controller Profile Configuration

```
configure terminal
cable downstream controller-profile 1
multicast-pool 20
Rf-channel 0 15
Type docsis
Frequency 111000000
Rf-output NORMAL
Qam-profile 1
Docsis-channel-id 1
cable downstream controller-profile 2
multicast-pool 20
Rf-channel 20 47
Type video sync
Frequency 231000000
Rf-output NORMAL
Qam-profile 14
```

Example: Downstream Sharing Configuration

```
cable rpd RPD01
identifier 0004.9f31.0979
core-interface te6/1/0
principal
rpd-ds 0 downstream-cable 6/0/0 profile 1
rpd-ds 0 downstream-cable 6/0/1 profile 2
rpd-us 0 upstream-cable 6/0/0 profile 1
r-dti 6
rpd-event profile 0
rpd-55d1-us-event profile 0
cable rpd RPD2
identifier 0004.9f31.1437
core-interface Te3/1/0
principal
rpd-ds 0 downstream-cable 3/0/0 profile 1
rpd-us 0 upstream-cable 3/0/0 profile 1
core-interface Te6/1/0
rpd-ds 0 downstream-cable 6/0/1 profile 2
r-dti 3
rpd-event profile 0
rpd-55d1-us-event profile 0
```

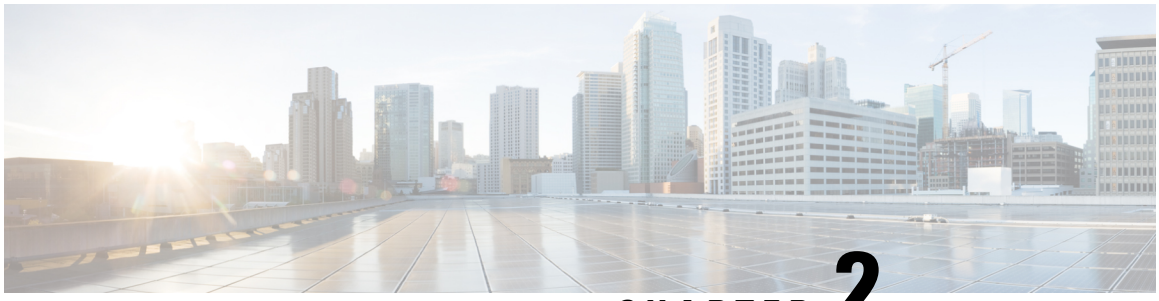
Feature Information for Remote PHY Controller Profile and RPD Configuration

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 3: Feature Information for Remote PHY Controller Profile and RPD Configuration

Feature Name	Releases	Feature Information
Large Scale Controller Support (32DS/64US) with node	Cisco 1x2 / Compact Shelf RPD Software 3.1	This feature was integrated into the Cisco Remote PHY Device.
256 RPD Support per Chassis	Cisco 1x2 / Compact Shelf RPD Software 3.1	This feature was integrated into the Cisco Remote PHY Device.
Controller profile configuration	Cisco 1x2 / Compact Shelf RPD Software 3.1	This feature was integrated into the Cisco Remote PHY Device.
US 128 channels	Cisco 1x2 / Compact Shelf RPD Software 3.1	This feature was integrated into the Cisco Remote PHY Device.



CHAPTER 2

Cisco Remote PHY Device Downstream Virtual Splitting

This document provides information on how to configure downstream virtual splitting on Remote PHY systems.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Use Cisco Feature Navigator to find information about the platform support and Cisco software image support. To access Cisco Feature Navigator, go to the link http://tools.cisco.com/ITDIT/CFN/. An account at the http://www.cisco.com/ site is not required.

Hardware Compatibility Matrix for Cisco Remote PHY Device

Note Unless otherwise specified, the hardware components introduced in a given Cisco Remote PHY Device Software Release are supported in all subsequent releases.

Table 4: Hardware Compatibility Matrix for the Cisco Remote PHY Device

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Node	Cisco 1x2 / Compact Shelf RPD Software 2.1 and Later Releases

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Intelligent Node (iNode)	Cisco 1x2 / Compact Shelf RPD Software 4.1 and Later Releases Cisco Intelligent Remote PHY Device 1x2 • PID—iRPD-1X2= • PID—iRPD-1X2-PKEY=

Note The -PKEY suffix in the PID indicates units that enable the SCTE-55-2 Out-of-Band protocol support.

Information about RPD Downstream Virtual Splitting

The primary use case for multicast delivery between CCAP-core and the RPD is for the delivery of broadcast video services from a single CCAP-core element to a number of RPDs. This allows the system to scale by allowing a single CCAP-core element to generate and serve streams to all the RPDs that are configured to receive the same broadcast lineup. Since broadcast serving groups are quite large (~100,000 or more subscribers), using multicast to deliver the same copy to hundreds of remote PHY devices provides significant cost savings for operators. This mechanism can be used for broadcast video delivered via MPEG QAM channels or for that delivered via IP over DOCSIS. It is meant for the replication of an entire QAM channel to multiple RPDs.

Configure RPD Downstream Virtual Splitting

This section describes how to configure RPD Downstream Virtual Splitting on Cisco cBR-8.

Configure Multicast DEPI Pool

To configure the multicast DEPI pool, complete the following procedure:

```
configure terminal
cable depi multicast pool id
{ip|ipv6} address ip mask
```

To verify the multicast DEPI pool configuration, use the **show cable depi multicast pool** command as shown in the example below:

```
Router# show cable depi multicast pool
Load for five secs: 4%/0%; one minute: 5%; five minutes: 5%
No time source, *09:23:41.545 CST Mon Apr 23 2018
POOL ID    Net IP           Net Mask         Redundant DESCRIPTION
1          227.0.0.0        255.255.255.0    FALSE
2          228.0.0.0        255.255.254.0    FALSE
127        227.226.225.0    255.255.255.0    FALSE     to TE9/1/1+TE9/1/7

POOL ID    IPv6                                          Redundant DESCRIPTION
```

```
6           FF3A::9000:0/126                                    FALSE
```

Configure Redundant Multicast DEPI Pool

When a secondary line card is configured, multicast IP addresses are assigned to its downstream controllers from the redundant multicast DEPI pool.

To configure the redundant multicast DEPI pool, complete the following procedure:

```
configure terminal
cable depi multicast pool id
redundant
```

To verify the multicast DEPI pool configuration, use the **show cable depi multicast pool** command as shown in this example:

```
Router# show cable depi multicast pool
Load for five secs: 4%/0%; one minute: 4%; five minutes: 4%
No time source, *14:14:13.780 CST Tue Aug 7 2018
POOL ID    Net IP           Net Mask         Redundant DESCRIPTION
1          227.0.0.0        255.255.0.0      FALSE
127        227.226.225.0    255.255.255.0    FALSE     to TE9/1/1+TE9/1/7

POOL ID    IPv6                                          Redundant DESCRIPTION
2          FF39::8000:0/120                              FALSE
4          FF39::9000:0/112                              TRUE
```

To view the IPv6 addresses assigned to the secondary linecard downstream controllers, use the **show cable depi multicast ipv6 all** command as shown in this example:

```
Router# show cable depi multicast ipv6 all
Load for five secs: 5%/0%; one minute: 5%; five minutes: 4%
No time source, *14:15:08.476 CST Tue Aug 7 2018
IPv6                                          POOL ID    CONTROLLER
FF39::9000:0                                  4          0/0/0(1-Te0/1/0)
FF39::9000:8                                  4          0/0/1(2-Te0/1/0)
FF39::9000:10                                 4          0/0/2(3-Te0/1/0)
FF39::9000:18                                 4          0/0/3(4-Te0/1/0)
FF39::9000:20                                 4          0/0/4(5-Te0/1/0
```

Note

- To view the IPv4 addresses, use the **show cable depi multicast ip all** command.
- One redundant DEPI pool is available for either IPv4 or IPv6 addresses.
- If you do not configure redundant pool, secondary linecard downstream controllers use the same IP as the downstream controllers in the primary linecard.
- You cannot use the redundant multicast pool in the downstream controller profile configuration.
- DEPI multicast pool can be configured as redundant pool if DEPI multicast pool contains less than 266 IP addresses, and if line card high avaiability is configured on the Cisco cBR-8.

Enable Multicast Sharing under Downstream Controller Profile

To enable the multicast sharing under downstream controller profile, complete the following procedure:

```
configure terminal
cable downstream controller-profile id
multicast-pool id
```

Then configure the other parameters of the controller profile and related RF channels.

Starting from Cisco 1x2 / Compact Shelf RPD Software 3.1, user can change the multicast pool for the downstream sharing controllers without configuring the RPD. See the following example for detailed configuration:

```
Router#config terminal
Router(config)#cable downstream controller-profile 111
Warning: changes to this profile will affect the following controllers:
Downstream controller-profile 111 is being used by controller Downstream-Cable:
         6/0/0,  6/0/1,

Confirm to continue? [no]: yes
Router(config-controller-profile)#multicast-pool 50
This profile is being used by the following RPDs:
Controller RPD DS Port List:
  RPD ID           I/F       Name
  ---------------- --------- ----------------
  0004.9f03.0214   Te6/1/0   rpd_b
  000c.2923.9991   Te6/1/0   rpd_a               ...

Confirm to continue? [no]: yes
```

To verify the multicast sharing is enabled under the downstream controller profile, use the **show cable downstream controller-profile** command as shown in the example below:

```
Router# show cable downstream controller-profile 1
Load for five secs: 8%/1%; one minute: 10%; five minutes: 10%
No time source, *07:14:32.551 CST Tue Nov 15 2016
Downstream controller-profile 1
Description:
Downstream controller-profile 1 is being used by controller Downstream-Cable:
  3/0/0,
  Admin:  UP
  MaxOfdmSpectrum: 0
  MaxCarrier: 128
  BasePower: 33.0 dBmV
  Mode: normal
  Frequency profile: unconfigured
  DS Splitting: Yes
  Multicast Pool ID: 1
```

Configure the RPD with the Same Downstream Controller and Profile

To configure the RPDs with the same downstream controller and profile, complete the following procedure:

```
configure terminal
cable rpd name
identifier id
core-interface TenGigabitEthernet slot/subslot/port
principal
rpd-ds 0 downstream-cable slot/subslot/port profile id
```

```
rpd-us 0 upstream-cable slot/subslot/port profile id
r-dti id
rpd-event profile id
rpd-55d1-us-event profile id
```

Note Configure at least 2 RPDs with the same downstream controller and profile to implement the multicast DEPI.

Configure the RPDs to different fiber-nodes

To configure the RPDs to different fiber-nodes, complete the following procedure:

```
configure terminal
cable fiber-node id
downstream Downstream-Cable slot/subslot/port
upstream Upstream-Cable slot/subslot/port
```

Note Configure at least 2 fiber-nodes with the same downstream controller to implement the multicast DEPI.

Configure the RPDs to MAC Domain

To configure the RPDs to the MAC domain, complete the following procedure:

```
configure terminal
interface cable slot/subslot/port
downstream Downstream-Cable slot/subslot/port rf-channel id
upstream index Upstream-Cable slot/subslot/port us-channel index
cable upstream index jumbo-grants
cable upstream balance-scheduling
cable upstream bonding-group id
upstream id
attributes 800000F0
cable bundle id
cable map-advance static value
cable sid-cluster-group num-of-cluster value
cable sid-cluster-switching max-request value
```

Note Different RPDs can be configured to share the same downstream controller under one MAC domain or different MAC domains.

Enable Multicast on Cisco cBR-8 Router

To enable the multicast on cBR-8, complete the following procedure:

```
configure terminal
ip multicast-routing distributed
```

Enable Multicast on Layer 2 Switch

To enable multicast on Layer 2 switch, complete the following procedure:

```
configure terminal
ip igmp snooping
vlan configuration vlan
ip igmp snooping querier ip
```

Only need to create IGMP Snooping Group on one switch between DPIC and RPD.

Create IGMP Snooping Group under vlan which is used for connection between DPIC and RPD.

IP address used for IGMP snooping querier can be any address that is not conflict with the existing IP address in the system.

Enable Multicast on Layer 3 Router

To enable multicast on Layer 3 router, complete the following procedure:

```
configure terminal
ip pim ssm default
interface gigabitEthernet 0/0/0
ip pim sparse-dense-mode
ip igmp version 3
```

SSM must be enabled on all routers between DPIC and RPD.

All PIM neighbor must be enabled on all routers.

PIM neighbor can use sparse-dense-mode or sparse-mode.

Verify RPD Downstream Virtual Splitting Configuration on cBR-8 Side

To verify the RPD Downstream Virtual Splitting configuration on cBR-8 side, complete the procedure as shown in the example below, and check if these criteria are met:

- The remote session ID begins with 0x8 in the output of the **show cable rpd depi | in Ds** command.

```
Router# show cable rpd depi | in Ds
0x40003F21 0x80003D22 1377638051 Ds3/0/0:0       est    04:20:36 1          P
0x40003F31 0x80003D32 1377638051 Ds3/0/0:16      est    04:20:35 3          P
0x40003F41 0x80003D42 1377638051 Ds3/0/0:32      est    04:20:35 5          P
0x40003F39 0x80003D3A 1377638051 Ds3/0/0:24      est    04:20:35 4          P
0x40003F29 0x80003D2A 1377638051 Ds3/0/0:8       est    04:20:34 2          P
0x40103F21 0x80003D22 1404837649 Ds3/0/0:0       est    00:07:21 14         P
0x40103F39 0x80003D3A 1404837649 Ds3/0/0:24      est    00:07:21 17         P
0x40103F41 0x80003D42 1404837649 Ds3/0/0:32      est    00:07:21 18         P
0x40103F29 0x80003D2A 1404837649 Ds3/0/0:8       est    00:07:21 15         P
0x40103F31 0x80003D32 1404837649 Ds3/0/0:16      est    00:07:21 16         P
```

- There is assigned IP and pool ID in the output of the **show cable depi multicast ip all** command.

```
Router# show cable depi multicast ip all
Load for five secs: 7%/2%; one minute: 8%; five minutes: 8%
```

```
No time source, *23:00:55.344 CST Sun Nov 13 2016
ASSIGNED IP      POOL ID    CONTROLLER
225.225.225.0    1          3/0/0
```

- The cable modem is online in the output of the **show cable modem rpd** command.

```
Router# show cable modem
Load for five secs: 8%/3%; one minute: 9%; five minutes: 9%
No time source, *16:06:52.191 CST Thu Mar 2 2017

 D
MAC Address    IP Address      I/F           MAC               Prim  RxPwr  Timing Num
 I
                                             State             Sid   (dBmv) Offset CPE
 P
5039.558a.6c1c 40.242.0.17     C7/0/0/U1     online            5     0.50   816    0
 N
5039.558a.754a 40.242.9.201    C7/0/0/U0     online            6     0.00   814    0
 N
5039.558a.754e 40.242.9.207    C7/0/0/U0     online            7     0.00   814    0
 N
5039.558a.6b98 40.242.0.16     C7/0/0/U0     online            8     0.00   817    0
 N
0025.2e34.4380 40.242.62.172   C7/0/1/U1     online            2     0.00   783    0
 N

Router# show cable rpd
Load for five secs: 8%/3%; one minute: 9%; five minutes: 9%
No time source, *16:06:55.706 CST Thu Mar 2 2017

MAC Address     IP Address       I/F       State        Role HA  Name
0004.9f03.0214  120.105.4.7      Te7/1/0   online       Pri  Act rpd_b
000c.2923.9991  120.105.4.6      Te7/1/0   online       Pri  Act rpd_a
000c.2923.9991  120.105.4.6      Te6/1/0   online       Aux  Act rpd_a

Router# show cable modem rpd 0004.9f03.0214
Load for five secs: 8%/3%; one minute: 9%; five minutes: 9%
No time source, *16:07:07.790 CST Thu Mar 2 2017

 D
MAC Address    IP Address      I/F           MAC               Prim  RxPwr  Timing Num
 I
                                             State             Sid   (dBmv) Offset CPE
 P
5039.558a.6c1c 40.242.0.17     C7/0/0/U1     online            5     0.50   816    0
 N
5039.558a.754a 40.242.9.201    C7/0/0/U0     online            6     0.00   814    0
 N
5039.558a.754e 40.242.9.207    C7/0/0/U0     online            7     0.00   814    0
 N
```

Verify RPD Virtual Downstream Splitting Configuration on Node Side

To verify the RPD Downstream Virtual Splitting configuration on node side, complete the procedure on RPD as shown in the example below, and check if these criteria are met:

- All L2TP session ID must be start with 800.

```
RPD# show l2tp session
L2TP Tunnel Information Total tunnels 1 sessions 13
LocSessID RemSessID LocTunID  RemTunID  State Type       Last Chg
```

```
80003d22  40103f21  9fef9255  53bc1f11  est   MCM        07:10:54 2016-11-13
80003d2a  40103f29  9fef9255  53bc1f11  est   MCM        07:10:57 2016-11-13
80003d42  40103f41  9fef9255  53bc1f11  est   MCM        07:10:56 2016-11-13
80003d32  40103f31  9fef9255  53bc1f11  est   MCM        07:10:59 2016-11-13
80003d3a  40103f39  9fef9255  53bc1f11  est   MCM        07:10:56 2016-11-13
```

- All downstream DEPI SrcIP must be multicast IP that is the same as cBR-8 side.

```
RPD# show downstream depi configuration
Channel PwSubtype     SessionId  SrcIp
0       MCM           2147499298 225.225.225.0
8       MCM           2147499306 225.225.225.0
16      MCM           2147499314 225.225.225.0
24      MCM           2147499322 225.225.225.0
32      MCM           2147499330 225.225.225.0
```

Example: RPD Downstream Virtual Splitting Configuration

The following example shows how to configure RPD Downstream Virtual Splitting:

```
Router# configure terminal
Router(config)# cable depi multicast pool 1
Router(config-multicast-pool)# ip address 225.225.225.0 255.255.255.0
Router(config-multicast-pool)# exit
Router(config)# cable downstream controller-profile 0
Router(config-controller-profile)# multicast-pool 1
Router(config-controller-profile)# max-carrier 128
Router(config-controller-profile)# base-channel-power 34
Router(config-controller-profile)# rf-chan 0 95
Router (config-prof-rf-chan)# type DOCSIS
Router (config-prof-rf-chan)# frequency 285000000
Router (config-prof-rf-chan)# rf-output NORMAL
Router (config-prof-rf-chan)# qam-profile 1
Router (config-prof-rf-chan)# power-adjust 0
Router (config-prof-rf-chan)# docsis-channel-id 1
Router (config-prof-rf-chan)# end
Router# configure terminal
Router(config)# cable rpd node_1
Router(config-rpd)# identifier 0004.9f03.0214
Router(config-rpd)# core-interface Te9/1/0
Router(config-rpd-core)# principal
Router(config-rpd-core)# rpd-ds 0 downstream-cable 9/0/0 profile 0
Router(config-rpd-core)# rpd-us 0 upstream-cable 9/0/0 profile 221
Router(config-rpd-core)# exit
Router(config-rpd)# r-dti 20
Router(config-rpd)# rpd-event profile 0
Router(config-rpd)# rpd-55d1-us-event profile 0
Router(config-rpd)# exit
Router(config)# cable rpd node_2
Router(config-rpd)# identifier 000c.2923.9991
Router(config-rpd)# core-interface Te9/1/0
Router(config-rpd-core)# principal
Router(config-rpd-core)# rpd-ds 0 downstream-cable 9/0/0 profile 0
Router(config-rpd-core)# rpd-us 0 upstream-cable 9/0/1 profile 221
Router(config-rpd-core)# exit
Router(config-rpd)# r-dti 20
Router(config-rpd)# rpd-event profile 0
Router(config-rpd)# rpd-55d1-us-event profile 0
Router(config-rpd)# exit
Router(config)# cable fiber-node 100
Router(config-fiber-node)# downstream Downstream-Cable 9/0/0
```

```
Router(config-fiber-node)# upstream Upstream-Cable 9/0/0
Router(config-fiber-node)# exit
Router(config)# cable fiber-node 101
Router(config-fiber-node)# downstream Downstream-Cable 9/0/0
Router(config-fiber-node)# upstream Upstream-Cable 9/0/1
Router(config-fiber-node)# exit
Router(config)# interface Cable 9/0/0
Router(config-if)# downstream Downstream-Cable 9/0/0 rf-channel 0
Router(config-if)# downstream Downstream-Cable 9/0/0 rf-channel 8
Router(config-if)# upstream 0 Upstream-Cable 9/0/0 us-channel 0
Router(config-if)# upstream 1 Upstream-Cable 9/0/0 us-channel 1
Router(config-if)# upstream 2 Upstream-Cable 9/0/0 us-channel 2
Router(config-if)# upstream 3 Upstream-Cable 9/0/0 us-channel 3
Router(config-if)# upstream 4 Upstream-Cable 9/0/1 us-channel 0
Router(config-if)# upstream 5 Upstream-Cable 9/0/1 us-channel 1
Router(config-if)# upstream 6 Upstream-Cable 9/0/1 us-channel 2
Router(config-if)# upstream 7 Upstream-Cable 9/0/1 us-channel 3
Router(config-if)# cable upstream 0 jumbo-grants
Router(config-if)# cable upstream balance-scheduling
Router(config-if)# cable upstream bonding-group 1
Router(config-upstream-bonding)# upstream 0
Router(config-upstream-bonding)# upstream 1
Router(config-upstream-bonding)# upstream 2
Router(config-upstream-bonding)# upstream 3
Router(config-upstream-bonding)# attributes 800000F0
Router(config-upstream-bonding)# exit
Router(config-if)# cable upstream bonding-group 2
Router(config-upstream-bonding)# upstream 4
Router(config-upstream-bonding)# upstream 5
Router(config-upstream-bonding)# upstream 6
Router(config-upstream-bonding)# upstream 7
Router(config-upstream-bonding)# attributes 8000000F
Router(config-upstream-bonding)# exit
Router(config-if)# cable bundle 1
Router(config-if)# cable map-advance static 1000
Router(config-if)# cable sid-cluster-group num-of-cluster 2
Router(config-if)# cable sid-cluster-switching max-request 2
Router(config-if)# exit
Router(config)# ip multicast-routing distributed
Router(config)# interface TenGigabitEthernet 9/1/0
Router(config-if)# ip address 192.168.3.1 255.255.255.0
Router(config-if)# end
```

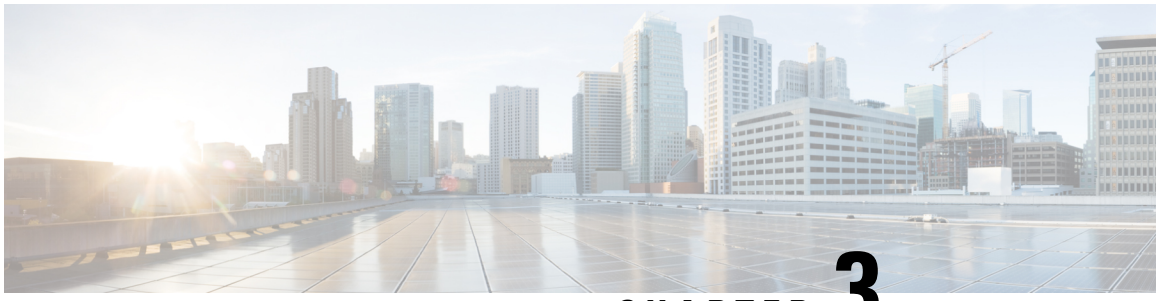
Feature Information for RPD Downstream Virtual Splitting

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 5: Feature Information for RPD Downstream Virtual Splitting

Feature Name	Releases	Feature Information
DS virtual splitting	Cisco 1x2 / Compact Shelf RPD Software 3.1	This feature was integrated into the Cisco Remote PHY Device.



CHAPTER 3

Cisco Remote PHY DS OFDM Channel Configuration

This document provides information on how to configure DOCSIS 3.1 DS OFDM channel on Remote PHY systems.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Use Cisco Feature Navigator to find information about the platform support and Cisco software image support. To access Cisco Feature Navigator, go to the link http://tools.cisco.com/ITDIT/CFN/. An account at the http://www.cisco.com/ site is not required.

Hardware Compatibility Matrix for Cisco Remote PHY Device

Note Unless otherwise specified, the hardware components introduced in a given Cisco Remote PHY Device Software Release are supported in all subsequent releases.

Table 6: Hardware Compatibility Matrix for the Cisco Remote PHY Device

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Node	Cisco 1x2 / Compact Shelf RPD Software 2.1 and Later Releases

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Intelligent Node (iNode)	Cisco 1x2 / Compact Shelf RPD Software 4.1 and Later Releases Cisco Intelligent Remote PHY Device 1x2 • PID—iRPD-1X2= • PID—iRPD-1X2-PKEY=

Note The -PKEY suffix in the PID indicates units that enable the SCTE-55-2 Out-of-Band protocol support.

Information About R-PHY DOCSIS 3.1 DS OFDM Channel

Cisco cBR routers support DS OFDM channels in an R-PHY system. The OFDM-channel-support includes two OFDM channels for each Remote PHY device (RPD) with a channel bandwidth up to 192 MHz and the modulation up to 4096 QAM.

RPD supports up to 128 SC-QAM channels when there are two or more OFDM channels. If more than 128 SC-QAM channels are already configured, you must configure the RPD core to reduce the number of SC-QAM channels before confiuring more OFDM channels.

Each OFDM channel supports a control profile, the NCP profile, and up to five data profiles. For a line card, a maximum of 32 DS OFDM channels are supported.

Note From Cisco IOS XE Amsterdam 17.6.1, CBR-CCAP-LC-G2-R line card supports a maximum of 80 DS OFDM channels.

Configure DS OFDM Channel

Configure OFDM Channel Profile

To configure the OFDM channel profile, run the following commands:

```
enable
configure terminal

cable downstream ofdm-chan-profile id
  description System Profile id
  cyclic-prefix value
  interleaver-depth value
  pilot-scaling value
  roll-off value
  subcarrier-spacing value
  profile-control {modulation-default mod_prof_id | modulation-profile mod_prof_id}
  profile-ncp modulation-default <mod_prof_id>
```

```
  profile-data channel_data_prof_id {modulation-default mod_prof_id | modulation-profile
mod_prof_id}
```

Configure RPD Port/Controller and Channel

To configure the port or controller and channel, use the following commands.

```
enable
configure terminal
cable rpd <rpd_name_string>
 identifier <xxxx.xxxx.xxxx>
 core-interface Te slot/subslot/port
  principal
  rpd-ds <port> downstream-cable slot/subslot/port profile <ID>
  rpd-us <port> upstream-cable slot/subslot/port profile <ID>

cable downstream controller-profile <ID>
max-ofdm-spectrum value

rf-chan [id]
type DOCSIS
frequency value
  rf-output NORMAL
  qam-profile id
  docsis-channel-id id
rf-chan [id]
  docsis-channel-id id
  ofdm channel-profile id start-frequency value width value [plc value]
```

The OFDM channel IDs range from 158 to 162.

In the following example, 2 OFDM channels 158 and 159 are configured:

```
Router# configure terminal
Router(config)# cable downstream controller-profile 6
Router(config-controller-profile)# max-carrier 128
Router(config-controller-profile)# max-ofdm-spectrum 384000000
Router(config-controller-profile)# rf-chan 0 23
Router(config-prof-rf-chan)# type DOCSIS
Router(config-prof-rf-chan)# qam-profile 1
Router(config-prof-rf-chan)# frequency 453000000
Router(config-prof-rf-chan)# rf-output NORMAL
Router(config-prof-rf-chan)# docsis-channel-id 1
Router(config-prof-rf-chan)# exit
Router(config-controller-profile)# rf-chan 158
Router(config-prof-rf-chan)# docsis-channel-id 159
Router(config-prof-rf-chan)# ofdm channel-profile 20 start-frequency 645000000 width 192000000
 plc 651000000
Router(config-prof-rf-chan)# exit
Router(config-controller-profile)# rf-chan 159
Router(config-prof-rf-chan)# docsis-channel-id 160
Router(config-prof-rf-chan)# ofdm channel-profile 20 start-frequency 837000000 width 192000000
 plc 930000000

Router(config)# cable rpd node0
Router(config-rpd)# identifier 0004.9f31.1234
Router(config-rpd)# core-interface Te9/1/0
Router(config-rpd-core)# principal
Router(config-rpd-core)# rpd-ds 0 downstream-cable 9/0/12 profile 6
Router(config-rpd-core)# rpd-us 0 upstream-cable 9/0/0 profile 3
Router(config-rpd-core)# exit
```

```
Router(config-rpd)# r-dti 8
Router(config-rpd)# rpd-event profile 0
Router(config-rpd)# rpd-55d1-us-event profile 0
```

Configure RF Channel Bandwidth in Wideband Interface

To add the RF channel to a wideband interface, and to specify the RF channel bandwidth allocated for the channel, use the following commands:

Note Cisco cBR router does not support Dynamic Bandwidth Sharing (DBS). Hence, the bandwidth-percentage value does not apply.

```
enable
configure terminal
interface Wideband-Cable{slot/subslot/port}:wideband-channel
 cable bundle id
 cable rf-channels channel-list grouplist bandwidth-percent percentage-bandwidth
```

Verify the Profile Ordering

To view the details of the profile downgrade ordering on a specific OFDM channel, run the following command:

```
Router#show controllers downstream-cable 7/0/0 rf-channel 158 prof-order

OFDM channel data profile order: [2/0/3:158]
-----------------------------------------------
Data Profile:       Downgrade Profile:
 Profile 1     ->    Profile 0
 Profile 2     ->    Profile 1
 Profile 3     ->    Profile 2
```

Verify OFDM Channel Profile

To view the details of an OFDM Channel Profile, run the following command:

```
Router# show controllers downstream-Cable 7/0/0 rf-channel 158 verbose

Chan State Admin Mod-Type  Start       Width     PLC      Profile-ID dcid output
                           Frequency
158   UP   UP   OFDM      807000000   192000000 963000000     20     162  NORMAL
 Resource status:   OK
 License: granted <20:11:58 CST Jul 3 2017>
 OFDM channel license spectrum width: 128200000
 Config lock status: Open
 OFDM config state: Configured

 OFDM channel details: [7/0/0:158]
----------------------------------------
 OFDM channel frequency/subcarrier range     : 807000000[ 128] - 998999999[3967]
 OFDM spectrum frequency/subcarrier range    : 800600000[   0] - 1005399999[4095]
 Active spectrum frequency/subcarrier range  : 808900000[ 166] - 997049999[3929]
 OFDM channel center frequency/subcarrier    : 903000000[2048]
 PLC spectrum start frequency/subcarrier     : 963000000[3248]
```

```
 PLC frequency/subcarrier                    : 965800000[3304]
 Channel width                               : 192000000
 Active Channel width                        : 128200000
 OFDM Spectrum width                         : 204800000
 Chan prof id                                : 20
 Cyclic Prefix                               : 1024
 Roll off                                    : 128
 Interleave depth                            : 16
 Spacing                                     : 50KHZ
 Pilot Scaling                               : 48
 Control modulation default                  : 1024
 NCP modulation default                      : 16
 Data modulation default                     : None
 Data modulation profile                     : None
 Lower guardband width in freq/subcarriers   : 1900000[38]
 Upper guardband width in freq/subcarriers   : 1900000[38]

 PLC spectrum frequencies [subcarriers]             :
  963000000[3248] - 968999999[3367]

 PLC channel frequencies [subcarriers]                :
  965800000[3304] - 966199999[3311]   Size: 8 subcarriers

 Excluded frequencies [subcarriers]               :
  800600000[   0] - 808899999[ 165]     865000000[1288] - 924999999[2487]
  997100000[3930] - 1005399999[4095]
  Count: 1532

 Pilot frequencies [subcarriers]                  :
  *:PLC pilots
  810150000[ 191]   812700000[ 242]   815250000[ 293]   817800000[ 344]
  820350000[ 395]   822900000[ 446]   825450000[ 497]   828000000[ 548]
  830550000[ 599]   833100000[ 650]   835650000[ 701]   838200000[ 752]
  840750000[ 803]   843300000[ 854]   845850000[ 905]   848400000[ 956]
  Count: 4

 Active frequencies [subcarriers]                 :
  808900000[ 166] - 864999999[1287]     925000000[2488] - 997099999[3929]
  Count: 2564

 Data frequencies [subcarriers]                  :
  808900000[ 166] - 810149999[ 190]     810200000[ 192] - 812699999[ 241]
  812750000[ 243] - 815249999[ 292]     815300000[ 294] - 817799999[ 343]
  817850000[ 345] - 820349999[ 394]     820400000[ 396] - 822899999[ 445]
  822950000[ 447] - 825449999[ 496]     825500000[ 498] - 827999999[ 547]

..
  Count: 2500

 Profiles:
  Number of profiles: 2
  CTRL profile (Profile A): rate: 864000 kbps
  Active frequencies [subcarriers]:
  Modulation:Start-freq[start-subcarrier] - End-freq[end-subcarrier]
  ---------------------------------------------------------------------
  1024 :808900000[ 166] - 810100000[ 190]     1024 :810200000[ 192] - 812650000[ 241]
  1024 :812750000[ 243] - 815200000[ 292]     1024 :815300000[ 294] - 817750000[ 343]
  1024 :817850000[ 345] - 820300000[ 394]     1024 :820400000[ 396] - 822850000[ 445]
  1024 :822950000[ 447] - 825400000[ 496]     1024 :825500000[ 498] - 827950000[ 547]

...

Active subcarrier count: 2500, ZBL count: 0
  Discontinuity time [days:hours:mins:secs]: 00:00:00:00
```

```
  NCP profile:
  Active frequencies [subcarriers]:
  Modulation:Start-freq[start-subcarrier] - End-freq[end-subcarrier]
  ------------------------------------------------------------------
  16   :808900000[ 166] - 810100000[ 190]     16   :810200000[ 192] - 812650000[ 241]
  16   :812750000[ 243] - 815200000[ 292]     16   :815300000[ 294] - 817750000[ 343]
  16   :817850000[ 345] - 820300000[ 394]     16   :820400000[ 396] - 822850000[ 445]
  16   :822950000[ 447] - 825400000[ 496]     16   :825500000[ 498] - 827950000[ 547]
…
  Active subcarrier count: 2500, ZBL count: 0

 CCCs:
   OCD CCC: 1
   DPD CCCs:
     Control profile  (Profile A) CCC: 1
         NCP profile  CCC: 1
 Resource config time taken: 29 msecs
 JIB channel number: 768
Chan Pr  EnqQ  Pipe  RAF  SyncTmr DqQ ChEn  RAF Tun# SessionId Valid P/S XFI 0[TkbRt MaxP]
     1[TkbRt MaxP]
 768  0  384     0   308      0   384  1    5551 0   16778240  TRUE   0  0 479610000 4485120
 383688000 4485120
 768  1  384     0  4786      0   384  1    2190 0   16778240  TRUE   0  0 479610000 4485120
 383688000 4485120
Encap Chan-id Data:0 PLC:5
Chan   Qos-Hi   Qos-Lo    Med-Hi   Med-Lo    Low-Hi   Low-Lo
 768    24576    16384     24576    16384     40960    24576
Chan  Med Low TB-neg Qos_Exc  Med_Xof  Low_Xof  Qdrops(H-M-L)  Pos Qlen(Hi-Med-lo) Fl Tgl_cnt
 Rdy_sts
  768   0   0      0       0        0        0    0    0    0  Y    0      0      0  0
    0 ff
Chan       Rate   Neg   Pos    LastTS  CurrCr  Pos  [PLC Rate Neg Pos]
 768   10485750 65535 65535 123395759 268431360   Y [MM 86 128 1024][EM 87 128 6144][TR 2
9 3072]
```

Verify OFDM Channel

To view the details of an OFDM channel, run the following command:

```
Router#show controllers downstream-Cable 7/0/0 counter ofdm-channel

Controller Chan# Profile/PLC Packets   Bytes MaxRate  Rate       Utilization
                                           (Mbps)   (Mbps)     (%)
7/0/0      158   Total        101694 9225522    -  0.015590   0.0
7/0/0      158   0             29216 2557604  864  0.004551   0.0
7/0/0      158   PLC-MMM       72474 6667608       0.011039
7/0/0      158   PLC-EM            0       0       0.000000
7/0/0      158   PLC-TR            0       0       0.000000
```

Verify OCD and DPD of MAC Domain

To display the MAC domain's OFDM Channel Descriptor (OCD) and Downstream Profile Descriptor (DPD) messages, use the **show cable mac-domain dpd** | **ocd** command in privileged EXEC mode.

```
Router# show cable mac-domain cable 7/0/0 ocd

DCID: 162  OFDM Controller:channel 7/0/0:158
```

```
OCD Message
  MAC Header
    Frame Control                   : 0xC2   (MAC specific, MAC msg, EHDR Off)
    MAC Parameters                  : 0x0
    Length                          : 190
    Header Check Sequence           : 0x84A2 (33954)
  MAC Management Header
?
    Destination MAC ADDR            : 01e0.2f00.0001
    Source MAC ADDR                 : c414.3c17.3ead
    Length                          : 172
    Destination SAP                 : 0
    Source SAP                      : 0
    Control                         : 3
    Version                         : 5
    Type                            : 49
    Multipart                       : 0    (Sequence number 0, Fragments 0)
  OCD fields
    DCID                            : 162
    CCC                             : 1
    TLV 0 Spacing                   : 50 KHz
    TLV 1 Cyclic Prefix             : 1024 samples
    TLV 2 Rolloff                   : 128 samples
    TLV 3 Spectrum Location         : 800600000 Hz
    TLV 4 Interleave Depth          : 16
    TLV 5 Subcarrier Assignment     : Continuous Pilots (list)
      0191  0242  0293  0344  0395  0446  0497  0548  0599  0650
      0701  0752  0803  0854  0905  0956  1007  1058  1109  1160
      1211  1262  2513  2564  2615  2666  2717  2768  2819  2870
      2921  2972  3023  3074  3125  3176  3227  3257  3269  3280
      3289  3326  3335  3346  3358  3398  3449  3500  3551  3602
      3653  3704  3755  3806  3857  3908
    TLV 5 Subcarrier Assignment     : Excluded Subcarriers (range)
                                    : 0000 - 0165
    TLV 5 Subcarrier Assignment     : Excluded Subcarriers (range)
                                    : 1288 - 2487
    TLV 5 Subcarrier Assignment     : Excluded Subcarriers (range)
                                    : 3930 - 4095
    TLV 5 Subcarrier Assignment     : PLC Subcarriers (range)
                                    : 3304 - 3311
    TLV 6 Primary Capable           : 0 (No)
--------------------------------------------------------------------------------
```

Verify Profile Management Data

To view the detailed profile management data associated with each cable modem.

```
Router#show cable modem c0c6.87ff.dabc prof-mgmt

Downstream Profile Management Data:
MAC Address            : c0c6.87ff.dcea
IP Address             : 60.11.0.12
IPv6 Address           : ---

RxMer Exempt Percent   : 2
RxMer Margin qDB       : 0
Automatic Prof Dwngrd  : Active

DCID                                : 162
  Configured Profile(s)             : 0
  Profile(s) in REG-RSP-MP          : 0
  Profile(s) in DBC-REQ             : N/A
```

```
  Current profile                      : 0  [1024-QAM]
  Percentages of ideal BL vs Curr Prof : 96 (better)  3 (equal)
  Downgrade profile                    : 0
  Recommend profile                    : 0
  Unfit profile(s)                     : N/A
  Recommend profile (Expired)          : N/A
  Unfit profile(s)  (Expired)          : N/A
Number of SubCarriers  : 4096
1st Active SubCarrier  : 166
# of Active SubCarriers: 3764
Tx Time                : 0h:15m:15s ago
Rx Time                : 0h:15m:15s ago
OFDM Profile Failure Rx: N/A
MER Poll Period   (min): 60
Recommend Timeout (min): 120
Unfit Timeout     (min): 60
Source              : OPT
Sub-    RxMER
Carrier
0x0000  00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
0x0020  00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
0x0040  00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
0x0060  00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
0x0080  00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
0x00A0  00000000 0000A5A3 A4A1A2A1 A5A3A39E A5A3A6A4 A6A1A6A2 A3A69FA2 A1A4A4A2
0x00C0  A2A0A4A4 A49EA7A6 A4A29EA4 A2A2A1A4 A3A1A1A4 A4A3A0A6 A4A1A4A6 A4A4A2A5
0x00E0  A5A2A3A5 A8A3A3A3 A6A1A1A0 A2A3A4A4 A3A2A19E A4A89FA3 A4A4A3A4 A4A4A5A2
0x0100  A5A3A1A1 A0A4A59E 9FA2A3A3 9F9FAAA4 A5A09FA4 A4A1A2A6 9DA1A1A0 A4A2A4A3
0x0120  A3A0A3A8 A29FA5A5 A3A6A1A0 A69EA1A2 A1A2A3A2 A1A2A3A5 9FA6A4A5 A1A7A4A4
0x0140  A5A4A5A1 A3A4A2A4 A2A2A4A3 A1A2A5A4 A19FA4A5 A1A0A5A4 9FA4A1A1 A6A2A59F
0x0160  A1A2A4A5 A3A5A4A1 A4A3A5A1 A3A3A5A0 A0A3A3A0 A2A3A3A3 A2A2A2A5 A5A4A4A3
0x0180  9EA4A3A1 A4A5A2A3 A29FA39F A6A1A0A2 A4A59FA3 A4A2A4A1 A2A4A3A3 A6A39DA2
0x01A0  A3A1A1A2 A3A2A2A1 A2A0A39F A7A39FA5 A1A4A4A1 A2A4A2A0 A6A49F9F A6A39D9F
0x01C0  9FA2A5A2 9BA1A1A0 A3A2A1A3 A39FA3A1 A19EA3A5 9DA1A0A0 A3A0A39F A0A3A2A1
0x01E0  A5A4A0A1 A0A39F9E A09FA2A4 9FA2A39F A2A3A49C A3A29FA0 A0A3A2A5 A3A0A1A1
… …
Upstream Profile Management Data:
```

Verify OCD and DPD Messages in RPD

To view OCD and DPD messages from RPD, run the following command. The output must be identical to the messages on Cisco cBR-8 routers.

```
RPD-config# show downstream ofdm configuration
OCD Message

  OCD fields
    DCID                           : 0
    CCC                            : 1
    TLV 0 Spacing                  : 50 KHz
    TLV 1 Cyclic Prefix            : 1024 samples
    TLV 2 Rolloff                  : 128 samples
    TLV 3 Spectrum Location        : 800600000 Hz
    TLV 4 Interleave Depth         : 16
    TLV 5 Subcarrier Assignment    : Continuous Pilots (list)
      191   242   293   344   395   446   497   548   599   650
      701   752   803   854   905   956   1007  1058  1109  1160
      1211  1262  2513  2564  2615  2666  2717  2768  2819  2870
      2921  2972  3023  3074  3125  3176  3227  3257  3269  3280
      3289  3326  3335  3346  3358  3398  3449  3500  3551  3602
      3653  3704  3755  3806  3857  3908
    TLV 5 Subcarrier Assignment    : Excluded Subcarriers (range)
```

```
                                    : 0    - 165
    TLV 5 Subcarrier Assignment     : Excluded Subcarriers (range)
                                    : 1288 - 2487
    TLV 5 Subcarrier Assignment     : Excluded Subcarriers (range)
                                    : 3930 - 4095
    TLV 5 Subcarrier Assignment     : PLC Subcarriers (range)
                                    : 3304 - 3311
    TLV 6 Primary Capable           : 1 (Yes)

DPD Message
  DPD fields
    DCID                            : 0
    Profile ID                      : 0
    CCC                             : 1
    TLV 5 Subcarrier Range/List     : Range (continuous)
      Modulation                    : 1024 (default value)
                                    : 0    - 4095
DPD Message
  DPD fields
    DCID                            : 0
    Profile ID                      : 255
    CCC                             : 1
    TLV 5 Subcarrier Range/List     : Range (continuous)
      Modulation                    : 16 (default value)
                                    : 0    - 4095
```

Verify per-Profile Counter on RPD

The following example shows how to verify the per-profile counter on RPD:

```
RPD-config# show downstream ofdm counter profile

Profile Pkts       Sum-Pkts   Bytes      Sum-Bytes  Codewords  Sum-Codewords
0       7735       7735       677110     677110     4815       4815
1       0          0          0          0          0          0
2       0          0          0          0          0          0
3       0          0          0          0          0          0
4       0          0          0          0          0          0
5       0          0          0          0          0          0
6       0          0          0          0          0          0
7       0          0          0          0          0          0
8       0          0          0          0          0          0
9       0          0          0          0          0          0
10      0          0          0          0          0          0
11      0          0          0          0          0          0
12      0          0          0          0          0          0
13      0          0          0          0          0          0
14      0          0          0          0          0          0
15      0          0          0          0          0          0
```

Verify the Drop Counter in DPS

To verify the drop counter, especially in the DPS module, run the following command:

```
RPD-config#show downstream channel counter
------------------- Packets counter in TPMI -------------------

Level     Rx-pkts    Rx-sum-pkts
```

```
Node Rcv  32690704   32690704
Depi Pkt  32471383   32471383

Port Chan Rx-pkts    Rx-sum-pkts
DS_0 0    3599407    3599407
DS_0 1    3605066    3605066


DS_0 5    3602293    3602293
DS_0 6    3596193    3596193
DS_0 7    3598393    3598393
DS_0 8    599        599
US_0 5    598656     598656

Port      Rx-pkts    Rx-sum-pkts Drop-pkts  Drop-sum-pkts
DS_0      28998897   28998897    0          0
US_0      3602539    3602539     0          0
US_1      2244       2244        0          0


------------------- Packets counter in DPMI -------------------

Field        Pkts       Sum-pkts
Dpmi Ingress 28844845   28844845
Pkt Delete   0          0
Data Len Err 0          0

Chan Flow_id Octs       Sum-octs   SeqErr-pkts SeqErr-sum-pkts
0    0       374242     374242     1           1
0    1       710485     710485     1           1
0    2       218477141  218477141  1           1
0    3       0          0          0           0
1    0       379530     379530     1           1
1    1       700973     700973     1           1
1    2       218859695  218859695  1           1
1    3       0          0          0           0
2    0       372126     372126     1           1
2    1       695623     695623     1           1


31   2       0          0          0           0
31   3       0          0          0           0
158  0       0          0          0           0
158  1       682214     682214     1           1
158  2       0          0          0           0
158  3       0          0          1           1
163  0       0          0          0           0
163  1       0          0          1           1
163  2       0          0          0           0
163  3       1654620    1654620    1           1


------------------- Packets counter in DPS -------------------

Chan Tx-packets Tx-octets  Drop-pkts  Tx-sum-pkts Tx-sum-octs Drop-sum-pkts
0    3599803    219580072  0          3599803     219580072   0
1    3605466    219958582  0          3605466     219958582   0
2    3602414    219728291  0          3602414     219728291   0
3    3604543    219858566  0          3604543     219858566   0


31   599        20366      0          599         20366       0
158  7797       682524     0          7797        682524      0
```

Configuration Example

The following example shows how to configure OFDM channel:

```
cable downstream ofdm-chan-profile 0
  description System Profile 0
  cyclic-prefix 1024
  interleaver-depth 16
  pilot-scaling 48
  roll-off 128
  subcarrier-spacing 50KHZ
  profile-control modulation-default 256-QAM
  profile-ncp modulation-default 16-QAM
  profile-data 1 modulation-default 1024-QAM

cable downstream controller-profile 100
 max-ofdm-spectrum 192000000
 rf-chan 0 7
  type DOCSIS
  frequency 453000000
  rf-output NORMAL
  qam-profile 1
  docsis-channel-id 1
 rf-chan 158
  docsis-channel-id 159
  ofdm channel-profile 0 start-frequency 645000000 width 192000000 plc 651000000

cable rpd node_0873
 identifier 0004.9f00.0873
 core-interface Te7/1/0
  principal
  rpd-ds 0 downstream-cable 7/0/0 profile 100
  rpd-us 0 upstream-cable 7/0/0 profile 1
```

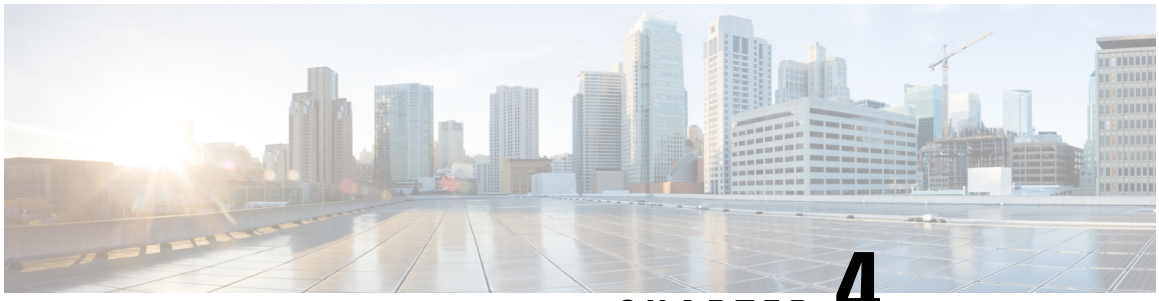
Feature Information for RPHY DS OFDM Channel Configuration

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 7: Feature Information for RPHY DS OFDM Channel Configuration

Feature Name	Releases	Feature Information
Remote PHY DS OFDM Channel Configuration	Cisco 1x2 / Compact Shelf RPD Software 3.1	This feature was integrated into the Cisco Remote PHY Device.



CHAPTER 4

Virtual Combining of Upstream Channels on RPD

This chapter provides information on the support for virtual combining of upstream channels on Cisco Remote PHY Devices.

Hardware Compatibility Matrix for Cisco Remote PHY Device

Note Unless otherwise specified, the hardware components introduced in a given Cisco Remote PHY Device Software Release are supported in all subsequent releases.

Table 8: Hardware Compatibility Matrix for the Cisco Remote PHY Device

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Node	Cisco 1x2 / Compact Shelf RPD Software 2.1 and Later Releases
Cisco GS7000 Super High Output Intelligent Node (iNode)	Cisco 1x2 / Compact Shelf RPD Software 4.1 and Later Releases Cisco Intelligent Remote PHY Device 1x2 • PID—iRPD-1X2= • PID—iRPD-1X2-PKEY=

Note The -PKEY suffix in the PID indicates units that enable the SCTE-55-2 Out-of-Band protocol support.

Information About Virtual Combining of Upstream Channels

Virtual Combining helps in supporting more RPDs than the number of US SGs, similar to the way multiple physical cables are combined to the same upstream RF port in I-CMTS architecture.

In RPHY, a group of Upstream External PHY Interface (UEPI) sessions with different pseudowires are set up for a single upstream channel for both CCAP core and RPD. However, with virtual-combing, multiple UEPI sessions are mapped to one physical channel in Cisco cBR-8 Routers.

Through this feature, Cisco cBR-8 routers support the binding of multiple US ports on RPDs to the same US controller. The USPHY configuration on the combined RPDs is the same. All combined RPDs must use the same type of USPHY chip.

You are notified if an RPD USPHY is incompatible with the USPHY configuration when a new RPD comes online.

The combined US ports may be in the same RPD. The combined US ports may be in different RPDs. The maximum number of combined US ports to the same controller must not exceed 8. The combined USPHY channels share the bandwidth of the combined channel.

At any instance, only one USPHY channel can transmit. Cisco cBR Series routers support the modems under a specific RPD even in combined US channel cases. It also supports all member USPHY channel information in a combined channel.

When monitoring a physical channel, the cable monitor monitors all member UEPI channels. Spectrum surveillance collects and calculates the SNR and CNR for each USPHY channel.

The OFDMA channels supported for the Virtual Combining feature on Remote PHY start from 8192. The number of ATDMA channels supporting this feature are 256 physical channels for IPHY and 1024 for Remote PHY.

Configure Virtual Combining of Upstream Channels

Configure RPD for Virtual Combining

The virtual combining of upstream channels is initiated automatically when users configure the same US controller for more than one US ports. The ports may be in the same RPD or different RPDs, but should be on the same line card).

In the following example, the US port 0 on RPD node_1 and US port 0 and 1 on RPD node_2 are combined to upstream-cable 9/0/2.

```
cable rpd node_<number>
 identifier badb.ad13.5d7e
 core-interface Te9/1/2
  principal
  rpd-ds 0 downstream-cable 9/0/2 profile 100
  rpd-us 0 upstream-cable 9/0/2 profile 221
 r-dti 1
!
cable rpd node_2
 identifier badb.ad13.5d96
 core-interface Te9/1/2
  principal
```

```
  rpd-ds 0 downstream-cable 9/0/2 profile 100
  rpd-us 0 upstream-cable 9/0/2 profile 221
  rpd-us 1 upstream-cable 9/0/2 profile 221
 r-dti 1
!
```

Verify Upstream Virtual Combining Details

To view the spectrum analysis measurements of the specified UEPI channels for virtual combining, use the following sample commands:

```
show cable spectrum-analysis Cable <slot/subslot/port> upstream <port> sid <Sid of modem
or noise> devID <0-7 Device ID>
Load for five secs: 5%/1%; one minute: 5%; five minutes: 5%
No time source, *11:16:00.436 CST Sat Feb 24 2018

Spectrum Analysis Measurements for Cable9/0/7: Upstream 0 Sid 1
Device ID: 1
Channel Center Frequency: 10000 kHz
Frequency Span:           3200 kHz
Number of Bins:           129
Bin Spacing:              25.0 kHz
Resolution Bandwidth:     42.750 kHz
Amplitude Data:
    Bin   1: -60.00 dBmV
    Bin   2: -60.00 dBmV
    Bin   3: -60.00 dBmV
    Bin   4: -32.00 dBmV
    Bin   5: -23.00 dBmV
    Bin   6: -22.00 dBmV
```

To view the signal quality of the specified channels supporting virtual combining, use the following sample commands:

```
show cable signal-quality cmts
I/F           DevID    CNiR            Expected Received
                       (dB)            Signal Power (dBmV)
Cable1/0/0/U0   0      31.0            0.0
Cable1/0/0/U0   1      31.0            0.0
Cable1/0/0/U0   2      31.0            0.0
Cable1/0/0/U1   0      31.0            0.0
Cable1/0/0/U1   1      31.0            0.0
Cable1/0/0/U2          -----           -----
Cable1/0/0/U3          -----           -----
Cable1/0/0/U4   0      31.0            0.0
Cable1/0/0/U5   0      31.0            0.0
```

To view the status of upstream channel combining, use the following sample commands:

```
show controllers upstream-cable 7/0/62 us-channel 0

Load for five secs: 5%/1%; one minute: 6%; five minutes: 5%
Time source is NTP, 18:05:11.271 CST Tue Feb 27 2018

Controller RPD US Port List:

DevID  RPD ID          US Port  I/F       Name
------ --------------- -------- --------- ------------
  0    0004.9f03.0226     0     Te7/1/1   0004.9f03.0226
  1    0004.9f03.0286     0     Te7/1/1   0004.9f03.0286
```

```
  2    1004.9f30.1500     0     Te7/1/0   1004.9f30.1500
  3    1004.9f30.1500     1     Te7/1/0   1004.9f30.1500

USPHY OFDMA support: NO

Controller 7/0/62 upstream 0  AdminState:UP OpState: UP
  atdma mode enabled
  Frequency 21.800 MHz, Channel Width 1.600 MHz, Symbol Rate 1.280 Msps
  Modulation Profile Group 221
  Modulations (64-QAM) - A-short 64-QAM, A-long 64-QAM, A-ugs 64-QAM

  Mapped to connector 62 and receiver 0
  Bind to Cable7/0/0 US0
  US phy MER(SNR)_estimate for good packets - 42.410 dB
  Spectrum Group is overridden
  Nominal Input Power Level 0 dBmV
  part_id=0x0000, rev_id=0x00, rev2_id=0x00
  Range Load Reg Size=0x58
  Request Load Reg Size=0x0E
  Minislot Size in number of Timebase Ticks is = 4
  Minislot Size in Symbols = 32
  Minislot Size in Bytes = 24

  UCD procedures on lch 0
  UCD ucd-succeed         (3   ) invalid-req         (0   ) md-dispatch         (0   )
  UCD mismatch-req        (0   ) start-sw            (0   ) start-state         (0   )
  UCD ccc-time            (0   ) end-sw              (0   ) end-state           (0   )
  UCD ucd-lch-tgc         (0   ) ucd-rcvr            (0   ) ucd-cdm-timeout     (0   )
  UCD ucd-no-reqtxn       (0   ) ucd-req-chn-mismatch(0   ) ucd-send-next-fail  (0   )
  UCD ucd-rpd-np          (0   ) ucd-upd-gcp-msg     (0   ) ucd-cfg-gcp-msg     (0   )
  UCD ucd-gcp-ack         (0   ) ucd-gcp-ack-timeout (0   ) ucd-gcp-nack        (0   )
  UCD ucd-gcp-timout      (0   ) ucd-ack-err         (0   ) ucd-timer-null      (0   )
  UCD ucd-proxy-timeout   (0   ) ucd-proxy-wrong-ack (0   )
  PHY: us errors 0  us recoveries 0 (enp 0)
  MAC PHY TSS: tss error start 0  tss error end 0
  MAC PHY Status: mask 0  int_index 0
  PHY: TSS late 0  discontinuous 0
  PHY: TSS mis-match 0  not-aligned 0
  PHY: TSS missed snapshots from phy 0
  Map Counts:0
LCH_state RUN_STEADY   , UCD_count 3, MD 0 chan 0
```

Configuration Example

This section provides example of how to configure the RPD for virtual combining of upstream channels.

Example for Configuring RPD for Virtual Combining

```
cable rpd node_1
 identifier badb.ad13.5d7e
 core-interface Te9/1/2
  principal
  rpd-ds 0 downstream-cable 9/0/2 profile 100
  rpd-us 0 upstream-cable 9/0/2 profile 221
 r-dti 1
!
cable rpd node_2
 identifier badb.ad13.5d96
```

```
 core-interface Te9/1/2
  principal
  rpd-ds 0 downstream-cable 9/0/2 profile 100
  rpd-us 0 upstream-cable 9/0/2 profile 221
  rpd-us 1 upstream-cable 9/0/2 profile 221
 r-dti 1
!
```

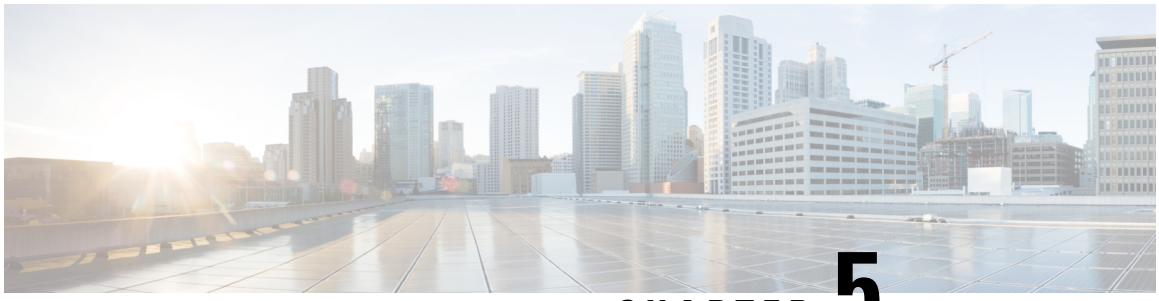
Feature Information for Virtual Combining of Upstream Channels

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 9: Feature Information for Virtual Combining of Upstream Channels

Feature Name	Releases	Feature Information
Virtual Combining of Upstream Channels on Remote PHY	Cisco 1x2 RPD Software 4.1	This feature was introduced on the Cisco Remote PHY Devices.



CHAPTER 5

Redundant Multicast DEPI Pool

This document describes how to configure redundant multicast DEPI pool.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Use Cisco Feature Navigator to find information about the platform support and Cisco software image support. To access Cisco Feature Navigator, go to the link http://tools.cisco.com/ITDIT/CFN/. An account at the http://www.cisco.com/ site is not required.

Redundant Multicast DEPI Pool

In DS sharing, the DS controller of the secondary line card uses the same multicast IP address as the primary line card DS controller. For a single RPD, the principal and standby Cores use different source IP addresses, but same group IP address in a multicast group. However, the NCS switch does not support one Group with multiple Sources in a multicast group. Hence, you must assign additional multicast IP addresses for standby cores.

Assign the additional multicast IP addresses to the DS controllers on the secondary line cards if the secondary line card is up.

When you enable the redundant multicast DEPI pool, the secondary line card is up in the redundancy line card group and the multicast IP addresses are assigned to secondary line card from the redundant multicast pool. All RPDs on standby cores are automatically cleared to be offline and later online again.

When you disable the redundant multicast pool, the IP addresses are removed from the redundant multicast pool, and all the RPD standby cores are cleared automatically. If you do not configure redundant pool, the secondary line card downstream controllers use the same IP as the downstream controllers in the primary line card.

You cannot use the redundant multicast pool in the downstream controller profile configuration.

Multicast IP address for the secondary line card is assigned based on the DS controller and the TenGE port. One DS controller can be assigend 8 IPv4/IPpv6 addresses from Tx/1/0 to Tex/1/7, where x is the secondary line card slot number. Hence, the redundant multicast DEPI pool needs a minimum of 266 IP addresses (32 controller for 8 ports for DOCSIS, 10 for OOB). If 266 IP addresses are not available, you can assign 4 IPv4/IPv6 addresses to the ports 0,2,4,6 on a single DS controller for multicast DEPI IP addresses on the secondary line card.

Configure Redundant Multicast DEPI Pool

This section describes how to configure the redundant multicast DEPI pool on Cisco cBR-8 routers.

Configuring Redundant Multicast DEPI Pool

When a secondary line card is configured, multicast IP addresses are assigned to its downstream controllers from the redundant multicast DEPI pool.

Step 1 Configure the multicast DEPI pool by using the following command:

```
configure terminal
cable depi multicast pool id{ip|ipv6} address ip mask
```

Step 2 Verify the multicast DEPI pool configuration.

```
show cable depi multicast pool
```

Example:

```
show cable depi multicast pool
Load for five secs: 7%/1%; one minute: 7%; five minutes: 7%
No time source, *15:57:05.512 CST Wed Aug 22 2018
POOL ID    Net IP           Net Mask         Redundant DESCRIPTION
1          227.0.0.0        255.255.255.0    FALSE
127        227.226.225.0    255.255.255.0    FALSE     to TE9/1/1+TE9/1/7

POOL ID    IPv6                Redundant DESCRIPTION
10         FF3A::9000:0/120    FALSE
```

Step 3 Configure the redundant multicast DEPI pool.

```
configure terminal
 cable depi multicast pool id
redundant
```

Step 4 Verify the redundant multicast DEPI pool configuration.

```
show cable depi multicast pool
```

Example:

```
show cable depi multicast pool
Load for five secs: 7%/1%; one minute: 7%; five minutes: 7%
No time source, *16:27:05.552 CST Wed Aug 22 2018
POOL ID    Net IP           Net Mask         Redundant DESCRIPTION
1          227.0.0.0        255.255.255.0    FALSE
127        227.226.225.0    255.255.255.0    FALSE     to TE9/1/1+TE9/1/7
```

```
POOL ID     IPv6                 Redundant DESCRIPTION
10          FF3A::9000:0/120     TRUE
```

Verify Assigned Multicast IP Addresses

Verify the multicast addresses that are assigned to the secondary linecard downstream controllers by running the `show cable depi multicast ip/ipv6 all` command, similar to the following example:

```
show cable depi multicast ipv6 all
Load for five secs: 6%/0%; one minute: 6%; five minutes: 7%
No time source, *14:23:14.522 CST Tue Aug 28 2018
IPv6              POOL ID    CONTROLLER
FF3E::8140:0      20         0/0/0(1-Te0/1/0)
FF3E::8140:8      20         0/0/1(2-Te0/1/0)
FF3E::8140:10     20         0/0/2(3-Te0/1/0)
FF3E::8140:18     20         0/0/3(4-Te0/1/0)
FF3E::8140:20     20         0/0/4(5-Te0/1/0)
FF3E::8140:28     20         0/0/5(6-Te0/1/0)
FF3E::8140:30     20         0/0/6(7-Te0/1/0)
……
```

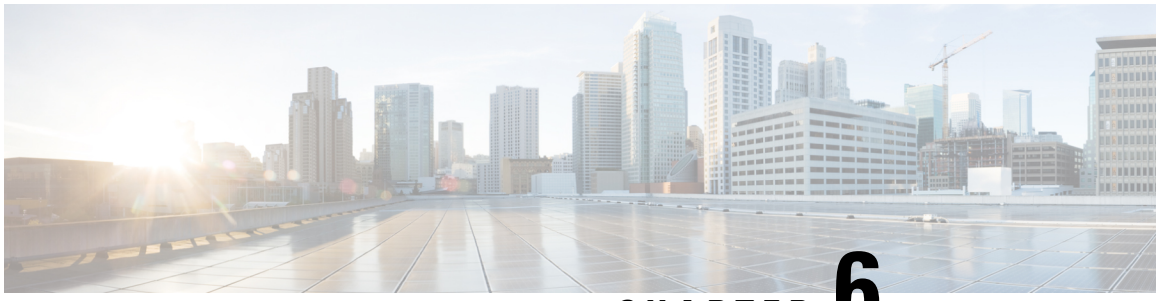
Feature Information for Redundant Multicast DEPI Pool

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 10: Feature Information for Redundant Multicast DEPI Pool

Feature Name	Releases	Feature Information
Redundant Multicast DEPI Pool	Cisco 1x2 / Compact Shelf RPD Software 4.1.2	This feature was introduced on the Cisco cBR Series Converged Broadband Routers.



CHAPTER 6

DOCSIS3.1 Downstream Resiliency for RPHY

This document describes how to configure the DOCSIS3.1 Downstream Resiliency on the Cisco Remote PHY Device.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Use Cisco Feature Navigator to find information about the platform support and Cisco software image support. To access Cisco Feature Navigator, go to the link http://tools.cisco.com/ITDIT/CFN/. An account at the http://www.cisco.com/ site is not required.

Hardware Compatibility Matrix for Cisco Remote PHY Device

Note Unless otherwise specified, the hardware components introduced in a given Cisco Remote PHY Device Software Release are supported in all subsequent releases.

Table 11: Hardware Compatibility Matrix for the Cisco Remote PHY Device

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Node	Cisco 1x2 / Compact Shelf RPD Software 2.1 and Later Releases

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Intelligent Node (iNode)	Cisco 1x2 / Compact Shelf RPD Software 4.1 and Later Releases Cisco Intelligent Remote PHY Device 1x2 • PID—iRPD-1X2= • PID—iRPD-1X2-PKEY=

Note The -PKEY suffix in the PID indicates units that enable the SCTE-55-2 Out-of-Band protocol support.

Information about DOCSIS3.1 Downstream Resiliency for RPHY

When DOCSIS3.1 cable modem reports non-primary RF channel failure for SCQAM or OFDM channel, actions performed by downstream resiliency is the same as DOCSIS3.0 cable modem. In other words, if RF channel impairment is below the resiliency threshold, CM's service flows are moved to Resiliency Bonding Group (RBG) or Narrow Band (NB) interface. If RF channel impairment is above the resiliency threshold, the impaired RF channel is temporarily removed from the bonding group.

The following table summarizes the CM-STATUS events for OFDM channel, and the action taken by the downstream resiliency module:

Table 12: CM-STATUS events for OFDM channel

Event Type Code	Event Description	DS Resiliency Action
1	MDD timeout	Move CM's service flows to RBG/NB or suspend RF from BG.
2	FEC lock failure	Move CM's service flows to RBG/NB or suspend RF from BG.
4	MDD recovery	Move CM's service flows back to original BG.
5	FEC lock recovery	Move CM's service flows back to original BG.
16	DS OFDM profile failure. A loss of FEC lock on one of the assigned downstream OFDM profiles of a channel.	DS OFDM Profile Manager will handle this event and take action.
20	NCP profile failure. Loss of FEC lock on NCP.	Move CM's service flows to RBG/NB or suspend RF from BG.
21	Loss of FEC lock on the PLC.	Move CM's service flows to RBG/NB or suspend RF from BG.

Event Type Code	Event Description	DS Resiliency Action
22	NCP profile recovery.	Move CM's service flows back to original BG.
23	FEC recovery on PLC channel.	Move CM's service flows back to original BG.
24	FEC recovery on OFDM profile.	Recovery of impairment reported by event 16. DS OFDM Profile Manager will handle this event and take action.

Configure DOCSIS3.1 Downstream Resiliency for RPHY

Configure DOCSIS3.1 Downstream Resiliency for RPHY

User must configure the command **cable rf-change-trigger percent** *value* **count** *number* to enable the downstream resiliency functionality.

To configure the trigger thresholds specific to OFDM RF impairment, follow the steps below:

```
enable
configure terminal
cable ofdm-rf-change-trigger percent value counter number [no-ncp-plc]
```

Trigger thresholds *value* and *number* apply globally to the non-primary OFDM RF channels. If this command is not configured, the trigger thresholds configured by the command **cable rf-change-trigger percent** *value* **count** *number* will be used for the non-primary OFDM channels.

With **no-ncp-plc** configured in the command, this feature will not take any action when CM reports CM-STATUS-EVENT 20 or 21.

Note The **cable rf-change-trigger percent** *value* **count** *number* command is optional and the configured trigger thresholds apply to non-primary OFDM channels only.

Display OFDM Specific CM-STATUS Events

To display the statistics of the OFDM specific CM-STATUS events, use the **show cable modem wideband rcs-status** command as shown in the example below:

```
router#show cable modem 4800.33ea.7072 wideband rcs-status verbose
CM  : 4800.33ea.7072
RF  : 3/0/0 0
  Status                  : UP
  FEC/QAM Failure         : 0
  Dup FEC/QAM Failure     : 0
  FEC/QAM Recovery        : 0
  Dup FEC/QAM Recovery    : 0
  MDD Failure             : 0
```

```
  Dup MDD Failure          : 0
  MDD Recovery             : 0
  Dup MDD Recovery         : 0
  Flaps                    : 0
  Flap Duration            : 00:00
RF  : 3/0/0 159
  Status                   : UP
  FEC/QAM Failure          : 0
  Dup FEC/QAM Failure      : 0
  FEC/QAM Recovery         : 0
  Dup FEC/QAM Recovery     : 0
  MDD Failure              : 0
  Dup MDD Failure          : 0
  MDD Recovery             : 0
  Dup MDD Recovery         : 0
  NCP PROF Failure         : 2         May 8  15:14:24
  Dup NCP PROF Failure     : 0
  NCP PROF Recovery        : 1         May 8  15:15:18
  Dup NCP PROF Recovery    : 0
  PLC Lock Recovery        : 1         May 8  15:15:46
  Dup PLC Lock Recovery    : 0
  Flaps                    : 0
  Flap Duration            : 00:00
  OFDM Profile Id : 2
  Status                   : UP
  Profile Failure          : 1         May 8  15:16:18
  DUP Profile Failure      : 0
  Profile Recovery         : 1         May 8  15:16:44
  DUP Profile Recovery     : 0
```

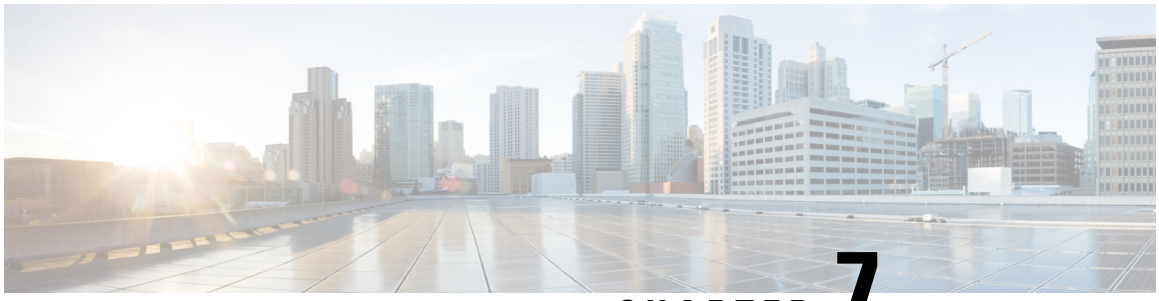
Feature Information for DOCSIS3.1 Downstream Resiliency for RPHY

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 13: Feature Information for DOCSIS3.1 Downstream Resiliency for RPHY

Feature Name	Releases	Feature Information
DOCSIS3.1 Downstream Resiliency for RPHY	Cisco 1x2 / Compact Shelf RPD Software 4.1	This feature was introduced on the Cisco Remote PHY Device.



CHAPTER 7

Dynamic Bonding Group for RPHY

The Dynamic Bonding Group (DBG) feature enables the system to automatically create bonding groups of different sizes based on the cable modems' capacity. It helps to manage the resources of all downstream bonding groups. When the number of available bonding groups reaches the lower limit, it reclaims the bonding groups that match the reclaim threshold set by the user. The modems used on these bonding groups are then moved to other bonding groups without primary channel change. This move makes space for new bonding group allocations. This automated way of creating and reclaiming bonding groups greatly reduces the management effort of RCC configuration. DBG also automatically accommodates primary channel and CM capacity distributions.

The load balancing feature leverages DBG to balance traffic among all channels. With DBG, the modem is assigned to the downstream bonding group without any static RCC configuration.

DBG supports the following:

- DOCSIS 3.0 and DOCSIS 3.1 channel types.
- DOCSIS 3.0 and DOCSIS 3.1 load balance.
- Interoperation with modem registration, load balancing, and high availability.
- Enhanced dynamic load balance to allow movement of modem without a change in the primary channel.
- Enhanced FPGA to allow channel utilization fairness.

This chapter describes how to configure the DBG feature on the Cisco Remote PHY Device.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Use Cisco Feature Navigator to find information about the platform support and Cisco software image support. To access Cisco Feature Navigator, go to the link http://tools.cisco.com/ITDIT/CFN/. An account at the http://www.cisco.com/ site is not required.

Hardware Compatibility Matrix for Cisco Remote PHY Device

Note Unless otherwise specified, the hardware components introduced in a given Cisco Remote PHY Device Software Release are supported in all subsequent releases.

Table 14: Hardware Compatibility Matrix for the Cisco Remote PHY Device

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Node	Cisco 1x2 / Compact Shelf RPD Software 2.1 and Later Releases
Cisco GS7000 Super High Output Intelligent Node (iNode)	Cisco 1x2 / Compact Shelf RPD Software 4.1 and Later Releases Cisco Intelligent Remote PHY Device 1x2 • PID—iRPD-1X2= • PID—iRPD-1X2-PKEY=

Note The -PKEY suffix in the PID indicates units that enable the SCTE-55-2 Out-of-Band protocol support.

Configure Dynamic Bonding Group

Before configuring DBG, it is assumed that interface Mac domain and fiber node are already configured on the Cisco cbr-8 router. The recommended primary channel distribution is one primary channel for contiguous four channels, such as 0, 4, 8, 12, 16, 20, 24, 28 and so on. For more information, see DOCSIS Interface and Fiber Node Configuration in the Cisco cBR Converged Broadband Routers DOCSIS Software Configuration Guide.

Enable Dynamic Bonding Group

DBG is disabled by default. Use **cable dynamic-bonding-group** command to enable DBG as shown in the following example:

```
ROUTER# configure terminal
ROUTER(config)# cable dynamic-bonding-group
ROUTER(config)# end
```

To configure the bonding group reclaim threshold, use **cable dynamic-bonding-group reclaim-threshold** command as shown in the following example:

```
ROUTER# configure terminal
```

```
ROUTER(config)# cable dynamic-bonding-group reclaim-threshold percent 5% modems 6
ROUTER(config)# end
```

5% is the default bonding group throughput percentage threshold, and 6 is the default cable modem count threshold. If the throughput of a bonding group is lower than 5% of all bonding groups' throughput, and this bonding group has less than 6 cable modems assigned to it, then this bonding group is reclaimed when the available bonding groups reach the lower limit (20%).

By default, cable modem registration and load balance trigger DBG creation when needed. If you want to disable the interoperation with cable modem registration and load balance, use the commands in the following example:

```
ROUTER# configure terminal
ROUTER(config)# no cable dynamic-bonding-group registration

ROUTER# configure terminal
ROUTER(config)# no cable dynamic-bonding-group load-balance
```

When DBG is enabled, we recommend you to complete the following configurations.

Enable DS-Resiliency and Configure Resiliency Bonding Group

To make sure that the modem is still in w-online state with maximum downstream capability when several RF channels are impaired, enable the ds-resiliency feature by running the following commands:

```
Router# configure terminal
Router(config)# cable resiliency ds-bonding
Router(config)# end


Router# configure terminal
Router(config)# interface wideband-Cable 3/0/1:30
Router(config-if)# cable ds-resiliency
Wideband-Cable3/0/1:30 is set to WB resiliency bonding group.
Remove any existing bundle and rf-channel configuration.
Router(config-if)# end
```

Enable ACFE

Enable ACFE feature to make sure that modem registration is not blocked because of QoS failures:

```
Router# configure terminal
Router(config)# cable acfe enable
Router(config)# end
```

Verify Dynamic Bonding Group Configuration

This section describes how to use certain **show** commands to verify if the dynamic bonding groups are created.

Check the modem's primary wideband interface using the **show cable modem wideband channel** command as shown in this example:

```
Router# show cable modem 4800.33ee.ebee wideband channel
MAC Address         IP Address         I/F          MAC         DSxUS     Primary
                                                    State                 WB
4800.33ee.ebee      30.132.15.246      C3/0/1/UB    w-online    32x2      Wi3/0/1:3
```

Check the modem's downstream tuner capability using the **show cable modem verbose | in DS Tuner** command as shown in the following example:

```
Router# show cable modem 4800.33ee.ebee verbose | in DS Tuner
DS Tuner Capability : 32
```

Check the related RCC using the **show cable mac-domain rcc** command as shown in the following example:

```
Router# show cable mac-domain c3/0/1 rcc
RCC-ID   RCP             RCs  MD-DS-SG  CMs  WB/RCC-TMPL       D3.0    D3.1
32       00 00 00 00 00  8    0         11   WB (Wi3/0/1:1)    Y       Y
33       00 00 00 00 00  32   0         6    WB (Wi3/0/1:3)    Y       Y
34       00 00 00 00 00  8    0         7    WB (Wi3/0/1:2)    Y       Y
35       00 00 00 00 00  8    0         7    WB (Wi3/0/1:4)    Y       Y
36       00 00 00 00 00  8    0         7    WB (Wi3/0/1:5)    Y       Y
```

Check the dynamically created bonding groups using the **show cable dynamic-bonding-group summary** command as shown in the following example:

```
Router# show cable dynamic-bonding-group summary
Dynamic bonding group: Enable
BG ID BG Name   BG Size CMs ServFlows Create Time         Create Client       BG State
RFid list
24834 Wi3/0/1:1 8       11  11        Sep 14 14:36:35.194 MODEM_ONLINE        OPERATIONAL
24832-24839
24836 Wi3/0/1:3 32      6    6        Sep 14 14:43:24.144 MODEM_ONLINE        OPERATIONAL
24832-24863
24835 Wi3/0/1:2 8       7    7        Sep 14 17:20:37.115 MODEM_ONLINE        OPERATIONAL
24840-24847
24837 Wi3/0/1:4 8       7    7        Sep 14 17:21:37.723 STATIC_LOAD_BALANCE OPERATIONAL
24856-24863
24838 Wi3/0/1:5 8       7    7        Sep 14 17:21:39.761 STATIC_LOAD_BALANCE OPERATIONAL
24848-24855
```

This example shows the DBG with D31 modems:

```
Router# show cable mac-domain c1/0/4 rcc
RCC-ID   RCP             RCs MD-DS-SG CMs   WB/RCC-TMPL      D3.0  D3.1
7        00 00 00 00 00  33  0        51    WB (Wi1/0/4:2)   N     Y
8        00 00 00 00 00  8   0        2     WB (Wi1/0/4:3)   Y     Y
9        00 00 00 00 00  8   0        1     WB (Wi1/0/4:4)   Y     Y
```

```
Router# show cable dynamic-bonding-group summary
Dynamic bonding group: Enable
BG ID BG Name      BG Size  CMs  ServFlows Create Time           Create Client        BG
State             RFid list
9219  Wi1/0/4:2    33       51   51        Sep 26 13:56:00.337   MODEM_ONLINE
OPERATIONAL          9216-9247, 9375
9220  Wi1/0/4:3    8        2    2         Sep 26 13:56:19.011   MODEM_ONLINE
OPERATIONAL          9216-9223
9221  Wi1/0/4:4    8        1    1         Sep 26 13:56:36.090   MODEM_ONLINE
OPERATIONAL          9240-9247
```

Table 15: Dynamic Bonding Group States

DBG State	Description
CREATE_WAITING_SUP	Line card sends a request to create DBG and waits for SUP to create the bonding group.

DBG State	Description
HOLD	DBG is created from SUP, or bonding group reverts from reclaim to ready-for-use state.
OPERATIONAL	If a modem is used on the bonding group after the HOLD state times out, the DBG state changes to OPERATIONAL.
RECLAIM_HOLD	Ready for reclaim. If no modem is used on the bonding group or match the reclaim in two minutes, the bonding group is reclaimed. The DBG state changes to RECLAIM_HOLD.
RECLAIM_MODEM_MOVING	Ready for reclaim. The modem is moved out of the bonding group.
RECLAIM_WAITING_SUP	Line card sends a DBG reclaim request and waits for SUP to reclaim the BG.

To display the detailed channel list information of dynamic bonding group, use the **show derived-config interface wideband** command as shown in the following example:

```
Router# show derived-config interface wideband-Cable 3/0/1:1
Building configuration...
Derived configuration: 113 bytes
!
interface Wideband-Cable3/0/1:1
  cable bundle 255
  cable rf-channels channel-list 0-7 bandwidth-percent 1
end
```

Check the usage of bonding group resource using the **show cable dynamic-bonding-group quota** command.

```
Router# show cable dynamic-bonding-group quota controller 3/0/1
slot/subslot/ctrlr: 3/0/1
Total BG number: 128
Used BG number (static/dynamic): 6(1/5) Available BG number: 122
Available BG list port: 0, 6-29, 31-127
```

Check the reclaimed bonding group using the **show cable dynamic-bonding-group reclaim-history summary** command:

```
Router# show cable dynamic-bonding-group reclaim-history summary
BG ID BG Name   BG Size Create Time     Create Client Reclaim Time    Reclaim Client RFid
list
24835 Wi3/0/1:2 16      Sep 14 14:40:27 MODEM_ONLINE  Sep 14 14:44:27 DBG_INTERNAL
24832-2484
```

Configure Load Balancing with Dynamic Bonding Group Enabled

If you want to use load balancing with the DBG enabled, we recommend that you configure the load balancing as shown here.

Enable Load Balancing for DOCSIS 3.0 and DOCSIS 3.1

To enable DOCSIS load balancing, run the following commands:

```
Router# config terminal
Router(config)# cable load-balance docsis-enable
Router(config)# end
```

When DOCSIS load balancing is enabled, run the following commands to enable load balancing for DOCSIS 3.0 and DOCSIS 3.1.

```
Router# config terminal
Router(config)# cable load-balance docsis30-enable
Router(config)# end
```

Enable DOCSIS 3.0 and DOCSIS 3.1 Static Load Balance

To balance the load of primary channels, enable static load balance using the following commands:

```
Router# configure terminal
Router(config)# cable load-balance docsis30-enable static
Router(config)# end
```

Enable DOCSIS 3.0 and DOCSIS 3.1 General Load Balance Group

To enable general load balance group, use cable load-balance docsis-group command as shown here:

```
Router# configure terminal
Router(config)# cable load-balance docsis-group fn 1 md c3/0/1
Router(config-lb-group)# no disable
Router(config-lb-group)# end
```

Enable Dynamic Load Balance and Fixed-Primary Channel Movement

To balance the load of all downstream channels based on utilization, enable dynamic load balance by running the following commands:

```
Router# configure terminal
Router(config)# cable load-balance docsis30-enable dynamic downstream
Router(config)# end
```

Fixed primary channel movement is disabled by default. With dynamic load balancing enabled, we recommend that you enable fixed primary channel movement to reduce service outage by running the following commands:

```
Router# configure terminal
Router(config)# cable load-balance fixed-primary-channel
Router(config)# end
```

Verify Static Load Balancing Configuration

This section describes how to use **show** commands to verify the configuration of the static load balancing.

Check the load of all primary channels using the **show cable load-balance docsis-group load** command as shown here:

```
Router# show cable load-balance docsis-group fn 1 md c3/0/1 load | in In
Interface            State   Group      Utilization Rsvd NBCM WB/UB Weight
In3/0/1:0(573 MHz)   initial 2147557888 0%(0%/0%)   0%   0    17    37
In3/0/1:4(597 MHz)   initial 2147557888 0%(0%/0%)   0%   0    17    37
In3/0/1:8(621 MHz)   initial 2147557888 0%(0%/0%)   0%   0    13    37
In3/0/1:12(645 MHz) initial 2147557888 0%(0%/0%)   0%   0    13    37
In3/0/1:16(669 MHz) initial 2147557888 0%(0%/0%)   0%   0    13    37
In3/0/1:20(693 MHz) initial 2147557888 0%(0%/0%)   0%   0    13    37
In3/0/1:24(717 MHz) initial 2147557888 0%(0%/0%)   0%   0    13    37
In3/0/1:28(741 MHz) initial 2147557888 0%(0%/0%)   0%   0    13    37
```

This command output lists all primary channels and shows the number of cable modems used with these channels. NBCM is the number of narrowband modems used with a channel while WBCM (WB/UB) is the number of wideband modems used with a channel. The total number of WBCMs must be balanced among all channels.

The difference between the total number of WBCMs used with any two channels is smaller or equal to the minimum threshold load. The default value of the minimum threshold load is 5.

This example shows the load in DOCSIS 3.1 static load balancing configuration:

```
Router# show cable load-balance docsis-group fn 33 md c3/0/0 load | i In
Interface            State    Group      Utilization Rsvd NBCM WB/UB Weight
In3/0/0:0(453 MHz)   initial  2147557408 1%(0%/1%)   0%   0    16    37
In3/0/0:8(501 MHz)   initial  2147557408 1%(0%/1%)   0%   0    16    37
In3/0/0:30(633 MHz) initial  2147557408 1%(0%/1%)   0%   0    12    37
In3/0/0:40(693 MHz) initial  2147557408 1%(0%/1%)   0%   0    15    37
In3/0/0:55(783 MHz) initial  2147557408 1%(0%/1%)   0%   0    12    37
In3/0/0:158(258 MHz initial  2147557408 1%(0%/1%)   0%   0    21    224

   - Above example, the modem count balanced with a configured threshold of 5

  - Count based load balancing is done only on sc-qam channels of equal weight. OFDM channel
 is of much higher weight and is excluded from the modem count calculations.
```

Check the load of all RF channels using the **show cable load-balance docsis-group rfch-util** command as shown in this example:

```
Router# show cable load-balance docsis-group fn 1 md c3/0/1 rfch-util
Interface  Pstate Pending-In Pending-Out Throughput(Kbps) Util NBCM WBCM
In3/0/1:0  up     No         No          0                0%   0    17
In3/0/1:1  NA     No         No          0                0%   0    17
In3/0/1:2  NA     No         No          0                0%   0    17
In3/0/1:3  NA     No         No          0                0%   0    17
In3/0/1:4  up     No         No          0                0%   0    17
In3/0/1:5  NA     No         No          0                0%   0    17
In3/0/1:6  NA     No         No          0                0%   0    17
In3/0/1:7  NA     No         No          0                0%   0    17
In3/0/1:8  up     No         No          0                0%   0    13
In3/0/1:9  NA     No         No          0                0%   0    13
In3/0/1:10 NA     No         No          0                0%   0    13
In3/0/1:11 NA     No         No          0                0%   0    13
In3/0/1:12 up     No         No          0                0%   0    13
In3/0/1:13 NA     No         No          0                0%   0    13
In3/0/1:14 NA     No         No          0                0%   0    13
In3/0/1:15 NA     No         No          0                0%   0    13
……
Average: 0.0
Variance: 0.0
```

This command lists the load information of the primary and secondary channels. WBCM is the number of wideband modems used with a channel.

Check the cable modem's internal state in load balancing using the **show cable load-balance docsis-group modem-list wideband** command as shown in this example:

```
Router# show cable load-balance docsis-group fn 1 md c3/0/1 modem-list wideband
Codes: M - Multicast, U - UGS, P - PCMM, F - Max-Failures, X - eXcluded
       L - L2vpn, R - RSVP, S - DS-Resiliency
Primary WB    MAC Address     Primary DS  RCC-ID Priority MUPFXLRS State
Wi3/0/1:0     (3)
              c8fb.2631.0e56  In3/0/1:20  41     0        ------   LB_CM_HOLD_EXPIRE_IN 36
              c8fb.26a6.c3dc  In3/0/1:16  41     0        ------   LB_CM_HOLD_EXPIRE_IN 37
              c8fb.2631.0d7e  In3/0/1:16  41     0        ------   LB_CM_HOLD_EXPIRE_IN 43
Wi3/0/1:1     (9)
              c8fb.2631.0c80  In3/0/1:0   32     0        ------   LB_CM_STATIC_MOVING
              c8fb.2631.0cae  In3/0/1:0   32     0        ------   LB_CM_STATIC_READY
              c8fb.2631.0db0  In3/0/1:24  42     0        ------   LB_CM_STATIC_MOVING
              c8fb.2631.0c10  In3/0/1:28  42     0        ------   LB_CM_STATIC_MOVING
              c8fb.2631.0d80  In3/0/1:16  41     0        ------   LB_CM_STATIC_MOVING
              c8fb.2631.0d26  In3/0/1:24  41     0        ------   LB_CM_STATIC_MOVING
              a4a2.4a2d.b4aa  In3/0/1:20  41     0        ------   LB_CM_STATIC_MOVING
              c8fb.2631.0e5c  In3/0/1:0   32     0        ------   LB_CM_STATIC_MOVING
              c8fb.2631.0cb0  In3/0/1:0   32     0        ------   LB_CM_STATIC_MOVING
Wi3/0/1:2     (3)
              c8fb.2631.0d2a  In3/0/1:12  34     0        ------   LB_CM_HOLD_EXPIRE_IN 27
              c8fb.2631.0e5a  In3/0/1:12  34     0        ------   LB_CM_STATIC_MOVING
              c8fb.2631.0bfe  In3/0/1:8   34     0        ------   LB_CM_STATIC_MOVING
Wi3/0/1:3     (2)
              4800.33ea.54be  In3/0/1:28  33     0        ------   LB_CM_DYNAMIC_READY
              4800.33ee.ebe6  In3/0/1:20  33     0        ------   LB_CM_HOLD_EXPIRE_IN 1
Wi3/0/1:4     (2)
              c8fb.2631.0e44  In3/0/1:24  42     0        ------   LB_CM_HOLD_EXPIRE_IN 40
              c8fb.2631.0a44  In3/0/1:28  42     0        ------   LB_CM_HOLD_EXPIRE_IN 42
```

Table 16: Cable Modem States

CM State	Description
LB_CM_STATIC_READY	Modem is ready for static load balance movement.
LB_CM_STATIC_MOVING	Modem is in movement triggered by static load balance.
LB_CM_HOLD_EXPIRE_IN	Modem is in hold for the next movement. The default hold time, in seconds, is 600.
LB_CM_DYANMIC_READY	Modem is ready for dynamic load balance movement.
LB_CM_DYANMIC_MOVING	Modem is in movement triggered by dynamic load balance.
LB_CM_DISABLED	Modem is not ready for movement. If the modem failure movement count reaches maximum failure threshold, then set the modem in LB_CM_DISABLED to avoid further movement.

Verify Dynamic Load Balancing Configuration

This section describes how to use the **show** commands to verify the configuration of the dynamic load balancing.

Check the utilization of all RF channels using **show cable load-balance docsis-group rfch-util** command as shown in this example:

```
Router# show cable load-balance docsis-group fn 320 md c3/0/0 rfch-util
Interface  Pstate Pending-In Pending-Out Throughput(Kbps) Util NBCM WBCM
Do3/0/0:0  up     No         No          11754            31%  0    308
Do3/0/0:1  up     No         No          11754            31%  0    296
Do3/0/0:2  up     No         No          11754            31%  0    333
Do3/0/0:3  up     No         No          11754            31%  0    296
Do3/0/0:4  up     No         No          11754            31%  0    297
Do3/0/0:5  up     No         No          11754            31%  0    331
Do3/0/0:6  up     No         No          11754            31%  0    299
Do3/0/0:7  up     No         No          11753            31%  0    268
Do3/0/0:8  up     No         No          11754            31%  0    302
Do3/0/0:9  up     No         No          11754            31%  0    331
Do3/0/0:10 up     No         No          11753            31%  0    308
Do3/0/0:11 up     No         No          11754            31%  0    305
Do3/0/0:12 NA     No         No          12862            34%  0    258
Do3/0/0:13 NA     No         No          12862            34%  0    258
Do3/0/0:14 NA     No         No          12862            34%  0    258
……
Average: 30.416
Variance: 1.701
```

The traffic among all RF channels is considered balanced when the difference between any two RF channel utilization is under the threshold load. The default percentage of threshold load is 10%.

To check the potential target bonding group for each of the source bonding group, use the **show cable load-balance docsis-group target dbg** and the **show cable load-balance docsis-group target wide** commands as shown in this example:

```
Router# show cable load-balance docsis-group fn 320 md c3/0/0 target dbg
Interface      Bg-Id       Size     Group          Target
Wi3/0/0:0      24577       4        2147557695
Wi3/0/0:3      24580       4        2147557695
Wi3/0/0:4      24581       8        2147557695
Wi3/0/0:5      24582       8        2147557695
Wi3/0/0:6      24583       24       2147557695     33% [24576, 24584-24587, 24589-24607]
Wi3/0/0:7      24584       16       2147557695     30% [24576, 24586-24587, 24595-24607]
Wi3/0/0:8      24585       16       2147557695
Wi3/0/0:9      24586       32       2147557695
Wi3/0/0:10     24587       24       2147557695     33% [24576, 24584-24587, 24589-24607]
Wi3/0/0:11     24588       8        2147557695
Wi3/0/0:12     24589       8        2147557695     27% [24596-24603]
Wi3/0/0:13     24590       8        2147557695
Wi3/0/0:14     24591       4        2147557695

Router# show cable load-balance docsis-group fn 5 md c1/0/4 target wide
Interface      Bg-Id       State    Group          Target
Wi1/0/4:2      9219        up       2147510276     Wi1/0/4:4
Wi1/0/4:3      9220        up       2147510276
Wi1/0/4:4      9221        up       2147510276
```

If there is no target bonding group in the output, it means that no bonding groups are created to balance traffic among RF channels.

A sample output for DOCSIS 3.1 modems with a configured threshold of 14% is shown. For utilization based load balancing to start on DOCSIS 3.1 modems, the OFDM channel must be utilized 100% and SC-QAM must have traffic. The utilization-based load balancing balances the traffic on the SC-QAM channels in a DOCSIS 3.1 modem.

```
Router# show cable load-balance docsis-group fn 5 md c1/0/4 rfch-util
Interface     Pstate  Pending-In  Pending-Out  Throughput(Kbps)  Util  NBCM  WBCM
In1/0/4:0     up      No          No           10632             28%   0     45
In1/0/4:1     NA      No          No           11226             29%   0     41
In1/0/4:2     NA      No          No           11225             29%   0     41
In1/0/4:3     NA      No          No           11225             29%   0     41
In1/0/4:4     down    No          No           11225             29%   0     41
In1/0/4:5     down    No          No           11225             29%   0     41
In1/0/4:6     down    No          No           11225             29%   0     41
In1/0/4:7     down    No          No           11225             29%   0     41
In1/0/4:8     up      No          No           10620             28%   0     43
....
....
In1/0/4:35    NA      No          No           6646              17%   0     6
In1/0/4:36    NA      No          No           6646              17%   0     6
In1/0/4:37    NA      No          No           6647              17%   0     6
In1/0/4:38    NA      No          No           6646              17%   0     6
In1/0/4:39    NA      No          No           6647              17%   0     6
In1/0/4:40    up      No          No           6088              16%   0     6
In1/0/4:41    NA      No          No           6648              17%   0     6
In1/0/4:42    NA      No          No           6647              17%   0     6
In1/0/4:43    NA      No          No           6647              17%   0     6
In1/0/4:44    NA      No          No           6646              17%   0     6
In1/0/4:45    NA      No          No           6646              17%   0     6
In1/0/4:46    No      No          No           6647              17%   0     6
In1/0/4:47    NA      No          No           6648              17%   0     6
In1/0/4:48    NA      No          No           6648              17%   0     6
In1/0/4:49    NA      No          No           6648              17%   0     6
In1/0/4:50    NA      No          No           6646              17%   0     6
In1/0/4:51    NA      No          No           6648              17%   0     6
In1/0/4:52    NA      No          No           6647              17%   0     6
In1/0/4:53    NA      No          No           6648              17%   0     6
In1/0/4:54    No      No          No           6647              17%   0     6
In1/0/4:55    NA      No          No           6648              17%   0     6
In1/0/4:56    NA      No          No           6647              17%   0     6
In1/0/4:57    NA      No          No           6647              17%   0     6
In1/0/4:58    NA      No          No           6646              17%   0     6
In1/0/4:59    NA      No          No           6645              17%   0     6
In1/0/4:60    NA      No          No           6646              17%   0     6
In1/0/4:61    NA      No          No           6646              17%   0     6
In1/0/4:62    NA      No          No           6647              17%   0     6
In1/0/4:63    NA      No          No           6647              17%   0     6
In1/0/4:159   NA      No          No           1819685           100%  0     47
```

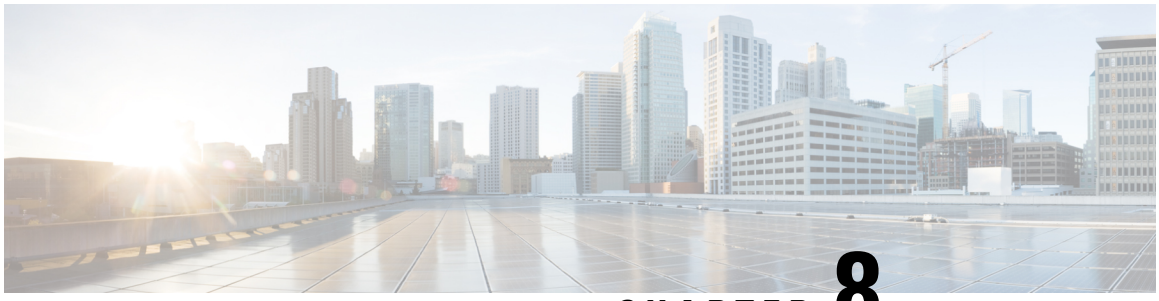
Feature Information for Dynamic Bonding Group

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 17: Feature Information for Dynamic Bonding Group

Feature Name	Releases	Feature Information
Dynamic Bonding Group	Cisco 1x2 / Compact Shelf RPD Software 4.1	This feature was introduced on the Cisco Remote PHY Device.



CHAPTER 8

Cisco Remote PHY Device IPv6

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Use Cisco Feature Navigator to find information about the platform support and Cisco software image support. To access Cisco Feature Navigator, go to the link http://tools.cisco.com/ITDIT/CFN/. An account at the http://www.cisco.com/ site is not required.

Hardware Compatibility Matrix for Cisco Remote PHY Device

Note Unless otherwise specified, the hardware components introduced in a given Cisco Remote PHY Device Software Release are supported in all subsequent releases.

Table 18: Hardware Compatibility Matrix for the Cisco Remote PHY Device

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Node	Cisco 1x2 / Compact Shelf RPD Software 2.1 and Later Releases

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Intelligent Node (iNode)	Cisco 1x2 / Compact Shelf RPD Software 4.1 and Later Releases Cisco Intelligent Remote PHY Device 1x2 • PID—iRPD-1X2= • PID—iRPD-1X2-PKEY=

Note The -PKEY suffix in the PID indicates units that enable the SCTE-55-2 Out-of-Band protocol support.

Information about RPD IPv6

The CableLabs' MHAv2 standards requires CCAP Core and RPD must support both IPv4 and IPv6, which means the Remote PHY Signaling between the CCAP Core and RPD is able to run on both IPv4 and IPv6 networks.

Note
- CCAP Core can support IPv4/IPv6 dual stack.
- RPD can support either IPv4 or IPv6 network.
- RPD does not support IPv4/IPv6 Dual Stack at the same time.
- RPD will try IPv6 connection first. When DHCPv6 failed, RPD will try DHCPv4.
- For single RPD, all the server addresses, protocols to communicate with it must be in the same IP version.

Configure RPD IPv6 Unicast Online

This section describes how to configure RPD IPv6 Unicast Online on Cisco cBR-8.

Configure Unicast IPv6

To configure Unicast IPv6, complete the following procedure:

1. Enable IPv6 unicast routing.

```
configure terminal
ipv6 unicast-routing
```

2. Configure IPv6 Address on DPIC interface.

```
configure terminal
interface TenGigabitEthernet slot/1/port
```

```
ipv6 enable
ipv6 address ipv6_address
```

Configure RPD core interface

To configure RPD core interface, complete the following procedure:

```
configure terminal
cable rpd name
identifier rpd_mac
core-interface tenG_interface
principal
rpd-ds id downstream-cable controller profile id
rpd-us id upstream-cable controller profile id
```

Configure IPv6 PTP Clock Option

To configure the IPv6 PTP Clock Option, complete the following procedure:

1. Configure CBR as secondary PTP, see the configuration example below:

```
configure terminal
    interface Loopback1588
        ip address 158.158.158.5 255.255.255.255
    ptp clock ordinary domain 0
        servo tracking-type R-DTI
        clock-port slave-from-903 slave
        delay-req interval -4
        sync interval -5
        sync one-step
        transport ipv4 unicast interface Lo15888 negotiation
        clock source 10.90.3.93
```

Note CCAP-Core as secondary PTP can only support IPv4.

2. Configure R-DTI for RPD PTP IPv6.

```
configure terminal
ptp r-dti number
ptp-domain domain
clock-port number
ethernet number
transport ipv6
clock source ipv6 address gateway ipv6 geteway
```

Note

- PTP domain and 1588 primary have same domain number.
- Clock source IPv6 address is 1588 primary IPv6 address.
- Gateway is next hop to 1588 primary, and it is optional.
- For RPD, ethernet 1=vbh0, ethernet 2=vbh1, ethernet 0 will choose either vbh0 or vbh1 which is functional as clock-port.

3. Associate R-DTI with RPD configuration.

```
configure terminal
cable rpd id
r-dti number
```

Verify IPv6 PTP Clock Option Configuration

To display the CBR PTP Status, use the **show ptp clock running** command as shown in the example below:

```
Router# show ptp clock running
Load for five secs: 6%/2%; one minute: 7%; five minutes: 8%
No time source, *05:11:13.610 UTC Sun Oct 22 2017
PTP Ordinary Clock [Domain 0]
         State          Ports          Pkts sent      Pkts rcvd      Redundancy Mode
         PHASE_ALIGNED  1              2478203        7512533        Hot standby
                              PORT SUMMARY
                                                                                PTP Master
Name           Tx Mode      Role         Transport    State        Sessions     Port Addr

slave-from-903 unicast      slave        Lo15888      Slave        1            10.90.3.93
```

To display the RPD PTP Status, use the **show ptp clock** command as shown in the example below:

```
Router# show ptp clock 0 config
Domain/Mode         :   0/OC_SLAVE
Priority 1/2/local  : 128/255/128
Profile             : 001b19000100-000000 E2E
Total Ports/Streams : 1  /1
--PTP Port  23, Enet Port   1 ----
  Port local Address :2001:120:102:70:7:1b71:476c:70ba
  Unicast   Duration :300 Sync Interval : -4
  Announce  Interval :  0 Timeout       : 11
  Delay-Req Intreval : -4 Pdelay-req    : -4
  Priority  local    :128 COS:  6   DSCP: 47
  ==Stream 0 : Port 23 Master IP: 2001:10:90:3::93

Router# show ptp clock 0 state
apr state       : PHASE_LOCK
clock state     : SUB_SYNC
current tod     : 1508640223   Sun Oct 22 02:43:43 2017
active stream   : 0
==stream    0   :
  port id       :                0
  master ip     : 2001:10:90:3::93
  stream state  :       PHASE_LOCK
  Master offset :             3490
  Path    delay :           -27209
```

```
  Forward delay :           -27333
  Reverse delay :           -27085
  Freq offset   :          6544364
  1Hz  offset   :               49

Router# show ptp clock 0 statistics
 AprState    4  :
           2@0-00:06:25.027          1@0-00:06:15.382          0@0-00:03:51.377
           4@0-00:03:32.176
 ClockState  5  :
           5@0-00:06:36.141          4@0-00:06:33.684          3@0-00:06:30.510
           2@0-00:06:25.512          1@0-00:06:24.982
 BstPktStrm  1  :
           0@0-00:06:15.987
 StepTime    1  :
   908222863@0-00:05:42.199
 AdjustTime  2589       :
        -339@1-20:18:42.949       -321@1-20:17:41.949         49@1-20:16:40.949
         145@1-20:15:39.949          6@1-20:14:38.949        261@1-20:13:37.949
         327@1-20:12:36.949         76@1-20:11:35.949        157@1-20:10:34.949
streamId  msgType           rx          rxProcessed     lost        tx
 0        SYNC              2549177     2549177         4292476931  0
 0        DELAY REQUEST     0           0               0           2549150
 0        P-DELAY REQUEST   0           0               0           0
 0        P-DELAY RESPONSE  0           0               0           0
 0        FOLLOW UP         0           0               0           0
 0        DELAY RESPONSE    2549144     2549144         4292476934  0
 0        P-DELAY FOLLOWUP  0           0               0           0
 0        ANNOUNCE          159330      159330          4294836225  0
 0        SIGNALING         1662        1662            0           1663
 0        MANAGEMENT        0           0               0           0
   TOTAL                    5259313     5259313         12879790090 2550813
```

Verify RPD IPv6 Configuration

To display the RPD IPv6 Status, use the **show cable rpd ipv6** command as shown in the example below:

```
Router# show cable rpd ipv6
Load for five secs: 7%/2%; one minute: 9%; five minutes: 8%
No time source, *14:03:13.622 UTC Sun Oct 22 2017
MAC Address     I/F       State        Role HA  Auth IP Address
0004.9f03.0226  Te0/1/6   online       Pri  Act N/A  2001:120:102:70:7:1B71:476C:70BA
0004.9f03.0232  Te0/1/7   online       Pri  Act N/A  ---
0004.9f03.0256  Te0/1/2   online       Pri  Act N/A  2001:120:102:70:3:830A:FAEA:CF7E
0004.9f03.0268  Te0/1/6   online       Pri  Act N/A  2001:120:102:70:7:41F1:7CCD:4475
0004.9f03.0268  Te6/1/6   online       Aux  Act N/A  2001:120:102:70:7:41F1:7CCD:4475
badb.ad13.5d7e  Te0/1/2   online       Pri  Act N/A  2001:120:102:70:3:FF46:1FF9:29FE
```

Configure IPv6 DS Splitting

This section describes how to configure RPD IPv6 DS splitting on Cisco cBR-8. In this configuration, different RPDs share the same DS SG traffic. For each DS sharing controller, one unique IPv6 multicast IP is assigned according to multicast pool. When RPD is IPv6 online, all DS sharing Controller associated multicast IPs are IPv6 type. Multiple DS controllers used by one RPD core must be either IPv4 or IPv6 and cannot be mixed. RPD sharing same DS Controller must only be IPv4 or IPv6 online and cannot be mixed. Multiple RPD cores in one RPD must only be IPv4 or IPv6 online and cannot be mixed.

Configure the multicast IPv6 DEPI pool

To configure multicast IPv6 DEPI pool, complete the following procedure:

```
configure terminal
cable depi multicast pool id
ipv6 address ip/prefix
```

Enable Multicast Sharing under Downstream Controller Profile

To configure Unicast IPV6, complete the following procedure (same as IPv4 downstream splitting):

```
configure terminal
cable downstream controller-profile id
multicast-pool id
```

Configure the RPD with the Same Downstream Controller and Profile

To configure the RPDs with the same downstream controller and profile, complete the procedure as shown in the example below (same as IPv4 downstream splitting):

```
configure terminal
    cable rpd node_1
        core-interface tenGigabitEthernet 9/1/0
               rpd-ds 0 controller downstream-cable 9/0/0 profile 0
               rpd-us 0 controller upstream-cable 9/0/0 profile 221
    cable rpd node_2
        core-interface tenGigabitEthernet 9/1/0
               rpd-ds 0 controller downstream-cable 9/0/0 profile 0
               rpd-us 0 controller upstream-cable 9/0/0 profile 221
```

Configure the RPDs to different fiber-nodes

To configure the RPDs to different fiber-nodes, complete the procedure as shown in the example below (same as IPv4 downstream splitting):

```
configure terminal
    cable fiber-node 100
           downstream Downstream-Cable 9/0/0
            upstream Upstream-Cable 9/0/0
    cable fiber-node 101
           downstream Downstream-Cable 9/0/0
            upstream Upstream-Cable 9/0/1
```

Configure the RPDs to MAC Domain

To configure the RPDs to the MAC domain, complete the procedure as shown in the example below (same as IPv4 downstream splitting):

```
configure terminal
    interface Cable9/0/0
        downstream Downstream-Cable 9/0/0 rf-channel 0
        downstream Downstream-Cable 9/0/0 rf-channel 8
        upstream 0 Upstream-Cable 9/0/0 us-channel 0
        upstream 1 Upstream-Cable 9/0/0 us-channel 1
        upstream 2 Upstream-Cable 9/0/0 us-channel 2
```

```
        upstream 3 Upstream-Cable 9/0/0 us-channel 3
        upstream 4 Upstream-Cable 9/0/1 us-channel 0
        upstream 5 Upstream-Cable 9/0/1 us-channel 1
        upstream 6 Upstream-Cable 9/0/1 us-channel 2
        upstream 7 Upstream-Cable 9/0/1 us-channel 3
        cable upstream bonding-group 1
          upstream 0
          upstream 1
          upstream 2
          upstream 3
          attributes 800000F0
        cable upstream bonding-group 2
          upstream 4
          upstream 5
          upstream 6
          upstream 7
          attributes 8000000F
```

Or use the following example (same as IPv4 downstream splitting):

```
configure terminal
    interface Cable9/0/0
        downstream Downstream-Cable 9/0/0 rf-channel 0
        upstream 0 Upstream-Cable 9/0/0 us-channel 0
        upstream 1 Upstream-Cable 9/0/0 us-channel 1
        upstream 2 Upstream-Cable 9/0/0 us-channel 2
        upstream 3 Upstream-Cable 9/0/0 us-channel 3
        cable upstream bonding-group 1
          upstream 0
          upstream 1
          upstream 2
          upstream 3
          attributes 800000F0
configure terminal
    interface Cable9/0/1
        downstream Downstream-Cable 9/0/0 rf-channel 8
        upstream 0 Upstream-Cable 9/0/1 us-channel 0
        upstream 1 Upstream-Cable 9/0/1 us-channel 1
        upstream 2 Upstream-Cable 9/0/1 us-channel 2
        upstream 3 Upstream-Cable 9/0/1 us-channel 3
        cable upstream bonding-group 1
          upstream 0
          upstream 1
          upstream 2
          upstream 3
          attributes 800000F0
```

Enable IPv6 multicast on Cisco cBR-8 Router

To enable the IPv6 multicast on cBR-8, complete the following procedure:

```
configure terminal
ipv6 multicast-routing
```

If cBR-8 and RPD are connected in L2 network, we recommend to enable MLD Snooping in L2 switches.

Verify the IPv6 DS Splitting Configuration

To display the IPv6 multicast DEPI pool, use the **show cable depi multicast pool ipv6** command as shown in the example below:

```
Router# show cable depi multicast pool ipv6
Load for five secs: 8%/2%; one minute: 7%; five minutes: 8%
No time source, *06:57:11.898 UTC Sun Oct 22 2017
POOL ID    IPv6                                          DESCRIPTION
22         FF3B::8000:0/100
50         FF3A::8000:0/126                              zyq
100        FF39::8000:0/120                              zyq
Infra_C05#show cable depi multicast pool ipv6 id 22
Load for five secs: 8%/2%; one minute: 8%; five minutes: 8%
No time source, *07:00:03.577 UTC Sun Oct 22 2017
POOL ID    IPv6                                          DESCRIPTION
22         FF3B::8000:0/100
```

To display the assigned IPv6 multicast address, use the **show cable depi multicast ipv6** command as shown in the example below:

```
Router# show cable depi multicast ipv6 all
Load for five secs: 10%/3%; one minute: 8%; five minutes: 8%
No time source, *07:01:33.659 UTC Sun Oct 22 2017
IPv6                                          POOL ID    CONTROLLER
FF3A::8000:0                                  50         9/0/2(291)
FF3A::8000:1                                  50         9/0/28(317)
FF39::8000:0                                  100        9/0/29(318)
FF3A::8000:2                                  50         9/0/30(319)
Infra_C05#show cable depi multicast ipv6 FF3A::8000:0
Load for five secs: 7%/2%; one minute: 8%; five minutes: 8%
No time source, *07:01:44.020 UTC Sun Oct 22 2017
IPv6                                          POOL ID    CONTROLLER
FF3A::8000:0                                  50         9/0/2(291)
```

To display the relationship between the downstream controller profile and IPv6 multicast Pool, use the **show cable downstream controller-profile** command as shown in the example below:

```
Router# show cable downstream controller-profile 100
Load for five secs: 24%/3%; one minute: 10%; five minutes: 8%
No time source, *07:10:28.074 UTC Sun Oct 22 2017

Downstream controller-profile 100, type RPHY
Description:
Downstream controller-profile 100 is being used by controller Downstream-Cable:
  0/0/30,
  Admin:  UP
  MaxOfdmSpectrum: 192000000
  MaxCarrier: 158
  Mode: normal
  Free freq block list has 3 blocks:
    45000000  - 449999999
    594000000 - 602999999
    795000000 - 1217999999
  DS Splitting: Yes
  Multicast Pool ID: 50
  OFDM frequency exclusion bands: None

Configured RF Channels:
Chan Admin Frequency  Type        Annex Mod  srate Qam-profile  dcid  output
 0    UP   453000000  DOCSIS       B    256   5361  1           1     NORMAL
 1    UP   459000000  DOCSIS       B    256   5361  1           2     NORMAL
 2    UP   465000000  DOCSIS       B    256   5361  1           3     NORMAL
```

To display the RPD associated with the downstream controller, use the **show controllers downstream-Cable** command as shown in the example below:

```
Router# show controllers downstream-Cable 9/0/2 rpd
Load for five secs: 8%/2%; one minute: 9%; five minutes: 8%
```

```
No time source, *07:14:20.326 UTC Sun Oct 22 2017
Controller RPD DS Port List:(2 of 2)
  RPD ID           I/F       Name
  ---------------- --------- ----------------
  badb.ad13.5d7e   Te9/1/2   node_3
  0004.9f03.0256   Te9/1/2   node_5
```

When the DS Controller IPv4/IPv6 type and the RPD IPv4/IPv6 online type conflicts, the RPD log prompts the confliction as shown in the example below:

```
Router# show cable rpd 0004.9f00.0979 Te3/1/0 log reverse
RPD ID I/F Severity Time LOG INFORMATION
---------------- ---------- ------------ ----------------------
-----------------------------------------
0004.9f00.0979 Te3/1/0 ERROR
2017-09-23 21:44:52.851 RPD 0004.9f00.0979 CoreTe 3/1/0 reset connection due to unmatched
IPv4/IPv6 between GCP connection(IPv6) and Downstream Sharing Controllers 3/1/0(IPv4)
0004.9f00.0979 Te3/1/0 ERROR
2017-09-23 21:44:50.817 RPD 0004.9f00.0979 CoreTe 3/1/0 reset connection due to unmatched
IPv4/IPv6 between GCP connection(IPv6) and Downstream Sharing Controllers 3/1/0(IPv4)
```

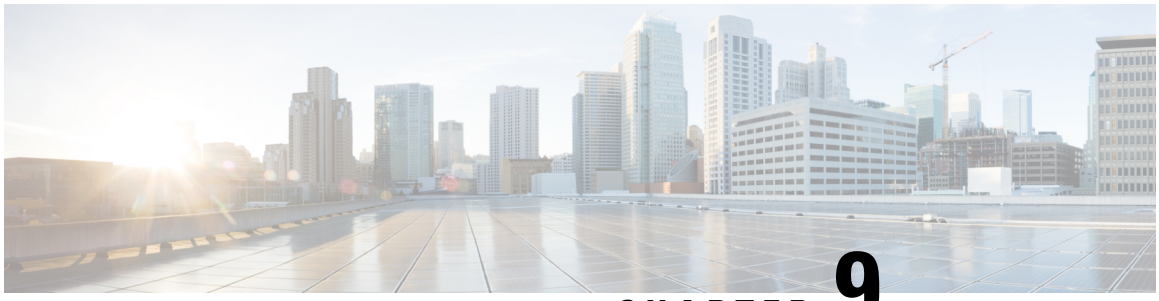
Feature Information for Remote-PHY Device IPv6

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 19: Feature Information for Remote-PHY Device IPv6

Feature Name	Releases	Feature Information
Remote-PHY Device IPv6	Cisco 1x2 / Compact Shelf RPD Software 3.1	This feature was introduced on the Cisco Remote PHY Device.



CHAPTER 9

DOCSIS 3.1 OFDMA Channel Configuration

This document describes the Remote PHY device DOCSIS 3.1 OFDMA channel configuration on the Cisco cBR Series Converged Broadband Router.

Finding Feature Information

Your software release may not support all the features that are documented in this module. For the latest feature information and caveats, see the release notes for your platform and software release. The Feature Information Table at the end of this document provides information about the documented features and lists the releases in which each feature is supported.

Use Cisco Feature Navigator to find information about the platform support and Cisco software image support. To access Cisco Feature Navigator, go to the link http://tools.cisco.com/ITDIT/CFN/. An account at the http://www.cisco.com/ site is not required.

Hardware Compatibility Matrix for Cisco Remote PHY Device

Note Unless otherwise specified, the hardware components introduced in a given Cisco Remote PHY Device Software Release are supported in all subsequent releases.

Table 20: Hardware Compatibility Matrix for the Cisco Remote PHY Device

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Node	Cisco 1x2 / Compact Shelf RPD Software 2.1 and Later Releases

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Intelligent Node (iNode)	Cisco 1x2 / Compact Shelf RPD Software 4.1 and Later Releases Cisco Intelligent Remote PHY Device 1x2 • PID—iRPD-1X2= • PID—iRPD-1X2-PKEY=

Note The -PKEY suffix in the PID indicates units that enable the SCTE-55-2 Out-of-Band protocol support.

Information about OFDMA Channel Configuration

DOCSIS 3.1 introduces modes for higher throughput and higher spectral efficiency while still allowing backward compatibility to DOCSIS 3.0. Orthogonal Frequency Division Multiple Access (OFDMA) channel has following features:

- Frequency-range up to 96 MHz
- Upstream spectrum 5 – 204 MHz
- 25 KHz and 50 KHz subcarrier spacing

Modulation Profile

A globally configured OFDMA modulation profile defines modulation orders and pilot patterns for different interval usage codes (IUC). It is also used to assign parameters for initial ranging and fine ranging.

Modulation Order	Support
BPSK	Yes
QPSK	Yes
8-QAM	Yes
16-QAM	Yes
32-QAM	Yes
64-QAM	Yes
128-QAM	Yes
256-QAM	Yes
512-QAM	Yes

Modulation Order	Support
1024-QAM	Yes
2048-QAM	Yes
4096-QAM	No

OFDMA Channel Exclusion Band

Ranges of frequencies can be excluded from all OFDMA channels on a port using the **ofdma-frequency-exclusion-band** command.

Exclusion and unused bands apply to OFDMA channels only. OFDMA channel never use frequencies in the exclusion band. So the legacy SC-QAM channel can be placed in this band. OFDMA channel does not use frequencies in the unused band set by **ofdma-frequency-unused-band** command for data traffic, but can send probes in them.

TLV66 OFDMA Configuration Read

When the RPD receives a TLV66 read-request for the configured OFDMA channels, it sends a TLV66 read-response message for the following OFDMA attributes.

If the OFDMA channel that is specified in the read-request is invalid or not configured, the RPD sends a read-response with error code and error message.

- AdminState(66.1)
- SubcarrierZeroFreq(66.3)
- FirstActiveSubcarrierNum(66.4)
- LastActiveSubcarrierNum(66.5)
- RollOffPeriod(66.6)
- CyclicPrefix(66.7)
- SubcarrierSpacing(66.8)
- NumSymbolsPerFrame(66.9)
- NumActiveSubcarriers(66.10)
- StartingMinislot(66.11)
- PreambleString(66.12)
- TargetRxPowerAdjust(66.13)
- EnableFlowTags(66.14)
- ScramblerSeed(66.15)
- ConfigMultiSectionTimingMer(66.16)
- BwReqAggrControlOfdma(66.17)

- UsChanId(66.18)
- ConfigChangeCount(66.19)
- DsChanId(66.20)
- BroadcastImRegionDuration(66.21)
- UnicastImRegionDuration(66.22)

Configure OFDMA Channel

Configure OFDMA Modulation Profile

The OFDMA modulation profile is used to configure initial ranging, fine ranging and data IUC parameters. To define the ofdma modulation profile to be applied to OFDMA channels, follow the steps below:

```
enable
configure terminal
cable mod-profile-ofdma id
subcarrier-spacing value
initial-rng-subcarrier value
fine-rng-subcarrier value
data-iuc id modulation value pilot-pattern value
```

Here is a configuration example:

```
Router# enable
Router# configure terminal
Router(config)# cable mod-profile-ofdma 425
  Router(config-ofdma-mod-profile)# subcarrier-spacing 25KHz
  Router(config-ofdma-mod-profile)# initial-rng-subcarrier 64
  Router(config-ofdma-mod-profile)# fine-rng-subcarrier 192
  Router(config-ofdma-mod-profile)# data-iuc 5 modulation 2048-QAM pilot-pattern 11
  Router(config-ofdma-mod-profile)# data-iuc 6 modulation 1024-QAM pilot-pattern 11
  Router(config-ofdma-mod-profile)# data-iuc 9 modulation 256-QAM pilot-pattern 11
  Router(config-ofdma-mod-profile)# data-iuc 10 modulation 128-QAM pilot-pattern 11
  Router(config-ofdma-mod-profile)# data-iuc 11 modulation 64-QAM pilot-pattern 11
  Router(config-ofdma-mod-profile)# data-iuc 12 modulation 32-QAM pilot-pattern 11
  Router(config-ofdma-mod-profile)# data-iuc 13 modulation 16-QAM pilot-pattern 11

Router# enable
Router# configure terminal
Router(config)# cable mod-profile-ofdma 451
Router(config-ofdma-mod-profile)# subcarrier-spacing 50KHz
Router(config-ofdma-mod-profile)# initial-rng-subcarrier 64
Router(config-ofdma-mod-profile)# fine-rng-subcarrier 128
Router(config-ofdma-mod-profile)# data-iuc 13 modulation 1024-QAM pilot-pattern 2
Router(config-ofdma-mod-profile)# exit
Router(config)# cable mod-profile-ofdma 472
Router(config-ofdma-mod-profile)# subcarrier-spacing 25KHz
Router(config-ofdma-mod-profile)# initial-rng-subcarrier 64
Router(config-ofdma-mod-profile)# fine-rng-subcarrier 128
Router(config-ofdma-mod-profile)# data-iuc 6 modulation 1024-QAM pilot-pattern 8
Router(config-ofdma-mod-profile)# data-iuc 9 modulation 1024-QAM pilot-pattern 8
Router(config-ofdma-mod-profile)# data-iuc 10 modulation 512-QAM pilot-pattern 8
Router(config-ofdma-mod-profile)# data-iuc 11 modulation 256-QAM pilot-pattern 8
```

```
Router(config-ofdma-mod-profile)# data-iuc 12 modulation 128-QAM pilot-pattern 9
Router(config-ofdma-mod-profile)# data-iuc 13 modulation 64-QAM pilot-pattern 9
```

Note

- Subcarrier spacing must match the subcarrier spacing of each channel profile in which it is configured.
- Modulation profiles 421 and 461 are the default modulation profiles for 25 KHz and 50 KHz subcarrier spacing respectively. You can add additional modulation profiles. The modulation profile range is between 401-500.
- You must configure subcarrier spacing, ranging, and data IUC 13 before applying modulation profile to a upstream channel.
- Regular pilot patterns (1-4/8-11) and boosted pilot patterns (5-7/12-14) cannot co-exist on the same upstream channel.
- We recommendto not change subcarrier spacing, ranging, and data IUC configuration of a modulation profile that is applied to a channel.

Verify OFDMA Modulation Profile Configuration

To display the OFDMA modulation profile details, use the **show cable modulation-profile ofdma** command as shown in the following example:

```
Router# show cable modulation-profile ofdma
Mod  Subc      IUC type    Act  Preamble  Bit        Pilot
     Spacing               subc Symbols   Loading    Pattern
421  25KHz     3  (IR)     64       4
               4  (FR)     192      1
               13 (data)                  16-QAM     8

423  25KHz     3  (IR)     64       4
               4  (FR)     128      1
               6  (data)                  1024-QAM   8
               10 (data)                  512-QAM    8
               11 (data)                  256-QAM    8
               12 (data)                  128-QAM    9
               13 (data)                  64-QAM     9

461  50KHz     3  (IR)     32       4
               4  (FR)     192      1
               13 (data)                  16-QAM     1

466  50KHz     3  (IR)     64       4
               4  (FR)     128      1
               13 (data)                  1024-QAM   2
```

Configure OFDMA Channel

To configure the OFDMA channel, follow these steps:

```
enable
configure terminal
cable upstream controller-profile id
us-channel id docsis-mode ofdma
```

```
us-channel id subcarrier-spacing value
us-channel id modulation-profile id
us-channel id frequency-range start-value end-value
us-channel id initial-rng-frequency-start value
us-channel id cyclic-prefix value roll-off-period value
us-channel id symbols-per-frame value
us-channel id data-iuc id band start-value end-value modulation value pilot-pattern
 value
```

To use QAM modulation in between specific bandwidth, use the **us-channel** *id* **data-iuc** *id* **band** *start-value end-value* **modulation** *value* **pilot-pattern** *value* command.

Here is a configuration example:

```
Router# enable
Router# configure terminal
Router(config)# cable upstream controller-profile 1
Router(config-controller-profile)# us-channel 12 docsis-mode ofdma
Router(config-controller-profile# us-channel 12 subcarrier-spacing 25KHz
Router(config-controller-profile)# us-channel 12 frequency-range 40000000 85000000
Router(config-controller-profile)# us-channel 12 modulation-profile 423
Router(config-controller-profile)# us-channel 12 cyclic-prefix 640 roll-off-period 224
Router(config-controller-profile)# us-channel 12 symbols-per-frame 9
Router(config-controller-profile)# us-channel 12 data-iuc 9 band 50000000 60000000 modulation
 512-QAM pilot-pattern 8
Router(config-controller-profile)# no us-channel 12 shutdown
```

Note

- A maximum of one OFDMA channel can be configured per controller. For this OFDMA channel, the us-channel index must be set to 12. This corresponds with OFDMA channel 0 on an RPD port.
- Change docsis-mode to **OFDMA** to enable OFDMA configuration options. These options are enabled by default on us-channel 12.
- We recommend that you configure no more than 4 active SC-QAMs while an OFDMA channel is present.
- OFDMA channel can be placed between 5 Mhz and 204 Mhz.
- Values of the options are often interdependent, changing one value may change other values or make them invalid.
- We recommend that you set subcarrier spacing and frequency range first. To achieve a higher OFDMA channel traffic throughput, configure OFDMA channel with 25kHz subcarrier spacing.
- Maximum of 4:1 upstream combining for OFDMA channels is supported.

Bind Upstream Controllers With RPHY Ports

If the upstream channel profile contains ODFMA channel, you can bind up to four RPD ports with the upstream controller.

```
cable rpd node1
 identifier badb.ad15.1288
 core-interface Te7/1/4
   principal
   rpd-ds 0 downstream-cable 7/0/30 profile 10
```

```
   rpd-us 0 upstream-cable 7/0/63 profile 1
   rpd-us 1 upstream-cable 7/0/63 profile 1

cable rpd node2
 identifier badb.ad15.1290
 core-interface Te7/1/4
   principal
   rpd-ds 0 downstream-cable 7/0/31 profile 10
   rpd-us 0 upstream-cable 7/0/63 profile 1
   rpd-us 1 upstream-cable 7/0/63 profile 1
```

Verify OFDMA Channel Configuration

To display the OFDMA channel configuration, use the **show controllers upstream-Cable us-channel** command as shown in the example below:

```
Router# show controllers upstream-Cable 1/0/4 us-channel 12
Controller RPD US Port List:
DevID RPD ID US Port I/F Name
------ --------------- -------- --------- ------------
0 badb.ad13.acfe 0 Te1/1/2 necker-5

USPHY OFDMA support: FULL


Controller 1/0/4 upstream 12  AdminState:UP OpState: UP
  ofdma mode enabled
  Channel Freq Range 35.500 MHz to 79.500 MHz
  Channel Subcarrier Index Range Cfg: 74, 953 Op: 74, 953
  Channel SC0 Freq Cfg: 31.800 MHz Op: 31.800 MHz
  #Excl bands: 2
  (   0,   73), ( 954, 2047),
  #Unused bands: 0
  Cyclic Prefix Size 96,  Rolloff Period Size 64
  Subcarrier Spacing 50KHz,  Symbols Per Frame 18 Subcarrier Per Minislot: 8

  Modulation Profile (ID 466, Subcarrier Spacing 50KHz)
    IUC type   Cfg   Act  Preamble Bit       Pilot
               subc  subc Symbols  Loading   Pattern
    3  (IR)    64    64      4       -         -
    4  (FR)    128   128     1       -         -
    13 (data)  -     -       -     1024-QAM    2
  Calculated Data burst profile:
  IUC  Group   Bit       Pilot   Start  Consec
               Loading   Pattern Mslot  Mslot
  13   0       1024-QAM  2       0       109

  #Total mslots:110 #Fine Rng capable:95 #Initial Rng capable:103
   Initial Rng - Freq 50.000MHz mslotOffset:36 #mslot in frame:8
  Minislot mapping:  mslot#(start_sc start_freq(Mhz) end_sc end_freq(Mhz)
   mslot type(E-Edge; B-Body; S-Share with SCQAM;
   I-Initial rng capable; F-Fine rng capable)
   (next Fine Rng capable minislot if current is not capable))
  0  (  74, 35.500,   81, 35.850, EIF ( - )), 1  (  82, 35.900,   89, 36.250, BIF ( - )),
  2  (  90, 36.300,   97, 36.650, BIF ( - )), 3  (  98, 36.700,  105, 37.050, BIF ( - )),
  4  ( 106, 37.100,  113, 37.450, BIF ( - )), 5  ( 114, 37.500,  121, 37.850, BIF ( - )),
  6  ( 122, 37.900,  129, 38.250, BIF ( - )), 7  ( 130, 38.300,  137, 38.650, BIF ( - )),
  8  ( 138, 38.700,  145, 39.050, BIF ( - )), 9  ( 146, 39.100,  153, 39.450, BIF ( - )),
  10 ( 154, 39.500,  161, 39.850, BIF ( - )), 11 ( 162, 39.900,  169, 40.250, BIF ( - )),
  12 ( 170, 40.300,  177, 40.650, BIF ( - )), 13 ( 178, 40.700,  185, 41.050, BIF ( - )),
  14 ( 186, 41.100,  193, 41.450, BIF ( - )), 15 ( 194, 41.500,  201, 41.850, BIF ( - )),
  16 ( 202, 41.900,  209, 42.250, BIF ( - )), 17 ( 210, 42.300,  217, 42.650, BIF ( - )),
```

```
18 ( 218, 42.700,  225, 43.050, BIF ( - )), 19 ( 226, 43.100,  233, 43.450, BIF ( - )),
20 ( 234, 43.500,  241, 43.850, BIF ( - )), 21 ( 242, 43.900,  249, 44.250, BIF ( - )),
22 ( 250, 44.300,  257, 44.650, BIF ( - )), 23 ( 258, 44.700,  265, 45.050, BIF ( - )),
24 ( 266, 45.100,  273, 45.450, BIF ( - )), 25 ( 274, 45.500,  281, 45.850, BIF ( - )),

26 ( 282, 45.900,  289, 46.250, BIF ( - )), 27 ( 290, 46.300,  297, 46.650, BIF ( - )),
28 ( 298, 46.700,  305, 47.050, BIF ( - )), 29 ( 306, 47.100,  313, 47.450, BIF ( - )),
30 ( 314, 47.500,  321, 47.850, BIF ( - )), 31 ( 322, 47.900,  329, 48.250, BIF ( - )),
32 ( 330, 48.300,  337, 48.650, BIF ( - )), 33 ( 338, 48.700,  345, 49.050, BIF ( - )),
34 ( 346, 49.100,  353, 49.450, BIF ( - )), 35 ( 354, 49.500,  361, 49.850, BIF ( - )),
36 ( 362, 49.900,  369, 50.250, BIF ( - )), 37 ( 370, 50.300,  377, 50.650, BIF ( - )),
38 ( 378, 50.700,  385, 51.050, BIF ( - )), 39 ( 386, 51.100,  393, 51.450, BIF ( - )),
40 ( 394, 51.500,  401, 51.850, BIF ( - )), 41 ( 402, 51.900,  409, 52.250, BIF ( - )),
42 ( 410, 52.300,  417, 52.650, BIF ( - )), 43 ( 418, 52.700,  425, 53.050, BIF ( - )),
44 ( 426, 53.100,  433, 53.450, BIF ( - )), 45 ( 434, 53.500,  441, 53.850, BIF ( - )),
46 ( 442, 53.900,  449, 54.250, BIF ( - )), 47 ( 450, 54.300,  457, 54.650, BIF ( - )),
48 ( 458, 54.700,  465, 55.050, BIF ( - )), 49 ( 466, 55.100,  473, 55.450, BIF ( - )),
50 ( 474, 55.500,  481, 55.850, BIF ( - )), 51 ( 482, 55.900,  489, 56.250, BIF ( - )),
52 ( 490, 56.300,  497, 56.650, BIF ( - )), 53 ( 498, 56.700,  505, 57.050, BIF ( - )),
54 ( 506, 57.100,  513, 57.450, BIF ( - )), 55 ( 514, 57.500,  521, 57.850, BIF ( - )),
56 ( 522, 57.900,  529, 58.250, BIF ( - )), 57 ( 530, 58.300,  537, 58.650, BIF ( - )),
58 ( 538, 58.700,  545, 59.050, BIF ( - )), 59 ( 546, 59.100,  553, 59.450, BIF ( - )),
60 ( 554, 59.500,  561, 59.850, BIF ( - )), 61 ( 562, 59.900,  569, 60.250, BIF ( - )),
62 ( 570, 60.300,  577, 60.650, BIF ( - )), 63 ( 578, 60.700,  585, 61.050, BIF ( - )),
64 ( 586, 61.100,  593, 61.450, BIF ( - )), 65 ( 594, 61.500,  601, 61.850, BIF ( - )),
66 ( 602, 61.900,  609, 62.250, BIF ( - )), 67 ( 610, 62.300,  617, 62.650, BIF ( - )),
68 ( 618, 62.700,  625, 63.050, BIF ( - )), 69 ( 626, 63.100,  633, 63.450, BIF ( - )),
70 ( 634, 63.500,  641, 63.850, BIF ( - )), 71 ( 642, 63.900,  649, 64.250, BIF ( - )),
72 ( 650, 64.300,  657, 64.650, BIF ( - )), 73 ( 658, 64.700,  665, 65.050, BIF ( - )),
74 ( 666, 65.100,  673, 65.450, BIF ( - )), 75 ( 674, 65.500,  681, 65.850, BIF ( - )),
76 ( 682, 65.900,  689, 66.250, BIF ( - )), 77 ( 690, 66.300,  697, 66.650, BIF ( - )),
78 ( 698, 66.700,  705, 67.050, BIF ( - )), 79 ( 706, 67.100,  713, 67.450, BIF ( - )),
80 ( 714, 67.500,  721, 67.850, BIF ( - )), 81 ( 722, 67.900,  729, 68.250, BIF ( - )),
82 ( 730, 68.300,  737, 68.650, BIF ( - )), 83 ( 738, 68.700,  745, 69.050, BIF ( - )),
84 ( 746, 69.100,  753, 69.450, BIF ( - )), 85 ( 754, 69.500,  761, 69.850, BIF ( - )),
86 ( 762, 69.900,  769, 70.250, BIF ( - )), 87 ( 770, 70.300,  777, 70.650, BIF ( - )),
88 ( 778, 70.700,  785, 71.050, BIF ( - )), 89 ( 786, 71.100,  793, 71.450, BIF ( - )),
90 ( 794, 71.500,  801, 71.850, BIF ( - )), 91 ( 802, 71.900,  809, 72.250, BIF ( - )),
92 ( 810, 72.300,  817, 72.650, BIF ( - )), 93 ( 818, 72.700,  825, 73.050, BIF ( - )),
94 ( 826, 73.100,  833, 73.450, BIF ( - )), 95 ( 834, 73.500,  841, 73.850, BI  (0  )),
96 ( 842, 73.900,  849, 74.250, BI  (0  )), 97 ( 850, 74.300,  857, 74.650, BI  (0  )),
98 ( 858, 74.700,  865, 75.050, BI  (0  )), 99 ( 866, 75.100,  873, 75.450, BI  (0  )),
100( 874, 75.500,  881, 75.850, BI  (0  )), 101( 882, 75.900,  889, 76.250, BI  (0  )),
102( 890, 76.300,  897, 76.650, BI  (0  )), 103( 898, 76.700,  905, 77.050, B   (0  )),
104( 906, 77.100,  913, 77.450, B   (0  )), 105( 914, 77.500,  921, 77.850, B   (0  )),
106( 922, 77.900,  929, 78.250, B   (0  )), 107( 930, 78.300,  937, 78.650, B   (0  )),
108( 938, 78.700,  945, 79.050, B   (0  )), 109( 946, 79.100,  953, 79.450, B   (0  )),

Mapped to connector 4 and receiver 108

Bind to Cable1/0/4 US4
MER(SNR) - Unknown - no modems online.
Spectrum Group is unassigned
Nominal Input Power Level 0 dBmV

UCD procedures on lch 0
UCD ucd-proxy-timeout   (0   ) ucd-proxy-wrong-ack (0   )
```

Verify the TLV66 OFDMA Configuration Read

```
R-PHY#show ofdma config
OFDMA Channel Configuration
RF Port                             : 0
```

```
RF channel                          : 0
State                               : UP
Starting Minislot                   : 2212398931
Target Rx Power Adjust              : 0
Enable Flow Tags                    : 1
Max Req Block Enq Timeout           : 0
Max Req Block Enq Number            : 0
Broadcast Im Region Duration        : 6
Unicast Im Region Duration          : 6
UCD Message
  UCD fields
    UCID                            : 8
    CCC                             : 78
    DSID                            : 0
    TLV 24 Change Bitmask           : 0x0000
    TLV 25 Timestamp Snapshot       : 08 3d e8 75 32 25 b7 b2 24
    TLV 26 Cyclic Prefix            : 96
    TLV 27 Rolloff Period           : 64 samples
    TLV 28 Subcarrier Spacing       : 25 KHz
    TLV 29 Subcarrier Zero Freq     : 36800000 Hz
    TLV 32 Symbols in Frame         : 9
    TLV 33 Randomization Seed       : 8153946
    TLV 3 Preamble String           : Preamble Superstring
      ff d7 d5 21 26 ec e5 e7 00 78 7f 63 6b 35 2e 29
      00 88 81 a5 bd 5f 72 7b 01 99 82 ee c7 e1 96 8d
      02 aa 87 33 48 22 bb 97 07 ff 89 55 d8 67 cc b9
      00 80 9b fe 68 a8 55 cb 00 18 1a c2 b9 f8 fe 5d
    TLV 6 Preamble String Extension : Preamble Superstring Extension
    TLV 30 Subcarrier Exclusion Band: Excluded Subcarriers
      [0000 - 0147]  [1908 - 4095]
    TLV 30 Subcarrier Unused Band   : Unused Subcarriers
    TLV 23 Burst Descriptor         : Burst Descriptor
      03 03 02 01 00 04 02 00 00 13 02 00 40
    TLV 23 Burst Descriptor         : Burst Descriptor
      04 03 02 01 00 04 02 00 00 14 02 01 00
    TLV 23 Burst Descriptor         : Burst Descriptor
      05 15 02 a8 6d
    TLV 23 Burst Descriptor         : Burst Descriptor
      09 15 02 98 6d
    TLV 23 Burst Descriptor         : Burst Descriptor
      0d 15 02 88 6d

OFDMA Channel Configuration
RF Port                             : 1
RF channel                          : 0
State                               : UP
Starting Minislot                   : 2212522598
Target Rx Power Adjust              : 0
Enable Flow Tags                    : 1
Max Req Block Enq Timeout           : 0
Max Req Block Enq Number            : 0
Broadcast Im Region Duration        : 5
Unicast Im Region Duration          : 5
UCD Message
  UCD fields
    UCID                            : 9
    CCC                             : 82
    DSID                            : 0
    TLV 24 Change Bitmask           : 0x0000
    TLV 25 Timestamp Snapshot       : 08 3e 06 a6 64 87 a8 59 d4
    TLV 26 Cyclic Prefix            : 512
    TLV 27 Rolloff Period           : 224 samples
    TLV 28 Subcarrier Spacing       : 25 KHz
    TLV 29 Subcarrier Zero Freq     : 1800000 Hz
```

```
TLV 32 Symbols in Frame         : 9
TLV 33 Randomization Seed       : 8153946
TLV 3 Preamble String           : Preamble Superstring
  ff d7 d5 21 26 ec e5 e7 00 78 7f 63 6b 35 2e 29
  00 88 81 a5 bd 5f 72 7b 01 99 82 ee c7 e1 96 8d
  02 aa 87 33 48 22 bb 97 07 ff 89 55 d8 67 cc b9
  00 80 9b fe 68 a8 55 cb 00 18 1a c2 b9 f8 fe 5d
TLV 6 Preamble String Extension : Preamble Superstring Extension
TLV 30 Subcarrier Exclusion Band: Excluded Subcarriers
  [0000 - 0147]  [0688 - 1768]  [3308 - 4095]
TLV 30 Subcarrier Unused Band   : Unused Subcarriers
  [0676 - 0687]  [3305 - 3307]
TLV 23 Burst Descriptor         : Burst Descriptor
  03 03 02 00 80 04 02 00 00 13 02 00 20
TLV 23 Burst Descriptor         : Burst Descriptor
  04 03 02 00 c0 04 02 00 00 14 02 00 c0
TLV 23 Burst Descriptor         : Burst Descriptor
  05 15 02 b8 80
TLV 23 Burst Descriptor         : Burst Descriptor
  06 15 02 a8 80
TLV 23 Burst Descriptor         : Burst Descriptor
  09 15 02 98 80
TLV 23 Burst Descriptor         : Burst Descriptor
  0a 15 02 88 80
TLV 23 Burst Descriptor         : Burst Descriptor
  0b 15 02 78 80
TLV 23 Burst Descriptor         : Burst Descriptor
  0c 15 02 68 80
TLV 23 Burst Descriptor         : Burst Descriptor
  0d 15 02 48 80
```

Configure Exclusion / Unused Bands

An OFDMA channel never uses frequencies that are located in exclusion bands. OFDMA probes are sent on frequencies that are located in the unused bands. Therefore exclusion bands must be used to prevent interference with SC-QAM channels. To configure the Exclusion / Unused Bands, follow these steps:

enable
configure terminal
cable upstream controller-profile *id*
cable ofdma-frequency-exclusion-band *start-value end-value*
cable ofdma-frequency-unused-band *start-value end-value*

Here is a configuration example:

```
Router# enable
Router# configure terminal
Router(config)# cable upstream controller-profile 33
Router(config-controller-profile)# cable ofdma-frequency-exclusion-band 48000000 54200000
Router(config-controller-profile)# cable ofdma-frequency-unused-band 50000000 52000000
Router(config-controller-profile)# us-channel 12 docsis-mode ofdma
Router(config-controller-profile)# us-channel 12 subcarrier-spacing 25KHz
Router(config-controller-profile)# us-channel 12 modulation-profile 423
Router(config-controller-profile)# us-channel 12 frequency-range 45000000 70000000
Router(config-controller-profile)# us-channel 12 cyclic-prefix 96 roll-off-period 64
Router(config-controller-profile)# us-channel 12 symbols-per-frame 18
```

Verify Exclusion / Unused Bands

To display the Exclusion / Unused Band configuration, use the **show controllers upstream-Cable us-channel** command as shown in the following example:

```
Router# show controllers upstream-Cable 1/0/2 us-channel 12
USPHY OFDMA support: FULL

Controller Exclusion Freq List:
( 40.000 MHz, 44.200 MHz),
Controller Unused Freq List:
( 50.000 MHz, 52.000 MHz),

Controller 1/0/9 upstream 12 AdminState:UP OpState: UP
ofdma mode enabled
Channel Freq Range 28.500 MHz to 69.500 MHz
Channel Subcarrier Index Range Cfg: 148, 1787 Op: 148, 1787
Channel SC0 Freq Cfg: 24.800 MHz Op: 24.800 MHz
#Excl bands: 3
( 0, 147), ( 608, 776), (1788, 4095),
#Unused bands: 3
( 596, 607), (1001, 1088), (1777, 1787),
```

Override OFDMA Modulation Profile Per Channel

It is possible to override the modulation and pilot pattern that is used by a particular IUC on a given OFDMA channel as shown with the following command.

enable
configure terminal
cable upstream controller profile *id*
us-channel *id* **data-iuc** *id* **band** *start-value end-value* **modulation** *value* **pilot-pattern** *value*

Here is a configuration example:

```
Router# enable
Router# configure terminal
Router(config)# cable upstream controller profile 33
Router(config-controller-profile)# us-channel 12 docsis-mode ofdma
Router(config-controller-profile)# us-channel 12 subcarrier-spacing 25KHz
Router(config-controller-profile)# us-channel 12 modulation-profile 423
Router(config-controller-profile)# us-channel 12 frequency-range 28000000 70000000
Router(config-controller-profile)# us-channel 12 cyclic-prefix 96 roll-off-period 64
Router(config-controller-profile)# us-channel 12 symbols-per-frame 18
Router(config-controller-profile)# us-channel 12 data-iuc 6 band 60000000 65000000 modulation
 128-QAM pilot-pattern 9
Router(config-controller-profile)# no us-channel 12 shutdown
```

Note Override values are removed from the US channel when changing modulation profile, including when the profile changes due to changes in subcarrier spacing.

Verify Override Configuration

To display the override configuration, use the **show controllers upstream-Cable us-channel** command as shown in the following example:

```
Router# show controllers upstream-Cable 1/0/2 us-channel 12
 .....
   Modulation Profile (ID 423, Subcarrier Spacing 25KHz)
    IUC type    Cfg    Act  Preamble Bit        Pilot
                subc   subc Symbols  Loading    Pattern
    3   (IR)    64     64      4       -          -
    4   (FR)    128    128     1       -          -
    6   (data)  -      -       -     1024-QAM     8
    10  (data)  -      -       -     512-QAM      8
    11  (data)  -      -       -     256-QAM      8
    12  (data)  -      -       -     128-QAM      9
    13  (data)  -      -       -     64-QAM       9
  Overwrite Data Profile:
  IUC  Start       End         Start   End    Bit       Pilot
       Freq(MHz)   Freq(MHz)   Subc    Subc   Loading   Pattern
  6      60.0       65.0       1408    1608   128-QAM   9

   Calculated Data burst profile:
   IUC  Group   Bit        Pilot    Start  Consec
                Loading    Pattern  Mslot  Mslot
   6    0       1024-QAM   8        0      61
   6    1       128-QAM    9        62     11
   6    2       1024-QAM   8        74     10
   10   0       512-QAM    8        0      84
   11   0       256-QAM    8        0      84
   12   0       128-QAM    9        0      84
   13   0       64-QAM     9        0      84
 ......
```

Bind OFDMA Channel Profile to Controller

To bind OFDMA channel profile to a controller, follow this example:

```
cable virtual-service-group sg-upstream-7-0-63 upstream-cable 7/0/63 profile 1

cable rpd node1
 identifier badb.ad15.1288
 core-interface Te7/1/4
   principal
   rpd-ds 0 downstream-cable 7/0/30 profile 10
   rpd-us 1 upstream-cable 7/0/63 profile 1
```

Note We recommend using separate channel profiles to debug issues on specific RPD port.

Bind OFDMA Upstream to Cable Interface

To associate upstream channels with a MAC domain and configure upstream bonding, follow these steps:

```
enable
configure terminal
```

```
interface Cable slot/subslot/interface
upstream id Upstream-Cable slot/subslot/interface us-channel id
cable upstream bonding-group id
upstream id
attributes value
cable bundle id
```

Here is a configuration example:

```
Router# enable
Router# configure terminal
Router(config)# interface Cable 1/0/4
Router(config-if)# downstream Integrated-Cable 1/0/4 rf-channel 0
Router(config-if)# downstream Integrated-Cable 1/0/4 rf-channel 16
Router(config-if)# upstream 0 Upstream-Cable 1/0/0 us-channel 0
Router(config-if)# upstream 1 Upstream-Cable 1/0/0 us-channel 1
Router(config-if)# upstream 2 Upstream-Cable 1/0/0 us-channel 2
Router(config-if)# upstream 3 Upstream-Cable 1/0/0 us-channel 3
Router(config-if)# upstream 6 Upstream-Cable 1/0/0 us-channel 12
Router(config-if)# cable upstream bonding-group 1
Router(config-upstream-bonding)# upstream 0
Router(config-upstream-bonding)# upstream 1
Router(config-upstream-bonding)# upstream 2
Router(config-upstream-bonding)# upstream 3
Router(config-upstream-bonding)# attributes 80000000
Router(config-upstream-bonding)# exit
Router(config-if)# cable upstream bonding-group 2
Router(config-upstream-bonding)# upstream 0
Router(config-upstream-bonding)# upstream 1
Router(config-upstream-bonding)# upstream 2
Router(config-upstream-bonding)# upstream 3
Router(config-upstream-bonding)# upstream 6
Router(config-upstream-bonding)# attributes 80000000
Router(config-upstream-bonding)# exit
Router(config-if)# cable bundle 1
```

Determine DOCSIS 3.1 Cable Modems and the Cable Modems Using OFDMA Upstreams

To display the DOCSIS 3.1 cable modem, use the **show cable modem docsis version d31-capable** command as shown in the following example:

```
Router# show cable modem docsis version d31-capable
MAC Address    I/F            MAC              Reg Oper DSxUS DS   RCC   US
                              State            Ver Ver        OFDM ID    OFDMA
4800.33ea.7012 C1/0/0/UB      w-online(pt)     3.1 3.1  33x4  1    5     1
203d.66ae.4169 C1/0/0/UB      w-online(pt)     3.1 3.1  33x4  1    5     1
```

To display DOCSIS PHY layer information for the cable modem, use the **show cable modem phy** command as shown in the following example:

```
Router# show cable modem 5039.5584.5bbe phy
MAC Address    I/F        Sid   USPwr  USMER Timing DSPwr  DSMER  Mode   DOCSIS
                             (dBmV) (SNR) Offset (dBmV) (SNR)         Prov
                                    (dB)                (dB)
5039.5584.5bbe C1/0/0/U0  15    38.75  ----- 2282   0.00   -----  ofdma  1.1
```

To display the cable modem using OFDMA upstream, use the **show cable modem phy** command as shown in the following example:

```
Router# show cable modem phy | include ofdma
5039.5584.5bbe C1/0/0/U0     15    38.75  ----- 2282    0.00  -----  ofdma  1.1
0895.2a9b.26f1 C1/0/0/U0     16    28.00  ----- 2146    0.00  -----  ofdma  1.1
```

To display the OFDMA channel capacity and utilization, use the **show interface cable mac-scheduler** command as shown in the following example:

```
Router# show interfaces cable 1/0/2 mac-scheduler 6
     DOCSIS 1.1 MAC scheduler for Cable1/0/2/U6 : rate 279807192
     Max potential performance for each configured IUC type
     IUC: 6     rate: 279807192
     IUC: 10    rate: 263104848
     IUC: 11    rate: 233779840
     IUC: 12    rate: 203019328
     IUC: 13    rate: 173899376
     wfq:None
     us_balance:OFF
     dpon_mode:OFF
     fairness:OFF
     Queue[Rng Polls] flows 0
     Queue[CIR Grants] flows 0
     Queue[BE(07) Grants] flows 0
     Queue[BE(06) Grants] flows 0
     Queue[BE(05) Grants] flows 0
     Queue[BE(04) Grants] flows 0
     Queue[BE(03) Grants] flows 0
     Queue[BE(02) Grants] flows 0
     Queue[BE(01) Grants] flows 0
     Queue[BE(00) Grants] flows 0
     Req Slots 38510548
     Req/Data Slots 1275
     Init Mtn Slots 47832
     Stn Mtn Slots 0
     IUC 5 Slots 0
     IUC 6 Slots 6378
     IUC 9 Slots 0
     IUC 10 Slots 254923830
     IUC 11 Slots 220
     IUC 12 Slots 4006
     IUC 13 Slots 251213508
     Avg upstream channel utilization : 0%
     Avg upstream channel utilization in 30 sec : 0%
     Avg percent contention slots : 96%
     Avg percent initial ranging slots : 0%
     Avg percent minislots lost on late MAPs : 0%

     MAP TSS: lch_state 10, init_retries 0
              late_initial_maps 0, late_ucd_maps 0
              mac-phy tss errors 0, missed ccc 0
```

Verify DOCSIS 3.1 Upstream OFDMA Channel Bonding Across DOCSIS 3.0 ATDMA Channels

DOCSIS 3.1 Upstream OFDMA channel can be bonded with DOCSIS 3.0 ATDMA channel. If the user wants to utilize non-best effort flows, it is recommended to bond the OFDMA channel with one or more ATDMA channels. A maximum of 1 OFDMA channel and 4 ATDMA channels can be bonded together.

Below is an output example showing the bonding group 8 has both OFDMA (channel 12) and ATDMA channels (channel 0, 1, 2, 3).

```
interface Cable6/0/0
downstream Integrated-Cable 6/0/0 rf-channel 1
downstream Integrated-Cable 6/0/0 rf-channel 158
upstream 0 Upstream-Cable 6/0/0 us-channel 0
upstream 1 Upstream-Cable 6/0/0 us-channel 1
upstream 2 Upstream-Cable 6/0/0 us-channel 2
upstream 3 Upstream-Cable 6/0/0 us-channel 3
upstream 6 Upstream-Cable 6/0/0 us-channel 12
cable upstream bonding-group 1
  upstream 0
  upstream 1
  upstream 2
  upstream 3
  attributes 80000000
cable upstream bonding-group 8
  upstream 0
  upstream 1
  upstream 2
  upstream 3
  upstream 6
  attributes 80000000
cable bundle 1
cable privacy accept-self-signed-certificate
end
```

Support for Line Card High Availability

N+1 line card high availability (LCHA) is supported for modems that are assigned OFDMA upstream channels. If LCHA is enabled, the modems remain active after switchover and revert.

Configure Line Card High Availability

For information on configuring for Line Card High Availability, go through the *Cable Line Card Process Restart* content in the topic *Consolidated Packages and SubPackages Management* in the document Cisco cBR Converged Broadband Routers Basic Configuration Guide for Cisco IOS XE.

Support for Line Card Process Restart

Linecard IOSd and linecard US-Scheduler (CDMAN) process restart (LCPR) is supported for modems that are assigned OFDMA upstream channels. If LCPR is enabled, remote phy devices remain active after process restarts.

Configure Line Card Process Restart

For information on configuring for Line Card Process Restart, go through the *Cable Line Card Process Restart* content in the topic *Consolidated Packages and SubPackages Management* in the document Cisco cBR Converged Broadband Routers Basic Configuration Guide for Cisco IOS XE.

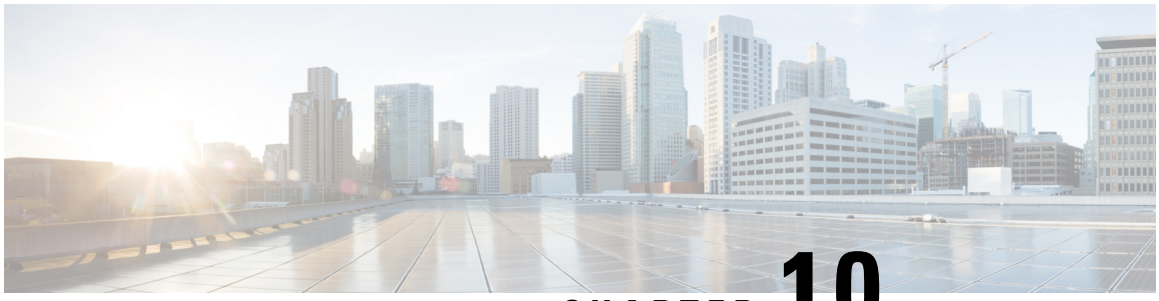
Feature Information for DOCSIS 3.1 OFDMA Channel Configuration

Use Cisco Feature Navigator to find information about the platform support and software image support. Cisco Feature Navigator enables you to determine which software images support a specific software release, feature set, or platform. To access Cisco Feature Navigator, go to the www.cisco.com/go/cfn link. An account on the Cisco.com page is not required.

Note The following table lists the software release in which a given feature is introduced. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Table 21: Feature Information for DOCSIS 3.1 OFDMA Channel Configuration

Feature Name	Releases	Feature Information
Remote PHY DOCSIS 3.1 OFDMA Channel Configuration	Cisco 1x2 / Compact Shelf RPD Software 5.1 Cisco IOS XE Fuji 16.9.1	This feature was introduced on the Cisco Remote PHY Device and Cisco cBR Series Converged Broadband Routers.
Support for Line Card High Availability	Cisco 1x2 / Compact Shelf RPD Software 6.1 Cisco IOS XE Gibraltar 16.10.1	This feature was introduced on the Cisco Remote PHY Device and Cisco cBR Series Converged Broadband Routers.
Support for Line Card Process Restart	Cisco 1x2 / Compact Shelf RPD Software 6.1 Cisco IOS XE Gibraltar 16.10.1	This feature was introduced on the Cisco Remote PHY Device and Cisco cBR Series Converged Broadband Routers.



CHAPTER 10

Spectrum Capture

Hardware Compatibility Matrix for Cisco Remote PHY Device

Note Unless otherwise specified, the hardware components introduced in a given Cisco Remote PHY Device Software Release are supported in all subsequent releases.

Table 22: Hardware Compatibility Matrix for the Cisco Remote PHY Device

Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Node	Cisco 1x2 / Compact Shelf RPD Software 2.1 and Later Releases
Cisco GS7000 Super High Output Intelligent Node (iNode)	Cisco 1x2 / Compact Shelf RPD Software 4.1 and Later Releases Cisco Intelligent Remote PHY Device 1x2 • PID—iRPD-1X2= • PID—iRPD-1X2-PKEY=

Note The -PKEY suffix in the PID indicates units that enable the SCTE-55-2 Out-of-Band protocol support.

Upstream Dynamic Modulation Profile

Modulation profiles define how information is transmitted upstream from a cable modem to the Cable Modem Termination System (CMTS). Remote PHY Core supports upstream dynamic modulation profiles from Cisco IOS XE Gibraltar 16.12.1x version.

Dynamic modulation profile does not work when the upstream sharing is enabled in R-PHY. A warning message appears when you configure the dynamic modulation profile in R-PHY upstream controller profile. It does not appear when configuring it in the I-CMTS upstream controller profile.

Verify Modulation Profile

To view the modulation profile used by the upstream channel on the SUP card, run the following command:

```
Router#show controllers upstream-Cable 9/0/10 us-channel 0

Controller RPD US Port List:

DevID  RPD ID          US Port  I/F       Name
------ --------------- -------- --------- ------------
  0    badb.ad13.417c     0     Te9/1/2   uscom3

USPHY OFDMA support: FULL


Controller 9/0/10 upstream 0  AdminState:UP OpState: UP
  atdma mode enabled
  Frequency 10.000 MHz, Channel Width 6.400 MHz, Symbol Rate 5.120 Msps
  Modulation Profile Group 399
  Modulations (16-QAM) - A-short 16-QAM, A-long 16-QAM, A-ugs 16-QAM

  Mapped to connector 10 and receiver 0
```

To view the modulation profile used by the upstream channel on a line card, run the following command:

To view the hop history of the upstream channel on a SUP card, run the following command:

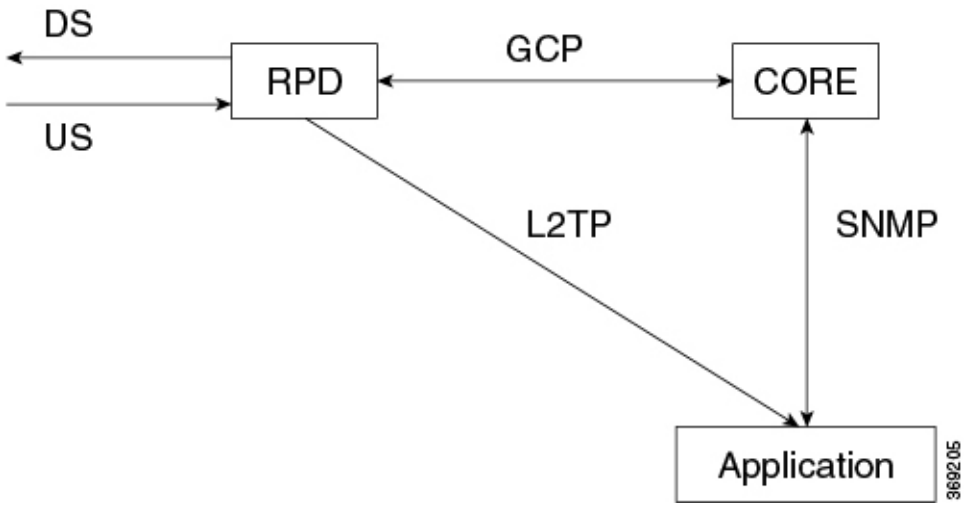
```
Router#show cable hop upstream-cable 9/0/10 us-channel 0 history
F = Frequency Hop, M = Modulation Change, C = Channel Width Change

Upstream         Action        Chg  Chg    Chg    Action
Channel          Time          Code From   To     Reason
UC9/0/10:U0     Sep 24 07:26:10 M   399    398    Test command enforced
                           Sep 24 07:26:03 M   400    399    Test command enforced
                           Sep 24 07:25:54 M   399    400    Test command enforced
                           Sep 24 07:21:27 M   400    399    SNR 30>=25
                           Sep 24 07:19:33 M   399    400    Test command enforced

                           Sep 24 07:09:27 M   398    399    SNR 26<28

                           Sep 23 12:21:25 C    1.6      6.4    Configuration changed
```

Spectrum Capture

Upstream triggered spectrum analysis measurement provides a wideband spectrum analyzer function in the CCAP. You can trigger this function to examine specific upstream transmissions and underlying noise or

interference during a quiet period. WBFFT stands for Wide Band Fast Fourier Transform. This feature allows all RPD US ports to enable an upstream spectrum analyzer built into the RPD's front end. RPD supports FreeRunning trigger mode.

Figure 1: Spectrum Capture Workflow



Note US PHY computes and directly sends US FFT data. RPD firmware does not handle this data. The firmware configures US PHY to send L2TP stream based on GCP TLV messages.

RPD 8.4 and following releases support Time IQ WBFFT Data on PNM upstream. You can now configure the poll interval and other parameters for free-run mode instead of fixed values in previous releases. All parameters can be configured by TLV41: UsSpectrumCapture.

Please see the following link for Cisco cBR-8 configuration of this feature:

https://www.cisco.com/c/en/us/td/docs/cable/cbr/configuration/guide/b_cbr_docsis_full_book_xe16_10/b_cbr_docsis_full_book_xe16_10_chapter_0100110.html

Note

1. This feature provides a stream of raw spectrum data only.
2. The application that interprets and presents the data in human readable format is not part of this feature.

Verifying Spectrum Capture Configuration

To verify if the spectrum capture is enabled, use **show bcm-register wbfft config** command as shown in the following example. The WBFFT Trigger Mode should be FreeRunning if this feature is enabled.

```
R-PHY#show bcm-register wbfft config
WBFFT Trigger Mode    : FreeRunning
Enable UTSC           : TRUE
Sample Num            : 4096
Session ID            : 44201020
```

```
PNM Dest IP          : 2001:30:84:0:1:0:66:1
PNM Dest Mac         : c414.3c16.d682

R-PHY#show bcm-register wbfft all 0
WBFFT Start Ctrl    [cc000000]     : 00000001
In Control          [cc000004]     : 00472F04
Out Control         [cc00000c]     : 0000009B
Timing Ctrl         [cc000010]     : 00000003
WBFFT FIRST WDW CF [cc000024]     : 00000920
WBFFT SCND WDW CF   [cc000028]     : 0000C660
WBFFT MIDL WDW CF   [cc00002c]     : 000061E0
WBFFT MAX CTL       [d0000048]     : 33800000
WBFFT Status        [cc000034]     : 00000000

WBFFTS In Ctrl      [d0000044]     : 00000100
WBFFT PKT BYTE                     : 004A0000
WBFFT PKT COUNT                    : 00004A00
```

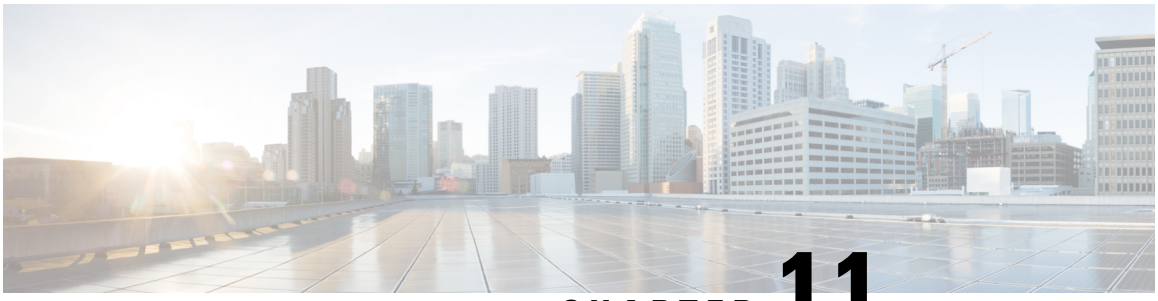
Feature Information for Spectrum Management

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 23: Feature Information for Spectrum Management

Feature Name	Releases	Feature Information
Upstream Dynamic Modulation Profile	Cisco 1x2 / Compact Shelf RPD Software 7.5	This feature was introduced in the Cisco Remote PHY Device.
Spectrum Capture	Cisco 1x2 / Compact Shelf RPD Software 6.4	This feature was integrated into the Cisco Remote PHY Device.



CHAPTER 11

Viavi Integration

Hardware Compatibility Matrix for Cisco Remote PHY Device

Note Unless otherwise specified, the hardware components introduced in a given Cisco Remote PHY Device Software Release are supported in all subsequent releases.

Table 24: Hardware Compatibility Matrix for the Cisco Remote PHY Device

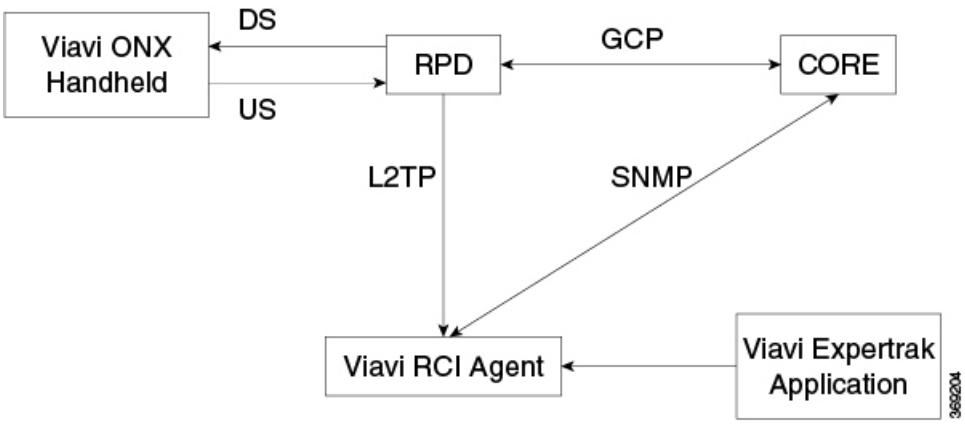
Cisco HFC Platform	Remote PHY Device
Cisco GS7000 Super High Output Node	Cisco 1x2 / Compact Shelf RPD Software 2.1 and Later Releases
Cisco GS7000 Super High Output Intelligent Node (iNode)	Cisco 1x2 / Compact Shelf RPD Software 4.1 and Later Releases Cisco Intelligent Remote PHY Device 1x2 • PID—iRPD-1X2= • PID—iRPD-1X2-PKEY=

Note The -PKEY suffix in the PID indicates units that enable the SCTE-55-2 Out-of-Band protocol support.

Viavi Integration

In this feature, RPD supports non-CCAP defined MAX-HOLD mode for spectrum capture that work with Viavi RCI Agent.

Figure 2: Viavi integration workflow



Note

1. Communications with core is implemented using SNMP.
2. Before using this feature, the NDF/NDR feature must be configured on cBR-8.
3. Viavi RCI Agent needs to be installed and configured on the system with Linux/Ubuntu operating system.

Verifying Spectrum Capture Configuration

To verify if the spectrum capture is enabled, use **show bcm-register wbfft config** command as shown in the following example. The WBFFT Trigger Mode should be FreeRunning if this feature is enabled.

```
R-PHY#show bcm-register wbfft config
WBFFT Trigger Mode   : FreeRunning
Enable UTSC          : TRUE
Sample Num           : 4096
Session ID           : 44201020
PNM Dest IP          : 2001:30:84:0:1:0:66:1
PNM Dest Mac         : c414.3c16.d682

R-PHY#show bcm-register wbfft all 0
WBFFT Start Ctrl   [cc000000]     : 00000001
In Control         [cc000004]     : 00472F04
Out Control        [cc00000c]     : 0000009B
Timing Ctrl        [cc000010]     : 00000003
WBFFT FIRST WDW CF [cc000024]     : 00000920
WBFFT SCND WDW CF  [cc000028]     : 0000C660
WBFFT MIDL WDW CF  [cc00002c]     : 000061E0
WBFFT MAX CTL      [d0000048]     : 33800000
WBFFT Status       [cc000034]     : 00000000
```

```
WBFFTS In Ctrl     [d0000044]     : 00000100
WBFFT PKT BYTE                    : 004A0000
WBFFT PKT COUNT                   : 00004A00
```

Feature Information for Viavi Integration

The following table provides release information about the feature or features described in this module. This table lists only the software release that introduced support for a given feature in a given software release train. Unless noted otherwise, subsequent releases of that software release train also support that feature.

Use Cisco Feature Navigator to find information about platform support and Cisco software image support. To access Cisco Feature Navigator, go to www.cisco.com/go/cfn. An account on Cisco.com is not required.

Table 25: Feature Information for Viavi Integration

Feature Name	Releases	Feature Information
Viavi Integration	Cisco 1x2 / Compact Shelf RPD Software 6.4	This feature was integrated into the Cisco Remote PHY Device.