Cisco Remote PHY Device Provisioning Guide for Cisco 1x2 / Compact Shelf RPD Software 4.1

First Published: 2018-03-30

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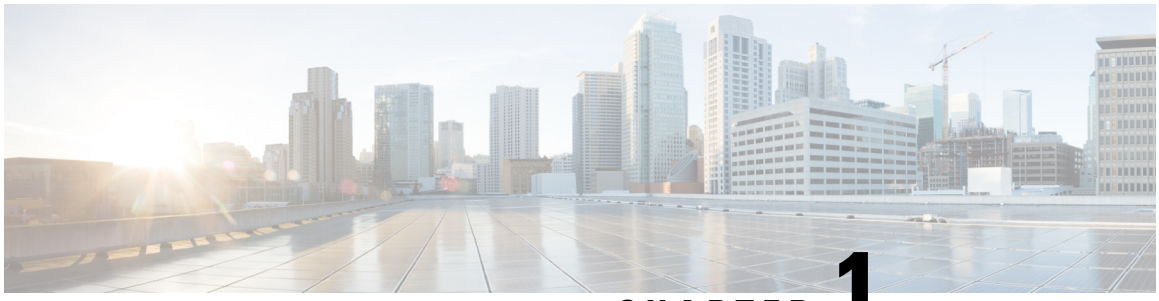


CHAPTER 1

Network Authentication

This document describes the Remote PHY device network authentication 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 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 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 Network Authentication

RPD must be able to operate in both authenticated and unauthenticated networks. Whether authentication is required for an RPD is determined by the network that it is connected to. In some cases, RPD is located in an untrusted network, and it must connect to devices inside the trusted network, which presents a potential security vulnerability. 802.1x is introduced to provide authentication services to eliminate the potential security issues.

802.1x is a Layer 2 protocol that uses EAP (Extensible Authentication Protocol) to provide authentication services. Following certificates are needed to use the network authentication:

- Cablelabs Root CA certificate: caRoot.pem
- CableLabs Device CA Certificate: deviceCA.pem
- RPD Certificate: rpdCert.pem, private key: rpd.key
- Cablelabs Service Provider CA Certificate: spCA.pem
- AAA Server Certificate: aaaCert.pem, private key: aaa.key

How to Enable Network Authentication

This section describes how to enable network authentication for RPD.

Installing Certificates in Radius Server

To install the certificate in Radius server, follow the steps below:

Step 1 Combine CA certificate for AAA server.

Example:

```
cat spCA.pem caRoot.pem > ca_root_srv.pem
```

Step 2 In freeRadius Server, copy "ca_root_srv.pem", "spCA.pem", "aaaCert.pem" and "aaa.key" to "/etc/freeradius/certs".

Configuring Radius Server

To install the certificate in RPD, follow the steps below:

Step 1 Define a new client in /etc/freeradius/clients.conf.

Example:

```
client rphytest_ng13 {
        ipaddr = 20.5.0.36
        secret = rphytest
        shortname = ng13_switch
        require_message_authenticator = yes
}
```

The "ipaddr" is the switch's management ip address.

Step 2 In "/etc/freeradius/eap.conf", change the following lines in "tls" to specify the server's private key file and certificate files.

Example:

```
tls {
      …
        private_key_file = ${certdir}/aaa.key
        certificate_file = ${certdir}/aaaCert.pem
        CA_file = ${cadir}/ca_root_srv.pem
}
```

Step 3 Start radius in radius sever.

Example:

```
sudo freeradius
```

Make sure only one freeradius instance is running.

Configuring Switch

To configure the switch, follow the steps below:

Note This procedure is for Catalyst 3750 switch, other switch may use different commands.

Step 1 Add the following configuration in global configuration mode.

Example:

```
dot1x system-auth-control   /* enable 802.1x */
aaa new-model
```

```
aaa authentication dot1x default group radius
radius-server host 10.79.41.103 auth-port 1812 key rphytest
```

Step 2 Add the following configuration under interface which connects to RPD.

Example:

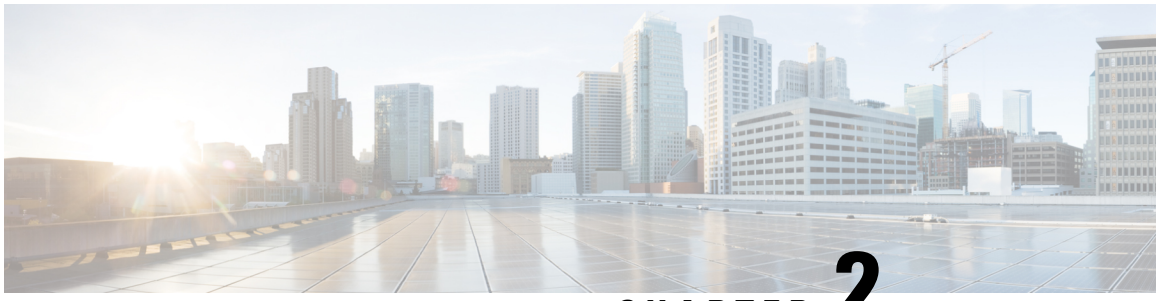
```
authentication port-control auto
dot1x pae authenticator
```

Verifying Authentication Status

To displays dot1x authentication information for RPD, use the **show dot1x** command as shown in the following example:

```
Router# show dot1x summary
 Interface        Core-id                  EAP_Received     Status
 vbh0             CORE-3415960568          True             UP

Router# show dot1x detail
Interface        Core-id                  EAP_Received        Status
vbh0             CORE-3415960568          True                UP
bssid=01:80:c2:00:00:03
freq=0
ssid=
id=0
mode=station
pairwise_cipher=NONE
group_cipher=NONE
key_mgmt=IEEE 802.1X (no WPA)
wpa_state=COMPLETED
ip_address=30.85.40.47
address=00:04:9f:00:03:73
Supplicant PAE state=AUTHENTICATED
suppPortStatus=Authorized
EAP state=SUCCESSselected
Method=13 (EAP-TLS)EAP TLS
cipher=ECDHE-RSA-AES256-SHA
tls_session_reused=0
eap_session_id=0d53798f5b46014cc92a4ac1151521bae6a14c98f919ab5e8c81a701b7272be7f812e7e5a75881768d74d311795a3b1f0e37bfa7fff7dcc4685d36f216bec59850
uuid=ab722cfb-84dc-5835-a905-edfec20f78c3
```



CHAPTER 2

Synchronizing Time on Cisco Remote PHY Devices

This section explains how to synchronize time on the Remote PHY (R-PHY) devices and CCAP core of the Cisco cBR Router.

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 2: 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 Time Synchronization

In a Remote PHY system, synchronizing its local timestamp and reference frequency to the cable converged access platform core function (CCAP Core) is important. The protocol used for this feature, the Precision Time Protocol (PTP), helps in synchronizing time between a CCAP core function and a series of remote PHY devices (RPD) that enable R-PHY and provides support for converged DOCSIS, video, and out-of-band (OOB) services.

Cisco CBR-8 supports PTP Ordinary Clock (OC) subordinate mode, in which the PTP suborinate ports are from the backhaul 10GE Ethernet ports or the management Ethernet ports of SUP PIC.

Remote DTI

Remote DOCSIS Timing Interface (R-DTI) is the network synchronization protocol used between CCAP-core and R-PHY. When traffic from the CCAP-Core is received on the downstream receiver, the following processes occur:

- Terminates DEPI framing
- Extracts the payload, frames it, modulates, and transmits it out

During the upstream process, the signal is received from the coax and the system demodulates it. From the FEC payload, the DOCSIS frames are extracted and placed in the UEPI encapsulation. The frames are then transmitted through the upstream transmitter to the CCAP core. A local CPU manages DEPI and GCP control planes, and interfaces with network management. A clocking circuit interfaces with the R-DTI and manages clocking for the R-DTI entity.

The GS7000 R-PHY supports map re-stamp option.

Restrictions for Configuring Time Synchronization

The following restrictions are applicable to configuring time synchronization on Cisco cBR-8.

- Cisco cBR-8 supports PTP subordinate on both SUP-PIC and DPIC.
- Cisco RPD PTP does not support pass-through mode. Pass-through mode means RPDs are communicating with PTP server through cBR-8, and cBR-8 is PTP unware of the communication between RPDs with PTP server.

How to Configure Time Synchronization

Configuring Time Interface and PTP domain

To configure time interface and PTP domain, use the following procedure.

```
enable
configure terminal
interface type [slot_#/]port_#
interface Loopback1588
  ip address <IP Address/subnet>

interface TenGigabitEthernet<slot/port>
  ip address <IP Address/subnet>

ip route < PTP master IP Address/subnet> < loopback IP Address>

ptp clock ordinary domain 0 (This is for CBR PTP connection)
 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 Lo1588 negotiation
  clock source < PTP master loopback IP Address>
```

The following table explains the parameters used in this example:

Table 3: Parameters for time interface and PTP domain configuration

Parameter	Description	Value Range	Default Value
ptp r-dti [id]		1-64	
description	R-DTI name or description		
ptp-domain [id]	Domain number of IEEE 1588	0-127	
local-priority [value]	Set local priority	128	128
priority1 [value]	Set priority1	0-255	128
priority2 [value]	Set priority2	0-255	255
mode [value]	R-DTI mode	other, slave master	slave
profile [value]	Set PTP ITU-T profile	default/G.8275.2	default
clock-port [id]	Configure clock port	1-32	
state [value]	Set Ethernet port admin status	other, up, down, testing	up

Parameter	Description	Value Range	Default Value
ethenet [value]	Set Ethernet port for clock port	0-32	The default value is clock port index
clock source [ip] gateway [ip]	Set clock address	ipv4 address, ipv6 address	
clock alternate-first	Select alternate source first		
transport [value]	Set transport encapsulation	other, ipv4, ipv6	ipv4
transport cos [value]	COS of 802.1Q	0-7	6
transport dscp [value]	DSCP of IP differentiated services	0-63	47
local-priority [value]	Set local priority	1-255	128
sync interval [value]	Set an interval for sync packets	0-7(-7 -0)	
announce interval [value]	Set an interval for announcement packets	0-3(-3 -0)	
delay-req interval [value]	Set an interval for PTP delay-req packets0-7(-7 -0)		
announce timeout [value]	Set timeout interval for announcement packets	3-255	
unicast grant-duration [value]	Set the grant duration time in seconds for unicast	60-1000	300
description	Clock port name or description		

Verifying Time Interface and PTP Domain Configuration

The following example shows how to verify the time interface and PTP domain configuration:

```
Router# show ptp clock running domain 0
Load for five secs: 5%/2%; one minute: 6%; five minutes: 6%
No time source, 15:16:20.421 CST Wed Mar 15 2017

                    PTP Ordinary Clock [Domain 0]
State          Ports Pkts sent Pkts rcvd Redundancy Mode
PHASE_ALIGNED  1     3687693   11177073  Hot standby
                              PORT SUMMARY
                                          PTP Master
Name           Tx Mode Role  Transport State Sessions Port Addr
slave-from-903 unicast slave Lo1588    Slave 2        10.10.10.11
```

```
                              SESSION INFORMATION
slave-from-903 [Lo1588] [Sessions 2]
Peer addr       Pkts in Pkts out In Errs Out Errs
10.10.10.11      5588900 1843789  0       0
10.10.10.12      5588173 1843904  0       0
```

Configure RPD PTP Connection

To configure RPD PTP connection, use the following commands.

```
enable
configure terminal
interface type [slot_#/]port_#
ptp r-dti 1 (RPD PTP connection)
 ptp-domain 0
 clock-port <same domain number with PTP server>
   clock source ip <IP Address> gateway ip <IP Address>
   clock source ip <IP Address> gateway ip <IP Address> alternate
  !--<clock-source is PTP master loopback ip, gw is the next hop to reach the ptp master
>--!
```

Verifying RPD PTP Connection Configuration

The following example shows how to verify the RPD PTP Connection configuration:

```
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  /2
--PTP Port   1, Enet Port   1 ----
  Port local Address :10.10.10.11
  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 1  Master IP: 10.10.10.11
  ==Stream 1 : Port 1  Master IP: 10.10.10.11
```

Associate R-DTI with RPD

To associate R-DTthe local prefix SID associated to the segment ID, use the following commands.

```
enable
configure terminal
interface type [slot_#/]port_#
cable rpd node1
identifier 0044.4f04.0044 (node vbh0 mac)
 core-interface Te3/1/0
 rpd-ds 0 downstream-cable 3/0/0 profile 3
 rpd-us 0 upstream-cable 3/0/0 profile 3
r-dti 1
rpd-event profile 0
```

Verifying Associating R-DTI with RPD

The following example shows how to verify whether the RPD is associated to R-DTI:

```
Router# show running-config
Load for five secs: 8%/2%; one minute: 9%; five minutes: 9%
Time source is user configuration, 11:00:17.381 CST Wed Mar 22 2017
Building configuration...
Current configuration : 107879 bytes
!
! Last configuration change at 10:59:23 CST Wed Mar 22 2017
!
version 16.6
service timestamps debug datetime msec localtime show-timezone
service timestamps log datetime msec localtime show-timezone
service internal
no platform punt-keepalive disable-kernel-core
platform ipccl log-history 0
platform punt-policer 10 10
platform punt-policer 10 10 high
platform punt-policer 80 10
platform punt-sbrl subscriber rate no-drop
platform shell
!
hostname RphyNode-L09
!
boot-start-marker
boot system harddisk:cbrsup-universalk9.16.05.01prd9.SPA.bin
boot-end-marker
!
!
----
!
cable tag 10
 name docsis1.0
 docsis-version docsis10
!
cable tag 11
 name docsis1.1
 docsis-version docsis11
!
-----
cable load-balance docsis-group 1
 restricted
 upstream Upstream-Cable 3/0/3 us-channel 0-3
 method utilization
 threshold load 15
 threshold load minimum 2
 policy pure-ds-load
 init-tech-list 4
 interval 60
 tag docsis1.0
 tag docsis1.1
 tag docsis2.0
 tag docsis3.0
!
---
cable metering ipdr-d3 session 1 type 1
cable metering source-interface TenGigabitEthernet4/1/1
cable modem remote-query 30 public
cable modem vendor 00.02.00 "Apache-ACB"
cable modem vendor E8.6D.52 "Motorola"
cable modem vendor 00.1F.E1 "Ambit"
cable modem vendor 00.1F.E2 "Ambit"
cable modem vendor 00.D0.DD "Sunrise"
!
!
----
```

```
!
no network-clock synchronization automatic
!
ptp clock boundary 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 Lo1588 negotiation
  clock source 10.10.10.11
  clock source 192.168.0.0
 clock-port master-local master
  transport ipv4 unicast interface Lo1588 negotiation
!
-----
r-dti 2
 rpd-event profile 0
!
ptp r-dti 2
 ptp-domain 0
 clock-port 1
   clock source ip 10.10.10.11
   clock source ip 192.168.0.0 alternate
!
ptp r-dti 3
 ptp-domain 0
 clock-port 1
   clock source ip 10.10.10.11
   clock source ip 192.168.0.0 alternate
!
ptp r-dti 10
 ptp-domain 0
 clock-port 1
   clock source ip 10.10.10.11
   clock source ip 192.168.0.0 alternate
   announce interval -3
   announce timeout 3
!
ptp r-dti 11
 ptp-domain 0
 priority1 101
 priority2 102
 local-priority 100
 clock-port 2
   ethernet 1
   clock alternate-first
   clock source ip 10.10.10.11
   clock source ip 192.168.0.0 alternate
   transport cos 0
   transport dscp 63
   sync interval -1
   announce timeout 255
   delay-req interval -7
   unicast grant-duration 60
   local-priority 255
!
ptp r-dti 12
 ptp-domain 0
 clock-port 1
   ethernet 0
   clock source ip 10.10.10.11
!
ptp r-dti 60
```

```
 ptp-domain 0
!
cable video
!
end
```

Verifying PTP Clock Functioning

To verify whether the PTP Clock is running, use the following commands:

```
Router#show ptp clock running
Load for five secs: one minute: 5%; five minutes:
Time source is NTP, 14 CST Fri Feb 17 2017
PTP Ordinary clock [Domain 0]
State         Ports pkts sent pkts rcvd Redundancy Mode
PHASE-ALIGNED 1     7339500   22245593  Hot standby
   Port Summary
Name           Tx Mode Role  Transport State Sessions PTP Master Port Addr
slave-from-903 unicast slave  L01588    Slave 2        10.10.10.11
```

Verifying PTP Clock Running Domain

The following example shows how to verify the PTP clock running domain:

```
Router#show ptp clock running domain 0
Load for five secs: 5%/2%; one minute: 6%; five minutes: 6%
No time source, 15:16:20.421 CST Wed Mar 15 2017
                     PTP Ordinary Clock [Domain 0]
State          Ports Pkts sent Pkts rcvd Redundancy Mode
PHASE_ALIGNED  1     3687693   11177073  Hot standby
                               PORT SUMMARY
                                          PTP Master
Name           Tx Mode Role  Transport State Sessions Port Addr
slave-from-903 unicast slave Lo1588    Slave 2        10.10.10.11

                              SESSION INFORMATION
slave-from-903 [Lo1588] [Sessions 2]
Peer addr       Pkts in Pkts out In Errs Out Errs
10.10.10.11      5588900 1843789  0       0
192.168.0.10     5588173 1843904  0       0
```

Verifying Time Sync State

To verify the status of time synchronization, use the show ptp clock <n> state command as given in the following example:

```
Router# show ptp clock 0 state
apr state       : PHASE_LOCK
clock state     : SUB_SYNC
current tod     : 1485414295   Thu Jan 26 07:04:55 2017
active stream   : 0
==stream    0   :
  port id       :                0
  master ip     :       10.10.10.11
  stream state  :       PHASE_LOCK
  Master offset :             -405
  Path    delay :           -17071
  Forward delay :           -17476
  Reverse delay :           -16623
  Freq offset   :          -291143
```

```
  1Hz  offset   :             -676
==stream    1   :
  port id       :                0
  master ip     :      192.168.0.11
  stream state  :       PHASE_LOCK
  Master offset :             -369
  Path    delay :            -1619
  Forward delay :            -1988
  Reverse delay :            -1260
  Freq offset   :          -297905
  1Hz  offset   :             -664
```

Verifying Time Sync Statistics

To verify the statistics of the time synchronization, use the show ptp clock <n> state command as given in the following example:

```
Router# show ptp clock 0 statistics
 AprState    4  :
  2@0-00:06:51.568 1@0-00:06:41.930 0@0-00:04:17.925
  4@0-00:03:58.724
 ClockState  5  :
  5@0-00:07:12.640 4@0-00:07:10.182 3@0-00:07:06.825
  2@0-00:06:51.825 1@0-00:06:51.530
 BstPktStrm  1  :
  0@0-00:06:42.029
 SetTime     1  :
  1000000000@0-00:04:00.045
 StepTime    1  :
  125126755@0-00:06:14.670
 AdjustTime  64 :
  -676@0-07:34:32.546 -733@0-07:33:31.545  -838@0-07:32:30.546
  -892@0-07:31:29.545 -935@0-07:30:28.545 -1033@0-07:29:27.545
  -914@0-07:28:26.546  916@0-07:26:24.545  2507@0-07:25:18.170
streamId  msgType           rx     rxProcessed lost        tx
 0        SYNC              433439 433439      4294574083  0
 0        DELAY REQUEST     0      0           0           433439
 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    433437 433437      4294548766  0
 0        P-DELAY FOLLOWUP  0      0           0           0
 0        ANNOUNCE          27098  27098       0           0
 0        SIGNALING         285    285         0           285
 0        MANAGEMENT        0      0           0           0
   TOTAL                    894259 894259      8589122849  433724
 1        SYNC              433435 433435      4294574085  0
 1        DELAY REQUEST     0      0           0           433439
 1        P-DELAY REQUEST   0      0           0           0
 1        P-DELAY RESPONSE  0      0           0           0
 1        FOLLOW UP         0      0           0           0
 1        DELAY RESPONSE    10351  10351       4104        0
 1        P-DELAY FOLLOWUP  0      0           0           0
 1        ANNOUNCE          27098  27098       4294901760  0
 1        SIGNALING         285    285         0           285
 1        MANAGEMENT        0      0           0           0
   TOTAL                    471169 471169      8589479949  433724
```

Configuration Examples

This section provides examples for configuring Cisco cBR for time synchronization.

Example: Configuring Time Interface and PTP Domain

The following example shows how to configure time interface and PTP domain:

```
enable
configure terminal
interface Loopback1588
ip address 10.10.10.11 255.255.255.224

interface TenGigabitEthernet5/1/3 (connect to PTP master)
ip address 192.168.0.13 255.255.255.224

ip route 10.10.10.11 255.255.255.224 192.168.0.12   (route to PTP master loopback ip)

ptp clock ordinary domain 0 (This is for cbr ptp connection)
 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 Lo1588 negotiation
 clock source 10.10.1.11 (PTP master loopback ip)
```

Example: Configure RPD PTP Connection

The following example shows how to configure RPD PTP connection:

```
enable
configure terminal
ptp r-dti 1
ptp-domain 0
 mode slave
 priority1 128
 priority2 255
 local-priority 128
 clock-port 1
   ethernet 1
   …
 clock-port 2
   ethernet 2
   …
clock-port 1
   ethernet 1
   state up
   transport ipv4
   clock source ip 10.10.1.12 gw 10.10.1.1
    clock source ip 192.168.0.0 gateway ip 10.10.1.2 alternate
   transport cos 6
   transport dscp 47
   sync interval -4
   announce interval 0
   announce timeout 11
   delay-req interval -4
   unicast grant-duration 300
   local-priority 128
```

Example: Associate R-DTI with RPD

The following example shows how to associate R-DTI with RPD:

```
enable
configure terminal
cable rpd node1
 identifier 0004.9f03.0061 (node vbh0 mac)
 core-interface Te3/1/0
 rpd-ds 0 downstream-cable 3/0/0 profile 3
 rpd-us 0 upstream-cable 3/0/0 profile 3
r-dti 1
 rpd-event profile 0
```

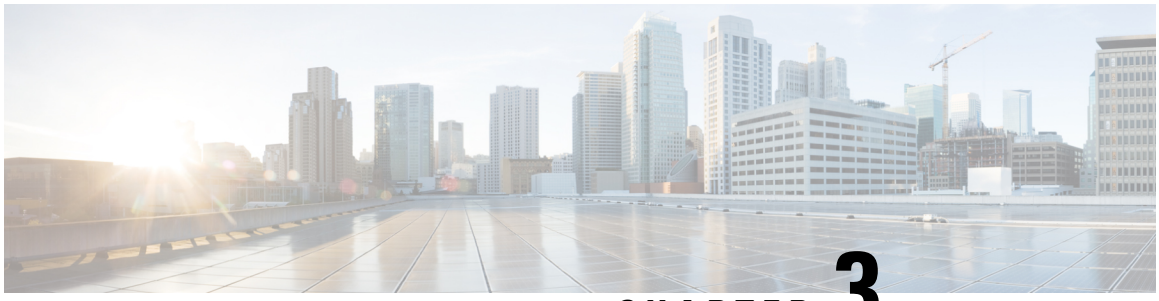
Feature Information for Synchronizing Time on R-PHY Devices

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 4: Feature Information for Synchronizing Time on R-PHY Devices

Feature Name	Releases	Feature Information
Synchronizing Time on R-PHY Devices	Cisco 1x2 / Compact Shelf RPD Software 3.1	This feature was integrated into the Cisco Remote PHY Device.



CHAPTER 3

DEPI/UEPI/L2TP integration with Cisco Remote PHY Device

This document describes how to configure the DEPI/UEPI/L2TP integration with RPD 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 5: 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 DEPI/UEPI/L2TP integration with RPD

DEPI

Downstream External PHY Interface (DEPI) is the downstream interface between the CCAP Core and the RPD. R-DEPI is based on DEPI. More specifically, it is an IP pseudowire between the MAC and PHY in an MHAv2 system that contains both a data path for DOCSIS frames, video packets, and OOB packets, as well as a control path for setting up, maintaining, and tearing down sessions.

UEPI

Upstream External PHY Interface (UEPI) is the upstream interface between the RPD and the CCAP Core. Like DEPI, it is an IP pseudowire between the PHY and MAC in an MHAv2 system that contains both a data path for DOCSIS frames, and a control path for setting up, maintaining, and tearing down sessions.

How to Configure DEPI/UEPI/L2TP integration with RPD

This section describes how to configure DEPI/UEPI/L2TP integration with RPD.

Configuring depi-class/l2tp-class Pair

It's not permitted to change the default l2tp-class configuration (rphy-l2tp-global-class) for R-DEPI by user, because the parameter values are fine tuned to accommodate most common cases.

If user wants to use parameter values other than the default ones, they can use manually defined depi-class/l2tp-class pair. To do so, follow the example below:

```
Router# configure terminal
Router(config)# l2tp-class l2tp_demo
Router(config-l2tp-class)#exit
Router(config)# depi-class depi_demo
Router(config-depi-class)#l2tp-class l2tp_demo
Router(config-depi-class)#exit
```

```
Router(config)#cable rpd node
Router(config-rpd)#core-interface Te1/1/7
Router(config-rpd-core)#depi depi_demo /* Be sure to configure when the RPD core is offline*/
Router(config-rpd-core)#end
```

Verifying the RPD Status

To verify the RPD status, use the **show cable rpd** command as shown in the example below:

```
Router# show cable rpd
Load for five secs: 6%/1%; one minute: 5%; five minutes: 5%
No time source, *04:52:03.936 UTC Tue Jan 17 2017

MAC Address     IP Address    I/F      State       Role   HA    Name
0004.9f00.0901  91.0.10.10    Te1/1/0  init(l2tp)  Pri    Act   node
```

Displaying DEPI Ralated 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 6: show cable rpd depi Field Descriptions

Field	Description
LocID	Local session ID.
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.

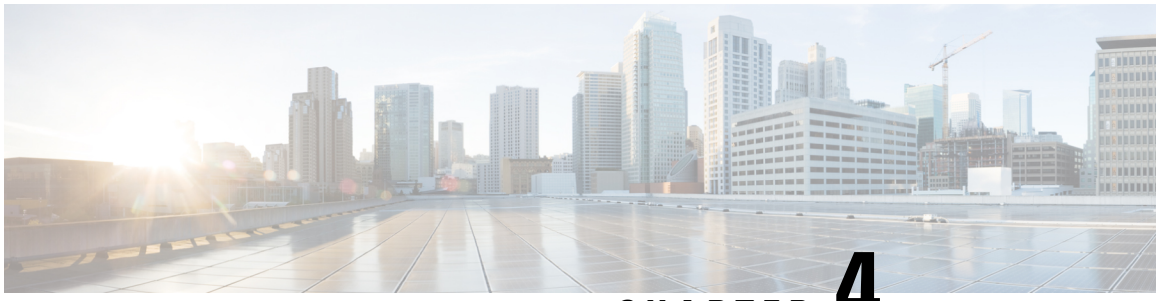
Feature Information for DEPI/UEPI/L2TP integration with RPD

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 7: Feature Information for DEPI/UEPI/L2TP integration with RPD

Feature Name	Releases	Feature Information
DEPI/UEPI/L2TP integration with RPD	Cisco 1x2 / Compact Shelf RPD Software 3.1	This feature was integrated into the Cisco Remote PHY Device.



CHAPTER 4

DEPI Latency Measurement

This document describes how to configure the DEPI latency measurement 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 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 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 DEPI Latency Measurement

The DEPI Latency Measurement (DLM) packet is a specific type of data packet used for measuring the network latency between the CCAP core and the RPD. There are two types of DLM packets, ingress DLM packet and egress DLM packet. The ingress DLM measures the latency between the CCAP core and the ingress point in the RPD, and the egress DLM measures the latency between the CCAP core and the egress point of the RPD. For now, only the ingress DLM is supported. Egress DLM will be supported in the future if required.

How to Configure DLM

This section describes how to configure DLM on Cisco cBR-8.

Configuring DLM

To configure DLM, complete the following procedure. DLM is disabled by default, only enabled when configured.

```
configure terminal
cable rpd name
core-interface interface_name
network-delay dlm interval_in_seconds
```

Verifying DLM Configuration

To verify the DLM configuration, use the **show cable rpd dlm** command as shown in the example below:

```
Router# show cable rpd 0000.bbaa.0002 dlm
Load for five secs: 4%/1%; one minute: 4%; five minutes: 4%
Time source is NTP, 13:12:36.253 CST Sun Jan 1 2017
DEPI Latency Measurement (ticks) for 0000.bbaa.0002
 Last Average DLM:              4993
 Average DLM (last 10 samples): 4990
 Max DLM since system on:       5199
```

```
Min DLM since system on:       4800
Sample #     Latency (usecs)
x------------x------------
0            491
1            496
2            485
3            492
4            499
5            505
6            477
7            474
8            478
9            471
```

The table below shows descriptions for the fields displayed by this command:

Table 9: show cable rpd dlm Field Descriptions

Field	Description
Last Average DLM	It means the last time average DLM (AD). At first, the Last Average DLM (LAD) is always 0, when the absolute value of (LAD - AD) exceeds or equal to 75us, LAD will be updated to be the value of AD, MAP advance triggered to update, AD will keep updating with the last (latest) 10 samples.

Example: DLM Configuration

The following example shows how to configure DLM:

```
Router# configure terminal
Router(config)#cable rpd 1
Router(config-rpd)#core-interface tenGigabitEthernet 3/1/0
Router(config-rpd-core)#network-delay dlm 10
```

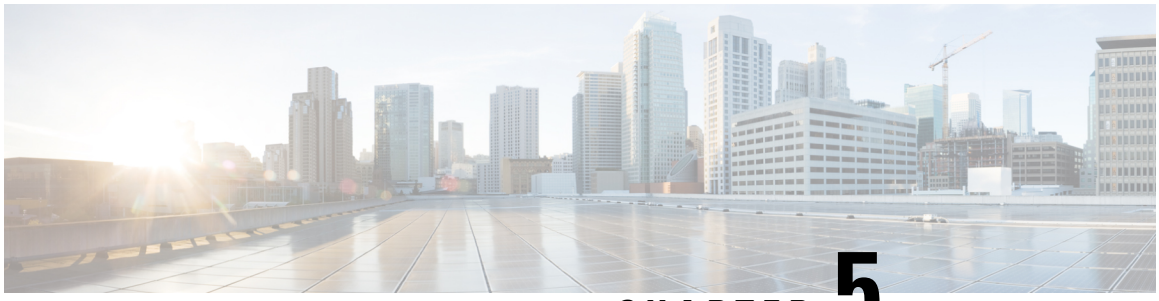
Feature Information for DLM

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 10: Feature Information for DLM

Feature Name	Releases	Feature Information
DEPI Latency Measurement	Cisco 1x2 / Compact Shelf RPD Software 3.1	This feature was integrated into the Cisco Remote PHY Device.



CHAPTER 5

Multiple Cores

This document describes the multiple cores in the Remote PHY system.

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 Multiple Cores

The RPD can be managed by more than one CCAP core. An RPD is controlled by exactly one principal CCAP core and zero or more auxiliary CCAP core(s). Each CCAP core manages a subset of RPD resources, e.g., particular channels or RF ports.

Principal core is responsible for the configuration of common parameters for the RPD and for certain device management functions. Principal core can provide DOCSIS, video or OOB service. Auxiliary cores are responsible for providing video or OOB services. They are restricted to the resource set assigned to them by the principal core.

Restrictions for Multiple Cores Configuration

The following restrictions are applicable to mutiple cores configuration:

- Maximum four cores are supported.
- DOCSIS controllers can only be configured to principal core, while video controllers can be configured to all cores.
- Only one core can be principal, the rest will be auxiliary.
- Principal core needs to be configured explicitly.
- At least one DOCSIS downstream controller and one upstream controller are needed for principal core.
- No upstream controller for auxiliary core and at least one downstream controller is needed for auxiliary core.
- Only single CMTS is supported.
- No downstram frequency and channel id overlap is allowed for all the cores.

How to Configure Multiple Cores

This section describes how to configure multiple cores on Cisco cBR-8.

Configuring Multiple Cores

To configure the multiple cores, follow the example below:

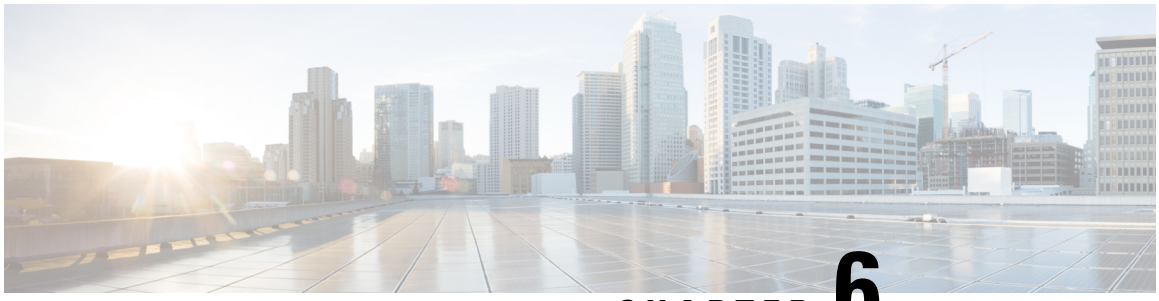
```
Router(config)# cable rpd sjc_block22   /* unique name for each rpd */
Router(config-rpd)# description rpd for sjc block 22
Router(config-rpd)# identifier 1122.3344.5566   /* unique id for each rpd.*/
Router(config-rpd)# rpd-ds 0 power-level 5   /* DS max-carrier and power-level info */
Router(config-rpd)# rpd-ds 0 dedicated-cw-tone cw1   /* DS pilot tone info */
Router(config-rpd)# core-interface Te3/1/0   /* Core side interface (D-PIC interface) for
services below */
Router(config-rpd-core)# principal   /* Specify the principal core */
Router(config-rpd-core)# rpd-ds 0 controller downstream-cable 3/0/0 profile 100 /* DS docsis
 channel config*/
Router(config-rpd-core)# rpd-ds 0 controller downstream-cable 3/0/1 profile 200 /* DS docsis
 channel config*/
Router(config-rpd-core)# rpd-ds 0 downstream-cable 3/0/2 profile 300 /* DS video channel
config*/
Router(config-rpd-core)# rpd-ds 0 downstream-cable 3/0/3 profile 400 /* DS video channel
config*/
Router(config-rpd-core)# rpd-us 0 upstream-cable 3/0/0 profile 101 /* US 0 docsis channel
config*/
Router(config-rpd-core)# rpd-us 1 upstream-cable 3/0/1 profile 101   /* US 1 docsis channel
 config*/
Router(config-rpd-core)# depi depi_rpd_block22    /* RPD DEPI configuration.*/
Router(config-rpd-core)# exit
Router(config-rpd)# core-interface Te9/1/1 /* Support multiple core-interface for cases
such as video is using separate LC*/
Router(config-rpd-core)# rpd-ds 0 downstream-cable 9/0/1 profile 200  /* DS video channel
config*/
Router(config-rpd-core)# depi depi_rpd_block22    /* RPD DEPI configuration.*/
Router(config-rpd-core)# exit
Router(config-rpd)# r-dti 1
Router(config-rpd)# rpd-event profile 0
```

Verifying Multiple Cores Configuration

To display the information of the principal and auxiliary cores, use the **show cable rpd** command as shown in the example below:

```
Router# show cable rpd
MAC Address     IP Address         I/F          State        Role HA  Name
0004.9f00.0907  120.100.2.20     Te1/1/6   online       Pri   Act  node
0004.9f00.0907  120.100.2.20     Te1/1/0   online       Aux  Act  node
0004.9f00.0907  120.100.2.20     Te1/1/1   online       Aux  Act  node
0004.9f00.0907  120.100.2.20     Te1/1/2   online       Aux  Act  node
```

Note Only the active cores are displayed, stand-by cores are hidden.



CHAPTER 6

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 12: 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 one OFDM channel for each Remote PHY device (RPD) with a channel bandwidth up to 192 MHz and the modulation up to 4096 QAM.

Each OFDM channel supports a control profile, the NCP profile, and up to five data profiles. For a line card, a maximum of 16 DS OFDM channels are supported.

Configure DS OFDM Channel

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]
```

Configuring 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.

Configuring 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
```

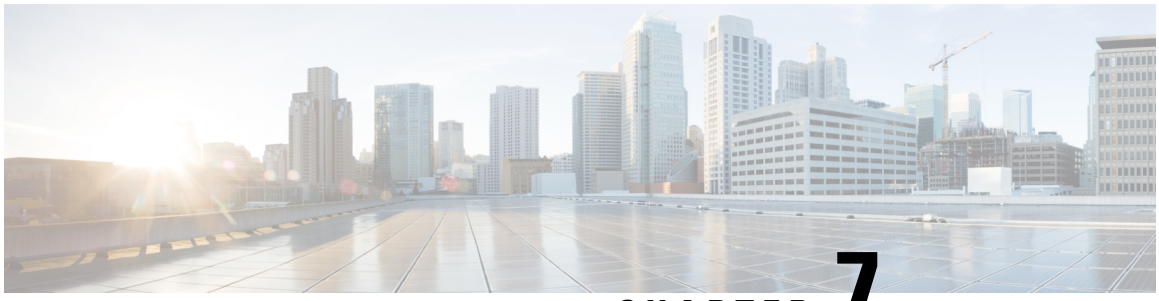
Feature Information for RPHY DS OFDM Channel Configuration

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 13: 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 7

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 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.

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

Configuration Example

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

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
```

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
!
```

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
!
```

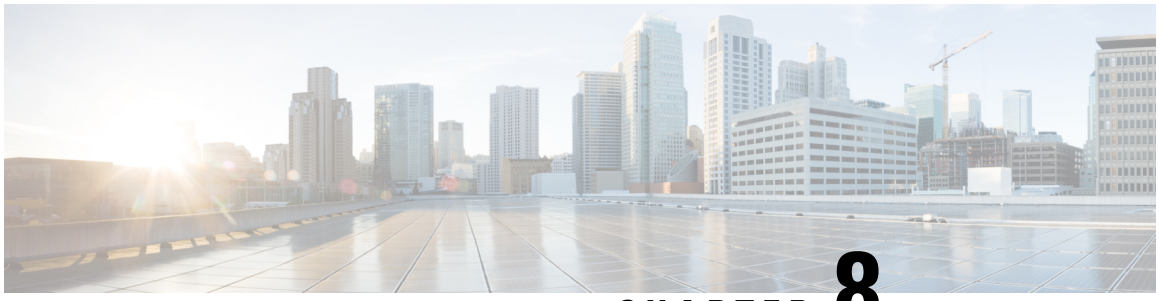
Feature Information for Virtual Combining of Upstream Channels

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 15: Feature Information for NIT Reference Support

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 8

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 16: 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 17: 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

Configuring 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.

Displaying 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
```

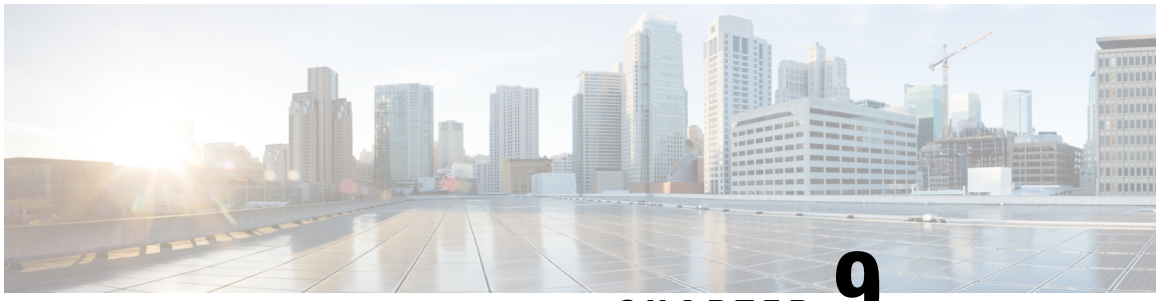
Feature Information for DOCSIS3.1 Downstream Resiliency for RPHY

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 18: 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 9

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 19: 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 20: 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 21: 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
```

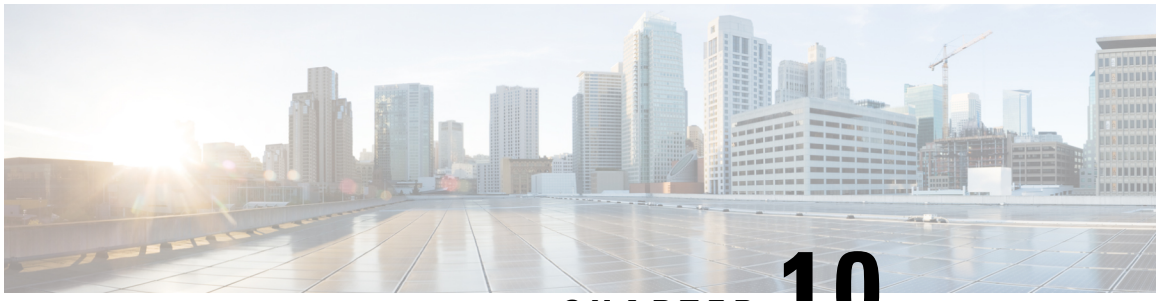
Feature Information for Dynamic Bonding Group

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 22: 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 10

Power Configuration for Compact Shelf

This document describes how to configure the RF channel's power level, the input power level for the upstream radio frequency (RF) carrier, and the base channel power level for Compact Shelf.

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 23: 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 Power Configuration for Compact Shelf

For Compact Shelf, new commands have been added to configure RF channel's power level, the input power level for the upstream radio frequency (RF) carrier, and the base channel power level.

How to Configure Base Power, Downstream Power Level, and Upstream Power Level

This section describes how to configure base power, downstream power level, and upstream power level on Compact Shelf.

Configuring Maximum Carriers

To configure the maximum number of carriers, complete the following procedure. The default number of maximum carriers specified is 158. The maximum number of carrier ranges from 1–158.

```
configure terminal
cable rpd name
rpd-ds port max-carrier value
```

This is an example of maximum carrier configuration:

```
Router# configure terminal
Router(config)#cable rpd node6
Router(config-rpd)#rpd-ds 0 max-carrier 128
```

Configuring Base Channel Power Level

To set the base channel power level, complete the following procedure. The base channel powel level range is 25–34.

configure terminal
cable rpd *name*
rpd-ds *port* **base-power** *value*

This is an example of base channel power level configuration.

```
Router# configure terminal
Router(config)#cable rpd node6
Router(config-rpd)# rpd-ds 0 base-power 30
```

Configuring RF Channel Power Level

To adjust the RF channel's power level, complete the following procedure. The RF channel power level range is 7–23

configure terminal
cable rpd *name*
rpd-ds *port* **rf-channel** *number* **power-adjust** *value*

This is an example of RF channel power power level.

```
Router# configure terminal
Router(config)#cable upstream controller-profile 221
Warning: changes to this profile will affect the following controllers:
          9/0/10,

Confirm to continue? [no]: yes
Router(config-controller-profile)#us
Router(config-controller-profile)#us-channel 0 pow
Router(config-controller-profile)#us-channel 0 power-level ?
  <-7 - 25>  Power level in dBmV(-4~25 for rphy-node, -7~23 for rphy-shelf)

Router(config-controller-profile)#us-channel 0 power-level 23
```