DOCSIS 3.1 Deep Dive

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DOCSIS 3.1 - 지금 당장은 현실성이 없다..?

상향 42MHz, 하향 1GHz 이상의 스펙트럼 확보

아날로그 채널

예산, 투자비용 문제

Monitoring Tool 교체

가입자 감소, 정체

DOCSIS 3.1은 현재 진행형

DOCSIS 3.1 service started in Atlanta and Nashville with 2Gbps speeds — Comcast

We will expand DOCSIS 3.1 service coverage for all area by 2017 — Comcast

Lab and Pilot test or deployment in progressing for DOCSIS 3.1 — COX, Liberty Global, Rogers, NBN

Finished DOCSIS 3.1 CM development and Lab test 2015, Field trial in 2016— A 사

DOCSIS 3.1 CM under developing, Field trial from end of 2016 — B 사

We are planning to have DOCSIS 3.1 test at targeted SO sites — C 사

가장 중요한 것은?

현재 서비스 기준으로 시스템을 확대 하더라고 DOCSIS 3.1에 대한 고려가 반드시 필요

Before Into the DOCSIS 3.1

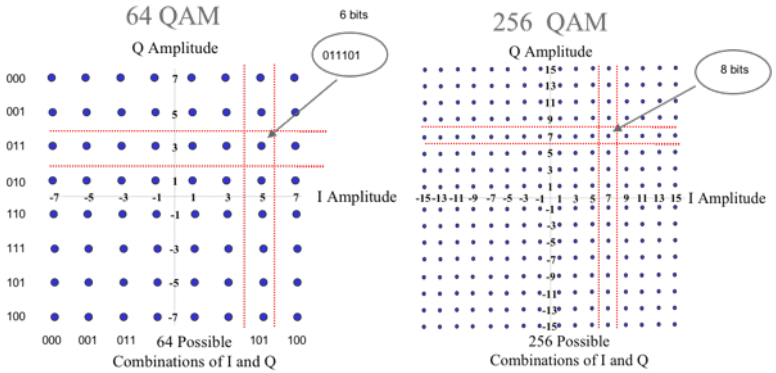
Speeds with DOCSIS 3.0

- Channel speed = (Symbol Rate * Modulation Rate) - overhead

  Symbol Rate is how often a signal arrives

  Modulation Rate is how many bits are carried by each signal

- Total Bonded Speed = number of channels * channel speed



How Can We Change Speeds In DOCSIS 3.0?

- Downstream
  - 256 QAM on 6 MHz channel in downstream (~38 Mbps per channel)
  - 5 Gbps / (38 Mbps / channel) = 131 channels

Not Practical

- Upstream
  - 64 QAM on 6.4 MHz channel in upstream (~27 Mbps)
  - 1 Gbps / (27 Mbps / 6.4 MHz channel) = 37 channel or 237 MHz of return spectrum

Not Possible

How Can We Fix Our Problems?

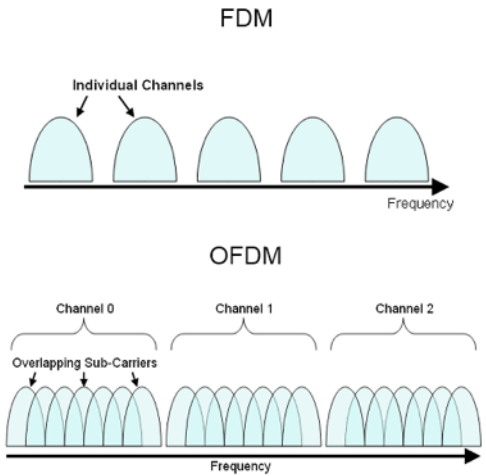
- Get more efficient at filling existing spectrum
- Increase the amount of spectrum available

DOCSIS 3.1 provides options to do both

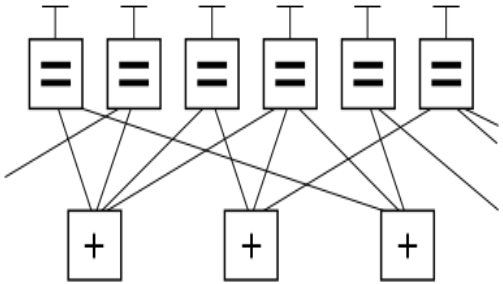
DOCSIS 3.1 – More Effective at Filling Spectrum

Beyond DOCSIS 3.0 Speeds

OFDM (Orthogonal FDM)

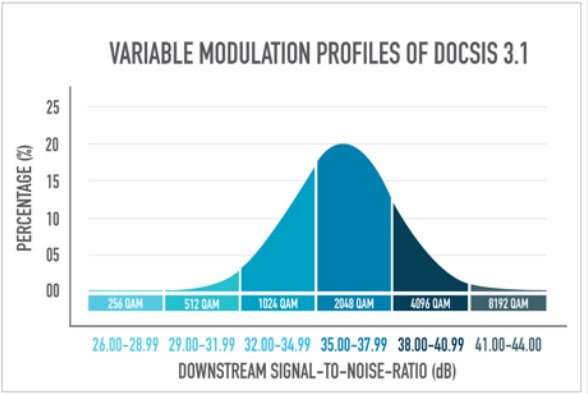


LDPC (Low Density Parity Check)



1024QAM ~ 4096QAM

Multiple Channel Profile

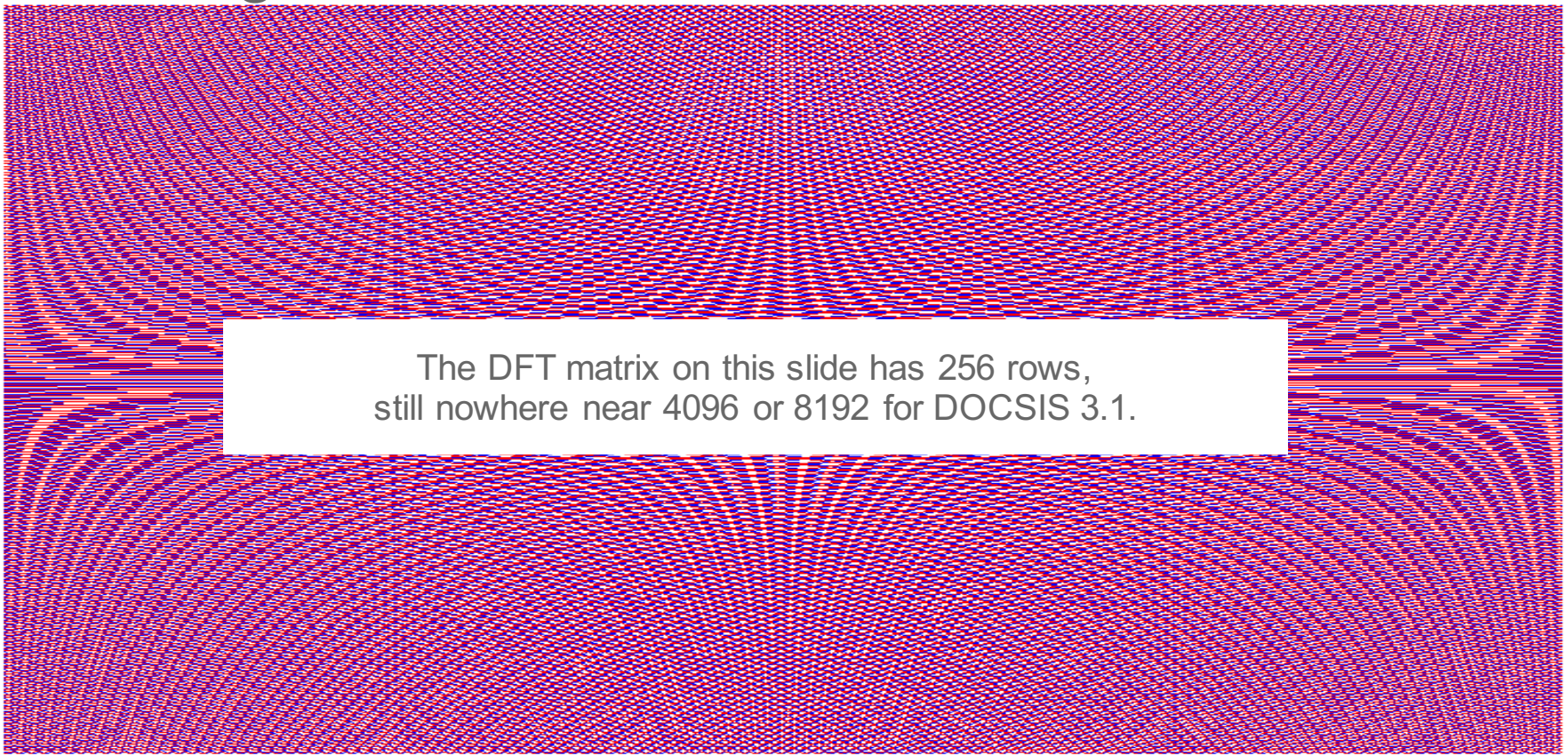


Into the DOCSIS 3.1

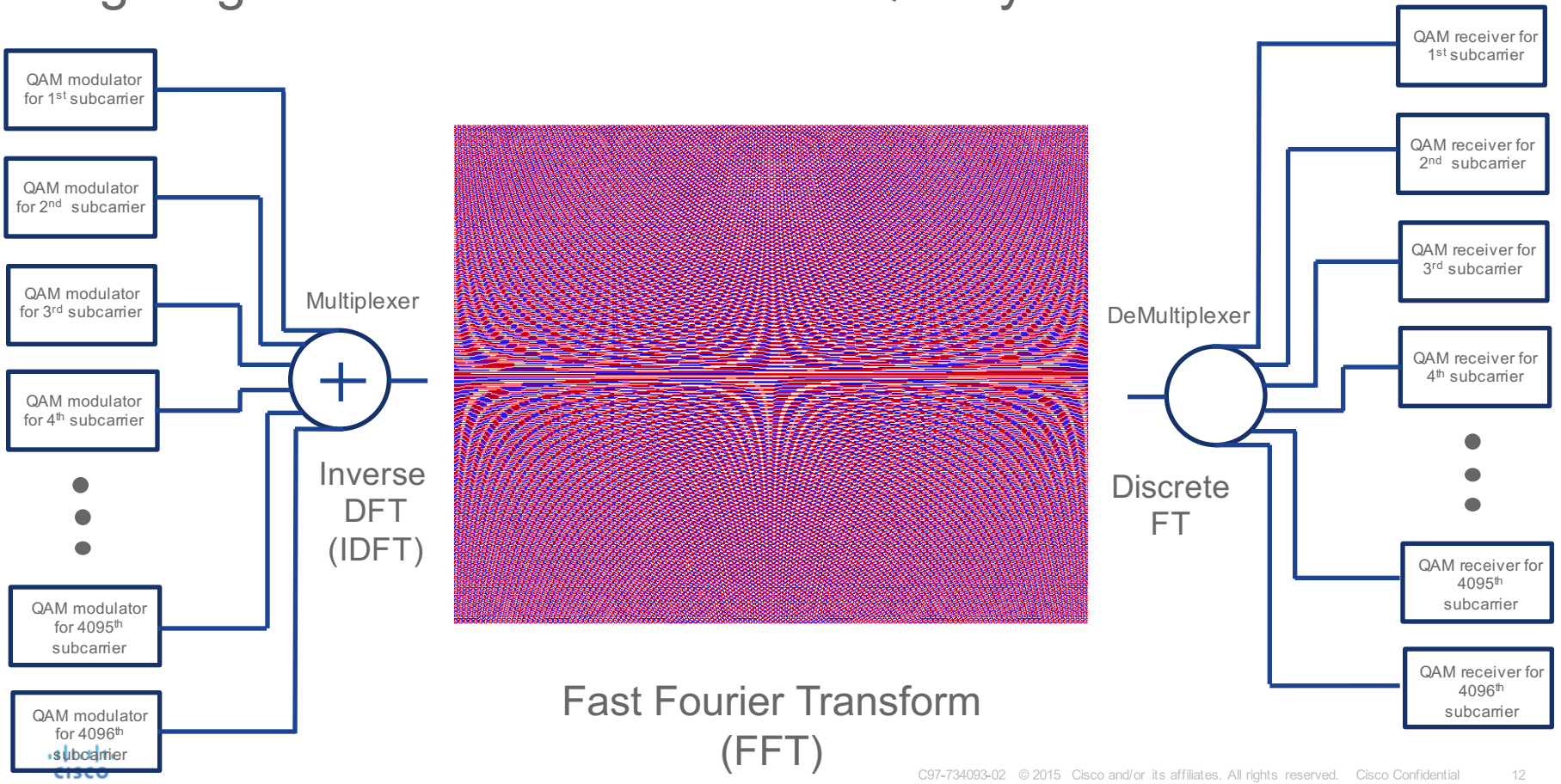
```
cable downstream ofdm-chan-profile 25
 cyclic-prefix 1024
 interleaver-depth 16
 pilot-scaling 48
 roll-off 128
 subcarrier-spacing 50KHZ
 profile-control modulation-default 1024-QAM
 profile-ncp modulation-default 16-QAM


controller Integrated-Cable 2/0/4
 max-ofdm-spectrum 144000000
 max-carrier 24
 base-channel-power 31
 rf-chan 0 23
  type DOCSIS
  frequency 462000000
  qam-profile 1
 rf-chan 158
  ofdm channel-profile 24 start-frequency 642000000 width
144000000 plc 644000000
```


How big is the DOCSIS 3.1 matrix?



Fighting with DFT and IDFT with Quality - OFDM Matrix



Fast Fourier Transform (FFT) Background

- Use FFT algorithm to speed up calculations of DFT and IDFT (moving between frequency and time domain)
- FFT size can be 4096 (4k FFT) for 50 kHz subcarrier or 8192 (8k FFT) for 25 kHz subcarrier for downstream
- Output of downstream FFT (referred to as OFDM Spectrum) will always be **204.8 MHz** (FFT size x subcarrier size)
- **Subcarriers outside of 192 MHz (or configured OFDM channel size) will be nulled as will guard bands and exclusion zones**
- Parameters like cyclic prefix samples and roll-off samples will be relative to a 204.8 MHz sampling rate

192 MHz downstream channel bandwidth				
FFT mode	**Theoretically available subcarriers**	**Maximum subcarriers in use**	**Carrier spacing**	**Sampling rate**
4K	4096	3800	50 kHz	204.8 MHz
8K	8192	7600	25 kHz	

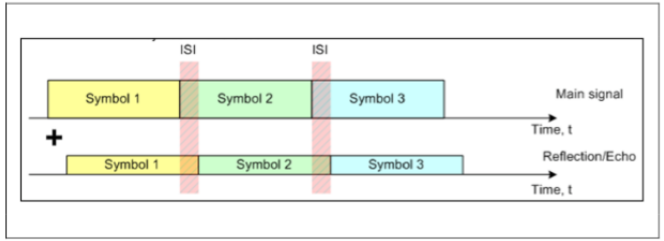
96 MHz upstream channel bandwidth				
FFT mode	**Theoretically available subcarriers**	**Maximum subcarriers in use**	**Carrier spacing**	**Sampling rate**
2K	2048	1900	50 kHz	102.4 MHz
4K	4096	3800	25 kHz	

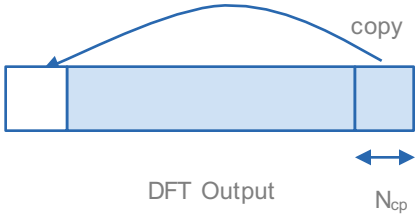
Don’t forget receiver synchronization

- To get the transmitter IFFT and receiver FFT to line up, we need to synchronize the receiver to the transmitter.
- Timing: Adjust symbol timing so the FFT starts at the right time.
  - Cyclic prefix: To make timing easier, the transmitter repeats part of the signal.
- Frequency: Adjust receiver to the correct center frequency.
  - Continuous pilots: Some subcarriers carry no data, and are used to measure frequency offset.
- Equalization: Adjust amplitude and phase of each subcarrier to remove channel effects.
  - Scattered pilots: Carry no data, visit each subcarrier location once every 128 symbols, used to measure channel response.

Cyclic Prefix Samples (N_{cp})

- Used to minimize effects of intersymbol interference caused by micro-reflections
- Copy a number of samples from end of OFDM symbol and place at beginning
- For downstream configurable from 192 – 1024 samples (0.9375 µs – 5.0 µs)
- Should be chosen as small as practical to limit overhead





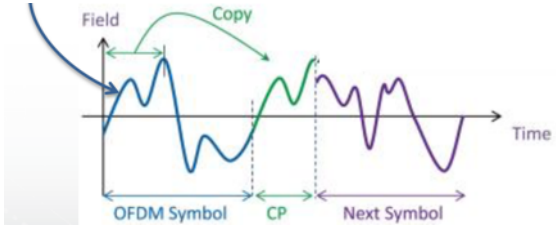


Table 7–34 - Cyclic Prefix (CP) Values

Cyclic Prefix (µs)	Cyclic Prefix Samples (N_{cp})
0.9375	192
1.25	256
2.5	512
3.75	768
5.0	1024

Sample of Cyclic Prefix

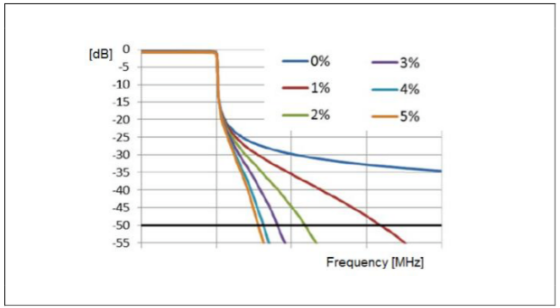
Sample of Cyclic Prefix

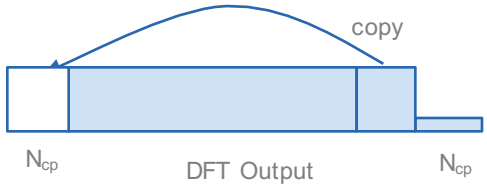
Roll-Off Period (N_{rp})

- Signal does not drop off instantly at edge so have roll-off to minimize impact to adjacent channels (minimize impact of adjacent channels on our signal as well)
- Define roll-off period samples also called taper region (N_{rp}= 64 – 256 samples)
- **Roll-off period samples N_{rp} must be smaller than cyclic prefix N_{cp}** (Roll-Off Period is integrated into the Cyclic Prefix)
- Recommended guard band settings based on roll-off are in Appendix V of D3.1 PHY specification

Table 7–5 - Roll-Off Prefix (RP) Values

Roll-Off Period (µs)	Roll-Off Period Samples (N_{RP})
0	0
0.3125	32
0.625	64
0.9375	96
1.25	128
1.5625	160
1.875	192
2.1875	224

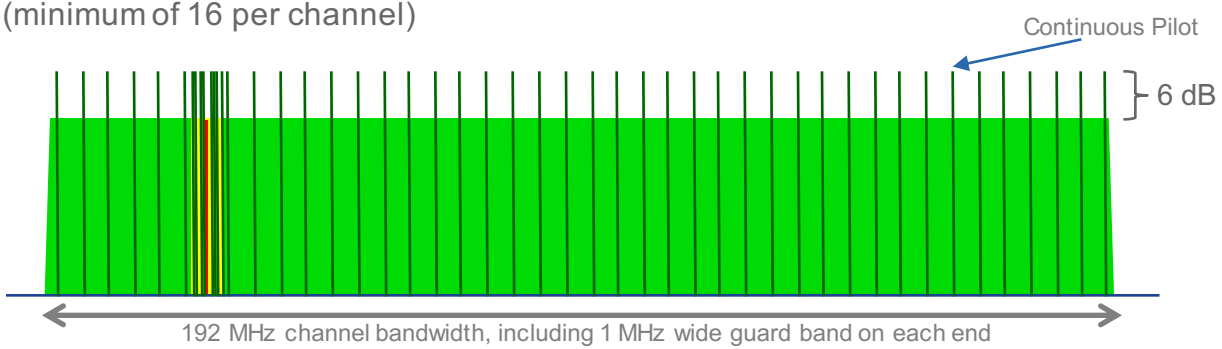




Cyclic Prefix and Roll-Off Period

Continuous Pilots

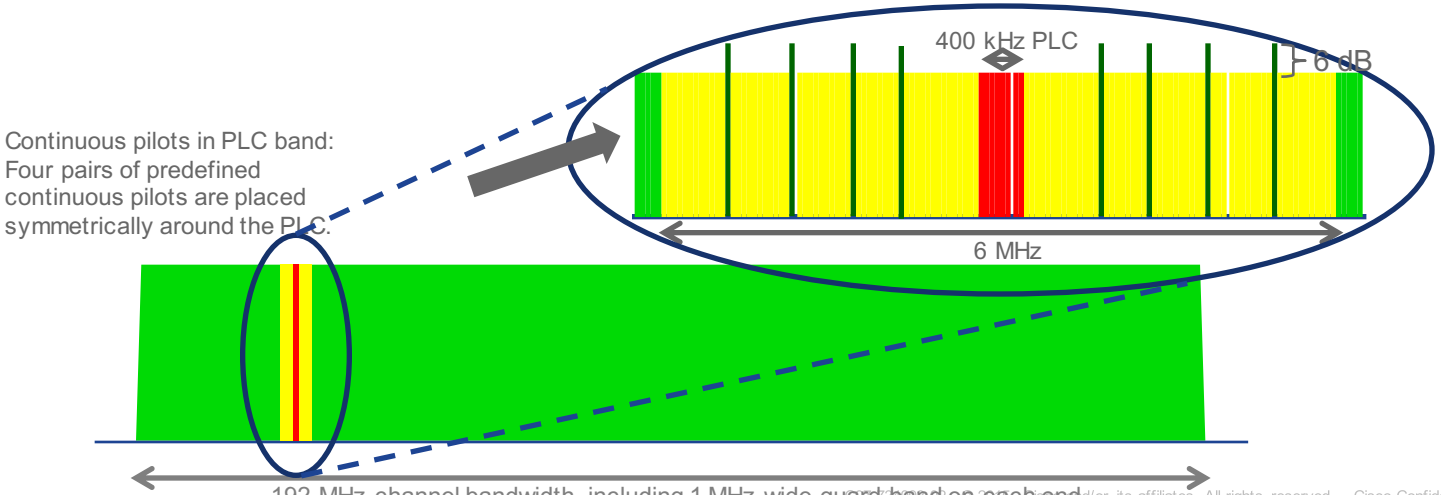
- Used to synchronize subcarriers and identify Physical Layer Link Channel (PLC) location
- Occur at same subcarrier location every time (in a regular pattern)
- 6 dB higher than other subcarriers / carry no data
- Number of pilots configurable (scale 48 – 120 relative to 192 MHz channel plus another 8 for PLC on cBR8)
  (minimum of 16 per channel)



Continuous pilots occur at the same frequency in every OFDM symbol, and are used for frequency and phase tracking. Continuous pilots do not carry data (they are BPSK modulated with a pseudo-random sequence, though).

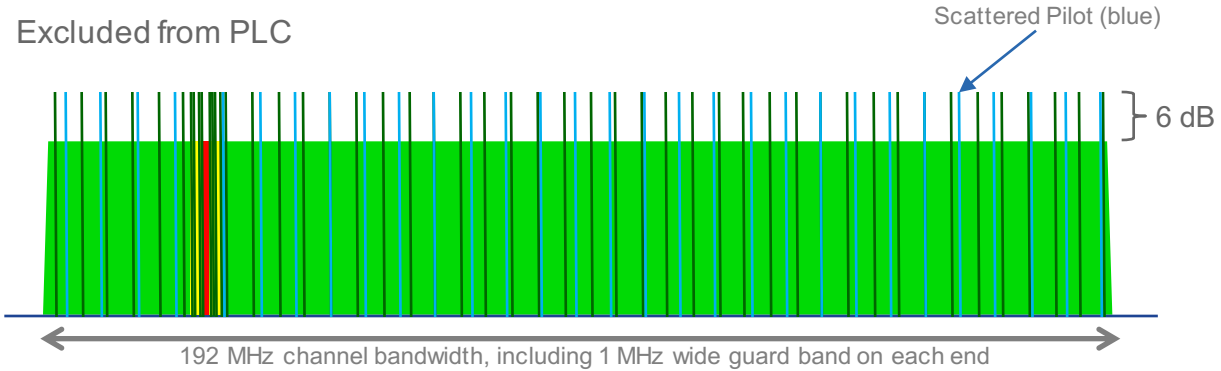
Physical Layer Link Channel

- Provides OFDM channel descriptor (OCD) and downstream profile descriptor (DPD) to modems
- Modem finds PLC based on pattern of continuous pilots
- PLC is 400 kHz wide and centered within 8 Continuous Pilot and 6 MHz continuous band
- PLC uses 16 QAM



Scattered Pilots

- Used for equalization and estimating subcarrier performance (RxMER)
- One pilot per 128 subcarriers (not configured) and location increments each symbol
- Not used if lands on same spot as continuous pilot
- 6 dB higher than other subcarriers / carry no data
- Excluded from PLC



Scattered pilots occur every 128 subcarriers (but not in the PLC band or in exclusion bands), and are used primarily for estimation of channel frequency response as part of the equalization process. Scattered pilots do not carry data (they are BPSK modulated with a pseudo-random sequence, though).

Next Codeword Pointer (NCP)

- LDPC FEC codewords are variable in size and can span multiple OFDM symbols
- Use different FEC codewords for different data profiles
- Next codeword pointer (NCP) used to tell modems where one FEC codeword ends and another starts
- NCP modulation profile – QPSK, 16 QAM, or 64 QAM (16 QAM default)
- 48 bits per NCP message (including FEC)
- Will have at least one NCP plus CRC message per symbol

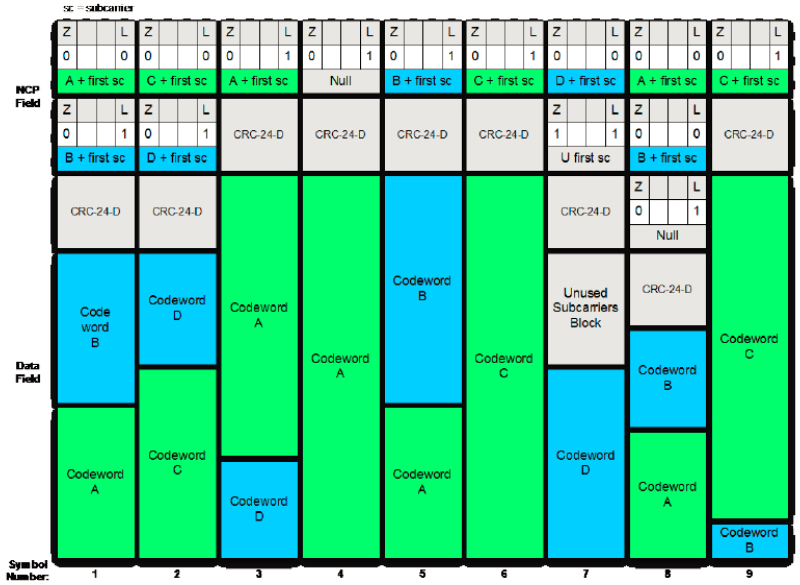
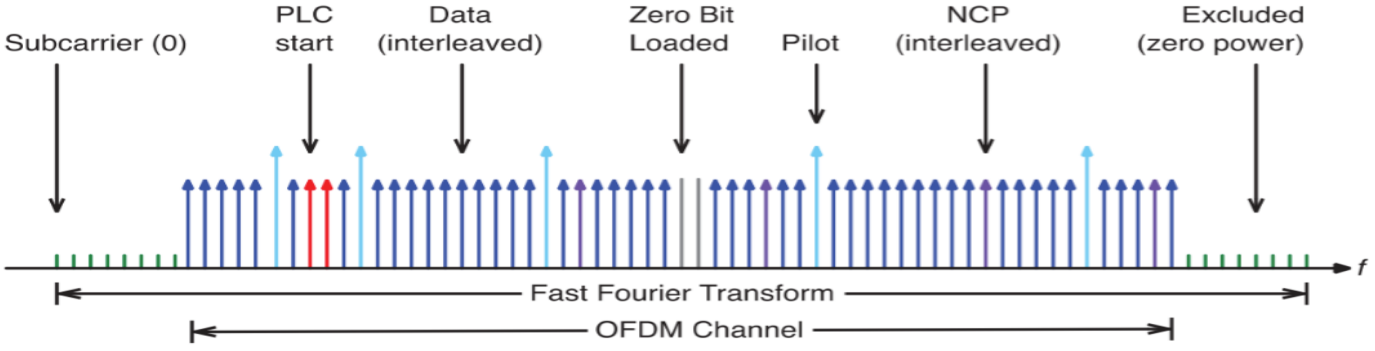


Figure 8-12 - NCP Examples

1.The CMTS MUST NOT place more than 11 NCP data message blocks plus a CRC for a total of 12 NCP MBs in an 8K OFDM symbol.
2.The CMTS MUST NOT place more than 12 NCP data message blocks plus two CRCs for a total of 14 NCP MBs in any two successive 4K OFDM symbols.

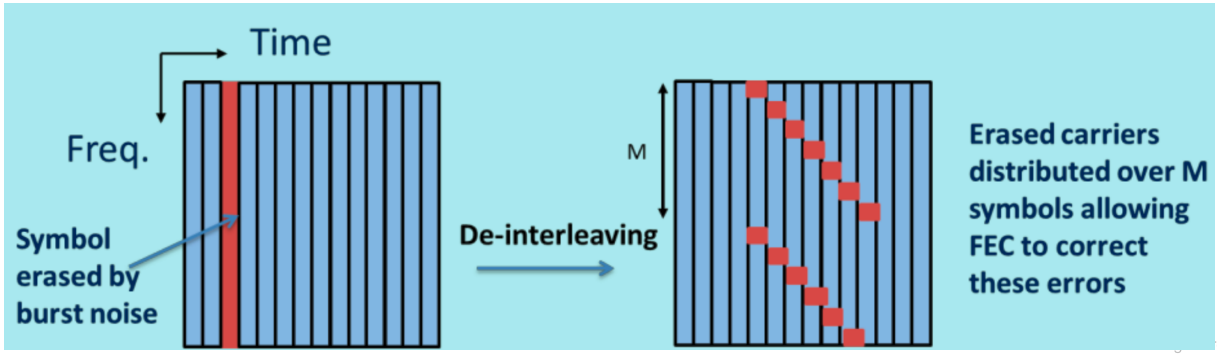


PLC = PHY Link Channel

NCP = Next Codeword Pointer

Interleaving Makes FEC More Effective

- FEC is most effective when bit errors are spaced over time but noise burst impacts large number of bits at once
- Interleave traffic so that burst errors are spread out
- DOCSIS 3.1 first interleaves traffic in time domain (interleave depth of 1 - 32 for 50 kHz; 1 - 16 for 25 kHz) then interleaves in frequency domain
- No extra overhead just introduces processing delay



DOCSIS PHY Overhead Comparison

- DOCSIS 3.0 and earlier (~12%):

  MPEG-2 TS (DS only) – 4B overhead per 188B (97.87% efficiency)

  Reed-Solomon FEC – 6B overhead per 128B (95.31% efficiency)

  Trellis coded modulation – 1 bit overhead per 20 bits (95.00% efficiency)

  FEC sync – 40 bit overhead per 78,848 bits (99.95% efficiency)

  Overhead = 1 – (97.87% x 95.31% x 95.00% x 99.95%) = 1 – 88.57%

- DOCSIS 3.1 (~20% - 50 kHz subcarriers / 192 MHz):

  LDPC / BCH FEC – 1984 bits overhead per 16200 bits (87.75% eff)

  Continuous Pilots 48 / 3800 subcarriers (98.74% eff)

  Scattered Pilots 1 / 128 subcarriers (or less) (99.22% eff)

  PLC – 16 subcarriers (400kHz + 8 CP) per OFDM block (99.58% eff for 192 MHz)

  Cyclic Prefix – configurable 192 – 1024 subcarriers (95.52% - 80.00% eff)

  Next Codeword Pointer (NCP) – varies on # and modulation order of NCP – 8 to 24 subcarriers per NCP message and have >1 (99.58% - 95.58% eff for 192 MHz)

D3.1 OFDM Downstream Channel Speeds

- Overhead percentage change with various configurations
- Maximize speeds by using widest channel and highest order modulation
- Minimize N_{cp} is more effective than minimizing guard bands
- Use highest NCP modulation you can reliably support

Double click spread sheet to change highlighted values

OFDM Downstream			
	4K FFT	8K FFT	
Size of channels (MHz) - 24-192 MHz[1]	192	192	MHz
FFT size (4K or 8K FFT)	4096	8192	subcarriers
Subcarrier spacing	50	25	kHz
Roll-off	128	128	samples[2]
Cyclic prefix (Ncp)	192	192	samples[2]
Ncp overhead	4%	2%	
Guard band on upper and lower edge (MHz)[3]	2	2	MHz
Number of active subcarriers	3760	7520	subcarriers
PLC overhead (number of subcarriers)	8	16	subcarriers
Continuous Pilot Scaling (48 - 120 subcarriers)	48	48	subcarriers
Continuous Pilots (include pilots for PLC)	56	56	subcarriers
Scattered Pilots (estimate)	29	58	subcarriers
Num of NCP (estimate >0)	2	2	
QAM order of NCP (QPSK, 16QAM, 64QAM)	4	4	bits / sym
NCP overhead (including CRC)	36	36	subcarriers
FEC overhead	12%	12%	8/9 code
Data QAM order (bits per symbol)	10	10	bits / sym
Data Rate (Mbps)	**1521.822**	**1576.394**	**Mbps**
Overhead % based on active subcarriers	19%	16%	
[1] If using exclusion bands, reduce channel size by amount of spectrum excluded for data rate			
[2] sampling rate is 204.8 MHz (based on OFDM spectrum - FFT size x subcarrier width)			
[3] Note that guard bands are based on Appendix V of D3.1 PHY spec based on roll-off and cyclic prefix			

Subcarrier Size – Pros and Cons

- 8192 FFT / 25 kHz subcarriers

  Less overhead – Next Codeword Pointer message and PLC pilots are subcarriers based; cyclic prefix N_{cp} size relative to FFT

  In theory, more granular to adapt to noise (modulation per 25 kHz)

  More complex – twice as many subcarriers as 50 kHz

  Less robust to noise – interleave depth / longer symbol duration

- 4096 FFT / 50 kHz subcarriers

  More robust to noise – interleave depth / shorter symbol duration

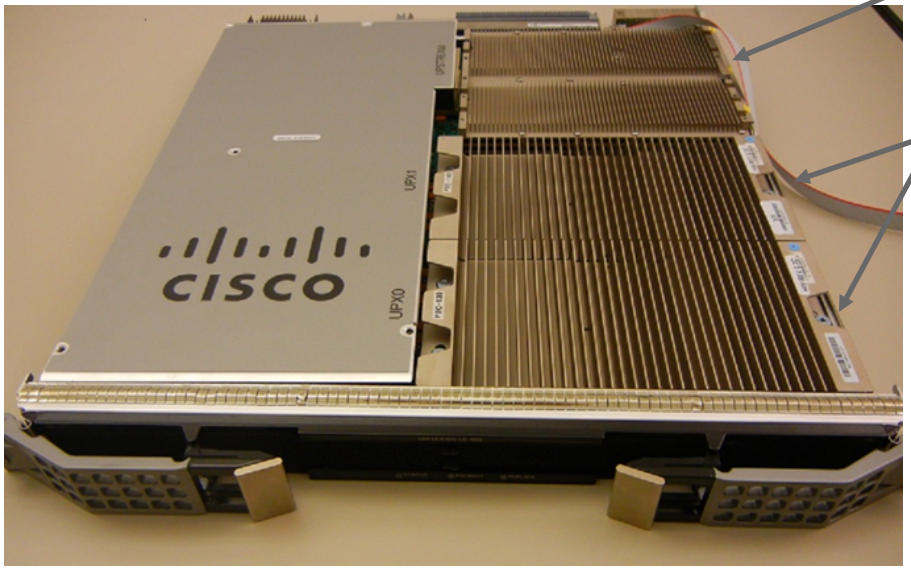
  Less complex – half as many subcarriers as 25 kHz (future "per-modem-profiles" would take less memory / computation)

  More overhead – Next Codeword Pointer, PLC pilots, cyclic prefix

  In theory, less granular to adapt to noise (modulation per 50 kHz)

Prerequisites for DOCSIS 3.1 Configuration

Cisco cBR8 Line Card – Modular PHY



DOCSIS US PHY module (D3.1 (Leoben 3) now shipping / IOS XE3.18)

DOCSIS DS PHY module (Gemini 2 – 2 per line card)

Full spectrum 54MHz – 1.2GHz

158 SC-QAM (96 narrowcast) plus two 192MHz OFDM per port

US still only run in DOCSIS 3.0 mode

Confirm DOCSIS 3.1 DS Hardware

- cBR8#show inventory

```
.....
NAME: "ATO clc 2", DESCR: "Cisco cBR CCAP Line Card"
PID: CBR-LC-8D31-16U30 , VID: V01, SN: CAT1906E1C3

NAME: "clc 2", DESCR: "Cisco cBR CCAP Line Card"
PID: CBR-CCAP-LC-40G , VID: V01, SN: CAT1906E1C3

NAME: "CLC Downstream PHY Module 2/0", DESCR: "Cable PHY Module"
PID: CBR-D31-DS-MOD , VID: V01 , SN: CAT1909E0XY

NAME: "CLC Downstream PHY Module 2/1", DESCR: "Cable PHY Module"
PID: CBR-D31-DS-MOD , VID: V01 , SN: CAT1909E12E
.....
```

- Note two **D3.1 DS Modules** installed on card in slot 2

This Card Would Not Support DOCSIS 3.1

- cBR8#show inventory

```
.....
NAME: "ATO clc 1", DESCR: "Cisco cBR CCAP Line Card"
PID: CBR-LC-8D30-16U30 , VID: V01, SN: CAT1910E11T

NAME: "clc 1", DESCR: "Cisco cBR CCAP Line Card"
PID: CBR-CCAP-LC-40G , VID: V01, SN: CAT1910E11T

NAME: "CLC Downstream PHY Module 1/0", DESCR: "Cable PHY Module"
PID: CBR-D30-DS-MOD , VID: V01 , SN: CAT1906E0DW

NAME: "CLC Downstream PHY Module 1/1", DESCR: "Cable PHY Module"
PID: CBR-D30-DS-MOD , VID: V01 , SN: CAT1906E0FD
.....
```

- Note two **D3.0 DS Modules** installed on card in slot 1

Confirm DS PHY Firmware Is Correct

- cBR8#show cable card 2/0 ds-phy display | include ver

img info: section 2, running ver **30013**, bundled 1000c G2 2000c G2-D31 **0**(micro)

img info: section 1, running ver **44141,** bundled 2000f G2 30103 G2-D31 **0**(apollo)

micro ver 30013, sector(1 base) 2, apollo ver 44141, sector(0 base) 1

cpld ver 7, sector(1 base) 1, psoc ver 40004, sector(1 base) 1

img info: section 2, running ver **30013**, bundled 1000c G2 2000c G2-D31 **0**(micro)

img info: section 1, running ver **44141**, bundled 2000f G2 30103 G2-D31 **0**(apollo)

micro ver 30013, sector(1 base) 2, apollo ver 44141, sector(0 base) 1

cpld ver 7, sector(1 base) 1, psoc ver 40004, sector(1 base) 1

XE 3.18SP no longer does automatic upgrade to Gemini DS modules (have “0” after bundle version) – firmware upgrades now done manually

Will Likely Need To Upgrade Gemini Firmware

- XE 3.18SP no longer does automatic Gemini upgrade
- Copy Gemini upgrade package to **harddisk**
- For Apollo upgrade

  cBR8#upgrade hw-programmable cable <slot #> dsphy **fpga** pkg_name /harddisk/cbrsup-rp-programmable-firmware.2016-04-22_gemini_44141.pkg

  After complete - cBR8#hw-module slot <slot #> reload

- For Micro upgrade

  cBR8#upgrade hw-programmable cable <slot #> dsphy **micro** pkg_name /harddisk/cbrsup-rp-programmable-firmware.2016-04-22_gemini_44141.pkg

  After complete - cBR8#hw-module slot <slot #> reload

(Note: currently need to reload card **twice** to upgrade both)

Confirm DOCSIS 3.1 Is Enabled on Cable Interface

- cBR8#**show interfaces cable 2/0/0 controller | begin Docsis 3.1**

  Mac-domain Docsis 3.1 related configurations in CLC:

  d31-mode enabled : **YES**

  mrc-mode enabled : YES

  mtc-mode : 2: MTC_PERMIT_ALL

  chassis_is_d31_capable : **YES**

  The overall D3.1 mode enabled : **YES**

- Can disable DOCSIS 3.1 per interface if necessary

  cBR8(config-if)#**no cable d31-mode**

DOCSIS 3.1 Configuration

cBR8 DOCSIS 3.1 DS Configuration Steps

1. Configure OFDM channel profile
   - Options for single or multiple data profiles
   - Options for mixed modulations
2. Configure OFDM spectrum on RF port
   - Options to define exclusion bands
3. Configure RF channel with frequency, channel width and OFDM channel profile (option for PLC placement)
4. Define a wideband interface that includes OFDM channel plus at least one D3.0 DS to act as primary
5. Still need other steps like fiber node, etc. as before (presentation does not cover any of these other steps)

OFDM Channel Profile – Minimal Requirement
Single Modulation Profile (0 / A)

- Configure OFDM channel profile in global configuration (0 – 19 reserved)

  cable downstream ofdm-chan-profile 25 (default values shown below)

  *cyclic-prefix **1024***

  interleaver-depth 16

  pilot-scaling 48

  roll-off 128

  subcarrier-spacing 50KHZ

  profile-control modulation-default 1024-QAM

  profile-ncp modulation-default 16-QAM

- Modems will use the control profile in above example for both data and DOCSIS control since no data profile is available

Recommended OFDM Channel Profile Settings To Maximize Speeds

cyclic-prefix 192 *(make value as low as HFC plant will support - 192 is lowest and 1024 is default)*

interleaver-depth 16 *(1 – 32 for 50 kHz subcarrier – default 16 is usually OK)*

pilot-scaling 48 *(keep at lowest setting – default is 48)*

roll-off 128 *(make as large as possible but must but less than cyclic prefix value)*

subcarrier-spacing 50KHZ *(less overhead for 25 kHz but most modem testing to date done with 50 kHz)*

profile-data 1 modulation-default 4096-QAM

(make data profile as high as HFC plant will support)

profile-ncp modulation-default 64-QAM

(make NCP as high as plant will support – most modem testing to date done with 16-QAM so may need to drop down)

OFDM Channel Profile - Multiple Data Modulation Profiles (0 / A, 1 / B and 2 / C)

```
cable downstream ofdm-chan-profile 24
 cyclic-prefix 192
 interleaver-depth 16
 pilot-scaling 48
 roll-off 128
 subcarrier-spacing 50KHZ
 profile-control modulation-default 1024-QAM
 profile-ncp modulation-default 16-QAM
 profile-data 1 modulation-default 2048-QAM
 profile-data 2 modulation-default 4096-QAM
```

- Modem will use first data profile (profile-data 1) by default
- cBR8 will periodically poll modem to gather RxMER and recommend best profile
- Can manually map modem to modulation in global config ***cable downstream ofdm-flow-to-profile profile-data <data#> mac-address <mac>***

Define OFDM Mixed Modulation Profile

- Want first and last 1 MHz of active OFDM channel to use 1024 QAM since seeing ingress noise from adjacent carriers
- Associate modulation order to various frequency ranges (can also configure using subcarrier numbering) – example has 2 MHz guard bands (one less excluded subcarrier at upper edge per Appendix V)

cable downstream ***ofdm-modulation-profile*** ***101***
subcarrier-spacing 50KHZ
width 192000000
start-freq 261000000
assign modulation-default ***2048-QAM***
assign modulation 1024-QAM range-subcarriers freq-abs 263000000 width ***1000000***
assign modulation 1024-QAM range-subcarriers freq-abs 450000000 width ***1050000***

cable downstream ***ofdm-modulation-profile*** ***102***
subcarrier-spacing 50KHZ
width 192000000
start-freq 261000000
assign modulation-default ***4096-QAM***
assign modulation 1024-QAM range-subcarriers freq-abs 263000000 width ***1000000***
assign modulation 1024-QAM range-subcarriers freq-abs 450000000 width ***1050000***

Associate Mixed Modulation To OFDM Channel Profile

cable downstream ofdm-chan-profile 30
cyclic-prefix 192
interleaver-depth 16
pilot-scaling 48
roll-off 256
subcarrier-spacing 50KHZ
profile-control modulation-default 1024-QAM
profile-ncp modulation-default 64-QAM
*profile-data 1 modulation-profile **101***
*profile-data 2 modulation-profile **102***

- Confirm settings match expectations with ***show cable ofdm-modulation-profile <#>***
- Also shows after applied to rf channel under integrated controller with ***show controllers integrated-cable x/y/z rf-channel <rf #> verbose*** (shown on slides 38 and 39)

Configure OFDM Spectrum On RF Port And Associate With RF Channel

```
controller Integrated-Cable 2/0/4
 max-ofdm-spectrum 144000000
 max-carrier 24
 base-channel-power 31
 rf-chan 0 23
  type DOCSIS
  frequency 462000000
  qam-profile 1
 rf-chan 158
  ofdm channel-profile 24 start-frequency 642000000 width 144000000 plc 644000000
```

- DOCSIS 3.1 OFDM channels start at rf-chan 158
- 144 MHz OFDM starting at 642MHz using channel profile 24 – PLC default frequency is first active subcarrier on 1 MHz boundary (should be in robust part of spectrum with no exclusion bands allowed in 6 MHz spectrum)
- Note that max spectrum / max carriers determine max channel power (DRFI)
- Power adjust under rf-ch 158 applies to entire OFDM channel
- *Freq-profile* setting under controller only required for D3.0 DS modules

Exclusion Band Options Available On RF Port

```
controller Integrated-Cable 2/0/4
 max-ofdm-spectrum 144000000
 max-carrier 24
 base-channel-power 31
 ofdm-freq-excl-band start-frequency 713000000 width 8000000
 rf-chan 0 23
  type DOCSIS
  frequency 462000000
  qam-profile 1
 rf-chan 158
  ofdm channel-profile 24 start-frequency 642000000 width 144000000 plc 644000000
```

- Configure exclusion bands per RF port (up to 64 per port) – minimum size 1MHz
- Require a minimum of 1 MHz guard band on either edge if excluding SC-QAM (may require more based on roll off setting)
- Above example assumes a 6 MHz SC-QAM center frequency of 717 MHz with 1 MHz guard band added on each side (8 MHz total exclusion band)
- Currently need to shut down controller to configure exclusion band
- Exclusion bands apply to all profiles on port (control, ncp, and data)

Define Wideband Interface Including One Or More D3.0 DS (Example of 24 D3.0 + OFDM)

```
interface Cable2/0/4
 downstream Integrated-Cable 2/0/3 rf-channel 0-23
 upstream 0 Upstream-Cable 2/0/3 us-channel 0
 upstream 1 Upstream-Cable 2/0/3 us-channel 1
 upstream 2 Upstream-Cable 2/0/3 us-channel 2
 upstream 3 Upstream-Cable 2/0/3 us-channel 3
 cable upstream bonding-group 2002
  upstream 0
  upstream 1
  upstream 2
  upstream 3
  attributes 80000000
 cable bundle 1
!
< note other wideband interfaces for SC-QAM also added but not shown>
!
interface Wideband-Cable2/0/4:6
 cable bundle 1
 cable rf-channels channel-list 0-23 158 bandwidth-percent 10
```


Useful Show Commands

Show Controllers Integrated-Cable x/y/z rf-channel <#>

- State should be “UP” / Admin should be “UP” – below shows rf-channel 158 which is 144 MHz OFDM channel starting at 642 MHz

*cBR8#**show controllers integrated-Cable 2/0/4 rf-channel 158***
Load for five secs: 3%/1%; one minute: 3%; five minutes: 3%
Time source is NTP, 16:23:06.002 EST Fri Feb 5 2016

Chan	State	Admin	Mod-Type	Start Freq	Width	PLC	Profile-ID	dcid	power output
158	**UP**	**UP**	OFDM	642000000	144000000	644000000	24	159	31 NORMAL

- Much more information with “verbose” option to be discussed later – at length!

Show PLC Information – OFDM Channel Descriptor (OCD)

- If nothing is displayed after command, OFDM channel is not working

*cBR8#**show cable mac-domain cable 2/0/4 ocd***

```
DCID: 159  OFDM Controller:channel 2/0/4:158

OCD Message
  MAC Header
    Frame Control                  : 0xC2   (MAC specific, MAC msg, EHDR Off)
    MAC Parameters                 : 0x0
    Length                         : 166
    Header Check Sequence          : 0x4D3E (19774)
  MAC Management Header
    Destination MAC ADDR           : 01e0.2f00.0001
    Source MAC ADDR                : 84b8.02cc.dd5e
    Length                         : 148
    Destination SAP                : 0
    Source SAP                     : 0
    Control                        : 3
    Version                        : 5
    Type                           : 49
    Multipart                      : 0    (Sequence number 0, Fragments 0)
  OCD fields
    DCID                           : 159
```


Show PLC Information – OFDM Channel Descriptor (OCD) - Continued

```
cBR8#show cable mac-domain cable 2/0/4 ocd
*** continued from previous slide ****
OCD fields
    DCID                              : 159
    CCC                               : 2
    TLV 0 Spacing                     : 50 KHz
    TLV 1 Cyclic Prefix               : 192 samples
    TLV 2 Rolloff                     : 128 samples
    TLV 3 Spectrum Location           : 611600000 Hz
    TLV 4 Interleave Depth            : 16
    TLV 5 Subcarrier Assignment       : Continuous Pilots (list)
      0657  0669  0680  0689  0726  0735  0746  0758  0803  0873
      0943  1013  1083  1153  1223  1293  1363  1433  1503  1573
      1643  1713  1783  1853  1923  1993  2223  2293  2363  2433
      2503  2573  2643  2713  2783  2853  2923  2993  3063  3133
      3203  3273  3343  3413
    TLV 5 Subcarrier Assignment       : Excluded Subcarriers (range)
                  : 0000 - 0647 << exclusion at start of spectrum
    TLV 5 Subcarrier Assignment       : Excluded Subcarriers (range)
                        : 2028 - 2187 << 8 MHz exclusion band configured
    TLV 5 Subcarrier Assignment       : Excluded Subcarriers (range)
                  : 3449 - 4095 << exclusion at end of spectrum
    TLV 5 Subcarrier Assignment       : PLC Subcarriers (range)
                                      : 0704 - 0711
    TLV 6 Primary Capable             : 0 (No)
-------------------------------------------------------------------
```


Show PLC Information – Downstream Profile Descriptor (DPD)

- If nothing is displayed after command, OFDM channel is not working

```
cBR8#show cable mac-domain cable 2/0/4 dpd

DCID: 159  OFDM Controller:channel 2/0/4:158

DPD Message
   *************** output omitted   ********************
DPD fields
    DCID                            : 159
    Profile ID                      : 0        <<< control profile
    CCC                             : 2
    TLV 5 Subcarrier Range/List     : Range (continuous)
      Modulation                    : 1024 (default value)  <<< using 1024 QAM
                                    : 0000 - 4095 <<applies to all subcarriers

*************** output omitted   ********************
 DPD fields
    DCID                            : 159
    Profile ID                      : 1       <<< data profile 1
    CCC                             : 2
    TLV 5 Subcarrier Range/List     : Range (continuous)
      Modulation                    : 2048 (default value)  <<< using 2048 QAM
                                    : 0000 - 4095 <<applies to all subcarriers
```

Show PLC Information – Downstream Profile Descriptor (DPD) - Continued

```
cBR8#show cable mac-domain cable 2/0/4 dpd

***** continued from previous slide *****

 *************** output omitted   ******************
  DPD fields
    DCID                            : 159
    Profile ID                      : 2          <<< data profile 2
    CCC                             : 2
    TLV 5 Subcarrier Range/List     : Range (continuous)
      Modulation                    : 4096 (default value)  <<< 4096 QAM
                                    : 0000 - 4095 <<applies to all subcarriers

*************** output omitted   ******************
DPD fields
    DCID                            : 159
    Profile ID                      : 255     <<< NCP profile (always 255)
    CCC                             : 2
    TLV 5 Subcarrier Range/List     : Range (continuous)
      Modulation                    : 16 (default value)  <<< 16 QAM
                                    : 0000 - 4095 <<applies to all subcarriers
--------------------------------------------------------------------------------
```

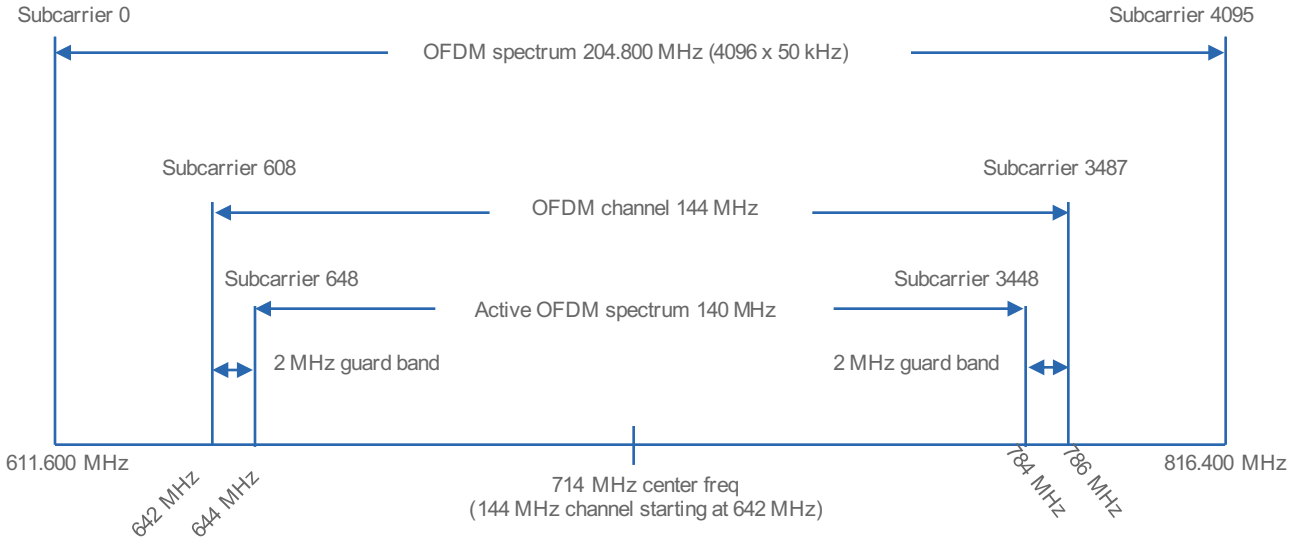

DPD Output With Mixed Modulation (OFDM Channel Profile 30 – Slides 21 & 22)

```
cBR8#show cable mac-domain cable 2/0/3 dpd
  ************** output omitted   ******************
DPD fields
    DCID                              : 159
    Profile ID                        : 0    <<< control profile
    CCC                               : 5
    TLV 5 Subcarrier Range/List       : Range (continuous)
      Modulation                      : 1024 (default value)    <<< use 1024 QAM
                                      : 0000 - 4095 <<applies to all subcarriers
************** output omitted   ******************
DPD fields
    DCID                              : 159
    Profile ID                        : 1     <<< data profile 1
    CCC                               : 6
    TLV 5 Subcarrier Range/List       : Range (continuous)
      Modulation                      : 1024          <<< use 1024 QAM
                                      : 0168 - 0187 <<< applies to first 1 MHz
                                        of active OFDM channel
    TLV 5 Subcarrier Range/List       : Range (continuous)
      Modulation                      : 1024        <<< use 1024 QAM
                                      : 3908 - 3928 <<< applies to last 1.05 MHz
                                        of active OFDM channel
    TLV 5 Subcarrier Range/List       : Range (continuous)
      Modulation                      : 2048 (default value)  <<< use 2048 QAM
                                      : 0000 - 4095 <<< applies as default to
                                        all other subcarriers
    ************** output omitted   ******************
```

Show Controllers Integrated-Cable x/y/z rf-channel <#> verbose

- "**Verbose**" option shows a lot of information that can be confusing if you don't understand terminology shown in diagram below

*cBR8#**show controllers integrated-Cable 2/0/4 rf-channel 158 verbose***



Show Controllers Integrated-Cable x/y/z rf-channel <#> verbose (Slide 1)

```
cBR8#show controllers integrated-Cable 2/0/4 rf-channel 158 verbose
 ********** output omitted  **********
 OFDM channel details: [2/0/4:158]
----------------------------------------
 OFDM channel frequency/subcarrier range     : 642000000[ 608] - 785999999[3487] << Freq range in HFC
 OFDM spectrum frequency/subcarrier range    : 611600000[  0] -  816399999[4095]
 Active spectrum frequency/subcarrier range  : 644000000[ 648] - 783999999[3448] <<OFDM -guardbands
 OFDM channel center frequency/subcarrier    : 714000000[2048]
 PLC spectrum start frequency/subcarrier     : 644000000[ 648] << start of 6 MHz PLC spectrum
 PLC frequency/subcarrier                    : 646800000[ 704] << start of 400 kHz PLC channel
 Channel width                               : 144000000  << OFDM channel width
 Active Channel width                        : 140050000  << active OFDM channel (without guard bands)
 OFDM Spectrum width                         : 204800000 << always 204.8 MHz for downstream
 Chan prof id                                : 24  << OFDM channel profile in use
 Cyclic Prefix                               : 192
 Roll off                                    : 128
 Interleave depth                            : 16
 Spacing                                     : 50KHZ
 Pilot Scaling                               : 48
 Control modulation default                  : 1024  << control modulation from OFDM channel profile 24
 NCP modulation default                      : 16
 Data modulation default                     : 1:2048 2:4096  << two data modulation profiles from profile 24
 Data modulation profile                     : None  << would see values here for mix modulation profiles
 Lower guardband width in freq/subcarriers   : 8400000[168]  (values incorrect – based on 192 MHz)
 Upper guardband width in freq/subcarriers   : 8350000[167]  (values incorrect – based on 192 MHz)
```


Show Controllers Integrated-Cable x/y/z rf-channel <#> verbose (Slide 2)

```
cBR8#show controllers integrated-Cable 2/0/4 rf-channel 158 verbose
 ********** output omitted  ********
 PLC spectrum frequencies [subcarriers]          :
  644000000[ 648] - 649999999[ 767]  << 6 MHz for PLC spectrum

 PLC channel frequencies [subcarriers]           :
  646800000[ 704] - 647199999[ 711]  Size: 8 subcarriers  << 400 kHz PLC channel location

 Excluded frequencies [subcarriers]              :
  611600000[   0] - 643999999[ 647]     << exclusion for lower guard band
  713000000[2028] - 720999999[2187]  << 8 MHz configured exclusion band from example
  784050000[3449] - 816399999[4095]  << exclusion for upper guard band
  Count: 1455

 Pilot frequencies [subcarriers]                 :
  *:PLC pilots
  644450000[ 657]* 645050000[ 669]* 645600000[ 680]* 646050000[ 689]*
  647900000[ 726]* 648350000[ 735]* 648900000[ 746]* 649500000[ 758]*
  651750000[ 803]  655250000[ 873]  658750000[ 943]  662250000[1013]
********** output omitted  ********
771750000[3203]  775250000[3273]  778750000[3343]  782250000[3413]
  Count: 44  << using 48 pilot scaling – 144MHz is 0.75 of 192 MHz so 36 pilots plus 8 for PLC

 Active frequencies [subcarriers]                :
  644000000[ 648] - 712999999[2027]    721000000[2188] - 784049999[3448]
  Count: 2641
```


Show Controllers Integrated-Cable x/y/z rf-channel <#> verbose (Slide 3)

*cBR8#**show controllers integrated-Cable 2/0/4 rf-channel 158 verbose***

```
*************** output omitted ******************* 
Data frequencies [subcarriers]                :
 644000000[ 648] - 644449999[ 656]    644500000[ 658] - 645049999[ 668]
*************** output omitted ******************* 
782300000[3414] - 784049999[3448]
 Count: 2589

Profiles:
 Number of profiles: 4
 CTRL profile (Profile A): rate: 1171520 kbps, usable rate: 1120000 kbps
 Active frequencies [subcarriers]:
 Modulation:Start-freq[start-subcarrier] - End-freq[end-subcarrier]
 ----------------------------------------------------
 1024 :644000000[ 648] - 644400000[ 656]    1024 :644500000[ 658] - 645000000[ 668]
 *************** output omitted ******************* 
 1024 :782300000[3414] - 784000000[3448]
 Active subcarrier count: 2589, ZBL count: 0

 Data profile 1 (Profile B): rate: 1288672 kbps, usable rate: 1232000 kbps << speed estimate
 Active frequencies [subcarriers]:
 Modulation:Start-freq[start-subcarrier] - End-freq[end-subcarrier]
 ----------------------------------------------------
 2048 :644000000[ 648] - 644400000[ 656]    2048 :644500000[ 658] - 645000000[ 668]
 *************** output omitted ******************* 
```


Show Controllers Integrated-Cable x/y/z rf-channel <#> verbose (Slide 4)

```
cBR8#show controllers integrated-Cable 2/0/4 rf-channel 158 verbose
 ********** output omitted  **********
  Data profile 2 (Profile C): rate: 1405824 kbps, usable rate: 1344000 kbps << speed estimate
  Active frequencies [subcarriers]:
  Modulation:Start-freq[start-subcarrier] - End-freq[end-subcarrier]
  ----------------------------------------------------------
  4096 :644000000[648] - 644400000[656]    4096 :644500000[658] - 645000000[668]

********** output omitted  **********
NCP profile:
  Active frequencies [subcarriers]:
  Modulation:Start-freq[start-subcarrier] - End-freq[end-subcarrier]
  ----------------------------------------------------------
16  :644000000[648] - 644400000[656]    16  :644500000[658] - 645000000[668]
  ********** output omitted  **********
16  :782300000[3414] - 784000000[3448]
  Active subcarrier count: 2589, ZBL count: 0

 CCCs:
   OCD CCC: 2
   DPD CCCs:
     Control profile  (Profile A) CCC: 2
     Data profile 1   (Profile B) CCC: 2
     Data profile 2   (Profile C) CCC: 2
         NCP profile  CCC: 2
```


Show Controllers Integrated-Cable x/y/z rf-channel <#> verbose (Slide 5)

*cBR8#**show controllers integrated-Cable 2/0/4 rf-channel 158 verbose***

Also includes more internal information that may be useful to DE's

```
**********output omitted **********
Resource config time taken: 7158 msecs
 JIB channel number: 776
Chan Pr EnqQ  Pipe  RAF   SyncTmr DqQ ChEn   RAF Pipe Phy0 Phy1 Tun# SessId 0[TkbRt MaxP]     1[TkbRt MaxP]
 776  0   384     1   238       0 384 0100  4282    1    0    1    2      0 479610000 4485120 383688000 4485120
 776  1   384     1   216       0 384 0100  3892    1    0    1    2      0 479610000 4485120 383688000 4485120
 776  2   384     1   198       0 384 0100  3568    1    0    1    2      0 479610000 4485120 383688000 4485120
 776  3   384     1  4786       0 384 0100  2190    1    0    1    2      0 479610000 4485120 383688000 4485120
 776  4   384     1  4786       0 384 0100  2190    1    0    1    2      0 479610000 4485120 383688000 4485120
 776  5   384     1  4786       0 384 0100  2190    1    0    1    2      0 479610000 4485120 383688000 4485120
 776  6   384     1  4786       0 384 0100  2190    1    0    1    2      0 479610000 4485120 383688000 4485120
 776  7   384     1     0      0 384 0100     0    1    0    1    2      0 479610000 4485120 383688000 4485120
Chan   Qos-Hi   Qos-Lo   Med-Hi   Med-Lo   Low-Hi   Low-Lo
 776   491520   245760   491520   245760   983040   491520
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
 776   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]
 776   10485750 65535 65535 184586343 268431360   Y [MM 102  128 1114][EM 103  128 6204][TR 2 9  3102]
DSPHY Info:
 Local rf port 0 , rf chan 158 pic loss 118
 non short CWs: = 0, shorts = 0, stuff bytes = 0 bch 0
 NCP msgs: = 0, PLC encodings = 0
 flow0 rcv 0 flow1 rcv 0 flow0 drops 0 flow1 drops 0
```


Show Controllers Integrated-Cable x/y/z rf-channel <#> verbose (Mixed Modulation - 1)

```
cBR8#show controllers integrated-Cable 2/0/3 rf-channel 158 verbose
 *************** output omitted   ******************
 OFDM channel frequency/subcarrier range     : 261000000[ 128] - 452999999[3967]
 OFDM spectrum frequency/subcarrier range    : 254600000[   0] - 459399999[4095]
 Active spectrum frequency/subcarrier range  : 263000000[ 168] - 450999999[3928]
 OFDM channel center frequency/subcarrier    : 357000000[2048]
 PLC spectrum start frequency/subcarrier     : 310000000[1108]
 PLC frequency/subcarrier                    : 312800000[1164]
 Channel width                               : 192000000
 Active Channel width                        : 188050000
 OFDM Spectrum width                         : 204800000
 Chan prof id                                : 30
 Cyclic Prefix                               : 192
 Roll off                                    : 128
 Interleave depth                            : 16
 Spacing                                     : 50KHZ
 Pilot Scaling                               : 48
 Control modulation default                  : 1024
 NCP modulation default                      : 64
 Data modulation default                     : None
 Data modulation profile                     : 1:101 2:102  <<
  From above - data profile 1 uses OFDM mod profile 101 and
           data profile 2 uses OFDM mod profile 102
 Lower guardband width in freq/subcarriers   : 8400000[168]
 Upper guardband width in freq/subcarriers   : 8350000[167]
```


Show Controllers Integrated-Cable x/y/z rf-channel <#> verbose (Mixed Modulation - 2)

```
cBR8#show controllers integrated-Cable 2/0/3 rf-channel 158 verbose

*************** output omitted  ******************

Data profile 1 (Profile B): rate: 1573190 kbps, usable rate: 1520000 kbps
Active frequencies [subcarriers]:
Modulation:Start-freq[start-subcarrier] - End-freq[end-subcarrier]
-------------------------------------------------------------
1024 :263000000[168] - 263950000[187]    2048 :264000000[188] - 264850000[205]
2048 :264950000[207] - 268650000[281]    2048 :268750000[283] - 272450000[357]
*************** output omitted  ******************
2048 :441950000[3747] - 445650000[3821]    2048 :445750000[3823] - 449450000[3897]
2048 :449550000[3899] - 449950000[3907]    1024 :450000000[3908] - 451000000[3928]
Active subcarrier count: 3697, ZBL count: 0

Data profile 2 (Profile C): rate: 1730509 kbps, usable rate: 1672000 kbps
Active frequencies [subcarriers]:
Modulation:Start-freq[start-subcarrier] - End-freq[end-subcarrier]
-------------------------------------------------------------
1024 :263000000[168] - 263950000[187]    4096 :264000000[188] - 264850000[205]
4096 :264950000[207] - 268650000[281]    4096 :268750000[283] - 272450000[357]
*************** output omitted  ******************
4096 :441950000[3747] - 445650000[3821]    4096 :445750000[3823] - 449450000[3897]
4096 :449550000[3899] - 449950000[3907]    1024 :450000000[3908] - 451000000[3928]
Active subcarrier count: 3697, ZBL count: 0
```


Show Cable Modem DOCSIS Version D31-capable

- Command shows all D3.1 capable modems registered (even if in D3.0 mode)

*cBR8#**show cable modem docsis version d31-capable***

MAC Address	I/F	MAC State	Reg Ver	Oper Ver	DSxUS	DS OFDM	RCC ID
fc52.8d5e.8400	C2/0/0/UB	w-online(pt)	3.1	3.1	33x8	1	112
0895.2a9b.3282	C2/0/0/UB	w-online(pt)	3.1	3.1	33x8	1	112

- Modems bonding on 33 DS (32 SC-QAM + 1 OFDM) x 8 US channels
- Make sure you don't see "0" under DS OFDM column or modem not running on OFDM channel

Show Cable Modem <MAC> Verbose Updated For DOCSIS 3.1 (Slide 1)

- Additional information added to show cable modem verbose command

```
cBR8#show cable modem 0895.2a9b.3282 verbose
MAC Address                          : 0895.2a9b.3282
IP Address                           : 10.8.2.141
*************** output omitted   ******************
Primary Wideband Channel ID          : 8193 (Wi2/0/0:0)
Primary Downstream                   : In2/0/0:8 (RfId : 8200, SC-QAM)
Wideband Capable                     : Y
DS Tuner Capability                  : 32
Downstream Channel DCID RF Channel : 9     2/0/0:8 (SC-QAM)
Downstream Channel DCID RF Channel : 1     2/0/0:0 (SC-QAM)
*************** output omitted   ******************
Downstream Channel DCID RF Channel : 32    2/0/0:31 (SC-QAM)
Downstream Channel DCID RF Channel : 159   2/0/0:158 (OFDM)
Downstream OFDM DCID                 : 159
Downstream OFDM Profile (in-use)     : 1
Downstream OFDM Profile (recomm)     : 1
sysDescr                             : Technicolor DOCSIS 3.1 advanced cable modem <<HW_REV:
1.0; VENDOR: Technicolor; BOOTR: 5.0.0; SW_REV: 01.F3.08.14.00; MODEL: TC4400-XM6>>
Downstream Power                     : 0.50 dBmV (SNR = 46.30 dB)
MAC Version                          : DOC3.1
Operational Version                  : DOC3.1
QoS Provisioned Mode                 : DOC1.1
```


Show Cable Modem <MAC> Verbose Updated For DOCSIS 3.1 (Slide 2)

```
cBR8#show cable modem 0895.2a9b.3282 verbose

********** output omitted **********

Extended Pkt Len Capability        : Max len of PDU = 2000 bytes, CMTS sent 2000
OFDM MRC Support                   : Max num of DS OFDM channels = 2
OFDM MTC Support                   : Max num of US OFDM channels = 2
DS OFDM Profile Support            : Max num of DS OFDM profile per channel = 5
DS OFDM QAM Modulation Support     : 0x1FD4{|QPSK|16|64|128|256|512|1024|2048|4096 QAM}
US OFDM QAM Modulation Support     : 0x1FFC{|QPSK|8|16|32|64|128|256|512|1024|2048|4096 QAM}
DS Lower Band Edge                 : 0x2{258 MHz}
DS Upper Band Edge                 : 0x1{1218 MHz}
Diplex Upper Band Edge             : 1081(-)

********** output omitted **********
```


Traffic Counts On OFDM Channels

*cBR8#**show controllers integrated-Cable 2/0/0 counter ofdm-channel***

Controller	Chan#	Profile/PLC	Packets	Bytes	Rate(Mbps)	Utilization(%)
2/0/0	158	Total	60733541943	92109825532843	1733.802312	99.9
2/0/0	158	0	4682417	318850940	0.005720	0.0
2/0/0	158	1	31002939800	47028148422606	891.491129	53.5
2/0/0	158	2	29716104829	45076018385689	842.207437	46.3
2/0/0	158	PLC-MMM	6689338	599810591	0.010761	
2/0/0	158	PLC-EM	0	0	0.000000	
2/0/0	158	PLC-TR	0	0	0.000000	

- Shows data profile 1 (2048 QAM) running 891.49 Mbps (53.5 %) and profile 2 (4096 QAM) running 842.21 Mbps (46.3%)
- Modems also using 32 DOCSIS 3.0 SC-QAM channels
- D3.1 modems will first fill OFDM channel before using D3.0 capacity
- May add “OFDM total capacity” column in future

Traffic Counts On DOCSIS 3.0 RF Channels

*cBR8#**show controllers integrated-Cable 2/0/0 counter rf-channel***

Contr	RF Chan	MPEG Packets Tx	MPEG bps	MPEG Mbps	Sync Packets Tx	MAP/UCD Packets Tx	User Mbps
2/0/0	0	11507025355	38804904	38.80	44615	1787085	33.06
2/0/0	1	11506205234	38802548	38.80	0	2230	35.09
2/0/0	2	11506201955	38800843	38.80	0	2230	35.08
2/0/0	3	11506202541	38801846	38.80	0	2230	35.08
2/0/0	4	11506019322	38795780	38.79	0	2230	34.99
2/0/0	5	11506014996	38794125	38.79	0	2230	34.98
2/0/0	6	11506014447	38795479	38.79	0	2230	34.98
2/0/0	7	11506014121	38794526	38.79	0	2230	34.98
2/0/0	8	11507003402	38804453	38.80	44614	1787075	33.05
2/0/0	9	11506276387	38801896	38.80	0	2230	35.06
**********	output omitted	**********					
2/0/0	30	11505441604	38763895	38.76	0	2230	34.75
2/0/0	31	11505444934	38765249	38.76	0	2230	34.75

- RF channels 0 and 8 are primary channels

OFDM Modulation Profile Selection

- Cable modem will use data-profile 1 if available when first coming online (use control profile if no data profile)
- cBR8 will gather RxMER from each modem using OFDM Profile Test (OPT) and recommends best profile (uses scattered pilots to test each subcarrier)
- The recommended profile will take effect when modem is reset (future release more graceful)
- If problems with too high of modulation order, modem generates OFDM failure via *CM status event*, profile is declared “unfit”, modem resets and comes up on a lower modulation profile if available (including control profile)
- Can manually configure a modem to a profile in global configuration with “*cable downstream ofdm-flow-to-profile profile-data <#> mac-address <mac>”* (has priority over other settings)

OFDM Modulation Profile Selection Settings

- cBR8 polls modem for RxMER every 60 min – can change with ***cable downstream ofdm-prof-mgmt. rxmer-poll-interval <#>*** (values 5 – 1440 minutes)
- Lifetime of a *recommended profile* is 120 minutes – can change with **cable downstream ofdm-prof-mgmt recommend-profile-age <#>** (values 5 – 1440 minutes)
- Lifetime of an *unfit profile* is 60 minutes – can change with **cable downstream ofdm-prof-mgmt unfit-profile-age <#>** (values 5 – 1440 minutes)
- If >2% of subcarriers are below recommended RxMER value, cBR8 will disqualify profile from recommendation – can change with ***cable downstream ofdm-prof-mgmt low-rxmer-sc-pct <%>***

Bit Loading Recommendation Used In Current Algorithm

Based on Table 7-41 in D3.1 PHY Specification

RxMER (in ¼ dB)	RxMER (dB)	QAM	Bit Loading
60	15	16	4
84	21	64	6
96	24	128	7
108	27	256	8
122	30.5	512	9
136	34	1024	10
148	37	2048	11
164	41	4096	12
184	46	8192	13
208	52	16384	14

Display Recommended Profiles Per Modem

- Can display recommended profile for all D3.1 modems

*cBR8#**show cable modem phy ofdm-profile*** *(current ECE release shows N/A)*

```
MAC Address      I/F            Chan         DCID  Curr  Recm
                                                   Prof  Prof
fc52.8d5e.8400   C2/0/0/UB      In2/0/0:158  159   2     1    << using 2 recommend 1
0895.2a9b.3282   C2/0/0/UB      In2/0/0:158  159   1     1
```

- Can display only modems that have recommended profile changes

*cBR8**#show cable modem phy ofdm-profile recommend***

```
MAC Address      I/F            Chan         DCID  Curr  Recm
                                                   Prof  Prof
fc52.8d5e.8400   C2/0/0/UB      In2/0/0:158  159   2     1
```

- Can reset selection algorithm per modem with "***clear cable modem <mac> delete***"

Display OFDM Profile Management Info.

```
cBR8#show cable modem 5039.5584.5bca prof-mgmt
MAC Address                : 5039.5584.5bca
IP Address                 : 10.24.1.23
IPv6 Address               : ---

Low RxMer SC Percent   : 10  <<  If >10% of subcarries have lower RxMER than
                                 profile requires, profile will not recommended
DCID                       : 159
Current profile            : 2   << currently running profile 2 (4096 QAM)
Downgrade profile          : 0
Recommend profile          : 1   << recommend using profile 1 (2048 QAM)
Unfit profile              : N/A
1st Active SubCarrier      : 648
# of Active SubCarriers    : 2801
Tx Time                    : 0h:01m:37s ago  << time since last cBR8 poll
Rx Time                    : 0h:01m:37s ago  << time since last modem response
Failure Rx                 : 28h:30m:26s ago
MER Poll Period   (min)    : 60
Recommend Timeout (min): 120
Unfit Timeout     (min)    : 60
Source                     : OPT   << RxMER values from OPT (ODS depreciated)
```

Display OFDM Profile Test (OPT) From Modem

*cBR8#**show cable modem 5039.5584.5bca prof-mgmt***

*************** *output continued from previous slide* *******************

Subcarrier number in Hexidecimal with 32 subcarriers per row (row starts at 0x280 = subcarrier 640)

Subcarrier 656 RxMER value of ¼ dB in Hexidecimal (0xA8 = 168 * ¼ = 42 dB)

RxMER values in groups of 4 subcarriers

Sub- RxMER ***(Note 0xFF for configured exclusion bands)***
Carrier

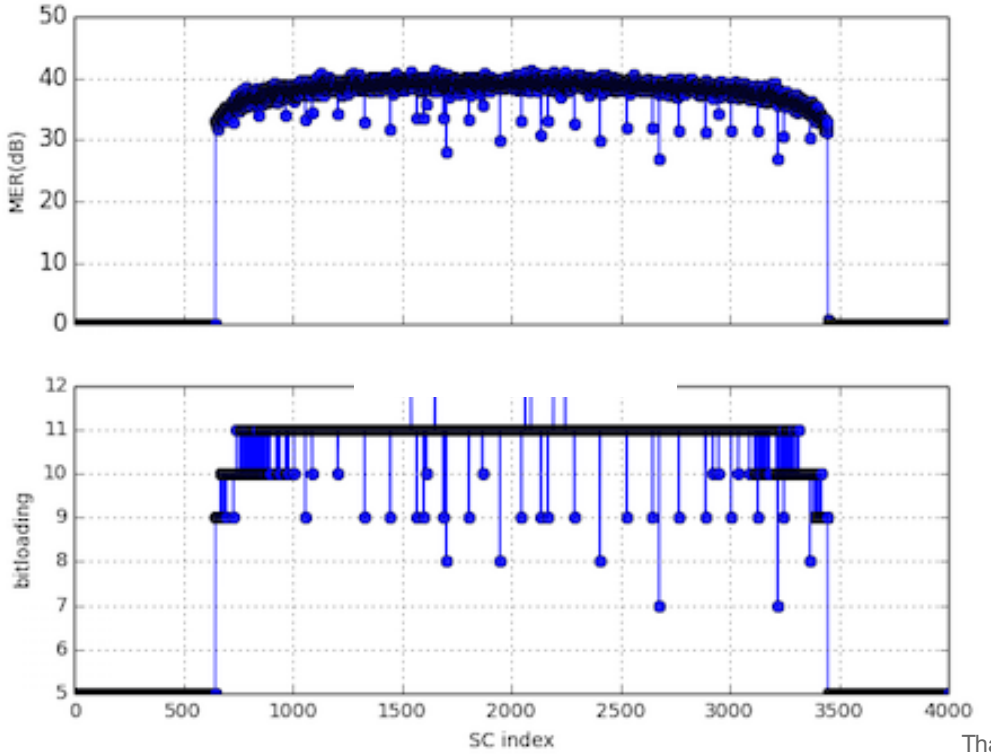
```
0x0000  00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
0x0020  00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
**************  output omitted *******************
0x0280  00000000  00000000  A4A4A3A0  A4A4A4A2  A8A2A1A0  9FA2A0A1  A0A7A39E  A5A5A0A0
0x02A0  A49FA4A4  A3A5A4A5  A8A6A5A6  A6A1A1A4  A3A2A3A1  A8A4A3A2  A1A4A2A1  A8A5A4A3
0x02C0  A2A5A1A3  A8A2A1A6  A4A1A4A1  A3A8A8A5  A5A8A5A4  A5A6A7A2  9EA4A4A3  A4A49FA1
**************  output omitted *******************
0x0D40  8E8F908E  8C8D908D  8B8C8B8A  898F8B8C  8F8F8A8A  8B8B8F8A  898A888C  8B8A8588
0x0D60  89878989  88888688  89848389  85858687  87878487  85878282  82000000  00000000
0x0D80  00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
**************  output omitted *******************
0x0FE0  00000000  00000000  00000000  00000000  00000000  00000000  00000000  00000000
```

Subcarrier 0x0D40 = 3392 **Subcarrier 3392 + 24 = 3416**

Note subcarrier 3416 has value of 0x89 = 137 * ¼ = 34.25 dB (under 2048 QAM recommendation)

Example of Subcarrier RxMER Data

- Most values ~ 40dB but over 2% subcarrier below 35 dB – cBR8 algorithm (with default settings) would recommend running 1024 QAM



Thanks Aimin Ding!

FEC Information From D3.1 Modem

- Telnet from cBR8 into Broadcom based on modem (DPC4011)

cmts3-lab#telnet 10.24.1.23
Trying 10.24.1.23 ... Open
Login: admin
Password: admin *(note normally shown)*
CM>
CM> **/cm_hal/ofdm_analyzer 32 0**

```
-------------|--------|---------------------------------|------------------------
             |   SNR  |         LDPC Statistics         |   FEC Sliding Window
   Profile   | Margin |     Total  Corrected  Uncorrect |     '*' = errored
-------------|--------|---------- ---------- ----------|------------------------
  A    1K-QAM|  10.71 |  46193478   15127648          0 | ......................
  B    1K-QAM|  10.71 |      3231       1449          0 | ......................
  C    4K-QAM|   5.36 |      2907       2857          0 | ......................
NCP    16-QAM|  27.21 |  27764058          0          0 | ......................

              Total Computations: 101
            RxMER - avg(log(S/N)): 40.48 dB
            RxMER - log(avg(S/N)): 40.22
```

- High correctable FEC codeword counts are normal
- SNR margin based on Broadcom setting (shown on next slide)

(Modem displays sometimes off – Profile B is actually 2048 QAM)

Bit Loading Information From D3.1 Modem

CM> **/cm_hal/ofdm_analyzer 32 0**

********** *output continued from previous slide* **********

```
--------|---------|-------------------------------------------------------------
  RxMER |    Max  |          RxMER Histogram for 2749 Subcarriers
    dB  | Bitload |
--------|---------|--------10--------20--------30--------40--------50--------60-
  29 dB |         |
  30 dB |  1K-QAM |
  31 dB |         |*
  32 dB |  2K-QAM |*
  33 dB |         |*
  34 dB |         |*
  35 dB |  4K-QAM |*
  36 dB |         |*
  37 dB |         |***
  38 dB |  8K-QAM |******
  39 dB |         |************
  40 dB |         |***************************
  41 dB | 16K-QAM |***********************************
  42 dB |         |********
  43 dB |         |*
  44 dB |         |
```

- Shows % of subcarriers that would be able to run given modulation
- CM> */cm_hal/ofdm_mer 32 10* (collects RxMER directly from modem)


CISCO