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Tech Notes

Upstream Modulation Profiles for Cable Linecards

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Contents

Introduction

Modulation profiles define how information will be transmitted upstream from a cable modem to the able Modem Termination System (CMTS). Many upstream modulation profile variables can be changed, such as guard time of the burst, preamble, modulation (quadrature phase shift keying (QPSK) or 16-quadrature amplitude modulation (QAM)), and Forward Error Correction (FEC) protection. Cisco has created three default profiles, QPSK, 16-QAM, and mix, to eliminate confusion, however, changes may be necessary depending on the application. Data over Cable Service Interface Specification

(DOCSIS) 2.0 has added 8, 32, and 64-QAM to the upstream modulation choices. This is known as advanced time division multiplex access (ATDMA). DOCSIS 2.0 also adds Synchronous Code Divsion Multiplexing (SCDMA), which will have its own default profiles when offered in the future.

Cisco did an extensive engineering program to properly code the correct profiles (based on the upstream PHY and card type) directly into the Cisco IOS®. Customers no longer have to manually enter the recommendations from this document. The differences in 15BC1 have been researched, lab-tested, and found to be correct. They should not need to be changed. These differences are also correct for the MC5x20 card , due to the fact that it uses a T1 PHY instead of the Broadcom PHY that all other cards use. The new Broadcom chip used in the MC28U also has different requirements than the old chip.

This table lists the modulation profile numbers that are used for specific cards in specific modes.

Profile Numbers	Linecards	DOCSIS Mode
1-10	MC28C & 16C/S	TDMA
21-30	MC5x20S	TDMA
121-130	MC5x20S	TDMA-ATDMA
221-230	MC5x20S	ATDMA
41-50	MC28U	TDMA
141-150	MC28U	TDMA-ATDMA
241-250	MC28U	ATDMA

The first number is always the default modulation profile for that type of card in a specific DOCSIS mode. Even if the 5x20 says that it is using profile 1, it really is not. The default would be profile 21. In 15BC2 code, you can issue the **sh cab modualtion-profile cx/y uz** command to see what is really being used. Also, unique word (UW) is not used for the TI chip.

This optimization project also changed the default minislot size from 64 symbols to the minimum requirement of 32 symbols. This makes the minislot size 8 bytes when using QPSK, 16 bytes when using 16-QAM, and 24 bytes when using 64-QAM. One caveat to this is the max burst from a cable modem is limited to 255 minislots. If the minislot is 8 bytes, then the max burst from a cable modem can only be 255*8=2040 bytes. This includes all PHY overhead and also fragmentation overhead. If attempting to allow single modems to have high US throughput, it is recommended to use a bigger minislot setting to satisfy the max burst settings in the cable modem's configuration file. If older modems seem to have problems when using 8-byte minislots, double the minislot size.

Note: There may be slight differences between Cisco IOS Software trains and versions. DOCSIS 1.1-based code (BC train) uses a shortened last code word (CW) as the default setting for short and long data grants. 1.0-based code (EC train) uses a fixed last CW as the default setting for these grants. If the modems fail to register and get stuck at init(d), it may be that the cable modem does not like the short grant profile, which is used for DHCP offers. DOCSIS 1.0-based code (EC train) uses a fixed last CW as the default setting.

The original default modulation profiles can be inefficient, depending on the DOCSIS extended header being used. These modulation profiles are optimized for five-byte extended headers. An inefficiency occurs when Cisco modems add one extra null byte to the extended header (Cisco modems do this for even alignment on a word boundary). This can have a drastic effect. It is not apparent if this only affects Cisco modems; for example, Toshiba modems use five-byte extended headers. More testing with multiple vendors is required.

Note: Piggybacking bandwidth requests require an extended header, and an extended header is also required if using baseline privacy interface plus (BPI+) security.

Tip: If not explicitly assigned with a modulation profile, each upstream port on a Cisco CMTS is assigned modulation profile 1 (QPSK) by default. Up to eight profiles can be configured. It is recommended to not change modulation profile 1. If more profiles are needed, start with number 2.

Prerequisites

Requirements

There are no specific requirements for this document.

Components Used

This document is not restricted to specific software and hardware versions.

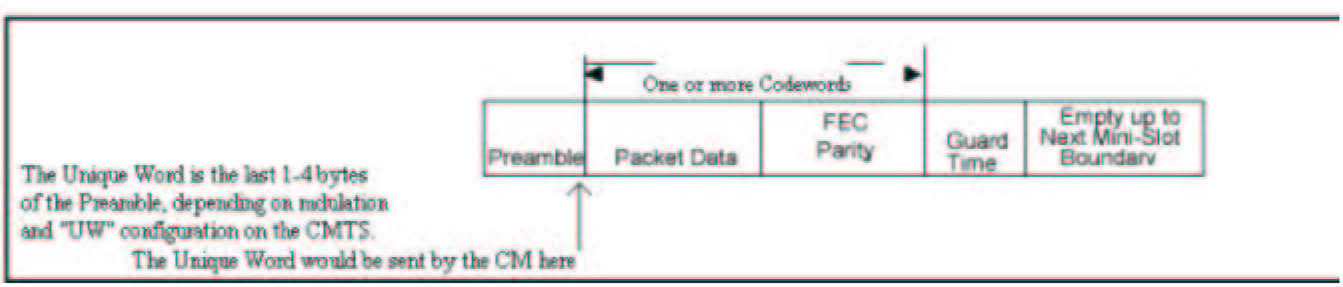
The information in this document was created from the devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If your network is live, make sure that you understand the potential impact of any command.

Conventions

For more information on document conventions, see the Cisco Technical Tips Conventions.

Upstream Bursts

To understand modulation profiles, you need to understand US bursts. This picture depicts what a US burst looks like.



The cable modem may burst to make a request, do station maintenance every 20 seconds or so, send short data packets, send long data packets, do initial maintenance to come online, and so on. A US burst starts with a preamble and ends with some guard time. The preamble is a way for the CMTS and cable modem to synchronize. Broadcom incorporates a UW at the end of the preamble for added synchronization. The guardband is used so that multiple bursts do not overlap with each other. The actual data in between the preamble and guardband is made up of Ethernet frames and DOCSIS overhead that have been cut into FEC CWs, with FEC added to each CW.

This picture is the output of a **debug** command on a Cisco cable modem that shows the preamble pattern.

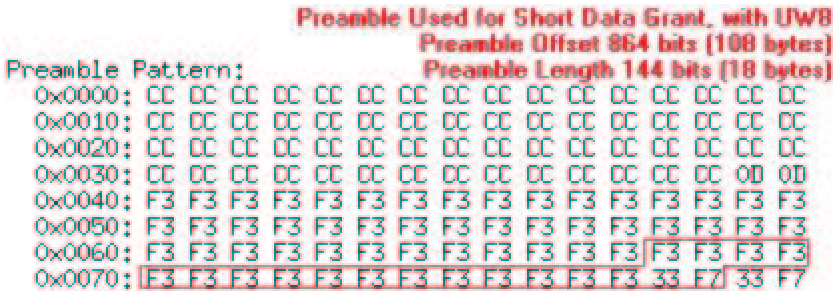
```
c0307-ubr7246#debug cable ucd
CMTS ucd debugging is on
c0307-ubr7246#debug cable int ca3/0
c0307-ubr7246#un all
Mar 21 13:16:11 est: UCD MESSAGE
Mar 21 13:16:11 est:   FRAME HEADER
Mar 21 13:16:11 est:     FC                            - 0xC2 ==
Mar 21 13:16:11 est:     MAC_PARM                      - 0x00
Mar 21 13:16:11 est:     LEN                           - 0x16A
Mar 21 13:16:11 est:   MAC MANAGEMENT MESSAGE HEADER
Mar 21 13:16:11 est:     DA                            - 01E0.2F00.0001
Mar 21 13:16:11 est:     SA                            - 0003.6C4A.E054
Mar 21 13:16:11 est:     msg LEN                       - 158
Mar 21 13:16:11 est:     DSAP                          - 0
Mar 21 13:16:11 est:     SSAP                          - 0
Mar 21 13:16:11 est:     control                       - 03
Mar 21 13:16:11 est:     version                       - 01
Mar 21 13:16:11 est:     type                          - 02 ==
Mar 21 13:16:11 est:   US Channel ID                   - 1
Mar 21 13:16:11 est:   Configuration Change Count      - 43
Mar 21 13:16:11 est:   Mini-Slot Size                  - 8
Mar 21 13:16:11 est:   DS Channel ID                   - 0
Mar 21 13:16:11 est:   Symbol Rate                     - 16
Mar 21 13:16:11 est:   Frequency                       - 6992000
Mar 21 13:16:11 est:   Preamble Pattern:
Mar 21 13:16:11 est:     0x0000: CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC
Mar 21 13:16:11 est:     0x0010: CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC
Mar 21 13:16:11 est:     0x0020: CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC
Mar 21 13:16:11 est:     0x0030: CC CC CC CC CC CC CC CC CC CC CC CC CC CC 0D 0D
Mar 21 13:16:11 est:     0x0040: F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3
Mar 21 13:16:11 est:     0x0050: F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3
Mar 21 13:16:11 est:     0x0060: F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3
Mar 21 13:16:11 est:     0x0070: F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 33 F7 33 F7
```

The pattern CC in hex is equivalent to 1100-1100. The preamble pattern F3 F3 in hex is equivalent to 1111 0011-1111 0011.

This picture shows the preamble length and offset. The offset is calculated based on the length and UW, which are set in the modulation profile.

```
Burst Descriptor 3                Short Data Grant IUC
  Interval Usage Code           - 5        With UW8
  Modulation Type               - 2 == QAM
  Differential Encoding         - 2 == OFF
  Preamble Length               - 144
  Preamble Value Offset         - 864
  FEC Error Correction          - 6
  FEC Codeword Length           - 75
  Scrambler Seed                - 0x0152
  Maximum Burst Size            - 6
  Guard Time Size               - 8
  Last Codeword Length          - 1 == FIXED
  Scrambler on/off              - 1 == ON
```

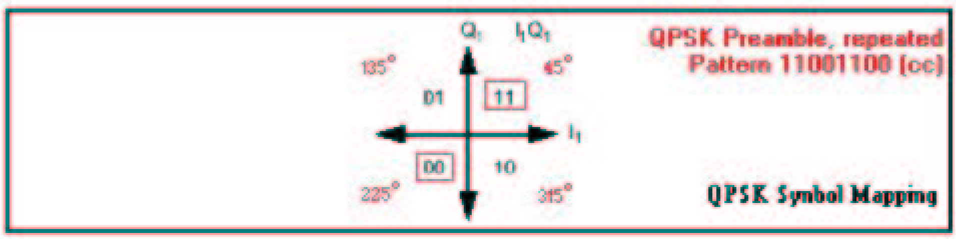
This picture shows the actual preamble used from the entire pattern. You can see the preamble using a steady pattern of F3 F3, but at the end a UW pattern is used of 33 F7.



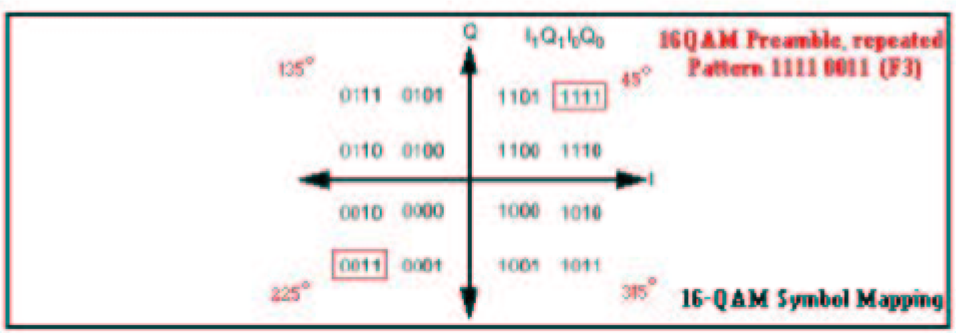
```
                                   Preamble Used for Short Data Grant, with UWB
                                            Preamble Offset 864 bits (108 bytes)
Preamble Pattern:                           Preamble Length 144 bits (18 bytes)
  0x0000: CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC
  0x0010: CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC
  0x0020: CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC CC
  0x0030: CC CC CC CC CC CC CC CC CC CC CC CC CC CC 0D 0D
  0x0040: F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3
  0x0050: F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3
  0x0060: F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3
  0x0070: F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 F3 33 F7 33 F7
```

The UW pattern 33 F7 in hex is equivalent to 0011 0011-1111 0111.

This picture is of the QPSK preamble constellation.

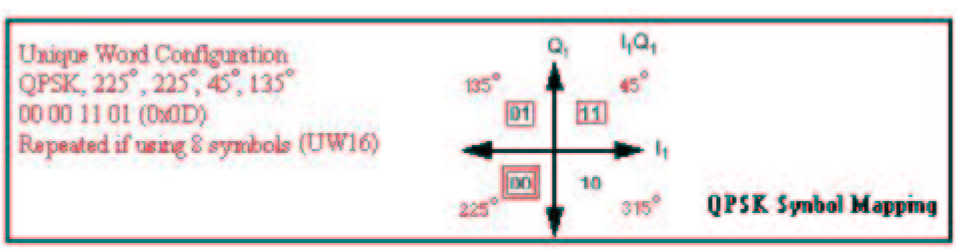


This picture is of the 16-QAM preamble constellation.

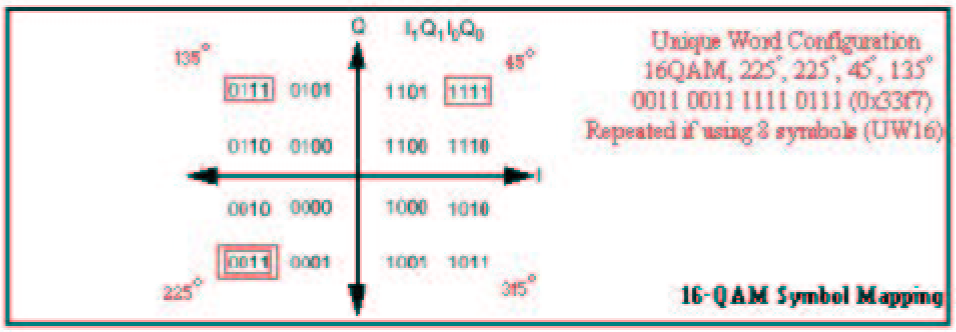


The preamble is a very stable pattern between two different states, and could be considered to be bi-phase shift keying (BPSK). This is why the preamble is used for US level measurements in zero-span mode. At the end of the preamble is a UW.

This picture is of the QPSK UW constellation.



This picture is of the 16-QAM UW constellation.



This section is included to provide an understanding of the preamble and the UW, as it has a very drastic effect on the modulation and whether or not packets are dropped. Whenever using 16-QAM with Broadcom, the UW should be 16 instead of the previous default of 8. More information on this will be covered later in this document.

Modulation Profile Tutorial

Complete these steps to configure the modulation profile.

1. Under global configuration, issue the **cable modulation-profile 1 qpsk** command.

2. Under the appropriate interface (cable 3/0), issue the **cable upstream 0 modulation profile 1** command. Or, leave it blank, as the default is modulation profile 1.

3. The actual profile when entered and viewed in the **show run** command is shown in the table below. Only the short and long interval usage codes (IUCs) for profile 1 may be displayed however.

Original Inefficient Profile

IUC	FEC T bytes	FEC CW	Max B	Guard Time	Mod Type	Scramble	Scramble Seed	Diff Enc	Preamble Length	Last CW	U
cable modulation-profile 1 short	5	75	6	8	QPSK	scrambler	152	no-diff	72	fixed	U
cable modulation-profile 1 long	8	220	0	8	QPSK	scrambler	152	no-diff	80	fixed	U

The **show cable modulation-profile** command produces the output shown in the table below.

Mod IUC	Type	Preamble Length	Diff Enco	FEC T bytes	FEC CW	Scramble Seed	Max B	Guard Time	Last CW	Scrambler	Preambl Offset

1 Request	QPSK	64	No	0x0	0x10	0x152	0	8	No	Yes	952
1 Initial	QPSK	128	No	0x5	0x22	0x152	0	48	No	Yes	896
1 Station	QPSK	128	No	0x5	0x22	0x152	0	48	No	Yes	896
1 Short	QPSK	72	No	0x5	0x4B	0x152	6	8	No	Yes	944
1 long	QPSK	80	No	0x8	0xDC	0x152	0	8	No	Yes	936

As you can see, the fields are not in the same places. The UW setting is not visible. You can see the **Preamble Offset**, which is not set, but calculated, based on what is set for the UW.

This list describes each column.

- **IUCs** are short, long, req, init, station, and so on. These are also known as information elements. The first three IUCs are for maintaining modem connectivity, while short and long IUCs are for actual data traffic.
- **Type** is 16-QAM or QPSK. This is expanded for DOCSIS 2.0.
- **Preamble Length** in bits is <2-512>. 16-QAM is usually double the **Preamble Length** over QPSK.
- **Diff Enco** means that different encoding is enabled. **No-diff** means that different encoding is disabled. Always use no-diff encoding.
- **FEC T bytes** are entered as decimal <0-10>, but shown in hex. 2* FEC T bytes size = bytes of FEC in each FEC code word (CW). Zero indicates no FEC. You can also disable FEC on the interface of each individual upstream port. This has been expanded to 16 for DOCSIS 2.0.
- **FEC CW** is the CW length information bytes (k) entered in decimal <16-253>, but shown in hex.

  Note: When using a shortened last CW, the last CW must be greater than or equal to 16 bytes. If less than 16 bytes, filler bytes are added to make it 16. A full CW is k+2*T, and must be less than or equal to 255 bytes total. If no FEC is used, CW has no meaning.
- **Scramble seed** is listed in hex <0-7FFF>. Do not change this.
- **Max B** is the maximum burst size in minislots <0-255>. Zero means no limit. Any burst less than or equal to the amount of bytes represented by the maximum burst will use this IUC.
- **Guard Time** is listed in symbols <0-255>. DOCSIS states that this needs to be at least five symbols. QPSK has two bits per symbol and 16-QAM has four bits per symbol.
- **Last CW** of fixed is the fixed last CW. Shortened is the shortened last CW and will state **Yes** in the column. Shortened eliminates extra stuffing.
- **Scrambler** means the scrambler is enabled, and no-scrambler means the scrambler is disabled.

Always keep the scrambler enabled.

- **Preamble Offset** is not entered into the configuration. It is calculated when you enter in the UW value of eight or 16. The sum of **Preamble Offset** plus **Preamble Length** will equal 1024, 768, 512, or 256 bits for UW16; if not, you can assume UW8 is being used.

  The UW is entered in the configuration of a profile, but does not show up in the **show** command output. UW16 means that a 16-bit UW is detected, and UW8 means that an eight-bit UW is detected.

  Caution: Be sure to use UW16 when using 16-QAM for short or long IUCs. Using UW8 with 16-QAM can cause uncorrectable FEC errors to increment. Issue the **show cable hop** command to verify.

Modulation Profile 3 (Mix) Example

Complete these steps:

1. Under global configuration, issue the **cable modulation profile 3 mix** command.
2. Under the appropriate interface (cable 3/0), issue the **cable up 0 modulation profile 3** command.
3. The actual profile when entered and displayed with the **show run** command is shown in the table below.

Original Inefficient Mixed Profile

IUC	FEC T bytes	FEC CW	Max B	Guard Time	Mod Type	Scramble	Scramble Seed	Diff Enc	Preamble Length	Last CW	UW
cable modulation-profile 3 request	0	16	0	8	QPSK	scrambler	152	no-diff	64	fixed	UW16
cable modulation-profile 3 initial	5	34	0	48	QPSK	scrambler	152	no-diff	128	fixed	UW16
cable modulation-profile 3 station	5	34	0	48	QPSK	scrambler	152	no-diff	128	fixed	UW16
cable modulation-profile 3 short	6	75	6	8	QPSK	scrambler	152	no-diff	144	fixed	UW8

cable modulation-profile 3 long	0	220	0	8	QPSK	scrambler	152	no-diff	160	fixed	UW8

The **show cable modulation-profile 3** command output is shown in the table below.

Mod IUC	Type	Preamble Length	Diff Enco	FEC T bytes	FEC CW	Scramble Seed	Max B	Guard Time	Last CW	Scrambler	Preambl Offset
3 Request	QPSK	64	no	0x0	0x10	0x152	0	8	No	Yes	0
3 Initial	QPSK	128	no	0x5	0x22	0x152	0	48	No	Yes	0
3 Station	QPSK	128	no	0x5	0x22	0x152	0	48	No	Yes	0
3 Short	QPSK	144	no	0x6	0x4B	0x152	6	8	No	Yes	0
Long	QPSK	160	no	0x8	0xDC	0x152	0	8	No	Yes	0

Note: Notice in the display above that the **Preamble Offset** indicates 0. The **Preamble Offset** will not show up until you assign this modulation profile to an upstream port.

Tip: Decrease the minislot size from eight ticks to four. This will keep the number of bytes in a minislot closer to 16 when you use the more complex modulation scheme. If the minislot size is left at eight ticks, the minimum burst sent will be at least 32 bytes. This is inefficient when sending upstream requests, which only require 16 bytes total. See Appendix B for minislot configuration.

DOCSIS 1.0-Based Code (EC and Earlier Cisco IOS Software Trains)

Consider Cisco modems with six-byte extended headers, and using all current Cisco CMTS defaults in the EC code, such as 1.6 MHz channel width, minislot size of eight ticks (16 bytes). The modulation profile is shown below.

```
cable modulation-profile 1 short 5 75 6 8 qpsk scrambler 152 no-diff 72 fixed
```

If sending 64-byte Ethernet frames (46-byte packet data unit (PDU) + 18-byte Ethernet header) on the upstream, the modem uses a long burst and the total packet size becomes 256 bytes. This will be 16 minislots. See Appendix A for the calculations. This is inefficient for a 46-byte PDU. The packet-per-second (PPS) rate for 64-byte packets will drop because of this. Concatenation can help with upstream throughput when sending 64-byte packets, but sending extra bytes wastes time.

This inefficiency could affect downstream TCP flows, because this will also be true for a TCP acknowledgment on the upstream. Even though an acknowledgment is less than 46 bytes, it will be padded to make it at least 46. Upstream concatenation can help tremendously, but it is still inefficient to send 256 bytes when only 96 bytes total are typically needed.

If the extended header is only five bytes as originally believed, the modem uses a short grant at six minislots, for a total of 96 bytes. This is a difference of 160 bytes (256-96).

Complete these steps to fix modulation profile 1 (QPSK):

1. Increase the FEC CW size from 75 to 76 for the short IUC.
2. Decrease the FEC T bytes from five to four for the short IUC.
   - If the minislot size is changed from the default of eight ticks to four, make sure the **Max Burst** field for the short IUC is changed from six to 12.
3. Shortened last CW is recommended for the short and long IUCs.
   - Modems with older code may have to be upgraded since they may not register when using shortened last CW in the IUCs.
4. If you want the FEC to be high, increase it to ten, and change the **Max Burst** field from six to seven.
   - If the minislot size is changed from the default of eight ticks to four, use eight T bytes of FEC, and make sure the **Max Burst** field for the short IUC is changed to 13.

This table lists the recommended profiles, assuming eight-tick minislots at 1.6 MHz, or four ticks at 3.2 MHz.

IUC	FEC T bytes	FEC CW	Max B	Guard Time	Mod Type	Scramble	Scramble Seed	Diff Enc	Preamble Length	Last CW	UW
cable modulation-prof 1 short	4	76	6	8	QPSK	scrambler	152	no-diff	72	short	UW8
cable modulation-prof 1 long	8	220	0	8	QPSK	scrambler	152	no-diff	80	short	UW8

Looking at the mix profile defaults and the same situation as above, 46-byte PDUs will use 288 bytes total. This is even worse than the QPSK example because of more **Preamble** and **Guard Time**.

Complete these steps to fix modulation profiles 2 (16-QAM) and 3 (mix):

1. Increase the FEC CW size from 75 to 76 for the short IUC.
2. Increase the FEC T bytes from six to seven for the short IUC.
3. Increase the **Max Burst** field from six to seven.
4. Be sure to use UW16 when using 16-QAM for short or long IUCs.

5. Shortened last CW for the short and long IUCs is recommended.
    - If you have old code on some modems and you enable shortened last CW in the modulation profile, it may not register. You will need to upgrade the modem code.
6. The **FEC T bytes** can be increased on a long IUC from eight to nine when using 16-QAM.

This table lists the recommended profiles, assuming four-tick minislots at 1.6 MHz, or two ticks at 3.2 MHz.

IUC	FEC T bytes	FEC CW	Max B	Guard Time	Mod Type	Scramble	Scramble Seed	Diff Enc	Preamble Length	Last CW	UW
cab modulation-prof 3 short	7	76	7	8	16-QAM	scrambler	152	no-diff	140	short	UW16
cab modulation-prof 3 long	9	220	0	8	16-QAM	scrambler	152	no-diff	160	short	UW16

DOCSIS 1.1-Based Code (BC Train)

Consider a Cisco modem with six-byte extended headers and using current Cisco CMTS defaults in the BC code, such as 1.6 MHz channel width, minislot size of eight ticks (16 bytes). The modulation profile is shown below.

```
cable modulation-prof 1 short 5 75 6 8 qpsk scrambler 152 no-diff 72 shortened
```

If sending 64-byte Ethernet frames (46-byte PDU) on the upstream, the modem uses a long burst and the total packet size becomes 112 bytes. This will be seven minislots. This is inefficient for a 46-byte PDU. The major difference is that BC code uses shortened last CW by default. DOCSIS 1.0 code (EC train) uses fixed last CW by default.

If the extended header is only five bytes, as originally believed, the modem ends up using a short grant at six minislots for a total of 96 bytes. This is a difference of 16 bytes (112-96).

Complete these steps to fix modulation profile 1 (QPSK):

1. Increase the FEC CW size from 75 to 76 for the short IUC.
2. Decrease the FEC T bytes from five to four for the short IUC.
    - If the minislot size is changed from the default of eight ticks to four, make sure the **Max Burst** field for the short IUC is changed from six to 12.
3. If you want the FEC to be high, increase it to ten and change the **Max Burst** field from six to seven.

- If the minislot size is changed from the default of eight ticks to four, use eight T bytes of FEC and make sure the **Max Burst** field for the short IUC is changed to 13.

This table lists the recommended profiles, assuming eight-tick minislots at 1.6 MHz, or four ticks at 3.2 MHz.

IUC	FEC T bytes	FEC CW	Max B	Guard Time	Mod Type	Scramble	Scramble Seed	Diff Enc	Preamble Length	Last CW	UW
cable modulation-prof 1 short	4	76	6	8	QPSK	scrambler	152	no-diff	72	short	UW8
cable modulation-prof 1 long	8	220	0	8	QPSK	scrambler	152	no-diff	80	short	UW8

Looking at the mix profile defaults and the same situation as above, 46-byte PDUs will use 288 bytes total. This is even worse than the QPSK example because of more **Preamble** and **Guard Time**.

Complete these steps to fix modulation profiles 2 (16-QAM) and 3 (mix):

1. Increase the FEC CW size from 75 to 76 for the short IUC.
2. Increase the FEC T bytes from six to seven for the short IUC.
3. Increase the **Max Burst** field from six to seven.
4. Be sure to use UW16 when using 16-QAM for short or long IUCs.
5. The FEC T bytes can be increased on a long IUC from eight to nine when using 16-QAM.

This table lists the recommended profiles, assuming four-tick minislots at 1.6 MHz, or two ticks at 3.2 MHz.

IUC	FEC T bytes	FEC CW	Max B	Guard Time	Mod Type	Scramble	Scramble Seed	Diff Enc	Preamble Length	Last CW	UW
cab modulation-prof 3 short	7	76	7	8	16-QAM	scrambler	152	no-diff	144	short	UW16
cab modulation-prof 3 long	9	220	0	8	16-QAM	scrambler	152	no-diff	160	short	UW16

Conclusion

It is imperative to understand how all the variables such as minislot size, channel width, modulation, and max burst size all work together. Setting the minislot size to a minimum adds better resolution between minislot usage. The current default settings from the factory may not be optimized for all situations. Appendix C explains some modulation profiles for voice-over-IP (VoIP) applications.

This section provides the recommendations for all legacy linecards (16x and 28C). There are different requirements for the latest linecards (28U and 5x20). See the Modulation Profile Addendum section of this document.

The configuration below is the most robust. QPSK is used (should be the default settings with latest IOS).

```
cab modulation-prof 1 request 0 16   0 8  qpsk scramb 152 no-diff 64  fixed uw1
cab modulation-prof 1 initial 5 34   0 48 qpsk scramb 152 no-diff 128 fixed uw1
cab modulation-prof 1 station 5 34   0 48 qpsk scramb 152 no-diff 128 fixed uw1
cab modulation-prof 1 short   4 76  12 8  qpsk scramb 152 no-diff 72  short uw8
cab modulation-prof 1 long    9 220  0 8  qpsk scramb 152 no-diff 80  short uw8
```

The configuration below uses best speed and a mix of QPSK and 16-QAM.

```
cab modulation-prof 2 request 0 16  0 8  qpsk scramb 152 no-diff 64  fixed uw16
cab modulation-prof 2 initial 5 34  0 48 qpsk scramb 152 no-diff 128 fixed uw16
cab modulation-prof 2 station 5 34  0 48 qpsk scramb 152 no-diff 128 fixed uw16
cab modulation-prof 2 short   7 76  7 8 16qam scramb 152 no-diff 144 short uw16
cab modulation-prof 2 long    9 232 0 8 16qam scramb 152 no-diff 160 short uw16
```

The configuration below uses a robust mix profile.

```
cab modulation-prof 3 request 0  16  0 8  qpsk scram 152 no-diff 64  fixed uw16
cab modulation-prof 3 initial 5  34  0 48 qpsk scram 152 no-diff 128 fixed uw16
cab modulation-prof 3 station 5  34  0 48 qpsk scram 152 no-diff 128 fixed uw16
cab modulation-prof 3 short   7  76  7 8 16qam scram 152 no-diff 144 short uw16
cab modulation-prof 3 long   10 153  0 8 16qam scram 152 no-diff 200 short uw16
```

In this configuration, the preamble was made longer on the long IUC and the CW size was decreased to give it a higher percentage of FEC coverage; 2*10/(2*10+153) = 11.5%.

The configuration below is used to track the flap list for entries.

```
cab modulation-prof 5 req     0 16  0 8  16qam scramb 152 no-diff 128 fixed uw1
cab modulation-prof 5 initial 5 34  0 48 qpsk  scramb 152 no-diff 128 fixed uw1
cab modulation-prof 5 station 5 34  0 48 16qam scramb 152 no-diff 256 fixed uw1
cab modulation-prof 5 short   7 76  7 8  16qam scramb 152 no-diff 144 short uw1
cab modulation-prof 5 long    9 232 0 8  16qam scramb 152 no-diff 160 short uw1
```

Levels to keep a cable modem online are done during station maintenance. Using 16-QAM for station maintenance will allow the modem to flap. Keep in mind power limitations at 16-QAM – max Tx of 55 dBmV. It may be warranted to issue the **cab u0 power-adjust continue 6** command. A `!` in the **sh cab modem** command means it is maxed out, and you may need to change the plant attenuation. Also, some older cable modems do not like using 16-QAM for initial maintenance. If initial maintenance is 16-QAM, the cable modem may not come back on, and there are no more flaps, which wastes more time trying to get cable modems online (they collide with each other). It also eats up time with the DHCP server if they do connect physically.

The CW was increased on the long IUC to fit exactly one, 232-B PacketCable UGS packet.

Modulation Profile Addendum

This addendum covers modulation profiles that are present in 15BC1 & BC2 IOS code. These profiles are used for legacy linecards such as the MC16x and MC28C, and also for the new linecards such as the MC28U used in a VXR chassis and the MC5x20S linecard used in the uBR10K. The MC5x20S cable linecard uses a T1 upstream chipset, while all other cable linecards utilize Broadcom. The IOS mentioned in this document was designed to make default modulation profiles possible without user configuration

Cable upstream ports can be configured for a new DOCSIS-mode. This mode cannot be changed in 15BC1 code, however, it is configurable in 15BC2 code. The modes available per upstream port will be TDMA, TDMA-ATDMA, or ATDMA.

```
ubr(config-if)#cab u0 docsis-mode ?
atdma           DOCSIS 2.0 ATDMA-only channel
tdma            DOCSIS 1.x-only channel
tdma-atdma      DOCSIS 1.x & DOCSIS 2.0 mixed channel
```

This list describes each state.

- TDMA-mode signifies legacy DOCSIS 1.0/1.1 mode.
- TDMA-ATDMA mode is for a mixed environment of DOCSIS 1.x and 2.0 cable modems on the same US frequency. DOCSIS 2.0 modems can use modulation schemes that the 1.x cable modems cannot. In this environment, the largest channel width is limited to 3.2 MHz.
- ATDMA-mode is used for DOCSIS 2.0 capability of 64-QAM and/or 6.4 MHz channel width.

Modulation profile numbers are designated for specific linecards. The first number of each group listed is always the default modulation profile for that type of card in a specific DOCSIS mode.

Note: Each linecard has a valid numbering scheme 1-10 for legacy cards, x2x for the MC5x20, and x4x for the MC28U linecard. This table lists the numbering scheme information.

Profile Numbers	Linecards	DOCSIS Mode
1-10	MC28C & 16C/S	TDMA
21-30	MC5x20S	TDMA
121-130	MC5x20S	TDMA-ATDMA
221-230	MC5x20S	ATDMA
41-50	MC28U	TDMA
141-150	MC28U	TDMA-ATDMA
241-250	MC28U	ATDMA
361- 370	MX5x20T	SCDMA

Tip: The most accurate way to identify the current modulation profile being used on an upstream port is to issue the **sh cab modulation-profile cx/y up z** command, which is available in 15BC2 code and greater. The profile shown in **sh run** or in **sh cab modulation-profile** command output may not be accurate.

Legacy Linecards (16x and 28C)

Complete these steps to make and assign modulation profiles for upstream operation:

1. Make the profile.

```
UBR-1(config)#cab modulation-profile ?
<1-10>  Modulation Profile Group
```

   Profiles in **bold** are Cisco-designed profiles.

```
UBR-1(config)#cab modulation-profile 2 ?
  initial              Initial Ranging Burst
  long                 Long Grant Burst

  mix                  Create default QPSK/QAM-16 mix modulation profile
  qam-16               Create default QAM-16 modulation profile
  qpsk                 Create default QPSK modulation profile
  reqdata              Request/data Burst
  request              Request Burst

  robust-mix           Create robust QPSK/QAM-16 mix modulation profile
  short                Short Grant Burst
  station              Station Ranging Burst
```

2. Assign the profile.

```
UBR-1(config-if)#cab u1 modulation-profile 2
```

   Issue the **sh cab modulation-profile** command. The new default settings are shown in this table. QPSK is listed first.

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble
1	request	qpsk	64	No	0x0	0x10	0x152	0	8	No	Yes
1	initial	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes
1	station	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes
1	short	qpsk	72	No	0x4	0x4C	0x152	12	8	Yes	Yes
1	long	qpsk	80	No	0x9	0xE8	0x152	0	8	Yes	Yes

   These are the settings if you pick mix.

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble
2	request	qpsk	64	No	0x0	0x10	0x152	0	8	No	Yes
2	initial	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes
2	station	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes
2	short	16qam	144	No	0x5	0x4C	0x152	7	8	Yes	Yes
2	long	16qam	160	No	0x8	0xE8	0x152	0	8	Yes	Yes

These are the settings if you pick robust-mix.

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble
3	request	qpsk	64	No	0x0	0x10	0x152	0	8	No	Yes
3	initial	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes
3	station	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes
3	short	16qam	144	No	0x5	0x4C	0x152	7	8	Yes	Yes
3	long	16qam	160	No	0xA	0xDC	0x152	0	8	Yes	Yes

Note: Entering modulation profiles and viewing them by issuing the **show run** command appear in this order:

```
IUC        FEC FEC Max Guard Mod  Scramble   Scramble Diff      Preamble Last   UW
            T  CW   B   Time Type  Seed                Enc        Length   CW
cable modu 1 request 0 16  0   8  qpsk scrambler 152  no-diff 64    fixed uw16
cable modu 1 initial 5 34  0  48  qpsk scrambler 152  no-diff 128   fixed uw16
```

Note: As you can see, the fields are not in the same places; some fields are entered as decimal but appear as hex in the **sh cab modulation** command output.

MC5x20S Linecards

The MC5x20S card has its own numbering scheme for modulation profiles.

```
RTP-ubr10k(config)#cab modulation-profile ?
<21-30>        DOCSIS 1.X Modulation Profile Group for MC520 Line Card
<121-130>      DOCSIS 1.X/2.0 Mixed Modulation Profile Group for MC520 Line Car
<221-230>      DOCSIS 2.0 Only ATDMA Modulation Profile Group for MC520 Line Ca
```

This is an example of a modulation profile for the MC5x20S linecard for TDMA-mode operation. The **bold** text shows Cisco-designed profiles.

```
RTP-ubr10k(config)#cab modulation-profile 21 ?
  initial             Initial Ranging Burst
```

```
long                    Long Grant Burst

mix                     Create default QPSK/QAM-16 mix modulation profile
qam-16                  Create default QAM-16 modulation profile
qpsk                    Create default QPSK modulation profile
reqdata                 Request/data Burst
request                 Request Burst

robust-mix              Create robust QPSK/QAM-16 mix modulation profile
short                   Short Grant Burst
station                 Station Ranging Burst
```

The new default settings are shown in this table.

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble	Pre Offst
21	request	qpsk	32	No	0x0	0x10	0x152	0	22	No	Yes	0
21	initial	qpsk	64	No	0x5	0x22	0x152	0	48	No	Yes	0
21	station	qpsk	64	No	0x5	0x22	0x152	0	48	No	Yes	0
21	short	qpsk	64	No	0x3	0x4C	0x152	12	22	Yes	Yes	0
21	long	qpsk	64	No	0x7	0xE8	0x152	0	22	Yes	Yes	0

These are the settings if you pick mix.

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble	Pre Offst
22	request	qpsk	32	No	0x0	0x10	0x152	0	22	No	Yes	0
22	initial	qpsk	64	No	0x5	0x22	0x152	0	48	No	Yes	0
22	station	qpsk	64	No	0x5	0x22	0x152	0	48	No	Yes	0
22	short	16qam	128	No	0x4	0x4C	0x152	7	22	Yes	Yes	0
22	long	16qam	128	No	0x7	0xE8	0x152	0	22	Yes	Yes	0

These are the settings if you pick robust-mix.

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble	Pre Offst
23	request	qpsk	32	No	0x0	0x10	0x152	0	22	No	Yes	0
23	initial	qpsk	64	No	0x5	0x22	0x152	0	48	No	Yes	0
23	station	qpsk	64	No	0x5	0x22	0x152	0	48	No	Yes	0
23	short	16qam	128	No	0x4	0x4C	0x152	7	22	Yes	Yes	0

23	long	16qam	128	No	0xA	0xDC	0x152	0	22	Yes	Yes	0

This is an example of a modulation profile for the MC5x20S linecard for mixed-mode operation.

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble	Pre Offst
122	request	qpsk	32	No	0x0	0x10	0x152	0	22	No	Yes	0
122	initial	qpsk	64	No	0x5	0x22	0x152	0	48	No	Yes	0
122	station	qpsk	64	No	0x5	0x22	0x152	0	48	No	Yes	0
122	short	qpsk	64	No	0x3	0x4C	0x152	12	22	Yes	Yes	0
122	long	qpsk	64	No	0x9	0xE8	0x152	0	22	Yes	Yes	0
122	a-short	qpsk	64	No	0x3	0x4C	0x152	12	22	Yes	Yes	0
122	a-long	qpsk	64	No	0x9	0xE8	0x152	0	22	Yes	Yes	0

This is an example of a modulation profile for the MC5x20S linecard for ATDMA-mode operation. The **bold** text shows Cisco-designed profiles.

```
RTP-ubr10k(config)#cab modulation-profile 221 ?
a-long                 Advanced Phy Long Grant Burst
a-short                Advanced Phy Short Grant Burst
a-ugs                  Advanced Phy Unsolicited Grant Burst

initial                Initial Ranging Burst
mix-high               Create default ATDMA QPSK/QAM-64 mix profile
mix-low                Create default ATDMA QPSK/QAM-16 mix profile
mix-medium             Create default ATDMA QPSK/QAM-32 mix profile
mix-qam                Create default ATDMA QAM-16/QAM-64 mix profile
qam-16                 Create default ATDMA QAM-16 profile
qam-32                 Create default ATDMA QAM-32 profile
qam-64                 Create default ATDMA QAM-64 profile
qam-8                  Create default ATDMA QAM-8 profile
qpsk                   Create default ATDMA QPSK profile
reqdata                Request/data Burst
request                Request Burst

robust-mix-high        Create robust ATDMA QPSK/QAM-64 mix mod profile
robust-mix-low         Create robust ATDMA QPSK/QAM-16 mix mod profile
robust-mix-mid         Create robust ATDMA QPSK/QAM-32 mix mod profile
station                Station Ranging Burst
```

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble	Pre Offst
221	request	qpsk	32	No	0x0	0x10	0x152	0	22	No	Yes	0
221	initial	qpsk	64	No	0x5	0x22	0x152	0	48	No	Yes	64
221	station	qpsk	64	No	0x5	0x22	0x152	0	48	No	Yes	64

221	a-short	64qam	64	No	0x6	0x4C	0x152	6	22	Yes	Yes	64
221	a-long	64qam	64	No	0x8	0xE8	0x152	0	22	Yes	Yes	64
221	a-ugs	64qam	64	No	0x8	0xE8	0x152	12	22	Yes	Yes	64

Caution: Notice the guardbands are different from other linecards. This is because the 5x20S linecard uses a T1 chip for upstream demodulation and has different requirements compared with Broadcom. These should never be manipulated from factory defaults.

Note: The defaults will also change depending on other interface settings. If minislot size is changed or cab default-phy-burst is changed to allow bigger concatenated packets past the default of 2000 bytes, then the max burst field may change in the modulation profile. The new code also assigns 2-tick minislots automatically to 3.2 MHz channel width, 4-ticks for 1.6 MHz, and so on.

MC28U Linecards

The MC28U card has its own numbering scheme for modulation profiles.

```
ubr7246-2(config)#cab modulation-profile ?
  <141-150>       DOCSIS 1.X/2.0 Mixed Modulation Profile Group for MCU Line Ca
  <241-250>       DOCSIS 2.0 Only ATDMA Modulation Profile Group for MCU Line C
  <41-50>         DOCSIS 1.X Modulation Profile Group for MCU Line Card
```

These are the new defaults:

```
ubr7246-2(config)#cab modulation-profile 41 ?
  initial             Initial Ranging Burst
  long                Long Grant Burst

  mix                 Create default QPSK/QAM-16 mix modulation profile
  qam-16              Create default QAM-16 modulation profile
  qpsk                Create default QPSK modulation profile
  reqdata             Request/data Burst
  request             Request Burst

  robust-mix          Create robust QPSK/QAM-16 mix modulation profile
  short               Short Grant Burst
  station             Station Ranging Burst
```

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble	Pre Offst
41	request	qpsk	64	No	0x0	0x10	0x152	0	8	No	Yes	0
41	initial	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes	0
41	station	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes	0
41	short	qpsk	100	No	0x3	0x4E	0x152	35	25	Yes	Yes	0
41	long	qpsk	80	No	0x9	0xE8	0x152	0	137	Yes	Yes	0

These are the settings if you pick mix.

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble	Pre Offst
42	request	qpsk	64	No	0x0	0x10	0x152	0	8	No	Yes	0
42	initial	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes	0
42	station	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes	0
42	short	16qam	200	No	0x5	0x4E	0x152	19	17	Yes	Yes	0
42	long	16qam	216	No	0x9	0xE8	0x152	139	77	Yes	Yes	0

This is an example of a modulation profile for the MC28U linecard for mixed-mode operation.

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble	Pre Offst
141	request	qpsk	64	No	0x0	0x10	0x152	0	8	No	Yes	396
141	initial	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes	6
141	station	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes	6
141	short	qpsk	100	No	0x3	0x4E	0x152	35	25	Yes	Yes	396
141	long	qpsk	80	No	0x9	0xE8	0x152	0	137	Yes	Yes	396
141	a-short	64qam	100	No	0x3	0x4E	0x152	14	14	Yes	Yes	396
141	a-long	64qam	160	No	0xB	0xE8	0x152	96	56	Yes	Yes	396

This is an example of a modulation profile for the MC28U linecard for atdma-mode operation.

Mod Type	IUC	Type	Preamble Length	Diff Enc	FEC T bytes	FEC K bytes	Scramble Seed	Max B Size	Guard Time	Last CW	Scramble	Pre Offst
241	request	qpsk	64	No	0x0	0x10	0x152	0	8	No	Yes	396
241	initial	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes	6
241	station	qpsk	128	No	0x5	0x22	0x152	0	48	No	Yes	6
241	a-short	64qam	100	No	9	0x4E	0x152	14	14	Yes	Yes	396
241	a-long	64qam	160	No	0xB	0xE8	0x152	96	56	Yes	Yes	396
241	a-ugs	16qam	108	No	0x9	0xE8	0x152	107	61	Yes	Yes	396

Note: Notice the preambles and guardbands are different from legacy cards and should not be made lower than factory settings. The defaults will also change depending on other interface settings. If minislot size is changed or cab default-phy-burst is changed to allow bigger concatenated packets past the default of 2000 bytes, then the max burst field may change in the modulation profile.

Appendix A

Total Packet Size Calculations for a 46-Byte PDU

The QPSK, 1.6 MHz, eight-tick minislots example is shown below.

(8 ticks/minislot * 6.25 usec/tick * 1.28 Msym/s * 2 bits/sym) / (8 bits/byte) = 16 bytes/minislot

Using the default settings for modulation profile 1, as shown below.

```
cable modulation-profile 1 short 5 75 6 8 qpsk scrambler 152 no-diff 72 fixed u
cable modulation-profile 1 long 8 220 0 8 qpsk scrambler 152 no-diff 80 fixed u
```

46-byte Ethernet frame + 18-byte Ethernet header + 6-byte DOCSIS header + 6-byte DOCSIS extended header = 76 bytes. A FEC CW size of 4B in hex equals 75 bytes. 76/75 = one full CW needed and one leftover byte. If using the default setting of fixed last CW, this would require two full CWs. That would give 2*(75+2*5) = 170 bytes + 9 bytes of Preamble + 2 bytes of Guard Time = 181 bytes. The Preamble was (72 bits) / (8 bits/byte) = 9 bytes. The Guard Time of eight symbols would be (8 sym*2 bits/sym) / (8 bit/byte) = 2 bytes.

181 / (16 bytes/minislot) = 11.3125 minislots needed. Round this up to 12. Since the default setting for max burst size for the short IUC is six, you would have to use the long IUC. Going through the math again, there are 76 bytes/220 byte FEC CW = 1 full CW needed + 2*8 = 236 bytes + 10 bytes of Preamble + 2 bytes of Guard Time = 248 bytes/16 = 15.5. Round up to 16*16 bytes/minislot = 256 bytes.

The modified modulation profile 1 is shown below.

```
cab modulation-prof 1 short 4 76 6 8 qpsk scrambler 152 no-diff 72 short uw8
```

46-byte Ethernet frame + 18-byte Ethernet header + 6-byte DOCSIS header + 6-byte DOCSIS extended header = 76 bytes. A FEC CW size of 76 means exactly one CW will be needed + 2*T. We have 76+2*4 = 84 bytes + 9 bytes of Preamble + 2 bytes of Guard Time = 95 bytes. 95/16 bytes/minislot = 5.9375 minislots needed. Round up to 6 = 6 minislots*16 bytes/minislot = 96 bytes.

Appendix B

Minislot Configuration

It is recommended to set the minislot size to a value that will make it eight or 16 bytes. This is sometimes not achievable because the DOCSIS limit states that the minislot must be at least 32 symbols.

This table table lists the channel width versus the number of ticks allowed for a minislot.

Channel Width	Ticks Allowed			
.2	32	64	128	

.4	16	32	64	128
.8	8	16	32	64
1.6	4	8	16	32
3.2	2	4	8	16
6.4	1	2	4	8

The number of ticks allowed will be affected by the symbol rate (channel width) used on the upstream. The modulation used and the number of ticks per minislot will affect the total amount of bytes in a minislot.

To configure the minislot size, issue the **cable upstream 0 minislot-size 8** command.

To verify the minislot size, issue the **show controllers** command.

```
ubr7246vxr#show controllers c3/0 u0
Cable3/0 Upstream 0 is up
Frequency 24.848 MHz, Channel Width 1.600 MHz, QPSK Symbol Rate 1.280 Msps
Spectrum Group 1, Last Frequency Hop Data Error: NO(0)
MC16S CNR measurement: 26 dB
Nominal Input Power Level 0 dBmV, Tx Timing Offset 2952
Ranging Backoff automatic (Start 0, End 3)
Ranging Insertion Interval automatic (60 ms)
Tx Backoff Start 0, Tx Backoff End 4
Modulation Profile Group 2
Concatenation is disabled
Fragmentation is enabled
part_id=0x3137, rev_id=0x03, rev2_id=0xFF
nb_agc_thr=0x0000, nb_agc_nom=0x0000
Range Load Reg Size=0x58
Request Load Reg Size=0x0E

Minislot size in number of timebase ticks = 8

Minislot size in symbols = 64
Bandwidth requests = 0xED97D0
Piggyback requests = 0x2DB623C
Invalid BW requests = 0xE4B
Minislots requested = 0x12B17492
Minislots granted = 0x12B16E64
Minislot size in bytes = 16
Map Advance (Dynamic): 2468 usecs
UCD count = 3566700
DES Ctrl Reg#0 = C000C043, Reg#1 = 4016
```

Appendix C

VoIP Modulation Profiles

VoIP calls are generally believed to operate best using short grants, but it may be worth testing the upstream usage with the short profile listed, then using the long profile to see if any difference is noticed. If you issue the **show interface c5/0/0 mac-scheduler** command in the BC code, you can see the upstream use percentage. Instead of trying to find out how many phone calls can be supported by making phone calls, just look at the utilization per call. If each phone uses about two percent upstream utilization, about 45 calls would put you at 90 percent. In EC code, the command is **show interface c3/0 upstream 0**.

There is the possibility of too much round-off error associated using this type of calculation. If that two percent was really 2.4 percent or 1.6 percent, you would get radically different results, but it could be used as a relative measurement or comparison when changing modulation profiles optimized for short or long IUCs.

G711 VoIP with No PHS at 20 ms Sampling

If using 20 ms sampling, a G.711 codec, no Payload Header Suppression (PHS), QPSK modulation, 3.2 MHz channel width, and two ticks as a minislot, the total voice packet size would be about 264 bytes after all the overhead is included. The modulation profile below is used.

```
cable modulation-prof 4 short 3 78 33 8 qpsk scrambler 152 no-diff 72 short uw8
```

G.711 = 64 kbps*20 ms of sampling = 1280 bits / (8 bits/byte) = 160-byte Voice frame + 18-byte Ethernet header + 6-byte DOCSIS header + 5-byte DOCSIS Extended Header + 3-byte UGS header + 40 bytes of IP/UDP/RTP header = 232 bytes. An FEC CW size of 4E in hex equals 78 bytes. 232/78 = 2 full CWs needed + a shortened last codeword. That would give 2*(78+3*2) + (76+3*2) = 250 bytes + 9 bytes of Preamble + 2 bytes of Guard Time = 261 bytes. 261 bytes / (8 bytes/minislot) = 32.625. Round up to 33*8 bytes/minislot = 264 bytes.

Note: If PHS is used, the packet size before FEC is added is reduced by approximately 40 bytes.

This modulation profile should allow you to get about 21 calls on a QPSK upstream using G.711. 264*8 = 2112 bits per 20 ms packet. 2112/20ms = 105.6 kbps per phone call. 2.56 Mbps total throughput-10% overhead (maintenance, reserved time for insertions, and contention time) = 2.2 Mbps / 105.6 kbps = 21.82. In reality, voice calls should be limited to about 65% to leave room for setting up and tearing down calls, allocating throughput for best effort traffic, and headroom for peak traffic. 65% of 21 would be about 13 calls.

The following modulation profiles and calculations assume 65% throughput allocation for VoIP traffic and a 5-byte extended header with a 3-byte UGS header. and 6-byte DOCSIS extended headers. Extended headers larger than this will require different modulation profiles.

Suggested VoIP Modulation Profiles

QPSK (using short grants); (1.6 MHz at four ticks = 13 calls or 3.2 MHz at two ticks = 29 calls)

```
cable modulation-profile 4 short 3 78 33 8 qpsk scrambler 152 no-diff 72 short
cable modulation-profile 4 long 8 220 0 8 qpsk scrambler 152 no-diff 80 short u
```

QPSK (using long grants); (1.6 MHz at four ticks = 13 calls or 3.2 MHz at two ticks = 29 calls)

```
cable modulation-profile 5 short 4 76 12 8 qpsk scrambler 152 no-diff 72 short
cable modulation-profile 5 long 9 232 0 8 qpsk scrambler 152 no-diff 80 short u
```

One caveat to this is large 1500-byte PDUs will require 1672 bytes vs. 1656 previously.

16-QAM (short); (1.6 MHz at four ticks = 27 calls or 3.2 MHz at two ticks = 56 calls)

```
cable modulation-prof 6 short 3 78 17 8 16qam scrambler 152 no-diff 144 short u
cable modulation-prof 6 long 9 220 0 8 16qam scrambler 152 no-diff 160 short uw
```

More FEC coverage (1.6 MHz at four ticks = 26 calls or 3.2 MHz at two ticks = 53 calls)

```
cable modulation-prof 6 short 4 58 18 8 16qam scrambler 152 no-diff 144 short u
```

One caveat to this is small 46-byte PDUs will require 128 bytes vs. 112 previously.

16-QAM (long); (1.6 MHz at two ticks = 26 calls or 3.2 MHz at two ticks = 53 calls)

```
cable modulation-prof 7 short 7 76 7 8 16qam scrambler 152 no-diff 144 short uw
cable modulation-prof 7 long 9 232 0 8 16qam scrambler 152 no-diff 160 short uw
```

More FEC coverage (1.6 MHz at four ticks = 26 calls or 3.2 MHz at two ticks = 53 calls)

```
cable modulation-prof 7 long 8 116 0 8 16qam scrambler 152 no-diff 160 short uw
```

One caveat to this is large 1500-byte PDUs will require 1792 bytes vs. 1680 previously.

QPSK (short); (.8 MHz at eight ticks = 5 calls)

```
cab modulation-prof 7 long  8 116  0 8 16qam scrambler 152 no-diff 160 short uw
```

The last example would probably be the lowest channel-width and modulation combination. The upstream serialization time would be 1.65 milliseconds. A channel width any narrower than .8 MHz would create an upstream serialization time that would violate the 2-ms latency limit unless using 16-QAM at .4 MHz.

The last example would not be recommended. A 1518-byte Ethernet frame would take more than 10 msec to send upstream and violate certain requirements. The upstream serialization time of the voice packet would be 1.65 milliseconds, which is below the 2-ms latency limit, but only 5 calls would be realized and not a very good business case.

Note: If the upstream packet serialization time is more than 2 ms, an error will occur. You may need to increase the upstream channel width and/or modulation. There is also reserved time for a 1500-B frame. If it takes more than 10 msec to serialize, then you will fail 10 msec VoIP, but technically, 20 msec VoIP should still work. Assuming an US using QPSK with a symbol rate of 640 ksym/s, you'll get 640 * 2 bits/sym / 8 = 160 kB/s. A 1518-B Ethernet frame will be about 1680 bytes total leading to 1680/160k = 10.5 msec.

G711 VoIP with No Payload Header Suppression (PHS) at 10 ms Sampling

VoIP at 20 ms sampling is recommended because 10 ms sampling creates 1/10 ms = 100 PPS to be used in the CPU for the upstream and downstream flows. This equals 200 PPS for one phone call. If two cable modems call each other, the total PPS would be 200 for both. This can be very taxing on the CMTS CPU.

QPSK (short); (1.6 MHz at four ticks = 10 calls or 3.2 MHz at two ticks = 21 calls)

```
cable modulation-prof 7 short 3 78 22 8 qpsk scrambler 152 no-diff 72 short uw8
cable modulation-prof 7 long 8 220 0 8 qpsk scrambler 152 no-diff 80 short uw8
```

16-QAM (short); (1.6 MHz at four ticks = 19 calls or 3.2 MHz at two ticks = 39 calls)

```
cab modulation-prof 8 short 4 78 12 8 16qam scrambler 152 no-diff 144 short uw1
cab modulation-prof 8 long 9 220 0 8 16qam scrambler 152 no-diff 160 short uw16
```

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