AMERICAN NATIONAL STANDARD

ANSI/SCTE 133 2010

Downstream RF Interface for Cable Modem Termination Systems
NOTICE

The Society of Cable Telecommunications Engineers (SCTE) Standards are intended to serve the public interest by providing specifications, test methods and procedures that promote uniformity of product, interchangeability and ultimately the long term reliability of broadband communications facilities. These documents shall not in any way preclude any member or non-member of SCTE from manufacturing or selling products not conforming to such documents, nor shall the existence of such standards preclude their voluntary use by those other than SCTE members, whether used domestically or internationally.

SCTE assumes no obligations or liability whatsoever to any party who may adopt the Standards. Such adopting party assumes all risks associated with adoption of these Standards, and accepts full responsibility for any damage and/or claims arising from the adoption of such Standards.

Attention is called to the possibility that implementation of this standard may require the use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. SCTE shall not be responsible for identifying patents for which a license may be required or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Patent holders who believe that they hold patents which are essential to the implementation of this standard have been requested to provide information about those patents and any related licensing terms and conditions. Any such declarations made before or after publication of this document are available on the SCTE web site at http://www.scte.org.

All Rights Reserved

© Society of Cable Telecommunications Engineers, Inc. 2010
140 Philips Road
Exton, PA 19341

DOCSIS® and M-CMTSTM are registered trademarks of Cable Television Laboratories, Inc., and used in this document with permission.
A.2.1 Normative References .......................................................................................................................... 28
A.3 TERMS AND DEFINITIONS .......................................................................................................................... 28
A.4 ACRONYMS AND ABBREVIATIONS ............................................................................................................. 28
A.5 FUNCTIONAL ASSUMPTIONS ...................................................................................................................... 28
A.5.1 Broadband Access Network ................................................................................................................. 29
A.5.2 Equipment Assumptions ....................................................................................................................... 29
A.5.3 Downstream Plant Assumptions .......................................................................................................... 29
A.6 PHYSICAL MEDIA DEPENDENT SUBLAYER SPECIFICATION ................................................................. 30
A.6.1 Scope .................................................................................................................................................... 30
A.6.2 EdgeQAM (EQAM) differences from CMTS ...................................................................................... 30
A.6.3 Downstream ......................................................................................................................................... 30
A.7 DOWNSTREAM TRANSMISSION CONVERGENCE SUBLAYER ............................................................... 40
A.7.1 Introduction ......................................................................................................................................... 40
A.7.2 MPEG Packet Format ......................................................................................................................... 40
A.7.3 MPEG Header for DOCSIS Data-Over-Cable .................................................................................... 40
A.7.4 MPEG Payload for DOCSIS Data-Over-Cable ................................................................................... 40
A.7.5 Interaction with the MAC Sublayer ..................................................................................................... 40
A.7.6 Interaction with the Physical Layer ..................................................................................................... 40
ANNEX B DOCS-DRF-MIB (NORMATIVE) ................................................................................................. 41
This page left blank intentionally.
1 SCOPE AND PURPOSE

1.1 Scope

This document defines the downstream radio-frequency interface [DRFI] specifications for:

- an edgeQAM (EQAM) modular device, or
- an integrated Cable Modem Termination System [CMTS] with multiple downstream channels per RF port, or
- an integrated CMTS beyond DOCSIS 2.0.

There are differences in the cable spectrum planning practices adopted for different networks in the world. Therefore two options for physical layer technology are included, which have equal priority and are not required to be interoperable. One technology option is based on the downstream multi-program television distribution that is deployed in North America using 6 MHz channeling. The other technology option is based on the corresponding European multi-program television distribution. Both options have the same status, notwithstanding that the document structure does not reflect this equal priority. The first of these options is defined in Sections 5, 6, 7, whereas the second is defined by replacing the content of those sections with the content of Annex A. Correspondingly, [ITU-T J.83-B] and [CEA-542-B] apply only to the first option, and [EN 300 429] only to the second. Compliance with this document requires compliance with the one or the other of these implementations, not with both. It is not required that equipment built to one option shall interoperate with equipment built to the other.

A DRFI-compliant device may be a single-channel only device, or it may be a multiple-channel device capable of generating one or multiple downstream RF carriers simultaneously on one RF output port. An EQAM may be a module of a modular cable modem termination system (M-CMTS) and be used for delivering a high-speed data service or it may serve as a component of a digital video or video-on-demand (VOD) system, delivering high quality digital video to subscribers. These specifications are crafted to enable an EQAM to be used without restriction in either or both service delivery scenarios simultaneously. “Simultaneous” in the early deployments means that if a RF output port has multiple QAM channels, some channel(s) may be delivering high-speed data while some other channel(s) may be delivering digital video. This specification enables future uses, wherein a single QAM channel may share bandwidth between high-speed data and digital video in the same MPEG transport stream.

Conceptually, an EQAM will accept input via an Ethernet link, integrate the incoming data into an MPEG transport stream, modulate one of a plurality of RF carriers, per these specifications, and deliver the carrier to a single RF output connector shared in common with all modulators. Conceivably, a single EQAM RF channel could be used for data and video simultaneously. The reason that an EQAM RF channel can be used for either is that both digital video and DOCSIS data downstream channels are based on ITU-T J.83 Annex B [ITU-T J.83-B] for cable networks in North America and EN 300 429 [EN 300 429] for cable networks deployed in Europe. On downstream channels complying to ITU-T J.83, Annex B, typically, the only difference between an EQAM RF channel operating in a video mode and an EQAM RF channel operating in DOCSIS data mode is the interleaver depth (see Sections 6.3.1 and 6.3.3). DOCSIS data runs in a low latency mode using a shallow interleaver depth at the cost of some burst protection. DOCSIS data can do this because if a transmission error occurs, the higher layer protocols will request re-transmission of the missing data. For video, the sequence of frames in the program is both time sensitive and order sensitive and cannot be re-transmitted. For this reason, video uses a deeper interleaver depth to provide more extensive burst protection and deliver more of the program content without loss. The penalty video pays is in latency. The entire program content is delayed by a few milliseconds, typically, and is invisible to the viewers of the program. The conflicting demands for interleaver depth are what prevent a single EQAM RF channel from being used optimally for video and DOCSIS data simultaneously. A traditional integrated CMTS, however, is used solely for DOCSIS data.

1.2 Purpose of Document

The purpose of this document is to define the RF characteristics required in the downstream transmitter(s) of CMTSs and EQAMs, sufficiently enough to permit vendors to build devices that meet the needs of multiple system operators (MSOs) around the world.
1.3 Organization of Document

This document will not attempt to wholly replicate the normative references provided in the document. However, it will use extracted portions of said documents where it adds clarity to this document. For fuller understanding of this document, the most recent versions of [ITU-T J.83-B] Annex B or [EN 300 429], respectively, as well as [DOCSIS2] should be available for reference.

1.4 Requirements

Throughout this document, the words that are used to define the significance of particular requirements are capitalized. These words are:

“MUST” This word or the adjective “REQUIRED” means that the item is an absolute requirement of this specification.

“MUST NOT” This phrase means that the item is an absolute prohibition of this specification.

“SHOULD” This word or the adjective “RECOMMENDED” means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighed before choosing a different course.

“SHOULD NOT” This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.

“MAY” This word or the adjective “OPTIONAL” means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.
2 REFERENCES

2.1 Normative References

In order to claim compliance with this standard, it is necessary to conform to the following standards and other works as indicated, in addition to the other requirements of this specification. Notwithstanding, intellectual property rights may be required to use or implement such normative references.


2.2 Informative References

This standard uses the following informative references.


[CMCI] Cable Modem CPE Interface, CM-SP-CMCI-C01-081104, November 4, 2008, Cable Television Laboratories, Inc.


### 2.3 Reference Acquisition

- Cable Television Laboratories, Inc., http://www.cablelabs.com/
- EIA: Electronic Industries Alliance, http://www.eia.org/new_contact/
- ITU: International Telecommunication Union (ITU), http://www.itu.int/home/contact/index.html
# 3 TERMS AND DEFINITIONS

This standard uses the following terms:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling (ceil)</td>
<td>Returns the first integer that is greater than or equal to a given value.</td>
</tr>
<tr>
<td>CM</td>
<td>Cable Modem. A modulator-demodulator at subscriber locations intended for use in conveying data communications on a cable television system.</td>
</tr>
<tr>
<td>CPE</td>
<td>Customer Premises Equipment. Equipment at the end user’s premises; may be provided by the service provider.</td>
</tr>
<tr>
<td>Carrier-to-Noise Ratio (C/N or CNR)</td>
<td>Carrier-to-Noise Ratio. The ratio of signal power to noise power in a defined measurement bandwidth. For digital modulation, CNR = Es/No, the energy-per symbol to noise-density ratio; the signal power is measured in the occupied bandwidth, and the noise power is normalized to the modulation-rate bandwidth. For analog NTSC video modulation, the noise measurement bandwidth is 4 MHz.</td>
</tr>
<tr>
<td>Decibels (dB)</td>
<td>Ratio of two power levels expressed mathematically as ( dB = 10\log_{10}(P_{OUT}/P_{IN}) ).</td>
</tr>
<tr>
<td>Decibel-Millivolt (dBmV)</td>
<td>Unit of RF power expressed in decibels relative to 1 millivolt over 75 ohms, where dBmV = ( 20\log_{10}(\text{value in mV}/1 \text{ mV}) ).</td>
</tr>
<tr>
<td>Encompassed Spectrum</td>
<td>The spectrum ranging from the lower band-edge of the lowest active channel frequency to the upper band-edge of the highest active channel frequency on an RF output port.</td>
</tr>
<tr>
<td>Electronic Industries Alliance (EIA)</td>
<td>A voluntary body of manufacturers which, among other activities, prepares and publishes standards.</td>
</tr>
<tr>
<td>EQAM</td>
<td>EdgeQAM modulator. A head end or hub device that receives packets of digital video or data. It re-packetizes the video or data into an MPEG transport stream and digitally modulates the digital transport stream onto a downstream RF carrier using quadrature amplitude modulation (QAM).</td>
</tr>
<tr>
<td>FEC</td>
<td>Forward Error Correction. A class of methods for controlling errors in a communication system. FEC sends parity information with the data which can be used by the receiver to check and correct the data.</td>
</tr>
<tr>
<td>Gap Channel</td>
<td>A channel within the encompassed spectrum which is not active; this occurs with non-contiguous channel frequency assignments on an RF output port.</td>
</tr>
<tr>
<td>Gigahertz (GHz)</td>
<td>A unit of frequency; 1,000,000,000 or ( 10^9 ) Hz.</td>
</tr>
<tr>
<td>Hertz (Hz)</td>
<td>A unit of frequency; formerly cycles per second.</td>
</tr>
<tr>
<td>HRC</td>
<td>Harmonic Related Carriers. A method of spacing channels on a cable television system with all carriers related to a common reference.</td>
</tr>
<tr>
<td>HFC</td>
<td>Hybrid Fiber/Coax System. A broadband bidirectional shared-media transmission system using optical fiber trunks between the head-end and the fiber nodes, and coaxial cable distribution from the fiber nodes to the customer locations.</td>
</tr>
<tr>
<td>IRC</td>
<td>Incremental Related Carriers. A method of spacing NTSC television channels on a cable television system in which all channels are offset up 12.5 kHz with respect to the [CEA-542-B] standard channel plan except for channels 5 and 6.</td>
</tr>
<tr>
<td>kilohertz (kHz)</td>
<td>Unit of frequency; 1,000 or ( 10^3 ) Hz; formerly kilocycles per second.</td>
</tr>
<tr>
<td>Media Access Control (MAC)</td>
<td>Used to refer to the layer 2 element of the system which would include DOCSIS framing and signaling.</td>
</tr>
<tr>
<td>Megahertz (MHz)</td>
<td>A unit of frequency; 1,000,000 or ( 10^6 ) Hz; formerly megacycles per second.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>MER</td>
<td>Modulation Error Ratio. The ratio of the average symbol power to average error power.</td>
</tr>
<tr>
<td>M/N</td>
<td>Relationship of integer numbers M,N that represents the ratio of the downstream symbol clock rate to the DOCSIS master clock rate.</td>
</tr>
<tr>
<td>Multiple System Operator (MSO)</td>
<td>A corporate entity that owns and/or operates more than one cable system.</td>
</tr>
<tr>
<td>Non-contiguous Channel Assignment</td>
<td>The encompassed spectrum on an RF output port contains gap channels (inactive channels).</td>
</tr>
<tr>
<td>NTSC</td>
<td>National Television Systems Committee. Committee which defined the analog, color television, broadcast standards in North America. The standards television 525-line video format for North American television transmission is named after this committee.</td>
</tr>
<tr>
<td>NGNA LLC</td>
<td>Company formed by cable operators to define a next-generation network architecture for future cable industry market and business requirements.</td>
</tr>
<tr>
<td>Physical Media Dependent Sublayer (PMD)</td>
<td>A sublayer of the Physical layer which is concerned with transmitting bits or groups of bits over particular types of transmission link between open systems and which entails electrical, mechanical and handshaking procedures.</td>
</tr>
<tr>
<td>QAM channel (QAM ch)</td>
<td>Analog RF channel that uses quadrature amplitude modulation (QAM) to convey information.</td>
</tr>
<tr>
<td>Quadrature Amplitude Modulation (QAM)</td>
<td>A modulation technique in which an analog signal’s amplitude and phase vary to convey information, such as digital data.</td>
</tr>
<tr>
<td>Radio Frequency (RF)</td>
<td>A portion of the electromagnetic spectrum from a few kilohertz to just below the frequency of infrared light.</td>
</tr>
<tr>
<td>Radio Frequency Interface (RFI)</td>
<td>Term encompassing the downstream and the upstream radio frequency interfaces.</td>
</tr>
<tr>
<td>Root Mean Square (RMS)</td>
<td>Square root of the mean value squared a function.</td>
</tr>
<tr>
<td>Self-Aggregation</td>
<td>Method used to compute the headend noise floor by summing measured noise from a single device over a specified output frequency range.</td>
</tr>
<tr>
<td>Standard Channel Plan (STD)</td>
<td>Method of spacing NTSC television channels on a cable television system defined in [ANSI/SCTE 02].</td>
</tr>
<tr>
<td>Upstream Channel Descriptor (UCD)</td>
<td>The MAC Management Message used to communicate the characteristics of the upstream physical layer to the cable modems.</td>
</tr>
<tr>
<td>Video on Demand (VoD)</td>
<td>System that enables individuals to select and watch video content over a network through an interactive television system.</td>
</tr>
</tbody>
</table>
4 ACRONYMS AND ABBREVIATIONS

This standard uses the following terms:

CMCI  Cable Modem CPE Interface
CMTS  Cable Modem Termination System
CW    Continuous Wave
dBc    Decibels relative to carrier power
DEPI  Downstream External-PHY Interface
DOCSIS® Data-Over-Cable Service Interface Specifications
DRFI  Downstream Radio Frequency Interface
DTI   DOCSIS Timing Interface
ERMI  Edge Resource Manager Interface
FCC   Federal Communications Commission
ISO   International Standards Organization
ITU   International Telecommunications Union
ITU-T Telecommunication Standardization Sector of the ITU
M-CMTSTM Modular Cable Modem Termination System
Ms    Millisecond. $10^{-3}$ second
MPEG  Moving Picture Experts Group
Ns    Nanosecond. $10^{-9}$ second
NGNA  Next Generation Network Architecture, see NGNA LLC
OSSI  Operations System Support Interface
PHY   Physical Layer
ppm   Parts per Million
Q     Quadrature modulation component
S-CDMA Synchronous Code Division Multiple Access
5 FUNCTIONAL ASSUMPTIONS

This section describes the characteristics of a cable television plant, assumed to be for the purpose of operating a data-over-cable system. It is not a description of EQAM or CMTS parameters. The data-over-cable system MUST be interoperable within the environment described in this section.

Whenever there is a reference in this section to frequency plans or compatibility with other services, or conflicts with any legal requirement for the area of operation, the latter shall take precedence. Any reference to NTSC analog signals in six MHz channels does not imply that such signals are physically present.

5.1 Broadband Access Network

A coaxial-based broadband access network is assumed. This may take the form of either an all-coax or hybrid fiber/coax (HFC) network. The generic term “cable network” is used here to cover all cases.

A cable network uses a shared-medium, “tree-and-branch” architecture, with analog transmission. The key functional characteristics assumed in this document are the following:

- Two-way transmission
- A maximum optical/electrical spacing between the DRFI-compliant device and the most distant CM of 100 miles in each direction, although typical maximum separation may be 10-15 miles
- A maximum differential optical/electrical spacing between the DRFI-compliant device and the closest and most distant modems of 100 miles in each direction, although this would typically be limited to 15 miles

At a propagation velocity in fiber of approximately 1.5 ns/ft, 100 miles of fiber in each direction results in a round-trip delay of approximately 1.6 ms. For further information, see [DOCSIS2], Appendix VIII.

5.2 Equipment Assumptions

5.2.1 Frequency Plan

In the downstream direction, the cable system is assumed to have a pass band with a lower edge between 50 and 54 MHz and an upper edge that is implementation-dependent but is typically in the range of 300 to 870 MHz. Within that pass band, NTSC analog television signals in six-MHz channels are assumed present on the Standard (STD), HRC, or IRC frequency plans of [CEA-542-B], as well as other narrowband and wideband digital signals.

5.2.2 Compatibility with Other Services

The CM and EQAM or CMTS MUST coexist with the other services on the cable network, for example:

1. They MUST be interoperable in the cable spectrum assigned for EQAM or CMTS-CM interoperation, while the balance of the cable spectrum is occupied by any combination of television and other signals, and
2. They MUST NOT cause harmful interference to any other services that are assigned to the cable network in spectrum outside of that allocated to the EQAM or CMTS. The latter is understood as:
   - No measurable degradation (highest level of compatibility),
   - No degradation below the perceptible level of impairments for all services (standard or medium level of compatibility), or
   - No degradation below the minimal standards accepted by the industry (for example, FCC for analog video services) or other service provider (minimal level of compatibility).
5.2.3 Fault Isolation Impact on Other Users

As downstream transmissions are on a shared-media, point-to-multipoint system, fault-isolation procedures should take into account the potential harmful impact of faults and fault-isolation procedures on numerous users of the data-over-cable, video, and other services.

For the interpretation of harmful impact, see Section 5.2.2 above.

5.3 Downstream Plant Assumptions

The DRFI specifications have been developed with the downstream plant assumptions of this section.

5.3.1 Transmission Levels

The nominal power level of the downstream RF signal(s) within a six-MHz channel (average power) is targeted to be in the range: -10 dBc to -6 dBc, relative to analog video carrier level (peak power) and will normally not exceed analog video carrier level.

5.3.2 Frequency Inversion

There will be no frequency inversion in the transmission path in either the downstream or the upstream directions (i.e., a positive change in frequency at the input to the cable network will result in a positive change in frequency at the output).

5.3.3 Analog and Digital Channel Line-up

In developing this specification, it was assumed that a maximum of 119 digital channels would be deployed in a headend. For the purposes of calculating CNR, protection for analog channels, it was assumed that analog channels are placed at lower frequencies in the channel line-up, versus digital channels.

5.3.4 Analog Protection Goal

One of the goals of the DRFI specification is to provide the minimum intended analog channel CNR protection of 60 dB for systems deploying up to 119 DRFI-compliant QAM channels.

The specification assumes that the transmitted power level of the digital channels will be 6 dB below the peak envelope power of the visual signal of analog channels, which is the typical condition for 256-QAM transmission. It is further assumed that the channel lineup will place analog channels at lower frequencies versus digital channels, and in systems deploying modulators capable of generating nine or more QAM channels on a single RF output port analog channels will be placed at center frequencies below 600 MHz. An adjustment of $10 \log_{10} \left( \frac{6 \text{ MHz}}{4 \text{ MHz}} \right)$ is used to account for the difference in noise bandwidth of digital channels versus analog channels. With the assumptions above, for a 119-QAM channel system, the specification in Item 5 of Table 6–5 equates to an analog CNR protection of 60 dB. With more QAM channels the analog protection is less. With the stated assumptions, the analog protection is:

$$\text{Analog Protection (dB)} = 80.76 - 10 \log_{10} (\text{Number of QAM Channels}).$$

For example, in a 143-QAM channel system, with the assumptions above, the specification equates to an analog CNR protection of 59.2 dB.
6 PHYSICAL MEDIA DEPENDENT SUBLAYER SPECIFICATION

6.1 Scope

This section applies to the first technology option referred to in Section 1.1. For the second option, refer to Annex A. This specification defines the electrical characteristics of the Downstream Radio Frequency Interface (DRFI) of a cable modem termination system (CMTS) or an edgeQAM (EQAM). It is the intent of this specification to define an interoperable DRFI-compliant device, such that any implementation of a CM can work with any EQAM or CMTS. It is not the intent of this specification to imply any specific implementation. Figure 6-1 shows the M-CMTS structure and interfaces.

Whenever a reference in this section to spurious emissions conflicts with any legal requirement for the area of operation, the latter shall take precedence.

![Figure 6-1 - Logical View of Modular CMTS and Interfaces](image)

The CMTS Network Side Interface [NSI], Modular CMTS Operation Support System Interface [M-OSSI], Radio Frequency Interface [RFI], and the Cable Modem CPE Interface [CMCI] are documented in existing DOCSIS specifications (see Section 2.2). The DOCSIS Timing Interface [DTI], Downstream External-PHY Interface [DEPI], Downstream Radio Frequency Interface (this specification), and Edge Resource Manager Interface [ERMI] require new specifications specific to the M-CMTS in a Next Generation Network Architecture [NGNA] environment.

6.2 EdgeQAM (EQAM) differences from CMTS

The EQAM is primarily the RF modulation and transmission module extracted from a consolidated CMTS. Because the CMTS has been divided into constituent parts into the modules, the EQAM needs to have a new interface to the Modular-CMTS (M-CMTS) MAC module. That new interface is an Ethernet interface, as specified in the [DEPI], needed to communicate with the now remote EQAM. DEPI constructs, semantics, and syntax, as well as any new EQAM components and processing, are defined in the DEPI documentation.

EQAMs may also interface to video servers, via the Ethernet interface, and provide a downstream RF transmission to deliver digital video services. The protocols necessary to implement video services over EQAMs are out of the scope of this document.
Several new features are supported in this specification. The DOCSIS 1.x and 2.0 specifications do not reflect the ability of vendors to support multiple RF channels per physical RF port. This document presents the requirements and optional functions that enable an EQAM, or a CMTS, with multiple channels per RF port to be tested, measured and, if successful, qualified.

For an M-CMTS, module synchronization is not as easy as with an integrated CMTS. A DRFI-compliant EQAM has a timing port on it that enables a high precision (DTI) to be used to distribute a common clock and timing signals. This permits the EQAM to be used in all modes, including S-CDMA mode, because of the high stability and low jitter of the external clock and distribution system. The DOCSIS Timing Interface is defined in the [DTI] specification.

### 6.3 Downstream

#### 6.3.1 Downstream Protocol

The downstream PMD sublayer MUST conform to ITU-T Recommendation J.83 Annex B [ITU-T J.83-B], except for Section B.6.2. Interleaver depths are defined in Section 6.3.3 of this document. The applicability of a particular interleaver depth depends on the data service provided on a particular QAM RF channel. Applicability of interleaver depths for service delivery, other than DOCSIS high-speed data, is beyond the scope of this document.

#### 6.3.2 Spectrum Format

The downstream modulator for each QAM channel of the EQAM, or CMTS, MUST provide operation with the RF signal format of \( S(t) = I(t) \cdot \cos(wt) + Q(t) \cdot \sin(wt) \), where \( t \) denotes time, \( w \) denotes RF angular frequency, and where \( I(t) \) and \( Q(t) \) are the respective Root-Nyquist filtered baseband quadrature components of the constellation, as specified in ITU-T Recommendation J.83, Annex B [ITU-T J.83-B].

#### 6.3.3 Scaleable Interleaving to Support Video and High-Speed Data Services

The CMTS or EQAM downstream PMD sublayer MUST support a variable-depth interleaver. [ITU-T J.83-B] defines the variable interleaver depths in “Table B.2/J.83 – Level 2 interleaving.”

A CMTS or EQAM MUST support the set of interleaver depths described in Table 6–1 and Table 6–2. A multiple-channel CMTS or EQAM which is capable of producing up to \( N = 32 \) RF channels on a single RF output port MUST be capable of providing up to the longest interleaver depth on all \( N \) channels. A multiple-channel CMTS or EQAM which is capable of producing \( N > 32 \) RF channels on a single RF output port MUST be capable of providing interleaver depth \( I = 128, J = 8 \) on at least 32 channels, and up to \( I = 128, J = 4 \) on the remaining number of channels. * Further requirements for operational availability of interleaver depths are given in Section 6.3.5.1.2, Sub-section 1.

* This requirement provides that a DRFI modulator capable of producing \( N > 32 \) RF channels on a single RF output port is allowed to be limited in the total amount of interleaver depth it must support, where it must support no more than maximum interleaving depth on 32 channels and half that depth on the other \( N - 32 \) channels. This amount of required interleaving depth is less than that which is required for all channels to be interleaved with the maximum depth for a single channel, on all \( N \) channels.
Table 6–1 - Low Latency Interleaver Depths

<table>
<thead>
<tr>
<th>Control Word</th>
<th>Interleaver Taps</th>
<th>Interleaver Increment</th>
<th>64-QAM 5.056941 Msym/sec 6 bits per symbol</th>
<th>256-QAM 5.360537 Msym/sec 8 bits per symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four Bits</td>
<td>I</td>
<td>J</td>
<td>Burst Protection</td>
<td>Latency</td>
</tr>
<tr>
<td>1001</td>
<td>8</td>
<td>16</td>
<td>5.9 uSec</td>
<td>0.22 mSec</td>
</tr>
<tr>
<td>0111</td>
<td>16</td>
<td>8</td>
<td>12 uSec</td>
<td>0.48 mSec</td>
</tr>
<tr>
<td>0101</td>
<td>32</td>
<td>4</td>
<td>24 uSec</td>
<td>0.98 mSec</td>
</tr>
<tr>
<td>0011</td>
<td>64</td>
<td>2</td>
<td>47 uSec</td>
<td>2.0 mSec</td>
</tr>
<tr>
<td>0001</td>
<td>128</td>
<td>1</td>
<td>95 uSec</td>
<td>4.0 mSec</td>
</tr>
</tbody>
</table>

Table 6–2 - Long Duration Burst Noise Protection Interleaver Depths

<table>
<thead>
<tr>
<th>Control Word</th>
<th>Interleaver Taps</th>
<th>Interleaver Increment</th>
<th>64-QAM 5.056941 Msym/sec 6 bits per symbol</th>
<th>256-QAM 5.360537 Msym/sec 8 bits per symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four Bits</td>
<td>I</td>
<td>J</td>
<td>Burst Protection</td>
<td>Latency</td>
</tr>
<tr>
<td>0000</td>
<td>128</td>
<td>1</td>
<td>95 uSec</td>
<td>4.0 mSec</td>
</tr>
<tr>
<td>0010</td>
<td>128</td>
<td>2</td>
<td>190 uSec</td>
<td>8.0 mSec</td>
</tr>
<tr>
<td>0100</td>
<td>128</td>
<td>3</td>
<td>285 uSec</td>
<td>12 mSec</td>
</tr>
<tr>
<td>0110</td>
<td>128</td>
<td>4</td>
<td>380 uSec</td>
<td>16 mSec</td>
</tr>
<tr>
<td>1000</td>
<td>128</td>
<td>5</td>
<td>475 uSec</td>
<td>20 mSec</td>
</tr>
<tr>
<td>1010</td>
<td>128</td>
<td>6</td>
<td>570 uSec</td>
<td>24 mSec</td>
</tr>
<tr>
<td>1100</td>
<td>128</td>
<td>7</td>
<td>664 uSec</td>
<td>28 mSec</td>
</tr>
<tr>
<td>1110</td>
<td>128</td>
<td>8</td>
<td>759 uSec</td>
<td>32 mSec</td>
</tr>
</tbody>
</table>

The interleaver depth, which is coded in a 4-bit control word contained in the FEC frame synchronization trailer, always reflects the interleaving in the immediately following frame. In addition, errors are allowed while the interleaver memory is flushed after a change in interleaving is indicated.

Refer to [ITU-T J.83-B] for the control bit specifications required to specify which interleaving mode is used.

6.3.4 Downstream Frequency Plan

The downstream frequency plan SHOULD comply with a Harmonic Related Carrier (HRC); Incremental Related Carrier (IRC), or Standard (STD) North American frequency plans, per [CEA-542-B] for digital QAM carriers. Operational frequencies MAY include all channels between, and including center frequencies of 57 MHz to 999 MHz. Operational frequencies MUST include at least 91 MHz to 867 MHz.

6.3.5 DRFI Output Electrical

EQAMs and CMTSs may be available in three distinct versions. The terminology “multiple channel device” will apply to either of the latter two versions; requirements that apply to only one of the latter two versions will be clearly delineated in each case:

- Single channel devices that can only generate one RF channel per physical RF port.
• Multiple channel devices capable of generating more than one channel, but no more than eight, simultaneously per physical RF port. A multiple channel device could be used to generate a single channel; even so, it is still defined as a multiple channel device.

• Multiple channel devices capable of generating more than eight channels simultaneously per physical RF port. Such a multiple channel device could be used to generate eight or fewer channels; even so, it is still defined as a greater-than-eight multiple channel device.

An N-channel per RF port device capable of generating no more than eight channels per port MUST comply with all requirements operating with all N channels on the RF port, and. MUST comply with all requirements for an N’-channel per RF port device operating with N’ channels on the RF port for all even values of N’ less than N, and for N’ = 1. An N-channel per RF port device capable of generating more than eight channels per port MUST comply with all requirements operating with all N channels on the RF port, and MUST comply with all requirements for an N’-channel per RF port device operating with N’ channels on the RF port for all values of N’ less than N.

For an N-channel per RF port device with N >= 9 and N’ < N/4, the applicable maximum power per channel and spurious emissions requirements are defined using a value of N’ = minimum( 4N’, ceiling[N/4]).

A single channel device MUST comply with all requirements for an N-channel device with N = 1.

These specifications assume that the DRFI device will be terminated with a 75 Ohm load.

If more than one CMTS or EQAM is packaged in a chassis, each CMTS or EQAM MUST meet the appropriate parameters and definitions in this specification, regardless of the number of other CMTSSs or EQAMs, their location in the chassis, or their configuration.

6.3.5.1 CMTS or EQAM Output Electrical

A CMTS or EQAM MUST output an RF modulated signal with the characteristics defined in Table 6–3, Table 6–4, Table 6–5, Table 6–6 and Table 6–7. The condition for these requirements is all N’ combined channels, commanded to the same average power, except for the Single Channel Active Phase Noise, Diagnostic Carrier Suppression, and power difference (Table 6–4) requirements, and except as described for Out-of-Band Noise and Spurious Requirements (Table 6–5).

Table 6–3 - RF Output Electrical Requirements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Frequency (fc) of any RF channel of a CM           T or EQAM</td>
<td>MAY be 57 MHz to 999 MHz ±30 kHz (Note 1)</td>
</tr>
<tr>
<td>Level</td>
<td>Adjustable. See Table 6–4.</td>
</tr>
<tr>
<td>Modulation Type</td>
<td>64-QAM, 256-QAM</td>
</tr>
<tr>
<td>Symbol Rate (nominal)</td>
<td>64-QAM 5.056941 Msym/sec</td>
</tr>
<tr>
<td>256-QAM 5.360537 Msym/sec</td>
<td></td>
</tr>
<tr>
<td>Nominal Channel Spacing</td>
<td>6 MHz</td>
</tr>
<tr>
<td>Frequency response</td>
<td>~ 0.18 Square Root Raised Cosine Shaping</td>
</tr>
<tr>
<td>64-QAM</td>
<td></td>
</tr>
<tr>
<td>256-QAM</td>
<td></td>
</tr>
<tr>
<td>Inband Spurious, Distortion, and Noise</td>
<td>Unequalized MER (Note 2) &gt; 35 dB</td>
</tr>
<tr>
<td>64-QAM</td>
<td></td>
</tr>
<tr>
<td>256-QAM</td>
<td></td>
</tr>
<tr>
<td>Equalized MER &gt; 43 dB</td>
<td></td>
</tr>
<tr>
<td>Inband Spurious and Noise</td>
<td>&lt;= -48dBc; where channel spurious and noise includes all discrete spurious, noise, carrier leakage, clock lines, synthesizer products, and other undesired transmitter products. Spurious and noise within ±50 kHz of the carrier is excluded. When N &gt; 1, noise outside the Nyquist bandwidth is excluded. See Table 6–5.</td>
</tr>
<tr>
<td>Out of Band Spurious and Noise</td>
<td>See Table 6–5.</td>
</tr>
</tbody>
</table>
### Parameter Value

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase Noise</td>
<td>Single Channel Active, N – 1 Channels Suppressed (see Section 6.3.5.1.2, item 6) 64-QAM and 256-QAM</td>
</tr>
<tr>
<td>All N Channels Active, (see Section 6.3.5.1.2, item 7) 64-QAM and 256-QAM</td>
<td>1 kHz - 10 kHz: -33dBc double sided noise power 10 kHz - 50 kHz: -51dBc double sided noise power</td>
</tr>
<tr>
<td>Output Impedance</td>
<td>75 ohms</td>
</tr>
<tr>
<td>Output Return Loss (Note 3)</td>
<td>&gt; 14 dB within an active output channel from 88 MHz to 750 MHz (Note 4) &gt; 13 dB within an active output channel from 750 MHz to 870 MHz &gt; 12 dB within an active output channel from 870 MHz to 1002 MHz &gt; 12 dB in every inactive channel from 54 MHz to 870 MHz &gt; 10 dB in every inactive channel from 870 MHz to 1002 MHz</td>
</tr>
<tr>
<td>Connector</td>
<td>F connector per [ANSI/SCTE 02]</td>
</tr>
</tbody>
</table>

**Table Notes:**

1. 30 kHz includes an allowance of 25 kHz for the largest FCC frequency offset normally built into upconverters.
2. MER (modulation error ratio) is determined by the cluster variance caused by the transmit waveform at the output of the ideal receive matched filter. MER includes all discrete spurious, noise, carrier leakage, clock lines, synthesizer products, distortion, and other undesired transmitter products. Unequalized MER also includes linear filtering distortion, which is compensated by a receive equalizer. Phase noise up to ±50 kHz of the carrier is excluded from inband specification, to separate the phase noise and inband spurious requirements as much as possible. In measuring MER, record length or carrier tracking loop bandwidth may be adjusted to exclude low frequency phase noise from the measurement. For equalized MER, receive equalizer coefficients are computed and applied with receiver operating with device under test. For unequalized MER, receive equalizer coefficients may be computed to flatten receiver response, if necessary, then are held fixed when device under test is connected. MER requirements assume measuring with a calibrated test instrument with its residual MER contribution removed.
3. Frequency ranges are edge-to-edge.
4. If the EQAM or CMTS provides service to a center frequency of 57 MHz (see line 1 in table), then the EQAM or CMTS MUST provide a return loss of > 14 dB within an active output channel, from 54 MHz to 750 MHz (fsub).

### 6.3.5.1.1 Power per Channel CMTS or EQAM

An EQAM or CMTS MUST generate an RF output with power capabilities as defined in Table 6–4. Channel RF power MAY be adjustable on a per channel basis with each channel independently meeting the power capabilities defined in Table 6–4. Channel RF power MUST be adjustable on a per channel basis as stated in Table 6–4. If the EQAM or CMTS has independent modulation capability on a per channel basis, then the channel RF power MUST be adjustable on a per channel basis, with each channel independently meeting the power capabilities defined in Table 6–4.

**Table 6–4 - DRFI Device Output Power**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of commanded transmit power per channel</td>
<td>&gt;= 8 dB below required power level specified below maintaining full fidelity over the 8 dB range</td>
</tr>
<tr>
<td>Range of commanded power per channel; adjusted on a per channel basis</td>
<td>MUST: 0 dBc to -2 dBc relative to highest commanded transmit power per channel, up to 8 dB below required power level (for modulators capable of generating 9 or more channels per single RF output port) MAY: required power (in table below) to required power - 8 dB, independently on each channel.</td>
</tr>
<tr>
<td>Commanded power per channel step size</td>
<td>&lt;= 0.2 dB Strictly monotonic</td>
</tr>
<tr>
<td>Power difference between any two adjacent channels in the 54-1002 MHz downstream spectrum (with commanded power difference removed if channel power is independently adjustable)</td>
<td>&lt;= 0.5 dB</td>
</tr>
<tr>
<td>Parameter</td>
<td>Value</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Power difference between any two non-adjacent channels in a 48 MHz contiguous bandwidth block (with commanded power difference removed if channel power is independently adjustable)</td>
<td>&lt;= 1 dB</td>
</tr>
<tr>
<td>Power difference between any two non-adjacent channels in the 54-1002 MHz downstream spectrum (with commanded power difference removed if channel power is independently adjustable)</td>
<td>&lt;= 2 dB</td>
</tr>
<tr>
<td>Power per channel absolute accuracy</td>
<td>±2 dB</td>
</tr>
<tr>
<td>Diagnostic carrier suppression (3 modes)</td>
<td></td>
</tr>
<tr>
<td>Mode 1: One channel suppressed</td>
<td>1) &gt;= 50 dB carrier suppression within the Nyquist bandwidth in any one 6 MHz active channel. This MUST be accomplished without service impacting discontinuity or detriment to the unsuppressed channels.</td>
</tr>
<tr>
<td></td>
<td>2) 50 dB carrier suppression within the Nyquist bandwidth in every 6 MHz active channel except one. This MUST be accomplished without service-impacting discontinuity or detriment to the remaining channel for modulators with N &lt;= 8, where N equals the maximum number of channels per port. For modulators with N &gt;= 9 the suppression is not required to be glitchless, and the remaining unsuppressed active channel is allowed to operate with increased power such as the total power of the N active channels combined.</td>
</tr>
<tr>
<td>Mode 2: All channels suppressed except one</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3) 50 dB carrier suppression within the Nyquist bandwidth in every 6 MHz active channel. The power allowed in the 6 MHz suppressed channel(s) by this carrier suppression requirement is combined with the spurious emissions requirements of the remaining (not suppressed) active channels to produce the ultimate test limit for power in the 6 MHz suppressed channel(s). In all three modes the output return loss of the suppressed channel(s) MUST comply with the Output Return Loss requirements for active channels given in Table 6–3 - RF Output Electrical Requirements.</td>
</tr>
<tr>
<td>RF output port muting</td>
<td>&gt;= 73 dB below the unmuted aggregate power of the RF modulated signal, in every 6 MHz channel from 54 MHz to 1002 MHz. The specified limit applies with all active channels commanded to the same transmit power level. Commanding a reduction in the transmit level of any, or all but one, of the active channels does not change the specified limit for measured muted power in 6 MHz. The output return loss of the output port of the muted device MUST comply with the Output Return Loss requirements for inactive channels given in Table 6–3 - RF Output Electrical Requirements.</td>
</tr>
<tr>
<td>Required power per channel for N channels combined onto a single RF port, for N &lt; 8, where N = maximum number of combined channels per port and N' = number of active combined channels per port (N' &lt;= N):</td>
<td>Required power in dBmV per channel</td>
</tr>
<tr>
<td>N' = 1</td>
<td>60 dBmV</td>
</tr>
<tr>
<td>N' = 2</td>
<td>56 dBmV</td>
</tr>
<tr>
<td>N' = 3</td>
<td>54 dBmV</td>
</tr>
<tr>
<td>N' = 4</td>
<td>52 dBmV</td>
</tr>
<tr>
<td>4 &lt; N' &lt;= 8</td>
<td>60 – ceil [3.6*log2(N')] dBmV</td>
</tr>
<tr>
<td>Required power per channel for N' channels combined onto a single RF port for N' &gt;= N /4 and N &gt;= 9:</td>
<td>Required power in dBmV per channel</td>
</tr>
<tr>
<td>N' &gt;= N /4</td>
<td>60 – ceil [3.6*log2(N')] dBmV</td>
</tr>
<tr>
<td>Required power per channel for N' channels combined onto a single RF port for N' &lt; N /4 and N &gt;= 9:</td>
<td>Required power in dBmV per channel, where N' = min [4N',ceil (N /4)]</td>
</tr>
<tr>
<td>1 &lt;= N' &lt; N /4</td>
<td>60 – ceil [3.6*log2(N')] dBmV</td>
</tr>
</tbody>
</table>
6.3.5.1.2 Independence of individual channel within the multiple channels on a single RF port

A potential use of a CMTS or an EQAM is to provide a universal platform that can be used for high-speed data services or for video services. For this reason, it is essential that interleaver depth be set on a per channel basis to provide a suitable transmission format for either video or data as needed in normal operation. Any \( N \)-channel block of a CMTS or EQAM MUST be configurable with at least two different interleaver depths, using any of the interleaver depths shown in Table 6–1 and Table 6–2. Although not as critical as per-channel interleaver depth control, there are strong benefits for the operator if the EQAM is provided with the ability to set RF power, center frequency, and modulation type on a per-channel basis.

1. A multiple-channel CMTS or EQAM MUST be configurable with at least two different interleaver depths among the \( N \) channels on an RF output port, with each channel using one of the two (or more) interleaver depths, on a per channel basis, see Table 6–1 - Low Latency Interleaver Depths and Table 6–2 for information on interleaver depths.

2. A multiple-channel CMTS or EQAM MUST provide for 3 modes of carrier suppression of RF power for diagnostic and test purposes, see Table 6–4, Item 6 for mode descriptions and carrier RF power suppression level.

3. A multiple-channel CMTS or EQAM MAY provide for independent adjustment of RF power in a per channel basis with each RF carrier independently meeting the requirements defined in Table 6–4.

4. A multiple-channel CMTS or EQAM MAY provide for independent selection of center frequency on a per channel basis, thus providing for non-contiguous channel frequency assignment with each channel independently meeting the requirements in Table 6–3. A multiple-channel CMTS or EQAM capable of generating nine or more channels on a single RF output port MUST provide for independent selection of center frequency with the ratio of number of active channels to gap channels in the encompassed spectrum being at least 2:1, and with each channel independently meeting the requirements in Table 6–3 except for spurious emissions (including Table 6–5). A multiple-channel CMTS or EQAM capable of generating nine or more channels on a single RF output port MUST meet the requirements of Table 6–3 when the ratio of number of active channels to gap channels in the encompassed spectrum is at least 4:1. (A ratio of number of active channels to gap channels of at least 4:1 provides that at least 80% of the encompassed spectrum contains active channels, and the number of gap channels is at most 20% of the encompassed spectrum.)

5. A multiple-channel CMTS or EQAM MAY provide for independent selection of modulation order, either 64-QAM or 256-QAM, on a per channel basis, with each channel independently meeting the requirements in Table 6–3.

6. A CMTS or EQAM MUST provide a test mode of operation, for out-of-service testing, configured for \( N \) channels but generating one-CW-per-channel, one channel at a time at the center frequency of the selected channel; all other combined channels are suppressed. One purpose for this test mode is to support one method for testing the phase noise requirements of Table 6–3. As such, the generation of the CW test tone SHOULD exercise the signal generation chain to the fullest extent practicable, in such manner as to exhibit phase noise characteristics typical of actual operational performance; for example, repeated selection of a constellation symbol with power close to the constellation RMS level would seemingly exercise much of the modulation and up-conversion chain in a realistic manner. The test mode MUST be capable of generating the CW tone over the full range of Center Frequency in Table 6–3.

7. A CMTS or EQAM MUST provide a test mode of operation, for out-of-service testing, generating one-CW-per-channel, at the center frequency of the selected channel, with all other \( N – 1 \) of the combined channels active and containing valid data modulation at operational power levels. One purpose for this test mode is to support one method for testing the phase noise requirements of Table 6–3. As such, the generation of the CW test tone SHOULD exercise the signal generation chain to the fullest extent practicable, in such manner as to exhibit phase noise characteristics typical of actual operational performance. For example, a repeated selection of a constellation symbol, with power close to the constellation RMS level, would seemingly exercise much of the modulation and upconversion chain in a realistic manner. For this test mode, it is acceptable that all channels operate at the same average power, including each of the \( N – 1 \) channels in valid operation, and the single channel with a CW tone at its center frequency. The test mode MUST be capable of generating the CW tone over the full range of Center Frequency in Table 6–3.

8. A CMTS or EQAM capable of generating more than eight channels per physical RF port MUST be capable of glitchless reconfiguration over a range of active channels from ceiling\[7*N’max/8\] to \( N’max \). Channels which
are undergoing configuration changes are referred to as the “changed channels.” The channels which are active and are not being reconfigured are referred to as the “continuous channels”. Each DRFI modulator capable of generating more than eight channels per physical RF port MUST accept a command setting $N_{\text{max}}$. Glitchless reconfiguration consists of any of the following actions while introducing no discontinuity or detriment to the continuous channels, where the modulator is operating in a valid DRFI-required mode both before and after the reconfiguration with an active number of channels staying in the range $\lceil 7 \times N_{\text{max}}/8 \rceil, N_{\text{max}}$ : adding and/or deleting one or more channels, and/or moving some channels to new RF carrier frequencies, and/or changing the interleaver depth, modulation, power level, or frequency on one or more channels. Any change in the modulation characteristics (power level, modulation density, interleaver parameters, center frequency) of a channel excuses that channel from being required to operate in a glitchless manner. For example, changing the power per channel of a given channel means that channel is not considered a continuous channel for the purposes of the glitchless modulation requirements. Glitchless operation is not required when $N_{\text{max}}$ is changed, even if no reconfigurations accompany the change in $N_{\text{max}}$.

If either center frequency (4) or modulation type (5), or both are independently adjustable on a per channel basis, then the CMTS or EQAM MUST provide for independent adjustment of RF power (3) on a per channel basis, with each RF carrier independently meeting the requirements defined in Table 6–3.

### 6.3.5.1.3 Out-of-Band Noise and Spurious Requirements for CMTS or EQAM

One of the goals of the DRFI specification is to provide the minimum intended analog channel CNR protection of 60 dB for systems deploying up to 119 DRFI-compliant QAM channels.

The specification assumes that the transmitted power level of the digital channels will be 6 dB below the peak envelope power of the visual signal of analog channels, which is the typical condition for 256-QAM transmission. It is further assumed that the channel lineup will place analog channels at lower frequencies than digital channels, and in systems deploying modulators capable of generating nine or more digital channels on a single RF port analog channels will be placed at center frequencies below 600 MHz. An adjustment of $10 \log_{10} (6 \text{ MHz} / 4 \text{ MHz})$ is used to account for the difference in noise bandwidth of digital channels, versus analog channels. With the assumptions above, for a 119-QAM channel system, the specification in item 5 of Table 6–5 equates to an analog CNR protection of 60dB.

Table 6–5, Table 6–6, and Table 6–7 list the out-of-band spurious requirements. In cases where the $N'$ combined channels are not commanded to the same power level, “dBc” denotes decibels relative to the strongest carrier among the active channels. When commanded to the same power level, “dBc” should be interpreted as the average channel power, averaged over the active channels, to mitigate the variation in channel power across the active channels (see Table 6–4), which is allowed with all channels commanded to the same power.

Modulators capable of generating $N \leq 8$ channels on a single RF output port MUST satisfy the out-of-band spurious emissions requirements of Table 6–5 with a contiguous block of $N'$ combined channels.

Modulators capable of generating $N \geq 9$ channels on a single RF output port MUST satisfy the out-of-band spurious emissions requirements of Table 6–5 in channels below 600 MHz and outside the encompassed spectrum when the active channels are contiguous or when the ratio of active channels to gap channels within the encompassed spectrum is 4:1 or greater.

Modulators capable of generating $N \geq 9$ channels on a single RF output port MUST satisfy the out-of-band spurious emissions requirements of Table 6–5, with 1 dB relaxation, in gap channels below 600 MHz and within the encompassed spectrum when the ratio of active channels to gap channels within the encompassed spectrum is 4:1 or greater.

Modulators capable of generating $N \geq 9$ channels on a single RF output port MUST satisfy the out-of-band spurious emissions requirements of Table 6–5, with 3 dB relaxation, when the ratio of active channels to gap channels within the encompassed spectrum is 4:1 or greater, in channels with center frequency at or above 600 MHz, outside the encompassed spectrum or in gap channels within the encompassed spectrum.

In cases where $N \geq 9$, and the $N'$ combined active channels are not contiguous, and the ratio of active channels to gap channels within the encompassed spectrum is 4:1 or greater, the spurious emissions requirements are determined by summing the spurious emissions power allowed in a given measurement bandwidth by each of the contiguous sub-blocks among the active channels. In the gap channels within the encompassed spectrum and below 600 MHz
there is a 1 dB relaxation in the spurious emissions requirements, so that within the encompassed spectrum the spurious emissions requirements (in absolute power) are 26% higher in the measurement band determined by the summing of the contiguous sub-blocks’ spurious emissions requirements. In all channels above 600 MHz there is a 3 dB relaxation in the spurious emissions requirements, so that the spurious emissions requirements (in absolute power) are double the power in the measurement band determined by the summing of the contiguous sub-blocks’ spurious emissions requirements. The following three paragraphs provide the details of the spurious emissions requirements for non-contiguous channel operation outside the encompassed spectrum; within the encompassed spectrum the same details apply except there is an additional 1 dB allowance below 600 MHz; and 3 dB allowance is applied above 600 MHz for all channels.

The full set of \( N' \) channels is referred to throughout this specification as the modulated channels or the active channels. However, for purposes of determining the spurious emissions requirements for non-contiguous transmitted channels, each separate contiguous sub-block of channels within the active channels is identified, and the number of channels in each contiguous sub-block is denoted as \( N_i \), for \( i = 1 \) to \( K \), where \( K \) is the number of contiguous sub-blocks. Therefore, \( N' = \sum_{i=1}^{K} N_i \). Note that \( K = 1 \) when and only when the entire set of active channels is contiguous. Also note that an isolated transmit channel, i.e., a transmit channel with empty adjacent channels, is described by \( N_i = 1 \) and constitutes a sub-block of one contiguous channel. Any number of the “contiguous sub-blocks” may have such an isolated transmit channel; if each active channel was an isolated channel, then \( K = N' \).

When \( N' \geq N'/4 \), Table 6–6 is used for determining the noise and spurious power requirements for each contiguous sub-block, even if the sub-block contains fewer than \( N'/4 \) active channels. When \( N' < N'/4 \), Table 6–7 is used for determining the noise and spurious power requirements for each contiguous sub-block. Thus, the noise and spurious power requirements for all contiguous sub-blocks of transmitted channels are determined entirely from Table 6–6 or entirely from Table 6–7, where the applicable table is determined by \( N' \) being greater than or equal to \( N'/4 \), or not. The noise and spurious power requirements for the ith contiguous sub-block of transmitted channels is determined from Table 6–6 or Table 6–7 using the value \( N_i \) for the “number of active channels combined per RF port”, and using “dBc” relative to the strongest carrier among all the active channels, and not just the strongest channel in the ith contiguous sub-block, in cases where the \( N' \) combined channels are not commanded to the same power. The noise and spurious emissions power in each measurement band, including harmonics, from all \( K \) contiguous sub-blocks, is summed (absolute power, NOT in dB) to determine the composite noise floor for the non-contiguous channel transmission condition.

For the measurement channels adjacent to a contiguous sub-block of channels, the spurious emissions requirements from the non-adjacent sub-blocks are divided on an equal “per Hz” basis for the narrow and wide adjacent measurement bands. For a measurement channel wedged between two contiguous sub-blocks, adjacent to each, the measurement channel is divided into three measurement bands, one wideband in the middle and two narrowbands each abutting one of the adjacent transmit channels. The wideband spurious and noise requirement is split into two parts, on an equal “per Hz” basis, to generate the allowed contribution of power to the middle band and to the farthest narrowband. The ceiling function is applied to the resulting sum of noise and spurious emissions, per Table Note 1 of Table 6–5, Table 6–6 and Table 6–7 to produce a requirement of \( \frac{1}{2} \) dB resolution.

Items 1 through 4 list the requirements in channels adjacent to the commanded channels.

Item 5 lists the requirements in all other channels further from the commanded channels. Some of these “other” channels are allowed to be excluded from meeting the Item 5 specification. All the exclusions, such as 2nd and 3rd harmonics of the commanded channel, are fully identified in the table.

Item 6 lists the requirements on the \( 2N' \) 2nd harmonic channels and the \( 3N' \) 3rd harmonic channels.
Table 6–5 - EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements for \(N \leq 8\)

<table>
<thead>
<tr>
<th>Item</th>
<th>Band</th>
<th>(N')</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>(N' &gt; 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adjacent channel up to 750 kHz from channel block edge</td>
<td>(&lt; -58) dBc</td>
<td>(&lt; -58) dBc</td>
<td>(&lt; -58) dBc</td>
<td>(&lt; -58) dBc</td>
<td>(&lt; -10 \log_{10} \left[ 10^{\frac{-58}{10}} + (0.75\times10^{\frac{-65}{10}} + (N'-2)\times10^{\frac{-73}{10}}) \right] )</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Adjacent channel (750 kHz from channel block edge to 6 MHz from channel block edge)</td>
<td>(&lt; -62) dBc</td>
<td>(&lt; -60) dBc</td>
<td>(&lt; -60) dBc</td>
<td>(&lt; -60) dBc</td>
<td>(&lt; -10 \log_{10} \left[ 10^{\frac{-62}{10}} + (5.25\times10^{\frac{-65}{10}} + (N'-2)\times10^{\frac{-73}{10}}) \right] )</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Next-adjacent channel (6 MHz from channel block edge to 12 MHz from channel block edge)</td>
<td>(&lt; -65) dBc</td>
<td>(&lt; -64) dBc</td>
<td>(&lt; -63.5) dBc</td>
<td>(&lt; -63) dBc</td>
<td>(&lt; -10 \log_{10} \left[ 10^{\frac{-66}{10}} + (N'-1)\times10^{\frac{-73}{10}} \right] )</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Third-adjacent channel (12 MHz from channel block edge to 18 MHz from channel block edge)</td>
<td>(&lt; -73) dBc</td>
<td>(&lt; -70) dBc</td>
<td>(&lt; -67) dBc</td>
<td>(&lt; -65) dBc</td>
<td>For (N'=5): -64.5 dBc; For (N'=6): -64 dBc; For (N'=7): -64 dBc; For (N' \geq 8): (-73 + 10 \log_{10} (N'))</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Noise in other channels (47 MHz to 1002 MHz) Measured in each 6 MHz channel excluding the following: a) Desired channel(s) b) 1st, 2nd, and 3rd adjacent channels (see Items 1, 2, 3, 4 in this table) c) Channels coinciding with 2nd and 3rd harmonics (see Item 6 in this table)</td>
<td>(&lt; -73) dBc</td>
<td>(&lt; -70) dBc</td>
<td>(&lt; -68) dBc</td>
<td>(&lt; -67) dBc</td>
<td>(&lt; -73 + 10 \log_{10} (N'))</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>In each of (2N') contiguous 6 MHz channels or in each of (3N') contiguous 6 MHz channels coinciding with 2nd harmonic and with 3rd harmonic components respectively (up to 1002 MHz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(&lt; -73 + 10 \log_{10} (N')), or -63 dBc, whichever is greater</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Lower out of band noise in the band of 5 MHz to 47 MHz Measured in 6 MHz channel bandwidth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(&lt; -50 + 10 \log_{10} (N'))</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Higher out of band noise in the band of 1002 MHz to 3000 MHz Measured in 6 MHz channel bandwidth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(&lt; -55 + 10 \log_{10} (N'))</td>
<td></td>
</tr>
</tbody>
</table>

Table Notes

1. All equations are Ceiling(Power, 0.5) dBc. Use “Ceiling(2*Power) / 2” to get 0.5 steps from ceiling functions that return only integer values. For example Ceiling(-63.9, 0.5) = -63.5 dBc.
2. Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with center frequency 600 MHz and above. For example -73 dBc becomes -70 dBc.
3. Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with center frequency below 600 MHz. For example -73 dBc becomes -72 dBc.
Table 6–6 - EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements $N \geq 9$ and $N' \geq N/4$

<table>
<thead>
<tr>
<th>Item</th>
<th>Band</th>
<th>$N'$</th>
<th>$N' &gt; 4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adjacent channel up to 750 kHz from channel block edge</td>
<td>$&lt; -58$ dBC</td>
<td>$&lt; -10 \log_{10} (10^{18.9/10} + (0.75/6) \times (10^{6.3/10} + (N'-2) \times 10^{-7.3/10}))$</td>
</tr>
<tr>
<td>2</td>
<td>Adjacent channel (750 kHz from channel block edge to 6 MHz from channel block edge)</td>
<td>$&lt; -60$ dBC</td>
<td>$&lt; -10 \log_{10} (10^{7.2/10} + (5.25/6) \times (10^{6.3/10} + (N'-2) \times 10^{-7.3/10}))$</td>
</tr>
<tr>
<td>3</td>
<td>Next-adjacent channel (6 MHz from channel block edge to 12 MHz from channel block edge)</td>
<td>$&lt; -64$ dBC</td>
<td>$&lt; -10 \log_{10} (10^{6.5/10} + (N'-1) \times 10^{-7.3/10})$</td>
</tr>
<tr>
<td>4</td>
<td>Third-adjacent channel (12 MHz from channel block edge to 18 MHz from channel block edge)</td>
<td>$&lt; -70$ dBC</td>
<td>For $N' = 5$: -64.5 dBc; For $N' = 6$: -64 dBc; For $N' = 7$: -64 dBc; For $N' &gt; 6$: $-73 + 10 \log_{10} (N')$</td>
</tr>
<tr>
<td>5</td>
<td>Noise in other channels (47 MHz to 1002 MHz) Measured in each 6 MHz channel excluding the following: a) Desired channel(s) b) 1st, 2nd, and 3rd adjacent channels (see Items 1, 2, 3, 4 in this table) c) Channels coinciding with 2nd and 3rd harmonics (see Item 6 in this table)</td>
<td>$&lt; -70$ dBC</td>
<td>$&lt; -73 + 10 \log_{10} (N')$</td>
</tr>
<tr>
<td>6</td>
<td>In each of 2$N'$ contiguous 6 MHz channels or in each of 3$N'$ contiguous 6 MHz channels coinciding with 2nd harmonic and with 3rd harmonic components respectively (up to 1002 MHz)</td>
<td>$&lt; -73 + 10 \log_{10} (N')$, or -63 dBc, whichever is greater</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Lower out of band noise in the band of 5 MHz to 47 MHz Measured in 6 MHz channel bandwidth</td>
<td>$&lt; -50 + 10 \log_{10} (N')$</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Higher out of band noise in the band of 1002 MHz to 3000 MHz Measured in 6 MHz channel bandwidth</td>
<td>$&lt; -55 + 10 \log_{10} (N')$ for $N' \leq 8$ $&lt; -60 + 10 \log_{10} (N')$ for $N' &gt; 8$</td>
<td></td>
</tr>
</tbody>
</table>

Table Note:
1. All equations are Ceiling(Power, 0.5) dBc. Use “Ceiling(2*Power) / 2” to get 0.5 steps from ceiling functions that return only integer values. For example Ceiling(-63.9, 0.5) = -63.5 dBc.
2. Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with center frequency 600 MHz and above. For example -73 dBc becomes -70 dBc.
3. Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with center frequency below 600 MHz. For example -73 dBc becomes -72 dBc.

Table 6–7 - EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements $N >= 9$ and $N' < N/4$

<table>
<thead>
<tr>
<th>Item</th>
<th>Band</th>
<th>$N''$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Adjacent channel up to 750 kHz from channel block edge</td>
<td>$&lt; -58$ dBC</td>
</tr>
<tr>
<td>2</td>
<td>Adjacent channel (750 kHz from channel block edge to 6 MHz from channel block edge)</td>
<td>$&lt; -60$ dBC</td>
</tr>
<tr>
<td>3</td>
<td>Next-adjacent channel (6 MHz from channel block edge to 12 MHz from channel block edge)</td>
<td>$&lt; -64$ dBC</td>
</tr>
<tr>
<td>Item</td>
<td>Band</td>
<td>$N''$</td>
</tr>
<tr>
<td>------</td>
<td>----------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>for $N &gt;= 9$ Maximum Number of Combined Channels per RF Port</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$N' &lt; N/4$ Number of Active Channels Combined per RF Port</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$N'' \equiv$ Effective Number of Active Channels for Spurious</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emissions Requirements= minimum($4N', \text{ceil}(N/4)$ )</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Third-adjacent channel (12 MHz from channel block edge to 18 MHz</td>
<td>$N'' &gt; 4$</td>
</tr>
<tr>
<td></td>
<td>from channel block edge).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Noise in other channels (47 MHz to 1002 MHz) Measured in each 6 MHz</td>
<td>$N'' &gt; 4$</td>
</tr>
<tr>
<td></td>
<td>channel excluding the following:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Desired channel(s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b) 1st, 2nd, and 3rd adjacent channels (see Items 1, 2, 3, 4 in</td>
<td></td>
</tr>
<tr>
<td></td>
<td>this table)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c) Channels coinciding with 2α and 3α harmonics (see Item 6 in this</td>
<td></td>
</tr>
<tr>
<td></td>
<td>table)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>In each of 2N' contiguous 6 MHz channels or in each of 3N'</td>
<td>$N'' &gt; 4$</td>
</tr>
<tr>
<td></td>
<td>contiguous 6 MHz channels coinciding with 2α harmonic and with 3α</td>
<td></td>
</tr>
<tr>
<td></td>
<td>harmonic components respectively (up to 1002 MHz)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Lower out of band noise in the band of 5 MHz to 47 MHz</td>
<td>$N'' &gt; 4$</td>
</tr>
<tr>
<td></td>
<td>Measured in 6 MHz channel bandwidth</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Higher out of band noise in the band of 1002 MHz to 3000 MHz</td>
<td>$N'' &gt; 4$</td>
</tr>
<tr>
<td></td>
<td>Measured in 6 MHz channel bandwidth</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table Notes**

1. All equations are Ceiling(Power, 0.5) dBc. Use “Ceiling(2*Power) / 2” to get 0.5 steps from ceiling functions that return only integer values. For example Ceiling(-63.9, 0.5) = -63.5 dBc.
2. Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with center frequency 600 MHz and above. For example -73 dBc becomes -70 dBc.
3. Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with center frequency below 600 MHz. For example -73 dBc becomes -72 dBc.

### 6.3.5.2 CMTS or EQAM Master Clock Jitter for Asynchronous Operation

An EQAM MUST implement a DTI client and client interface per the [DTI] specification. The Master Clock specifications are defined in the [DTI] specification. The DTI client provides the Master Clock. An integrated CMTS not actively serviced by a DTI server MUST include a Master Clock with the specifications as follows:

The 10.24 MHz Master Clock MUST have, over a temperature range of 0 to 40 degrees C and for up to ten years from date of manufacture (see Note below):

- A frequency accuracy of $\leq \pm 5$ ppm
- A drift rate $\leq 10^{-9}$ per second, and
- An edge jitter of $\leq 10$ nSec peak-to-peak ($\pm 5$ nSec)

**Note:** This specification MAY also be met by synchronizing the DRFI device Master Clock oscillator to an external frequency reference source. If this approach is used, the internal DRFI device Master Clock MUST have a frequency accuracy of $\pm 20$ ppm over a temperature range of 0 to 40 degrees C, up to 10 years from date of manufacture, when no frequency reference source is connected. The drift rate and edge jitter MUST be as specified above.

The drift rate and jitter requirements on the DRFI device Master Clock implies that the duration of two adjacent segments of 10,240,000 cycles will be within 30 nSec, due to 10 nSec jitter on each segments’ duration, and 10 nSec due to frequency drift. Durations of other counter lengths also may be deduced: adjacent 1,024,000 segments, $\leq 21$ nSec; 1,024,000 length segments separated by one 10,240,000-cycle segment, $\leq 30$ nSec; adjacent 102,400,000 segments, $\leq 120$ nSec. The DRFI device Master Clock MUST meet such test limits in 99% or more measurements.
6.3.5.3 CMTS or EQAM Master Clock Jitter for Synchronous Operation

In addition to the requirements in Section 6.3.5.2, the 10.24 MHz CMTS Master Clock MUST meet the following double sideband phase noise requirements over the specified frequency ranges:

- \[-50 + 20 \log \left( \frac{f_{MC}}{10.24} \right) \text{ dBc (i.e., } \leq 0.05 \text{ nSec RMS)} \text{ 10 Hz to 100 Hz}\]
- \[-58 + 20 \log \left( \frac{f_{MC}}{10.24} \right) \text{ dBc (i.e., } \leq 0.02 \text{ nSec RMS) 100 Hz to 1 kHz}\]
- \[-50 + 20 \log \left( \frac{f_{MC}}{10.24} \right) \text{ dBc (i.e., } \leq 0.05 \text{ nSec RMS) 1 kHz to 10 kHz}\]
- \[-50 + 20 \log \left( \frac{f_{MC}}{10.24} \right) \text{ dBc (i.e., } \leq 0.05 \text{ nSec RMS) 10 kHz to } \frac{f_{MC}}{2}\]

\(f_{MC}\) is the frequency of the measured master clock in MHz. The value of \(f_{MC}\) MUST be either an integral multiple or divisor of 10.24 MHz. For example, if a 20.48 MHz oscillator is used as the master clock frequency source, and there is no explicit 10.24 MHz clock to test, the 20.48 MHz clock may be used with \(f_{MC}\) equal to 20.48 in the above expressions.

Specifications for EQAM Master Clock jitter in synchronous operation are contained in the [DTI] specification.

6.3.5.4 CMTS or EQAM Master Clock Frequency Drift for Synchronous Operation

The frequency of the CMTS Master Clock MUST NOT drift more than \(10^{-8}\) per second.

Specifications for EQAM Master Clock frequency drift in synchronous operation is contained in the DTI specification.

6.3.6 CMTS or EQAM Clock Generation

This section contains the EQAM and CMTS requirements for locking the Downstream Symbol Clock to the Master Clock.

CMTS Clock Generation

The CMTS MUST lock the Downstream Symbol Clock to the CMTS Master Clock using the M/N divisors provided in Table 6–8.

6.3.6.1 EQAM Clock Generation

An EQAM operates with an active DTI interface which provides a 10.24 MHz Master Clock. An EQAM MUST lock the Downstream Symbol Clock to the Master Clock using the M/N divisors provided in Table 6–8.

6.3.6.2 Downstream Symbol Rate

Let \(f_b'\) represent the rate of the Downstream Symbol Clock which is locked to the Master Clock and let \(f_m'\) represent the rate of the Master Clock locked to the Downstream Symbol Clock. Let \(f_b\) represent the nominal specified downstream symbol rate and let \(f_m\) represent the nominal Master Clock rate (10.24 MHz). With the Downstream Symbol Clock locked to the Master Clock, the following equation MUST hold:

\[ f_b' = f_m' \frac{M}{N} \]

With the Master Clock locked to the Downstream Symbol Clock, the following equation MUST hold:

\[ f_m' = f_b' \frac{N}{M} \]

Note that M and N in Table 6–8 are unsigned integer values, each representable in 16 bits and result in a value of \(f_b'\) or \(f_m'\) that is not more than \(\pm 1\) ppm from its specified nominal value.

The standard deviation of the timing error of the EQAM/CMTS RF symbol clock, referenced to the Master Clock, MUST be less than 1.5 ns measured over 100 seconds.

Table 6–8 lists the downstream modes of operation, their associated nominal symbol rates, \(f_{bn}\) values for M and N, the resulting synchronized clock rates and their offsets from their nominal values.
### Table 6–8 - Downstream symbol rates & parameters for synchronization with Master Clock

<table>
<thead>
<tr>
<th>Downstream mode</th>
<th>Nominal Specified Symbol Rate, fb (MHz)</th>
<th>M/N</th>
<th>Master Clock Rate, fm' (MHz)</th>
<th>Downstream Symbol Rate, fb' (MHz)</th>
<th>Offset from Nominal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annex B, 64-QAM</td>
<td>5.056941</td>
<td>401/812</td>
<td>10.239990...</td>
<td>5.056945...</td>
<td>0.95 ppm</td>
</tr>
<tr>
<td>Annex B, 256-QAM</td>
<td>5.360537</td>
<td>78/149</td>
<td>10.240000...</td>
<td>5.360536...</td>
<td>0.02 ppm</td>
</tr>
</tbody>
</table>

6.3.7 Downstream Symbol Clock Jitter for Synchronous Operation

The downstream symbol clock MUST meet the following double sideband phase noise requirements over the specified frequency ranges:

- $< [-53 + 20\log(f_{DS}/5.057)] \text{ dBc } (i.e., < 0.07 \text{ nSec RMS})$ 10 Hz to 100 Hz
- $< [-53 + 20\log(f_{DS}/5.057)] \text{ dBc } (i.e., < 0.07 \text{ nSec RMS})$ 100 Hz to 1 kHz
- $< [-53 + 20\log(f_{DS}/5.057)] \text{ dBc } (i.e., < 0.07 \text{ nSec RMS})$ 1 kHz to 10 kHz
- $< [-36 + 20\log(f_{DS}/5.057)] \text{ dBc } (i.e., < 0.5 \text{ nSec RMS})$ 10 kHz to 100 kHz
- $< [-30 + 20\log(f_{DS}/5.057)] \text{ dBc } (i.e., < 1 \text{ nSec RMS})$ 100 kHz to $f_{DS}/2$

$f_{DS}$ is the frequency of the measured clock in MHz. The value of $f_{DS}$ MUST be an integral multiple or divisor of the downstream symbol clock. For example, an $f_{DS} = 20.227764$ MHz clock may be measured if there is no explicit 5.056941 MHz clock available.

A DRFI-compliant device MUST provide a means for clock testing in which:

- The device provides test points for direct access to the master clock and the downstream symbol clock.

Alternatively, a DRFI conformant device MUST provide a test mode in which:

- The downstream QAM symbol sequence is replaced with an alternating binary sequence (1, -1, 1, -1, 1, -1...) at nominal amplitude, on both I and Q.
- The device generates the downstream symbol clock from the 10.24 MHz reference clock as in normal synchronous operation.

If an explicit downstream symbol clock, which is capable of meeting the above phase noise requirements, is available (e.g., a smooth clock without clock domain jitter), this test mode is not required.

6.3.8 Downstream Symbol Clock Drift for Synchronous Operation

The frequency of the downstream symbol clock MUST NOT drift more than $10^{-8}$ per second.

6.3.9 Timestamp Jitter

The DOCSIS timestamp jitter MUST be less than 500 nsec peak-to-peak at the output of the Downstream Transmission Convergence Sublayer. This jitter is relative to an ideal Downstream Transmission Convergence Sublayer that transfers the MPEG packet data to the Downstream Physical Media Dependent Sublayer with a perfectly continuous and smooth clock at the MPEG packet data rate. Downstream Physical Media Dependent Sublayer processing MUST NOT be considered in timestamp generation and transfer to the Downstream Physical Media Dependent Sublayer.

Thus, any two timestamps $N1$ and $N2$ ($N2 > N1$) which were transferred to the Downstream Physical Media Dependent Sublayer at times $T1$ and $T2$ respectively must satisfy the following relationship:

$$\left| \frac{N2-N1}{f_{CMTS}} - (T2-T1) \right| < 500 \times 10^{-9}$$

In the equation, the value of $(N2-N1)$ is assumed to account for the effect of rollover of the timebase counter, and $T1$ and $T2$ represent time in seconds. $f_{CMTS}$ is the actual frequency of the CMTS master timebase and may include a
fixed frequency offset from the nominal frequency of 10.24 MHz. This frequency offset is bounded by a requirement further below in this section.

The jitter includes inaccuracy in timestamp value and the jitter in all clocks. The 500 nsec allocated for jitter at the Downstream Transmission Convergence Sublayer output MUST be reduced by any jitter that is introduced by the Downstream Physical Media Dependent Sublayer.

**NOTE:** Jitter is the error *(i.e., measured)* relative to the CMTS Master Clock. (The CMTS Master Clock is the 10.24 MHz clock used for generating the timestamps.)
7 DOWNSTREAM TRANSMISSION CONVERGENCE SUBLAYER

7.1 Introduction

The downstream transmission convergence layer used in the M-CMTS is defined as a continuous series of 188-byte MPEG [ISO 13818] packets. These packets consist of a 4-byte header followed by 184 bytes of payload. The header identifies the payload as belonging to the Data-Over-Cable MAC. Other values of the header may indicate other payloads. The mixture of MAC payloads and those of other services is optional and is controlled by the CMTS.

Figure 7–1 illustrates the interleaving of DOCSIS MAC bytes with other digital information (digital video in the example shown).

| header=DOC | DOC MAC payload |
| header=video | digital video payload |
| header=video | digital video payload |
| header=DOC | DOC MAC payload |
| header=video | digital video payload |
| header=DOC | DOC MAC payload |
| header=video | digital video payload |

Figure 7–1 - Example of Interleaving MPEG Packets in Downstream

7.2 MPEG Packet Format

The format of an MPEG Packet carrying DOCSIS data is shown in Figure 7–2. The packet consists of a 4-byte MPEG Header, a pointer_field (not present in all packets), and the DOCSIS Payload.

| MPEG Header (4 bytes) | pointer_field (1 byte) | DOCSIS Payload (183 or 184 bytes) |

Figure 7–2 - Format of an MPEG Packet

7.3 MPEG Header for DOCSIS Data-Over-Cable

The format of the MPEG Transport Stream header is defined in Section 2.4 of [ISO 13818]. The particular field values that distinguish Data-Over-Cable MAC streams are defined in Table 7–1. Field names are from the ITU specification.

The MPEG Header consists of 4 bytes that begin the 188-byte MPEG Packet. The format of the header for use on a DOCSIS Data-Over-Cable PID MUST be as shown in Table 7–1. The header format conforms to the MPEG standard, but its use is restricted in this specification to not allow inclusion of an adaptation_field in the MPEG packets.
Table 7-1 - MPEG Header Format for DOCSIS Data-Over-Cable Packets

<table>
<thead>
<tr>
<th>Field</th>
<th>Length (bits)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sync_byte</td>
<td>8</td>
<td>0x47; MPEG Packet Sync byte.</td>
</tr>
<tr>
<td>transport_error_indicator</td>
<td>1</td>
<td>Indicates that an error has occurred in the reception of the packet. This bit is reset to zero by the sender, and set to one whenever an error occurs in the transmission of the packet.</td>
</tr>
<tr>
<td>payload_unit_start_indicator</td>
<td>1</td>
<td>A value of one indicates the presence of a pointer_field as the first byte of the payload (fifth byte of the packet).</td>
</tr>
<tr>
<td>transport_priority</td>
<td>1</td>
<td>Reserved; set to zero.</td>
</tr>
<tr>
<td>PID</td>
<td>13</td>
<td>DOCSIS Data-Over-Cable well-known PID (0x1FFE).</td>
</tr>
<tr>
<td>transport_scrambling_control</td>
<td>2</td>
<td>Reserved, set to '00'.</td>
</tr>
<tr>
<td>adaptation_field_control</td>
<td>2</td>
<td>'01'; use of the adaptation_field is not allowed on the DOCSIS PID.</td>
</tr>
<tr>
<td>continuity_counter</td>
<td>4</td>
<td>Cyclic counter within this PID.</td>
</tr>
</tbody>
</table>

7.4 MPEG Payload for DOCSIS Data-Over-Cable

The MPEG payload portion of the MPEG packet will carry the DOCSIS MAC frames. The first byte of the MPEG payload will be a ‘pointer_field’ if the payload_unit_start_indicator (PUSI) of the MPEG header is set.

7.4.1 stuff_byte

This standard defines a stuff_byte pattern having a value (0xFF) that is used within the DOCSIS payload to fill any gaps between the DOCSIS MAC frames. This value is chosen as an unused value for the first byte of the DOCSIS MAC frame. The ‘FC’ byte of the MAC Header will be defined to never contain this value. (FC_TYPE = ‘11’ indicates a MAC-specific frame, and FC_PARM = ‘11111’ is not currently used and, according to this specification, is defined as an illegal value for FC_PARM.)

7.4.2 pointer_field

The pointer_field is present as the fifth byte of the MPEG packet (first byte following the MPEG header) whenever the PUSI is set to one in the MPEG header. The interpretation of the pointer_field is as follows:

The pointer_field contains the number of bytes in this packet that immediately follow the pointer_field that the CM decoder will skip past before looking for the beginning of an DOCSIS MAC Frame. A pointer field MUST be present if it is possible to begin a Data-Over-Cable MAC Frame in the packet, and MUST point to either:

- the beginning of the first MAC frame to start in the packet, or
- to any stuff_byte preceding the MAC frame.

7.5 Interaction with the MAC Sublayer

MAC frames may begin anywhere within an MPEG packet. MAC frames may span MPEG packets, and several MAC frames may exist within an MPEG packet.

The following figures show the format of the MPEG packets that carry DOCSIS MAC frames. In all cases, the PUSI flag indicates the presence of the pointer_field as the first byte of the MPEG payload.

Figure 7–3 shows a MAC frame that is positioned immediately after the pointer_field byte. In this case, the pointer_field is zero, and the DOCSIS decoder will begin searching for a valid FC byte, at the byte immediately following the pointer_field.
Figure 7–3 - Packet Format where a MAC Frame Immediately Follows the Pointer Field

Figure 7–4 shows the more general case, where a MAC Frame is preceded by the tail of a previous MAC Frame and a sequence of stuffing bytes. In this case, the pointer_field still identifies the first byte after the tail of Frame #1 (a stuff_byte) as the position where the decoder should begin searching for a legal MAC sublayer FC value. This format allows the multiplexing operation in the CMTS to immediately insert a MAC frame that is available for transmission if that frame arrives after the MPEG header and pointer_field have been transmitted.

In order to facilitate multiplexing of the MPEG packet stream carrying DOCSIS data with other MPEG-encoded data, the CMTS SHOULD NOT transmit MPEG packets with the DOCSIS PID which contain only stuff_bytes in the payload area. MPEG null packets SHOULD be transmitted instead.

NOTE: There are timing relationships implicit in the DOCSIS MAC sublayer, which must also be preserved by any MPEG multiplexing operation.

Figure 7–4 - Packet Format with MAC Frame Preceded by Stuffing Bytes

Figure 7–5 shows that multiple MAC frames may be contained within the MPEG packet. The MAC frames may be concatenated one after the other or be separated by an optional sequence of stuffing bytes.

Figure 7–5 - Packet Format Showing Multiple MAC Frames in a Single Packet

Figure 7–6 shows the case where a MAC frame spans multiple MPEG packets. In this case, the pointer_field of the succeeding frame points to the byte following the last byte of the tail of the first frame.

Figure 7–6 - Packet Format where a MAC Frame Span Multiple Packets

The Transmission Convergence sublayer must operate closely with the MAC sublayer in providing an accurate timestamp to be inserted into the Time Synchronization message.

7.6 Interaction with the Physical Layer

The MPEG-2 packet stream MUST be encoded according to [ITU-T J.83-B], including MPEG-2 transport framing using a parity checksum as described in [ITU-T J.83-B].
Annex A  Additions and Modifications for European Specification

This annex applies to the second technology option referred to in Section 1.1. For the first option, refer to Sections 5, 6, and 7.

This annex describes the physical layer specifications required for the EuroDOCSIS integrated CMTS and EuroDOCSIS EQAM. This is an optional annex and in no way affects certification of equipment adhering to the North American technology option described in the sections referenced above.

The numbering of the paragraphs has been maintained such that the suffix after the letter for the annex refers to the part of the specification where the described changes apply. As a consequence, some heading numbers might be missing in this annex, since no change is required to the relevant paragraph in the main body of the document.

A.1  Scope and purpose

See Section 1.

A.2  References

A.2.1  Normative References

In order to claim compliance with this specification, it is necessary to conform to the following standards and other works as indicated, in addition to the other requirements of this specification. Notwithstanding, intellectual property rights may be required to use or implement such normative references.


[IEC-61169-24]  IEC 61169-24 Revision: 02 Chg: Date: 00/00/02 Radio-Frequency Connectors - Part 24: Sectional Specification - Radio Frequency Coaxial Connectors With Screw Coupling, Typically For Use In 75 Ohm Cable Distribution Systems (Type F).


[EN 300 429]  ETSI EN 300 429 V1.2.1: Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems", April 1998.

A.3  Terms and Definitions

See Section 3.

A.4  Acronyms and Abbreviations

See Section 4.

A.5  Functional Assumptions

This section describes the characteristics of a cable television plant, assumed to be for the purpose of operating a data-over-cable system. It is not a description of EQAM or CMTS parameters. The data-over-cable system MUST be interoperable within the environment described in this section.

Whenever a reference to frequency plans or to compatibility with other services in this section conflicts with a legal requirement for the area of operation, the latter shall take precedence. Any reference to analog TV signals in a particular frequency band does not imply that such signals are physically present.
A.5.1 Broadband Access Network

A coaxial-based broadband access network is assumed. This may take the form of either an all-coax or hybrid fiber/coax (HFC) network. The generic term “cable network” is used here to cover all cases.

A cable network uses a shared-medium, “tree-and-branch” architecture, with analog transmission. The key functional characteristics assumed in this document are the following:

- Two-way transmission
- A maximum optical/electrical spacing between the DRFI-compliant device and the most distant CM of 160 km (route meters) in each direction
- A maximum differential optical/electrical spacing between the DRFI-compliant device and the closest and most distant modems of 160 km (route meters) in each direction

At a propagation velocity in fiber of approximately 5 ns/m, 160 km of fiber in each direction results in a round-trip delay of approximately 1.6 ms. For further information, see [DOCSIS2], Appendix VIII.

A.5.2 Equipment Assumptions

A.5.2.1 Frequency Plan

In the downstream direction, the cable system is assumed to have a pass band with a typical lower edge between 47 and 87.5 MHz, and an upper edge that is implementation-dependent, but is typically in the range of 300 to 862 MHz. Within that pass band, PAL/SECAM analog television signals in 7/8 MHz channels and FM radio signals are assumed to be present, as well as other narrowband and wideband digital signals. 8 MHz channels are used for data communication.

A.5.2.2 Compatibility with Other Services

The CM and EQAM or CMTS MUST coexist with the other services on the cable network, for example:

a. They MUST be interoperable in the cable spectrum assigned for EQAM- or CMTS-CM interoperation while the balance of the cable spectrum is occupied by any combination of television and other signals; and

b. They MUST NOT cause harmful interference to any other services that are assigned to the cable network in spectrum outside of that allocated to the EQAM or CMTS. The latter is understood as:

- No measurable degradation (highest level of compatibility),
- No degradation below the perceptible level of impairments for all services (standard or medium level of compatibility), or
- No degradation below the minimal standards accepted by the industry or other service provider (minimal level of compatibility).

A.5.2.3 Fault Isolation Impact on Other Users

See Section 5.2.3.

A.5.3 Downstream Plant Assumptions

See Section 5.3.

A.5.3.1 Transmission Levels

The nominal average power level of the downstream RF signal(s) within an 8 MHz channel is targeted to be in the range of -13 dBc to 0 dBc, relative to analog peak video carrier level and will normally not exceed analog peak video carrier level, (typically between -10 to -6 dBc for 64-QAM and between -6 to -4 dBc for 256-QAM).

A.5.3.2 Frequency Inversion

See Section 5.3.2.
A.5.3.3 Analog and Digital Channel Line-up
In developing this technology option, it was assumed that a maximum of 85 digital channels would be deployed in a headend. For the purposes of calculating CNR protection for analog channels, it was assumed that analog channels are placed at lower frequencies in the channel line-up than digital channels.

A.5.3.4 Analog Protection Goal
One of the goals of the DRFI specification is to provide the minimum intended analog channel CNR protection of 59 dB measured in a 5.08 MHz wide frequency band for systems deploying up to 85 DRFI-compliant QAM channels. For purposes of calculation, it is assumed that the transmitted power level of the digital channels will be 5 dB below the peak envelope power of the visual signal of analog channels, which is within the range of typical conditions for 256-QAM transmission. It is further assumed, for the purpose of calculation, that the channel line-up will place analog channels at lower frequencies than digital channels, and that in systems deploying modulators capable of generating nine or more channels on a single RF output port analog channels will be placed at center frequencies below 600 MHz. An adjustment of $10\log_{10}(8 \text{ MHz} / 5.08 \text{ MHz})$ is used to account for the difference in bandwidth used to define the noise requirements for DRFI-compliant digital QAM channels, versus analog PAL channels. With the assumptions above, for an 85-QAM channel system, the specification in item 5 of Table A–4 equates to an analog CNR protection of 59 dB.

A.6 Physical Media Dependent Sublayer Specification

A.6.1 Scope
This section applies to the second technology option referred to in Section 1.1. In cases where the requirements for both technology options are identical, a reference is provided to the main text. For the remainder of this section see Section 6.1.

A.6.2 EdgeQAM (EQAM) differences from CMTS
See Section 6.2.

A.6.3 Downstream

A.6.3.1 Downstream Protocol
The downstream PMD sublayer MUST conform to [EN 300 429].

A.6.3.2 Spectrum Format
The downstream modulator for each QAM channel of the EQAM or CMTS MUST provide operation with the RF signal format of $S(t) = I(t)\cdot\cos(\omega t) + Q(t)\cdot\sin(\omega t)$, where $t$ denotes time, $\omega$ denotes RF angular frequency and where $I(t)$ and $Q(t)$ are the respective Root-Nyquist filtered baseband quadrature components of the constellation, as specified in [EN 300 429].

A.6.3.3 Scaleable Interleaving to Support Video and High-Speed Data Services
The CMTS or EQAM downstream PMD sublayer MUST support the interleaver with the characteristics defined in Table A–1. This interleaver mode fully complies with [EN 300 429].

<table>
<thead>
<tr>
<th>Table A–1 - Interleaver characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interleaver Taps</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>I</td>
</tr>
<tr>
<td>12</td>
</tr>
</tbody>
</table>
A.6.3.4 **Downstream Frequency Plan**

It is up to the operator to decide which frequencies to use to meet national and network requirements.

A.6.3.5 **DRFI Output Electrical**

See Section 6.3.5.

A.6.3.5.1 **CMTS or EQAM Output Electrical**

A CMTS or EQAM MUST output an RF-modulated signal with the characteristics defined in Table A–2, Table A–3, and Table A–4. The condition for these requirements is that all N’ channels delivered to a single RF output port are commanded to the same average power. That condition does not apply to the requirement on Single Channel Active Phase Noise (Table A–2), Diagnostic Carrier Suppression and Power Difference (Table A–3), and except as described for Out-of-Band Noise and Spurious Requirements (Table A–4).

A.6.3.5.1.1 **Output Electrical per RF Port**

Table A–2 shows the electrical output requirements per RF port.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Frequency ($f_c$) of any RF channel of a CMTS or EQAM</td>
<td>MAY be 85 MHz to 999 MHz ±30 kHz at 250 kHz increments, MUST be 112 MHz to 858 MHz ±30 kHz at 250 kHz increments</td>
</tr>
<tr>
<td>Level</td>
<td>Adjustable. See Table A–3.</td>
</tr>
<tr>
<td>Modulation Type</td>
<td>64-QAM, 256-QAM</td>
</tr>
<tr>
<td>Symbol Rate (nominal)</td>
<td>64-QAM 6.952 Msym/sec 256-QAM 6.952 Msym/sec</td>
</tr>
<tr>
<td>Nominal Channel Spacing</td>
<td>8 MHz</td>
</tr>
<tr>
<td>Frequency response</td>
<td>~ 0.15 Square Root Raised Cosine Shaping</td>
</tr>
<tr>
<td>Inband Spurious, Distortion, and Noise</td>
<td>Unequalized MER (Note 1) &gt; 35 dB Equalized MER &gt; 43 dB</td>
</tr>
<tr>
<td>Inband Spurious and Noise ($f_c$ ± 4 MHz)</td>
<td>&lt;= -46.7 dBc; where channel spurious and noise includes all discrete spurious, noise, carrier leakage, clock lines, synthesizer products, and other undesired transmitter products. Spurious and noise within ±50 kHz of the carrier is excluded. When N &gt; 1, noise outside the Nyquist bandwidth is excluded.</td>
</tr>
<tr>
<td>Out of Band Spurious and Noise</td>
<td>See Table A–4.</td>
</tr>
<tr>
<td>Phase Noise</td>
<td>01 kHz - 10 kHz: -33dBc double sided noise power 10 kHz - 50 kHz: -51dBc double sided noise power 50 kHz - 3 MHz: -51dBc double sided noise power</td>
</tr>
<tr>
<td>Single Channel Active, N – 1 Channels Suppressed (see Section 6.3.5.1.2, item 5)</td>
<td>64-QAM and 256-QAM</td>
</tr>
<tr>
<td>All N Channels Active (see Section 6.3.5.1.2, Item 6)</td>
<td>1 kHz - 10 kHz: -33dBc double sided noise power 10 kHz - 50 kHz: -51dBc double sided noise power</td>
</tr>
<tr>
<td>Output Impedance</td>
<td>75 ohms</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td>&gt; 14 dB within an active output channel in the frequency range from 108 MHz to 862 MHz (Note 2) &gt; 12 dB in every inactive channel from 81 MHz to 862 MHz &gt; 10 dB in every inactive channel above 862 MHz</td>
</tr>
<tr>
<td>Connector</td>
<td>F connector per [IEC-61169-24]</td>
</tr>
</tbody>
</table>

**Table Notes:**
1. MER (modulation error ratio) is determined by the cluster variance caused by the transmit waveform at the output of the ideal receive matched filter. MER includes all discrete spurious, noise, carrier leakage, clock lines, synthesizer products, distortion,
and other undesired transmitter products. Unequalized MER also includes linear filtering distortion, which is compensated by a receive equalizer. Phase noise up to ±50 kHz of the carrier is excluded from inband specification, to separate the phase noise and inband spurious requirements as much as possible. In measuring MER, record length or carrier tracking loop bandwidth may be adjusted to exclude low frequency phase noise from the measurement. For equalized MER, receive equalizer coefficients are computed and applied with receiver operating with device under test. For unequalized MER, receive equalize coefficients may be computed to flatten receiver response, if necessary, then are held fixed when device under test is connected. MER requirements assume measuring with a calibrated test instrument with its residual MER contribution removed.

2. If the EQAM or CMTS provides service to a center frequency of 85 MHz (see line 1 in table) and above then the EQAM or CMTS MUST provide a return loss > 14 dB within an active output channel in the frequency range from 81 MHz to 108 MHz. If the EQAM or CMTS provides service to a center frequency of 999 MHz (see line 1 in table) and below then the EQAM or CMTS MUST provide a return loss > 14 dB within an active output channel in the frequency range from 862 MHz to 1003 MHz.

A.6.3.5.1.2 Power per Channel CMTS or EQAM
An EQAM or CMTS MUST generate an RF output with power capabilities as defined in Table A–3. Channel RF power MAY be adjustable on a per channel basis with each channel independently meeting the power capabilities defined in Table A–3. If the EQAM or CMTS has independent modulation capability on a per channel basis, then the channel RF power MUST be adjustable on a per channel basis with each channel independently meeting the power capabilities defined in Table A–3.

<table>
<thead>
<tr>
<th>Table A–3 - DRFI Device Output Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>Range of commanded transmit power per channel</td>
</tr>
<tr>
<td>Commanded power per channel step size</td>
</tr>
<tr>
<td>Power difference between any two adjacent channels in a block (with commanded power difference removed if channel power is independently adjustable)</td>
</tr>
<tr>
<td>Power difference between any two non-adjacent channels in a block (with commanded power difference removed if channel power is independently adjustable)</td>
</tr>
<tr>
<td>Power per channel absolute accuracy</td>
</tr>
</tbody>
</table>

Diagnostic carrier suppression (3 modes)

Mode 1: One channel suppressed
1) >= 50 dB carrier suppression within the Nyquist bandwidth in any one 8 MHz active channel. This MUST be accomplished without service-impacting discontinuity or detriment to the unsuppressed channels.

Mode 2: All channels suppressed except one
2) >= 50 dB carrier suppression within the Nyquist bandwidth in every 8 MHz active channel except one. This MUST be accomplished without service-impacting discontinuity or detriment to the remaining channel for modulators with N =< 8, where N equals the maximum number of channels per port. For modulators with N => 9 the suppression is not required to be glitchless, and the remaining unsuppressed active channel is allowed to operate with increased power such as the total power of the N’ active channels combined.

Mode 3: All channels suppressed
3) >= 50 dB carrier suppression within the Nyquist bandwidth in every 8 MHz active channel.
The power allowed in the 8 MHz suppressed channel(s) by this carrier suppression requirement is combined with the spurious emissions requirements of the remaining (not suppressed) active channels to produce the ultimate test limit for power in the 8 MHz suppressed channel(s).

In all three modes the output return loss of the suppressed channel(s) MUST comply with the Output Return Loss requirements for active channels given in Table A–2 - Output Electrical Requirements per RF Port.
Parameter | Value
---|---
RF output port muting | >= 71.5 dB below the unmuted aggregate power of the RF modulated signal, in every 8 MHz channel from 86 MHz to 1006 MHz.

The specified limit applies with all active channels commanded to the same transmit power level. Commanding a reduction in the transmit level of any, or all but one, of the active channels does not change the specified limit for measured muted power in 8 MHz.

The output return loss of the output port of the muted device MUST comply with the Output Return Loss requirements for inactive channels given in Table A–2 - Output Electrical Requirements per RF Port.

<table>
<thead>
<tr>
<th>Required power per channel for N channels combined onto a single RF port with N &lt; 8, where N = maximum number of combined channels per port and ( N' = ) number of active combined channels per port (N' &lt;= N):</th>
<th>Required power in dBmV per channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>( N' = 1 )</td>
<td>60 dBmV</td>
</tr>
<tr>
<td>( N' = 2 )</td>
<td>56 dBmV</td>
</tr>
<tr>
<td>( N' = 3 )</td>
<td>54 dBmV</td>
</tr>
<tr>
<td>( N' = 4 )</td>
<td>52 dBmV</td>
</tr>
<tr>
<td>4 &lt; ( N' &lt; 8 )</td>
<td>60 – ceil [3.6*log2(N)] dBmV</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required power per channel for ( N' ) channels combined onto a single RF port with ( N' &gt;= N/4 ) and ( N' &gt; 9 ):</th>
<th>Required power in dBmV per channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>( N' &gt; N/4 )</td>
<td>60 – ceil[3.6*log2(N')] dBmV</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required power per channel for ( N' ) channels combined onto a single RF port with ( N' &lt; N/4 ) and ( N &gt; 9 ):</th>
<th>Required power in dBmV per channel, where ( N'' = ) min[4*N', ceil(N/4)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 &lt; ( N' &lt; N/4 )</td>
<td>60 – ceil[3.6*log2(N'')] dBmV</td>
</tr>
</tbody>
</table>

A.6.3.5.1.3 Independence of individual channel within the multiple channels on a single RF port

A potential use of a CMTS or an EQAM is to provide a universal platform that can be used for high-speed data services or for video services. There are strong benefits for the operator if the multiple-channel CMTS or the EQAM is provided with the ability to set RF power, center frequency and modulation type on a per-channel basis.

1. A multiple-channel CMTS or EQAM MUST provide for 3 modes of carrier suppression of RF power for diagnostic and test purposes. See Table A–2 for mode descriptions and carrier RF power suppression levels.

2. A multiple-channel CMTS or EQAM MAY provide for independent adjustment of RF power in a per channel basis with each RF carrier independently meeting the requirements defined in Table A–3.

3. A multiple-channel CMTS or EQAM MAY provide for independent selection of center frequency on a per channel basis, thus providing for non-contiguous channel frequency assignment, with each channel independently meeting the requirements in Table A–3. A multiple-channel CMTS or EQAM capable of generating nine or more channels on a single RF output port MUST provide for independent selection of center frequency with the ratio of number of active channels to gap channels in the encompassed spectrum being at least 2:1, and with each channel independently meeting the requirements in Table A–3 except for spurious emissions (including Table A–4). A multiple-channel CMTS or EQAM capable of generating nine or more channels on a single RF output port MUST meet the requirements of Table A–3 when the ratio of number of active channels to gap channels in the encompassed spectrum is at least 4:1. (A ratio of number of active channels to gap channels of at least 4:1 provides that at least 80% of the encompassed spectrum contains active channels, and the number of gap channels is at most 20% of the encompassed spectrum.)

4. A multiple-channel CMTS or EQAM MAY provide for independent selection of modulation order, either 64-QAM or 256-QAM, on a per channel basis, with each channel independently meeting the requirements in Table A–2.

5. A CMTS or EQAM MUST provide a test mode of operation, for out-of-service testing, configured for N channels, but generating one-CW-per-channel, one channel at a time at the center frequency of the selected channel; all other of the combined channels are suppressed. One purpose for this test mode is to support one
method for testing the phase noise requirements of Table A–2. As such, the generation of the CW test tone SHOULD exercise the signal generation chain to the fullest extent practicable, in such manner as to exhibit phase noise characteristics typical of actual operational performance; for example, repeated selection of a constellation symbol with power close to the constellation RMS level would seemingly exercise much of the modulation and up-conversion chain in a realistic manner. The test mode MUST be capable of generating the CW tone over the full range of Center Frequency in Table A–2.

6. A CMTS or EQAM MUST provide a test mode of operation for out-of-service testing, generating one-CW-per-channel, at the center frequency of the selected channel, with all other \( N - 1 \) of the combined channels active and containing valid data modulation at operational power levels. One purpose for this test mode is to support one method for testing the phase noise requirements of Table A–2. As such, the generation of the CW test tone SHOULD exercise the signal generation chain to the fullest extent practicable, in such manner as to exhibit phase noise characteristics typical of actual operational performance. For example, a repeated selection of a constellation symbol, with power close to the constellation RMS level, would seemingly exercise much of the modulation and up-conversion chain in a realistic manner. For this test mode, it is acceptable that all channels operate at the same average power, including each of the \( N - 1 \) channels in valid operation, and the single channel with a CW tone at its center frequency. The test mode MUST be capable of generating the CW tone over the full range of Center Frequency in Table A–2.

7. A CMTS or EQAM capable of generating more than eight channels per physical RF port MUST be capable of glitchless reconfiguration over a range of active channels from ceiling\( \left\lceil \frac{7N'_\text{max}}{8} \right\rceil \) to \( N'_\text{max} \). Channels which are undergoing configuration changes are referred to as the “changed channels”. The channels which are active and are not being reconfigured are referred to as the “continuous channels”. Each DRFI modulator capable of generating more than eight channels per physical RF port MUST accept a command setting \( N'_\text{max} \). Glitchless reconfiguration consists of any of the following actions while introducing no discontinuity or detriment to the continuous channels, where the modulator is operating in a valid DRFI-required mode both before and after the reconfiguration with an active number of channels staying in the range \( \left\lceil \frac{7N'_\text{max}}{8} \right\rceil \leq N'_\text{max} \): adding and/or deleting one or more channels, and/or moving some channels to new RF carrier frequencies, and/or changing the modulation, power level, or frequency on one or more channels. Any change in the modulation characteristics (power level, modulation density, center frequency) of a channel excuses that channel from being required to operate in a glitchless manner. For example, changing the power per channel of a given channel means that channel is not considered a continuous channel for the purposes of the glitchless modulation requirements. Glitchless operation is not required when \( N'_\text{max} \) is changed, even if no reconfigurations accompany the change in \( N'_\text{max} \).

If either center frequency 0 or modulation type 0, or both are independently adjustable on a per channel basis, then the CMTS or EQAM MUST provide for independent adjustment of RF power 0 on a per channel basis, with each RF carrier independently meeting the requirements defined in Table A–2.

A.6.3.5.1.4 Out-of-Band Noise and Spurious Requirements for CMTS or EQAM

One of the goals of the DRFI specification is to provide the minimum intended analog channel CNR protection of 59 dB measured in a 5.08 MHz wide frequency band for systems deploying up to 85 DRFI-compliant QAM channels.

For purposes of calculation, it is assumed that the transmitted power level of the digital channels will be 5 dB below the peak envelope power of the visual signal of analog channels, which is within the range of typical conditions for 256-QAM transmission. It is further assumed, for the purpose of calculation, that the channel lineup will place analog channels at lower frequencies than digital channels, and that in systems deploying modulators capable of generating nine or more channels on a single RF output port analog channels will be placed at center frequencies below 600 MHz. An adjustment of \( 10 \times \log_{10}(8 \text{ MHz} / 5.08 \text{ MHz}) \) is used to account for the difference in bandwidth used to define the noise requirements for DRFI-compliant digital QAM channels, versus analog PAL channels. With the assumptions above, for a 85-QAM channel system, the specification in item 5 of Table A–4 equates to an analog CNR protection of 59 dB.

Table A–4 lists the out-of-band spurious requirements. In cases where the \( N' \) combined channels are not commanded to the same power level, “dBc” denotes the logarithmic power ratio relative to the strongest carrier among the active channels. When commanded to the same power level, "dBc" should be interpreted as the average channel power,
averaged over the active channels, to mitigate the variation (See Table A–3) in channel power across the active channels, which is allowed with all channels commanded to the same power.

Modulators capable of generating $N <= 8$ channels on a single RF output port MUST satisfy the out-of-band spurious emissions requirements of Table A–4 with a contiguous block of $N'$ combined channels.

Modulators capable of generating $N >= 9$ channels on a single RF output port MUST satisfy the out-of-band spurious emissions requirements of Table A–4 in channels with center frequencies below 600 MHz and outside the encompassed spectrum when the active channels are contiguous or when the ratio of active channels to gap channels within the encompassed spectrum is 4:1 or greater.

Modulators capable of generating $N >= 9$ channels on a single RF output port MUST satisfy the out-of-band spurious emissions requirements of Table A–4, with 1 dB relaxation, in gap channels within the encompassed spectrum when the ratio of active channels to gap channels within the encompassed spectrum is 4:1 or greater and when the center frequency of the channel is below 600 MHz.

Modulators capable of generating $N >= 9$ channels on a single RF output port MUST satisfy the out-of-band spurious emissions requirements of Table A–4, with 3 dB relaxation, in gap channels within the encompassed spectrum and in channels outside the encompassed spectrum when the ratio of active channels to gap channels within the encompassed spectrum is 4:1 or greater.

In cases where $N >= 9$, and the $N'$ combined active channels are not contiguous, and the ratio of active channels to gap channels within the encompassed spectrum is 4:1 or greater, the spurious emissions requirements are determined by summing the spurious emissions power allowed in a given measurement bandwidth by each of the contiguous sub-blocks among the active channels. In the gap channels within the encompassed spectrum and with center frequency below 600 MHz there is a 1 dB relaxation in the spurious emissions requirements, so that within the encompassed spectrum the spurious emissions requirements (in absolute power) are 26% higher power in the measurement band determined by the summing of the contiguous sub-blocks’ spurious emissions requirements. In all channels with center frequencies at or above 600 MHz there is a 3 dB relaxation in the spurious emissions requirements, so that the spurious emissions requirements (in absolute power) are double the power in the measurement band determined by the summing of the contiguous sub-blocks’ spurious emissions requirements. The following three paragraphs provide the details of the spurious emissions requirements for non-contiguous channel operation outside the encompassed spectrum; within the encompassed spectrum the same details apply except there is an additional 1 dB allowance in channels with center frequencies below 600 MHz; 3 dB allowance is applied to all channels with center frequencies above 600 MHz.

The full set of $N'$ channels is referred to throughout this specification as the modulated channels or the active channels. However, for purposes of determining the spurious emissions requirements for non-contiguous transmitted channels, each separate contiguous sub-block of channels within the active channels is identified, and the number of channels in each contiguous sub-block is denoted as $N_i$, for $i = 1$ to $K$, where $K$ is the number of contiguous sub-blocks. Therefore, $N' = \sum_{i=1}^{K} N_i$. Note that $K = 1$ when and only when the entire set of active channels is contiguous. Also note that an isolated transmit channel, i.e., a transmit channel with empty adjacent channels, is described by $N_i = 1$ and constitutes a sub-block of one contiguous channel. Any number of the “contiguous sub-blocks” may have such an isolated transmit channel; if each active channel was an isolated channel, then $K = N'$.

When $N' >= N/4$, Table A–5 is used for determining the noise and spurious power requirements for each contiguous sub-block, even if the sub-block contains fewer than $N/4$ active channels. When $N' < N/4$, Table A–6 is used for determining the noise and spurious power requirements for each contiguous sub-block. Thus, the noise and spurious power requirements for all contiguous sub-blocks of transmitted channels are determined entirely from Table A–5 or entirely from Table A–6, where the applicable table is determined by $N'$ being greater than or equal to $N/4$, or not. The noise and spurious power requirements for the ith contiguous sub-block of transmitted channels is determined from Table A–5 or Table A–6 using the value $N_i$ for the “number of active channels combined per RF port”, and using “dBc” relative to the strongest carrier among all the active channels, and not just the strongest channel in the ith contiguous sub-block, in cases where the $N'$ combined channels are not commanded to the same power. The noise and spurious emissions power in each measurement band, including harmonics, from all $K$ contiguous sub-blocks, is summed (absolute power, NOT in dB) to determine the composite noise floor for the non-contiguous channel transmission condition.
For the measurement channels adjacent to a contiguous sub-block of channels, the spurious emissions requirements from the non-adjacent sub-blocks are divided on an equal “per Hz” basis for the narrow and wide adjacent measurement bands. For a measurement channel wedged between two contiguous sub-blocks, adjacent to each, the measurement channel is divided into three measurement bands, one wideband in the middle and two narrowbands each abutting one of the adjacent transmit channels. The wideband spurious and noise requirement is split into two parts, on an equal “per Hz” basis, to generate the allowed contribution of power to the middle band and to the farthest narrowband. The ceiling function is applied to the resulting sum of noise and spurious emissions, per Table Note 1 of Table A–4, Table A–5 and Table A–6 to produce a requirement of ½ dB resolution.

Items 1 through 4 list the requirements in channels adjacent to the commanded channels.

Item 5 lists the requirements in all other channels further from the commanded channels. Some of these “other” channels are allowed to be excluded from meeting the Item 5 specification. All the exclusions, such as 2nd and 3rd harmonics of the commanded channel, are fully identified in the table.

Item 6 lists the requirements on the $2N'$ 2nd harmonic channels and the $3N'$ 3rd harmonic channels.

### Table A–4 - EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements for $N <= 8$

with $N \equiv$ Maximum Number of Combined Channels per RF Port and $N' \equiv$ Number of Active Channels Combined per RF Port

<table>
<thead>
<tr>
<th>Item</th>
<th>Band</th>
<th>$N'$ (for $N &lt;= 8$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Adjacent channel up to 750 kHz from channel block edge</td>
<td>$&lt;-58$ dBc</td>
</tr>
<tr>
<td></td>
<td>Adjacent channel (750 kHz from channel block edge to 8 MHz from channel block edge)</td>
<td>$&lt;-60.5$ dBc</td>
</tr>
<tr>
<td>2</td>
<td>Next-adjacent channel (8 MHz from channel block edge to 16 MHz from channel block edge)</td>
<td>$&lt;-63.5$ dBc</td>
</tr>
<tr>
<td>3</td>
<td>Third-adjacent channel (16 MHz from channel block edge to 24 MHz from channel block edge).</td>
<td>$&lt;-71.5$ dBc</td>
</tr>
<tr>
<td>4</td>
<td>Noise in other channels (80 MHz to 998 MHz) Measured in each 8 MHz channel excluding the following: a) Desired channel(s) b) 1st, 2nd, and 3rd adjacent channels (see Items 1, 2, 3, 4 in this table) c) Channels coinciding with 2nd and 3rd harmonics (see Item 6 in this table)</td>
<td>$&lt;-71.5$ dBc</td>
</tr>
<tr>
<td>5</td>
<td>Noise in each of 2N contiguous 8 MHz channels or in each of 3N contiguous 8 MHz channels coinciding with 2nd harmonic and with 3rd harmonic components respectively (up to 998 MHz)</td>
<td>$&lt;-71.5 + 10\log_{10}(N)$, or $-63$ dBc, whichever is greater</td>
</tr>
<tr>
<td>6</td>
<td>Lower out-of-band noise in the band of 5 MHz to 65 MHz Measured in 8 MHz channel bandwidth</td>
<td>$&lt;-50 + 10\log_{10}(N')$</td>
</tr>
<tr>
<td>7</td>
<td>Higher out-of-band noise in the band of 998 MHz to 3000 MHz Measured in 8 MHz channel bandwidth</td>
<td>$&lt;-55 + 10\log_{10}(N')$</td>
</tr>
</tbody>
</table>
### Table Note
1. All equations are Ceiling(Power, 0.5) dBc. Use "Ceiling(2*Power) / 2" to get 0.5 steps from ceiling functions that return only integer values. For example Ceiling(-63.9, 0.5) = -63.5 dBc.
2. Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with center frequency at 600 MHz and above. For example -71.5 dBc becomes -68.5 dBc.
3. Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with center frequency below 600 MHz. For example -71.5 dBc becomes -70.5 dBc.

### Table A–5 - EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements for N >= 9 and N’ ≥ N/4 with N ≡ Maximum Number of Combined Channels per RF Port and N’ ≡ Number of Active Channels Combined per RF Port

<table>
<thead>
<tr>
<th>Item</th>
<th>Band</th>
<th>N’ (for N &lt;= 8)</th>
<th>N &gt;4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Adjacent channel up to 750 kHz from channel block edge</td>
<td>&lt; -58 dBc</td>
<td>&lt; -58 dBc</td>
</tr>
<tr>
<td>2</td>
<td>Adjacent channel (750 kHz from channel block edge to 8 MHz from channel block edge)</td>
<td>&lt; -59 dBc</td>
<td>&lt; -58.5 dBc</td>
</tr>
<tr>
<td>3</td>
<td>Next-adjacent channel (8 MHz from channel block edge to 16 MHz from channel block edge)</td>
<td>&lt; -63 dBc</td>
<td>&lt; -62.5 dBc</td>
</tr>
<tr>
<td>4</td>
<td>Third-adjacent channel (16 MHz from channel block edge to 24 MHz from channel block edge).</td>
<td>&lt; -68.5 dBc</td>
<td>&lt; -66.5 dBc</td>
</tr>
<tr>
<td>5</td>
<td>Noise in other channels (80 MHz to 998 MHz) Measured in each 8 MHz channel excluding the following: a) Desired channel(s) b) 1st, 2nd, and 3rd adjacent channels (see Items 1, 2, 3, 4 in this table) c) Channels coinciding with 2nd and 3rd harmonics (see Item 6 in this table)</td>
<td>&lt; -68.5 dBc</td>
<td>&lt; -66.5 dBc</td>
</tr>
<tr>
<td>6</td>
<td>In each of 2N’ contiguous 8 MHz channels or in each of 3N’ contiguous 8 MHz channels coinciding with 2nd harmonic and with 3rd harmonic components respectively (up to 998 MHz)</td>
<td>&lt; -71.5 + 10\log_{10}(N’), or -63 dBc, whichever is greater</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Lower out of band noise in the band of 5 MHz to 65 MHz Measured in 8 MHz channel bandwidth</td>
<td>&lt; -50 + 10\log_{10}(N')</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Higher out of band noise in the band of 998 MHz to 3000 MHz Measured in 8 MHz channel bandwidth</td>
<td>&lt; -55 + 10\log_{10}(N') for N’ &lt;= 8</td>
<td>&lt; -60 + 10\log_{10}(N') for N’ &gt; 8</td>
</tr>
</tbody>
</table>

### Table Note
1. All equations are Ceiling(Power, 0.5) dBc. Use "Ceiling(2*Power) / 2" to get 0.5 steps from ceiling functions that return only integer values. For example Ceiling(-63.9, 0.5) = -63.5 dBc.
2. Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with center frequency at 600 MHz and above. For example -71.5 dBc becomes -68.5 dBc.
3. Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with center frequency below 600 MHz. For example -71.5 dBc becomes -70.5 dBc.
Table A–6 - EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements for \(N \geq 9\) and \(N' < N/4\) with \(N \equiv \text{Maximum Number of Combined Channels per RF Port and}\)
\(N' \equiv \text{Number of Active Channels Combined per RF Port and}\)
\(N'' \equiv \text{Effective Number of Active Channels for Spurious Emissions Requirements}\)

<table>
<thead>
<tr>
<th>Item</th>
<th>Band</th>
<th>(N'' = \text{minimum}[4^N', \text{ceiling}(N/4)])</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(for (N \geq 9) and (N' &lt; N/4))</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>Adjacent channel up to 750 kHz from channel block edge</td>
<td>-58 dBc</td>
</tr>
<tr>
<td>2</td>
<td>Adjacent channel (750 kHz from channel block edge to 8 MHz from channel block edge)</td>
<td>-59 dBc</td>
</tr>
<tr>
<td>3</td>
<td>Next-adjacent channel (8 MHz from channel block edge to 16 MHz from channel block edge)</td>
<td>-63 dBc</td>
</tr>
<tr>
<td>4</td>
<td>Third-adjacent channel (16 MHz from channel block edge to 24 MHz from channel block edge)</td>
<td>-68.5 dBc</td>
</tr>
<tr>
<td>5</td>
<td>Noise in other channels (80 MHz to 998 MHz) Measured in each 8 MHz channel excluding the following: a) Desired channel(s) b) 1st, 2nd, and 3rd adjacent channels (see Items 1, 2, 3, 4 in this table) c) Channels coinciding with 2nd and 3rd harmonics (see Item 6 in this table)</td>
<td>-68.5 dBc</td>
</tr>
<tr>
<td>6</td>
<td>In each of (2N') contiguous 8 MHz channels or in each of (3N') contiguous 8 MHz channels coinciding with 2nd harmonic and with 3rd harmonic components respectively (up to 998 MHz)</td>
<td>-71.5 + 10\log_{10} (N'), or -63 dBc, whichever is greater</td>
</tr>
<tr>
<td>7</td>
<td>Lower out of band noise in the band of 5 MHz to 65 MHz Measured in 8 MHz channel bandwidth</td>
<td>&lt; -50 + 10\log_{10} (N')</td>
</tr>
<tr>
<td>8</td>
<td>Higher out of band noise in the band of 998 MHz to 3000 MHz Measured in 8 MHz channel bandwidth</td>
<td>&lt; -55 + 10\log_{10} (N') for (N' \leq 8) &lt; -60 + 10\log_{10} (N') for (N' &gt; 8)</td>
</tr>
</tbody>
</table>

Table Notes
1. All equations are Ceiling(Power, 0.5) dBc. Use “Ceiling(2*Power) / 2” to get 0.5 steps from ceiling functions that return only integer values. For example Ceiling(-63.9, 0.5) = -63.5 dBc.
2. Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with center frequency at 600 MHz and above. For example -71.5 dBc becomes -68.5 dBc.
3. Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with center frequency below 600 MHz. For example -71.5 dBc becomes -70.5 dBc.

A.6.3.5.2 CMTS or EQAM Master Clock Jitter for Asynchronous Operation
See Section 6.3.5.2.
A.6.3.5.3 CMTS or EQAM Master Clock Jitter for Synchronous Operation
See Section 6.3.5.3.
A.6.3.5.4 CMTS or EQAM Master Clock Frequency Drift for Synchronous Operation
See Section 6.3.5.4.
A.6.3.6 **CMTS or EQAM Clock Generation**

When the 10.24 MHz Master Clock is provided by the DTI interface, a DRFI-compliant device MUST lock the Downstream Symbol Clock to the 10.24 MHz Master Clock using the M/N divisors provided in Table A–7.

A.6.3.6.1 **CMTS Clock Generation**

The CMTS MUST lock the Downstream Symbol Clock to the CMTS Master Clock using the M/N divisors provided in Table A–7.

A.6.3.6.2 **EQAM Clock Generation**

Because it operates with an active DTI interface, an EQAM MUST lock the Downstream Symbol Clock to the Master Clock using the M/N divisors provided in Table A–7.

A.6.3.6.3 **Downstream Symbol Rate**

Let \( f'_b \) represent the rate of the Downstream Symbol Clock, which is locked to the Master Clock, and let \( f'_{m} \) represent the rate of the Master Clock locked to the Downstream Symbol Clock. Let \( f_b \) represent the nominal specified downstream symbol rate and let \( f_m \) represent the nominal Master Clock rate (10.24 MHz). With the Downstream Symbol Clock locked to the Master Clock, the following equation MUST hold:

\[
 f'_b = f_m \times \frac{M}{N} 
\]

With the Master Clock locked to the Downstream Symbol Clock, the following equation MUST hold:

\[
 f'_{m} = f_b \times \frac{N}{M} 
\]

Note that M and N in Table A–7 are unsigned integer values, each representable in 16 bits, and result in a value of \( f'_b \) or \( f'_{m} \) that is not more than ±1 ppm from its specified nominal value.

The standard deviation of the timing error of the EQAM/CMTS RF symbol clock, referenced to the DTI Server Master Clock, MUST be less than 1.5 ns measured over 100 seconds.

Table A–7 lists the downstream modes of operation, their associated nominal symbol rates, \( f_b \), values for M and N, the resulting synchronized clock rates and their offsets from their nominal values.

<table>
<thead>
<tr>
<th>Downstream mode</th>
<th>Nominal Specified Symbol Rate, ( f_b ) (MHz)</th>
<th>M/N</th>
<th>Master Clock Rate, ( f'_m ) (MHz)</th>
<th>Downstream Symbol Rate, ( f'_b ) (MHz)</th>
<th>Offset from Nominal</th>
</tr>
</thead>
<tbody>
<tr>
<td>[EN 300 429], 64-QAM</td>
<td>6.952</td>
<td>869/1280</td>
<td>10.240...</td>
<td>6.952</td>
<td>0 ppm</td>
</tr>
<tr>
<td>[EN 300 429], 256-QAM</td>
<td>6.952</td>
<td>869/1280</td>
<td>10.240...</td>
<td>6.952</td>
<td>0 ppm</td>
</tr>
</tbody>
</table>

A.6.3.7 **Downstream Symbol Clock Jitter for Synchronous Operation**

The downstream symbol clock MUST meet the following double sideband phase noise requirements over the specified frequency ranges:

- \(< [-53 + 20\times \log (f_{DS}/6.952)] \) dBc (i.e., < 0.07 ns RMS) 10 Hz to 100 Hz
- \(< [-53 + 20\times \log (f_{DS}/6.952)] \) dBc (i.e., < 0.07 ns RMS) 100 Hz to 1 kHz
- \(< [-53 + 20\times \log (f_{DS}/6.952)] \) dBc (i.e., < 0.07 ns RMS) 1 kHz to 10 kHz
- \(< [-36 + 20\times \log (f_{DS}/6.952)] \) dBc (i.e., < 0.5 ns RMS) 10 kHz to 100 kHz
- \(< [-30 + 20\times \log (f_{DS}/6.952)] \) dBc (i.e., < 1 ns RMS) 100 kHz to \( f_{DS} / 2 \)
$f_{DS}$ is the frequency of the measured clock in MHz. The value of $f_{DS}$ MUST be an integral multiple or divisor of the downstream symbol clock. For example, an $f_{DS} = 27.808$ MHz clock may be measured if there is no explicit 6.952 MHz clock available.

A DRFI-compliant device MUST provide a means for clock testing in which:

- The device provides test points for direct access to the master clock and the downstream symbol clock.

Alternatively, a DRFI-conformant device MUST provide a test mode in which:

- The downstream QAM symbol sequence is replaced with an alternating binary sequence (1, -1, 1, -1, 1, -1...) at nominal amplitude, on both I and Q.
- The device generates the downstream symbol clock from the 10.24 MHz reference clock as in normal synchronous operation.

If an explicit downstream symbol clock, which is capable of meeting the above phase noise requirements, is available (e.g., a smooth clock without clock domain jitter), this test mode is not required.

A.6.3.8 Downstream Symbol Clock Drift for Synchronous Operation

See Section 6.3.8.

A.6.3.9 Timestamp Jitter

See Section 6.3.9.

A.7 Downstream Transmission Convergence Sublayer

A.7.1 Introduction

See Section 7.1.

A.7.2 MPEG Packet Format

See Section 7.2.

A.7.3 MPEG Header for DOCSIS Data-Over-Cable

See Section 7.3.

A.7.4 MPEG Payload for DOCSIS Data-Over-Cable

See Section 7.4.

A.7.5 Interaction with the MAC Sublayer

See Section 7.5.

A.7.6 Interaction with the Physical Layer

The MPEG-2 packet stream MUST be encoded according to [EN 300 429].
Annex B  DOCS-DRF-MIB (normative)

DOCS-DRF-MIB DEFINITIONS ::= BEGIN

IMPORTS
    MODULE-IDENTITY, OBJECT-IDENTITY, OBJECT-TYPE, Unsigned32
    FROM SNMPv2-SMI
    TruthValue, AutonomousType
    FROM SNMPv2-TC
    OBJECT-GROUP, MODULE-COMPLIANCE
    FROM SNMPv2-CONF
    PhysicalIndexOrZero, PhysicalIndex
    FROM ENTITY-MIB
    ifIndex, InterfaceIndexOrZero
    FROM IF-MIB
    docsIfDownstreamChannelEntry
    FROM DOCS-IF-MIB
    clabProjDocsis
    FROM CLAB-DEF-MIB;

docsDrfMib MODULE-IDENTITY
    LAST-UPDATED    "200812090000Z" -- December 9, 2008
    ORGANIZATION    "Cable Television Laboratories, Inc"
    CONTACT-INFO
        "Postal: Cable Television Laboratories, Inc.
        858 Coal Creek Circle
        Louisville, Colorado 80027-9750
        U.S.A.
        Phone: +1 303-661-9100
        Fax:   +1 303-661-9199
        E-mail: mibs@cablelabs.com"
    DESCRIPTION
        "This MIB module contains the management objects for the
        management of the Downstream RF Interface specification.
        Copyright 1999-2008 Cable Television Laboratories, Inc.
        All rights reserved."
    REVISION "200812090000Z"  -- December 9, 2008
    DESCRIPTION
        "Revised Version includes ECN DRFI-N-08.0697-2 and
        and published as CM-SP-DRFI-I07-081209."
    REVISION "200712060000Z"  -- December 6, 2007
    DESCRIPTION
        "Initial version, published as part of the CableLabs
        M-OSSI specification, CM-SP-M-OSSI-I07-071206, via ECN
        M-OSSI-N-07.0562-5."
    ::= { clabProjDocsis 23 }

-- ------------------------------
-- Textual Conventions
-- ------------------------------

-- ------------------------------
-- Main Groups
-- ------------------------------
docsDrfNotifications OBJECT IDENTIFIER ::= { docsDrfMib 0 }

-- DOCSIS DRF objects

-- PHY Parameters dependencies OBJECT-IDENTITY definitions

docsDrfRegistry OBJECT-IDENTITY
  STATUS current
  DESCRIPTION "Registration point for M-CMTS characterization of PHY
  parameters dependencies."
  ::= { docsDrfObjects 1 }

docsDrfPhyParamFixValue OBJECT-IDENTITY
  STATUS current
  DESCRIPTION "Indicates that this PHY parameter is fixed and cannot
  be changed."
  ::= { docsDrfRegistry 1 }

docsDrfPhyParamSameValue OBJECT-IDENTITY
  STATUS current
  DESCRIPTION "Indicates that the PHY parameter value is the same for
  the elements in a dependency group; thus, a change in
  the PHY parameter of an element in the group will change
  the PHY parameter value in the other elements of the
  dependency group."
  ::= { docsDrfRegistry 2 }

docsDrfPhyParamAdjacentValues OBJECT-IDENTITY
  STATUS current
  DESCRIPTION "Indicates that the PHY parameter has an adjacency or
  sequence pattern for the elements in a dependency group
  e.g., A group of channels all using J.83 Annex A, may set
  frequencies in the group by setting a 6 MHz spacing
  between the channels in the group. Vendors may rather
  use a more detailed vendor-specific OBJECT-IDENTITY or a
  table pointer to describe this type of PHY parameter
  dependency."
  ::= { docsDrfRegistry 3 }

docsDrfPhyParamFrequencyRange OBJECT-IDENTITY
  STATUS current
  DESCRIPTION "This object indicates that the frequency in a TSID Group
  is constrained to a frequency range. Vendors may extend
  the MIB construct containing this reference to detail such
  constraints or rather use a more detailed vendor-specific
  OBJECT-IDENTITY or a table pointer to describe the
  frequency range supported."
  ::= { docsDrfRegistry 4 }

-- ---------------------------------------------------------------------
docsDrfDownstreamCapabilitiesTable OBJECT-TYPE
SYNTAX SEQUENCE OF DocsDrfDownstreamCapabilitiesEntry
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION "This table contains the QAM channel capabilities for the Downstream Interface PHY parameters."
::= { docsDrfObjects 3 }

DocsDrfDownstreamCapabilitiesEntry OBJECT-TYPE
SYNTAX DocsDrfDownstreamCapabilitiesEntry
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION "A conceptual row for this table."
INDEX { ifIndex }
 ::= { docsDrfDownstreamCapabilitiesTable 1 }

DocsDrfDownstreamCapabilitiesEntry ::= SEQUENCE
{ 
  docsDrfDownstreamCapabFrequency                    BITS,
  docsDrfDownstreamCapabBandwidth                    BITS,
  docsDrfDownstreamCapabPower                        BITS,
  docsDrfDownstreamCapabModulation                   BITS,
  docsDrfDownstreamCapabInterleaver                  BITS,
  docsDrfDownstreamCapabJ83Annex                     BITS,
  docsDrfDownstreamCapabConcurrentServices           BITS,
  docsDrfDownstreamCapabServicesTransport            BITS,
  docsDrfDownstreamCapabMuting                       BITS
}

paramsDrfDownstreamCapabFrequency OBJECT-TYPE
SYNTAX BITS {
  qamDependency(0),
  adjacentChannel(1),
  adjacentChannelOrder(2)
}
MAX-ACCESS read-only
STATUS current
DESCRIPTION "The QAM channel frequency capabilities. 'qamDependency' BIT set to '1' indicates the QAM channel frequency value has dependencies with other QAM channels and an entry that includes this QAM channel is in docsDrfGroupDependencyTable for the PHY parameter 'frequency'.

'adjacentChannel' BIT set to '1' indicates the QAM channel frequencies in the dependency group (DEPI TSID group) are adjacent and constrained in a frequency range based on the number of QAM channels in the dependency group.

'adjacentChannelOrder' BIT set to '1' indicates the QAM channel frequency adjacency is based in the QAM channel sequence like entPhysicalParentRelPos in EntPhysicalTable or other vendor sequence.

E.g., a dependency group of four QAM channels with 'adjacentChannelOrder' BIT set to '1': The 4th QAM channel in the sequence gets a frequency assignment f + 1*bandwidth when the frequency value of the 3rd QAM channel in the sequence is set to f. Similarly the 1st QAM channel in the sequence gets a
frequency assignment of f - 2*bandwidth and the 2nd QAM channels gets a frequency of f - 1*bandwidth.

'adjacentChannel' 'adjacentChannelOrder' BITs may be set to '1' when a dependency group includes the QAM channel of this M-CMTS Downstream interface and the value of the object docsDrfGroupDependencyType is docsDrfPhyParamAdjacentValues.

'adjacentChannel' BIT may be set to '1' if 'qamDependency' BIT is set to '1'. The same way, 'adjacentChannelOrder' BIT may be set to '1' and implies 'adjacentChannel' BIT is set to '1'."

::= { docsDrfDownstreamCapabilitiesEntry 1 }

docsDrfDownstreamCapabBandwidth OBJECT-TYPE
SYNTAX      BITS {
    qamDependency(0),
    chan6Mhz(1),
    chan8Mhz(2)
}
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
"The QAM channel Bandwidth capabilities.
'qamDependency' BIT set to '1' indicates the QAM channel bandwidth value has dependencies with other QAM channels as indicated in docsDrfGroupDependencyTable.

'chan6Mhz' set to '1' indicates 6 MHz channel width support.
'chan8Mhz' set to '1' indicates 8 MHz channel width support.

When 'qamDependency' BIT is set to '1', a set to the channel bandwidth PHY parameter of a QAM channels in a dependency group (with docsDrfGroupDependencyType set to docsDrfPhyParamSameValue), sets the same channel bandwidth value to all QAM channels in the dependency group."

::= { docsDrfDownstreamCapabilitiesEntry 2 }

docsDrfDownstreamCapabPower OBJECT-TYPE
SYNTAX      BITS {
    qamDependency(0)
}
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
"The QAM channel Power capabilities.
'qamDependency' BIT set to '1' indicates the QAM channel power value has dependencies with other QAM channels as indicated in docsDrfGroupDependencyTable.

When 'qamDependency' BIT is set to '1', a set to the power level PHY parameter of a QAM channels in a dependency group (with docsDrfGroupDependencyType set to docsDrfPhyParamSameValue), sets the same power level to all QAM channels in the dependency group."

::= { docsDrfDownstreamCapabilitiesEntry 3 }

docsDrfDownstreamCapabModulation OBJECT-TYPE
SYNTAX      BITS {
qamDependency(0),
qam64(1),
qam256(2)
}

MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
"The QAM channel Modulation capabilities.
'qamDependency' BIT set to '1' indicates the QAM channel modulation value has dependencies with other QAM channels as indicated in docsDrfGroupDependencyTable.

'qam64' set to '1' indicates 64-QAM modulation support.
'qam256' set to '1' indicates 256-QAM modulation support.

When 'qamDependency' BIT is set to '1', a set to the modulation PHY parameter of a QAM channels in a dependency group (with docsDrfGroupDependencyType set to docsDrfPhyParamSameValue), sets the same modulation type to all QAM channels in the dependency group."
::= { docsDrfDownstreamCapabilitiesEntry 4 }

docsDrfDownstreamCapabInterleaver OBJECT-TYPE
SYNTAX      BITS {
    qamDependency(0),
    taps8Increment16(1),
    taps16Increment8(2),
    taps32Increment4(3),
    taps64Increment2(4),
    taps128Increment1(5),
    taps128Increment17(6),
    taps128Increment3(8),
    taps128Increment4(9),
    taps128Increment5(10),
    taps128Increment6(11),
    taps128Increment7(12),
    taps128Increment8(13)
}

MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
"The QAM channel Interleaver capabilities.
'qamDependency' BIT set to '1' indicates the QAM channel interleave value has dependencies with other QAM channels as indicated in docsDrfGroupDependencyTable.

'taps8Increment16' set to '1' indicates the support of j = 8, i = 16 interleave.
'taps16Increment8' set to '1' indicates the support of j = 16, i = 8 interleave.
'taps32Increment4' set to '1' indicates the support of j = 32, i = 4 interleave.
'taps64Increment2' set to '1' indicates the support of j = 64, i = 2 interleave.
'taps128Increment1' set to '1' indicates the support of j = 128, i = 1 interleave.
'taps128Increment17' set to '1' indicates the support of
j = 12, i = 17 interleave.
'taps128increment2' set to '1' indicates the support of j = 128, i = 2 interleave.
'taps128increment3' set to '1' indicates the support of j = 128, i = 3 interleave.
'taps128increment4' set to '1' indicates the support of j = 128, i = 4 interleave.
'taps128increment5' set to '1' indicates the support of j = 128, i = 5 interleave.
'taps128increment6' set to '1' indicates the support of j = 128, i = 6 interleave.
'taps128increment7' set to '1' indicates the support of j = 128, i = 7 interleave.
'taps128increment8' set to '1' indicates the support of j = 128, i = 8 interleave.

When 'qamDependency' BIT is set to '1', a set to the interleave PHY parameter of a QAM channels in a dependency group (with docsDrfGroupDependencyType set to docsDrfPhyParamSameValue), sets the same Interleave value to all QAM channels in the dependency group."

::= { docsDrfDownstreamCapabilitiesEntry 5 }

docsDrfDownstreamCapabJ83Annex OBJECT-TYPE
SYNTAX     BITS {
    qamDependency(0),
    annexA(1),
    annexB(2),
    annexC(3)
}
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
"The QAM channel J.83 Annex Capabilities.
'qamDependency' BIT set to '1' indicates the QAM channel J.83 Annex value has dependencies with other QAM channels as indicated in docsDrfGroupDependencyTable.

'annexA' set to '1' indicates J.83 Annex A support.
'annexB' set to '1' indicates J.83 Annex B support.
'annexC' set to '1' indicates J.83 Annex C support.

When 'qamDependency' BIT is set to '1', a set to the J.83 Annex PHY parameter of a QAM channels in a dependency group (with docsDrfGroupDependencyType set to docsDrfPhyParamSameValue), sets the same J.83 Annex value to all QAM channels in the dependency group."

::= { docsDrfDownstreamCapabilitiesEntry 6 }

docsDrfDownstreamCapabConcurrentServices OBJECT-TYPE
SYNTAX     BITS {
    qamDependency(0),
    videoAndDocsis(1)
}
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION

"The QAM channel Concurrent Services Capabilities.
'qamDependency' BIT set to '1' indicates the QAM channel
is part of a dependency group that supports concurrent
services mode as indicated in
docsDrfGroupDependencyTable.

'videoAndDocsis' BIT set to '1' indicates video transport
and DOCSIS transport can be supported simultaneously.

Video and DOCSIS transport service types are described in
docsDrfDownstreamCapabServicesTransport."

::= { docsDrfDownstreamCapabilitiesEntry 7 }

docsDrfDownstreamCapabServicesTransport OBJECT-TYPE
SYNTAX      BITS { qamDependency(0), mpeg2OverIP(1), dmpt(2), psp(3) }
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION

"The QAM channel Services transports modes Capabilities.

'qamDependency' BIT set to '1' indicates the QAM channel
Service transport type has dependencies with other QAM
channels as indicated in
docsDrfGroupDependencyTable.

'mpeg2OverIP' set to '1' indicates video transports as
conventional VoD is supported (known as MPT mode, MPEG-2
transport). 'dmpt' set to 1 indicates DOCSIS MPT mode (D-MPT) support.
'psp' set to 1 indicates DOCSIS Packet Streaming Protocol
mode (PSP) support.

When 'qamDependency' BIT is set to '1', a request to set
a QAM channel to a service type in a dependency group
(with docsDrfGroupDependencyType set to
docsDrfPhyParamSameValue) may be rejected."

::= { docsDrfDownstreamCapabilitiesEntry 8 }

docsDrfDownstreamCapabMuting OBJECT-TYPE
SYNTAX      BITS { qamDependency(0) }
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION

"The QAM channel muting capabilities.

'qamDependency' BIT set to '1' indicates the QAM Mute
state has dependencies with other QAM channels as
indicated in docsDrfGroupDependencyTable.

When 'qamDependency' BIT is set to '1', a request to
mute a QAM channels in a dependency group (with
docsDrfGroupDependencyType set to
docsDrfPhyParamSameValue), sets all QAM channels in the
dependency group to mute."

::= { docsDrfDownstreamCapabilitiesEntry 9 }
-- DRF Group Dependency of PHY parameters Definitions
-- Defines the group of QAM channels that may be impacted for
-- individual QAM channels PHY parameters changes. Extends ENTITY-MIB
-- 
-- docsDrfGroupDependencyTable OBJECT-TYPE
SYNTAX      SEQUENCE OF DocsDrfGroupDependencyEntry
MAX-ACCESS  not-accessible
STATUS      current
DESCRIPTION
"This table describes the rules that identify groups of
QAM channels with PHY parameters dependencies.
A PHY parameter dependency group means that a set to
a QAM channel parameter may affect the value of
other QAM Channels in the group.

TSID is a broadcast term borrowed by the M-CMTS
architecture to represent a unique identifier of QAM
channels in the M-CMTS architecture.

TSID Group is the DEPI concept of a set of QAM channels
with a PHY parameter dependency. This module refers to
TSID group as a PHY dependency Group.

This table uses the ENTITY-MIB physical component structure
to allows the managed system to describe the QAM channels' PHY
parameters dependencies. A management entity can use
the information from this table to generate the DEPI TSID
Groups.

Examples of PHY dependencies could be usage of adjacent
frequencies, or QAM channels of RF ports restricted, or
same interleaver value, modulation and J.83 Annex value.

Additional details and rules to describe the PHY parameter
dependency is indicated in
docsDrfGroupDependencyType.
Vendors may extend via other MIB modules the usage of
docsDrfGroupDependencyType."
::= { docsDrfObjects 4 }

docsDrfGroupDependencyEntry OBJECT-TYPE
SYNTAX      DocsDrfGroupDependencyEntry
MAX-ACCESS  not-accessible
STATUS      current
DESCRIPTION
"A conceptual row of this table.

QAM channels are modeled as PhysicalClass 'port' from
the ENTITY-MIB.
An QAM channel can be represented as part of an entity
MIB containment tree as follows:
  chassis(device)
    .container(Slot)
      .module(field-replaceable-module)
        .module ( Physical RF spigot)
          . port (QAM channel)

PhysicalClass 'stack' is left optional and not included
as a reference or examples for this table.

Based on the hardware capabilities the Agent will create
entries in this table including the entPhysicalEntry of
the close element to the root (e.g., up to 'chassis' or
'stack') including the PHY parameter of the dependency
as part of the entry index

The Aggregation is then defined as all the QAM channels
(entity PhysicalClass = 'port') below the tree as
indicated in entyPhysicalContainsTable.

Logical or software dependencies of the QAM channels PHY
parameters in addition to the hardware dependency entries
can be present and MUST persist during system
re-initialization. The storage realization of hardware
dependent entries are 'permanent' or 'readOnly'. The
storage realization of logical dependency entries is
'nonVolatile'.

PHY parameter dependencies that are logically defined may
be present in this table but its configuration is outside
of the scope of this MIB Module, including the definition
of simulated Physical components such backplane types or
modules accomplish its logical grouping.

PHY parameters with no Physical entities associated in
this table indicate no PHY dependencies for certain groups
of QAM channels.

Administrative changes to the
docsDrfGroupDependencyPhyParamLock are preserved in
non-volatile memory upon system re-initialization.

Note that any change in the system due to the
insertion or removal or components will reset to factory
default the entries associated with those components.

An entry in this table is reflected in the MIB object
docsIfMExtDownstreamTSIDGroupPhyParamFlag for individual
QAM channels.

A recursive method to find the PHY dependency group of an
QAM channel A, PHY parameter X is as follows:

The parent tree of QAM channel A is recursively calculated
by navigating entyPhysicalContainsTable from bottom to top
Pi(P1..Pn)

The list Mj (M1..Mn) of
docsDrfGroupDependencyPhysicalIndex represents the
values from this table with PHY parameter
docsDrfGroupDependencyPhyParam X and/or 'all'

The list Qi (Q1..n) is the list of matches of Mi in Pi
Qi with the lower position in the entyPhysicalContainsTable
is selected Qy and My is the group criteria selected.

All QAM channels Bi below My are candidates for inclusion
in the dependency group.

Each Bi is verified as A for its own BPi parent tree to
verify that in effect My is the lowest denominator in Mi
BPi intersection to become part of the Dependency Group
of A.
INDEX { docsDrfGroupDependencyPhyParam,
        docsDrfGroupDependencyPhysicalIndex }
::= { docsDrfGroupDependencyTable 1 }

DocsDrfGroupDependencyEntry ::= SEQUENCE
{
  docsDrfGroupDependencyPhyParam         INTEGER,
  docsDrfGroupDependencyPhysicalIndex    PhysicalIndexOrZero,
  docsDrfGroupDependencyGroupID          Unsigned32,
  docsDrfGroupDependencyType             AutonomousType
}

docsDrfGroupDependencyPhyParam OBJECT-TYPE
SYNTAX      INTEGER {
  noDependencies(0),
  all(1),
  frequency(2),
  bandwidth(3),
  power(4),
  modulation(5),
  interleave(6),
  annex(7),
  symbolRate(8),
  mute(9)
}
MAX-ACCESS  not-accessible
STATUS      current
DESCRIPTION
"This object represents the type of PHY parameter
that may have dependencies when setting an individual
object in the dependency group.
The value 'all' may be used as a wildcard to indicate
all PHY parameters have dependencies. The other
enumeration values are common QAM PHY parameters.
The opposite to 'all' is 'noDependencies', which indicates
no dependencies in PHY parameters, but is only used to
indicate no dependencies across all the device. Thus,
when used, 'noDependencies' is accompanied by
docsDrfGroupDependencyPhysicalIndex '0' as the only
entry in the table.
In this way it is clearly distinguished when a device
has dependencies instead of an empty table."
::= { docsDrfGroupDependencyEntry 1 }

docsDrfGroupDependencyPhysicalIndex OBJECT-TYPE
SYNTAX      PhysicalIndexOrZero
MAX-ACCESS  not-accessible
STATUS      current
DESCRIPTION
"Indicates the physical element from where the PHY
parameter dependency for QAM channels is derived.
All the QAM channels elements under this Physical index
will belong to a dependency group of the specified PHY
parameter."
::= { docsDrfGroupDependencyEntry 2 }

docsDrfGroupDependencyGroupId OBJECT-TYPE
SYNTAX      Unsigned32 (1..127)
MAX-ACCESS  read-only
STATUS      current
DESCRIPTION
"The internal ID assigned for the QAM channels in the
dependency group.
The value of this object is unique in the scope of the
PHY parameter being mapped.
::= { docsDrfGroupDependencyEntry 3 }

docsDrfGroupDependencyType OBJECT-TYPE
SYNTAX AutonomousType
MAX-ACCESS read-only
STATUS current
DESCRIPTION
"The description of the type of dependency associated
with this dependency group.
 Basic type of dependencies are docsDrfPhyParamSameValue,
docsDrfPhyParamAdjacentValues, docsDrfPhyParamFrequencyRange.
 Vendors may define their own rules and policies to describe
 their implementation dependency definitions such as
 RowPointers to table entries or OBJECT-IDENTITY clauses.
 If the dependency is not described this object is set to
 zeroDotZero, although the dependency does exist."
::= { docsDrfGroupDependencyEntry 4 }

-- ---------------------------------------------------------------------
-- DRF Channel Block configuration
-- Configuration and diagnostic of block Channels.
-- This table is only for Channels Blocks Physical containments
-- Other configuration parameters (PHY) applicable to all channels in a
-- QAM Channel Block are set through the DS (QAM) channel interface and
-- configuration objects
-- ---------------------------------------------------------------------
docsDrfChannelBlockTable OBJECT-TYPE
SYNTAX SEQUENCE OF DocsDrfChannelBlockEntry
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION
"This table configure attributes of block channels and
 Controls channel Block Tests.
 A channel block is an ENTITY-MIB containment of
 PhysicalClass 'module' that represent an RF connector."
::= { docsDrfObjects 5 }

docsDrfChannelBlockEntry OBJECT-TYPE
SYNTAX DocsDrfChannelBlockEntry
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION
"The conceptual row of this table.
Entries in this table are created at system
Initialization for Block Channels compliant to DRFI
Specification.
Sets in entries of this table persist after system
initialization."
INDEX { docsDrfChannelBlockPhysicalIndex }
::= { docsDrfChannelBlockTable 1 }

DocsDrfChannelBlockEntry ::= SEQUENCE
{
    docsDrfChannelBlockPhysicalIndex     PhysicalIndex,
docsDrfChannelBlockNumberChannels     Unsigned32,
docsDrfChannelBlockCfgNumberChannels  Unsigned32,
docsDrfChannelBlockMute              TruthValue,
docsDrfChannelBlockTestType          INTEGER,
docsDrfChannelBlockTestIdIndex       InterfaceIndexOrZero
}
docsDrfChannelBlockPhysicalIndex OBJECT-TYPE
SYNTAX PhysicalIndex
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION "The Physical Index of the QAM Channel Block."
::= { docsDrfChannelBlockEntry 1 }

docsDrfChannelBlockNumberChannels OBJECT-TYPE
SYNTAX Unsigned32
MAX-ACCESS read-only
STATUS current
DESCRIPTION "The Number of QAM Channels N associated with this entry.
The value of this attribute corresponds to the number of channels that can be transmitted from this block"
::= { docsDrfChannelBlockEntry 2 }

docsDrfChannelBlockCfgNumberChannels OBJECT-TYPE
SYNTAX Unsigned32
MAX-ACCESS read-write
STATUS current
DESCRIPTION "The Number of QAM Channels N' to configure for the QAM block.
This number corresponds to the number of channels that are configured to be currently transmitted by the block.
The maximum number of channels per block follows the consideration of maximum number of digital channels in a headend described in the DRFI specification.
As a rule N' is valid if it is less than or equal to N.
In addition N minimal requirements consist of even numbers and 1 (one QAM channel per Block Channel). Odd number of QAM channels per Block Channel are optional for implementation.
A Set to an invalid value or not supported value returns Error 'wrongValue'."
::= { docsDrfChannelBlockEntry 3 }

docsDrfChannelBlockMute OBJECT-TYPE
SYNTAX TruthValue
MAX-ACCESS read-write
STATUS current
DESCRIPTION "The Mute control object for the Block Channel.
A set to this object to 'true' is reflected in ifOperStatus set to 'down' of the QAM channels associated to the block Channel.
The opposite, a set to this object to 'false', is not necessarily reflected as ifOperStatus set to 'up' since other interface conditions might prevent such status."
::= { docsDrfChannelBlockEntry 4 }

docsDrfChannelBlockTestType OBJECT-TYPE
SYNTAX INTEGER { noTest(1), offOthersNormal(2),
allOff(3),
onOthersOff(4),
cwOnOthersOff(5),
cwOnOthersNormal(6),
clockTest(7)
}
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"A set of in-service and out-of-service test modes.
The value 'noTest'(1) is the normal condition after
reinitialization where the QAM channels are expected in
operation.

'noTest'
It is also used to take out of testing mode
a QAM channel within the block.

In-service tests modes:
'offOthersNormal'
It is the condition where the QAM Channel indicated in
docsDrfChannelBlockTestIfIndex has its carrier
suppressed and the other channels in the
Block Channel are operational.
'allOff'
All QAM channel carriers in the channel block are
Suppressed.
'onOthersOff'
It is the condition where the QAM channel indicated in
docsDrfChannelBlockTestIfIndex is in operation
and the other QAM channels in the channel Block have
their carriers suppressed.

Out-of-service test modes:
'cwOnOthersOff'
It is the condition where the QAM channel indicated in
docsDrfChannelBlockTestIfIndex transmits a
continuous wave (CW) while the other QAM
channels in the channel Block have their carriers
suppressed.
'cwOnOthersNormal'
It is the condition where the QAM channel indicated in
docsDrfChannelBlockTestIfIndex transmits a
continuous wave (CW) while the other QAM channels in
the channel Block are operational.

clockTest'
It is the condition where the QAM channel indicated in
docsDrfChannelBlockTestIfIndex transmits a sequence
of alternating -1 and 1 symbols.

This object value does not persist after system
Reinitialization.
The value of this object is meaningless if
docsDrfChannelBlockTestIfIndex is set to zero."
::= { docsDrfChannelBlockEntry 5 }

docsDrfChannelBlockTestIfIndex OBJECT-TYPE
SYNTAX InterfaceIndexOrZero
MAX-ACCESS read-write
STATUS current
DESCRIPTION
"The ifIndex of the QAM channel to perform the QAM
channel test.  
A Set to a value that does not correspond to a QAM Channel within the Block channel returns error 'wrongValue'.  
A set to zero stops a current test execution.

::= { docsDrfChannelBlockEntry 6 }

-- Conformance definitions

-- Conformance definitions

docsDrfConformance OBJECT IDENTIFIER ::= { docsDrfMib 2 }
docsDrfCompliances OBJECT IDENTIFIER ::= { docsDrfConformance 1 }
docsDrfGroups OBJECT IDENTIFIER ::= { docsDrfConformance 2 }

docsDrfDeviceCompliance MODULE-COMPLIANCE
  STATUS current
  DESCRIPTION "The compliance statement DOCSIS DRFI compliant devices."

  MODULE -- this MODULE

  -- conditionally mandatory groups

  MANDATORY-GROUPS {
    docsDrfGroup
  }

  ::= { docsDrfCompliances 1}

docsDrfCmtsCompliance MODULE-COMPLIANCE
  STATUS current
  DESCRIPTION "The compliance statement for CMTS compliant devices."

  MODULE -- this MODULE

  -- conditionally mandatory groups

  MANDATORY-GROUPS {
    docsDrfGroup,
    docsDrfCmtsGroup
  }

  ::= { docsDrfCompliances 2}

docsDrfGroup OBJECT-GROUP
  OBJECTS {
    docsDrfDownstreamCapabFrequency,
    docsDrfDownstreamCapabBandwidth,
    docsDrfDownstreamCapabPower,
    docsDrfDownstreamCapabModulation,
    docsDrfDownstreamCapabInterleaver,
    docsDrfDownstreamCapabJ83Annex,
    docsDrfDownstreamCapabConcurrentServices,
    docsDrfDownstreamCapabServicesTransport,
    docsDrfDownstreamCapabMuting,
    docsDrfGroupDependencyGroupID,
    docsDrfGroupDependencyType,
    docsDrfChannelBlockNumberChannels,
docsDrfChannelBlockCfgNumberChannels,
docsDrfChannelBlockMute,
docsDrfChannelBlockTestType,
docsDrfChannelBlockTestIfIndex
}
STATUS current
DESCRIPTION "Group of objects implemented in M-CMTS compliant devices."
::= { docsDrfGroups 1 }

docsDrfCmtsGroup OBJECT-GROUP
OBJECTS {
docsDrfDownstreamPhyDependencies
}
STATUS current
DESCRIPTION "Group of objects specific for CMTS."
::= { docsDrfGroups 2 }

END