

Final draft **ETSI EN 302 878-3** V1.1.0 (2011-09)



**Access, Terminals, Transmission and Multiplexing (ATTM);  
Third Generation Transmission Systems for  
Interactive Cable Television Services - IP Cable Modems;  
Part 3: Downstream Radio Frequency Interface;  
DOCSIS 3.0**

---

Reference

DEN/ATTM-003006-3

---

Keywords

access, broadband, cable, data, IP, IPCable,  
modem

**ETSI**

650 Route des Lucioles  
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C  
Association à but non lucratif enregistrée à la  
Sous-Préfecture de Grasse (06) N° 7803/88

---

**Important notice**

Individual copies of the present document can be downloaded from:

<http://www.etsi.org>

The present document may be made available in more than one electronic version or in print. In any case of existing or perceived difference in contents between such versions, the reference version is the Portable Document Format (PDF). In case of dispute, the reference shall be the printing on ETSI printers of the PDF version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at

<http://portal.etsi.org/tb/status/status.asp>

If you find errors in the present document, please send your comment to one of the following services:

[http://portal.etsi.org/chaicor/ETSI\\_support.asp](http://portal.etsi.org/chaicor/ETSI_support.asp)

---

**Copyright Notification**

No part may be reproduced except as authorized by written permission.  
The copyright and the foregoing restriction extend to reproduction in all media.

© European Telecommunications Standards Institute 2011.  
All rights reserved.

DECT™, PLUGTESTS™, UMTS™ and the ETSI logo are Trade Marks of ETSI registered for the benefit of its Members.  
3GPP™ and LTE™ are Trade Marks of ETSI registered for the benefit of its Members and  
of the 3GPP Organizational Partners.  
GSM® and the GSM logo are Trade Marks registered and owned by the GSM Association.

# Contents

Intellectual Property Rights .....	6
Foreword.....	6
1 Scope and purpose.....	7
1.1 Scope .....	7
1.2 Purpose of Document .....	7
1.3 Use of References in the present document.....	8
1.4 Requirements.....	8
2 References .....	8
2.1 Normative references .....	8
2.2 Informative references.....	9
3 Definitions and abbreviations.....	9
3.1 Definitions.....	9
3.2 Abbreviations .....	11
4 Void.....	12
5 Functional Assumptions .....	12
5.1 Broadband Access Network .....	12
5.2 Equipment Assumptions.....	12
5.2.1 Frequency Plan .....	12
5.2.2 Compatibility with Other Services.....	12
5.2.3 Fault Isolation Impact on Other Users .....	13
5.3 Downstream Plant Assumptions.....	13
5.3.1 Transmission Levels .....	13
5.3.2 Frequency Inversion .....	13
5.3.3 Analog and Digital Channel Line-up.....	13
5.3.4 Analog Protection Goal .....	13
6 Physical Media Dependent Sublayer Specification.....	14
6.1 Scope .....	14
6.2 EdgeQAM (EQAM) differences from CMTS .....	14
6.3 Downstream .....	15
6.3.1 Downstream Protocol .....	15
6.3.2 Spectrum Format .....	15
6.3.3 Scaleable Interleaving to Support Video and High-Speed Data Services .....	15
6.3.4 Downstream Frequency Plan.....	16
6.3.5 DRFI Output Electrical.....	16
6.3.5.1 CMTS or EQAM Output Electrical .....	17
6.3.5.1.1 Power per Channel CMTS or EQAM.....	18
6.3.5.1.2 Independence of individual channel within the multiple channels on a single RF port.....	19
6.3.5.1.3 Out-of-Band Noise and Spurious Requirements for CMTS or EQAM .....	21
6.3.5.2 CMTS or EQAM Master Clock Jitter for Asynchronous Operation.....	25
6.3.5.3 CMTS or EQAM Master Clock Jitter for Synchronous Operation .....	26
6.3.5.4 CMTS or EQAM Master Clock Frequency Drift for Synchronous Operation.....	26
6.3.6 CMTS or EQAM Clock Generation .....	26
6.3.6.1 CMTS Clock Generation.....	26
6.3.6.2 EQAM Clock Generation.....	26
6.3.6.3 Downstream Symbol Rate.....	26
6.3.7 Downstream Symbol Clock Jitter for Synchronous Operation .....	27
6.3.8 Downstream Symbol Clock Drift for Synchronous Operation .....	27
6.3.9 Timestamp Jitter .....	27
7 Downstream Transmission Convergence Sublayer .....	28
7.1 Introduction .....	28
7.2 MPEG Packet Format.....	28
7.3 MPEG Header for DOCSIS Data-Over-Cable .....	28

7.4	MPEG Payload for DOCSIS Data-Over-Cable.....	29
7.4.1	stuff_byte.....	29
7.4.2	pointer_field.....	29
7.5	Interaction with the MAC Sublayer.....	29
7.6	Interaction with the Physical Layer.....	30
<b>Annex A (normative): Additions and Modifications for European Specification.....</b>		<b>31</b>
A.1	Scope and purpose.....	31
A.2	Void.....	31
A.3	Terms and definitions.....	31
A.4	Acronyms and abbreviations.....	31
A.5	Functional Assumptions.....	31
A.5.1	Broadband Access Network.....	31
A.5.2	Equipment Assumptions.....	32
A.5.2.1	Frequency Plan.....	32
A.5.2.2	Compatibility with Other Services.....	32
A.5.2.3	Fault Isolation Impact on Other Users.....	32
A.5.3	Downstream Plant Assumptions.....	32
A.5.3.1	Transmission Levels.....	32
A.5.3.2	Frequency Inversion.....	32
A.5.3.3	Analog and Digital Channel Line-up.....	33
A.5.3.4	Analog Protection Goal.....	33
A.6	Physical Media Dependent Sublayer Specification.....	33
A.6.1	Scope.....	33
A.6.2	EdgeQAM (EQAM) differences from CMTS.....	33
A.6.3	Downstream.....	33
A.6.3.1	Downstream Protocol.....	33
A.6.3.2	Spectrum Format.....	33
A.6.3.3	Scaleable Interleaving to Support Video and High-Speed Data Services.....	33
A.6.3.4	Downstream Frequency Plan.....	34
A.6.3.5	DRFI Output Electrical.....	34
A.6.3.5.1	CMTS or EQAM Output Electrical.....	34
A.6.3.5.1.1	Output Electrical per RF Port.....	34
A.6.3.5.1.2	Power per Channel CMTS or EQAM.....	35
A.6.3.5.1.3	Independence of individual channel within the multiple channels on a single RF port.....	36
A.6.3.5.1.4	Out-of-Band Noise and Spurious Requirements for CMTS or EQAM.....	38
A.6.3.5.2	CMTS or EQAM Master Clock Jitter for Asynchronous Operation.....	42
A.6.3.5.3	CMTS or EQAM Master Clock Jitter for Synchronous Operation.....	42
A.6.3.5.4	CMTS or EQAM Master Clock Frequency Drift for Synchronous Operation.....	42
A.6.3.6	CMTS or EQAM Clock Generation.....	43
A.6.3.6.1	CMTS Clock Generation.....	43
A.6.3.6.2	EQAM Clock Generation.....	43
A.6.3.6.3	Downstream Symbol Rate.....	43
A.6.3.7	Downstream Symbol Clock Jitter for Synchronous Operation.....	43
A.6.3.8	Downstream Symbol Clock Drift for Synchronous Operation.....	44
A.6.3.9	Timestamp Jitter.....	44
A.7	Downstream Transmission Convergence Sublayer.....	44
A.7.1	Introduction.....	44
A.7.2	MPEG Packet Format.....	44
A.7.3	MPEG Header for DOCSIS Data-Over-Cable.....	44
A.7.4	MPEG Payload for DOCSIS Data-Over-Cable.....	44
A.7.5	Interaction with the MAC Sublayer.....	44
A.7.6	Interaction with the Physical Layer.....	44

<b>Annex B (normative):</b>	<b>DOCS-DRF-MIB .....</b>	<b>45</b>
History .....		60

---

## Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<http://ipr.etsi.org>).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

---

## Foreword

This final draft European Standard (EN) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM), and is now submitted for the Vote phase of the ETSI standards Two-step Approval Procedure.

The present document is part 3 of a multi-part deliverable. Full details of the entire series can be found in part 1 [i.7].

<b>Proposed national transposition dates</b>	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

---

# 1 Scope and purpose

## 1.1 Scope

The present document defines the RF characteristics required in the downstream transmitter(s) of DOCSIS 3.0 CMTSs and EQAMs, sufficiently enough to permit vendors to build devices that meet the needs of cable operators around the world.

In addition to defining these requirements for a DOCSIS 3.0 device, the present document could also be applicable to other devices such as:

- an Edge QAM (EQAM) not being used for DOCSIS 3.0 services; or
- an integrated Cable Modem Termination System (CMTS) with multiple downstream channels per RF port previous to DOCSIS 3.0.

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 channelling. 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 clauses 5, 6 and 7, whereas the second is defined by replacing the content of those clauses with the content of annex A. Correspondingly, [4] and [2] apply only to the first option, and EN 300 429 [8] only to the second. Compliance with the present 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 will 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. The present document 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 Recommendation J.83 [4], annex B for cable networks in North America and EN 300 429 [8] for cable networks deployed in Europe. On downstream channels complying to ITU-T Recommendation J.83 [4], 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 clauses 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 the present 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 cable operators around the world.

## 1.3 Use of References in the present document

The present 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 the present document. For fuller understanding of the present document, the most recent versions of [4] annex B or EN 300 429 [8], respectively, as well as ES 202 488-2 [1] should be available for reference.

## 1.4 Requirements

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

"MUST"	This word 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 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 behaviour is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behaviour described with this label.
"MAY"	This word 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

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <http://docbox.etsi.org/Reference>.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

### 2.1 Normative references

The following referenced documents are necessary for the application of the present document.

- [1] ETSI ES 202 488-2: "Access and Terminals (AT); Second Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 2: Radio frequency interface specification".
- [2] CEA-542-C (February 2009): "Cable Television Channel Identification Plan".
- [3] ANSI/SCTE 02 (2006): "Specification for "F" Port, Female, Indoor".
- [4] ITU-T Recommendation J.83 (2007), Annex B: "Digital multi-programme systems for television, sound and data services for cable distribution".
- [5] ISO/IEC 13818-1 (2007): "Information technology -- Generic coding of moving pictures and associated audio information: Systems".
- [6] Cable Television Laboratories, Inc. CM-SP-RFIV2.0-C02-090422 (April 2009): "Data-Over-Cable Service Interface Specifications - DOCSIS 2.0 - Radio Frequency Interface Specification".



- [7] IEC 61169-24 (2009): "Radio-frequency connectors - Part 24: Sectional specification - Radio frequency coaxial connectors with screw coupling, typically for use in 75 ohm cable networks (type F)".
- [8] ETSI EN 300 429: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems".

## 2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] Cable Television Laboratories, Inc. SP-CMTS-NSII01-960702 (July 1996): "Data Over Cable Interface Specifications - Cable Modem Termination System - Network Side Interface Specification".
- [i.2] Cable Television Laboratories, Inc. CM-SP-M-OSSI-I08-081209 (December 2008): "Data-Over-Cable Service Interface Specifications - Modular Headend Architecture - M-CMTS Operations Support System Interface Specification".
- [i.3] Cable Television Laboratories, Inc. CM-SP-CMCI-C01-081104 (November 2008): "Data-Over-Cable Service Interface Specifications - Cable Modem to Customer Premise Equipment Interface".
- [i.4] Cable Television Laboratories, Inc. CM-SP-DEPI-I08-100611 (June 2010): "Data-Over-Cable Service Interface Specifications - Modular Headend Architecture - Downstream External PHY Interface Specification".
- [i.5] Cable Television Laboratories, Inc. CM-SP-DTI-I05-081209 (December 2008): "Data-Over-Cable Service Interface Specifications - Modular Headend Architecture - DOCSIS Timing Interface Specification".
- [i.6] Cable Television Laboratories, Inc. CM-SP-ERMI-I03-081107 (November 2008): "Data-Over-Cable-Service-Interface Specifications - Modular Headend Architecture - Edge Resource Manager Interface Specification".
- [i.7] ETSI EN 302 878-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 1: General; DOCSIS 3.0".

---

## 3 Definitions and abbreviations

### 3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

**Cable Modem (CM):** modulator-demodulator at subscriber locations intended for use in conveying data communications on a cable television system

**Carrier-to-Noise Ratio (C/N or CNR):** ratio of signal power to noise power in a defined measurement bandwidth. For digital modulation,  $CNR = E_s/N_0$ , 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.

**ceiling (ceil):** returns the first integer that is greater than or equal to a given value

**Customer Premises Equipment (CPE):** equipment at the end user's premises; may be provided by the service provider

**decibels (dB):** ratio of two power levels expressed mathematically as  $dB = 10\log_{10}(P_{OUT}/P_{IN})$

**decibel-milliVolt (dBmV):** unit of RF power expressed in decibels relative to 1 millivolt over 75  $\Omega$ , where  $dBmV = 20\log_{10}(\text{value in mV}/1 \text{ mV})$

**encompassed spectrum:** 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

**Electronic Industries Alliance (EIA):** voluntary body of manufacturers which, among other activities, prepares and publishes standards

**EdgeQAM Modulator (EQAM):** 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).

**Forward Error Correction (FEC):** 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.

**gap channel:** channel within the encompassed spectrum which is not active; this occurs with non-contiguous channel frequency assignments on an RF output port

**GigaHertz (GHz):** unit of frequency; 1,000,000,000 or 10<sup>9</sup> Hz

**Harmonic Related Carriers (HRC):** method of spacing channels on a cable television system with all carriers related to a common reference

**Hertz (Hz):** unit of frequency; formerly cycles per second

**Hybrid Fibre/Coaxial system (HFC):** broadband bidirectional shared-media transmission system using optical fibre trunks between the head-end and the fibre nodes, and coaxial cable distribution from the fibre nodes to the customer locations

**Incremental Related Carriers (IRC):** 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 [2] standard channel plan except for channels 5 and 6

**kiloHertz (kHz):** unit of frequency; 1,000 or 10<sup>3</sup> Hz; formerly kilocycles per second

**Media Access Control (MAC):** used to refer to the layer 2 element of the system which would include DOCSIS framing and signalling

**MegaHertz (MHz):** unit of frequency; 1,000,000 or 10<sup>6</sup> Hz; formerly megacycles per second

**Modulation Error Ratio (MER):** ratio of the average symbol power to average error power

**M/N:** relationship of integer numbers M,N that represents the ratio of the downstream symbol clock rate to the DOCSIS master clock rate

**non-contiguous channel assignment:** encompassed spectrum on an RF output port contains gap channels (inactive channels)

**National Television Systems Committee (NTSC):** committee which defined the analog, colour television, broadcast standards in North America. The standards television 525-line video format for North American television transmission is named after this committee.

**NGNA LLC:** company formed by cable operators to define a next-generation network architecture for future cable industry market and business requirements

**Physical Media Dependent sublayer (PMD):** 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

**QAM channel (QAM ch):** analog RF channel that uses Quadrature Amplitude Modulation (QAM) to convey information

**Quadrature Amplitude Modulation (QAM):** modulation technique in which an analog signal's amplitude and phase vary to convey information, such as digital data

**Radio Frequency (RF):** portion of the electromagnetic spectrum from a few kilohertz to just below the frequency of infrared light

**Radio Frequency Interface (RFI):** term encompassing the downstream and the upstream radio frequency interfaces

**Root Mean Square (RMS):** square root of the mean value squared a function

**self-aggregation:** method used to compute the headend noise floor by summing measured noise from a single device over a specified output frequency range

**Standard Channel Plan (STD):** method of spacing NTSC television channels on a cable television system defined in [3]

**Upstream Channel Descriptor (UCD):** MAC Management Message used to communicate the characteristics of the upstream physical layer to the cable modems

**Video on Demand (VoD):** system that enables individuals to select and watch video content over a network through an interactive television system

## 3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CM	Cable Modem
CMCI	Cable Modem CPE Interface
CMTS	Cable Modem Termination System
CNR	Carrier-to-Noise Ratio
CPE	Customer Premises Equipment
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
EIA	Electronic Industries Alliance
EQAM	EdgeQAM Modulator
ERMI	Edge Resource Manager Interface
FCC	Federal Communications Commission
FEC	Forward Error Correction
HFC	Hybrid Fibre/Coaxial system
HRC	Harmonic Related Carriers
IRC	Incremental Related Carriers
ISO	International Standards Organization
ITU	International Telecommunications Union
ITU-T	Telecommunication Standardization Sector of the ITU
MAC	Media Access Control
M-CMTS	Modular Cable Modem Termination System
MER	Modulation Error Ratio
MPEG	Moving Picture Experts Group
Ms	Millisecond. $10^{-3}$ second
NGNA	Next Generation Network Architecture, see <i>NGNA LLC</i>
Ns	Nanosecond. $10^{-9}$ second
NTSC	National Television Systems Committee
OSSI	Operations System Support Interface
PHY	Physical Layer
PID	Package Identifier
PMD	Physical Media Dependent sublayer
ppm	Parts per Million
PUSI	Payload Unit Start Indicator
Q	Quadrature modulation component
QAM	Quadrature Amplitude Modulation
RF	Radio Frequency
RFI	Radio Frequency Interface
RMS	Root Mean Square

S-CDMA	Synchronous Code Division Multiple Access
STD	Standard Channel Plan
UCD	Upstream Channel Descriptor
VoD	Video on Demand

## 4 Void

## 5 Functional Assumptions

This clause 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 clause.

Whenever there is a reference in this clause 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 6 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 fibre/coaxial (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 the present 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 miles to 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 fibre of approximately 1,5 ns/ft, 100 miles of fibre in each direction results in a round-trip delay of approximately 1,6 ms. For further information, see ES 202 488-2 [1], annex R.

### 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 MHz and 54 MHz and an upper edge that is implementation-dependent but is typically in the range of 300 MHz to 870 MHz. Within that pass band, NTSC analog television signals in 6-MHz channels are assumed present on the Standard (STD), HRC, or IRC frequency plans of [2], 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 clause 5.2.2.

## 5.3 Downstream Plant Assumptions

The present document has been developed with the downstream plant assumptions of this clause.

### 5.3.1 Transmission Levels

The nominal power level of the downstream RF signal(s) within a 6-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 the present document, 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 present document is to provide the minimum intended analog channel CNR protection of 60 dB for systems deploying up to 119 DRFI-compliant QAM channels.

The present document 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 centre frequencies below 600 MHz. An adjustment of  $10 \cdot \log_{10}(6 \text{ MHz} / 4 \text{ MHz})$  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 60 dB. With more QAM channels the analog protection is less. With the stated assumptions, the analog protection is:

$$\text{Analog Protection (dB)} = 80,76 - 10 \cdot \log_{10}(\text{Number of QAM Channels}).$$

For example, in a 143-QAM channel system, with the assumptions above, the specification equates to an analog CNR protection of 59,2 dB.

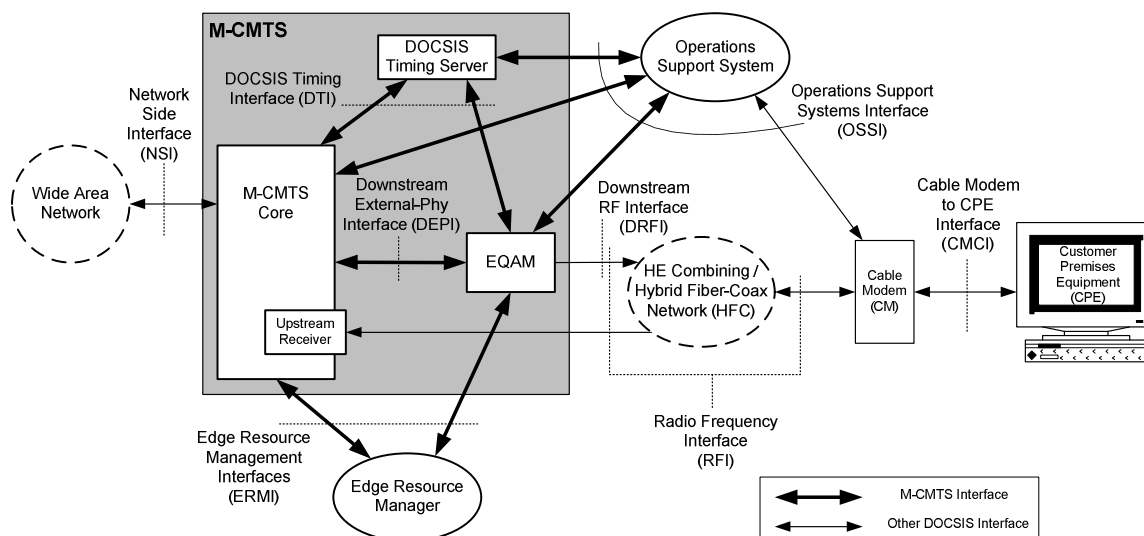
## 6 Physical Media Dependent Sublayer Specification

### 6.1 Scope

This clause applies to the first technology option referred to in clause 1. For the second option, refer to annex A.

The present document 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 clause 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**

The CMTS Network Side Interface [i.1], Modular CMTS Operation Support System Interface [i.3], Radio Frequency Interface (RFI), and the Cable Modem CPE Interface [i.3] are documented in existing DOCSIS specifications (see clause 2.2). The DOCSIS Timing Interface [i.5], Downstream External-PHY Interface [i.4], Downstream Radio Frequency Interface (the present document), and Edge Resource Manager Interface [i.6] 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 [i.4], 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 the present document.

Several new features are supported in the present document. The DOCSIS 1.x and 2.0 specifications do not reflect the ability of vendors to support multiple RF channels per physical RF port. The present 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 [i.5] specification.

## 6.3 Downstream

### 6.3.1 Downstream Protocol

The downstream PMD sublayer MUST conform to ITU-T Recommendation J.83 [4], annex B, except for clause B.6.2. Interleaver depths are defined in clause 6.3.3 of the present 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 the present 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  $S(t) = I(t) \cdot \cos(\omega t) + Q(t) \cdot \sin(\omega t)$ , 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 ITU-T Recommendation J.83 [4], annex B.

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

The CMTS or EQAM downstream PMD sublayer MUST support a variable-depth interleaver. ITU-T Recommendation J.83 [4] 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 tables 6-1 and 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 (see note). Further requirements for operational availability of interleaver depths are given in clause 6.3.5.1.2, item 1.

NOTE: 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 will support, where it supports 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**

Control Word	Interleaver Taps	Interleaver Increment	64-QAM 5,056941 Msym/sec 6 bits per symbol		256-QAM 5,360537 Msym/sec 8 bits per symbol	
			Burst Protection	Latency	Burst Protection	Latency
Four Bits	I	J				
1001	8	16	5,9 $\mu$ s	0,22 ms	4,1 $\mu$ s	0,15 ms
0111	16	8	12 $\mu$ s	0,48 ms	8,2 $\mu$ s	0,33 ms
0101	32	4	24 $\mu$ s	0,98 ms	16 $\mu$ s	0,68 ms
0011	64	2	47 $\mu$ s	2,0 ms	33 $\mu$ s	1,4 ms
0001	128	1	95 $\mu$ s	4,0 ms	66 $\mu$ s	2,8 ms

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

Control Word	Interleaver Taps	Interleaver Increment	64-QAM 5,056941 Msym/s 6 bits per symbol		256-QAM 5,360537 Msym/s 8 bits per symbol	
			Burst Protection	Latency	Burst Protection	Latency
Four Bits	I	J				
0000	128	1	95 $\mu$ s	4,0 ms	66 $\mu$ s	2,8 ms
0010	128	2	190 $\mu$ s	8,0 ms	132 $\mu$ s	5,6 ms
0100	128	3	285 $\mu$ s	12 ms	198 $\mu$ s	8,4 ms
0110	128	4	380 $\mu$ s	16 ms	264 $\mu$ s	11 ms
1000	128	5	475 $\mu$ s	20 ms	330 $\mu$ s	14 ms
1010	128	6	570 $\mu$ s	24 ms	396 $\mu$ s	17 ms
1100	128	7	664 $\mu$ s	28 ms	462 $\mu$ s	20 ms
1110	128	8	759 $\mu$ s	32 ms	528 $\mu$ s	22 ms

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 [4] 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 [2] for digital QAM carriers. Operational frequencies MAY include all channels between, and including centre 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  $N \geq 9$  and  $N' < N/4$ , the applicable maximum power per channel and spurious emissions requirements are defined using a value of  $N'' = \text{minimum}(4N', \text{ceiling}[N/4])$ .

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  $\Omega$  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 CMTSs 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 tables 6-3, 6-4, 6-5, 6-6 and 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**

Parameter	Value
Centre Frequency ( $f_c$ ) of any RF channel of a CMTS or EQAM	MAY be 57 MHz to 999 MHz $\pm$ 30 kHz (see note 1) MUST be at least 91 MHz to 867 MHz $\pm$ 30 kHz
Level	Adjustable (see table 6-4)
Modulation Type	64-QAM , 256-QAM
Symbol Rate (nominal)	
64-QAM	5,056941 Msym/s
256-QAM	5,360537 Msym/s
Nominal Channel Spacing	6 MHz
Frequency response	
64-QAM	~ 0,18 Square Root Raised Cosine Shaping
256-QAM	~ 0,12 Square Root Raised Cosine Shaping
Inband Spurious, Distortion, and Noise	Unequalized MER (see note 2) > 35 dB Equalized MER > 43 dB
Inband Spurious and Noise	$\leq$ -48 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 $\pm$ 50 kHz of the carrier is excluded. When $N > 1$ , noise outside the Nyquist bandwidth is excluded.
Out of Band Spurious and Noise	See table 6-5.
Phase Noise	
Single Channel Active, $N - 1$ Channels Suppressed (see clause 6.3.5.1.2, item 6)	
64-QAM and 256-QAM	1 kHz - 10 kHz: -33 dBc double sided noise power 10 kHz - 50 kHz: -51 dBc double sided noise power 50 kHz - 3 MHz: -51 dBc double sided noise power
All $N$ Channels Active, (see clause 6.3.5.1.2, item 7)	
64-QAM and 256-QAM	1 kHz - 10 kHz: -33 dBc double sided noise power 10 kHz - 50 kHz: -51 dBc double sided noise power
Output Impedance	75 $\Omega$
Output Return Loss (see note 3)	> 14 dB within an active output channel from 88 MHz to 750 MHz (see note 4) > 13 dB within an active output channel from 750 MHz to 870 MHz >12 dB within an active output channel from 870 MHz to 1 002 MHz > 12 dB in every inactive channel from 54 MHz to 870 MHz > 10 dB in every inactive channel from 870 MHz to 1 002 MHz
Connector	F connector per [3]
NOTE 1: 30 kHz includes an allowance of 25 kHz for the largest FCC frequency offset normally built into upconverters.	
NOTE 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 $\pm$ 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.	
NOTE 3: Frequency ranges are edge-to-edge.	
NOTE 4: If the EQAM or CMTS provides service to a centre 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 (fedge).	

## 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

Parameter	Value
Range of commanded transmit power per channel	$\geq 8$ dB below required power level specified below maintaining full fidelity over the 8 dB range
Range of commanded power per channel; adjusted on a per channel basis	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: <i>required power</i> (in table below) to <i>required power - 8 dB</i> , independently on each channel.
Commanded power per channel step size	$\leq 0,2$ dB Strictly monotonic
Power difference between any two adjacent channels in the 54 MHz to 1 002 MHz downstream spectrum (with commanded power difference removed if channel power is independently adjustable)	$\leq 0,5$ dB
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)	$\leq 1$ dB
Power difference between any two non-adjacent channels in the 54 MHz to 1 002 MHz downstream spectrum (with commanded power difference removed if channel power is independently adjustable)	$\leq 2$ dB
Power per channel absolute accuracy	$\pm 2$ dB
Diagnostic carrier suppression (3 modes) Mode 1: One channel suppressed  Mode 2: All channels suppressed except one  Mode 3: All channels suppressed	<ol style="list-style-type: none"> <li>1) <math>\geq 50</math> 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.</li> <li>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 <math>N \leq 8</math>, where N equals the maximum number of channels per port. For modulators with <math>N \geq 9</math> 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.</li> <li>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).</li> </ol> <p>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.</p>

Parameter	Value
RF output port muting	<p><math>\geq 73</math> dB below the unmuted aggregate power of the RF modulated signal, in every 6 MHz channel from 54 MHz to 1 002 MHz.</p> <p>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.</p> <p>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.</p>
Required power per channel for $N$ channels combined onto a single RF port. for $N < 8$ , where: $N \equiv$ maximum number of combined channels per port and $N' \equiv$ number of active combined channels per port ( $N' \leq N$ ): $N' = 1$ $N' = 2$ $N' = 3$ $N' = 4$ $4 < N' \leq 8$	Required power in dBmV per channel  60 dBmV 56 dBmV 54 dBmV 52 dBmV $60 - \text{ceil} [3,6 * \log_2(N')] \text{ dBmV}$
Required power per channel for $N'$ channels combined onto a single RF port for $N' \geq N/4$ and $N \geq 9$ : $N' \geq N/4$	Required power in dBmV per channel  $60 - \text{ceil} [3,6 * \log_2(N')] \text{ dBmV}$
Required power per channel for $N'$ channels combined onto a single RF port for $N' < N/4$ and $N \geq 9$ : $1 \leq N' < N/4$	Required power in dBmV per channel, where $N'' \equiv \min [4N', \text{ceil} [N/4]]$ $60 - \text{ceil} [3,6 * \log_2(N'')] \text{ dBmV}$

### 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, centre 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 centre 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 centre 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 centre 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 Centre 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 centre 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 centre frequency. The test mode MUST be capable of generating the CW tone over the full range of Centre 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  $\text{ceiling}[7*N'_{\text{max}}/8]$  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  $\{\text{ceiling}[7*N'_{\text{max}}/8], N'_{\text{max}}\}$ : 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, centre 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 centre 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 centre frequencies below 600 MHz. An adjustment of  $10 \cdot \log_{10}(6 \text{ MHz} / 4 \text{ MHz})$  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 60 dB.

Tables 6-5, 6-6 and 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 centre 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 power 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  $i$ th 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  $i$ th 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 tables 6-5, 6-6 and 6-7 to produce a requirement of 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 2<sup>nd</sup> and 3<sup>rd</sup> harmonics of the commanded channel, are fully identified in the table.

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

**Table 6-5: EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements for  $N \leq 8$**

for $N \leq 8$ Maximum Number of Combined Channels per RF Port $N \equiv$ Maximum Number of Combined Channels per RF Port $N' \equiv$ Number of Active Channels Combined per RF Port						
Item	Band	$N'$				
		1 (dBc)	2 (dBc)	3 (dBc)	4 (dBc)	$N' > 4$
1	Adjacent channel up to 750 kHz from channel block edge	< -58	< -58	< -58	< -58	$< 10 \cdot \log_{10} [10^{-58/10} + (0,75/6)^* (10^{-65/10} + (N'-2) \cdot 10^{-73/10})]$
2	Adjacent channel (750 kHz from channel block edge to 6 MHz from channel block edge)	< -62	< -60	< -60	< -60	$< 10 \cdot \log_{10} [10^{-62/10} + (5,25/6)^* (10^{-65/10} + (N'-2) \cdot 10^{-73/10})]$
3	Next-adjacent channel (6 MHz from channel block edge to 12 MHz from channel block edge)	< -65	< -64	< -63,5	< -63	$< 10 \cdot \log_{10} [10^{-65/10} + (N'-1) \cdot 10^{-73/10}]$
4	Third-adjacent channel (12 MHz from channel block edge to 18 MHz from channel block edge)	< -73	< -70	< -67	< -65	For $N' = 5$ : -64,5 dBc; For $N' = 6$ : -64 dBc; For $N' = 7$ : -64 dBc; For $N' \geq 8$ : $< -73 + 10 \cdot \log_{10}(N')$
5	Noise in other channels (47 MHz to 1 002 MHz) Measured in each 6 MHz channel excluding the following: a) Desired channel(s) b) 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> adjacent channels (see items 1, 2, 3, 4 in this table) c) Channels coinciding with 2 <sup>nd</sup> and 3 <sup>rd</sup> harmonics (see item 6 in this table)	< -73	< -70	< -68	< -67	$< -73 + 10 \cdot \log_{10}(N')$
6	In each of $2N'$ contiguous 6 MHz channels or in each of $3N'$ contiguous 6 MHz channels coinciding with 2 <sup>nd</sup> harmonic and with 3 <sup>rd</sup> harmonic components respectively (up to 1 002 MHz)	$< -73 + 10 \cdot \log_{10}(N')$ , or -63 dBc, whichever is greater				
7	Lower out of band noise in the band of 5 MHz to 47 MHz Measured in 6 MHz channel bandwidth	$< -50 + 10 \cdot \log_{10}(N')$				
8	Higher out of band noise in the band of 1 002 MHz to 3 000 MHz Measured in 6 MHz channel bandwidth	$< -55 + 10 \cdot \log_{10}(N')$				
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.						
NOTE 2: Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with centre frequency 600 MHz and above. For example -73 dBc becomes -70 dBc.						
NOTE 3: Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with centre 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  $N' \geq N/4$**

for $N \geq 9$ Maximum Number of Combined Channels per RF Port $N' \geq N/4$ Number of Active Channels Combined per RF Port					
Item	Band	$N'$			$N' > 4$
		2 (dBc)	3 (dBc)	4 (dBc)	
1	Adjacent channel up to 750 kHz from channel block edge	< -58	< -58	< -58	$< 10 * \log_{10} [10^{-58/10} + (0,75/6) * (10^{-65/10} + (N'-2) * 10^{-73/10})]$
2	Adjacent channel (750 kHz from channel block edge to 6 MHz from channel block edge)	< -60	< -60	< -60	$< 10 * \log_{10} [10^{-62/10} + (5,25/6) * (10^{-65/10} + (N'-2) * 10^{-73/10})]$
3	Next-adjacent channel (6 MHz from channel block edge to 12 MHz from channel block edge)	< -64	< -63,5	< -63	$< 10 * \log_{10} [10^{-65/10} + (N'-1) * 10^{-73/10}]$
4	Third-adjacent channel (12 MHz from channel block edge to 18 MHz from channel block edge)	< -70	< -67	< -65	For $N' = 5$ : -64,5 dBc; For $N' = 6$ : -64 dBc; For $N' = 7$ : -64 dBc; For $N' \geq 8$ : $< -73 + 10 * \log_{10} (N')$
5	Noise in other channels (47 MHz to 1 002 MHz) Measured in each 6 MHz channel excluding the following: a) Desired channel(s) b) 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> adjacent channels (see items 1, 2, 3, 4 in this table) c) Channels coinciding with 2 <sup>nd</sup> and 3 <sup>rd</sup> harmonics (see item 6 in this table)	< -70	< -68	< -67	$< -73 + 10 * \log_{10} (N')$
6	In each of $2N'$ contiguous 6 MHz channels or in each of $3N'$ contiguous 6 MHz channels coinciding with 2 <sup>nd</sup> harmonic and with 3 <sup>rd</sup> harmonic components respectively (up to 1 002 MHz)	$< -73 + 10 * \log_{10} (N')$ , or -63 dBc, whichever is greater			
7	Lower out of band noise in the band of 5 MHz to 47 MHz Measured in 6 MHz channel bandwidth	$< -50 + 10 * \log_{10} (N')$			
8	Higher out of band noise in the band of 1 002 MHz to 3 000 MHz Measured in 6 MHz channel bandwidth	$< -55 + 10 * \log_{10} (N')$ for $N' \leq 8$ $< -60 + 10 * \log_{10} (N')$ for $N' > 8$			
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.					
NOTE 2: Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with centre frequency 600 MHz and above. For example -73 dBc becomes -70 dBc.					
NOTE 3: Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with centre 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  $N \geq 9$  and  $N' < N/4$**

for $N \geq 9$ Maximum Number of Combined Channels per RF Port $N' < N/4$ Number of Active Channels Combined per RF Port $N'' \equiv$ Effective Number of Active Channels for Spurious Emissions Requirements = $\text{minimum}[4N', \text{ceil}(N/4)]$					
Item	Band	$N''$			
		2 (dBc)	3 (dBc)	4 (dBc)	$N'' > 4$
1	Adjacent channel up to 750 kHz from channel block edge	< -58	< -58	< -58	$< 10 * \log_{10} [10^{-58/10} + (0,75/6)^* (10^{-65/10} + (N''-2) * 10^{-73/10})]$
2	Adjacent channel (750 kHz from channel block edge to 6 MHz from channel block edge)	< -60	< -60	< -60	$< 10 * \log_{10} [10^{-62/10} + (5,25/6)^* (10^{-65/10} + (N''-2) * 10^{-73/10})]$
3	Next-adjacent channel (6 MHz from channel block edge to 12 MHz from channel block edge)	< -64	< -63,5	< -63	$< 10 * \log_{10} [10^{-65/10} + (N''-1)^* 10^{-73/10}]$
4	Third-adjacent channel (12 MHz from channel block edge to 18 MHz from channel block edge)	< -70	< -67	< -65	For $N'' = 5$ : -64,5 dBc; For $N'' = 6$ : -64 dBc; For $N'' = 7$ : -64 dBc; For $N'' \geq 8$ : $< -73 + 10 * \log_{10}(N)$
5	Noise in other channels (47 MHz to 1 002 MHz) Measured in each 6 MHz channel excluding the following: a) Desired channel(s) b) 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> adjacent channels (see items 1, 2, 3, 4 in this table) c) Channels coinciding with 2 <sup>nd</sup> and 3 <sup>rd</sup> harmonics (see item 6 in this table)	< -70	< -68	< -67	$< -73 + 10 * \log_{10}(N)$
6	In each of $2N'$ contiguous 6 MHz channels or in each of $3N'$ contiguous 6 MHz channels coinciding with 2 <sup>nd</sup> harmonic and with 3 <sup>rd</sup> harmonic components respectively (up to 1 002 MHz)	$< -73 + 10 * \log_{10}(N'')$ , or -63 dBc, whichever is greater			
7	Lower out of band noise in the band of 5 MHz to 47 MHz Measured in 6 MHz channel bandwidth	$< -50 + 10 * \log_{10}(N'')$			
8	Higher out of band noise in the band of 1 002 MHz to 3 000 MHz Measured in 6 MHz channel bandwidth	$< -55 + 10 * \log_{10}(N'')$ for $N'' \leq 8$ $< -60 + 10 * \log_{10}(N'')$ for $N'' > 8$			
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.					
NOTE 2: Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with centre frequency 600 MHz and above. For example -73 dBc becomes -70 dBc.					
NOTE 3: Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with centre 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 [i.5] specification. The Master Clock specifications are defined in the [i.5] 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 °C to 40 °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  $\leq 10^{-8}$  per second; and
- An edge jitter of  $\leq 10$  ns peak-to-peak ( $\pm 5$  ns).

This requirement 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 °C to 40 °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 ns, due to 10 ns jitter on each segments' duration, and 10 ns due to frequency drift. Durations of other counter lengths also may be deduced: adjacent 1,024,000 segments,  $\leq 21$  ns; 1,024,000 length segments separated by one 10,240,000-cycle segment,  $\leq 30$  ns; adjacent 102,400,000 segments,  $\leq 120$  ns. 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 clause 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:

- $< [-50 + 20 \cdot \log(f_{MC}/10,24)]$  dBc (i.e.  $< 0,05$  ns RMS) 10 Hz to 100 Hz.
- $< [-58 + 20 \cdot \log(f_{MC}/10,24)]$  dBc (i.e.  $< 0,02$  ns RMS) 100 Hz to 1 kHz.
- $< [-50 + 20 \cdot \log(f_{MC}/10,24)]$  dBc (i.e.  $< 0,05$  ns RMS) 1 kHz to 10 kHz.
- $< [-50 + 20 \cdot \log(f_{MC}/10,24)]$  dBc (i.e.  $< 0,05$  ns RMS) 10 kHz to  $f_{MC}/2$ .

$f_{MC}$  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 [i.5] 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 clause contains the EQAM and CMTS requirements for locking the Downstream Symbol Clock to the Master Clock.

### 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 6-8.

### 6.3.6.2 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.

### 6.3.6.3 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:

$$f_b' = f_m \cdot M/N$$

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

$$f_m' = f_b \cdot N/M$$

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 s.

Table 6-8 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 6-8: Downstream symbol rates and parameters for synchronization with Master Clock**

Downstream mode	Nominal Specified Symbol Rate, $f_b$ (MHz)	M/N	Master Clock Rate, $f_m'$ (MHz)	Downstream Symbol Rate, $f_b'$ (MHz)	Offset from Nominal
Annex B, 64-QAM	5,056941	401/812	10,239990	5,056945	0,95 ppm
Annex B, 256-QAM	5,360537	78/149	10,240000	5,360536	0,02 ppm

### 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:

- $< [-53 + 20 \cdot \log(f_{DS}/5,057)]$  dBc (i.e.  $< 0,07$  ns RMS) 10 Hz to 100 Hz.
- $< [-53 + 20 \cdot \log(f_{DS}/5,057)]$  dBc (i.e.  $< 0,07$  ns RMS) 100 Hz to 1 kHz.
- $< [-53 + 20 \cdot \log(f_{DS}/5,057)]$  dBc (i.e.  $< 0,07$  ns RMS) 1 kHz to 10 kHz.
- $< [-36 + 20 \cdot \log(f_{DS}/5,057)]$  dBc (i.e.  $< 0,5$  ns RMS) 10 kHz to 100 kHz.
- $< [-30 + 20 \cdot \log(f_{DS}/5,057)]$  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  $f_{DS} = 20,227764$  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 ns 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:

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

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.  $f_{\text{CMTS}}$  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 clause.

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 [5] 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
header=video	digital video 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 bytes 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 clause 2.4 of [5]. 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**

Field	Length (bits)	Description
sync_byte	8	0x47; MPEG Packet Sync byte.
transport_error_indicator	1	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.
payload_unit_start_indicator	1	A value of one indicates the presence of a pointer_field as the first byte of the payload (fifth byte of the packet).
transport_priority	1	Reserved; set to zero.
PID	13	DOCSIS Data-Over-Cable well-known PID (0x1FFE).
transport_scrambling_control	2	Reserved, set to '00'.
adaptation_field_control	2	'01'; use of the adaptation_field is not allowed on the DOCSIS PID.
continuity_counter	4	Cyclic counter within this PID.

## 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

The present document 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.

MPEG Header (PUSI = 1)	pointer_field (= 0)	MAC Frame (up to 183 bytes)	stuff_byte(s) (0 or more)
---------------------------	------------------------	--------------------------------	------------------------------

**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 need to also be preserved by any MPEG multiplexing operation.

MPEG Header (PUSI = 1)	<code>pointer_field</code> (= M)	Tail of MAC Frame #1 (M bytes)	<code>stuff_byte(s)</code> (0 or more)	Start of MAC Frame #2
---------------------------	-------------------------------------	-----------------------------------	---	--------------------------

**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.

MPEG Header (PUSI = 1)	<code>pointer_field</code> (= 0)	MAC Frame #1	MAC Frame #2	<code>stuff_byte(s)</code> (0 or more)	MAC Frame #3
---------------------------	-------------------------------------	-----------------	-----------------	---	-----------------

**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.

MPEG Header (PUSI = 1)	<code>pointer_field</code> (= 0)	<code>stuff_byte(s)</code> (0 or more)	Start of MAC Frame #1 (up to 183 bytes)	
MPEG Header (PUSI = 0)	Continuation of MAC Frame #1 (184 bytes)			
MPEG Header (PUSI = 1)	<code>pointer_field</code> (= M)	Tail of MAC Frame #1 (M bytes)	<code>stuff_byte(s)</code> (0 or more)	Start of MAC Frame #2 (M bytes)

**Figure 7-6: Packet Format where a MAC Frame Spans 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 [4], including MPEG-2 transport framing using a parity checksum as described in [4].

---

## Annex A (normative): Additions and Modifications for European Specification

This annex applies to the second technology option referred to in clause 1.1. For the first option, refer to clauses 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 clauses 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 clause 1.

---

### A.2 Void

---

### A.3 Terms and definitions

See clause 3.1.

---

### A.4 Acronyms and abbreviations

See clause 3.2.

---

## A.5 Functional Assumptions

This clause 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 clause.

Whenever a reference to frequency plans or to compatibility with other services in this clause 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 fibre/coaxial (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 the present 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 fibre of approximately 5 ns/m, 160 km of fibre in each direction results in a round-trip delay of approximately 1,6 ms. For further information, see ES 202 488-2 [1], annex R.

## 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 MHz and 87,5 MHz, and an upper edge that is implementation-dependent, but is typically in the range of 300 MHz 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 clause 5.2.3.

## A.5.3 Downstream Plant Assumptions

See clause 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 dBc to -6 dBc for 64-QAM and between -6 dBc to -4 dBc for 256-QAM).

### A.5.3.2 Frequency Inversion

See clause 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 centre frequencies below 600 MHz. An adjustment of  $10 \cdot \log_{10} (8 \text{ MHz} / 5,08 \text{ MHz})$  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 clause applies to the second technology option referred to in clause 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 clause see clause 6.1.

### A.6.2 EdgeQAM (EQAM) differences from CMTS

See clause 6.2.

### A.6.3 Downstream

#### A.6.3.1 Downstream Protocol

The downstream PMD sublayer MUST conform to EN 300 429 [8].

#### 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 [8].

#### A.6.3.3 Scalable 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 [8].

Table A-1: Interleaver characteristics

Interleaver Taps	Interleaver Increment	64-QAM 6,952 Msym/sec 6 bits per symbol		256-QAM 6,952 Msym/sec 8 bits per symbol	
		Burst Protection	Latency	Burst Protection	Latency
I	J				
12	17	18 $\mu$ s	0,43 ms	14 $\mu$ s	0,32 ms

### 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 clause 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 tables A-2, A-3 and 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 A-2: Output Electrical Requirements per RF Port

Parameter	Value
Centre Frequency ( $f_c$ ) of any RF channel of a CMTS or EQAM	MAY be 85 MHz to 999 MHz $\pm$ 30 kHz at 250 kHz increments MUST be 112 MHz to 858 MHz $\pm$ 30 kHz at 250 kHz increments
Level	Adjustable (see table A-3)
Modulation Type	64-QAM, 256-QAM
Symbol Rate (nominal)	
64-QAM	6,952 Msym/s
256-QAM	6,952 Msym/s
Nominal Channel Spacing	8 MHz
Frequency response	
64-QAM	$\sim$ 0,15 Square Root Raised Cosine Shaping
256-QAM	$\sim$ 0,15 Square Root Raised Cosine Shaping
Inband Spurious, Distortion, and Noise	Unequalized MER (see note 1) > 35 dB Equalized MER > 43 dB
Inband Spurious and Noise ( $f_c \pm 4$ MHz)	$\leq$ -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 $\pm$ 50 kHz of the carrier is excluded. When $N > 1$ , noise outside the Nyquist bandwidth is excluded.
Out of Band Spurious and Noise	See table A-4.
Phase Noise	
Single Channel Active, $N - 1$ Channels Suppressed (see clause 6.3.5.1.2, item 5)	1 kHz - 10 kHz: -33 dBc double sided noise power 10 kHz - 50 kHz: -51 dBc double sided noise power 50 kHz - 3 MHz: -51 dBc double sided noise power
64-QAM and 256-QAM	
All $N$ Channels Active (see Clause 6.3.5.1.2, item 6)	1 kHz - 10 kHz: -33 dBc double sided noise power 10 kHz - 50 kHz: -51 dBc double sided noise power
64-QAM and 256-QAM	
Output Impedance	75 $\Omega$

Parameter	Value
Output Return Loss	> 14 dB within an active output channel in the frequency range from 108 MHz to 862 MHz (see note 2) > 12 dB in every inactive channel from 81 MHz to 862 MHz > 10 dB in every inactive channel above 862 MHz
Connector	F connector per IEC-61169-24 [7]
NOTE 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 $\pm 50$ 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.	
NOTE 2: If the EQAM or CMTS provides service to a centre 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 centre 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 1 003 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 A-3: DRFI Device Output Power**

Parameter	Value
Range of commanded transmit power per channel	$\geq 8$ dB below required power level specified below maintaining full fidelity over the 8 dB range.
Commanded power per channel step size	$\leq 0,2$ dB strictly monotonic
Power difference between any two adjacent channels in a block (with commanded power difference removed if channel power is independently adjustable)	$\leq 0,5$ dB
Power difference between any two non-adjacent channels in a block (with commanded power difference removed if channel power is independently adjustable)	$\leq 1$ dB
Power per channel absolute accuracy	$\pm 2$ dB
Diagnostic carrier suppression (3 modes) Mode 1: One channel suppressed  Mode 2: All channels suppressed except one	1) $\geq 50$ 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.  2) $\geq 50$ 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 $N \leq 8$ , where N equals the maximum number of channels per port. For modulators with $N \geq 9$ 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.

Parameter	Value
Mode 3: All channels suppressed	3) $\geq 50$ 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.
RF output port muting	$\geq 71,5$ dB below the unmuted aggregate power of the RF modulated signal, in every 8 MHz channel from 86 MHz to 1 006 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.
Required power per channel for N channels combined onto a single RF port with $N < 8$ , where N $\equiv$ maximum number of combined channels per port and N' $\equiv$ number of active combined channels per port ( $N' \leq N$ ): N' = 1 N' = 2 N' = 3 N' = 4 $4 < N' < 8$	Required power in dBmV per channel  60 dBmV 56 dBmV 54 dBmV 52 dBmV $60 - \text{ceil}[3,6 * \log_2(N)]$ dBmV
Required power per channel for N' channels combined onto a single RF port with $N' \geq N/4$ and $N' > 9$ : $N' > N/4$	Required power in dBmV per channel  $60 - \text{ceil}[3,6 * \log_2(N')]$ dBmV
Required power per channel for N' channels combined onto a single RF port with $N' < N/4$ and $N' > 9$ : $1 < N' < N/4$	Required power in dBmV per channel, where $N'' = \min[4 * N', \text{ceil}(N/4)]$  $60 - \text{ceil}[3,6 * \log_2(N'')]$ dBmV

#### 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, centre 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 centre 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 centre 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 centre 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 Centre 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 centre 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 centre frequency. The test mode MUST be capable of generating the CW tone over the full range of Centre 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  $\text{ceiling}[7*N'_{\text{max}}/8]$  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  $\{\text{ceiling}[7*N'_{\text{max}}/8], N'_{\text{max}}\}$ : 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, centre 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 centre 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 centre frequencies below 600 MHz. An adjustment of  $10 \cdot \log_{10} (8 \text{ MHz} / 5,08 \text{ MHz})$  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  $N \leq 8$  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  $N \geq 9$  channels on a single RF output port MUST satisfy the out-of-band spurious emissions requirements of table A-4 in channels with centre 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  $N \geq 9$  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 centre frequency of the channel is below 600 MHz.

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 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 and when the centre frequency of the channel is at or above 600 MHz.

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 with centre 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 centre 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 centre frequencies below 600 MHz; 3 dB allowance is applied to all channels with centre 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,  $N' = \sum_{i=1 \text{ to } K} N_i$ . 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 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  $i$ th 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  $i$ th 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 tables A-4, A-5 and A-6 to produce a requirement of 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 2<sup>nd</sup> and 3<sup>rd</sup> harmonics of the commanded channel, are fully identified in the table.

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

**Table A-4: EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements for  $N \leq 8$  with  $N \equiv$  Maximum Number of Combined Channels per RF Port and  $N' \equiv$  Number of Active Channels Combined per RF Port**

Item	Band	$N'$ (for $N \leq 8$ )				
		1 (dBc)	2 (dBc)	3 (dBc)	4 (dBc)	$N > 4$
1	Adjacent channel up to 750 kHz from channel block edge	< -58	< -58	< -58	< -58	$< 10 \cdot \log_{10} [10^{-58/10} + (0,75/8)^* (10^{-63,5/10} + (N-2) \cdot 10^{-71,5/10})]$
2	Adjacent channel (750 kHz from channel block edge to 8 MHz from channel block edge)	< -60,5	< -59	< -58,5	< -58,5	$< 10 \cdot \log_{10} [10^{-60,5/10} + (7,25/8)^* (10^{-63,5/10} + (N-2) \cdot 10^{-71,5/10})]$
3	Next-adjacent channel (8 MHz from channel block edge to 16 MHz from channel block edge)	< -63,5	< -63	< -62,5	< -62	$< 10 \cdot \log_{10} [10^{-63,5/10} + (N-1) \cdot 10^{-71,5/10}]$
4	Third-adjacent channel (16 MHz from channel block edge to 24 MHz from channel block edge)	< -71,5	< -68,5	< -65,5	< -64	For $N = 5$ : < -63 dBc; For $N = 6$ : < 62,5 dBc; For $N = 7$ : < 62,5 dBc; For $N \geq 8$ : < -71,5 + $10 \cdot \log_{10}(N)$
5	Noise in other channels (80 MHz to 998 MHz) Measured in each 8 MHz channel excluding the following: a) Desired channel(s) b) 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> adjacent channels (see items 1, 2, 3, 4 in this table) c) Channels coinciding with 2 <sup>nd</sup> and 3 <sup>rd</sup> harmonics (see item 6 in this table)	< -71,5	< -68,5	< -66,5	< -65,5	< -71,5 + $10 \cdot \log_{10}(N)$
6	In each of 2N contiguous 8 MHz channels or in each of 3N contiguous 8 MHz channels coinciding with 2nd harmonic and with 3 <sup>rd</sup> harmonic components respectively (up to 998 MHz)	< -71,5 + $10 \cdot \log_{10}(N)$ , or -63 dBc, whichever is greater				
7	Lower out-of-band noise in the band of 5 MHz to 65 MHz Measured in 8 MHz channel bandwidth	< -50 + $10 \cdot \log_{10}(N)$				
8	Higher out-of-band noise in the band of 998 MHz to 3 000 MHz Measured in 8 MHz channel bandwidth	< -55 + $10 \cdot \log_{10}(N)$				

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.

NOTE 2: Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with centre frequency at 600 MHz and above. For example -71,5 dBc becomes -68,5 dBc.

NOTE 3: Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with centre 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  $N \geq 9$  and  $N' \geq N/4$  with  $N \equiv$  Maximum Number of Combined Channels per RF Port and  $N' \equiv$  Number of Active Channels Combined per RF Port**

Item	Band	$N'$ (for $N \geq 9$ and $N' \geq N/4$ )			
		2 (dBc)	3 (dBc)	4 (dBc)	$N' > 4$
1	Adjacent channel up to 750 kHz from channel block edge	< -58	< -58	< -58	$< 10 \cdot \log_{10} [10^{-58/10} + (0,75/8)^* (10^{-63,5/10} + (N'-2) \cdot 10^{-71,5/10})]$
2	Adjacent channel (750 kHz from channel block edge to 8 MHz from channel block edge)	< -59	< -58,5	< -58,5	$< 10 \cdot \log_{10} [10^{-60,5/10} + (7,25/8)^* (10^{-63,5/10} + (N'-2) \cdot 10^{-71,5/10})]$
3	Next-adjacent channel (8 MHz from channel block edge to 16 MHz from channel block edge)	< -63	< -62,5	< -62	$< 10 \cdot \log_{10} [10^{-63,5/10} + (N'-1) \cdot 10^{-71,5/10}]$
4	Third-adjacent channel (16 MHz from channel block edge to 24 MHz from channel block edge)	< -68,5	< -65,5	< -64	For $N' = 5$ : < -63 dBc; For $N' = 6$ : < -62,5 dBc; For $N' = 7$ : < -62,5 dBc; For $N' \geq 8$ : < $-71,5 + 10 \cdot \log_{10} (N)$
5	Noise in other channels (80 MHz to 998 MHz) Measured in each 8 MHz channel excluding the following: a) Desired channel(s) b) 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> adjacent channels (see items 1, 2, 3, 4 in this table) c) Channels coinciding with 2 <sup>nd</sup> and 3 <sup>rd</sup> harmonics (see item 6 in this table)	< -68,5	< -66,5	< -65,5	< $-71,5 + 10 \cdot \log_{10} (N)$
6	In each of $2N'$ contiguous 8 MHz channels or in each of $3N'$ contiguous 8 MHz channels coinciding with 2nd harmonic and with 3 <sup>rd</sup> harmonic components respectively (up to 998 MHz)	< $-71,5 + 10 \cdot \log_{10} (N)$ , or -63 dBc, whichever is greater			
7	Lower out of band noise in the band of 5 MHz to 65 MHz Measured in 8 MHz channel bandwidth	< $-50 + 10 \cdot \log_{10} (N)$			
8	Higher out of band noise in the band of 998 MHz to 3 000 MHz Measured in 8 MHz channel bandwidth	< $-55 + 10 \cdot \log_{10} (N)$ for $N' \leq 8$ < $-60 + 10 \cdot \log_{10} (N)$ for $N' > 8$			
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.					
NOTE 2: Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with centre frequency at 600 MHz and above. For example -71,5 dBc becomes -68,5 dBc.					
NOTE 3: Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with centre 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  $N \equiv$  Maximum Number of Combined Channels per RF Port and  $N' \equiv$  Number of Active Channels Combined per RF Port and  $N'' \equiv$  Effective Number of Active Channels for Spurious Emissions Requirements**

Item	Band	$N'' = \text{minimum}[4*N', \text{ceiling}(N/4)]$ (for $N \geq 9$ and $N' < N/4$ )			
		2 (dBc)	3 (dBc)	4 (dBc)	$N'' > 4$
1	Adjacent channel up to 750 kHz from channel block edge	< -58	< -58	< -58	$< 10 * \log_{10} [10^{-58/10} + (0,75/8)^* (10^{-63,5/10} + (N'-2)*10^{-71,5/10})]$
2	Adjacent channel (750 kHz from channel block edge to 8 MHz from channel block edge)	< -59	< -58,5	< -58,5	$< 10 * \log_{10} [10^{-60,5/10} + (7,25/8)^* (10^{-63,5/10} + (N'-2)*10^{-71,5/10})]$
3	Next-adjacent channel (8 MHz from channel block edge to 16 MHz from channel block edge)	< -63	< -62,5	< -62	$< 10 * \log_{10} [10^{-63,5/10} + (N'-1)*10^{-71,5/10}]$
4	Third-adjacent channel (16 MHz from channel block edge to 24 MHz from channel block edge)	< -68,5	< -65,5	< -64	For $N' = 5$ : < -63 dBc; For $N' = 6$ : < -62,5 dBc; For $N' = 7$ : < -62,5 dBc; For $N' \geq 8$ : < -71,5 + $10 * \log_{10} (N')$
5	Noise in other channels (80 MHz to 998 MHz) Measured in each 8 MHz channel excluding the following: a) Desired channel(s) b) 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> adjacent channels (see items 1, 2, 3, 4 in this table) c) Channels coinciding with 2 <sup>nd</sup> and 3 <sup>rd</sup> harmonics (see item 6 in this table)	< -68,5	< -66,5	< -65,5	< -71,5 + $10 * \log_{10} (N')$
6	In each of $2N'$ contiguous 8 MHz channels or in each of $3N'$ contiguous 8 MHz channels coinciding with 2 <sup>nd</sup> harmonic and with 3 <sup>rd</sup> harmonic components respectively (up to 998 MHz)	< -71,5 + $10 * \log_{10} (N')$ , or -63 dBc, whichever is greater			
7	Lower out of band noise in the band of 5 MHz to 65 MHz Measured in 8 MHz channel bandwidth	< -50 + $10 * \log_{10} (N')$			
8	Higher out of band noise in the band of 998 MHz to 3 000 MHz Measured in 8 MHz channel bandwidth	< -55 + $10 * \log_{10} (N')$ for $N' \leq 8$ < -60 + $10 * \log_{10} (N')$ for $N' > 8$			

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.

NOTE 2: Add 3 dB relaxation to the values specified above for noise and spurious emissions requirements in all channels with centre frequency at 600 MHz and above. For example: -71,5 dBc becomes -68,5 dBc.

NOTE 3: Add 1 dB relaxation to the values specified above for noise and spurious emissions requirements in gap channels with centre 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 clause 6.3.5.2.

#### A.6.3.5.3 CMTS or EQAM Master Clock Jitter for Synchronous Operation

See clause 6.3.5.3.

#### A.6.3.5.4 CMTS or EQAM Master Clock Frequency Drift for Synchronous Operation

See clause 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:

$$f_b' = f_m * M/N$$

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

$$f_m' = f_b * N/M$$

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  $\pm 1$  ppm from its specified nominal value.

The standard deviation of the timing error of the EQAM/CMTS RF symbol clock, referenced to the DTI Server Master Clock, MUST be less than 1,5 ns measured over 100 s.

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 A-7: Downstream symbol rates & parameters for synchronization with the Master Clock**

Downstream mode	Nominal Specified Symbol Rate, $f_b$ (MHz)	M/N	Master Clock Rate, $f_m'$ (MHz)	Downstream Symbol Rate, $f_b'$ (MHz)	Offset from Nominal
EN 300 429 [8], 64-QAM	6,952	869/1280	10,240	6,952	0 ppm
EN 300 429 [8], 256-QAM	6,952	869/1280	10,240	6,952	0 ppm

### 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:

- $< [-53 + 20 * \log(f_{DS}/6,952)]$  dBc (i.e.  $< 0,07$  ns RMS) 10 Hz to 100 Hz.
- $< [-53 + 20 * \log(f_{DS}/6,952)]$  dBc (i.e.  $< 0,07$  ns RMS) 100 Hz to 1 kHz.
- $< [-53 + 20 * \log(f_{DS}/6,952)]$  dBc (i.e.  $< 0,07$  ns RMS) 1 kHz to 10 kHz.
- $< [-36 + 20 * \log(f_{DS}/6,952)]$  dBc (i.e.  $< 0,5$  ns RMS) 10 kHz to 100 kHz.
- $< [-30 + 20 * \log(f_{DS}/6,952)]$  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, etc.) 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 clause 6.3.8.

### A.6.3.9 Timestamp Jitter

See clause 6.3.9.

---

## A.7 Downstream Transmission Convergence Sublayer

### A.7.1 Introduction

See clause 7.1.

### A.7.2 MPEG Packet Format

See clause 7.2.

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

See clause 7.3.

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

See clause 7.4.

### A.7.5 Interaction with the MAC Sublayer

See clause 7.5.

### A.7.6 Interaction with the Physical Layer

The MPEG-2 packet stream MUST be encoded according to EN 300 429 [8].

## Annex B (normative): DOCS-DRF-MIB

```

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."
    ::= { clabProjDocsis 23 }

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

-----
-- Main Groups
-----

docsDrfNotifications OBJECT IDENTIFIER ::= { docsDrfMib 0 }
docsDrfObjects        OBJECT IDENTIFIER ::= { docsDrfMib 1 }

-----
-- 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 }

-----
-- DOCSIS DRF Interface Extension objects
-----

docsDrfDownstreamTable OBJECT-TYPE
  SYNTAX      SEQUENCE OF DocsDrfDownstreamEntry
  MAX-ACCESS  not-accessible
  STATUS      current
  DESCRIPTION
    "Extensions for the DOCSIS RFI Downstream
    docsIfDownstreamChannelTable."
  ::= { docsDrfObjects 2 }

docsDrfDownstreamEntry OBJECT-TYPE
  SYNTAX      DocsDrfDownstreamEntry
  MAX-ACCESS  not-accessible
  STATUS      current
  DESCRIPTION
    "A conceptual row for this table.
    There is a corresponding entry for each entry of
    docsIfDownstreamChannelTable."
  AUGMENTS { docsIfDownstreamChannelEntry }
  ::= { docsDrfDownstreamTable 1 }

DocsDrfDownstreamEntry ::= SEQUENCE
  {
    docsDrfDownstreamPhyDependencies      BITS
  }

```

```
docsDrfDownstreamPhyDependencies OBJECT-TYPE
  SYNTAX BITS {
    frequency(0),
    bandwidth(1),
    power(2),
    modulation(3),
    interleaver(4),
    j83Annex(5),
    symbolRate(6),
    mute(7)
  }
  MAX-ACCESS read-only
  STATUS current
  DESCRIPTION
    "The summary of the Downstream Interface
    dependencies based on the constraints of
    docsDrfGroupDependencyEntry.
    A BIT position set to '1' indicates the PHY parameter
    belongs to a dependency group.
    A BIT position set to '0', indicates the PHY parameter
    does not belong to a dependency group.

    For Interfaces configured via DEPI this information is
    reflected in the DEPI session as DEPI TSID group
    dependencies.

    If this object value is the zero-length string, it indicates
    this interface is configurable via DEPI but no session is
    currently active."
  ::= { docsDrfDownstreamEntry 1 }
```

```
-----
-- DRF Downstream Interface Capabilities
-----
```

```
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
}
```

docsDrfDownstreamCapabFrequency 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  $f + 1 \cdot \text{bandwidth}$  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  $f - 2 \cdot \text{bandwidth}$  and the 2nd QAM channels gets a frequency of  $f - 1 \cdot \text{bandwidth}$ .

'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),
        taps128increment2(7),
        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.

'taps12increment17' 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.

'videoAndDcscis' 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 allow 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 of 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,
  docsDrfChannelBlockTestIfIndex        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
-----

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

```

---

## List of figures

Figure 6-1: Logical View of Modular CMTS and Interfaces .....	14
Figure 7-1: Example of Interleaving MPEG Packets in Downstream .....	28
Figure 7-2: Format of an MPEG Packet.....	28
Figure 7-3: Packet Format where a MAC Frame Immediately Follows the Pointer Field .....	29
Figure 7-4: Packet Format with MAC Frame Preceded by Stuffing Bytes .....	30
Figure 7-5: Packet Format Showing Multiple MAC Frames in a Single Packet.....	30
Figure 7-6: Packet Format where a MAC Frame Spans Multiple Packets .....	30

## List of tables

Table 6-1: Low Latency Interleaver Depths.....	15
Table 6-2: Long Duration Burst Noise Protection Interleaver Depths .....	16
Table 6-3: RF Output Electrical Requirements .....	17
Table 6-4: DRFI Device Output Power.....	18
Table 6-5: EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements for $N \leq 8$ .....	23
Table 6-6: EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements $N \geq 9$ and $N' \geq N/4$ ....	24
Table 6-7: EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements $N \geq 9$ and $N' < N/4$ ....	25
Table 6-8: Downstream symbol rates and parameters for synchronization with Master Clock .....	27
Table 7-1: MPEG Header Format for DOCSIS Data-Over-Cable Packets .....	29
Table A-1: Interleaver characteristics .....	34
Table A-2: Output Electrical Requirements per RF Port.....	34
Table A-3: DRFI Device Output Power .....	35
Table A-4: EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements for $N \leq 8$ with $N \equiv$ Maximum Number of Combined Channels per RF Port and $N' \equiv$ Number of Active Channels Combined per RF Port.....	40
Table A-5: EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements for $N \geq 9$ and $N' \geq N/4$ with $N \equiv$ Maximum Number of Combined Channels per RF Port and $N' \equiv$ Number of Active Channels Combined per RF Port.....	41
Table A-6: EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements for $N \geq 9$ and $N' < N/4$ with $N \equiv$ Maximum Number of Combined Channels per RF Port and $N' \equiv$ Number of Active Channels Combined per RF Port and $N'' \equiv$ Effective Number of Active Channels for Spurious Emissions Requirements .....	42
Table A-7: Downstream symbol rates & parameters for synchronization with the Master Clock .....	43

---

## History

<b>Document history</b>				
V1.1.0	April 2011	Public Enquiry	PE 20110818:	2011-04-20 to 2011-08-18
V1.1.0	September 2011	Vote	V 20111112:	2011-09-13 to 2011-11-14