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Dostop, priključki, prenos in multipleksiranje (ATTM) - Tretja generacija prenosnih sistemov za storitve interaktivne kabelske televizije - IP-kabelski modemi - 3. del: Navzdolnji radiofrekvenčni vmesnik - DOCSIS 3.0

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

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Foreword

This European Standard (EN) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

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].

National transposition dates	
Date of adoption of this EN:	14 November 2011
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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.

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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 = Es/No, the energy-per symbol to noise-density ratio; the signal power is measured in the occupied bandwidth, and the noise power is normalized to the modulation-rate bandwidth. For analog NTSC video modulation, the noise measurement bandwidth is 4 MHz.

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 = 10log10(POUT/PIN)

deciBel-milliVolt (dBmV): unit of RF power expressed in decibels relative to 1 millivolt over 75 Ω, where dBmV = 20log10(value in mV/1 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 109 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 103 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 106 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 *NGNA LLC*
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.

Harmful interference is understood as:

- any measurable degradation (highest level of compatibility); or
- any degradation above the perceptible level of impairments for any service (standard or medium level of compatibility); or
- any degradation above 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 $10*log_{10}$ *(6 MHz / 4 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:

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

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.

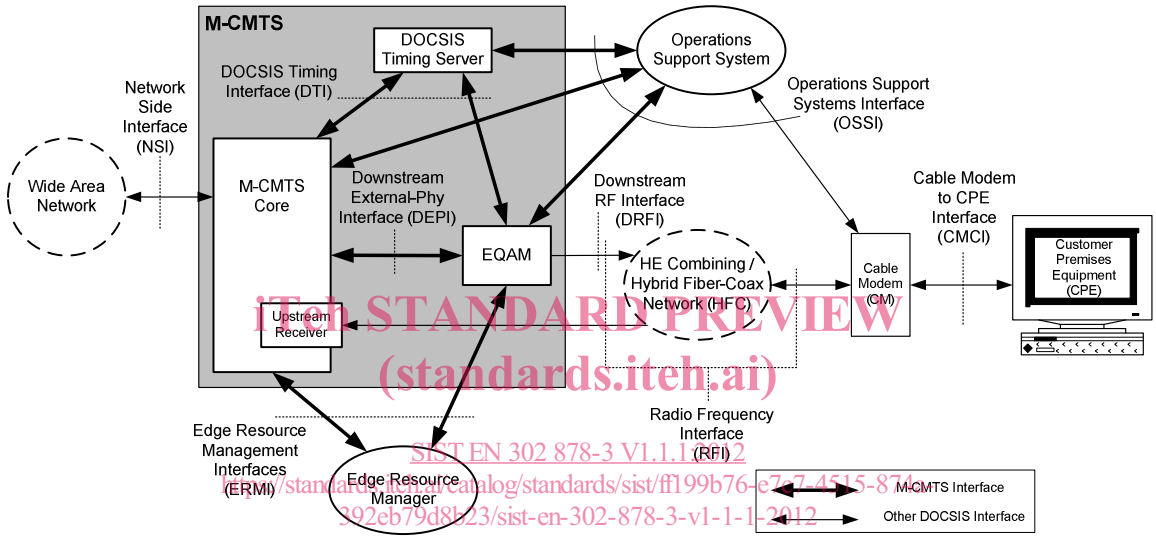

Figure 6-1: Logical View of Modular CMTS and Interfaces

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.