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# ANGA

**Specification for the passive Network Termination Point in  
DOCSIS 3.0 Environment  
Network and Provisioning requirements**

**Version 1.01**

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## Foreword

This interface specification is designed to describe the functioning of the interface at the passive Network Termination Point in DOCSIS 3.0 Environment according to Sec. 5 FTEG (German law on radio equipment and terminal equipment). It reflects the changes in law in force as of Aug 1, 2016 which aim to shift the network boundaries.

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## Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be used.

"**must**" and "**must not**" are **NOT** allowed in ANGA deliverables except when used in direct citation.

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# Introduction

Cable networks have advanced from a purely coaxial based distribution system. Incremental network changes made up of diverse technologies allow for bi-directional services while retaining most of the customer premises installation. Changes to the German Telekommunikationsgesetz (TKG) allow customers to become part of the neighbourhoods' network backbone. They may establish connections to the Cable Modem Termination System (CMTS) and supporting systems as long as the customer devices are attached to the passive Network Termination Point in a technically correct manner. Hence, only cable modems conforming to the OPERATOR defined interface specification and operational values shall be attached to the pNTP.

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## 1 Scope

This interface specification describes and specifies the main characteristics of the dedicated data interface in the OPERATOR cable network at the user's coaxial passive network termination point. This interface specification describes the typical limits or values within which the network characteristics can be expected to remain for networks that are built according to OPERATOR specifications at installation time.

The interface specification does not apply under abnormal operating conditions such as:

- operating conditions arising as a result of operating services other than DOCSIS 3.0 over the dedicated data interface (see e.g. PHY, MULPI, CMCI, OSSI, SEC and EN 60728-1).
- operating conditions arising as a result of a fault, maintenance and construction work or to minimize the extend of interruption of service.
- operating conditions arising as a result of force majeure or third party interference.
- operating conditions arising as a result of test signal injection governed by regulation.
- In case of non-compliance of a network user's installation or non-compliance of equipment with the relevant standards or non-compliance with the technical requirements for connection, established either by this interface specification or the public authorities including the relevant limits for electromagnetic compatibility.

The characteristics given in this interface specification are intended to be used to derive and specify requirements for equipment such as coaxial cables and cable modems to connect them to the dedicated data interface. The values in this interface specification take precedence over requirements in equipment product standards and in installation standards. The given characteristics are not intended to be used as electromagnetic compatibility levels or user emission limits in the OPERATOR network.

This interface specification may be changed at any time to reflect changes made to the network as required by Sec. 5 Para. 2 FTEG. Anyone using this specification is requested to regularly check for the newest version at the respective website as published by BNetzA. This standard may be superseded in total or in part by the terms of a contract between an individual user of this specification and the OPERATOR.

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## 2 References

### 2.1 Normative references

- [1] ETSI ETS 300 019-1-3 “Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-3: Classification of environmental conditions; Stationary use at weather protected locations”
- [2] Deutsche Bundespost FTZ 1 R 8 – 15, Dezember 1985 “Technische und betriebliche Bedingungen für die Überlassung von Hauptanschlüssen, posteigenen Leitungen und Stromwegen sowie Direkt-Datenverbindungen (und für die Zulassung amtsberechtigter privater Leitungen) Teil 15: Breitbandanschlüsse”
- [3] IEC 61169-24:2001 “Radio-frequency connectors – Part 24: Sectional specification – Radio frequency coaxial connectors with screw coupling, typically for use in 75 ohm cable distribution systems (type F)”
- [4] IEC 61169-24:2009 “Radio-frequency connectors – Part 24: Sectional specification – Radio frequency coaxial connectors with screw coupling, typically for use in 75 Ω cable networks (type F)”
- [5] SCTE 02 2015 “Specification for “F” Port, Female, Indoor
- [6] DIN EN 60728-1:2008 “Cable networks for television signals, sound signals and interactive services - Part 1: System performance of forward paths; German version EN 60728-1:2008”
- [7] DIN EN 60728-4 “Cable networks for television signals, sound signals and interactive services - Part 4: Passive wideband equipment for coaxial cable networks (IEC 60728-4); German version EN 60728-4”
- [8] DIN EN 60728-11:2005 “Cable networks for television signals, sound signals and interactive services - Part 11: Safety; German version EN 60728-11:2005”
- [9] DIN EN 60728-11:2011 “Cable networks for television signals, sound signals and interactive services - Part 11: Safety; German version EN 60728-11:2010”
- [10] CableLabs “Data Over Cable Service Interface Specifications, DOCSIS 3.0 Physical Layer Specification CM-SP-PHYv3.0-I12-150305”
- [11] CableLabs “Data Over Cable Service Interface Specifications, DOCSIS 3.0 MAC and Upper Layer Protocols Interface Specification CM-SP-MULPIv3.0-I29-151210”
- [12] CableLabs “Data Over Cable Service Interface Specifications, DOCSIS 3.0 Operations Support System Interface Specification CM-SP-OSSv3.0-I28-151210”
- [13] CableLabs “Data Over Cable Service Interface Specifications, DOCSIS 3.0 Security Specification CM-SP-SECV3.0-I15-130808”
- [14] CableLabs “Data Over Cable Service Interface Specifications, DOCSIS 3.0 Cable Modem to Customer Premise Equipment Interface Specification CM-SP-CMCIv3.0-I02-140729”
- [15] Excentis “EuroDOCSIS BPI+ Requirements: 2007”

### 2.2 Informative references

- [i.1] SchuTSEV, 13.05.2009 “Verordnung zum Schutz von öffentlichen Telekommunikationsnetzen und Sende- und Empfangsfunkanlagen, die in definierten Frequenzbereichen zu Sicherheitszwecken betrieben werden.”

- [i.2] ETSI ES 201 488 “Data Over Cable Service Interface Specifications (DOCSIS); Radio Frequency Interface Specifications”
- [i.3] EN 60966-2-6:2009 “Radio frequency and coaxial cable assemblies - Part 2-6: Detail specification for cable assemblies for radio and TV receivers - Frequency range 0 MHz to 3000 MHz, IEC 61169-24 connectors (IEC 60966-2-6:2009)”
- [i.4] IEC 60966-2-7:2015 “Radio frequency and coaxial cable assemblies - Part 2-7: Detail specification for cable assemblies for radio and TV receivers - Frequency range 0 MHz to 3 000 MHz, IEC 61169-47 connectors”
- [i.5] EN 61169-47:2012 “Sectional specification for radio-frequency coaxial connectors with clamp coupling typically for use in 75  $\Omega$  cable networks (type F-Quick)”
- [i.6] DIN EN 60728-1-1:2010 „Cable networks for television signals, sound signals and interactive services – Part 1-1: RF cabling for two way home networks; German version EN 60728-1-1:2010“
- [i.7] EN 50289-3-9 “Communication cables - Specifications for test methods - Part 3-9: Mechanical test methods; Bending tests”

## 3 Definitions, symbols and abbreviations

### 3.1 Definitions

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

**Cable Modem Termination System (CMTS):** cable modem termination system, located at the cable television system headend or distribution hub, which provides complementary functionality to the cable modem to enable data connectivity to a wide-area network

**Cable Network:** coaxial-based broadband access network in the form of either an all-coax or Hybrid-Fibre/Coax (HFC) network

**Carrier Hum Modulation:** peak-to-peak magnitude of the amplitude distortion relative to the RF carrier signal level due to the fundamental and low-order harmonics of the power-supply frequency

**Composite Second Order beat (CSO):** peak of the average level of distortion products due to second-order non-linearity's in cable system equipment

**Composite Triple Beat (CTB):** peak of the average level of distortion components due to third-order non-linearity's in cable system equipment

**customer:** human being or organization that accesses the network in order to communicate via the services provided by the network

**downstream:** in cable television, the direction of transmission from the headend to the subscriber

**dynamic range:** ratio between the greatest signal power that can be transmitted over a multichannel analogue transmission system without exceeding distortion or other performance limits, and the least signal power that can be utilized without exceeding noise, error rate or other performance limits

**group delay:** difference in transmission time between the highest and lowest of several frequencies through a device, circuit or system

**High Frequency (HF):** Used in the present document to refer to the entire subsplit (5 MHz to 30 MHz) and extended subsplit (5 MHz to 65 MHz) band used in return channel communications over the cable television network

**hum modulation:** undesired modulation of the television visual carrier by the fundamental or low-order harmonics of the power supply frequency, or other low-frequency disturbances

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

**impulse noise:** noise characterized by non-overlapping transient disturbances

**layer:** subdivision of the Open System Interconnection (OSI) architecture, constituted by subsystems of the same rank

**micro-reflections:** echoes in the forward transmission path due to departures from ideal amplitude and phase characteristics

**mid split:** frequency division scheme that allows bi-directional traffic on a single coaxial cable

**passive network termination point (pNTP):** customer terminal with minimum optical/electrical spacing to the CMTS

**PHYsical (PHY) layer:** layer 1 in the Open System Interconnection (OSI) architecture; the layer that provides services to transmit bits or groups of bits over a transmission link between open systems and which entails electrical, mechanical and handshaking procedures

**Quadrature Amplitude Modulation (QAM):** method of modulating digital signals onto a radio-frequency carrier signal involving both amplitude and phase coding

**Radio Frequency (RF):** in cable television systems, this refers to electromagnetic signals in the range 5 MHz to 1 GHz

**return loss (RL):** parameter describing the attenuation of a guided wave signal (e.g. via a coaxial cable) returned to a source by a device or medium resulting from reflections of the signal generated by the source

**terminal:** equipment connected to a telecommunication network to provide access to one or more specific services

## 3.2 Abbreviations

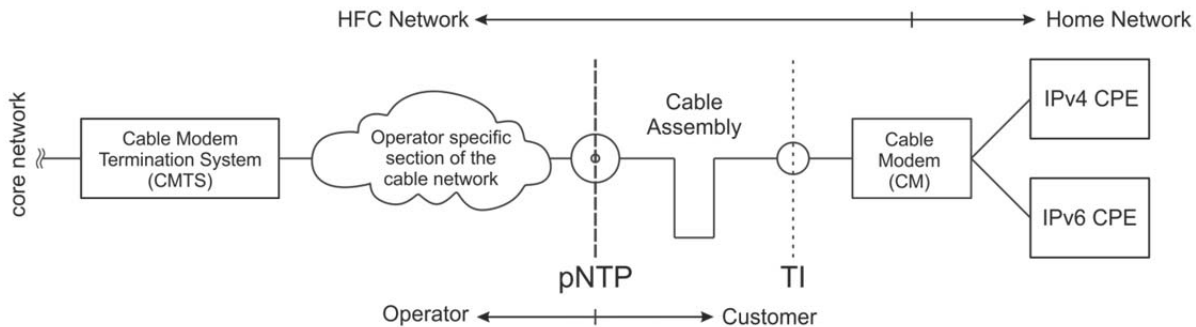
BER	Bit Error Rate
C/N or CNR	Carrier-to-Noise Ratio
CENELEC	European Committee for Electrotechnical Standardization
CM	Cable Modem
CPE	Customer Premise Equipment
CSO	Composite Second Order beat
CTB	Composite Triple Beat
DIN	Deutsches Institut für Normung
DOCSIS	Data Over Cable Service Interface Specifications
ETSI	European Telecommunications Standards Institute
FM	Frequency Modulation
HF	High Frequency
HFC	Hybrid-Fibre/Coax
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
MER	Modulation Error Ratio
PER	Packet Error Rate
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase-Shift Keying
RF	Radio Frequency
pNTP	passive Network Termination Point

TI Terminal Input  
SNR Signal to Noise Ratio

## 4 RF Interface Connector

### 4.1 General

Clause 4 describes and defines the mechanical coaxial connector and connection requirements at the customers pNTP.



**Figure 1: Location of the pNTP within the HFC network.**

*NOTE: The terminal connection to the pNTP requires an appropriate coaxial cable assembly. Implementation examples for such assemblies are given in Annex 1.*

### 4.2 Environmental Profile

The technical requirements of the present document apply under the environmental profiles in [1] assuming accordance with [8] or [9]. If not stated otherwise Class 3.1 typically applies for pNTP inside customer homes.

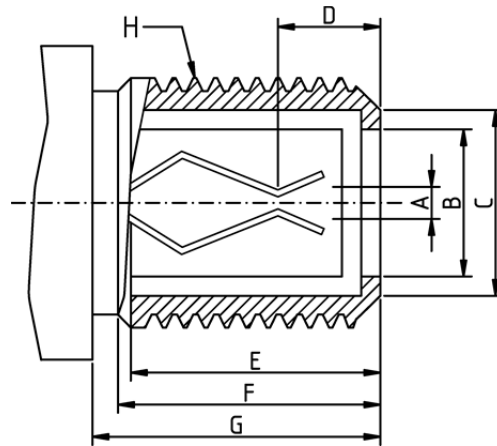
### 4.3 Mechanical interface description for coaxial connector with socket centre contact

The pNTP mechanical interface consists of a type F connector with socket centre contact conforming to either [3] or [4] that interfaces with corresponding type F male connectors whose diameters of the centre conductor shall be between 0.74 mm and 1.13 mm. The minimum maintained retention force shall be 0.3 N.

The nominal tightening torque for screw type F connectors is typical 3.4 Nm  $\pm$  10% (Absolute maximum tightening torque as per [5]). Networks conforming to [2] which are not supplied with type F pNTP may be supported by OPERATOR provided interface adapters.

*NOTE: The use of screw type F connectors is discouraged.*





**Figure 2: Type F connector with socket centre contact**

**Table 1: Mechanical Interface Dimensions**

Dimension	Nominal
A	accepts 0.74 – 1.13 mm
B-H	according to [3] or [4]
NOTE: The mechanical Interface is compatible with [i.5]	

## 4.4 Electrical Performance Characteristics

This clause describes the nominal electrical performance characteristics in the frequency range from DC to 862 MHz.

The nominal system impedance is 75  $\Omega$ . This impedance is the reference impedance for all passive coaxial components such as cables, connectors and wall outlets in the specified frequency range. Impedance mismatch results in a lower return loss.

The DC contact resistance of the centre conductor junction of the type F connector with socket centre contact to male F centre conductor shall be less than 25 m $\Omega$  and the DC contact resistance shall be less than 10 m $\Omega$ .

NOTE: The resulting contact resistance when using copper-clad steel conductors is typically greater than 10 m $\Omega$ .

The minimum nominal return loss of the pNTP is given in the table below.

**Table 2: Minimum Return Loss**

Frequency Range [MHz]	Nominal <sup>1</sup> :
5 to 47	$\geq 14$ dB
47 to 862	14 dB – 1.5 dB/octave, $\geq 10$ dB
<sup>1</sup> : see [7]	

## 5 Network RF Characteristics

This clause describes and defines the RF parameters and requirements at the customer's pNTP.

### 5.1 Downstream RF characteristics

#### 5.1.1 Downstream Frequency Range

The channel spacing takes into account downstream path channel bandwidths of 7 MHz (analogue TV only) and 8 MHz. During the course of the migration to digital services analogue channels according to ITU-R 470 BT (B, G PAL) can be replaced by digital channels resulting in a uniform channel spacing of 8 MHz from 110 MHz to 862 MHz. DOCSIS 3.0 channels are grouped into blocks of 4, 8 or more.

The DOCSIS downstream frequency range according to [10], B.6.3.2 shall be 112 to 858 MHz (centre frequency, 112 to 1002 MHz optional).

#### 5.1.2 Downstream RF performance

**Table 3: 862 MHz Network Downstream Performance Characteristics at the pNTP**

Parameter	Nominal ratings and characteristics	Absolute maximum ratings and characteristics during normal operation
total input power	< 93 dB( $\mu$ V) ([10], B.6.3.2)	
analogue carriers		68
analogue video carrier level	60 to 77 dB( $\mu$ V) ([6], Chapter 5.4.1)	80 dB( $\mu$ V)
signal tilt	$\leq 12$ dB ([6], Chapter 5.4.2)	
channel signal tilt		$\leq 8$ dB
group delay	$\leq 100$ ns ([6], Chapter 5.6.2)	
64 QAM signal level	47 to 67 dB( $\mu$ V) (see [6], Chapter 5.4.1)	
64 QAM BER (pre FEC)	$< 1 \times 10^{-7}$ (typ. $1 \times 10^{-8}$ )	$1 \times 10^{-4}$ (see [6], Chapter 5.8)
64 QAM MER	$\geq 26$ dB (typ. 30 dB, see [6], Chapter 5.8)	$\geq 23$ dB
256 QAM signal level	54 to 74 dB( $\mu$ V) (see [6], Chapter 5.4.1)	
256 QAM BER (pre FEC)	$< 1 \times 10^{-6}$ (typ. $1 \times 10^{-7}$ )	$1 \times 10^{-4}$ (see [6], Chapter 5.8)
256 QAM MER	$\geq 32$ dB (see [6], Chapter 5.8)	$\geq 29$ dB

**Table 4: Micro reflections at the pNTP**

time	nominal value <sup>1</sup>
$\leq 0,5 \mu$ s	-10 dBc
$\leq 1,0 \mu$ s	-15 dBc
$\leq 1,5 \mu$ s	-20 dBc
$> 1,5 \mu$ s	-31.5 dBc
<sup>1</sup> see [10], B.5.2.1	

NOTE: OPERATOR specific Downstream RF performance parameters may differ from the values given in the tables above.

### 5.2 Upstream RF characteristics

#### 5.2.1 Upstream Frequency Range

The upstream spectrum used for DOCSIS operation is divided into 3.2 MHz and 6.4 MHz wide channels in the frequency range from 5 MHz to 65 MHz.

## 5.2.2 Upstream RF performance

**Table 5: 862 MHz Network Upstream Characteristics at the pNTP**

Parameter	Nominal ratings and characteristics at installation time	Absolute maximum ratings and characteristics
single upstream level range	96 dB( $\mu$ V) to 110 dB( $\mu$ V)	114 dB( $\mu$ V)
C/(N+I) <sup>2</sup> .		$\geq 71$ dB <sup>1</sup> .
BER <sup>2</sup> .		$\leq 10^{-9}$
PER <sup>2</sup> .		$\leq 10^{-8}$
amplitude ripple	0.5 dB/MHz <sup>3</sup> .	
group delay ripple	200 ns/MHz <sup>3</sup> .	
carrier hum modulation	$\leq -23$ dBc	
<sup>1</sup> . OPERATOR specific <sup>2</sup> . 16 QAM in 3.2 MHz channel <sup>3</sup> . see [10], 5.2.2		

**Table 6: Spurious Emissions in 5.12 MHz upstream channel**

Parameter	During Burst transmission <sup>1</sup>	Between Bursts <sup>1</sup>
Inband	-40 dBc	-72 dBc
Adjacent channel	-44 dBc to -50 dBc <sup>2</sup> ; (should -48 dBc to -53 dBc)	-72 dBc
Adjacent Band	-44 dBc to -54 dBc <sup>2</sup> ; (should -50 dBc to -60 dBc)	-72 dBc
87.5 to 108 MHz in 250 kHz	$\leq 30$ dB( $\mu$ V)	$\leq 15$ dB( $\mu$ V)
108 to 136 MHz in 4.75 MHz	$\leq 20$ dB( $\mu$ V)	$\leq 15$ dB( $\mu$ V)
<sup>1</sup> . see [10], B.6.2.22.1 <sup>2</sup> . according to symbol rate		

NOTE: OPERATOR specific Upstream RF performance parameters and requirements may differ from the values given in the tables above.

## 6 DOCSIS 3.0 Physical Interface Requirements

The following table describes the DOCSIS physical interface requirements at the pNTP based on and in line with [10].

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## 7 DOCSIS 3.0 MULPI Interface Requirements

The following table describes the DOCSIS MULPI interface requirements at the pNTP based on and in line with [11].

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	L.8.4	Partial Service		x		
	L.9	Data Forwarding		x		
	L.9.1	General Forwarding Requirements		x		
	L.10	Cable Modem - CMTS Interaction		x		
	L.11	Dynamic Operations		x		
	L.12	Supporting Future New Cable Modem Capabilities		x		
<b>ANNEX M</b>		<b>PROPORTIONAL-INTEGRAL-ENHANCED ACTIVE QUEUE MANAGEMENT ALGORITHM (NORMATIVE)</b>	<b>x</b>			
	M.1	PIE AQM Constants and Variables				x
	M.2	PIE AQM Control Path				x
	M.3	M.3 PIE AQM Data Path				x
<b>APPENDIX I</b>		<b>MAC SERVICE DEFINITION (INFORMATIVE)</b>	<b>x</b>		<b>x</b>	
	I.1	MAC Service Overview	x	x		
	I.1.1	MAC Service Parameters	x		x	
	I.2	MAC Data Service Interface	x		x	
	I.2.1	MAC_DATA_INDIVIDUAL.request	x		x	
	I.2.2	MAC_DATA_GROUP.request	x		x	
	I.2.3	MAC_DATA_INTERNAL.request	x		x	
	I.2.4	MAC_GRANT_SYNCHRONIZE.indicate	x		x	
	I.2.5	MAC_CMTS_MASTER_CLOCK_SYNCHRONIZE.indicate	x		x	
	I.3	MAC Control Service Interface	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	I.3.1	MAC_REGISTRATION_RESPONSE.indicate	x		x	
	I.3.2	MAC_CREATE_SERVICE_FLOW.request	x		x	
	I.3.3	MAC_CREATE_SERVICE_FLOW.response	x		x	
	I.3.4	MAC_CREATE_SERVICE_FLOW.indicate	x		x	
	I.3.5	MAC_DELETE_SERVICE_FLOW.request	x		x	
	I.3.6	MAC_DELETE_SERVICE_FLOW.response	x		x	
	I.3.7	MAC_DELETE_SERVICE_FLOW.indicate	x		x	
	I.3.8	MAC_CHANGE_SERVICE_FLOW.request	x		x	
	I.3.9	MAC_CHANGE_SERVICE_FLOW.response	x		x	
	I.3.10	MAC_CHANGE_SERVICE_FLOW.indicate	x		x	
	I.4	MAC Service Usage Scenarios	x		x	
	I.4.1	Transmission of PDUs from Upper Layer Service to MAC DATA Service	x		x	
	I.4.2	Reception of PDUs to Upper Layer Service from MAC DATA Service	x		x	
	I.4.3	Sample Sequence of MAC Control and MAC Data Services	x		x	
<b>APPENDIX II</b>		<b>PLANT TOPOLOGIES (INFORMATIVE)</b>	<b>x</b>	<b>x</b>		
	II.1	Single Downstream and Single Upstream per Cable Segment	x	x		
	II.2	Multiple Downstreams and Multiple Upstreams per Cable Segment	x	x		
	II.2.1	HFC Plant Topologies	x	x		
	II.2.2	Normal Operation	x	x		
	II.2.3	Initial Ranging	x	x		
	II.2.4	Dynamic Channel Change	x	x		
<b>APPENDIX III</b>		<b>DOCSIS TRANSMISSION AND CONTENTION RESOLUTION (INFORMATIVE)</b>	<b>x</b>	<b>x</b>		
	III.1	Multiple Transmit Channel Mode	x	x		

Index		Description	relevant for IF Spec	informative	mandatory	optional
	III.1.1	Introduction	x	x		
	III.1.2	Variable Definitions	x	x		
	III.1.3	State Examples	x	x		
	III.1.4	Function Examples	x	x		
	III.2	Non-Multiple Transmit Channel Mode	x	x		
	III.2.1	Introduction	x	x		
	III.2.2	Variable Definitions	x	x		
	III.2.3	State Examples	x	x		
	III.2.4	Function Examples	x	x		
<b>APPENDIX IV</b>		<b>UNSOLICITED GRANT SERVICES (INFORMATIVE)</b>	<b>x</b>		<b>x</b>	
	IV.1	Unsolicited Grant Service (UGS)	x		x	
	IV.1.1	Introduction	x	x		
	IV.1.2	Configuration Parameters	x		x	
	IV.1.3	Operation	x		x	
	IV.1.4	Jitter	x		x	
	IV.1.5	Synchronization Issues	x		x	
	IV.2	Unsolicited Grant Service with Activity Detection (UGS-AD)	x		x	
	IV.2.1	Introduction	x		x	
	IV.2.2	MAC Configuration Parameters	x		x	
	IV.2.3	Operation	x		x	
	IV.2.4	Example	x		x	
	IV.2.5	Talk Spurt Grant Burst	x		x	
	IV.2.6	Admission Considerations	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	IV.3	Multiple Transmit Channel Mode Considerations for Unsolicited Grant Services	x		x	
<b>APPENDIX V</b>		<b>ERROR RECOVERY EXAMPLES (INFORMATIVE)</b>	<b>x</b>	<b>x</b>		
<b>APPENDIX VI</b>		<b>SDL NOTATION (INFORMATIVE)</b>				
<b>APPENDIX VII</b>		<b>NOTES ON ADDRESS CONFIGURATION IN DOCSIS 3.0 (INFORMATIVE)</b>	<b>x</b>	<b>x</b>		
<b>APPENDIX VIII</b>		<b>IP MULTICAST REPLICATION EXAMPLES (INFORMATIVE)</b>	<b>x</b>	<b>x</b>		
	VIII.1	Scenario I: First Multicast Client joiner to a multicast session (Start of a new Multicast Session)	x	x		
	VIII.1.1	Scenario 1 - Case 1				
	VIII.1.2	Scenario 1 - Case 2				
	VIII.1.3	Scenario I - Case 3				
	VIII.2	Scenario II: A Multicast Client joining an existing multicast session that is being forwarded bonded, with FC-Type 10 (Typical 3.0 Multicast Mode of Operation)	x	x		
	VIII.2.1	Scenario II - Case 1				
	VIII.2.2	Scenario II - Case 2				
	VIII.2.3	Scenario II - Case 3				
<b>APPENDIX IX</b>		<b>IGMP EXAMPLE FOR DOCSIS 2.0 BACKWARDS COMPATIBILITY MODE (INFORMATIVE)</b>				
	IX.1	Events				
	IX.2	Actions				
<b>APPENDIX X</b>		<b>CM MULTICAST DSID FILTERING SUMMARY (INFORMATIVE)</b>	<b>x</b>	<b>x</b>		
<b>APPENDIX XI</b>		<b>EXAMPLE DHCPV6 SOLICIT MESSAGE CONTENTS (INFORMATIVE)</b>	<b>x</b>	<b>x</b>		
<b>APPENDIX XII</b>		<b>DYNAMIC OPERATIONS EXAMPLES (INFORMATIVE)</b>	<b>x</b>	<b>x</b>		
	XII.1	Dynamic Channel Change Example Operation				

Index		Description	relevant for IF Spec	informative	mandatory	optional
	XII.1.1	Example Signaling				
	XII.1.2	Example Timing				
	XII.2	Dynamic Bonding Change Example Operation				
	XII.2.1	Change to Transmit Channel Set and Service Flow SID Cluster Assignments				
	XII.2.2	Change to Receive Channel Set and Downstream Resequencing Channel List				
	XII.3	Autonomous Load Balancing Example				
<b>APPENDIX XIII</b>		<b>ACKNOWLEDGEMENTS (INFORMATIVE)</b>				
	XIII.1	MAC Focus Team				
	XIII.2	USCB Focus Team				
	XIII.3	IPv6 Focus Team				
	XIII.4	IP Multicast Focus Team				
<b>APPENDIX XIV</b>		<b>REVISION HISTORY (INFORMATIVE)</b>				
	XIV.1	Engineering Changes for CM-SP-MULPIv3.0-I02-061222				
	XIV.2	Engineering Changes for CM-SP-MULPIv3.0-I03-070223				
	XIV.3	Engineering Changes for CM-SP-MULPIv3.0-I04-070518				
	XIV.4	Engineering Changes for CM-SP-MULPIv3.0-I05-070803				
	XIV.5	Engineering Changes for CM-SP-MULPIv3.0-I06-071206				
	XIV.6	Engineering Changes for CM-SP-MULPIv3.0-I07-080215				
	XIV.7	Engineering Changes for CM-SP-MULPIv3.0-I08-080522				
	XIV.8	Engineering Changes for CM-SP-MULPIv3.0-I09-090121				
	XIV.9	Engineering Changes for CM-SP-MULPIv3.0-I10-090529				
	XIV.10	Engineering Changes for CM-SP-MULPIv3.0-I11-091002				

Index		Description	relevant for IF Spec	informative	mandatory	optional
	XIV.11	Engineering Changes for CM-SP-MULPIv3.0-I12-100115				
	XIV.12	Engineering Changes for CM-SP-MULPIv3.0-I13-100611				
	XIV.13	Engineering Changes for CM-SP-MULPIv3.0-I14-101008				
	XIV.14	Engineering Changes for CM-SP-MULPIv3.0-I15-110210				
	XIV.15	Engineering Changes for CM-SP-MULPIv3.0-I16-110623				
	XIV.16	Engineering Changes for CM-SP-MULPIv3.0-I17-111711				
	XIV.17	Engineering Changes for CM-SP-MULPIv3.0-I18-120329				
	XIV.18	Engineering Changes for CM-SP-MULPIv3.0-I19-120809				
	XIV.19	Engineering Change for CM-SP-MULPIv3.0-I20-121113				
	XIV.20	Engineering Change for CM-SP-MULPIv3.0-I21-130404				
	XIV.21	Engineering Changes for CM-SP-MULPIv3.0-I22-130808				
	XIV.22	Engineering Changes for CM-SP-MULPIv3.0-I23-131120				
	XIV.23	Engineering Changes for CM-SP-MULPIv3.0-I24-140403				
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	XIV.25	Engineering Changes for CM-SP-MULPIv3.0-I26-150305				
	XIV.26	Engineering Change for CM-SP-MULPIv3.0-I27-150528				
	XIV.27	Engineering Change for CM-SP-MULPIv3.0-I28-150827				
	XIV.28	Engineering Change for CM-SP-MULPIv3.0-I29-151210				

## 8 DOCSIS 3.0 OSSI Interface Requirements

The following table describes the DOCSIS OSSI interface requirements at the pNTP based on and in line with [12].

TABLE 9

Index		Description	relevant for IF Spec	informative	mandatory	optional
<b>1</b>		<b>SCOPE</b>	<b>x</b>	<b>x</b>		
	1.1	Introduction and Purpose	x	x		
	1.2	Background	x	x		
	1.2.1	Broadband Access Network	x	x		
	1.2.2	DOCSIS Network and System Architecture	x	x		
	1.2.3	Service Goals	x	x		
	1.2.4	Statement of Compatibility	x	x		
	1.2.5	Reference Architecture	x	x		
	1.2.6	DOCSIS 3.0 Documents	x	x		
	1.3	Requirements	x	x		
	1.4	Conventions	x	x		
	1.5	Organization of Document	x	x		
<b>2</b>		<b>REFERENCES</b>	<b>x</b>	<b>x</b>		
	2.1	Normative References	x	x		
	2.2	Informative References	x	x		
	2.3	Reference Acquisition	x	x		
<b>3</b>		<b>TERMS AND DEFINITIONS</b>	<b>x</b>	<b>x</b>		
<b>4</b>		<b>ABBREVIATIONS AND ACRONYMS</b>	<b>x</b>	<b>x</b>		
<b>5</b>		<b>OVERVIEW AND THEORY OF OPERATIONS</b>	<b>x</b>	<b>x</b>		
	5.1	DOCSIS 3.0 OSSI Key Features			x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	5.1.1	Fault Management Features	x		x	
	5.1.2	Configuration Management Features	x		x	
	5.1.3	Performance Management Features	x		x	
	5.1.4	Security Management Features	x		x	
	5.1.5	Accounting Management Features		x		
	5.2	Technical Overview		x		
	5.2.1	Architectural Overview	x	x		
	5.2.2	Management Protocols	x	x		
	5.2.3	Object Model s	x	x		
<b>6</b>		<b>OSSI MANAGEMENT PROTOCOLS</b>	<b>x</b>			
	6.1	SNMP Protocol	x		x	
	6.1.1	Requirements for IPv6	x		x	
	6.2	IPDR Protocol	x	x		
<b>7</b>		<b>OSSI MANAGEMENT OBJECTS</b>	<b>x</b>	<b>x</b>		
	7.1	SNMP Management Information Bases (MIBS)	x		x	
	7.1.1	IETF Drafts and Others	x		x	
	7.1.2	IETF RFCs	x		x	
	7.1.3	Managed Objects Requirements	x		x	
	7.2	IPDR Service Definition Schemas	x	x		
<b>8</b>		<b>OSSI FOR PHY, MAC AND NETWORK LAYERS</b>	<b>x</b>	<b>x</b>		
	8.1	Fault Management Features	x	x		
	8.1.1	SNMP Usage	x		x	
	8.1.2	Event Notification	x		x	



Index		Description	relevant for IF Spec	informative	mandatory	optional
	8.1.3	Throttling, Limiting and Priority for Event, Trap and Syslog	x		x	
	8.1.4	SNMPv3 Notification Receiver Config file TLV	x		x	
	8.1.5	Non-SNMP Fault Management Protocols	x		x	
	8.2	Configuration Management	x	x		
	8.2.1	Version Control	x		x	
	8.2.2	System Configuration	x		x	
	8.2.3	Secure Software Download	x		x	
	8.2.4	CM Configuration Files, TLV-11 and MIB OIDs/Values	x		x	
	8.2.5	IPDR Exporter Configuration	x	x		
	8.3	Accounting Management	x	x		
	8.3.1	Subscriber Usage Billing and Class of Services	x	x		
	8.3.2	DOCSIS Subscriber Usage Billing Requirements	x		x	
	8.4	Performance Management	x	x		
	8.4.1	Treatment and Interpretation of MIB Counters	x		x	
	8.5	Security Management	x			
	8.5.1	CMTS SNMP Modes of Operation	x		x	
	8.5.2	CMTS SNMP Access Control Configuration	x		x	
	8.5.3	CM SNMP Modes of Operation	x		x	
	8.5.4	CM SNMP Access Control Configuration	x		x	
	8.5.5	IPDR Streaming Protocol Security Model	x	x		
<b>9</b>		<b>OSSI FOR CMCI</b>	<b>x</b>			
	9.1	SNMP Access via CMCI		x		
	9.2	Console Access		x		

Index		Description	relevant for IF Spec	informative	mandatory	optional
	9.3	CM Diagnostic Capabilities	x			x
	9.4	Protocol Filtering	x			x
<b>10</b>		<b>OSSI FOR CM DEVICE</b>		<b>vendor specific</b>		
	10.1	CM LED Requirements and Operation		vendor specific		
	10.1.1	Power On, Software Application Image Validation and Self Test		vendor specific		
	10.1.2	Scan for Downstream Channel		vendor specific		
	10.1.3	Resolve CM-SG and Range		vendor specific		
	10.1.4	Operational		vendor specific		
	10.1.5	Data Link and Activity		vendor specific		
	10.2	Additional CM Operational Status Visualization Features		vendor specific		
	10.2.1	Secure Software Download		vendor specific		
<b>ANNEX A</b>		<b>Detailed MIB Requirements (Normative)</b>	<b>x</b>		<b>x</b>	
<b>ANNEX B</b>		<b>IPTR for DOCSIS Cable Data Systems Subscriber Usage Billing Records (Normative)</b>		<b>x</b>		
<b>ANNEX C</b>		<b>Auxiliary Schemas for DOCSIS IPDR Service Definitions (Normative)</b>		<b>x</b>		
<b>ANNEX D</b>		<b>Format and Content for Event, SYSLOG, and SNMP Notification (NORMATIVE)</b>	<b>x</b>		<b>x</b>	
<b>ANNEX E</b>		<b>Annex E Application of MGMD-STD-MIB to DOCSIS 3.0 MGMD Devices (NORMATIVE)</b>	<b>x</b>		<b>x</b>	
<b>ANNEX F</b>		<b>Protocol Filtering (Normative)</b>	<b>x</b>		<b>x</b>	
<b>ANNEX G</b>		<b>DIAGNOSTIC LOG (Normative)</b>	<b>x</b>		<b>x</b>	
<b>ANNEX H</b>		<b>Requirements for DOCS-IFEXT2-MIB (Normative)</b>			<b>x</b>	
<b>ANNEX I</b>		<b>Load Balancing Requirements (Normative)</b>	<b>x</b>			<b>x</b>
<b>ANNEX J</b>		<b>Enhanced Signal Quality Monitoring Requirements (Normative)</b>	<b>x</b>		<b>x</b>	
<b>ANNEX K</b>		<b>DOCSIS 3.0 Data Type Definitions (Normative)</b>	<b>x</b>		<b>x</b>	
<b>ANNEX L</b>		<b>Security Requirements (Normative)</b>	<b>x</b>		<b>x</b>	

Index	Description	relevant for IF Spec	informative	mandatory	optional
ANNEX M	Multicast Requirements (Normative)				x
ANNEX N	CM and CMTS Status Reporting Requirements (Normative)	x		x	
ANNEX O	Media Access Control (MAC) Requirements (Normative)	x		x	
ANNEX P	Subscriber Management Requirements (Normative)	x			?
ANNEX Q	DOCSIS 3.0 SNMP MIB Modules (Normative)	x		x	
ANNEX R	IPDR Service Definition Schemas (Normative)		x		
ANNEX S	Additions and Modifications for Chinese Specification		x		
APPENDIX I	Business Process Scenarios For Subscriber Account Management (Informative)		x		
APPENDIX II	Summary of CM Authentication and Code File Authentication (Informative)		x		
APPENDIX III	DOCSIS IPDR Sample Instance Documents (Informative)		x		
APPENDIX IV	IPDR/SP Message Encoding Details		x		
APPENDIX V	Signal Quality Use Cases (Informative)		x		
APPENDIX VI	Object Model Notation		x		
APPENDIX VII	Receive Channel Obejct Model		x		
APPENDIX VIII	RECOMMENDED CMTS EXPORTER CONFIGURATION		x		

## 9 DOCSIS 3.0 SEC Interface Requirements

[15] is mandatory.

The following table describes the DOCSIS SEC interface requirements at the pNTP based on and in line with [13].

TABLE 10

Index		Description	relevant for IF Spec	informative	mandatory	optional
<b>1</b>		<b>SCOPE</b>	x	x		
	1.1	Introduction and Purpose	x	x		
	1.2	Background	x	x		
	1.2.1	Broadband Access Network	x	x		
	1.2.2	Network and System Architecture	x	x		
	1.2.3	Service Goals	x	x		
	1.2.4	Statement of Compatibility	x	x		
	1.2.5	Reference Architecture	x	x		
	1.2.6	DOCSIS 3.0 Documents	x	x		
	1.3	Requirements	x	x		
	1.4	Conventions	x	x		
<b>2</b>		<b>REFERENCES</b>	x		x	
	2.1	Normative References	x		x	
	2.2	Informative References	x	x		
	2.3	Reference Acquisition	x		x	
<b>3</b>		<b>TERMS AND DEFINITIONS</b>	x		x	
<b>4</b>		<b>ABBREVIATIONS AND ACRONYMS</b>	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
<b>5</b>		<b>OVERVIEW</b>	x	x		
	5.1	New DOCSIS 3.0 Security Features	x		x	
	5.2	Technical Overview	x		x	
	5.2.1	BPI+ Architecture	x		x	
	5.2.2	Secure Provisioning	x		x	
	5.3	Operation	x		x	
	5.3.1	Cable Modem Initialization	x		x	
	5.3.2	Cable Modem Key Update Mechanism	x		x	
	5.3.3	Cable Modem Secure Software Download	x		x	
<b>6</b>		<b>ENCRYPTED DOCSIS MAC FRAME FORMATS</b>				
	6.1	CM Requirements	x		x	
	6.2	CMTS Requirements	x	x		
	6.3	Variable-Length PDU MAC Frame Format	x		x	
	6.3.1	Baseline Privacy Extended Header Formats	x		x	
	6.4	Fragmentation MAC Frame Format	x		x	
	6.5	Registration Request (REG-REQ-MP) MAC Management Messages	x		x	
	6.6	Use of the Baseline Privacy Extended Header in the MAC Header	x		x	
<b>7</b>		<b>BASELINE PRIVACY KEY MANAGEMENT (BPKM) PROTOCOL</b>	x		x	
	7.1	State Models	x		x	
	7.1.1	Introduction	x		x	
	7.1.2	Encrypted Multicast	x		x	
	7.1.3	Selecting Cryptographic Suites	x		x	
	7.1.4	Authorization State Machine	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	7.1.5	TEK State Machine	x		x	
	7.2	Key Management Message Formats	x		x	
	7.2.1	Packet Formats	x		x	
	7.2.2	BPKM Attributes	x		x	
<b>8</b>		<b>EARLY AUTHENTICATION AND ENCRYPTION (EAE)</b>	x		x	
	8.1	Introduction	x		x	
	8.2	EAE Signaling	x		x	
	8.3	EAE Encryption	x		x	
	8.4	EAE Enforcement	x		x	
	8.4.1	CMTS and CM behaviors when EAE is Enabled	x		x	
	8.4.2	EAE enforcement determination	x		x	
	8.4.3	EAE Enforcement of DHCP Traffic	x		x	
	8.4.4	CMTS and CM Behavior when EAE is Disabled	x		x	
	8.4.5	EAE Exclusion List	x		x	
	8.4.6	Interoperability issues	x		x	
	8.5	Authentication Reuse	x		x	
	8.6	BPI+ Control by Configuration File	x		x	
	8.6.1	EAE Enabled	x		x	
	8.6.2	EAE Disabled	x		x	
<b>9</b>		<b>SECURE PROVISIONING</b>	x	x		
	9.1	Introduction	x	x		
	9.2	Encryption of Provisioning Messages	x		x	
	9.3	Securing DHCP	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	9.3.1	Securing DHCP on the Cable Network Link	x		x	
	9.3.2	DHCPv6	x		x	
	9.4	TFTP Configuration File Security	x			x
	9.4.1	Introduction	x			x
	9.4.2	CMTS Security Features for Configuration File Download	x			x
	9.5	Securing REG-REQ-MP Messages	x		x	
	9.6	Source Address Verification	x		x	
	9.7	Address Resolution Security Considerations	x	x		
<b>10</b>		<b>USING CRYPTOGRAPHIC KEYS</b>	x	x		
	10.1	CMTS	x	x		
	10.2	Cable Modem	x		x	
	10.3	Authentication of Dynamic Service Requests	x		x	
	10.3.1	CM	x		x	
	10.3.2	CMTS	x	x		
<b>11</b>		<b>CRYPTOGRAPHIC METHODS</b>	x	x		
	11.1	Packet Data Encryption	x		x	
	11.2	Encryption of the TEK	x		x	
	11.3	HMAC-Digest Algorithm	x		x	
	11.4	TEKs, KEKs and Message Authentication Keys	x		x	
	11.5	Public-Key Encryption of Authorization Key	x		x	
	11.6	Digital Signatures	x		x	
	11.7	The MMH-MIC	x		x	
	11.7.1	The MMH Function	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	11.7.2	Definition of MMH-MAC	x		x	
	11.7.3	Calculating the DOCSIS MMH-MAC	x		x	
	11.7.4	MMH Key Derivation for CMTS Extended MIC	x		x	
	11.7.5	Shared Secret Recommendations	x	x		
	11.7.6	Key Generation Function	x		x	
<b>12</b>		<b>PHYSICAL PROTECTION OF KEYS IN THE CM</b>	x		x	
<b>13</b>		<b>BPI+ X.509 CERTIFICATE PROFILE AND MANAGEMENT</b>	x		x	
	13.1	BPI+ Certificate Management Architecture Overview	x		x	
	13.2	Cable Modem Certificate Storage and Management in the CM	x		x	
	13.3	Certificate Processing and Management in the CMTS	x	x		
	13.3.1	CMTS Certificate Management Model	x	x		
	13.3.2	Certificate Validation	x		x	
	13.4	Certificate Revocation	x		x	
	13.4.1	Certificate Revocation Lists	x		x	
	13.4.2	Online Certificate Status Protocol	x		x	
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	14.2	Overview	x	x		
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Index		Description	relevant for IF Spec	informative	mandatory	optional
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	14.3.7	Error Codes	x		x	
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	C.2	Theory of Operation	x		x	
	C.3	SA Mapping State Model	x		x	
	C.3.1	Brief Description of States	x		x	
	C.3.2	Brief Description of Messages	x		x	
	C.3.3	Brief Description of Events	x		x	
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	D.3	System Operation	x		x	
	D.3.1	CMTS with BPI Capability	x	x		
	D.3.2	CMTS with BPI+ Capability	x	x		

Index		Description	relevant for IF Spec	informative	mandatory	optional
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	I.4.2	RSA decryption details	x	x		
	I.4.3	Hashing details	x	x		
	I.5	Key Request	x	x		
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	I.6.1	TEK encryption details	x	x		
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	I.7	Packet PDU encryption (DES)	x	x		
	I.7.1	CBC only	x	x		
	I.7.2	CBC with residual block processing	x	x		
	I.7.3	Runt frame	x	x		
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Index		Description	relevant for IF Spec	informative	mandatory	optional
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	I.10.2	CBC with residual block processing	x	x		
	I.10.3	Runt frame	x	x		
	I.11	Encryption of PDU with Payload Header Suppression (AES)	x	x		
	I.11.1	Downstream	x	x		
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	III.1.2	tbsCertificate.serialNumber	x		x	
	III.1.3	tbsCertificate.signature and signatureAlgorithm	x		x	
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Index		Description	relevant for IF Spec	informative	mandatory	optional
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	III.2.4	CM Code File Format	x		x	
<b>APPENDIX IV</b>		<b>ACKNOWLEDGEMENTS (INFORMATIVE)</b>	x	x		
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	V.1	Engineering Changes for CM-SP-SECv3.0-I02-061222	x	x		
	V.2	Engineering Changes for CM-SP-SECv3.0-I03-070223	x	x		
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	V.4	Engineering Changes for CM-SP-SECv3.0-I05-070803	x	x		
	V.5	Engineering Changes for CM-SP-SECv3.0-I06-071206	x	x		
	V.6	Engineering Change for CM-SP-SECv3.0-I07-080215	x	x		
	V.7	Engineering Changes for CM-SP-SECv3.0-I08-080522	x	x		
	V.8	Engineering Change for CM-SP-SECv3.0-I09-090121	x	x		
	V.9	Engineering Change for CM-SP-SECv3.0-I10-090529	x	x		
	V.10	Engineering Change for CM-SP-SECv3.0-I11-091002	x	x		
	V.11	Engineering Changes for CM-SP-SECv3.0-I12-100115	x	x		
	V.12	Engineering Change for CM-SP-SECv3.0-I13-100611	x	x		
	V.13	Engineering Changes for CM-SP-SECv3.0-I14-120809	x	x		

Index		Description	relevant for IF Spec	informative	mandatory	optional
	V.14	Engineering Change for CM-SP-SECv3.0-I15-130808	x	x		

## 10 DOCSIS 3.0 CMCI Interface Requirements

The following table describes the DOCSIS CMCI interface requirements at the pNTP based on and in line with [14].

TABLE 11

Index				Description	relevant for IF Spec	informative	mandatory	optional
<b>1</b>				<b>SCOPE</b>	x	x		
	1.1			Introduction and Purpose	x	x		
	1.2			Requirements	x	x		
<b>2</b>				<b>REFERENCES</b>	x	x		
	2.1			Normative References	x		x	
	2.2			Informative References	x	x		
	2.3			Reference Acquisition	x		x	
<b>3</b>				<b>TERMS AND DEFINITIONS</b>	x		x	
<b>4</b>				<b>ABBREVIATIONS AND ACRONYMS</b>	x		x	
<b>5</b>				<b>OVERVIEW</b>	x	x		
	5.1			Service Goals	x	x		
	5.2			Reference Architecture	x		x	
<b>6</b>				<b>NORMATIVE REQUIREMENTS</b>	x	x		
	6.1			List of CM Interfaces	x		x	
	6.2			External CPE Interfaces				
		6.2.1		Ethernet				
			6.2.1.1	Data Link Layer				
			6.2.1.2	Physical (PHY) Layer				
		6.2.2		Universal Serial Bus (USB)				
			6.2.2.1	Overview and goals				

Index				Description	relevant for IF Spec	informative	mandatory	optional
			6.2.2.2	Signaling Stack Summary for USB CMCI				
			6.2.2.3	End-to-end USB Cable Modem protocol stack				
			6.2.2.4	Data Link Layer				
			6.2.2.4.1	802.2 Logical Link Controller (LLC) Sublayer				
			6.2.2.4.2	802.3 Filtering				
			6.2.2.4.3	802.3 Medium Access Control (MAC) Sublayer 16				
			6.2.2.4.4	Ethernet				
			6.2.2.4.5	Address Length				
			6.2.2.4.6	USB Management and Framing Sublayer				
			6.2.2.4.7	USB Protocol Sublayer				
			6.2.2.5	Physical (PHY) Layer				
<b>APPENDIX I</b>				<b>ACKNOWLEDGMENTS</b>	x	x		
<b>APPENDIX II</b>				<b>REVISION HISTORY</b>	x	x		
	II.1			Engineering Change incorporated into CM-SP-CMCIv3.0-I02-140729:	x	x		

## Annex 1 (informative): Implementation Advice

### 1.1 Coaxial cable assemblies

Successful operation of cable modems attached to the cable network requires the consideration of environmental conditions such as electromagnetic fields and handling habits of the customer.

Examples of working coaxial cable assemblies no longer than 3 m operating in the transverse electromagnetic mode (TEM) are given in [i.3] with the following recommended parameters and exemptions:

Downstream signal levels at the cable modem RF port are reduced according to the frequency dependent attenuation of the cable assemblies. Other quality parameters could be affected by the length of the cable assembly if the total cable length of the cable assembly is greater than 300 cm [i.6, 5.3.2].

The cable assembly should be specified over the frequency range DC to 2400 MHz.

The use of type F screw connectors is discouraged as customers cannot be expected to adjust the required tightening torque of 3.4 Nm. Therefore, the use of connectors in accordance with [i.5] is strongly recommended.

The screening effectiveness requirements for cable assemblies are highly OPERATOR network specific. A typical calculation results in the following requirements:

**Table 12: OPERATOR specific Screening Effectiveness of coaxial cable assemblies (calculated)**

Frequency [MHz]	Value [dB]
30 to 80	75
108 to 790	75
790 to 862	83

**Table 13: OPERATOR specific Transfer Impedance of coaxial cable assemblies (calculated)**

Frequency [MHz]	Value [mΩ/m]
5 to 12	≤ 5.2
12 to 30	≤ 5.0



**Table 14: OPERATOR specific parameters for coaxial cable assemblies**

Parameter	Value
Cable length	≤ 300 cm
Frequency range	5 to 2400 MHz
Screening effectiveness	N/A
Connector	According to [i.4]
One end	90 degrees angled
Other end	Straight
Attenuation	
5 to 1006 MHz	≤ 0.6 dB/m
1006 to 2400 MHz	≤ 0.9 dB/m
Return Loss	
5 to 12 MHz	≥ 20 dB
12 to 30 MHz	≥ 25 dB
30 to 300 MHz	≥ 25 dB
300 to 470 MHz	≥ 23 dB
470 to 1006 MHz	≥ 18 dB
1006 to 1700 MHz	≥ 15 dB
1700 to 2400 MHz	≥ 12 dB
Cable bend radius	≤ 30 mm
Cable stress test	According to [i.7]
Pull off/ push on force	≥ 40 N
Inner conductor	0.74 to 1.13 mm
Color mark on the connector	Red

The cable assemblies shall comply to RoHS and WEEE environmental regulations as defined by the EU.

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## 1.2 Cable Modem RF Port Characteristics

For successful operation at many compatible pNTPs the cable modem/cable assembly has to fulfil all requirements described in [10], [i.1] or later. OPERATOR supplied cable modems could be tested against more challenging parameters. The determination of suitable RF port characteristics for the cable modem is left to the manufacturer.

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## Annex 2 (informative): Change History

Date	Version	Information about changes
2016/05/31	0.9	Peer Review
2016/06/30	0.9.1	Final review
2016/07/01	0.9.2	Final review rev 2
2016/07/04	1.0	Final Version 1.0 (2016-07)
2016/07/18	1.01	Update table 9 in Final Version 1.0 (2016-07)

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## History

<b>Document history</b>		
<b>&lt;Version&gt;</b>	<b>&lt;Date&gt;</b>	<b>&lt;Milestone&gt;</b>
1	2016/07/04	Initial version V1.0 (2016-7)
1.01	2016/07/18	Initial version V1.01 (2016-7) Update table 9 section 8