

INTERFACE DESCRIPTION

MSO SPECIFIC INTERFACE DESCRIPTION

Deutsche Telekom Gruppe, <Telekom Deutschland GmbH >

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0.1	22.3.2016	MF	initial document structure
0.1a	5.4.2016	FJ	structure amendments
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0.2a	10.5.2016	MF/AM	technology sections errata
0.3	12.5.2016	AM/RL	technology information applied
0.4	3.6.2016	AM/TB/MF	line up with ANGA document
0.5	15.6.2016	AM/RL	RFC updated
0.6	1.7.2016	KS/JS	orthographically and grammatically review and changes
1.0	11.7.2016	AM/TB/MF/JF	final review and compile
1.0a	12.7.2016	AM/TB/MF	added missing sections 6 + 7
1.0b	13.7.2016	TB/MF	added abbreviations
1.1	19.7.2016	MF/JS	orthographically and grammatically review and changes
1.2	04.04.2017	MF/JS	Update: Network access
1.3	08.05.2018	MF/JS	SIP based voice service added

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1 Base specifications

1.1 DOCSIS (ANGA Template)

The interface specification for the passive network termination point, the access to the DOCSIS network and the generic network and provisioning requirements are covered in the document in **Appendix A**, referred as **base specification** throughout this document.

The base specification was discussed and created in a forum under participation of several cable network operator, external consultants and cable industry experts and moderated by ANGA.

The base specification in its current form references the industry standard DOCSIS 3.0 and incorporates the relevant parts of the PHY, MULPI, OSSI and SEC specifications.

Any additions or MSO specific changes or amendments are covered in this document.

2 Scope

This document contains MSO specific information and specifications, beyond the definitions made in the base specification, for customer owned network termination devices which can be connected and operated on the MSO network.

Any information provided in this document must be taken into account, evaluated and any technical specifications and requirements must be fulfilled to claim full compatibility of the device to the MSO network. Definitions in this document supersede definitions and assumptions made in the base specification.

The equipment vendor is liable for damages and defects and must ensure proper operation, there is no obligation by the MSO to evaluate any customer owned network termination to proof compatibility or detect malfunctions.

The MSO operates the service in Germany, so any specifications and all certificates must follow the European version or subsections in the specification documents. This especially applies to:

- DOCSIS → Euro DOCSIS Specifications, MIBS and X.509 certificate chain
- PacketCable → EuroPacketCable Specifications, MIBS and X.509 certificate chain

3 MSO Name and relevant specification parts

MSO	Specification Part		Supported by MSO
Telekom	1.	Base specifications	X
Telekom	1.1	DOCSIS (ANGA Template)	X
Telekom	2.	Scope	X
Telekom	3.	MSO Name and relevant specification parts	X
Telekom	4.	Definitions, symbols and abbreviations	X
Telekom	4.1	Definitions	X
Telekom	4.2	Abbreviations	X
Telekom	5.	Basic Service Definition	X
Telekom	6.	L1 Network Access	X
Telekom	7.	L2 Network Access	X
Telekom	8.	IP (Internet) Services	X
Telekom	8.1	IPv4 operations	X
Telekom	8.1.1	DHCP IPv4 Operation	X
Telekom	8.2	IPv6 operations	X
Telekom	8.3	DS-lite operations	X
Telekom	9.	Voice Services	X
Telekom	9.1	PacketCable 1.x based Voice Services	X
Telekom	9.2	SIP based Voice Services	X
Telekom	10.	Other services	X
Telekom	11.	Management, service and support	X
Telekom	12.	Safeguard clause	X

4 Definitions, symbols and abbreviations

4.1 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

4.2 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
CoNT	Customer Owned Network Termination Device
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
MGCP	Media Gateway Control Protocol
NCS	Network Control Signalling
PER	Packet Error Rate
POTS	Plain old telephony service
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase-Shift Keying
RF	Radio Frequency
pNTP	passive Network Termination Point
SIP	Session Initiation Protocol
TI	Terminal Input
SNR	Signal to Noise Ratio
MIB	Management Information Base
RFC	Request for Comment
MSO	Multiple Service Operator
L[1-7]	OSI Layer [1-7]

5 Basic Service Definition

The MSO grants network access to compatible devices which are following the MSO Interface specification. The customer will be able to use the following services, which are referenced as basic services throughout this document:

- L1 Network Access
- L2 Network Access
- IP (Internet) Service
- Voice Services

6 L1 Network Access

The CoNT must be capable of bonding a minimum number of downstream and upstream channels. Those minimum requirements are

Bandwidth	≥ 400 Mbit/s	16 SC QAM	Downstream
Bandwidth	0 – 400 Mbit/s	8 SC QAM	Downstream
Bandwidth	0 – 30 Mbit/s	4 Channels	Upstream

Minimum channel requirements for bandwidths beyond the previously shown limits are calculated with the following formula :

$$\# \text{ of SC QAM} \times 50 \text{ Mbit/s} = \text{achievable bandwidth downstream}$$

Vendors may offer CoNT with higher bonding capabilities in downstream and upstream direction.

7 L2 network access

The L2 network access is entirely covered in the base specification

8 IP (Internet) Services

The following section provides information regarding the IP and Internet Services which will be provided by the MSO. The following definition is set:

- IPv4 support is mandatory
- IPv6 support is mandatory
- DS-lite support is mandatory

The specification only references RFC's which must be supported in addition to the base RFC's which are mandatory to provide basic IPv4, IPv6 and DS-lite protocol operations.

8.1 IPv4 operations

Internet Protocol Version 4 is a widely used protocol in data communication over different types of networks. The logical connection between participating devices is set up by providing identification to each device.

In order to use the internet service, a compatible device must retrieve identification data (IP address) from the MSO backend systems. IPv4 addresses will only be assigned dynamically and may change on any network connect or device restart.

8.1.1 DHCP IPv4 Operation

The following RFC's must be supported for an address assignment performed via DHCP:

- RFC951, updated by 1395, 1497, 1532, 1542, 5494
- RFC2131, updated by 3396, 4361, 5494, 6842
- RFC2132

Any static or stateless configuration approach of IP address information, DNS services or routes on the WAN connection is incompatible with the MSO requirements and specifications.

8.2 IPv6 operations

Internet Protocol Version 6 is the successor of IPv4 and supports a much larger number of nodes due to an increased address space. The logical connection between participating devices is set up by providing identification to each device.

In order to use the internet service, a compatible device must retrieve identification data (IP address / Ipv6 prefix) from the MSO backend systems. IPv6 addresses and IPv6 prefixes will only be assigned dynamically and are subject to change on any network connect or device restart.

IPv6 addresses on the WAN side are exclusively provided through DHCPv6, SLAAC is not supported and must remain disabled.

The following RFC's must be supported:

- RFC2131 (IPv4)
- RFC2132 (IPv4 and IPv6)
- RFC3315, updated by 4361, 5494, 6221, 6422, 6644, 7083, 7227, 7283, 7550
- RFC6221, RFC6422, RFC6644, RFC6842

Any static or stateless configuration approach of IP address information, DNS services or routes on the WAN connection is incompatible with the MSO requirements and specifications.

8.3 DS-lite operations

DS-lite is a very important IPv4 – IPv6 transition technology and must be supported by any router which connects to the MSO network. The MSO may drop single stack or dual stack operation at any time and move to an IPv6 only network where the customer owned network termination devices will operate as a B4 element.

The following RFC's must be supported for DS-Lite operation:

- RFC6233, updated by RFC 7335

9 Voice Services

9.1 PacketCable 1.x based Voice Services

Telephony services are provided leveraging the PacketCable Standard in Version 1.x. The following section describes the relevant PacketCable specifications for the voice service.

The PacketCable based voice services do not use any credentials due to the principle of centralized call logic and sophisticated device identification through certificates and provisioning.

The following PacketCable Specifications are relevant:

Specification	Title	IF spec relevant
PKT-SP-ASP1.5-I02-070412	Audio Server Protocol	
PKT-SP-ATPBX1.5-I01-060419	Analog Trunking for PBX Specification	
PKT-SP-BV16-Codec1.5-I01-031030	BroadVoice 16 Speech Codec Specification	x
PKT-SP-CMSPROV1.5-I02-070412	CMS Subscriber Provisioning	
PKT-SP-CMSS1.5-I07-120412	CMS to CMS Signaling	
PKT-SP-CODEC1.5-I04-120412	Audio/Video Codecs	x
PKT-SP-DQOS1.5-I04-090624	Dynamic Quality-of-Service	x
PKT-SP-EM1.5-I03-070412	Event Messages	x
PKT-SP-ESP1.5-I02-070412	Electronic Surveillance	x
PKT-SP-EVEMIB1.5-I02-050812	Management Event MIB Specification	x
PKT-SP-MEM1.5-I05-100527	Management Event Mechanism	x
PKT-SP-MIB-EXMTA1.5-I01-050128	MTA Extension MIB	x
PKT-SP-MIB-EXSIG1.5-I05-121030	Signaling Extension MIB	x
PKT-SP-MIB-MTA1.5-I01-050128	MTA MIB	x
PKT-SP-MIBS1.5-I03-090624	MIBs Framework Specification	x
PKT-SP-NCS1.5-I04-120412	Network-Based Call Signaling Protocol	x
PKT-SP-PROV1.5-I04-090624	MTA Device Provisioning	x
PKT-SP-SEC1.5-I03-090624	Security	x
PKT-SP-TGCP1.5-I04-120412	PSTN Gateway Call Signaling Protocol Specification	

9.2 SIP based voice services

SIP based voice service are provided based on the IETF RFC 3261 standard and its extensions. SIP services, opposite to PacketCable based voice services, are not auto provisioned, the customer must enter and apply the data manually. The SIP credentials follow the schema shown below, equipment vendors should provide a compatible input interface for data entry into the device:

```
SIP username:    (^0|^0049) ([2-9]) (\d{5,}) .{10,20}
SIP authname:    (^0|^0049) ([2-9]) (\d{5,}) .{10,20}
SIP password:    (?=.*\d) (?=.*[a-z]) (?=.*[A-Z]) .{6,10}
SIP registrar:   <host>.<domain>.tld
SIP proxy:       <host>.<domain>.tld
```


10 Other services

There are no other services supported by the MSO.

11 Management, service and support

The management, service and support responsibility for the network termination device will shift from the MSO to the customer and respectively to the equipment supplier. Nevertheless, the MSO may require access to the CoNT under some circumstances. The customer must actively permit this support access and may open it to the MSO personnel on a case by case or permanent basis. Any use of this support access and any data retrieval should be controllable and auditable by the customer.

It is therefore recommended that equipment vendors implement certain control mechanisms which enable the customer to limit management and support access.

The following Management OID's shall be accessible by the MSO if the customer permits the remote management operation. Any other MIB access is not required and should be blocked on the CoNT.

RF Parameter Modem

Index OID	1.3.6.1.2.1.2.2.1.1
Sequence	2
MIB Name	RFC1213-MIB
is Table	Y
TableName	ifTable

RF Parameter Modem DS 1

Index OID	1.3.6.1.2.1.2.2.1.1
Sequence	3
MIB Name	RFC1213-MIB
is Table	Y
TableName	ifTable

RF Parameter Modem US 1

Index OID	1.3.6.1.2.1.2.2.1.1
Sequence	4
MIB Name	RFC1213-MIB
is Table	Y
TableName	ifTable

RF Parameter Modem DS n (bonding)

Index OID	1.3.6.1.2.1.2.2.1.1
Sequence	[48-79]
MIB Name	RFC1213-MIB
is Table	Y
TableName	ifTable

RF Parameter Modem US n (bonding)

Index OID	1.3.6.1.2.1.2.2.1.1
Sequence	[80-87]
MIB Name	RFC1213-MIB
is Table	Y
TableName	ifTable

Modem Serial Number

Index OID	1.3.6.1.2.1.69.1.1.4
Sequence	0
MIB Name	DOCS-CABLE-DEVICE-MIB
is Table	N
TableName	N/A

Time and Date

Index OID	1.3.6.1.2.1.69.1.1.2
Sequence	0
MIB Name	DOCS-CABLE-DEVICE-MIB
is Table	N
TableName	N/A

Current SW Version

Index OID	1.3.6.1.2.1.69.1.3.5
Sequence	0
MIB Name	DOCS-CABLE-DEVICE-MIB
is Table	N
TableName	N/A

System Description

Index OID	1.3.6.1.2.1.1.1
Sequence	0
MIB Name	RFC1213-MIB
is Table	N
TableName	N/A

DOCSIS HF Downstream Parameters

Index OID	1.3.6.1.2.1.2.2.1.1
Sequence	any
MIB Name	DOCS-IF-MIB
is Table	Y
TableName	docsIfDownstreamChannelTable

DOCSIS HF Upstream Parameters

Index OID	1.3.6.1.2.1.2.2.1.1
Sequence	any
MIB Name	DOCS-IF-MIB
is Table	Y
TableName	docslfUpstreamChannelTable

DOCSIS HF Quality Parameters

Index OID	1.3.6.1.2.1.2.2.1.1
Sequence	any
MIB Name	DOCS-IF-MIB
is Table	Y
TableName	docslfSignalQualityTable

DOCSIS HF TX Power

Index OID	1.3.6.1.2.1.10.127.1.2.2.1.3
Sequence	0
MIB Name	DOCS-IF-MIB
is Table	N
TableName	N/A

12 Safeguard clause

If any of the information provided in this document are invalid or otherwise, then to the extent and within the jurisdiction which that information is illegal, invalid or unenforceable, it shall be severed and deleted from this clause and the remaining information shall survive, remain in full force and effect and continue to be binding and enforceable.

APPENDIX A

ANGA 100 001 v1.01 (2016-07)

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.

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.

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.

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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3 Definitions, symbols and abbreviations

3.1 Definitions

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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.

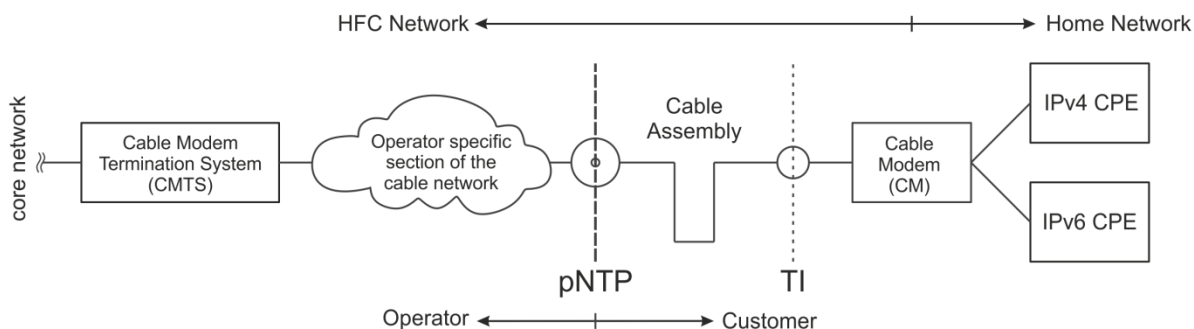


Figure 1: Location of the pNTP within the HFC network.

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.

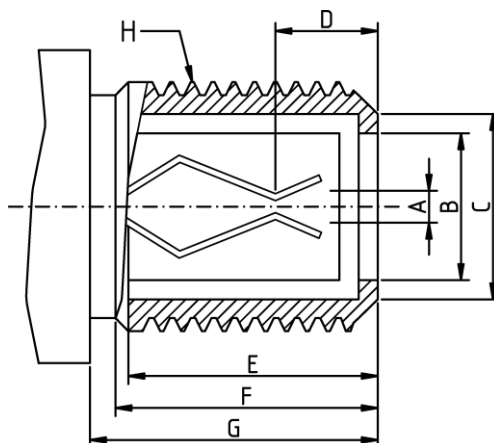


Figure 2: Type F connector with socket centre contact

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 Ω . 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 Ω and the DC contact resistance shall be less than 10 m Ω .

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

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

Table 2: Minimum Return Loss

Frequency Range [MHz]	Nominal ¹ :
5 to 47	≥ 14 dB
47 to 862	14 dB – 1.5 dB/octave, ≥ 10 dB
¹ : 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(μ V) ([10], B.6.3.2)	
analogue carriers		68
analogue video carrier level	60 to 77 dB(μ V) ([6], Chapter 5.4.1)	80 dB(μ V)
signal tilt	≤ 12 dB ([6], Chapter 5.4.2)	
channel signal tilt		≤ 8 dB
group delay	≤ 100 ns ([6], Chapter 5.6.2)	
64 QAM signal level	47 to 67 dB(μ V) (see [6], Chapter 5.4.1)	
64 QAM BER (pre FEC)	$< 1 \times 10^{-7}$ (typ. 1×10^{-8})	1×10^{-4} (see [6], Chapter 5.8)
64 QAM MER	≥ 26 dB (typ. 30 dB, see [6], Chapter 5.8)	≥ 23 dB
256 QAM signal level	54 to 74 dB(μ V) (see [6], Chapter 5.4.1)	
256 QAM BER (pre FEC)	$< 1 \times 10^{-6}$ (typ. 1×10^{-7})	1×10^{-4} (see [6], Chapter 5.8)
256 QAM MER	≥ 32 dB (see [6], Chapter 5.8)	≥ 29 dB

Table 4: Micro reflections at the pNTP

time	nominal value ¹
$\leq 0,5 \mu$ s	-10 dBc
$\leq 1,0 \mu$ s	-15 dBc
$\leq 1,5 \mu$ s	-20 dBc
$> 1,5 \mu$ s	-31.5 dBc
¹ 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(μ V) to 110 dB(μ V)	114 dB(μ V)
C/(N+I) ² .		≥ 71 dB ¹ .
BER ² .		$\leq 10^{-9}$
PER ² .		$\leq 10^{-8}$
amplitude ripple	0.5 dB/MHz ³ .	
group delay ripple	200 ns/MHz ³ .	
carrier hum modulation	≤ -23 dBc	
¹ . OPERATOR specific ² . 16 QAM in 3.2 MHz channel ³ . see [10], 5.2.2		

Table 6: Spurious Emissions in 5.12 MHz upstream channel

Parameter	During Burst transmission ¹	Between Bursts ¹
Inband	-40 dBc	-72 dBc
Adjacent channel	-44 dBc to -50 dBc ² ; (should -48 dBc to -53 dBc)	-72 dBc
Adjacent Band	-44 dBc to -54 dBc ² ; (should -50 dBc to -60 dBc)	-72 dBc
87.5 to 108 MHz in 250 kHz	≤ 30 dB(μ V)	≤ 15 dB(μ V)
108 to 136 MHz in 4.75 MHz	≤ 20 dB(μ V)	≤ 15 dB(μ V)
¹ . see [10], B.6.2.22.1 ² . 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].

TABLE 7

Index		Description	relevant for IF Spec	informative	mandatory	optional
1		SCOPE				
	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	
	1.5	Organization of Document	x		x	
2		REFERENCES				
	2.1	Normative References	x		x	
	2.2	Informative References		x		
	2.3	Reference Acquisition	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
3		TERMS AND DEFINITIONS	x		x	
4		ABBREVIATIONS AND ACRONYMS	x		x	
5		FUNCTIONAL ASSUMPTIONS	x		x	
	5.1	Equipment Assumptions		x		
	5.1.1	Frequency Plan		x		
	5.1.2	Compatibility with Other Services		x		
	5.1.3	Fault Isolation Impact on Other Users		x		
	5.1.4	Cable System Terminal Devices		x		
	5.2	RF Channel Assumptions		x		
	5.2.1	Transmission Downstream		x		
	5.2.2	Transmission Upstream		x		
	5.3	Transmission Levels		x		
	5.4	Frequency Inversion		x		
6		PHYSICAL MEDIA DEPENDENT SUBLAYER SPECIFICATION				
	6.1	Scope			x	
	6.2	Upstream	x		x	
	6.2.1	Overview	x		x	
	6.2.2	Signal Processing Requirements	x		x	
	6.2.3	Modulation Formats	x		x	
	6.2.4	R-S Encode	x		x	
	6.2.5	Upstream R-S Frame Structure for DOCSIS 3.0 Multiple Transmit Channel mode Enabled	x		x	
	6.2.6	Upstream R-S Frame Structure for DOCSIS 3.0 Multiple Transmit Channel mode Not Enabled	x		x	
	6.2.7	TDMA Byte Interleaver	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	6.2.8	Scrambler (Randomizer)	x		x	
	6.2.9	TCM Encoder		x		
	6.2.10	Preamble Prepend	x		x	
	6.2.11	Modulation Rates	x		x	
	6.2.12	S-CDMA Framer and Interleaver		x		
	6.2.13	S-CDMA Framer		x		
	6.2.14	Symbol Mapping			x	
	6.2.15	S-CDMA Spreader		x		
	6.2.16	Transmit Pre-Equalizer	x		x	
	6.2.17	Spectral Shaping	x		x	
	6.2.18	Relative Processing Delays		x		
	6.2.19	Transmit Power Requirements	x		x	
	6.2.20	Burst Profiles	x		x	
	6.2.21	Burst Timing Convention	x		x	
	6.2.22	Fidelity Requirements	x		x	
	6.2.23	Upstream Demodulator Input Power Characteristics	x		x	
	6.2.24	Upstream Electrical Output from the CM	x		x	
	6.2.25	Upstream CM Transmitter Capabilities	x		x	
	6.3	Downstream				
	6.3.1	Downstream Protocol and Interleaving Support	x		x	
	6.3.2	Downstream Electrical Input to CM	x		x	
	6.3.3	CM BER Performance	x		x	
	6.3.4	Downstream Multiple Receiver Capabilities	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	6.3.5	Non-Synchronous DS Channel Support	x		x	
ANNEX A		TIMING REQUIREMENTS FOR SUPPORTING BUSINESS SERVICES OVER DOCSIS				
	A.1	CMTS	x		x	
	A.2	CM	x		x	
ANNEX B		ADDITIONS AND MODIFICATIONS FOR EUROPEAN SPECIFICATION				
	B.1	Scope	x		x	
	B.1.1	Introduction and Purpose	x		x	
	B.1.2	Background	x		x	
	B.1.3	Requirements	x		x	
	B.1.4	Conventions	x		x	
	B.1.5	Organization of Document	x		x	
	B.2	References	x		x	
	B.2.1	Normative References	x		x	
	B.2.2	Informative References	x		x	
	B.2.3	Reference Acquisition	x		x	
	B.3	Terms and Definitions	x		x	
	B.4	Abbreviations and Acronyms	x		x	
	B.5	Functional Assumptions	x		x	
	B.5.1	Equipment Assumptions	x		x	
	B.5.2	RF Channel Assumptions	x		x	
	B.5.3	Transmission Levels	x		x	
	B.5.4	Frequency Inversion	x		x	
	B.6	Physical Media Dependent Sublayer Specification	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	B.6.1	Scope	x		x	
	B.6.2	Upstream	x		x	
	B.6.3	Downstream	x		x	
ANNEX C		MPEG HEADER SYNCHRONIZATION AND RECOVERY				
	C.1	MPEG Header Synchronization and Recovery in the North American Technology Option		x		
	C.2	MPEG Header Synchronization and Recovery in the European Technology Option	x		x	
ANNEX D		ADDITIONS AND MODIFICATIONS FOR CHINESE SPECIFICATION				
	D.1	Scope		x		
	D.1.1	Introduction and Purpose		x		
	D.1.2	Background		x		
	D.1.3	Requirements		x		
	D.1.4	Conventions		x		
	D.1.5	Organization of Document		x		
	D.2	References		x		
	D.2.1	Normative References		x		
	D.2.2	Informative References		x		
	D.2.3	Reference Acquisition		x		
	D.3	Terms and Definitions		x		
	D.4	Abbreviations and Acronyms		x		
	D.5	Functional Assumptions		x		
	D.5.1	Equipment Assumptions		x		
	D.5.2	RF Channel Assumptions		x		
	D.5.3	Transmission Levels		x		

Index		Description	relevant for IF Spec	informative	mandatory	optional
	D.5.4	Frequency Inversion		x		
	D.6	Physical Media Dependent Sublayer Specification		x		
	D.6.1	Scope		x		
	D.6.2	Upstream		x		
	D.6.3	Downstream		x		
APPENDIX I		EXAMPLE PREAMBLE SEQUENCE				
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	I.2	Example Preamble Sequence	x		x	
APPENDIX II		S-CDMA FRAMING				
	II.1	Coded Subsymbol Numbering		x		
	II.2	Uncoded Subsymbol Numbering		x		
	II.3	Framer Output Numbering		x		
	II.4	Comments		x		
APPENDIX III		AMBIENT TEMPERATURE AND WIND LOADING EFFECTS				
	III.1	Synchronization Tolerances to Plant Delay Variations	x		x	
	III.2	Change in Propagation Delay Due to Temperature Changes	x		x	
	III.2.1	Fiber Delay Changes Due to Temperature	x		x	
	III.2.2	Coaxial Cable Delay Changes Due to Temperature	x		x	
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APPENDIX IV		DESCRIPTION OF UPSTREAM TRANSMIT CHANNEL SET CAPABILITY: EXAMPLE CALCULATIONS FOR REPORTING AND FIGURING THE NUMBER OF ACTIVE CHANNELS SUPPORTED				
APPENDIX V		DESCRIPTION OF UPSTREAM CHANNEL POWER CONTROL WITH MULTIPLE UPSTREAM CHANNELS				
	V.1	DOCSIS 2.0 Parameters Extended to Multiple Transmit Channel mode	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	V.2	New Parameters in DOCSIS 3.0 Upstream Power Control ("loading," Pload_n, Pload_min_set, Dynamic Range Window, Pload_multi_n)	x		x	
	V.3	Example Upstream Power Control with Multiple Transmit Channel mode Enabled	x		x	
	V.4	Examples Regarding Concurrent and Consecutive Changes in Pr_n and Pload_min_set	x		x	
APPENDIX VI		EXAMPLE SPURIOUS EMISSIONS NOISE POWER LIMITS WITH MULTIPLE CHANNELS BURSTING	x		x	
APPENDIX VII		ACKNOWLEDGEMENTS		x		
APPENDIX VIII		REVISION HISTORY				
	VIII.1	Engineering Changes incorporated into CM-SP-PHYv3.0-I02-061222				
	VIII.2	Engineering Changes incorporated into CM-SP-PHYv3.0-I03-070223				
	VIII.3	Engineering Changes incorporated into CM-SP-PHYv3.0-I04-070518				
	VIII.4	Engineering Changes incorporated into CM-SP-PHYv3.0-I05-070803				
	VIII.5	Engineering Changes incorporated into CM-SP-PHYv3.0-I06-080215				
	VIII.6	Engineering Changes incorporated into CM-SP-PHYv3.0-I07-080522				
	VIII.7	Engineering Changes incorporated into CM-SP-PHYv3.0-I08-090121				
	VIII.8	Engineering Change incorporated into CM-SP-PHYv3.0-I09-101008				
	VIII.9	Engineering Changes incorporated into CM-SP-PHYv3.0-I10-111117				
	VIII.10	Engineering Change incorporated into CM-SP-PHYv3.0-I11-130808.				
	VIII.11	Engineering Changes incorporated into CM-SP-PHYv3.0-I12-150305.				

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].

TABLE 8

Index		Description	relevant for IF Spec	informative	mandatory	optional
1		SCOPE	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	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		
2		REFERENCES	x	x		
	2.1	Normative References	x	x		
	2.2	Informative References	x	x		
	2.3	Reference Acquisition	x	x		
3		TERMS AND DEFINITIONS	x	x		
4		ABBREVIATIONS AND ACRONYMS	x	x		
5		OVERVIEW AND THEORY OF OPERATIONS	x	x		
	5.1	DOCSIS 3.0 MULPI Key Features	x	x		

Index		Description	relevant for IF Spec	informative	mandatory	optional
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	5.2.2	DOCSIS MAC Operation	x		x	
	5.2.3	Multicast Operation	x		x	
	5.2.4	Network and Higher Layer Protocols	x		x	
	5.2.5	CM and CPE Provisioning and Management	x		x	
	5.2.6	Relationship to the Physical HFC Plant Topology	x		x	
	5.2.7	Cable Modem Service Group (CM-SG)	x	x	x	
	5.2.8	CMTS Downstream Service Model Example	x	x		
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	6.1.2	Definitions	x		x	
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	6.2	MAC Frame Formats	x	x		
	6.2.1	Generic MAC Frame Format	x		x	
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	6.4	MAC Management Messages	x		x	
	6.4.1	MAC Management Message Header	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	6.4.2	Time Synchronization (SYNC)	x		x	
	6.4.3	Upstream Channel Descriptor (UCD)	x		x	
	6.4.4	Upstream Bandwidth Allocation Map (MAP)	x		x	
	6.4.5	Ranging Request Messages	x		x	
	6.4.6	Ranging Response (RNG-RSP)	x		x	
	6.4.7	Registration Request Messages	x		x	
	6.4.8	Registration Response Messages	x		x	
	6.4.9	Registration Acknowledge (REG-ACK)	x		x	
	6.4.10	Upstream Channel Change Request (UCC-REQ)	x		x	
	6.4.11	Upstream Channel Change Response (UCC-RSP)	x		x	
	6.4.12	Dynamic Service Addition - Request (DSA-REQ)	x		x	
	6.4.13	Dynamic Service Addition - Response (DSA-RSP)	x		x	
	6.4.14	Dynamic Service Addition - Acknowledge (DSA-ACK)	x		x	
	6.4.15	Dynamic Service Change - Request (DSC-REQ)	x		x	
	6.4.16	Dynamic Service Change - Response (DSC-RSP)	x		x	
	6.4.17	Dynamic Service Change - Acknowledge (DSC-ACK)	x		x	
	6.4.18	Dynamic Service Deletion - Request (DSD-REQ)	x		x	
	6.4.19	Dynamic Service Deletion - Response (DSD-RSP)	x		x	
	6.4.20	Dynamic Channel Change - Request (DCC-REQ)	x		x	
	6.4.21	Dynamic Channel Change - Response (DCC-RSP)	x		x	
	6.4.22	Dynamic Channel Change - Acknowledge (DCC-ACK)	x		x	
	6.4.23	Device Class Identification Request (DCI-REQ)	x			x
	6.4.24	Device Class Identification Response (DCI-RSP)	x			x

Index		Description	relevant for IF Spec	informative	mandatory	optional
	6.4.25	Upstream Transmitter Disable (UP-DIS)	x		x	
	6.4.26	Test Request (TST-REQ)	x			x
	6.4.27	Downstream Channel Descriptor (DCD)	x		x	
	6.4.28	MAC Domain Descriptor (MDD)	x		x	
	6.4.29	Dynamic Bonding Change Request (DBC-REQ)	x		x	
	6.4.30	Dynamic Bonding Change Response (DBC-RSP)	x		x	
	6.4.31	Dynamic Bonding Change Acknowledge (DBC-ACK)	x		x	
	6.4.32	DOCSIS Path Verify Request (DPV-REQ)	x			x
	6.4.33	DOCSIS Path Verify Response (DPV-RSP)	x			x
	6.4.34	Status Report (CM-STATUS)	x		x	
	6.4.35	CM Control Request (CM-CTRL-REQ)	x		x	
	6.4.36	CM Control Response (CM-CTRL-RSP)	x		x	
	6.4.37	Energy Management Request (EM-REQ)	x			x
	6.4.38	Energy Management Response (EM-RSP)	x			x
	6.4.39	Status Report Acknowledge (CM-STATUS-ACK)	x		x	
7		MEDIA ACCESS CONTROL PROTOCOL OPERATION				
	7.1	Timing and Synchronization	x		x	
	7.1.1	Global Timing Reference	x		x	
	7.1.2	CM Synchronization	x		x	
	7.1.3	Ranging	x		x	
	7.1.4	Timing Units and Relationships	x		x	
	7.2	Upstream Data Transmission	x		x	
	7.2.1	Upstream Bandwidth Allocation	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	7.2.2	Upstream Transmission and Contention Resolution	x		x	
	7.2.3	Upstream Service Flow Scheduling Services	x		x	
	7.2.4	Continuous Concatenation and Fragmentation	x		x	
	7.2.5	Pre-3.0 DOCSIS Concatenation and Fragmentation	x	x		
7.3		Upstream - Downstream Channel Association within a MAC Domain	x		x	
	7.3.1	Primary Downstream Channels	x		x	
	7.3.2	MAP and UCD Messages	x		x	
	7.3.3	Multiple MAC Domains	x		x	
7.4		DSID Definition	x		x	
7.5		Quality of Service	x		x	
	7.5.1	Concepts	x	x		
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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].

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	6.1	SNMP Protocol	x		x	
	6.1.1	Requirements for IPv6	x		x	
	6.2	IPDR Protocol	x	x		
7		OSSI MANAGEMENT OBJECTS	x	x		
	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		
8		OSSI FOR PHY, MAC AND NETWORK LAYERS	x	x		
	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		
9		OSSI FOR CMCI	x			
	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
10		OSSI FOR CM DEVICE		vendor specific		
	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		
ANNEX A		Detailed MIB Requirements (Normative)	x		x	
ANNEX B		IPTR for DOCSIS Cable Data Systems Subscriber Usage Billing Records (Normative)		x		
ANNEX C		Auxiliary Schemas for DOCSIS IPDR Service Definitions (Normative)		x		
ANNEX D		Format and Content for Event, SYSLOG, and SNMP Notification (NORMATIVE)	x		x	
ANNEX E		Annex E Application of MGMD-STD-MIB to DOCSIS 3.0 MGMD Devices (NORMATIVE)	x		x	
ANNEX F		Protocol Filtering (Normative)	x		x	
ANNEX G		DIAGNOSTIC LOG (Normative)	x		x	
ANNEX H		Requirements for DOCS-IFEXT2-MIB (Normative)			x	
ANNEX I		Load Balancing Requirements (Normative)	x			x
ANNEX J		Enhanced Signal Quality Monitoring Requirements (Normative)	x		x	
ANNEX K		DOCSIS 3.0 Data Type Definitions (Normative)	x		x	
ANNEX L		Security Requirements (Normative)	x		x	

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
1		SCOPE	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		
2		REFERENCES	x		x	
	2.1	Normative References	x		x	
	2.2	Informative References	x	x		
	2.3	Reference Acquisition	x		x	
3		TERMS AND DEFINITIONS	x		x	
4		ABBREVIATIONS AND ACRONYMS	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
5		OVERVIEW	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	
6		ENCRYPTED DOCSIS MAC FRAME FORMATS				
	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	
7		BASELINE PRIVACY KEY MANAGEMENT (BPKM) PROTOCOL	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	
8		EARLY AUTHENTICATION AND ENCRYPTION (EAE)	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	
9		SECURE PROVISIONING	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		
10		USING CRYPTOGRAPHIC KEYS	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		
11		CRYPTOGRAPHIC METHODS	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	
12		PHYSICAL PROTECTION OF KEYS IN THE CM	x		x	
13		BPI+ X.509 CERTIFICATE PROFILE AND MANAGEMENT	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	
14		SECURE SOFTWARE DOWNLOAD	x	x		
	14.1	Introduction	x	x		
	14.2	Overview	x	x		
	14.3	Software Code Upgrade Requirements	x		x	
	14.3.1	Code File Processing Requirements	x		x	
	14.3.2	Code File Access Controls	x		x	
	14.3.3	Cable Modem Code Upgrade Initialization	x		x	
	14.3.4	Code Signing Guidelines	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	14.3.5	Code Verification Requirements	x		x	
	14.3.6	DOCSIS Interoperability	x		x	
	14.3.7	Error Codes	x		x	
	14.4	Security Considerations (Informative)	x	x		
ANNEX A		TFTP CONFIGURATION FILE EXTENSIONS (NORMATIVE)	x	x		
	A.1	Encodings	x		x	
	A.1.1	Baseline Privacy Configuration Setting	x		x	
	A.2	Parameter Guidelines	x		x	
ANNEX B		TFTP OPTIONS (NORMATIVE)	x		x	
ANNEX C		DOCSIS 1.1/2.0 DYNAMIC SECURITY ASSOCIATIONS (NORMATIVE)	x		x	
	C.1	Introduction	x	x		
	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	
	C.3.4	Actions	x		x	
ANNEX D		BPI/BPI+ INTEROPERABILITY	x	x		
	D.1	DOCSIS BPI/BPI+ Interoperability Requirements	x		x	
	D.2	BPI 40-bit DES Export Mode Considerations	x		x	
	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
ANNEX E		ADDITIONS AND MODIFICATIONS FOR CHINESE SPECIFICATION				
	E.1	Security requirement differences for C-DOCSIS				
APPENDIX I		EXAMPLE MESSAGES, CERTIFICATES, PDUS AND CODE FILE (INFORMATIVE)	x	x		
	I.1	Notation	x	x		
	I.2	Authentication Info	x	x		
	I.2.1	CA Certificate details	x	x		
	I.3	Authorization Request	x	x		
	I.3.1	CM Certificate details	x	x		
	I.4	Authorization Reply	x	x		
	I.4.1	RSA encryption details	x	x		
	I.4.2	RSA decryption details	x	x		
	I.4.3	Hashing details	x	x		
	I.5	Key Request	x	x		
	I.5.1	HMAC digest details	x	x		
	I.6	Key Reply	x	x		
	I.6.1	TEK encryption details	x	x		
	I.6.2	HMAC details	x	x		
	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		
	I.7.4	40-bit key	x	x		

Index		Description	relevant for IF Spec	informative	mandatory	optional
	I.8	Encryption of PDU with Payload Header Suppression (DES)	x	x		
	I.8.1	Downstream	x	x		
	I.8.2	Upstream	x	x		
	I.9	Fragmented packet encryption (DES)	x	x		
	I.10	Packet PDU encryption (AES)	x	x		
	I.10.1	CBC only	x	x		
	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		
	I.11.2	Upstream	x	x		
	I.12	Fragmented packet encryption (AES)	x	x		
	I.13	Secure Software Download CM Code File	x	x		
APPENDIX II		EXAMPLE OF MULTILINEAR MODULAR HASH (MMH) ALGORITHM IMPLEMENTATION	x	x		
APPENDIX III		CERTIFICATE AUTHORITY & PROVISIONING GUIDELINES	x		x	
	III.1	Certificate Format and Extensions	x		x	
	III.1.1	tbsCertificate.validity.notBefore and tbsCertificate.validity.notAfter	x		x	
	III.1.2	tbsCertificate.serialNumber	x		x	
	III.1.3	tbsCertificate.signature and signatureAlgorithm	x		x	
	III.1.4	tbsCertificate.issuer and tbsCertificate.subject	x		x	
	III.1.5	tbsCertificate.issuerUniqueID and tbsCertificate.subjectUniqueID	x		x	
	III.1.6	tbsCertificate.extensions	x		x	

Index		Description	relevant for IF Spec	informative	mandatory	optional
	III.1.7	Code Verification Certificate Format	x		x	
	III.1.8	signatureValue	x		x	
	III.2	Certificate Provisioning	x		x	
	III.2.1	DOCSIS Root CA	x		x	
	III.2.2	Digital Certificate Validity Period and Re-issuance	x		x	
	III.2.3	CM Code File Signing Policy	x		x	
	III.2.4	CM Code File Format	x		x	
APPENDIX IV		ACKNOWLEDGEMENTS (INFORMATIVE)	x	x		
APPENDIX V		REVISION HISTORY (INFORMATIVE)	x	x		
	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		
	V.3	Engineering Changes for CM-SP-SECv3.0-I04-070518	x	x		
	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
1				SCOPE	x	x		
	1.1			Introduction and Purpose	x	x		
	1.2			Requirements	x	x		
2				REFERENCES	x	x		
	2.1			Normative References	x		x	
	2.2			Informative References	x	x		
	2.3			Reference Acquisition	x		x	
3				TERMS AND DEFINITIONS	x		x	
4				ABBREVIATIONS AND ACRONYMS	x		x	
5				OVERVIEW	x	x		
	5.1			Service Goals	x	x		
	5.2			Reference Architecture	x		x	
6				NORMATIVE REQUIREMENTS	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				
APPENDIX I				ACKNOWLEDGMENTS	x	x		
APPENDIX II				REVISION HISTORY	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.

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.

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)

History

Document history		
<Version>	<Date>	<Milestone>
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