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

Version 1.0

ANGA Verband Deutscher Kabelnetzbetreiber e.V.

Nibelungenweg 2
D-50996 Köln Germany

Tel.: +49 221 390 900 17 Fax: +49 221 390 900 10

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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.

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-OSSIv3.0-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 asemblies - 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 Ω 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 Commitee 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.

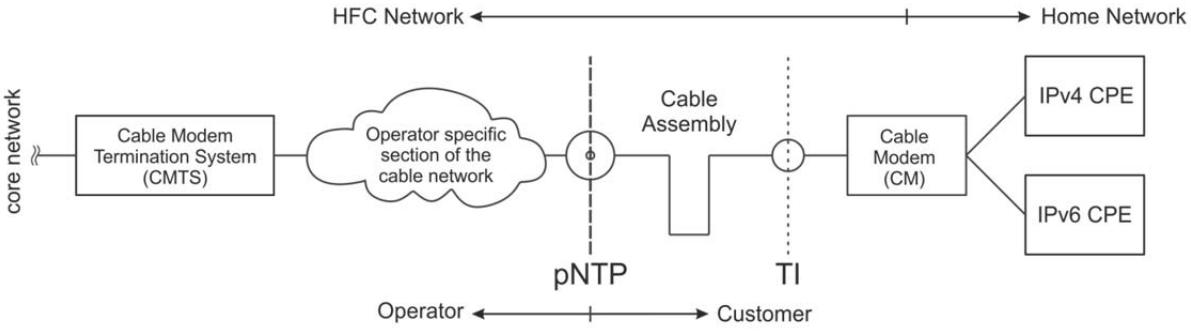

Figure 1: Location of the pNTP within the HFC network.

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 ± 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.

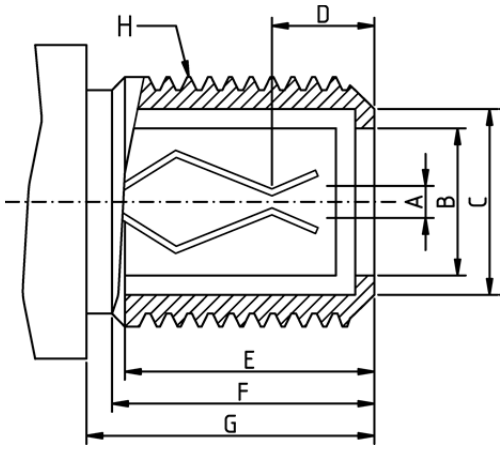

Figure 2: Type F connector with socket centre contact

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 mΩ and the DC contact resistance shall be less than 10 mΩ.

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

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(µV) ([10], B.6.3.2)	
analogue carriers		68
analogue video carrier level	60 to 77 dB(µV) ([6], Chapter 5.4.1)	80 dB(µV)
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(µV) (see [6], Chapter 5.4.1)	
64 QAM BER (pre FEC)	< 1 x 10^{-7} (typ. 1 x 10^{-8})	1 x 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(µV) (see [6], Chapter 5.4.1)	
256 QAM BER (pre FEC)	< 1 x 10^{-6} (typ. 1 x 10^{-7})	1 x 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.]
≤ 0,5 µs	-10 dBc
≤ 1,0 µs	-15 dBc
≤ 1,5 µs	-20 dBc
> 1,5 µs	-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(µV) to 110 dB(µV)	114 dB(µV)
C/(N+I)[2.]		≥ 71 dB[1.]
BER[2.]		≤ 10^{-9}
PER[2.]		≤ 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(µV)	≤ 15 dB(µV)
108 to 136 MHz in 4.75 MHz	≤ 20 dB(µV)	≤ 15 dB(µV)
[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].

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	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

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Index			Description	relevant for IF Spec	informative	mandatory	optional
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		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	
APPENDIX II			**PLANT TOPOLOGIES (INFORMATIVE)**	**x**	**x**		
	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		
APPENDIX III			**DOCSIS TRANSMISSION AND CONTENTION RESOLUTION (INFORMATIVE)**	**x**	**x**		
	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		
APPENDIX IV			**UNSOLICITED GRANT SERVICES (INFORMATIVE)**	**x**		**x**	
	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	
APPENDIX V			**ERROR RECOVERY EXAMPLES (INFORMATIVE)**	**x**	**x**		
APPENDIX VI			**SDL NOTATION (INFORMATIVE)**				
APPENDIX VII			**NOTES ON ADDRESS CONFIGURATION IN DOCSIS 3.0 (INFORMATIVE)**	**x**	**x**		
APPENDIX VIII			**IP MULTICAST REPLICATION EXAMPLES (INFORMATIVE)**	**x**	**x**		
	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				
APPENDIX IX			**IGMP EXAMPLE FOR DOCSIS 2.0 BACKWARDS COMPATIBILITY MODE (INFORMATIVE)**				
	IX.1		Events				
	IX.2		Actions				
APPENDIX X			**CM MULTICAST DSID FILTERING SUMMARY (INFORMATIVE)**	**x**	**x**		
APPENDIX XI			**EXAMPLE DHCPV6 SOLICIT MESSAGE CONTENTS (INFORMATIVE)**	**x**	**x**		
APPENDIX XII			**DYNAMIC OPERATIONS EXAMPLES (INFORMATIVE)**	**x**	**x**		
	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				
APPENDIX XIII			**ACKNOWLEDGEMENTS (INFORMATIVE)**				
	XIII.1		MAC Focus Team				
	XIII.2		USCB Focus Team				
	XIII.3		IPv6 Focus Team				
	XIII.4		IP Multicast Focus Team				
APPENDIX XIV			**REVISION HISTORY (INFORMATIVE)**				
	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				
	XIV.24		Engineering Changes for CM-SP-MULPIv3.0-I25-140729				
	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
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	
5			**OVERVIEW**	x	x		
	5.1		New DOCSIS 3.0 Security Features	x		x	

Index			Description	relevant for IF Spec	informative	mandatory	optional
	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	
		7.1.5	TEK State Machine	x		x	
	7.2		Key Management Message Formats	x		x	

Index			Description	relevant for IF Spec	informative	mandatory	optional
		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	
		9.3.1	Securing DHCP on the Cable Network Link	x		x	
		9.3.2	DHCPv6	x		x	

Index			Description	relevant for IF Spec	informative	mandatory	optional
	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	
		11.7.2	Definition of MMH-MAC	x		x	
		11.7.3	Calculating the DOCSIS MMH-MAC	x		x	

Index			Description	relevant for IF Spec	informative	mandatory	optional
		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	
		14.3.5	Code Verification Requirements	x		x	
		14.3.6	DOCSIS Interoperability	x		x	

Index			Description	relevant for IF Spec	informative	mandatory	optional
		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		
ANNEX E			**ADDITIONS AND MODIFICATIONS FOR CHINESE SPECIFICATION**				
	E.1		Security requirement differences for C-DOCSIS				

Index			Description	relevant for IF Spec	informative	mandatory	optional
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		
	I.8		Encryption of PDU with Payload Header Suppression (DES)	x	x		
		I.8.1	Downstream	x	x		

Index			Description	relevant for IF Spec	informative	mandatory	optional
		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	
		III.1.7	Code Verification Certificate Format	x		x	
		III.1.8	signatureValue	x		x	

Index			Description	relevant for IF Spec	informative	mandatory	optional
	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		
	V.14		Engineering Change for CM-SP-SECv3.0-I15-130808	x	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	
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	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**		
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	1.2				Requirements	x	x		
2					**REFERENCES**	x	x		
	2.1				Normative References	x		x	
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3					**TERMS AND DEFINITIONS**	x		x	
4					**ABBREVIATIONS AND ACRONYMS**	x		x	
5					**OVERVIEW**	x	x		
	5.1				Service Goals	x	x		
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			6.2.1.1		Data Link Layer				
			6.2.1.2		Physical (PHY) Layer				
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Index					Description	relevant for IF Spec	informative	mandatory	optional
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				6.2.2.4.3	802.3 Medium Access Control (MAC) Sublayer 16				
				6.2.2.4.4	Ethernet				
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				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 One end Other end	According to [i.4] 90 degrees angled Straight
Attenuation 5 to 1006 MHz 1006 to 2400 MHz	 ≤ 0.6 dB/m ≤ 0.9 dB/m
Return Loss 5 to 12 MHz 12 to 30 MHz 30 to 300 MHz 300 to 470 MHz 470 to 1006 MHz 1006 to 1700 MHz 1700 to 2400 MHz	 ≥ 20 dB ≥ 25 dB ≥ 25 dB ≥ 23 dB ≥ 18 dB ≥ 15 dB ≥ 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)

History

Document history		
<Version>	<Date>	<Milestone>
1	2016/07/04	Initial version V1.0 (2016-7)