Telecommunications Standards Advisory Committee (TSAC)

Technical Specification

Cable Modems connected to High-Speed Data-Over-Cable-Systems

IDA TS CM
Issue 2, October 2013

Infocomm Development Authority of Singapore
Resource Management & Standards
10 Pasir Panjang Road
#10-01 Mapletree Business City
Singapore 117438

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IDA TS CM Issue 2, October 2013	Technical Specification for Cable Modems connected to High-Speed Data-Over-Cable-Systems
TSAC SWG Chairman	Pyai Phyo Aung, Senior Engineer (Business Solutions & Fixed Services, StarHub Information Services and Network Engineering), StarHub Ltd
TSAC SWG/TF Editors	Pyai Phyo Aung, Senior Engineer (Business Solutions & Fixed Services, StarHub Information Services and Network Engineering), StarHub Ltd
	Woo Yim Leng, Senior Manager (Resource Management & Standards), Infocomm Development Authority of Singapore

List of TSAC SWG Members

SN	Organisation	Name
1	Singapore Telecommunications Ltd	Mr Tay Wee Chin Senior Manager
2	StarHub Ltd	Mr Pyai Phyo Aung Senior Engineer
3		Mr Chow Yew Weng Manager
4		Mr Jason Ng Wee Peng Senior Engineer
5	Infocomm Development Authority of Singapore	Ms Woo Yim Leng Senior Manager
6		Mr Ian Teo Manager

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Mr Raymond Lee — Director (Resource Management & Standards)
Infocomm Development Authority of Singapore

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Ms Tan Sze Siang	Deputy Director (Digital Broadcasting Deployment Office) Media Development Authority
Mr Patrick Scodeller	Chief Technical Officer M1 Limited
Mr Lee Wing Kai	General Manager Engineering Radio Planning M1 Limited
Assoc Prof Li Kwok Hung	Nanyang Technological University School of Electrical & Electronic Engineering
Assoc Prof Xiao Gaoxi	Nanyang Technological University School of Electrical & Electronic Engineering
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Prof Ko Chi Chung	National University of Singapore Department of Electrical & Computer Engineering
Assoc Prof Tham Chen Khong	National University of Singapore Department of Electrical & Computer Engineering
Mr Chong Siew Loong	Vice President (Network and Systems) Nucleus Connect Pte Ltd
Mr Tiong Onn Seng	Director – Project Opennet Pte Ltd

Mr Daniel Teo	Director – Technical Services Opennet Pte Ltd
Mr Aw Peng Soon	Chairman of SiTF Wireless Chapter VP, ANTLabs Singapore Infocomm Technology Federation
Mr Huang Ee Choon	Deputy Director Communications & Information Technology Singapore Institute of Technology
Mr Lee Siak Kwee	Director (Radio Network Access & Quality) Singapore Telecommunications Ltd
Mr Lim Yong Nam	Director (Voice Engineering, Next Gen IP Networks) Singapore Telecommunications Ltd
Mr Lee Yeu Ching	Director (Outside Plant Engineering) Singapore Telecommunications Ltd
Mr Soh Keng Hock	Director (Private IP Engineering) Singapore Telecommunications Ltd
Dr Wong Woon Kwong	Director of the Office of Research and Industry Collaborations Singapore University of Technology and Design
	Standards Division Spring Singapore
Mr Tay Wei Kiang	Assistant Vice President Business Solutions & Fixed Services StarHub Integrated Network Engineering StarHub Ltd
Mr Liong Hang Chew	Assistant Vice President Personal Solutions & Integrated Applications StarHub Integrated Network Engineering StarHub Ltd
Ms Woo Yim Leng	Senior Manager Infocomm Development Authority of Singapore

Contents

1 Scope

1.1 This Specification defines the Radio Frequency Interface (RFI) requirements of the Cable Modem (CM) for connection to 2nd and 3rd generations of the high-speed data-over-cable systems (DOCS) based on the following ITU-T Recommendations:

	ITU-T Rec.	Title	Equivalent DOCS Interface Spec.
(a)	J.122 (12/2007)	Second-generation transmission systems for interactive cable television services – IP cable modems	DOCSIS 2.0
(b)	J.222.1 (07/2007)	Third-generation transmission systems for interactive cable television services – IP cable modems: Physical Layer specification	DOCSIS 3.0
	J.222.2 (07/2007)	Third-generation transmission systems for interactive cable television services – IP cable modems: MAC and upper layer protocols	
	J.222.3 (11/2007)	Third-generation transmission systems for interactive cable television services – IP cable modems: Security services	

CM shall comply with requirements outlined in this Specification in accordance with (a) J.122; or (b) J.222.1, J.222.2 and J.222.3.

1.2 The intent is to permit deployment of data-over-cable systems in a multi-vendor inter-operable environment. The simplified form of data-over-cable service is shown in Figure 1 where bi-directional Internet Protocol (IP) traffic is transferred transparently between the cable system head-end and the customer premises, over all-coaxial or hybrid fibre-coax (HFC) network.

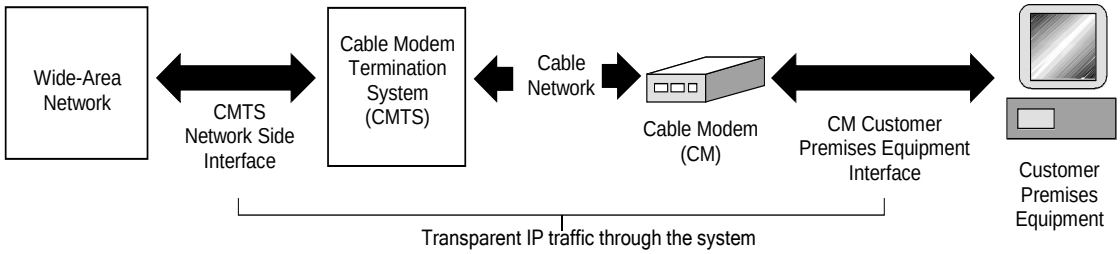


Figure 1 (Figure 1-1 of ITU-T Rec. J.112 Annex B/J.122 & Figure 1-2 of ITU-T Rec.J.222.1):
Transparent IP traffic through the data-over-cable system

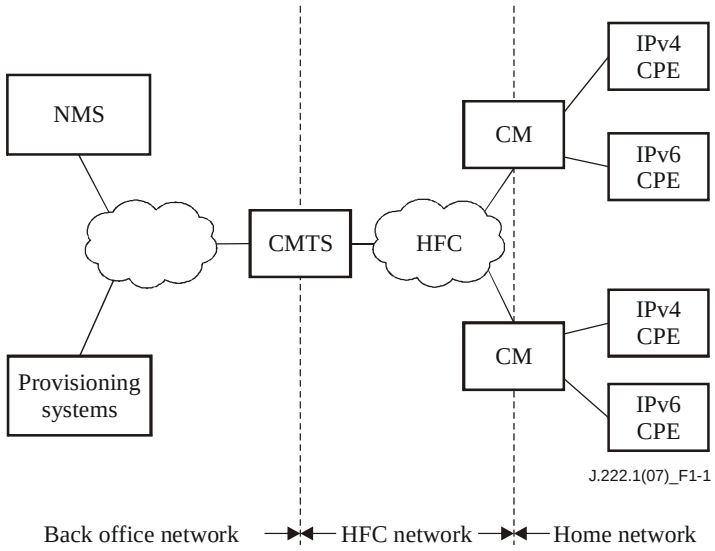


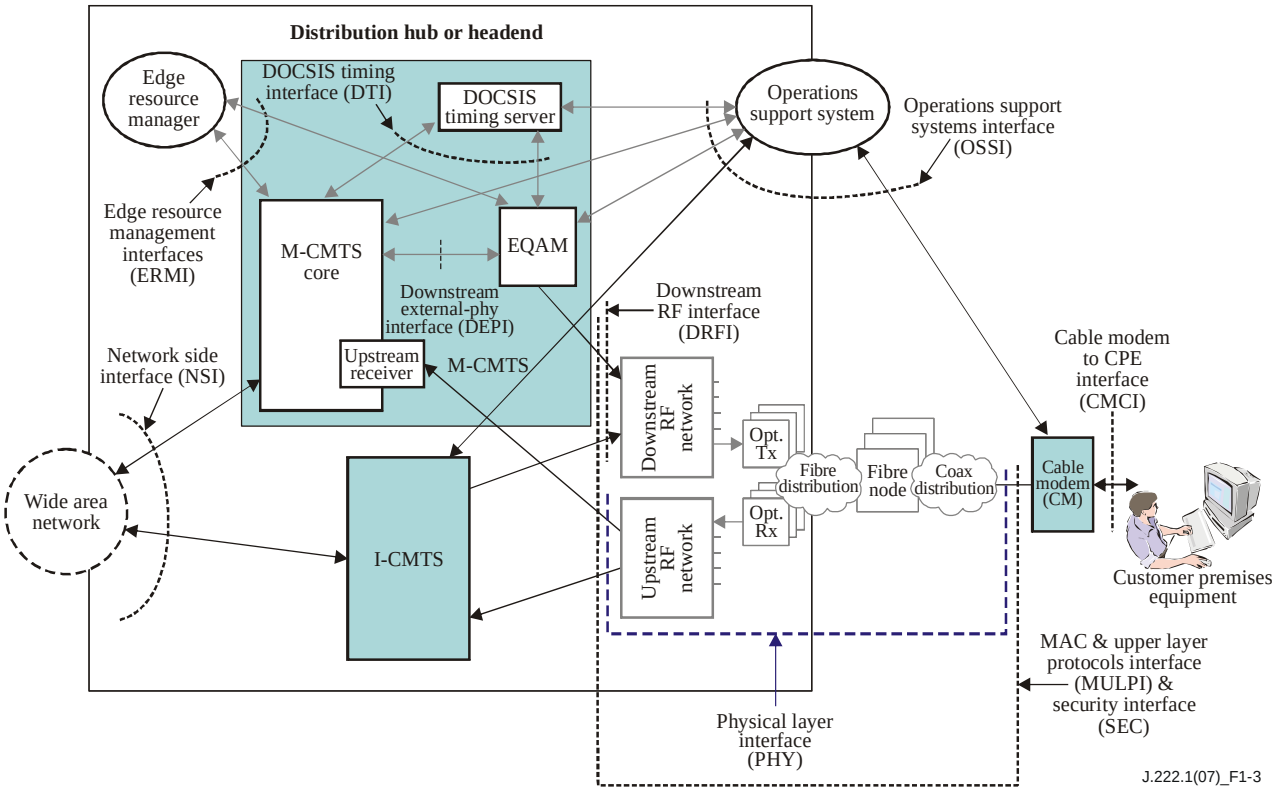
Figure 2 (Figure 1-1 of ITU-T Rec. J.222.1):
The DOCSIS Network

1.3 The CM connects to the operator's HFC network and to a home network, bridging packets between them. Many Customer Premises Equipment (CPE) devices can connect to the CMs' Local Area Network (LAN) interfaces. CPE devices can be embedded with the CM in a single device, or they can be separate standalone devices, as shown in Figure 2. CPE devices may use IPv4, IPv6 or both forms of IP addressing. Examples of typical CPE devices are home routers, set-top devices, personal computers, etc. The CMTS connects the operator's back office (Network Management System and Provisioning Systems) and core network with the HFC network. Its main function is to forward packets between these two domains, and between upstream and downstream channels on the HFC network.

1.4 The reference architecture is shown in Figure 3.

1.5 The third-generation transmission systems based on ITU-T Recommendations J.222.1 to J.222.3, introduce a number of new features that built upon what were present in previous ITU-T Recommendations J.112 and J.122. The ITU-T Recommendation J.222.2 includes key new features for the MAC and Upper Layer Protocols Interface, and defines the MAC layer protocols as well as requirements for upper layer protocols (e.g., IP, DHCP, etc.).

1.6 Specific local network implementations are also included as Annex B to this Specification. The CM shall be able to inter-work properly with the local cable network, and tested according to requirements set out in Annex B.



NOTE – Lighter shaded areas are related functionality, but out of the scope of this Recommendation.

Figure 3 (Figure 1-3 of ITU-T Rec. J.222.1):
Data-over-cable reference architecture

2 General Requirements

2.1 Power Supply

The equipment may be AC powered or DC powered. For AC powered equipment, the Specification shall be complied with when operating from an AC mains supply of voltage, 230V ± 10% and frequency, 50 Hz ± 2%. Where external power supply is used, e.g. AC adaptor, it shall not affect the capability of the equipment to meet the Specification.

2.2 Identification of Equipment

The equipment shall be marked with the supplier or manufacturer's name or identification mark, and the supplier or manufacturer's model or type reference. The markings required shall be legible, indelible and readily visible.

2.3 Electromagnetic Compatibility & Electrical Safety Requirements

2.3.1 The equipment shall comply with the limits for conducted disturbance at the mains terminals and telecommunication ports, and the limits for radiated disturbance defined in the ISO/IEC CISPR 22.

2.3.2 The equipment shall comply with the IEC 60950-1 safety standard[1]. The requirements in IEC 60950-1 that are applicable to the equipment [e.g. class of equipment, type of telecommunication network voltage (TNV) circuit and types of components] shall be identified and complied with.

[1] The safety standard includes, among others, protection of telecommunications network service personnel and users of other equipment connected to the network from hazards in the equipment.

3 References

3.1 For the technical requirements captured in this Specification, reference has been made to the following documents:

ITU-T Rec. J.122 (12/2007)	Second-generation transmission systems for interactive cable television services – IP cable modems
ITU-T Rec. J.222.1 (07/2007)	Third-generation transmission systems for interactive cable television services – IP cable modems: Physical Layer specification
ITU-T Rec. J.222.2 (07/2007)	Third-generation transmission systems for interactive cable television services – IP cable modems: MAC and upper layer protocols
ITU-T Rec. J.222.3 (11/2007)	Third-generation transmission systems for interactive cable television services – IP cable modems: Security services
ITU-T Rec. J.125 (12/2007)	Link Privacy for Cable Modem Implementations
ITU-T Rec. J.167 (12/2007)	Media terminal adapter (MTA) device provisioning requirements for the delivery of real-time services over cable television networks using cable modems
ITU-T Rec. J.173 (11/2005)	IPCablecom embedded MTA primary line support
ITU-T Rec. J.160 (11/2005)	Architectural framework for the delivery of time critical services over cable television networks using cable modems
ITU-T Rec. J.161 (06/2007)	Audio codec requirements and usage for the provision of bidirectional audio service over cable television networks using cable modems
ITU-T Rec. J.162 (12/2007)	Network call signalling protocol for the delivery of time critical services over cable television networks using cable modems
IEC 60950-1: 2005	Information Technology Equipment – Safety
IEC CISPR 22: 2008	Information Technology Equipment – Radio disturbance characteristics – Limits and methods of measurement

4 General CM – DOCS Requirements

Note: Conformance with requirements outlined in this Specification is mandatory unless indicated as an optional requirement, general information, or denoted with a "MAY" in the Remarks column.

Table 1: Scope and Purpose			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.1**	**Remarks**
Scope & Purpose	**1**	**1**	The first[2] technology option has been adopted in Singapore, which is based on the downstream multi-programme television distribution, which deploys 6 MHz channelling, and supports upstream transmission in the 5-42 MHz region.
Network and system architecture	-	1.2.2	CPE devices may use IPv4, IPv6 or both forms of IP addressing. Examples of typical CPE devices are home routers, set-top devices, personal computers, etc.
Statement of compatibility	1.3.4	1.2.4	Second generation of the interface commonly referred to as DOCSIS 2.0 must be backward and forward compatible. DOCSIS 3.0 compliant CMs MUST interoperate seamlessly with DOCSIS 2.0 and DOCSIS 1.X CMTSs, albeit in the 2.0 and 1.X modes, as the case may be..
References	**2**	**2**	Normative and Informative
Definitions and abbreviations	**3**	**3**	General Information
Abbreviations, acronyms and conventions	**-**	**4**	General Information

[2] StarHub Cable Vision (SCV) has implemented the first option, which is based on the technology option deployed in North America.

Table 2: Functional assumptions			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.1**	**Remarks**
Functional assumptions	**4**	**5**	The data-over-cable system MUST be interoperable within the environment described in this clause.
Frequency plan	4.2.1	5.1.1	Whenever any reference in this clause to frequency plans or compatibility with other services conflicts with any legal requirement for the area of operation, the latter shall take precedence.
Compatibility with other services	4.2.2	5.1.2	The CM and CMTS MUST coexist with the other services on the cable network.
Fault isolation impact on other users	4.2.3	5.1.3	Fault-isolation procedures should take into account the potential harmful impact of faults and fault-isolation procedures on numerous users of the data-over-cable and other services.
Cable System Terminal Devices	4.2.4	5.1.4	The CM MUST meet and preferably exceed all applicable regulations for cable system termination devices and cable ready consumer equipment as defined in national regulations. None of these national specific requirements may be used to relax any of the specifications contained elsewhere within the present document.
Transmission downstream	4.3.1	5.2.1	Assumed downstream RF channel transmission characteristics
Transmission upstream	4.3.2	5.2.2	Assumed upstream RF channel transmission characteristics
Transmission Levels	4.4	5.3	The nominal power level of the upstream CM signal(s) will be as low as possible to achieve the required margin above noise and interference.
Frequency Inversion	4.5	5.4	There will be no frequency inversion in the transmission path in either the downstream or upstream directions.

Table 3: Communication Protocols		
Title	**ITU-T Rec. J.122**	**Remarks**
Communication protocols	**5**	
Protocol stack	**5.1**	
CM and CMTS as hosts	5.1.1	The CM MUST function as IP hosts.
		The CM MUST support IP and ARP over DIX link-layer framing.
		The CM MAY transmit frames that are smaller than the DIX 64 byte minimum on an upstream channel. (See Note 1)
		The CM MAY also support IP and ARP over SNAP framing. (See Note 1)
		The CM MUST function as LLC hosts.
		The CM MUST respond appropriately to TEST and XID requests. (See Note 2)
Data forwarding through the CM and CMTS	5.1.2	Heading
General	5.1.2.1	Forwarding of IP traffic MUST be supported. Other network layer protocols MAY be supported. The ability to restrict the network layer to a single protocol such as IP MUST be supported.
CMTS forwarding rules	5.1.2.2	General Information
CM forwarding rules	5.1.2.3	

Table 3: Communication Protocols (Continued)		
Title	**ITU-T Rec. J.122**	**Remarks**
The MAC Forwarder	**5.2**	General Information
Network Layer	**5.3**	The network layer protocol is the Internet protocol (IP) version 4, as defined in [RFC 791], and IP version 6, as defined in [RFC3513]
Requirements for IGMP management	5.3.1	Active and Passive IGMF devices MUST support IGMPv2 [RFC-2236]. (See Note 3)
IGMP timer requirements	5.3.1.1	
CMTS rules	5.3.1.2	General Information
CM rules	5.3.1.3	CM MUST support IGMP following the cable specific rules given in this clause.
		The CM must implement the passive IGMP mode.
		In active IGMP mode, the CM must have the capability to switch between modes. (See Note 3)
Above the Network Layer	5.4	In addition to the transport of user data, there are several network management and operation capabilities, which depend upon the Network Layer. These include: – SNMP (Simple Network Management Protocol [RFC-1157]) MUST be supported. – TFTP (Trivial File Transfer Protocol [RFC-1350]) MUST be supported. – DHCP (Dynamic Host Configuration Protocol [RFC-2131]) MUST be supported. – Time of Day Protocol [RFC-868], MUST be supported. – DHCP, TFTP and ToD client messages generated by the CM MUST only be sent via the RF Interface. – The CM's DHCP, TFTP and ToD client MUST ignore DHCP, TFTP and ToD server messages received on the CMCI port.
Data Link Layer	5.5	
LLC sublayer	5.5.1	
Link-layer security sublayer	5.5.2	
MAC sublayer	5.5.3	General Information
Physical Layer	5.6	General Information
Downstream transmission convergence sublayer	5.6.1	The downstream transmission convergence sublayer is defined in clause 7.
PMD sublayer	5.6.2	The physical media dependent sublayer is defined in clause 6.
Note 1: Not supported by StarHub Cable Vision. Note 2: The CPE Controlled Cable Modem (CCCM) hard ware must not respond to [ISO8802-2] LLC host request (TEST and XID) addressed to either a Host CPE MAC address or the CM MAC address – this is the responsibility of the host CPE. The CM must pass TEST and XID frames transparently to the host CPE without responding to them on its own. Note 3: StarHub Cable Vision requires CM to implement the IGMP mode.		

5 Physical Layer Specification

Table 4: Physical Media Dependent Sublayer Specification			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.1**	**Remarks**
Physical Media Dependent Sublayer Specification	**6**	**6**	Heading
Scope	**6.1**	**6.1**	First technology option
Upstream	**6.2**	**6.2**	Heading
Overview	6.2.1	6.2.1	The upstream physical media dependent (PMD) sublayer uses an FDMA/TDMA (herein called TDMA mode) or FDMA/TDMA/S-CDMA (herein called S-CDMA mode) burst type format, which provides six modulation rates and multiple modulation formats. The use of TDMA or S-CDMA mode is configured by the CMTS via MAC messaging.
Signal processing requirements	6.2.2	6.2.2	
Modulation formats	6.2.3	6.2.3	
FEC Encode	-	-	
R-S encode	6.2.4	6.2.4	
R-S frame structure	6.2.5	-	
Upstream R-S frame structure for DOCSIS 3.0 multiple transmit channel mode enabled	-	6.2.5	This clause applies to CMs operating in DOCSIS 3.0 multiple transmit channel mode enabled in the upstream direction.
Upstream R-S frame structure for DOCSIS 3.0 multiple transmit channel mode not enabled	-	6.2.6	
TDMA byte interleaver	6.2.6	6.2.7	
Scrambler (Randomizer)	6.2.7	6.2.8	
TCM encoder	6.2.8	6.2.9	
Preamble prepend	6.2.9	6.2.10	
Modulation rates	6.2.10	6.2.11	
S-CDMA framer and interleaver	6.2.11	6.2.12	
S-CDMA framer	6.2.12	6.2.13	
Symbol mapping	6.2.13	6.2.14	
S-CDMA spreader	6.2.14	6.2.15	
Transmit pre-equalizer	6.2.15	6.2.16	
Spectral shaping	6.2.16	6.2.17	
Relative processing delays	6.2.17	6.2.18	
Transmit power requirements	6.2.18	6.2.19	
Burst profiles	6.2.19	6.2.20	
Burst timing convention	6.2.20	6.2.21	
Fidelity requirements	6.2.21	6.2.22	
Upstream demodulator input power characteristics	6.2.22	6.2.23	
Upstream electrical output from the CM	6.2.23	6.2.24	
Upstream CM transmitter capabilities	-	6.2.25	

Table 4: Physical Media Dependent Sublayer Specification (Continued)			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.1**	**Remarks**
Downstream	**6.3 (**Note 1)	**6.3**	Heading
Downstream Protocol	6.3.1	6.3.1	
Scalable Interleaving to Support Low Latency	6.3.2		
Downstream protocol and interleaving support	-	6.3.1	
Downstream Frequency Plan	6.3.3	-	General Information
CMTS Electrical Output	6.3.4	-	General Information
Downstream Electrical Input to CM	6.3.5	6.3.2	
CM BER Performance	6.3.6	6.3.3	
Downstream multiple receiver capabilities	-	6.3.4	
Non-synchronous DS channel support	-	6.3.5	
CMTS Timestamp Jitter	6.3.7	-	General Information
CMTS clock generation	6.3.8	-	General Information
CMTS downstream symbol clock jitter for synchronous operation	6.3.9	-	General Information
CMTS downstream symbol clock drift for synchronous operation	6.3.10	-	General Information
Timing requirements for supporting business services over DOCSIS	**-**	**Annex A**	Optional
Additions and modifications for 8 MHz channel spacing	**-**	**Annex B**	Not Applicable
MPEG header synchronization and recovery	**-**	**Annex C**	Optional
Japan specification additions	**-**	**Annex D**	Not Applicable
Example preamble sequence	**-**	**Appendix I**	General Information
S-CDMA framing	**-**	**Appendix II**	General Information
Ambient temperature and wind loading effects	**-**	**Appendix III**	General Information
Description of upstream transmit channel set capability: Example calculations for reporting and figuring the number of active channels supported	**-**	**Appendix IV**	General Information
Description of upstream channel power control with multiple upstream channels	**-**	**Appendix V**	General Information
Example spurious emissions noise power limits with multiple channels bursting	**-**	**Appendix VI**	General Information
Note 1: This Recommendation applies only to a CMTS supporting exactly one QAM channel per RF output port.			

Table 5 : Downstream Transmission Convergence Sublayer		
Title	**ITU-T Rec. J.122**	**Remarks**
Downstream Transmission Convergence Sublayer	**7**	
Introduction	**7.1**	First technology option
MPEG Packet Format	**7.2**	
MPEG Header for DOCS Data-Over-Cable	**7.3**	
MPEG Payload for DOCS Data-Over-Cable	**7.4**	
Interaction with the MAC Sublayer	**7.5**	
Interaction with the Physical Layer	**7.6**	
MPEG Header Synchronization and Recovery	**7.7**	Optional (Note 1)
Note 1: Not supported by StarHub Cable Vision.		

6 Media Access Control Specification

Table 6 : Media Access Control Specification			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.2**	**Remarks**
Media Access Control Specification	**8**	**6**	Heading
Introduction	**8.1**	6.1	Heading
Overview	8.1.1	6.1.1	General Information
Definitions	8.1.2	6.1.2	Heading
MAC-Sublayer Domain	8.1.2.1	6.1.2.1	General Information
MAC Service Access Point	8.1.2.2	6.1.2.2	General Information
Service Flows	8.1.2.3	6.1.2.3	For the network to function properly, the CM MUST support at least 1 upstream and 1 downstream Service Flow.
Upstream Intervals, Mini-Slots and 6.25-Microsecond Increments	8.1.2.4		General Information
Upstream Intervals, Mini-Slots and Timebase Tick Increments	-	6.1.2.4	General Information
MAC Frame	8.1.2.5	6.1.2.5	General Information
Logical upstream channels	8.1.2.6	6.1.2.6	
DOCS 2.0-only logical upstreams	8.1.2.7	-	
Future Use	8.1.3	6.1.3	
MAC Frame Formats	**8.2**	**6.2**	Heading
Generic MAC Frame Format	8.2.1	6.2.1	
PMD Overhead	8.2.1.1	6.2.1.1	
MAC Frame Transport	8.2.1.2	6.2.1.2	
Ordering of Bits and Octets	8.2.1.3	6.2.1.3	
MAC Header Format	8.2.1.4	6.2.1.4	
Data PDU	8.2.1.5	6.2.1.5	
Packet-Based MAC Frames	8.2.2	6.2.2	
ATM Cell MAC Frames	8.2.3	6.2.3	
Reserved PDU MAC Frames	8.2.4	-	
MAC-Specific Headers	8.2.5	6.2.4	
Extended MAC Headers	8.2.6	6.2.5	
Fragmented MAC Frames	8.2.7	-	
Error-Handling	8.2.8	-	
Segment Header Format	**-**	**6.3**	
MAC Management Messages	**8.3**	**6.4**	Heading
MAC Management Message Header	8.3.1	6.4.1	
Time Synchronization (SYNC)	8.3.2	6.4.2	Transmitted by CMTS
Upstream Channel Descriptor (UCD)	8.3.3	6.4.3	Transmitted by CMTS
Upstream Bandwidth Allocation Map (MAP)	8.3.4	6.4.4	Generated by CMTS
Ranging Request (RNG-REQ)	8.3.5	6.4.5	
Ranging Response (RNG-RSP)	8.3.6	6.4.6	Transmitted by CMTS
Registration Request (REG-REQ)	8.3.7	6.4.7	The CM transmits a Registration Request message after receipt of a CM configuration file as specified in clause 10.2.
Registration Response (REG-RSP)	8.3.8	6.4.8	Transmitted by CMTS
Registration Acknowledge (REG-ACK)	8.3.9	6.4.9	

Table 6 : Media Access Control Specification (Continued)			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.2**	**Remarks**
Upstream Channel Change Request (UCC-REQ)	8.3.10	6.4.10	May be transmitted by CMTS However, for backward compatibility, a CM MUST support the receipt of an UCC-REQ message.
Upstream Channel Change Response (UCC-RSP)	8.3.11	6.4.11	
Dynamic Service Addition – Request (DSA-REQ)	8.3.12	6.4.12	
Dynamic Service Addition – Response (DSA-RSP)	8.3.13	6.4.13	
Dynamic Service Addition – Acknowledge (DSA-ACK)	8.3.14	6.4.14	
Dynamic Service Change – Request (DSC-REQ)	8.3.15	6.4.15	
Dynamic Service Change – Response (DSC-RSP)	8.3.16	6.4.16	
Dynamic Service Change – Acknowledge (DSC-ACK)	8.3.17	6.4.17	
Dynamic Service Deletion – Request (DSD-REQ)	8.3.18	6.4.18	
Dynamic Service Deletion – Response (DSD-RSP)	8.3.19	6.4.19	
Dynamic Channel Change – Request (DCC-REQ)	8.3.20	6.4.20	
Dynamic Channel Change – Response (DCC-RSP)	8.3.21	6.4.21	
Dynamic Channel Change – Acknowledge (DCC-ACK)	8.3.22	6.4.22	General Information
Device Class Identification Request (DCI-REQ)	8.3.23	6.4.23	Optional (Note 1)
Device Class Identification Response (DCI-RSP)	8.3.24	6.4.24	General Information
Upstream Transmitter Disable (UP-DIS)	8.3.25	6.4.25	Optional (Note 1)
Initial ranging request (INIT-RNG-REQ)	8.3.26	-	
Test request (TST-REQ)	8.3.27	6.4.26	
Downstream Channel Descriptor (DCD)	-	6.4.27	The format and usage of the DCD message is defined in [ITU-T J.128].
MAC Domain Descriptor (MDD)	-	6.4.28	
Dynamic Bonding Change Request (DBC-REQ)	-	6.4.29	Transmitted by CMTS.
Dynamic Bonding Change Response (DBC-RSP)	-	6.4.30	
Dynamic Bonding Change Acknowledge (DBC-ACK)	-	6.4.31	Transmitted by CMTS.
DOCSIS Path Verify Request (DPV-REQ)	-	6.4.32	
DOCSIS Path Verify Response (DPV-RSP)	-	6.4.33	
Status Report (CM-STATUS)	-	6.4.34	
CM Control Request (CM-CTRL-REQ)	-	6.4.35	
CM Control Response (CM-CTRL-RSP)	-	6.4.36	
Note 1: Requirements are mandatory if clauses are applicable.			

Table 7 : Media Access Control Protocol Operation			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.2**	**Remarks**
Media Access Control Protocol Operation	**9**	**7**	Heading
Upstream Bandwidth Allocation	**9.1**	**7.2.1**	
The Allocation Map MAC Management Message	9.1.1	7.2.1.1	General Information
Information Elements	9.1.2	7.2.1.2	
Requests	9.1.3	-	
Requesting with Multiple Transmit Channel Mode Disabled	-	7.2.1.3	
Requesting with Multiple Transmit Channel Mode Enabled	-	7.2.1.4	
Information Element Feature Usage Summary	9.1.4	7.2.1.5	
Map Transmission and Timing	9.1.5	7.2.1.6	
Protocol Example	9.1.6	7.2.1.7	
MAP generation example – Two logical upstreams	9.1.7	7.2.1.8	
Support for Multiple Channels	**9.2**	-	Optional (Note 1)
Timing and Synchronisation	**9.3**	**7.1**	
Global Timing Reference	9.3.1	7.1.1	
CM Channel Acquisition	9.3.2	-	
CM Synchronization	-	7.1.2	
Ranging	9.3.3	7.1.3	
Timing Units and Relationships	9.3.4	7.1.4	
Upstream Transmission and Contention Resolution	**9.4**	**7.2.2**	General Information
Contention Resolution Overview	9.4.1	7.2.2.1	
Transmit Opportunities	9.4.2	7.2.2.2	
CM Bandwidth Utilization	9.4.3	7.2.2.3	
Data Link Encryption Support	**9.5**	**7.8**	
MAC Messages	9.5.1	7.8.1	
Framing	9.5.2	7.8.2	
Multiple Transmit Channel Mode Operation and Packet Encryption	-	7.8.3	
Note 1: Not supported by StarHub Cable Vision.			

Table 8 : Quality Of Service & Fragmentation			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.2**	**Remarks**
Quality of Service & Fragmentation	**10**	**-**	General Information
Theory of Operation	**10.1**	**-**	General Information
Quality of Service	**-**	**7.5**	Heading
Concepts	-	7.5.1	Heading
Service Flows	-	7.5.1.1	
Classifiers	-	7.5.1.2	
Concepts	10.1.1	7.5.1	
Object Model	10.1.2	7.5.2	General Information
Service Classes	10.1.3	7.5.3	
Authorization	10.1.4	7.5.4	
Types of Service Flows	10.1.5	-	
States of Service Flows	-	7.5.5	
Service Flows and Classifiers	10.1.6	7.5.6	
General Operation	10.1.7	7.5.7	Heading
Static Operation	10.1.7.1	7.5.7.1	
Dynamic Service Flow Creation – CM initiated	10.1.7.2	7.5.7.2	
Dynamic Service Flow Creation – CMTS initiated	10.1.7.3	7.5.7.3	General Information
Dynamic Service Flow Modification and Deletion	10.1.7.4	7.5.7.3	General Information
QoS Support for Joined IP Multicast Traffic	-	7.5.8	General Information
Other Multicast and Broadcast Traffic	-	7.5.9	General Information
Upstream Service Flow Scheduling Services	**10.2**	**7.2.3**	
Unsolicited Grant Service	10.2.1	7.2.3.1	
Real-Time Polling Service	10.2.2	7.2.3.2	
Unsolicited Grant Service with Activity Detection	10.2.3	7.2.3.3	
Non-Real-Time Polling Service	10.2.4	7.2.3.4	
Best Effort Service	10.2.5	7.2.3.5	
Other services	10.2.6	7.2.3.6	
Parameter applicability for upstream service scheduling	10.2.7	7.2.3.7	
CM transmit behaviour	10.2.8	7.2.3.8	
Fragmentation	**10.3**	-	
CM Fragmentation Support	10.3.1	-	
CMTS Fragmentation Support	10.3.2	-	General Information
Fragmentation Example	10.3.3	-	General Information
Continuous Concatenation and Fragmentation	-	7.2.4	
Pre-3.0 DOCSIS Concatenation and Fragmentation	-	7.2.5	
Upstream – Downstream Channel Association within a MAC Domain	**-**	**7.3**	Heading
Primary Downstream Channels		7.3.1	
MAP and UCD Messages		7.3.2	
DSID Definition	**-**	**7.4**	
Downstream Traffic Priority	**-**	**7.6**	
Payload Header Suppression	**10.4**	**7.7**	

Table 9 : Channel Bonding			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.2**	**Remarks**
Channel bonding	**-**	**8**	
Upstream and Downstream Common Aspects	**-**	**8.1**	Heading
Service Flow Assignment	-	8.1.1	
CMTS Bonding and Topology Requirements	-	8.1.2	General Information
Downstream Channel Bonding	**-**	**8.2**	Heading
Multiple Downstream Channel Overview	-	8.2.1	
CMTS Downstream Bonding Operation	-	8.2.2	General Information
Sequenced Downstream Packets	-	8.2.3	
Cable Modem Physical Receive Channel Configuration	-	8.2.4	
QoS for Downstream Channel Bonding	-	8.2.5	
Upstream Channel Bonding	**-**	**8.3**	
Granting Bandwidth	-	8.3.1	General Information
Upstream Transmissions with Upstream Channel Bonding	-	8.3.2	
Data Forwarding	**-**	**9**	
General Forwarding Requirements	**-**	**9.1**	
CMTS Forwarding Rules	-	9.1.1	General Information
CM Address Acquisition, Filtering and Forwarding Rules	-	9.1.2	The CM MUST support forwarding of IP traffic (both IPv4 and IPv6).
Multicast Forwarding	**-**	**9.2**	Heading
Introduction	-	9.2.1	
Downstream Multicast Forwarding	-	9.2.2	
Downstream Multicast Traffic Encryption	-	9.2.3	
Static Multicast Session Encodings	-	9.2.4	
IGMP and MLD Support	-	9.2.5	
Encrypted Multicast Downstream Forwarding Example	-	9.2.6	
IP Multicast Join Authorization	-	9.2.7	General Information

Table 10: Cable Modem - CMTS Interaction			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.2**	**Remarks**
Cable Modem – CMTS Interaction	**11**	**10**	General Information
CMTS Initialization	**11.1**	**10.1**	General Information
Cable Modem Initialization	**11.2**	-	
Scanning and synchronization to downstream	11.2.1	-	
Obtain upstream parameters	11.2.2	-	
Message flows during scanning and upstream parameter acquisition	11.2.3	-	General Information
Ranging and automatic adjustments	11.2.4	-	
Device class identification	11.2.5	-	
Establish IP connectivity	11.2.6	-	
Establish time of day	11.2.7	-	
Transfer operational parameters	11.2.8	-	
Registration	11.2.9	-	
Baseline privacy initialization	11.2.10	-	
Service IDs during CM initialization	11.2.11	-	
Multiple-channel support	11.2.12	-	
Standard Operation	**11.3**	-	
Periodic signal level adjustment	11.3.1	-	
Changing upstream channel descriptor message parameters	11.3.2	-	
Changing upstream channels	11.3.3	-	
Cable Modem Initialization and Reinitialization	**-**	**10.2**	
Scan for Downstream Channel	-	10.2.1	
Continue Downstream Scanning	-	10.2.2	
Service Group Discovery and Initial Ranging	-	10.2.3	
Authentication	-	10.2.4	
Establishing IP Connectivity	-	10.2.5	
Registration with the CMTS	-	10.2.6	
Baseline Privacy Initialization	-	10.2.7	If the CM is provisioned to run Baseline Privacy and EAE was not enabled, the CM MUST initialize Baseline Privacy operations, as described in [ITU-T J.222.3].
Service IDs During CM Initialization	-	10.2.8	
Periodic Maintenance	**-**	**10.3**	
Fault Detection and Recovery	**-**	**10.4**	
DOCSIS Path Verification	**-**	**10.5**	
Fault Detection and Recovery	**11.5**	-	
Prevention of Unauthorised Transmissions	11.5.1	-	

Table 10: Cable Modem - CMTS Interaction (Continued)			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.2**	**Remarks**
Dynamic Service	**11.4**	-	
Dynamic Service Flow State Transitions	11.4.1	-	General Information
Dynamic Service Addition	11.4.2	-	Heading
CM Initiated Dynamic Service Addition	11.4.2.1	-	
CMTS Initiated Dynamic Service Addition	11.4.2.2	-	General Information
Dynamic Service Addition State Transition Diagrams	11.4.2.3	-	General Information
Dynamic Service Change	11.4.3	-	
Dynamic Service Deletion	11.4.4	-	
CM Initiated Dynamic Service Deletion	11.4.4.1	-	
CMTS Initiated Dynamic Service Deletion	11.4.4.2	-	General Information
Dynamic Service Deletion State Transition Diagrams	11.4.4.3	-	General Information
Dynamically Changing Downstream and/or Upstream Channels	11.4.5	-	
Dynamic Operations	**-**	**11**	Heading
Upstream Channel Descriptor Changes	**-**	**11.1**	
Dynamic Service Flow Changes	**-**	**11.2**	
Pre-3.0 DOCSIS Upstream Channel Changes	**-**	**11.3**	
Dynamic Downstream and/or Upstream Channel Changes	**-**	**11.4**	
Dynamic Bonding Change (DBC)	**-**	**11.5**	
Autonomous Load Balancing	**-**	**11.6**	

Table 11: Supporting Future New Cable Modem Capabilities			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.2**	**Remarks**
Supporting Future New Cable Modem Capabilities	**10**	**12**	Heading
Downloading Cable Modem Operating Software	**10.1**	**12.1**	

Table 12: Annexes & Appendices to ITU-T Rec. J.122 and J.222.2			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.2**	**Remarks**
Well-known Addresses	**Annex A**	**Annex A**	
Parameters and Constants	**Annex B**	**Annex B**	
Common Radio Frequency Interface Encoding	**Annex C**	**Annex C**	General Information
Encoding for Configuration and MAC-Layer Messaging	**C.1**	**C.1**	
Configuration File and Registration Settings	C.1.1	C.1.1	
Configuration-File-Specific Settings	C.1.2	C.1.2	
Registration-Request/Response-Specific Encoding	C.1.3	C.1.3	
Dynamic-Service-Message-Specific Encoding	C.1.4	C.1.4	
Registration, Dynamic Service and Dynamic Bonding Settings	-	C.1.5	
Quality-of-Service-Related Encodings	**C.2**	**C.2**	Heading
Packet Classification Encodings	C.2.1	C.2.1	
Service Flow Encodings	C.2.2	C.2.2	
Encoding for Other Interfaces	**C.3**	**C.3**	Heading
Telephone Settings Option	C.3.1	-	Optional
Baseline Privacy Configuration Settings Option	C.3.2	C.3.1	Optional (See ITU-T J.222.3).
Confirmation Codes	**C.4**	**C.4**	
Confirmation Codes for Dynamic Channel Change	C.4.1	-	General Information
Confirmation Codes for Major Errors	C.4.2	-	General Information
CM Configuration Interface Specification	**Annex D**	**Annex D**	Heading
CM IP Addressing	**D.1**	-	Heading
DHCP Fields used by the CM	D.1.1	-	See Note 1
CM Configuration	**D.2**	**D.1**	Heading
CM Binary Configuration File Format	D.2.1	D.1.1	
Configuration File Settings	D.2.2	D.1.2	–
Configuration File Creation	D.2.3	D.1.3	
Configuration Verification	**D.3**	**D.2**	
Note 1: The CM MUST be capable of filtering all broadcast traffic from the local LAN or host CPE, with the exception of DHCP (as identified by the destination port number in the UDP header) and ARP packets			

Table 12: Annexes & Appendices to ITU-T Rec. J.122 and J.222.2 (Continued)			
Title	**ITU-T Rec. J.122**	**ITU-T Rec. J.222.2**	**Remarks**
The Data-Over-Cable Spanning Tree Protocol	**Annex E**	**Annex L**	
Standard Receive Channel Profile Encodings	**-**	**Annex E**	
European Specification Additions	**Annex F**	**-**	Not Applicable (See Note 2)
DOCS 2.0 and 1.0/1.1 interoperability	**Annex G**	**-**	
The DOCS MAC/PHY interface (DMPI)	**Annex H**	**Annex F**	
Compatibility with Previous Versions of DOCSIS	**-**	**Annex G**	
DHCPv6 Vendor Specific Information Options for DOCSIS 3.0	**-**	**Annex H**	
-	**Annex I**	**Annex I**	Left blank intentionally.
Japan specification additions	**Annex J**	**-**	Not Applicable (See Note 2)
DHCPv4 Vendor Identifying Vendor Specific Options for DOCSIS 3.0	**-**	**Annex J**	
DHCP Information Options for DOCSIS 3.0	**-**	**Annex K**	
MAC Service Definition	**Appendix I**	**Appendix I**	Does not form part of J.122/J.222.2.
Example Preamble Sequence	**Appendix II**	-	Does not form part of J.122.
Multiple Upstream Channel	**Appendix III**	**-**	Does not form part of J.122.
Plant Topologies	**-**	**Appendix II**	Does not form part of J.222.2.
DOCSIS Transmission and Contention Resolution	**-**	**Appendix III**	Does not form part of J.222.2.
DOCS Transmission and Contention Resolution	**Appendix IV**	**-**	Does not form part of J.122.
IGMP Example	**Appendix V**	**-**	Does not form part of J.122.
Unsolicited Grant Services	**Appendix VI**	**Appendix IV**	Does not form part of J.122/J.222.2.
Unsolicited Grant Services (UGS)	**VI.1**	**IV.1**	
Unsolicited Grant Services with Activity Detection (UGS-AD)	**VI.2**	**IV.2**	
S-CDMA framing	**Appendix VII**	**-**	Does not form part of J.122.
Ambient temperature and wind loading effects	**Appendix VIII**	**-**	Does not form part of J.122.
Error Recovery Examples	**-**	**Appendix V**	Does not form part of J.222.2.
SDL Notation	**-**	**Appendix VI**	Does not form part of J.222.2.
Notes on Address Configuration in DOCSIS 3.0	**-**	**Appendix VII**	Does not form part of J.222.2.
IP Multicast Replication Examples	**-**	**Appendix VIII**	Does not form part of J.222.2.
IGMP Example for DOCSIS 2.0 Backwards Compatibility Mode	**-**	**Appendix XI**	Does not form part of J.222.2.
CM Multicast DSID Filtering Summary	**-**	**Appendix X**	Does not form part of J.222.2.
Example DHCPv6 Solicit Message Contents	**-**	**Appendix XI**	Does not form part of J.222.2.
Dynamic Operations Examples	**-**	**Appendix XII**	Does not form part of J.222.2.
Note 2: This Annex applies to the second technology option, and describes the physical layer specifications required for the EuroDOCSIS cable modems. It is not supported by StarHub Cable Vision.			

Table 13 : Security Services		
Title	**ITU-T Rec.**	**Remarks**
Link Privacy for Cable Modem Implementations	J.125	The CM must support MAC layer privacy services for CMTS-CM communications, providing cable modem users with data privacy across the cable network and preventing unauthorised users from gaining access to network's RF MAC services.
Third-generation transmission systems for interactive cable television services – IP cable modems: Security services	J.222.3	

Annex A

IPCablecom Embedded MTA Primary Line Support (ITU-T Rec. J.173)

A.1 If the CM is integrated (or embedded) with an IPCablecom Media Terminal Adapter (MTA), in addition to the requirements outlined in this Specification, the following requirements shall be applicable for the delivery of Public Switched Telephone Network (PSTN) services.

A.2 The MTA is an IPCablecom client device that can be standalone or integrated with the CM as shown in Figure A.1 (Figure 1/ITU-T Rec. J.160). The IPCablecom architecture contains three networks: the "DOCSIS HFC access network", the "Managed IP network" and the PSTN.

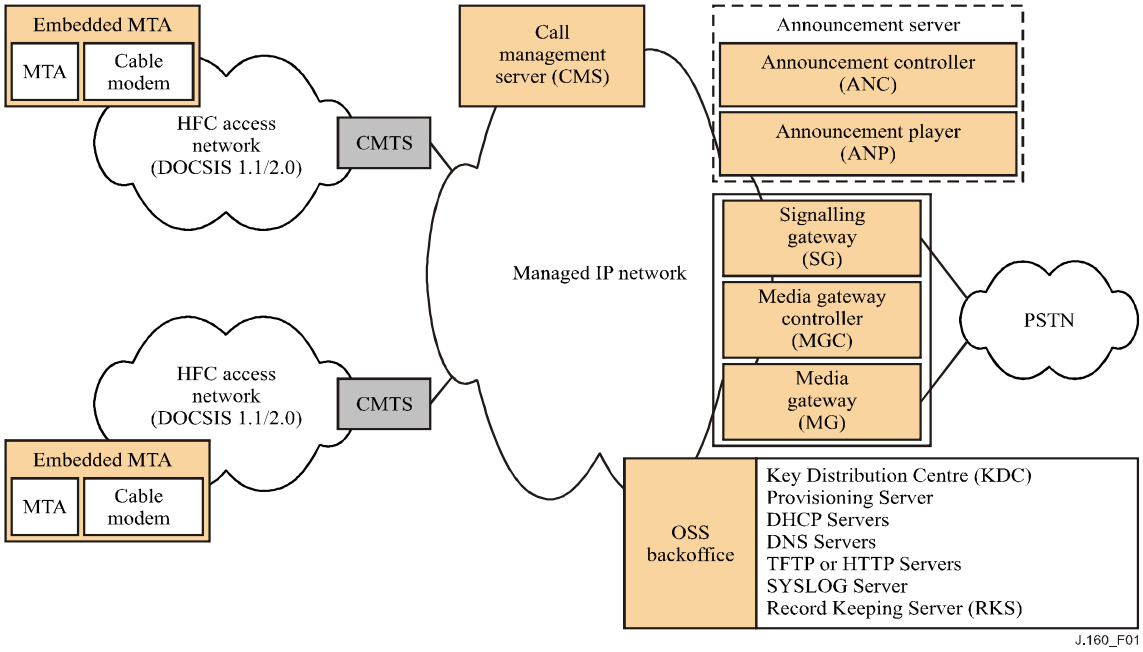


Figure A.1 (Figure 1/J.160): IPCablecom Reference Architecture

A.4 The E-MTA shall comply with the following requirements, with reference to the ITU-T Rec. J.173.

Table A.1 : IPCablecom Embedded Media Terminal Adapter		
Title	**ITU-T Rec. J.173**	**Remarks**
Introduction	**5**	To enable the support of PSTN services, the following requirements have been identified: a) E-MTA monitoring requirements; b) E-MTA power requirements; and c) MTA analogue port requirements

Table A.1 : IPCablecom Embedded Media Terminal Adapter		
Title	**ITU-T Rec. J.173**	**Remarks**
Media Terminal Adapter (MTA)	**5.1**	The MTA contains a subscriber-side interface to the Customer Premises Equipment (CPE), e.g. a telephone set; and a network-side interface to call control elements in the network. The MTA provides codecs, signalling, and encapsulation functions required for media transport and call signalling. The MTA is connected to other IPCablecom network elements via the Hybrid Fibre Coaxial (HFC) access network (as defined in this Specification, in accordance with the ITU-T Rec. J.122). The IPCablecom MTA shall support the Network Call Signalling (NCS) protocol defined in the ITU-T Rec. J.162. An embedded MTA (E-MTA) is a single hardware device that incorporates a cable modem as well as an IPCablecom MTA.
E-MTA monitoring requirements	**6**	
E-MTA alarms	**6.1**	
CM failures	6.1.1	Refer to ITU-T Rec. J.122 for the events that the CM and the CMTS must detect.
MTA failures	6.1.2	
E-MTA telemetry	**6.2**	
E-MTA power requirements	**7**	This clause provides general guidelines that must be adapted to the local environment. There are 2 basic methods to power the E-MTA: a) Local power with battery backup; and b) Network powering
MTA analogue port requirements	**8**	The subscriber side of this interface is an analogue interface consistent with the requirements for connecting to the NTP in scenario 1 as described the IDA TS PSTN Issue 2 (XXX 2013). The network side of this interface is a digital interface to the IP-based IPCablecom network, which rides on top of the ITU-T Rec. J.122 transport. The interface requirements shall be consistent with § 1 to § 7 of the IDA TS PSTN Issue 2 (XXX 2013), in the following areas: a) Loop Start Signalling b) General Supervision c) General Ringing d) Voice Grade Analogue Transmission (G.711 audio codec as specified in ITU-T Rec. J.161)

Table A.1 : IPCablecom Embedded Media Terminal Adapter		
Title	**ITU-T Rec.**	**Remarks**
Media terminal adapter (MTA) device provisioning requirements for the delivery of real-time services over cable television networks using cable modems	J.167	The provisioning of an IPCablecom embedded-MTA device by a single provisioning and network management provider shall be in accordance with the ITU-T Rec. J.167.

Annex B

StarHub Specific Requirements

NOTE

The following notations are used:

CR Conformance Requirement
M Mandatory Requirement
O Optional Requirement

StarHub Cable Vision's Specific Requirement		CR	Remarks
CM Adjacent Channel Power	BIE-TP-01	–	Heading
Adjacent Channel Power Test	BIE-TP-01	M	CM adjacent channel power MUST be at least –44dBc, for an upper/lower adjacent channel bandwidth of 1.6MHz. CM adjacent channel power MUST be at least –41dBc, for an upper/lower adjacent channel bandwidth of 3.2MHz.
Harmonics	BIE-TP-01	M	The 2nd and 3rd harmonics of the upstream centre frequency, measured in 160kHz bandwidth, MUST be at least –47dBc.
CM Throughput Performance Specifications	BIE-TP-02	M	In the downstream direction at a rate of 2930 packet/sec and packet size of 64bytes, packet losses MUST be less than 0.1%. In the downstream direction at a rate of 124 packet/sec and packet size of 1518 bytes, packet losses MUST be less than 0.1%.
CM Registration Test	BIE-TP-03	M	The CM MUST register with the CMTS within 60 seconds under un-congested traffic.
		M	The CM MUST register within 60 seconds even under 98 percent upstream channel utilization on the CMTS.
CM Frequency Agility Test - Frequency Hopping Test	BIE-TP-04	M	The CM MUST be capable of hopping to a specified upstream channel when commanded by the CMTS.
CM Applications Test	BIE-TP-09	–	Heading
VPN	BIE-TP-09	M	The CM MUST permit the customer initiated VPN client to successfully create a VPN tunnel through the CM The CM MUST permit data to be transmitted successfully between the client and the VPN connected network.
OS support	BIE-TP-09	M	The CM (Ethernet connection) MUST support Windows and MacOS..

StarHub Cable Vision's Specific Requirement		CR	Remarks
CM Applications Test (Continued)	BIE-TP-09	–	Heading
HTTP server	BIE-TP-09	O	HTTP server should have the following levels of access control: a) No CPE access after registration (Ethernet) b) Restricted access after registration (i.e. no access to DS/US info, Headend info) c) Unrestricted access after registration
		O	CM internal web pages should provide information on: a) Initialization status b) Software version c) CM up-time & DHCP lease information d) HFC & CPE interface MAC addresses e) Transmit & receive power level f) CPE MAC & IP addresses learnt by CM g) Filter list h) Event list of at least 100 entries
		M	The CM MUST have the capability of disabling access to the CM's http server/management interface via the CM's configuration file parameters.
Filters	BIE-TP-09	O	CM should support the following filters: a) MAC address filtering b) Forced reboot via SNMP set command c) ARP storm filtering d) ARP filtering e) Permit/deny multicast access f) Enable/Disable CPE traffic (Ethernet) g) 1 IP source address filter per CPE h) Rate-limiting on each SNMP trap
QOS Classifier Specifications Test	BIE-TP-015	–	Heading
MAC SA	BIE-TP-015	M	The CM MUST be capable of classifying via a packet's MAC source address
IP ToS	BIE-TP-015	M	The CM MUST be capable of classifying via a packet's ToS.
IP protocol	BIE-TP-015	M	The CM MUST be capable of classifying via a packet's IP protocol
IP source address	BIE-TP-015	M	The CM MUST be capable of classifying via a packet's IP source address
TCP/UDP source port start/end	BIE-TP-015	M	The CM MUST be capable of classifying via TCP/UDP source start/end port
Service flows	BIE-TP-015	M	The CM MUST support a minimum of four (4) downstream and four (4) upstream service flows.
QOS Service-Flow Encoding Test	BIE-TP-016	–	Heading
QoS timeout	BIE-TP-016	M	The CM MUST be capable defaulting to the primary service flow when the QoS timeout occurs. The CM MUST observe traffic priority settings. The higher priority MUST be given lower delay and higher buffering preference.
Interoperability Test	BIE-TP-020	M	The CM shall be tested successfully for interoperability with StarHub's cable network. Where applicable, the CM should have received the CableLabs certification, and be listed as CableLabs DOCSIS 2.0 (or) DOCSIS 3.0 certified products[3].

[3] For connection to the SCV cable network, this is a mandatory requirement.

Annex C
Corrigendum/Addendum

Changes to IDA TS CM Issue 1 Rev 1, May 11			
Page	**TS Ref.**	**Items Changed**	**Date of Issue**
—	—	The IDA TS CM Issue 2 (Oct 2013) has superseded the IDA TS CM Issue 1 (May 2011). This Specification defines the RFI requirements for Cable Modems connecting to 2nd and 3rd generations of high-speed Data-Over-Cable Systems based on the following ITU-T Recommendations: (a) J.122 (12/2007) [DOCSIS 2.0 equivalent] (b) J.222.1, J.222.2 & J.222.3 [DOCSIS 3.0 equivalent] For conformity assessment, the CM shall comply with requirements outlined in the IDA TS CM Issue 2, in accordance with (a) J.122; or (b) J.222.1, J.222.2 and J.222.3. A new Annex A has been added to this Specification, which streamlines conformity assessment requirements for the CM to be integrated with the IPCablecom MTA for supporting analogue PSTN terminal equipment, and delivering PSTN services over the J.122 transport.	29 Oct 2013

Changes to IDA TS CM Issue 1, Jul 05			
Page	**TS Ref.**	**Items Changed**	**Date of Issue**
—	—	Change of IDA's address at cover page to Mapletree Business City.	1 May 11

Changes to IDA TS CM 2			
Page	**TS Ref.**	**Items Changed**	**Date of Issue**
—	—	The IDA TS CM Issue 1 (Jul 05) has superseded the IDA TS CM 2 Issue 1 (2 Jan 03). It has also incorporated the EMC requirements, previously published under the IDA TS EMC Issue 1 Rev 1.	21 Jul 05
—	—	Title of Specification has been renamed as "Technical Specification for Cable Modems connected to the Radio Frequency Interface of the High-speed Data-Over-Cable Systems (DOCSIS 1.1)" [IDA TS CM Issue 1]. Changes are mainly editorial in nature. There are no changes to the technical requirements.	21 Jul 05