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TESTING

EXCENTIS

SP-STB-v3.0-I01-110411

EuroDOCSIS 2.0 or 3.0 CM in a DVB-C Set-Top Box v3.0 Requirements Specification

--- Project Reference ---
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1 Introduction

This document is part of a suite of specifications that describe requirements for the qualification of an embedded bi-directional EuroDOCSIS 2.0 or 3.0 cable modem within a DVB-C set-top box (STB/CM). The objective of defining specific requirements for a STB/CM is to create a "black box" qualification test approach for the EuroDOCSIS cable modem (CM) embedded in a DVB-C set-top box (STB), making the process as similar as possible between different STB manufacturers/products and stand-alone EuroDOCSIS CMs. It is the primary purpose of this document to address only the changes necessary for the EuroDOCSIS 2.0/3.0 qualification of embedded CM-functionality when compared to stand-alone EuroDOCSIS 2.0/3.0 CMs.

The term EuroDOCSIS is used throughout this document to signify products that are implementing the European technology option contained in DOCSIS 2.0 and 3.0 specifications.

Part of this document is based on the eDOCSIS specification [15].

1.1 Governing Documents

Baseline conditions are defined for each sub-system that refer back to EuroDOCSIS, DOCSIS, and other industry standard specifications. At the time of publication of this document, the editions indicated were valid. All standards and specifications are subject to revision. Users of this specification are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

[1] Data-Over-Cable Service Interface Specifications – DOCSIS 2.0 Radio Frequency Interface Specification, CM-SP-RFIv2.0-C02-090422 Annex F: European Specification Additions.

[2] Data-Over-Cable Service Interface Specifications – Cable Modem to Customer Premises Equipment Interface (CMCI) Specification, SP-CMCI-C01-081104.

[3] Data-Over-Cable Service Interface Specifications – Baseline Privacy Plus Interface Specification, CM-SP-BPI+-C01-081104

[4] Data-Over-Cable Service Interface Specifications DOCSIS 2.0– Operations Support System Interface Specification, CM-SP-OSSIv2.0-C01-081104.

[5] ANSI/SCTE Specification for "F" Port, Female, Indoor, ANSI/SCTE 02 2006 (formerly IPS SP 406).

[6] Radio frequency connectors, Part 2: Coaxial unmatched connector, IEC 61169-2.

[7] Radio Frequency connectors, Part 24: Radio frequency coaxial connectors with screw coupling, typically for use in 75 Ohm cable distribution systems (type F), IEC 61169-24.

[8] Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems, ETSI EN 300 429 V1.2.1.

[9] Sound and television broadcast receivers and associated equipment - Radio disturbance characteristics - Limits and methods of measurement, CENELEC EN 55013:2001/A1:2003/A2:2006.

[10] Data-Over-Cable Service Interface Specifications - DOCSIS 3.0 Security Specification, CM-SP-SECv3.0-I13-100611.

[11] Data-Over-Cable Service Interface Specifications - DOCSIS 3.0 Cable Modem to Customer Premise Equipment Interface Specification, CM-SP-CMCIv3.0-I01-080320.

[12] Data-Over-Cable Service Interface Specifications - DOCSIS 3.0 Physical Layer Specification, CM-SP-PHYv3.0-I09-101008 Annex B: Additions and modifications for European Specification.

[13] Data-Over-Cable Service Interface Specifications - DOCSIS 3.0 MAC and Upper Layer Protocols Interface Specification, CM-SP-MULPIv3.0-I15-110210.

[14] Data-Over-Cable Service Interface Specifications - DOCSIS 3.0 Operations Support System Interface Specification, CM-SP-OSSIv3.0-I14-110210.

[15] Data-Over-Cable Service Interface Specifications - eDOCSIS™ Specification, CM-SP-eDOCSIS –I21-101008.

[16] EuroDOCSIS BPI+ Requirements Rev 07, EuroDOCSIS.BPI+Req

[17] SNMPv2 Management Information Base for the Internet Protocol using SMIv2, RFC 2011

[18] The Interfaces Group MIB, RFC 2863

[19] Management Information Base for the Internet Protocol (IP), RFC 4293

Governing documents can be acquired here:

- DOCSIS specifications: Cable Television Laboratories, Inc. (CableLabs®) www.cablelabs.com
- EuroDOCSIS requirements: Excentis www.excentis.com
- ANSI/SCTE standards : Society of Cable Telecommunications Engineers (SCTE) www.scte.org
- IEC standards: International Electrotechnical Commission (IEC) www.iec.ch
- ETSI standards: European Telecommunications Standards Institute (ETSI) www.etsi.org
- CENELEC standards : European Committee for Electrotechnical Standardization (CENELEC) www.cenelec.eu
- RFCs: Internet Engineering Task Force (IETF) www.ietf.org

1.2 Compliance Notation

Throughout this document, the words used to provide normative statements are capitalized as shown below:

MUST	This word or the adjective “REQUIRED” means that the item is an absolute requirement of this specification.
MUST NOT	This phrase means that the item is an absolute prohibition of this specification.
SHOULD	This word or the adjective “RECOMMENDED” means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighed before choosing a different course.
SHOULD NOT	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.

MAY	This word or the adjective "OPTIONAL" means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

2 Cable Modem Embedded in STB

2.1 General

The CM embedded in a STB is called eCM for the remainder of this specification. A STB with an eCM is called STB/CM.

2.2 Reference Model

For this specification two reference models for STB/CM are defined:

- STB/CM without an RF bypass
- STB/CM with an RF bypass

There are different requirements on the physical layer between the two types of STB/CMs.

The reference model for a STB/CM with no bypass is shown in Figure 1.

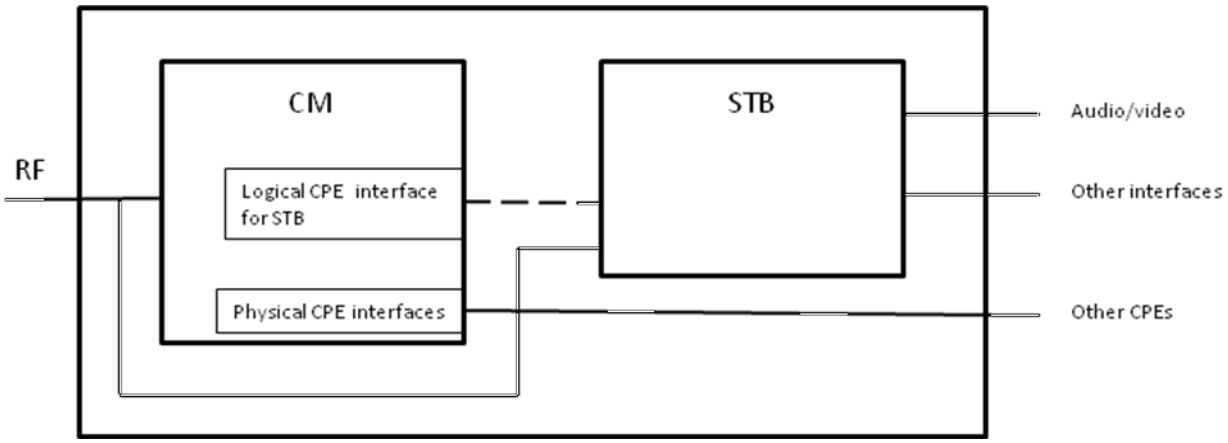

Figure 1: Reference model for STB/CM with no bypass

The reference model for a STB/CM with an RF bypass is shown in Figure 2.

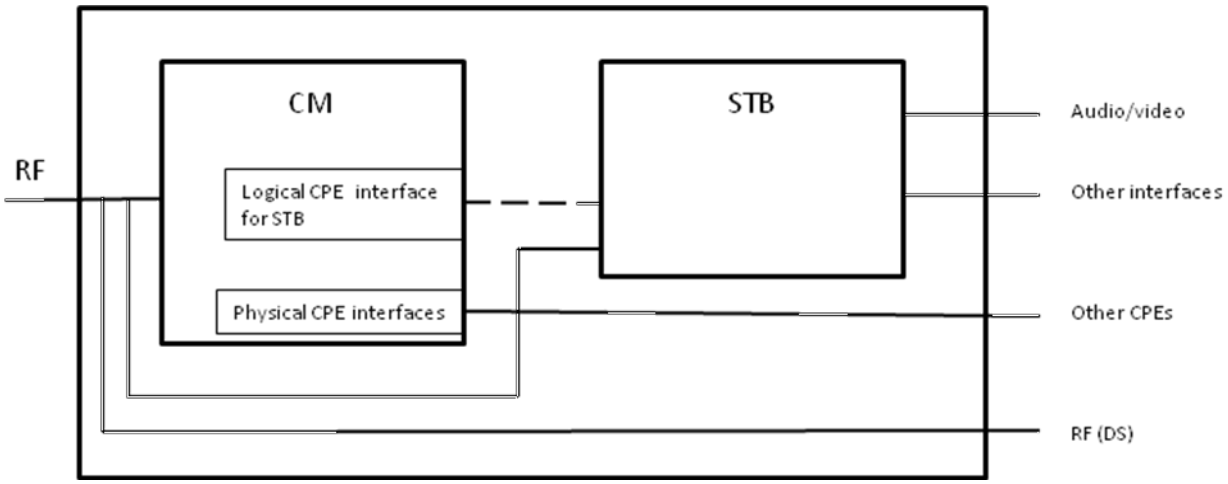

Figure 2: Reference model for STB/CM with RF bypass

2.3 General Requirements

The eCM MUST provide an SNMP agent which is logically separate from any other SNMP agent in the device.

The eCM MUST act as an entity distinct from the STB that is embedded in the device.

The interface between CM-part and STB-part MUST be a logical interface.

The eCM MUST meet the requirements of an equivalent stand-alone cable modem as specified in the applicable DOCSIS specifications (European technology option - EuroDOCSIS). In case any requirement in this specification conflicts with a requirement in the DOCSIS specifications, the requirement in this specification takes precedence for the eCM.

2.4 Physical Layer Requirements

2.4.1 Electrical Input to the CM

The STB/CM MUST accept an RF modulated signal with the characteristics defined in Table 1.

Modulation format	STB/CM without RF bypass	STB/CM with RF bypass
64 QAM	43 to 73 dBµV	45 to 75 dBµV
256 QAM	47 to 77 dBµV	51 to 77 dBµV

Table 1: RF input requirements

2.4.2 Downstream Power Reporting Accuracy

The accuracy for the MIB that reports the received downstream power at the mechanical connector of the STB/CM is defined in Table 2.

Modulation	Absolute Accuracy	Differential Accuracy for STB/CM without an additional splitter	Differential Accuracy for STB/CM with an additional splitter
64 QAM	±3 dB	±0.5 dB per 1 dB step	±1 dB per 2 dB step
256 QAM	±3 dB	±0.5 dB per 1 dB step	±1 dB per 2 dB step

Table 2: Downstream power reporting accuracy

Differential accuracy means the allowed deviation from the actual difference in received power to the reported receive power. For example, the actual receive power is 51 dBμV, the modem reports 53 dBμV. The downstream power is incremented by 2 dB, this means, the actual downstream power is now 53 dBμV. The modem has to report between 54 and 56 dBμV.

2.4.3 Mechanical Connector Specification

The RF connector can be either an F connector [5], [7] or IEC 169-2 connector [6].

2.4.4 Electrical Output from the STB/CM

In case the STB/CM has a remodulated output, it is assumed that the cable operator frees up two channels in the spectrum around the carrier frequency on which the remodulator functions. The STB/CM MUST be in compliance with EN 55013 [13].

This causes no loss on the network, because the cable operator is keeping these channels free for remodulator use. The remodulator channel can be selected during installation.

2.5 Software Download

Software upgrade to the STB/CM uses either or both a non-EuroDOCSIS software upgrade mechanism (e.g. carousel mechanism) or the EuroDOCSIS TFTP method.

2.5.1 Software Upgrade by EuroDOCSIS TFTP Mechanism

Section 5.2.7.1.1 of eDOCSIS [15] is applicable.

2.5.2 Software Upgrade by a Non-EuroDOCSIS Mechanism

In addition to TFTP download, alternative software upgrade mechanisms MAY be supported by STBs deployed on a network. Typically, this would be a carousel mechanism. The STB/CM MUST support either EuroDOCSIS TFTP upgrade or an alternative method; it MAY support both. If the EuroDOCSIS TFTP method is not supported, the system MUST be resilient to data corruption and misinformation. Any alternative method MAY employ TFTP but MUST NOT rely on the presence of a EuroDOCSIS TFTP server.

When the STB/CM supports a software download system different than the EuroDOCSIS mechanism section 5.2.7.1.2 of eDOCSIS [15] is applicable.

2.6 BPI+ Certificates

The private key of the eCM for BPI+ MUST be protected according to the requirements on the physical protection of keys specified in [3] for all STB/CMs.

2.7 Interface Requirements

2.7.1 General Interface Requirements

The bridging function of the eCM between the RF port and the CPE interfaces (logical or physical) MUST be equivalent to that of a multi-port learning bridge. Each CPE interface of the CM-part MUST comply with the CM Forwarding Rules defined in DOCSIS [1], [13]. In particular:

- The eCM MUST count the MAC addresses of the STB-part toward the total allowed by the Maximum Number of CPEs configuration setting at the eCM. Note that this means that with a default value of 1, any external CPEs will not be able to receive or send data through the eCM.
- The eCM MUST apply the packet forwarding and filtering rules defined in the DOCSIS RFI/MULPI specifications [1], [13] and in DOCSIS OSSI [4], [14].
- An eCM embedded into a device which contains a STB that supports IPv6 MUST support Layer-2 bridging of:
  - IPv6 frames (Ethertype 0x86DD) using standard bridging rules (docsDevFilterIpTable is not applicable for IPv6 packets,)
  - Packets required for the IPv6 provisioning of the STB-part, in particular the IPv6 Link Local Scope All Nodes Address (33-33-00-00-00-01, FF02::1) and the Solicited Node Addresses packets for the STB-part (in the range 33-33-F-xx-xx-xx, FF02::1:FFxx:xxxx). The CM-part needs to implement some mechanism that allows it to forward IPv6 packets required for provisioning to the appropriate Solicited Node Addresses.

2.8 Operations Support Requirements

2.8.1 Resetting the STB/CM

When the MIB object docsDevResetNow is set to true (1) the eCM MUST reboot. Setting this variable SHOULD NOT reboot the entire STB.

2.8.2 MAC Address Learning

The MAC addresses corresponding to the internal CPE devices MUST be present in the dot1dTpFdbAddress table that represents the learned or provisioned MAC addresses. The eCM MUST acquire the MAC addresses of the internal CPE devices before learning MAC addresses of devices connected to the external CPE interfaces. The acquisition of the MAC addresses of the internal CPE devices MUST be via address-learning or via looking up the addresses for these internal CPE devices in the nonvolatile memory of the eCM.

Provisioned MAC addresses take priority over learned MAC addresses. Embedded MAC addresses (e.g. STB-part) take precedence over provisioned MAC addresses. If the number of

allowed CPE devices that is granted access is lower than the number of internal CPE devices, the MAC addresses that are allowed access MUST be used according to their numbering, i.e. the MAC address corresponding to interface 16 “eMTA” has the highest precedence, then the MAC address corresponding to interface “17”, and so on up to the number of allowed CPE devices that are granted access.

2.8.3 ifTable Requirements

The eCM MUST represent the logical interface to the STB-part with an entry in the ifTable with ifType other(1) as described in DOCSIS OSSI [4], [14]. IfIndex 17 must be used to represent the logical interface between eCM and the STB-part. Any interfaces which are not directly connected to the eCM MUST NOT be reported in the ifTable.

The ifXTable in accordance with RFC 2863 [18] must be supported. The default value of ifLinkUpDownTrapEnable is enabled(1) for all of the logical interfaces.

The ifStackTable in accordance with RFC 2863 [18] MUST be supported. An eCM logical interface(s) MUST NOT contain any sub-layers. Table 3 summarizes the eCM assignment of ifIndexes to its connected interfaces. Table 4 defines the details of the ifTable entries for the interface between eCM and STB-part.

Interface	Type
1	Primary CPE Interface
2	CATV-MAC
3	One of the CATV downstream interfaces
4	One of the CATV upstream interfaces
5-15	Additional CPE interfaces
16	eMTA interface
17	STB interface
18	Reserved – Logical interface for STB
19	Reserved – Logical Interface
20	Reserved – Logical Interface
20	Reserved – Logical interface
21-31	Reserved – Logical Interfaces
32-47	Reserved for additional CPE Interfaces
48-79	Reserved for additional CATV Downstream Interfaces
80-111	Reserved for additional CATV upstream interfaces

Table 3: Interface designation

RFC 2863 MIB object	Value
ifIndex	17
ifDescr	“Set-Top Box Embedded IP Interface”
ifType	other
ifMtu	0
ifSpeed	0
ifPhysAddress	<empty-string>
ifAdminStatus	up(1), down(2) (other values optional)
ifOperstatus	up(1), down(2) (other values optional)
iflastChange	<per RFC 2863>
ifInOctets	(n)
ifInUcastPkts	(n)
ifInNUcastPkts	Deprecated
ifInDiscards	0
ifInErrors	0
ifInUnknownProtos	0
ifOutOctets	(n)
ifOutUcastPkts	(n)
ifOutNUcastPkts	Deprecated
ifOutDiscards	0
ifOutErrors	0
ifOutQLen	Deprecated
ifSpecific	Deprecated

Table 4: ifTable MIB object details for DOCSIS device interfaces

2.8.4 ipNetToMediaTable and ipNetToPhysicalTable Requirements

If the STB/CM contains an embedded device that does not support IPv6 for provisioning and management, then the eCM MUST support the RFC 2011 ipNetToMediaTable [17] and populate the entries as per Table 5.

RFC 2011 MIB object	Value
ipNetToMediaIfIndex	17
ipNetToMediaPhysAddress	STB MAC Address
ipNetToMediaNetAddress	STB IP Address, if acquired, otherwise 0.0.0.0.
ipNetToMediaType	static(4)

Table 5: RFC 2011 ipNetToMediaTable

If all embedded devices support the IPv6 protocol for provisioning and management, the eCM MUST support the RFC 4293 ipNetToPhysicalTable [19] and populate the entries as per Table 6.

RFC 4293 MIB object	Value
ipNetToPhysicalIfIndex	17
ipNetToPhysicalPhysAddress	STB MAC Address
ipNetToPhysicalAddressType	IPv4(1) or IPv6(2) as applicable
ipNetToPhysicalNetAddress	STB IP Address, if acquired; otherwise a zero-length string
ipNetToPhysicalLastUpdated	<refer to RFC 4293 [19]>
ipNetToPhysicalType	Static (4)
ipNetToPhysicalState	<refer to RFC 4293 [19]>
ipNetToPhysicalRowStatus	'active'

Table 6: RFC 4293 requirements

2.8.5 RFC 1493/RFC 4188 Requirements

Section 5.2.3.3 of eDOCSIS [15] is applicable where the STB is an eSAFE. Section 5.2.3.3.1 is not applicable.

2.9 DHCPv4 Option 43 Syntax Requirements

Section 5.2.4 up to and including section 5.2.4.3 of eDOCSIS [15] are applicable.

As suboption 3, the eCM has to report "ECM:ESTB".

2.10 DHCPv6 Vendor Specific Option Syntax Requirements

Section 5.2.5 of eDOCSIS [15] is applicable.

2.11 MAC Layer Requirements

2.11.1 Ranging Hold-off

The CM-part has to set bit#3 (DSG/eSTB) of the Ranging Hold-off support TLV (TLV 5.16). For more information refer to [13] section C.1.3.1.

2.12 Time-of-Day

STB/CM MUST acquire Time-of-Day (ToD). The ToD used by the CM MAY be either the DVB MPEG transport stream (TDT/ToT) clock or the EuroDOCSIS ToD clock, unless the STB uses the EuroDOCSIS TFTP code download mechanism, in which case the EuroDOCSIS ToD clock MUST be used.

3 STB Internal EuroDOCSIS IP Access

STBs with a EuroDOCSIS 2.0 and 3.0 cable modem have the capability of providing IP access internal to the STB without the need for a connection to an external PC. To simulate internal IP access for testing purposes, IP data needs to be communicated via a socket interface on the STB. Manufacturers MUST provide a software application to run on the STB that can provide UDP echo capabilities at a minimum. Additionally, such an application MAY duplicate all of the applicable test functionality currently required for stand-alone EuroDOCSIS CM testing such as packet loss, packet delay, packet jitter and packet misordering.

3.1 Architecture Overview

Figure 3 illustrates a general architecture for the STB networking software layers (Ethernet, USB or other external routing ports are not shown). As shown by this figure, the networking portion of a typical STB with a EuroDOCSIS 2.0 and 3.0 cable modem consists of five layers, namely:

a) Cable Modem Software
b) Data Forwarder
c) TCP/IP Stack
d) Socket API
e) Middleware / Applications

Color-coded layers in Figure 3 are the layers that will be engaged and tested by executing the test application.

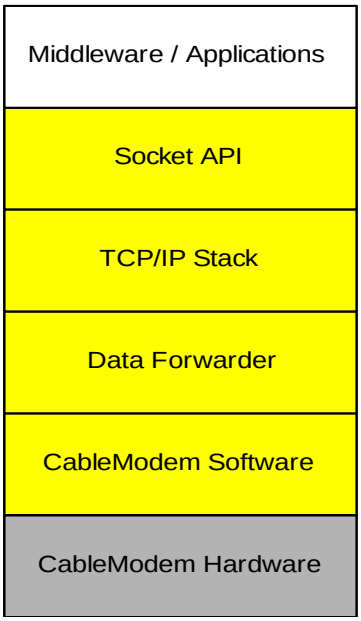

Figure 3: STB networking software layers

It is important to realize that the scope and functionality of this test software is limited to testing the internal IP connectivity of the STB and does not cover the Middleware or Application's functionality. Although the test application may run alongside Middleware and/or third party applications, it is not the intent of the test application to test these layers (such testing should be left to the middleware providers, equipment manufacturers, and cable operators and is outside the scope of STB with EuroDOCSIS 2.0 and 3.0 qualification).

The test application is intended to test the ability to receive and generate packets from the socket layer through the cable modem interface; hence running and interfacing through the same APIs as the Middleware and other applications such as Web browsing and EPG applications. In this way, the test software simulates real world IP traffic over the STB's cable modem in a manner that is application and Middleware independent.

The software stack shown in Figure 3 is one possible implementation of the networking functionality for a STB/CM.

3.2 Test Application Specification

3.2.1 Enabling/Disabling the Test Application

By default the test application MUST be disabled. The manufacturer can use any mechanism to enable the test application. Manufacturers MUST provide the details of how to enable the test application to the testing body.

3.2.1 Functionality

The test application provides a basic UDP echo capability. It MUST listen on port 10001 and echo packets received on this port to the originating port of the originating host.

When a packet is received on port 10001, a subset of the received packet data is returned to the original sender. The data portion of the test packets comprises a two byte MagicNumber, a two byte EchoLength, a two byte number representing the number of times the packet needs to be echoed and a variable length data payload as shown in Figure 4.

MagicNumber (2)	EchoLength (2)	EchoCount (2)	DataPayload (N)

Figure 4: Packet formatting

The MagicNumber is used to make sure that the application does not echo unintended packets. The test application MUST compare the value in the received packet to the value defined below. If the MagicNumber does not match, the packet MUST be dropped. The MagicNumber consists of two bytes: the first byte is 45_h, the second byte is 75_h.

The EchoLength determines the number of bytes in the data portion of the echoed UDP packet.

The minimum total length of a packet (this means including all headers, CRC, …) that needs to be echoed is 64 byte, the maximum length is 1518 byte. As a consequence, the minimum EchoLength is 22_d (14 byte Ethernet Header + 20 byte IP Header + 8 byte UDPheader + 4 bytes CRC = 46 bytes total header).

It is up to the server application to make sure only valid lengths are represented in the downstream packet. The packets that are sent by the application MUST be smaller than or have the same length as the received packet. For this reason, the downstream packet MUST NOT define that the length of the packet that needs to be echoed is longer than the received packet.

Although the external application that sends out the downstream packets has to make sure that only valid lengths are used, receiving illegal packets MUST NOT cause the STB to go to an unrecoverable unstable condition. The STB/CM MUST still be able to be remotely brought to a full operational state, the STB/CM SHOULD ignore "illegal" packets.

The EchoCount determines the number of times that the packet needs to be sent back. If the packet does not need to be reflected this value is set to 0.

The echoed packet consists of the MagicNumber, the EchoLength, the EchoCount and <EchoLength> bytes of DataPayload. The echoed DataPayload is composed using a ones complement operation on the first two bytes of the received DataPayload padded by the <EchoLength-2> following bytes of the received DataPayload.

An example for the first 6 bytes of the data portion of the echoed packet is given in Figure 5 with the following parameters:

EchoCount = 2

EchoLength = 16

45_h	75_h	10_h	00_h	02_h	00_h

Figure 5: Example for the first 6 bytes of the data portion of the echoed packet

Figure 6 shows an example of a packet originating from the server application, Figure 7 shows the reply packet created by the test application for the received packet of Figure 6.

Description	Data (hex)
MAC Destination	00 d0 37 24 7a a5
MAC Source	00 04 75 7e df f2
Ethernet II Type	08 00
Version + Header Length	45
Type of Service	00
Total Length	00 2e
Identification	a1 24
Flags + Offset	00 00
TTL + Protocol	80 11
Checksum	00 00
Source IP	0a 0b 00 1e
Destination IP	0a 0b 00 cc
Source Port	04 70
Destination Port	27 11
UDP Length	00 1a
UDP Checksum	c7 9d
MagicNumber	45 75
EchoLength	12 00
EchoCount	01 00
First two bytes of DataPayload	3f 26
Rest of DataPayload	0f 00 00 00 10 00 00 00 41 00 00 00 ed 00 00 00 72 00 00 01

Figure 6: Example of packet originating from server application

Description	Data (hex)
MAC Destination	00 04 75 7e df f2
MAC Source	00 d0 37 24 7a a5

Ethernet II Type	08 00
Version + Header Length	45
Type of Service	00
Total Length	00 2e
Identification	b5 27
Flags + Offset	00 00
TTL + Protocol	80 11
Checksum	70 98
Source IP	0a 0b 00 cc
Destination IP	0a 0b 00 1e
Source Port	27 11
Destination Port	04 70
UDP Llength	00 1a
UDP checksum	45 ea
Magic number	45 75
EchoLength	12 00
Echocount	01 00
First two bytes of DataPayload	c0 d9
Rest of DataPayload	0f 00 00 00 10 00 00 00 41 00 00 00 ed 00 00 00 72 00 00 01

Figure 7: Reply packet from STB on packet from figure 6

4 STB Loading

DVB-compliant streams are played out during EuroDOCSIS qualification testing to ensure that the STB/CM does not generate unwanted RF distortion products and that no misbehavior of the video processing is caused by the operation of the eCM.

5 Revision History

Version	Date	Comment
SP-STB-v3.0-I01-110411	2011/4/11	Initial version