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Telecommunications
Engineers***

**ENGINEERING COMMITTEE
Digital Video Subcommittee**

AMERICAN NATIONAL STANDARD

ANSI/SCTE 40 2011

Digital Cable Network Interface Standard

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Digital Cable Network Interface Standard

1.0 SCOPE

This standard defines the characteristics and normative specifications for the digital network interface between a cable television system and commercially available digital cable products that are used to access multi-channel television programming (See Figure 1). The network interface is also compatible with existing analog and digital set-top terminal equipment owned by cable operators and with terminal equipment developed via the OpenCable™ specification process (See www.opencable.com). All specifications in this document apply at the Demarcation Point except as specifically noted. Specifications noted to apply at the terminal device are applicable regardless of whether that device is owned by the subscriber or the cable operator. The key functional characteristics assumed in this document are the following:

- The cable network provides services utilizing 6-MHz in-band channel(s), out-of-band forward data channel(s), and out-of-band reverse data channel(s). The 6-MHz in-band channels follow the CEA-542-C channel-tuning plan. However, the frequency location can change over time such that analog and digital channels could be located anywhere in the downstream operating range. Nothing in this standard precludes the use of other narrowband or wideband digital signals.
- The 6 MHz in-band channels are used to transport digital services (QAM modulated MPEG-2 transport streams) as well as analog services (NTSC AM-VSB channels). Nothing in this standard precludes the use of other modulation modes.
- Services are either in the clear or protected using conditional access technology.

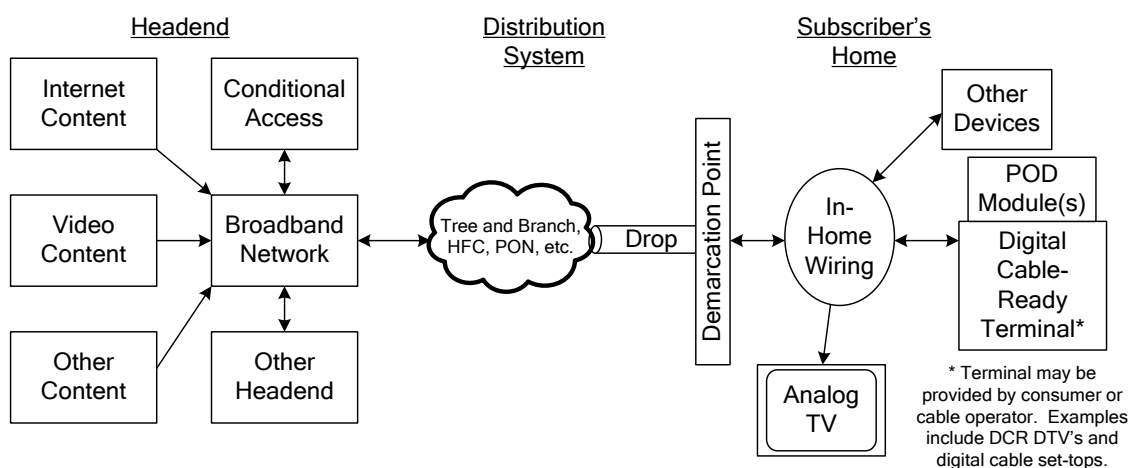


Figure 1 Cable Network Interface

2.0 DEFINITIONS AND ACRONYMS

2.1 Compliance Notation

“SHALL”	This word or the adjective “REQUIRED” means that the item is an absolute requirement of this specification.
“SHALL 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 weighted 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.

2.2 Glossary

64 QAM	Quadrature Amplitude Modulation with 64 constellation points
256 QAM	Quadrature Amplitude Modulation with 256 constellation points
AAL5	ATM Adaptation Layer 5
AC-3	A digital audio encoding scheme. The audio encoding format adopted by the ATSC, standardized in A/52[9].
AM	Amplitude Modulation
AM-VSB	Amplitude Modulation – Vestigial Sideband - used to broadcast analog NTSC video signals.
ATM	Asynchronous Transfer Mode - A switching and transport protocol that allows data, voice, and video to be carried over a single physical network. ATM is ideal for interactive applications that require dynamic routing and resource allocation.
ATSC	Advanced Television Systems Committee
Cable	Cable Television Systems

Carrier	An RF signal used to carry information (video, audio, data) by some modulation scheme.
CEA	Consumer Electronics Association
CFR	Code of Federal Regulations
Closed Captioning	A textual description of dialog in a video program
Complete Main	A complete audio program (dialogue, music and effects)
Composite video	A baseband representation of a video signal containing luminance and chrominance information.
Conditional Access System	A system that controls and permits access to video, audio, and data that is being transmitted.
Content Advisory Descriptor	A defined method for describing the contents of a program based on a number of rating scales.
C/N	Carrier to Noise Ratio
CTB	Composite Triple Beat – a third order distortion caused by mixing three carriers (A+B-C) that falls on the fundamental of a carrier.
CSO	Composite Second Order – The sum effect of all second order distortion products.
Demarcation Point	As specified in FCC Rules 47 CFR Section 76.5(mm), which is typically a point at (or about) twelve inches outside of where the cable wire enters the subscriber's premises.
dB	Decibel - A logarithmic value of a ratio
dBc	Decibels relative to carrier amplitude
dBm	Decibels relative to one milliwatt
dBmV	Decibels relative to one millivolt across a given impedance (75 ohms in North American cable systems). For direct correspondence to normal settings by common test equipment, in this document, all RF signal and power levels are represented in units of dBmV (decibels relative to 1 millivolt RMS, across 75 ohms). Note that this is used independent of the bandwidth of the signal level being noted, although if not noted the bandwidth is considered to be 6 MHz. The dBmV values measured in any given bandwidth are converted directly to units of dBm (decibels relative to one milliwatt) by subtracting 48.75. For example, a +20 dBmV value in this document is equivalent to -28.75 dBm.
DOCSIS	Data Over Cable Service Interface Specifications
Downstream	Transmission from Headend to terminal device

Drop Cable	A coaxial cable from a subscriber tap to the Demarcation Point
DSM-CC	Digital Storage Media-Command and Control (ISO/IEC 13818-6)
DSG	DOCSIS Set-top Gateway
DTV	Digital Television – A general term for the digital coding and transmission of an Audio / Video Program.
EAS	Emergency Alert System
ES	Elementary Stream – A generic term for a stream of data of one particular type. Typically these streams are of Video or Audio Types.
FAT	(Forward Application Transport) Channel - A data channel carried from the headend to the terminal device in a modulated channel at a rate of 26.97 or 38.81 Mbps. See Annex A of SCTE 07[2]. MPEG-2 transport is used to multiplex video, audio, and data into the FAT channel. The FAT Channel is also considered the “In-band” channel. The FAT channel is used for MPEG-2 compressed video and audio.
FCC	Federal Communications Commission.
FDC	Forward Data Channel - A data channel carried from the headend to the terminal device in a modulated channel at a rate of 1.544 to 3.088 Mbps.
Headend	The control center of a cable television system, where incoming signals are amplified, converted, processed, and combined into a common cable, along with any locally originated programming, for transmission to subscribers.
Host	The part of a generic terminal device that does not contain the network specific characteristics.
HRC	Harmonically Related Carrier
ID	Identifier
IF	Intermediate Frequency. A signal processing stage between RF and baseband.
Interleaving	A communications technique for reordering associated bytes over a longer period of time to reduce the effects of burst noise.
IP	The network layer (layer 3) of the <i>Open Systems Interconnection</i> reference model.
IRC	Incrementally Related Carrier
ITU	International Telecommunications Union
kbps	Kilobits per second- bits per second in thousands
kHz	Kilohertz - Cycles per second, in thousands

MAC	Media Access Control
Mbps	Megabits per second- bits per second, in Millions
MHz	Megahertz - Cycles per second, in Millions
MPEG	Moving Picture Experts Group - An international standards-setting group, working to develop standards for compressed full-motion video, audio, and other associated information.
MPEG-2	Refers to the ISO/IEC 13818 multi-part standard
mV	Millivolt – Thousandths of a Volt
Noise	An undesired or unintended element of a signal.
NTSC	National Television Systems Committee – Refers to the Analog Color Television Standard as used in North America
OOB	Out-of-Band – Outside of the programming channels band. The OOB channels provide communication channels between the network and the terminal.
PES	Packetized Elementary Stream
PHY	Physical Layer
PID	Packet Identifier – A unique integer value used to identify the contents of an MPEG-2 Transport Stream packet.
POD / POD Module	Point of Deployment Module (CableCARD™) - A module to be provided by the MSO that contains all of the network specific characteristics for a terminal device.
p-p	Peak to peak
PSI	Program Specific Information – Normative data that is necessary for the demultiplexing of transport streams and the regeneration of programs.
PSIP	Program and System Information Protocol – A method of describing Naming and Navigation data for a multi program transport stream as defined in ATSC A/65[27].
QAM	Quadrature Amplitude Modulation – A radio frequency modulation scheme, defined ANSI/SCTE 07[2] that combines phase and amplitude modulation.
QPSK	Quadrature Phase Shift Keying - A signaling and modulation scheme in which an RF carrier is phase shifted to signal digital data.
Randomization	A coding method that provides for even distribution of the symbols in the QAM constellation, which enables the demodulator to maintain proper lock.

RDC	Reverse Data Channel - A data channel transmitted from the terminal device to the headend in a modulated channel at a rate of 0.256 to 3.088 Mbps.
Reed Solomon	A coding method that adds parity symbols to a data packet thereby providing a forward error correction capability.
RF	Radio Frequency – Used to describe the part of the electromagnetic frequency spectrum that is used to transmit video, audio, and data over the air or via coaxial cable.
RRT	Rating Region Table
SCTE	Society of Cable Telecommunications Engineers - The technical and applied science leader for the cable telecommunications industry for professional development, information, certification and standards.
SI	Service/System Information
SMPTE	Society of Motion Picture and Television Engineers – A Standards Organization devoted to advancing theory and application in motion imaging, including film, television, video, computer imaging, and telecommunications.
TS	Transport Stream – An MPEG-2 Transport Stream as described in ISO/IEC 13818-1[14]
TV	Television
Upstream	Transmission from terminal device to Headend
V	Volt – Unit of Electrical Potential
VBI	Vertical Blanking Interval - In analog video, the interval after the last displayed line of video in a field and before the first displayed line of video in the next field, during which a television receiver will synchronize vertically.

3.0 NORMATIVE REFERENCES

The following documents contain provisions, which, through reference in this text, constitute provisions of this standard. At the time of subcommittee approval, the editions indicated were valid. All standards are subject to revision, and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the documents listed below.

3.1 SCTE References

1. ANSI/SCTE 02 2006 : "F" Port (Female Indoor) Physical Dimensions

2. ANSI/SCTE 07 2006 : Digital Video Transmission Standard for Cable Television
3. ANSI/SCTE 43 2005 : Digital Video Systems Characteristics Standard for Cable Television
4. ANSI/SCTE 54 2009 : Digital Video Service Multiplex and Transport System Standard for Cable Television
5. ANSI/SCTE 55-1 2009 : Digital Broadband Delivery System: Out-of-band Transport – Mode A
6. ANSI/SCTE 55-2 2008 : Digital Broadband Delivery System: Out-of-band Transport – Mode B
7. ANSI/SCTE 65 2008 : Service Information Delivered Out-of-Band for Digital Cable Television
8. ANSI/SCTE 18 2007 : Emergency Alert Message for Cable

3.2 Standards from other Organizations

9. ATSC A/52:2010: ATSC Digital Audio Standard (AC-3)(E-AC-3) Standard
10. ATSC A/53 Parts 3 (2009) and 5 (2010): ATSC Digital Television Standard,
11. CEA-23-A: RF Interface Specification for Television Receiving Devices and Cable Television Systems
12. CEA-542-C: Cable Television Channel Identification plan
13. CEA-608-E (ANSI): Line 21 Data Services
14. ISO/IEC 13818-1:2007: Information technology -- Generic coding of moving pictures and associated audio information: Systems (*MPEG-2 Systems*)

4.0 INFORMATIVE REFERENCES

The following documents provide valuable information to the reader but are not required when complying with this standard.

4.1 SCTE References

15. ANSI/SCTE 20 2004 : Standard Methods for Carriage of Closed Captions and non-Real Time Sampled Video

16. ANSI/SCTE 21 2001R2006 : Standard for Carriage of NTSC VBI Data in Cable Digital Transport Stream
17. ANSI/SCTE 106 2010: DOCSIS[®] Set-Top Gateway (DSG) Specification
18. ANSI/SCTE 127 2007: Carriage of Vertical Blanking Interval (VBI) Data in North American Digital Television Bitstreams
19. ANSI/SCTE 128 2010-a: AVC Video Systems and Transport Constraints for Cable Television
20. ANSI/SCTE 157 2008: VC-1 Video Systems and Transport Constraints for Cable Television
21. ANSI/SCTE 22-1 2002R2007: Data-Over-Cable Service Interface Specification DOCSIS 1.0 Radio Frequency Interface (RFI)
22. ANSI/SCTE 23-1 2010: DOCSIS 1.1 Part 1: Radio Frequency Interface
23. ANSI/SCTE 79-1 2009: DOCSIS 2.0 Part 1: Radio Frequency Interface
24. ANSI/SCTE 135-1 2008: DOCSIS 3.0 Part 1: Physical Layer Specification

4.2 Standards from Other Organizations

25. ITU-T J.83 (12/07): Digital multi-programme systems for television, sound and data services for cable distribution
26. SMPTE 170M: Television - Composite Analog Video Signal - NTSC for Studio Applications
27. ATSC A/65:2009 ATSC Program and System Information Protocol for Terrestrial Broadcast and Cable
28. CEA-708-D: Digital Television (DTV) Closed Captioning
29. CEA-766-C: U.S. and Canadian Region Rating Table (RRT) and Content Advisory Descriptor for Transport of Content Advisory Information Using ATSC A/65, A66 and A67 Program and System Information Protocol (PSIP)
30. ISO/IEC 13818-2:2000/Cor.2:2007: Technical Corrigendum 2
31. ISO/IEC 13818-6:1998/Cor 2:2002: Information technology -- Generic coding of moving pictures and associated audio information -- Part 6: Extensions for DSM-CC (MPEG-2 Digital Storage Media-Command and Control)

5.0 REFERENCE ACQUISITION

SCTE Standards:

Society of Cable Telecommunications Engineers Inc., 140 Philips Road, Exton, PA 19341
Phone: 1-800-542-5040, Fax: 610-363-5898 Internet: <http://www.scte.org>;
email: standards@scte.org

CEA Standards:

Global Engineering Documents, World Headquarters, 15 Inverness Way East, Englewood,
CO USA 80112-5776; Phone 800-854-7179; Fax 303-397-2740; Internet
<http://global.ihs.com>; email global@ihs.com

ANSI/CEA Standards:

American National Standards Institute, Customer Service, 11 West 42nd Street, New York
NY 10036; Phone 212-642 4900; Fax 212-302-1286; email: sales@ansi.org; Internet:
<http://www.ansi.org>

FCC Documents:

ITS, Inc. 1231 20th Street, N.W. Washington, DC 20036; Phone 202 857 3800 Fax 202
857 3814; Internet: <http://www.itsdocs.com/>; email: service@itsdocs.com

ATSC Standards:

Advanced Television Systems Committee (ATSC), 1776 K Street NW STE 200 -
Washington, DC 20006-2304; Ph.-202.872.9160 Fax-202.872.9161;
<http://www.atsc.org/standards.html>

ISO/IEC Standards:

Global Engineering Documents, World Headquarters, 15 Inverness Way East, Englewood,
CO. USA 80112-5776; Phone 800-854-7179; Fax 303-397-2740; Internet:
<http://global.ihs.com>; email global@ihs.com.

ITU Standards:

ITU Sales and Marketing Service, International Telecommunication Union, Place des
Nations CH-1211, Geneva 20, Switzerland; Phone +41 22 730 6141; Fax +41 22 730
5194; Internet: <http://www.itu.org/> email sales@itu.int

OpenCable Specifications:

Cable Television Laboratories, Inc., 400 Centennial Parkway, Louisville, CO 80027;
Phone 303-661-9100; Fax 303-661-9199; Internet: <http://www.opencable.com/>;
email: opencable@cablelabs.com

SMPTE

Society of Motion Picture and Television Engineers, 3 Barker Ave., 5th Floor, White Plains, NY 10601; Phone: +1 (914) 761-1100; Fax: +1 (914) 761-3115
<https://store.smpte.org/>

6.0 PHYSICAL LAYER CHARACTERISTICS

6.1 RF Interface

The physical interface between the cable TV system and the terminal device at the terminal device input shall be as defined in ANSI/SCTE 02[1].

6.1.1 Maximum Individual Carrier Amplitude

The maximum rms value of any individual received signal whose frequency is between 0.5 MHz and 30 MHz shall not exceed -7 dBm (+42 dBmV across 75 ohms) measured at the input to the terminal device.

No signal power limits are specified between 30 MHz and 54 MHz. Receivers are not expected to operate properly in the presence of signals in the 30 to 54 MHz band near the levels specified for signals below 30 MHz.

The maximum rms value of any individual signal whose frequency exceeds 54 MHz shall be less than 10 mV across a 75 ohm terminating impedance (+20 dBmV) measured at the input to the terminal device. Receivers are not expected to properly receive signals of individual carriers that fall outside the limits of Table 4 line 14

6.2 Frequency Plan

Cable systems deliver analog and digital services to terminal devices directly connected to the cable system in a downstream passband. This passband is local system-dependent but typically has a 54 MHz lower edge and an upper edge in the range of 300 to 1002 MHz. Within that passband, NTSC analog television signals and Forward Application Transport channels in 6-MHz channels may be present and shall adhere to the standard, HRC or IRC frequency plans of CEA-542[12]. Forward Data Channels may be present in the 70-130 MHz range.

The cable network may support any portion or all of the 5-30 MHz, 5-42 MHz or 5-85 MHz passband in the upstream direction. NTSC analog television signals in 6 MHz channels, as well as other narrowband and wideband signals, may be present anywhere within these network supported passbands. Reverse Data Channels may be present anywhere within the 5-42 MHz passband.

6.3 Communications Channels

The cable network shall have the following communications channels:

1. Forward Application Transport (FAT) channels.
2. Forward Data Channels (FDC).

The cable network may have the following communications channels:

1. NTSC Analog channels.
2. Reverse Data Channels (RDC).
3. DOCSIS Upstream and Downstream Channels

The FDC and RDC are referred to as *out-of-band* (OOB) channels. Frequency bands for each channel are given in Table 1 below.

Table 1. Digital Cable Network Frequency Bands	
FAT channels and NTSC Analog channels	54 to 1002 MHz
OOB FDCs	70 to 130 MHz
OOB RDCs	5 to 42 MHz

The cable network may support Reverse Data Channels (RDCs) within any portion or all of the 5 MHz to 42 MHz passband in the upstream direction.

6.3.1 Forward Application Transport (FAT) Channels

The forward application transport channels shall be Quadrature Amplitude Modulation (QAM) channels that comply with ITU J83.B / ANSI/SCTE 07[2] . Either 64 QAM or 256 QAM may be used to transport approximately 26.97 or 38.81 megabits/second, respectively. See Annex A of SCTE 07. FAT channels may be located anywhere in the 54 to 1002 MHz range. The physical layer protocol for FAT channels is shown in Figure 2 FAT Channel Physical Layer Protocol.

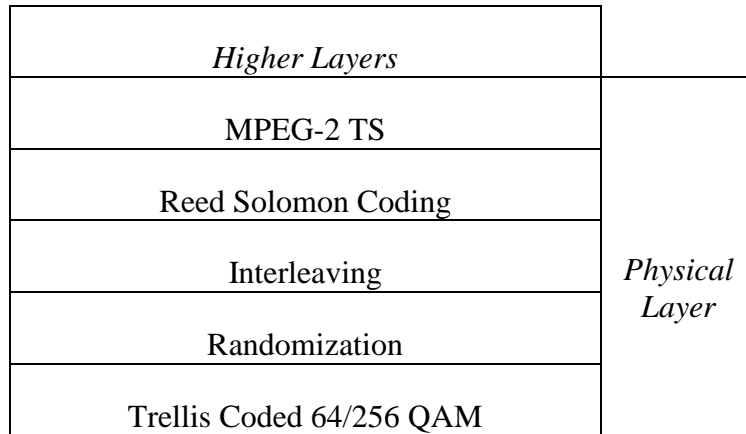


Figure 2 FAT Channel Physical Layer Protocol

6.3.2 NTSC Analog Channels

The analog channels shall be NTSC RF AM-VSB modulated signals in accordance with current cable-system practice and applicable FCC rules. NTSC Analog channels may be located anywhere in the 54 to 1002 MHz range.

6.3.3 Out-Of-Band Forward Data Channels (FDC)

Each forward data channel shall be as defined in ANSI/SCTE 55-1 2009 or ANSI/SCTE 55-2 2008 with the additional requirements specified in Table 2. The FDCs may be located anywhere in the 70 to 130 MHz, and are spaced between the 6-MHz Analog and/or FAT channels. Figure 3 shows the lower layer protocol stacks for the out-of-band FDCs.

Table 2. FDC Channel: RF Transmission Characteristics		
1.	Transmission Rate	1.544/3.088 Mbps, ANSI/SCTE 55-2 2.048 Mbps, ANSI/SCTE 55-1
2.	RF Channel Spacing (Bandwidth)	1.0/2.0 MHz, ANSI/SCTE 55-2 1.8 MHz, ANSI/SCTE 55-1
3.	RF Frequency Range	70 MHz to 130 MHz
4.	Nominal Carrier Frequency	Any integer multiple of 250 kHz between the minimum and maximum carrier frequencies, inclusive of the specified fixed frequency of 104.200 MHz.
5.	Minimum Carrier Level at terminal input	-15 dBmV
6.	Maximum Carrier Level at terminal input	+15 dBmV
7.	C/(N+I) in Nyquist bandwidth	≥ 20 dB
8.	Group Delay Variation	200 ns maximum measured over Nyquist bandwidth

ANSI/SCTE 55-2	ANSI/SCTE 55-1	
<i>Payload</i>	<i>Payload</i>	
ATM Cell Format	Data Link Layer	
Link/Physical Layer:	MAC Sublayer	OOB FDC Lower Layer Protocols
– Reed-Solomon	– MAC Packet	
– Interleaving	– MPEG-2 TS	
– SL-ESF Frame Payload Structure	Physical Layer:	
– SL-ESF Format	– Randomizer	
– Randomizer	– Reed-Solomon	
– QPSK/differential coding	– Interleaving	
	– QPSK/differential coding	

Figure 3 Out-of-band Forward Data Channel Lower Layer Protocols

6.3.4 Out-Of-Band Reverse Data Channels (RDC)

When present, each reverse data channel shall be as defined in ANSI/SCTE 55-1 2009 or ANSI/SCTE 55-2 2008, with the additional requirements specified in Table 3. The

RDCs may be present anywhere within the network-supported passband as defined in Table 3. Figure 4 shows the lower layer protocol stacks for the out-of-band RDCs.

Table 3. RDC Channel: RF Transmission Characteristics		
1.	RF Transmission Rate	1.544/3.088 Mbps, ANSI/SCTE 55-2 256 kbps, ANSI/SCTE 55-1
2.	RF Channel Spacing (Bandwidth)	1.0/2.0 MHz, ANSI/SCTE 55-2 192 kHz, ANSI/SCTE 55-1
3.	RF Frequency Range	5 MHz to 42 MHz.
4.	Nominal Carrier Frequency	ANSI/SCTE 55-2 : Any integer multiple of 250 kHz between 5.0 MHz and 42.0 MHz, inclusive. ANSI/SCTE 55-1 : Any integer multiple of 192 kHz between 8.096 MHz and 40.160 MHz, inclusive.

ANSI/SCTE 55-2	ANSI/SCTE 55-1	
<i>Payload</i>	<i>Payload</i>	
Data link Layer/AAL5	Data link Layer/AAL5	OOB RDC Lower Layer Protocols
MAC Sublayer – MAC Signaling Message – ATM Cell Format	MAC Sublayer: – MAC Packet sublayer – ATM Cell Format	
Physical Layer: – Reed-Solomon – Randomizer – Burst QPSK/ – differential coding	Physical Layer – Randomizer – Reed-Solomon – Burst QPSK/ – differential coding	

Figure 4 Out-of-band Reverse Data Channel Lower Layer Protocols

6.3.5 DOCSIS Upstream and Downstream Channels

DOCSIS upstream and downstream signals are present on many cable systems. Some of these DOCSIS signals have very similar characteristics to the signals specified in this standard but they are distinct and specified in separate standards including but not limited to SCTE 22-1, SCTE 23-1, SCTE 79-1 and SCTE 135-1. The limits of this standard apply to DOCSIS as an undesired signal.

6.4 Downstream Transmission Characteristics

The Downstream Transmission Characteristics are contained in Table 4 and Table 2. Analog and FAT signals shall meet their respective characteristics specified in Table 4 when measured on the subscriber's premises at the end of a properly terminated Drop Cable. OOB FDC signals shall meet the characteristics specified in Table 2 when measured on the subscriber's premises at the end of a properly terminated Drop Cable.

Table 4. Analog and FAT Channel: RF Transmission Characteristics		
1.	RF Channel Spacing	6 MHz
2.	RF Frequency Range	54 MHz to 1002 MHz IRC/HRC/Standard Channel Plans.
3.	Transit delay from headend to most distant customer	≤ 0.800 ms (typically much less)
4.	Carrier-to-noise-plus-interference ratio, $C/(N+I)$, in a 6-MHz band where $C/(N+I)$ includes the simultaneous presence of all additive impairments in the 6-MHz channel bandwidth including CTB, CSO, and other forms of discrete interference. The carrier, noise, and interference are all subject to any linear channel distortions (micro-reflections) present in the transmission path. C/N (analog channels)	Not less than 27 dB for 64 QAM; 33 dB for 256 QAM; 43 dB for AM-VSB analog
5.	CTB	Not greater than -53 dBc referenced to inband carrier levels for analog channels.
6.	CSO	Not greater than -53 dBc referenced to inband carrier levels for analog channels
7.	Carrier-to-any other discrete interference (ingress)	Not greater than -53 dBc
8.	AM Hum Modulation	Not greater than 3% p-p
9.	Group Delay Variation	≤ 0.37 μ s/MHz across the 6-MHz channel
10.	Chroma / Luma Delay	≤ 170 ns (AM-VSB analog)
11.	Phase Noise	≤ -86 dBc/Hz @ 10 kHz offset (relative to the center of QAM signal spectrum)
12.	Maximum Amplitude Variation across the 6-MHz channel (digital channels) Maximum Amplitude Variation across the 6-MHz channel (analog channels)	≤ 6 dB p-p ≤ 4 dB p-p

13.	Bound for a single dominant micro-reflection	-10 dB at $\leq 0.5 \mu\text{s}$ -15 dB at $\leq 1.0 \mu\text{s}$ -20 dB at $\leq 1.5 \mu\text{s}$ -30 dB at $\leq 4.5 \mu\text{s}$ Micro-reflections longer than 4.5 microseconds are included under item 4 (of this table) as a contributor to the interference I in $C/(N+I)$. Micro-reflections, if present, shall not cause the channel Group Delay Variation and Maximum Amplitude Variation in Table 4.9 and 4.12 respectively to be exceeded.
14.	Carrier level at the terminal input	64 QAM: -15 dBmV to + 15 dBmV 256 QAM: -12 dBmV to +15 dBmV Analog Visual Carrier (c): 0 dBmV to +15 dBmV Analog Aural Carrier: -10 dBc to -17 dBc

6.4.1 RF Signal Levels and Adjacent Channel Characteristics

6.4.1.1 RF Signal Levels

To determine the adjacent channel characteristics between digital and NTSC analog signals, the following information is provided.

The visual signal level of an analog signal is required to be within ± 3 dB of the visual signal level of any adjacent analog channel (within a 6-MHz nominal frequency separation) as specified in FCC Rules 47 CFR Section 76.605(a)(4)(i).

The nominal relative carrier power level is defined as the difference between the power level of each digitally modulated carrier type relative to the reference analog carrier power level, expressed in dB. Each nominal relative carrier power level is uniquely specified within a range and applies to all carriers of a given type for a cable system at the Demarcation Point, as given in Table 5 below.

Table 5. Nominal Relative Carrier Power Levels	
Analog NTSC	0 dB (reference level)
256 QAM FAT	-5 ± 2 dB
QPSK FDC	-8 ± 5 dB
64 QAM FAT	-10 ± 2 dB

The variation in signal power of each individual carrier shall be within ± 3 dB of its nominal relative carrier power level.

The analog signal power shall be measured as the Peak Envelope Power, which is the average carrier power measured during the horizontal sync interval. The FAT digital signal power shall be measured as the average signal power in a 6 MHz channel. The FDC digital signal power shall be measured as the average signal power over the appropriate bandwidth as defined in SCTE 55-1 or SCTE 55-2.

6.4.1.2 Adjacent Channel Characteristics

The worst-case Adjacent Channel performance shall be characterized according to Table 6.

Table 6. Adjacent Channel Characteristics			
	<i>Desired (D) Channel Modulation</i>	<i>Undesired (U) Adjacent Channel Modulation</i>	<i>Worst Case D/U Ratio</i>
1	Analog NTSC	64 QAM	+2 dB
2	Analog NTSC	256 QAM	-3 dB
3	Analog NTSC	QPSK FDC	-3 dB
4	64 QAM FAT	Analog NTSC	-18 dB
5	64 QAM FAT	256 QAM	-15 dB
6	64 QAM FAT	QPSK FDC	-15 dB
7	256 QAM FAT	Analog NTSC	-13 dB
8	256 QAM FAT	64 QAM	-5 dB
9	256 QAM FAT	QPSK FDC	-10 dB
10	QPSK FDC	Analog NTSC	-19 dB
11	QPSK FDC	64 QAM	-11 dB
12	QPSK FDC	256 QAM	-16 dB
13	Analog NTSC	Analog NTSC	-3 dB
14	64 QAM FAT	64 QAM	-6 dB
15	256 QAM FAT	256 QAM	-6 dB
16	QPSK FDC	QPSK FDC	-6 dB
<ul style="list-style-type: none"> • <i>Independent of the D/U ratios, the C/(N+I) and the absolute signal levels shall meet the requirements for those parameters as described elsewhere in the specification.</i> • <i>Good engineering practice normally requires that only a single FDC channel be adjacent to a FAT channel.</i> 			

The Worst Case D/U Ratio (Desired-to-Undesired carrier level Ratio) in Table 6 is derived from the Table 5 nominal levels and the Section 6.4.1.1 requirement that individual signals to be within ± 3 dB of those levels. This ratio occurs when a desired carrier is -3 dB with respect to the minimum level allowed by Table 5 and the undesired carrier is +3 dB with respect to the maximum level allowed by Table 5.

For example, line 1 in Table 6 refers to a worst case condition where a desired analog NTSC signal has 2 dB more power than an adjacent undesired 64 QAM carrier. This occurs when the desired analog NTSC signal variation is -3 dB with respect to the Table 5 analog NTSC reference level of 0 dB. The undesired 64 QAM signal variation is +3 dB above the -8 dB maximum allowed Nominal Relative Carrier Power Level in the range specified for 64 QAM in Table 5. This results in a worst

case level of -5 dB with respect to the reference level. The D/U ratio is therefore -3 dB minus -5 dB = +2 dB D/U ratio.

The worst case analog NTSC into analog NTSC D/U ratio in Table 6, line 13 is limited to -3 dB by the FCC rule referenced in Section 6.4.1.1.

6.4.1.3 Limits for Digital Signals

Independent of meeting the requirements specified in sections 6.4.1.1 and 6.4.1.2 above, the level of digital signals shall fall within the ranges specified in Table 4 (QAM FAT), Table 2.5 and Table 2.6 (QPSK FDC) measured at the input to the terminal device. These absolute carrier level ranges are the only parameters that limit individual carrier levels across the 54 to 1002 MHz frequency band.

7.0 TRANSPORT LAYER PROTOCOLS

7.1 Forward Application Transport (FAT) Channels

The MPEG-2 Transport Stream protocol, defined in ISO/IEC 13818-1 MPEG-2 Systems[14], shall be used as the Transport Layer of the FAT channels. The protocols and messages defined in this layer are used to transport a variety of digital services, including digital audio-visual services, digital multi-media services, and information services.

The protocol stack of MPEG-based services is shown in Figure 5. The digital multiplex and transport system is defined in ANSI/SCTE 54[4]. It is a compatible subset of the MPEG-2 Systems specification defined in ISO/IEC 13818-1.

The overall system multiplexing approach is a combination of multiplexing at two different layers. In the first layer, single program Transport Streams are formed by multiplexing Transport Stream (TS) packets from one or more Packetized Elementary Stream (PES) sources. In the second layer, many single program Transport Streams are combined to form a multi-program Transport Stream. The multi-program stream includes Program Specific Information (PSI) that identifies each program and its components.

In addition to MPEG-2 Video, AC-3 Audio, System Tables and other System Information, MPEG-2 Transport packets are used to carry other services and information. The MPEG-2 Transport layer allows new ancillary services to be added to the basic service at any time in the future. The transport and other protocol layers for these additional services and information are currently undefined.

Video, Audio ES	System Tables and other System Information
MPEG-2 PES	MPEG-2 PSI and MPEG-2 Private Sections carrying other System Information
MPEG-2 TS	
FAT Channel Physical Layer	

Figure 5 FAT Channel Transport Layer Protocol

7.2 Out-of-Band Forward Data Channels (FDC)

The out-of-band forward data channels are defined above in Section 6.3.3 and Figure 3. The out-of-band forward data channels are used for control and access messages, application code download, electronic program guide data and other data services as applicable.

Transport layer protocols for out-of-band forward channels are defined in ANSI/SCTE 55-2 and ANSI/SCTE 55-1.

7.3 Out-of-Band Reverse Data Channels (RDC)

When present, the RDC channels are as defined above in 6.3.4 and Figure 4. The out-of-band reverse channels carry traffic from the terminal device to the headend equipment. The RDCs utilize IP packets with ATM AAL5 to transport information.

8.0 SERVICES AND RELATED PROTOCOL STACKS

In this section service and related protocol stacks are defined. Figure 6 and Figure 7 show the inter-relations among the service channels, logic interfaces and applications.

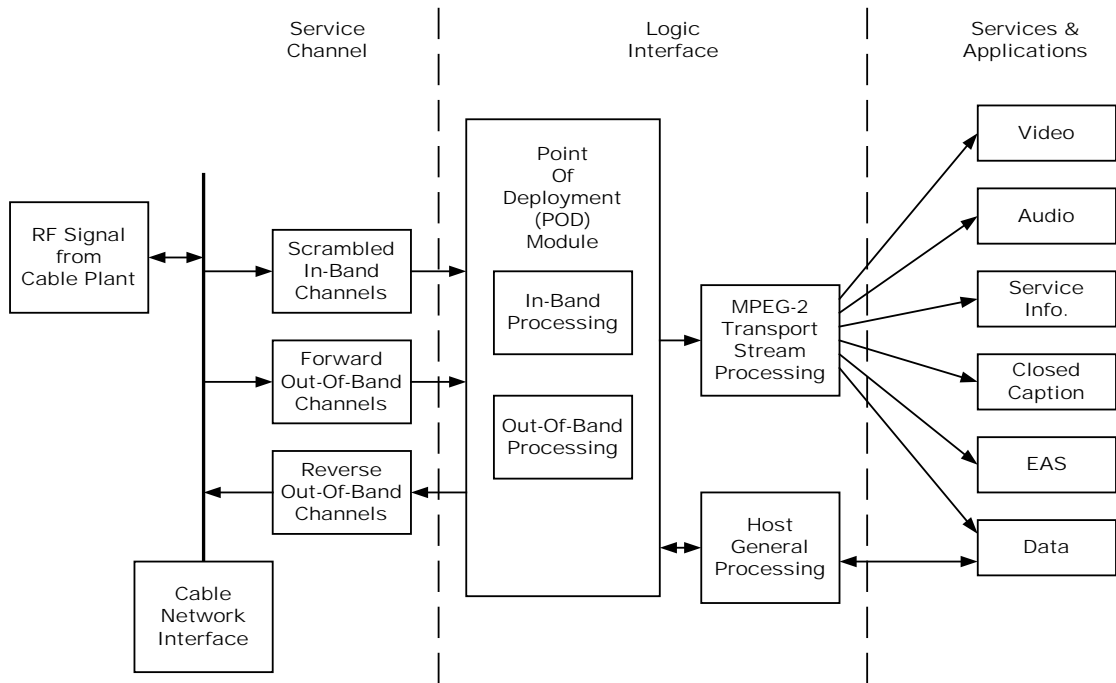


Figure 6 Interrelation of Service Channels, Logic Interfaces and Applications for Scrambled Programming

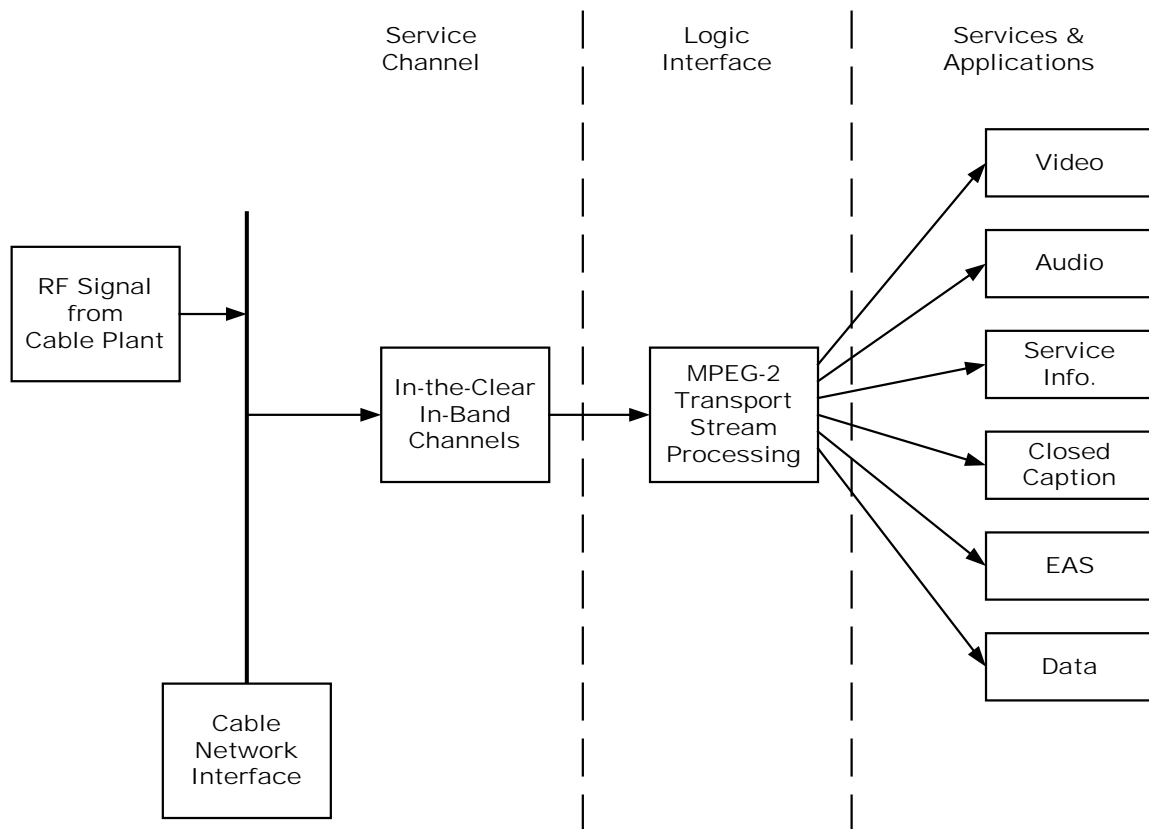


Figure 7 Interrelation of Service Channels, Logic Interfaces and Applications for Unscrambled Programming

8.1 Audio-Visual Services

Audio-Visual services are provided on either or both the analog channels and the FAT channels. These services include analog and digital broadcast, on-demand services, premium, tiered, and other video services.

8.1.1 Analog Audio-Visual Services

Analog video and audio are provided in accordance with current cable-system practice and applicable FCC rules. Along with the analog service, data may be sent in the NTSC Vertical Blanking Interval (VBI) lines (See Section 8.1.3 below) that are then processed by the terminal device in compliance with FCC Rules 47 CFR Section 15.119. The demodulated NTSC signal is the Composite signal defined in SMPTE-170M [26].

8.1.2 Digital Audio-Visual Services

Digital Audio-Visual services are provided as either MPEG-2 compressed video (ISO/IEC 13818-2[1]), AVC/H.264 compressed video as constrained by ANSI/SCTE 128[19], or

VC-1 compressed video as constrained by ANSI/SCTE 157[20] and AC-3 audio (ATSC A/52 as constrained by ATSC A/53 Parts 3 and 5[10]). A modified protocol stack for both analog and digital Audio-Visual services is shown in Figure 8. The video formats are those specified in ANSI/SCTE 43[3] for MPEG-2, ANSI/SCTE 128[19] for AVC/H.264 and SCTE 157[20] for VC-1. The constraints and extensions that apply to video are specified in ANSI/SCTE 43[3], ANSI/SCTE 128[19] or SCTE 157[20]. When audio is present, ANSI/SCTE 54[4] requires at least one Complete Main audio service to be present.

Video	VBI Data	Stereo /Mono /Pro-logic	Video	Audio	Data
Composite Video Baseband Signal		Audio Baseband Signal	PES packet		
			Conditional Access		
NTSC Baseband			MPEG-2 TS		
			64/256 QAM Baseband Signal		
NTSC/AM-VSB IF			64/256 QAM/IF		
6-MHz RF Signal (CEA-542-C)					

Figure 8 Modified Protocol Stack for Audio-Visual Services

8.1.3 VBI Services

VBI signals are found on lines 10 through 20 of the analog waveform, with closed captioning signals found on line 21. Field 1, Field 2, or both may carry VBI signals. Certain VBI services have been standardized by SCTE for carriage within a digital television system. VBI services are documented by ANSI/SCTE 127[18].

8.2 Data Services

Broadcast data services may be provided via FAT channels and out-of-band FDCs. Standards for data services are beyond the scope of this document.

8.3 In-Band Service/System Information

When system information is provided with transport streams containing one or more unscrambled programs, that data shall be formatted as defined in Section 5.7.1 of ANSI/SCTE 54[4].

8.4 Out-of-Band Service/System Information

When one or more scrambled services are offered on the cable system, System and Service Information for those services is carried to each POD (CableCARD™) module deployed by the cable operator for all services for which the POD module has entitlements. System and Service Information is carried in an out-of-band Forward Data Channel, as defined in section 6.3.3 above, using the formats described in ANSI/SCTE 65[7] or through an application appropriate to the terminal device. Nothing in this standard precludes the use of other modes for providing service information to products that include features or functions needed to support interactive services. This information is carried in MPEG-2 private sections mapped into either MPEG-TS packets in ANSI/SCTE 55-1 or IP/AAL5 packets in ANSI/SCTE 55-2 . Figure 9 shows the protocol stack for Service/System Information.

It is the responsibility of the POD module to provide System and Service Information across the HOST-POD interface in Extended Channel data flows, using *Service_type MPEG_section*, as defined in ANSI/SCTE 65 or for the appropriate application to present the service information. The System and Service Information provided shall conform to one or more of the profiles specified in ANSI/SCTE 65.

ANSI/SCTE 55-2	ANSI/SCTE 55-1
OOB-SI ANSI/SCTE 65	OOB-SI ANSI/SCTE 65
MPEG-2 private section	MPEG-2 private section
AAL5	
ATM cell Format	MPEG-2 TS
ANSI/SCTE 55-2 PHY	ANSI/SCTE 55-1 PHY

Figure 9 Protocol Stack for Out-of-Band Service/System Information

8.5 Emergency Alert System (EAS)

Emergency Alert System (EAS) is used to alert viewers of incoming emergency messages. The origination of these emergency alert messages could be from a variety of sources: National, State or Local government, and etc. Emergency alert messages may be conveyed to a viewer by means of a textual overlay on the TV screen or via audio announcements that may pre-empt the audio source of a normal broadcast program or by other means at the discretion of the operator and without impact to the receiver.

The EAS message syntax is compatible with MPEG-2 transport and is defined in ANSI/SCTE 18[8]. When present on inband transmission, messages conforming to ANSI/SCTE 18 shall appear in transport packet with the same PID that is used for Service/System Information (SI). The table ID for the EAS message is 0xD8 as defined in ANSI/SCTE 18. The protocol stack is shown in Figure 10. When present on out-of-band (OOB) transmission, the EAS message shall be transmitted according to ANSI/SCTE 18.

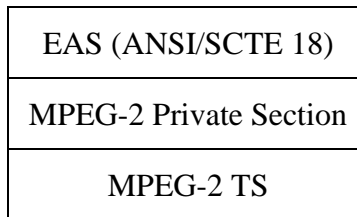


Figure 10 Protocol Stack for Inband EAS

8.6 Closed Captioning

Closed captioning data is associated with the video program and encoded by the program provider. The cable network shall deliver these signals, when available, as specified in the following sub-paragraphs.

8.6.1 Analog Television Programs

For analog television programs, the encoding of the closed captioning data shall be in accordance with FCC Rules 47 CFR Section 15.119 and CEA-608[13]. For NTSC, closed captioning data, when present, is carried in line 21 of the vertical blanking interval (VBI).

8.6.2 Digital Television Programs

For digital television programs, when closed captioning data is provided, it shall be provided in accordance with ANSI/SCTE 43[3]. Changes to closed captioning encoding and transport format may occur at any time within a given service.

The caption service descriptor is carried according to ANSI/SCTE 54 [6].

8.7 Digital Television (DTV) Content Advisory Information

The content advisory descriptor, when present, shall be carried according to section 5.8.3.7 of ANSI/SCTE 54[4].
