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Telecommunications
Engineers***

**ENGINEERING COMMITTEE
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ANSI/SCTE 40 2004

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 network interface between a cable television plant and commercially available consumer equipment that is used to access multi-channel television programming. The interface is also compatible with existing set-top terminal equipment owned by cable operators and with terminal equipment developed via the OpenCable™ specification process (see www.opencable.com). In this standard the Cable Network Interface is defined as the interface between the cable drop and the input terminals of the first device located on the subscriber's premises regardless of whether that device is owned by the subscriber or the cable operator. A coaxial-based broadband access network is assumed. This may take the form of either an all-coax or hybrid-fiber/coax (HFC) network. The generic term "cable network" is used here to cover all cases. Cable networks typically use a shared-medium, tree-and-branch architecture with analog and/or digital transmission. The key functional characteristics assumed in this document are the following:

- Two-way transmission.
- The maximum optical/electrical spacing between the cable headend and the most distant deployed terminal equipment is 100 miles, although typical maximum separation may be 10-15 miles.
- A maximum differential optical/electrical spacing between the cable headend and the closest and most distant deployed terminal equipment is 100 miles, although this would typically be limited to 15 miles.

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 are used to transport digital services as well as analog services. These services may be either in the clear or scrambled.

A typical channel plan for a cable network places analog services (NTSC AM-VSB channels) in the 54 to 450/550 MHz range; and digital services (QAM MPEG-2 multiplex channels) in the 450/550 to 864 MHz range (*Note 1*). These channels shall all comply with the EIA/CEA-542-A channel-tuning plan. However, the frequency location may change over time such that analog and digital channels may be located anywhere in the downstream operating range.

Note:

1. *Nothing in this standard precludes the use of other modulation modes.*

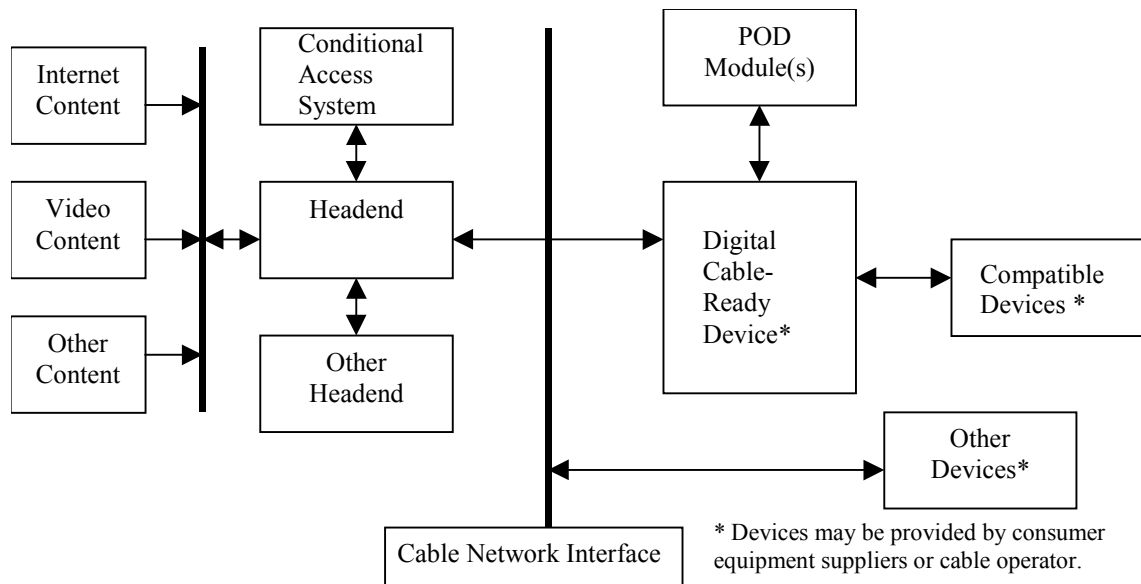


Figure 1 Cable Network Interface

2.0 DEFINITIONS AND ACRONYMS

2.1 Definitions

As used in this document, “*shall*” or “*will*” denotes a mandatory provision of the standard. “*Should*” denotes a provision that is recommended but not mandatory. “*May*” denotes a feature whose presence does not preclude compliance that may or may not be present at the option of the implementer.

2.2 Glossary

| | |
|--------------------|--|
| AAI5 | ATM Adaptation Layer 5 |
| AC-3 | Audio Code 3 – A Dolby digital audio encoding scheme. The audio encoding format adopted by the ATSC. |
| AM | Amplitude Modulation |
| AM-VSB | Amplitude Modulation – Vestigial Sideband - used to broadcast analog NTSC video signals. |
| Application | Software function |
| 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 |

| | |
|------------------------------------|--|
| BER | Bit Error Rate - The number of erroneous bits divided by the total number of bits over a stipulated period of time. Usually expressed as a number and a power of 10. |
| Bit | An indivisible unit of digital data represented as 1 or 0. |
| bps | Bits per second |
| Broadcast | A service that is delivered to all subscribers. Each subscriber may select a particular broadcast channel out of many. |
| Byte | An octet of associated bits |
| Cable | Cable Television Systems |
| Carrier | An RF signal used to carry information (video, audio, data) by some modulation scheme. |
| CAT | Conditional Access Table |
| CFI | Call For Information |
| CFR | Code of Federal Regulations |
| Closed Captioning | A textual description of dialog in a video program, this information is carried in Line 21 of the NTSC signal. |
| Coax | Coaxial Cable |
| 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. |
| CVCT | Cable-Virtual Channel Table: Digital Program Naming and Navigation information in a cable specific format. |
| 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) |
| Downstream | Transmission from Headend to terminal device |
| DSM-CC | Digital Storage Media-Command and Control (ISO/IEC 13818-6) |
| DTV | Digital Television – A general term for the digital coding and transmission of an Audio / Video Program. |
| DTVCC | Digital Television Closed Captioning |
| DVS | Digital Video Subcommittee |
| EAS | Emergency Alert System |
| ECM | Entitlement Control Message – Private Conditional Access information that specifies control words and possibly other stream-specific, scrambling, and/or control parameters. |
| EIA | Electronic Industries Alliance |
| EIT | Event Information Table |
| EMM | Entitlement Management Message – Private Conditional Access information that specifies the authorization level or services of specific decoders. |
| ES | Elementary Stream – A generic term for a stream of data of one particular type. Typically these streams are of Video or Audio Types. |
| ETT | Extended Text Table |
| FAT | (Forward Application Transport) Channel - A data channel carried from the headend to the terminal device in a modulated channel at a rate of 27 or 36 Mbps. 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: <ul style="list-style-type: none"> • MPEG-2 compressed video and audio • Application download • Variable Bit rate (VBR) application download • Entitlement control messages • Broadcast data |
| 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. The FDC carries IP traffic only for: <ul style="list-style-type: none"> • Conditional access for analog signals • Entitlement management messages for digital signals • General messaging • Application download • PC data services • Variable bit rate (VBR) download • Broadcast data • Network management |
| 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. |
| HFC | Hybrid Fiber Coax - A cable network featuring optical fiber from a headend location to a neighborhood node, and coaxial cable from the node to individual homes. |
| 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 spreading associated bytes over a longer period of time to reduce the effects of burst noise. |
| IP | The network layer (layer 3) of the OSI Internet protocol, providing connectionless datagram service. |
| 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 |
| MGT | Master Guide Table |
| 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 multiple parts of the ISO/IEC 13818 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. |
| Passband | The part of a signal spectrum not to be attenuated by a filtering function. |
| PAT | Program Association Table |
| 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. |
| PMT | Program Map Table |
| POD / POD Module | Point of Deployment Module - A module to be provided by the MSO that contains all of the network specific characteristics for a terminal device. |
| 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/65A. |
| QAM | Quadrature Amplitude Modulation – A signaling modulation scheme, defined in ITU-T J.83B 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 decreases the chance of a DC offset being applied to the RF signal. |

| | |
|---------------------|--|
| 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. The RDC carries IP traffic only for: <ul style="list-style-type: none"> • Messaging • Personal computer data services • Network management |
| Reed Solomon | A coding method that adds check bytes 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 |
| SI | System and Service 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. |
| STT | System Time Table |
| TS | Transport Stream – An MPEG-2 Transport Stream as described in ISO/IEC 13818-1 |
| TV | Television |
| TVCT | Terrestrial Virtual Channel Table |
| 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. |
| VCT | Virtual Channel Table |
| 256 QAM | Quadrature Amplitude Modulation with 256 constellation points |
| 64 QAM | Quadrature Amplitude Modulation with 64 constellation points |

3.0 NORMATIVE REFERENCES

The following documents contain provisions, which, through reference in this text, constitute provisions of this standard. At the time of publication, 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

ANSI/SCTE 01 1996 (formerly IPS SP 400): "F" Port (Female Outdoor) Physical Dimensions

ANSI/SCTE 07 2000 (formerly DVS 031): Digital Video Transmission Standard for Cable Television

ANSI/SCTE 20 2001 (formerly DVS 157): Standard Methods for Carriage of Closed Captions and non-Real Time Sampled Video

ANSI/SCTE 21 2001 (formerly DVS 053): Standard for Carriage of NTSC VBI Data in Cable Digital Transport Stream

ANSI/SCTE 43 2003 (formerly DVS 258): Digital Video Systems Characteristics Standard for Cable Television

ANSI/SCTE 54 2003 (formerly DVS 241): Digital Video Service Multiplex and Transport System Standard for Cable Television

ANSI/SCTE 55-1 2002 (formerly DVS 178): Digital Broadband Delivery System: Out-of-band Transport – Mode A

ANSI/SCTE 55-2 2002 (formerly DVS 167): Digital Broadband Delivery System: Out-of-band Transport – Mode B

ANSI/SCTE 65 2002 (formerly DVS 234): Service Information Delivered Out-of-Band for Digital Cable Television

SCTE 18 2001 (formerly DVS 208): Emergency Alert Message for Cable

3.2 Standards from other Organizations

ATSC A/52A: ATSC Digital Audio Standard (AC-3), Revision A, August 20, 2001.

ATSC A/53B: ATSC Digital Television Standard, Revision B

ATSC A/65A: ATSC Program and System Information Protocol for Terrestrial Broadcast and Cable

EIA-23: RF Interface Specification for Television Receiving Devices and Cable Television Systems

EIA/CEA-542-A: Cable Television Channel Identification plan

EIA/CEA-608-B: Line 21 Data Services

EIA-708-B: Digital Television (DTV) Closed Captioning

EIA/CEA-766-A: 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)

ISO/IEC 13818-1:2000: Information technology -- Generic coding of moving pictures and associated audio information: Systems (*MPEG-2 Systems*)

ISO/IEC 13818-2:2000: Information technology -- Generic coding of moving pictures and associated audio information: Video, (*MPEG-2 Video*)

ISO/IEC 13818-2:2000/Cor.1:2002: Technical Corrigendum 1

ISO/IEC 13818-6:1998: 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)

ITU-T J.83B (04/97): Digital multi-programme systems for television, sound and data services for cable distribution

4.0 INFORMATIVE REFERENCES

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

4.1 SCTE References

SCTE DVS/110: Response to SCTE DVS CFI Cable Headend and Distribution Systems (Informative)

SCTE DVS/111 (rev.1): Digital Headend and Distribution CFI Phase 1.0 System Description (Informative)

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

EIA 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/EIA 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.itdocs.com/>; email: service@itdocs.com

ATSC Standards:

Advanced Television Systems Committee (ATSC), 1750 K Street NW, Suite 1200,
Washington, DC 20006; Phone 202-828-3130; Fax 202-828-3131; Internet
<http://www.atsc.org>.

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.int>; 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

6.0 PHYSICAL LAYER CHARACTERISTICS

6.1 RF Interface

The mechanical and electrical interface between the cable TV system and the terminal device shall be as defined in EIA-23 section 3, with the additional requirements specified below in sections 6.1.1 – 6.5.

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. 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.

6.2 Frequency Plan

In the downstream direction, for the delivery of analog and digital services to terminal devices directly connected to the cable system, the cable system shall have a passband with a lower edge of 54 MHz (*Note 2*) and an upper edge that is local system-dependent but is typically in the range of 300 to 864 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 EIA/CEA-542-A. Forward Data Channels may be present in the 70-130 MHz range.

The cable network may support any portion or all of the 5-42 MHz passband in the upstream direction. Reverse Data Channels may be present anywhere within the network-supported passband.

Note:

2. 54 MHz is a nominal value and the actual lower edge may be lower due to offsets, for example 53.75 MHz would be used in the case of an HRC system.

6.3 Communications Channels

The Cable Interface-Network shall have the following communications channels:

1. Forward Application Transport (FAT) channels, which carry digital information via MPEG-2 Transport Streams.
2. NTSC Analog channels with Vertical Blanking Interval (VBI) signals for closed captioning, as may be required.
3. Forward Data Channels (FDC).
4. Reverse Data Channels (RDC).

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

| Table A. Digital Cable Network Frequency Bands | |
|---|-------------------------------|
| FAT channels and NTSC Analog channels | 54 to 864 MHz |
| OOB FDCs | 70 to 130 MHz |
| OOB RDCs | 5 to 42 MHz (<i>Note 3</i>) |

Note:

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

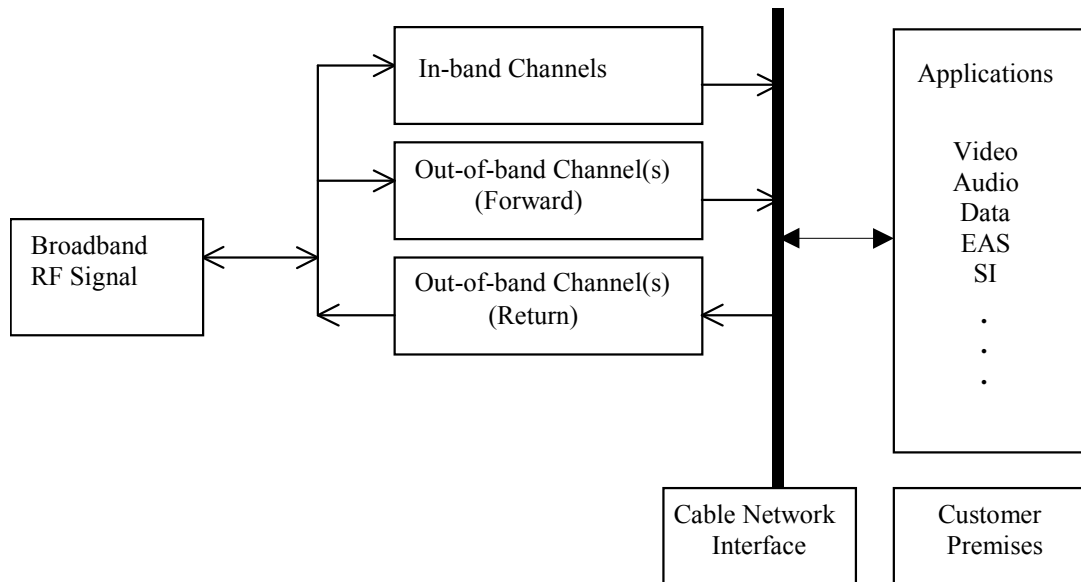
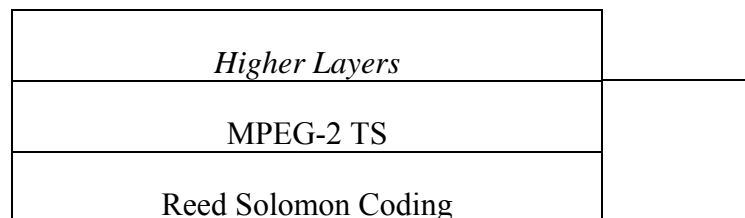


Figure 2 Cable Services and Interface

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 2000 (formerly DVS 031). Either 64 QAM or 256 QAM may be used to transport approximately 27 or 39 megabits/second, respectively. FAT channels may be located anywhere in the 54 to 864 MHz range. The physical layer protocol for FAT channels is shown in Figure 3.



| | |
|--------------------------|-----------------------|
| Interleaving | <i>Physical Layer</i> |
| Randomization | |
| Trellis Coded 64/256 QAM | |

Figure 3 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 864 MHz range.

6.3.2.1 Vertical Blanking Interval

The Vertical Blanking Interval (VBI) of an analog television signal may contain data on line 21. During this period, the headend may insert VBI data signals on VBI line 21 for closed captioning. VBI data may be inserted within field 1, field 2, or both, on any analog channel operating in the 54 to 864 MHz range. The VBI signals shall conform to FCC part 15.119 and EIA/CEA-608-B. The VBI waveform shall conform to Figure 17 of section 73.699 of the FCC Rules.

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

The forward data channels shall be QPSK-modulated channels having the characteristics shown in Table C in section 6.4 below. The FDCs may be located anywhere in the 70 to 130 MHz range as defined in Table C, and are spaced between the 6-MHz NTSC Analog and/or FAT channels.

The two alternatives for out-of-band FDCs are defined in ANSI/SCTE 55-2 2002 (formerly DVS 167) and ANSI/SCTE 55-1 2002 (formerly DVS 178). The FDCs specified by ANSI/SCTE 55-2 2002 (formerly DVS 167) support data rates of 1.544 and 3.088 Mbps. The FDCs specified in ANSI/SCTE 55-1 2002 (formerly DVS 178) support a data rate of 2.048 Mbps. Figure 4 shows the lower layer protocol stacks for the out-of-band FDCs. It should be noted that in ANSI/SCTE 55-2 2002 (formerly DVS 167), time critical aspects of the Media Access Control (MAC) protocol sub-layer are implemented in the SL-ESF Frame Payload Structure. The remainder of the MAC sub-layer is implemented via the MAC message in the Payload.

| ANSI/SCTE 55-2 2002 (formerly DVS 167) | ANSI/SCTE 55-1 2002 (formerly DVS 178) | |
|---|---|----------------------------------|
| <i>Payload</i> | <i>Payload</i> | |
| ATM Cell Format | Data Link Layer | OOB FDC Lower Layer Protocols |
| Link/Physical Layer: – Reed-Solomon – Interleaving | MAC Sublayer – MAC Packet – MPEG-2 TS | |
| – SL-ESF Frame Payload Structure – SL-ESF Format – Randomizer | Physical Layer: – Randomizer – Reed-Solomon – Interleaving | |
| – QPSK/differential coding | – QPSK/differential coding | |

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

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

The reverse data channels shall be QPSK-modulated channels having the characteristics shown in Table F in section 6.5 below. The RDCs may be present anywhere within the network-supported passband as defined in Table F. There are two alternatives for the out-of-band RDCs defined in ANSI/SCTE 55-2 2002 (formerly DVS 167) and ANSI/SCTE 55-1 2002 (formerly DVS 178). Figure 5 shows the lower layer protocol stacks for the out-of-band RDC's.

| ANSI/SCTE 55-2 2002 (formerly DVS 167) | ANSI/SCTE 55-1 2002 (formerly DVS 178) | |
|---|--|-------------------------------------|
| <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 5 Out-of-band Reverse Data Channel Lower Layer Protocols

For complete information on FDCs and RDCs, see ANSI/SCTE 55-2 2002 (formerly DVS 167) and ANSI/SCTE 55-1 2002 (formerly DVS 178).

6.4 Downstream Transmission Characteristics

The Downstream Transmission Characteristics are contained in Table B. Analog and FAT Channel: RF Transmission Characteristics and Table C. FDC Channel: RF Transmission Characteristics as provided below. Analog and FAT signals shall meet the characteristics specified in Table B when measured on the subscriber's premises at the end of a properly terminated drop cable and OOB FDC signals shall meet the characteristics specified in Table C when measured on the subscriber's premises at the end of a properly terminated drop cable.

| Table B. Analog and FAT Channel: RF Transmission Characteristics | | |
|--|--|--|
| 1. | RF Channel Spacing | 6 MHz |
| 2. | RF Frequency Range | 54 MHz to 864 MHz IRC/HRC/Standard Channel Plans. |
| 3. | Transit delay from headend to most distant customer | ≤ 0.800 msec (typically much less) |
| 4. | Carrier-to-noise 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, other discrete interference. 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 worse than -53 dBc referenced to inband carrier levels for analog channels. (Note 4) |
| 6. | CSO | Not worse than -53 dBc referenced to inband carrier levels for analog channels. (Note 4) |
| 7. | Carrier-to-any other discrete interference (ingress) | Not worse than -53 dBc (Note 4) |
| 8. | AM Hum Modulation | Not greater than 3% p-p |
| 9. | Group Delay Variation | ≤ 0.25 μsec/MHz across the 6-MHz channel |
| 10. | Chroma / Luma Delay | ≤ 170 ns (AM-VSB analog) |
| 11. | Phase Noise | ≤ -88 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) | ≤ 5 dB p-p □ 4 dB p-p |

| | | |
|-----|--|---|
| 13. | Micro-reflections bound for dominant echo | -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 rarely occur in conventional cable television systems. Moreover very low-level micro-reflections (e.g., -40dB) longer than 4.5 microseconds may not be measured reliably. Therefore, micro-reflections longer than 4.5 microseconds shall be considered under item 4 (of this table) as a contributor to C/(N+I) |
| 14. | Burst Noise (<i>Note 5</i>) | Not longer than 25 μs at 10-Hz repetition rate |
| 15. | Carrier level at the terminal input <i>(Note 6)</i> | 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 |

Notes:

4. For digital channels, CTB, CSO and other discrete interference are included in the overall C/(N+I) parameter in Table B.4.
5. Burst noise is statistical in nature and a reference level should be defined. Studies on this are continuing.
6. See section 6.4.1 for the allowable variation in level between adjacent channels.

| Table C. FDC Channel: RF Transmission Characteristics | | |
|--|--|---|
| 1. | Transmission Rate | 1.544/3.088 Mbps, ANSI/SCTE 55-2 2002 (formerly DVS 167) 2.048 Mbps, ANSI/SCTE 55-1 2002 (formerly DVS 178) |
| 2. | RF Channel Spacing | 1.0/2.0 MHz, ANSI/SCTE 55-2 2002 (formerly DVS 167) 1.8 MHz, ANSI/SCTE 55-1 2002 (formerly DVS 178) |
| 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 RMS (<i>Note 7</i>) |
| 6. | Maximum Carrier Level at terminal input | +15 dBmV RMS (<i>Note 7</i>) |
| 7. | C/(N+I) in Nyquist bandwidth | ≥ 20 dB |
| 8. | Group Delay flatness in channel, measured over Nyquist bandwidth | 200 ns max |

Note:

7. See section 6.4.1 for the allowable variation in level between adjacent channels.

6.4.1 RF Signal Levels and Adjacent Channel Characteristics

6.4.1.1 RF Signal Levels

The visual signal level of an analog signal shall 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 part 76.605. To determine the adjacent channel characteristics between digital and analog signals, the following information is provided. The nominal relative carrier power levels for analog and digital signals are given in Table D. Nominal Relative Carrier Power Levels below.

| Table D. Nominal Relative Carrier Power Levels | |
|---|-------------------------|
| Analog channel | 0 dBc (reference level) |
| 256 QAM FAT | -5 \pm 2 dBc |
| QPSK FDC | -8 \pm 5 dBc |
| 64 QAM FAT | -10 \pm 2 dBc |

The average signal power of a digital signal shall be within ± 6 dB of its nominal level. It should be noted that the nominal carrier power levels provided above shall

fall within the absolute power range for digital signals (see Table B.15 for QAM FAT and Table C.5-C.6 for QPSK FDC). The analog signal power is measured as the Peak Envelope Power (PEP), which is the carrier power measured during the horizontal sync interval. The digital signal power is measured as the average signal power.

6.4.1.2 Adjacent Channel Characteristics

The worst-case Adjacent Channel performance shall be characterized according to the Table E. Adjacent Channel Characteristics, as provided below.

| Table E. 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 | -1 dB |
| 2 | Analog NTSC | 256 QAM | -6 dB |
| 3 | Analog NTSC | QPSK FDC | -6 dB |
| 4 | 64 QAM | Analog NTSC | -21 dB |
| 5 | 64 QAM | 256 QAM | -21 dB |
| 6 | 64 QAM | QPSK FDC | -21 dB |
| 7 | 256 QAM | Analog NTSC | -16 dB |
| 8 | 256 QAM | 64 QAM | -11 dB |
| 9 | 256 QAM | QPSK FDC | -16 dB |
| 10 | QPSK FDC | Analog NTSC | -22 dB |
| 11 | QPSK FDC | 64 QAM | -17 dB |
| 12 | QPSK FDC | 256 QAM | -22 dB |
| * <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> | | | |

To understand how these D/U ratios are derived, consider the following example: The desired signal is Analog NTSC with a nominal level of 0 dBc and the undesired signal is 64 QAM with a nominal level of -10 ± 2 dBc. In the worst case the Analog NTSC signal will be at its weakest level, 3 dB below nominal, (0 dBc - 3 dB = -3 dBc) and the 64 QAM signal will be at its strongest level, 6 dBc above nominal, which itself may be + 2 dB above -10 dBc ($-10 \text{ dBc} + 2 \text{ dB} + 6 \text{ dB} = -2 \text{ dBc}$). Thus the undesired 64 QAM signal is 1 dB stronger than the desired Analog NTSC signal in the worst case.

To understand how these D/U ratios are applied to establish permissible levels for adjacent signals of differing type, consider the following example: Given a 256

QAM signal at its minimum permissible absolute level of -12 dBmV, an analog NTSC signal on an adjacent channel is constrained to lie between 0 dBmV, its minimum permissible level, and +4 dBmV, i.e., 16 dB stronger than the 256 QAM signal on the adjacent channel.

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 B.15 (QAM FAT) and Table C.5-C.6 (QPSK FDC).

6.5 Upstream Transmission Characteristics

The Upstream Transmission Characteristics are contained in Table F. RDC Channel: RF Transmission Characteristics, as provided below.

| Table F. RDC Channel: RF Transmission Characteristics | | |
|--|---------------------------|--|
| 1. | RF Transmission Rate | 1.544/3.088 Mbps, ANSI/SCTE 55-2 2002 (formerly DVS 167) 256 kbps, ANSI/SCTE 55-1 2002 (formerly DVS 178) |
| 2. | RF Channel Spacing | 1.0/2.0 MHz, ANSI/SCTE 55-2 2002 (formerly DVS 167) 192 kHz, ANSI/SCTE 55-1 2002 (formerly DVS 178) |
| 3. | RF Frequency Range | 5 MHz to 42 MHz. <i>(Note 8)</i> |
| 4. | Nominal carrier frequency | ANSI/SCTE 55-2 2002 (formerly DVS 167): Any integer multiple of 250 kHz between 5.0 MHz and 42.0 MHz, inclusive. ANSI/SCTE 55-1 2002 (formerly DVS 178): Any integer multiple of 192 kHz between 8.096 MHz and 40.160 MHz, inclusive. |

Note:

8. *The cable network may support any portion or all of the 5-42 MHz passband in the upstream direction. The Reverse Data Channels may be present anywhere within the network-supported passband.*

7.0 TRANSPORT LAYER PROTOCOLS

7.1 Forward Application Transport (FAT) Channels

The MPEG-2 Transport Stream protocol, defined in ISO/IEC 13818-1:2000: MPEG-2 Systems, 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 6. The digital multiplex and transport system is defined in ANSI/SCTE 54 2003 (formerly DVS 241). It is a

compatible subset of the MPEG-2 Systems specification defined in ISO/IEC 13818-1:2000.

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 may be 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, AC3 Audio, System Tables and other System Information, MPEG-2 Transport packets may be 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 6 FAT Channel Transport Layer Protocol

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

The out-of-band forward data channels may be used for control and access messages, application code download and electronic program guide data. If capacity is available, other data services may be transmitted through this channel. For on-demand applications, the out-of-band forward channels may be used to support control and signaling flows between the terminal and the media server.

There are alternatives for out-of-band forward channels defined in ANSI/SCTE 55-2 2002 (formerly DVS 167) and ANSI/SCTE 55-1 2002 (formerly DVS 178). The FDCs specified by ANSI/SCTE 55-2 2002 (formerly DVS 167) utilize ATM cell structure to transport information. The FDCs specified by ANSI/SCTE 55-1 2002 (formerly DVS 178) utilize an MPEG-2 TS packet structure to transport information. Detailed descriptions of the MAC processing associated with these alternatives are found in the respective documents,

ANSI/SCTE 55-2 2002 (formerly DVS 167) and ANSI/SCTE 55-1 2002 (formerly DVS 178).

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

The out-of-band reverse channels carry all 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 7 and Figure 8 show the inter-relations among the service channels, logic interfaces and applications.

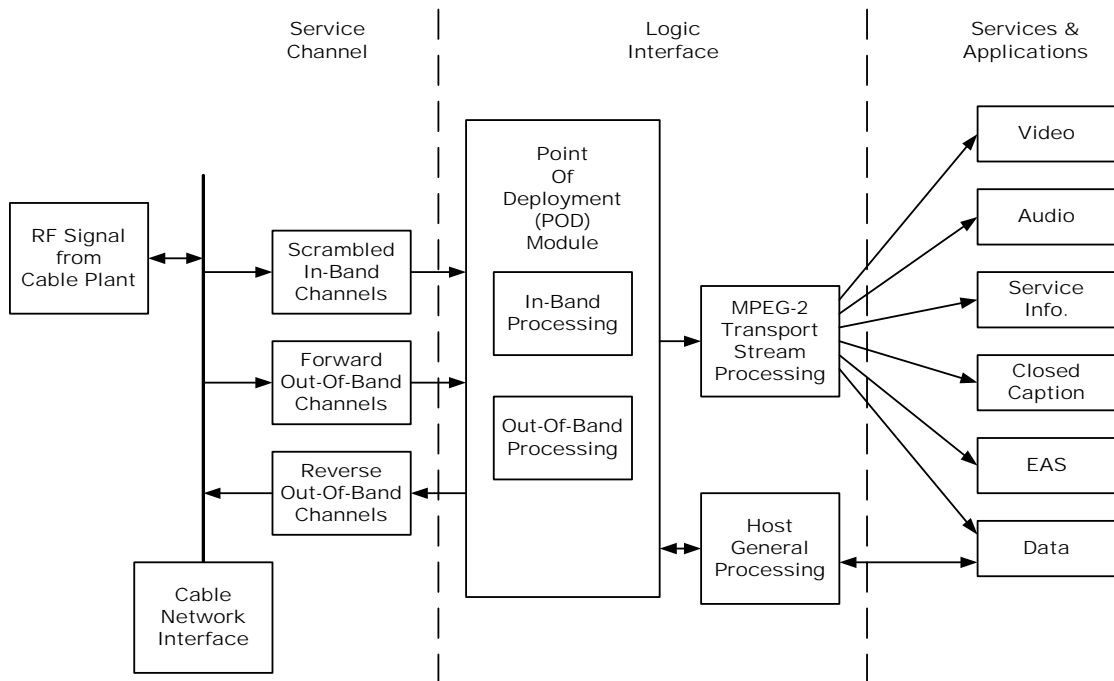


Figure 7 Interrelation of Service Channels, Logic Interfaces and Applications for Scrambled Programming

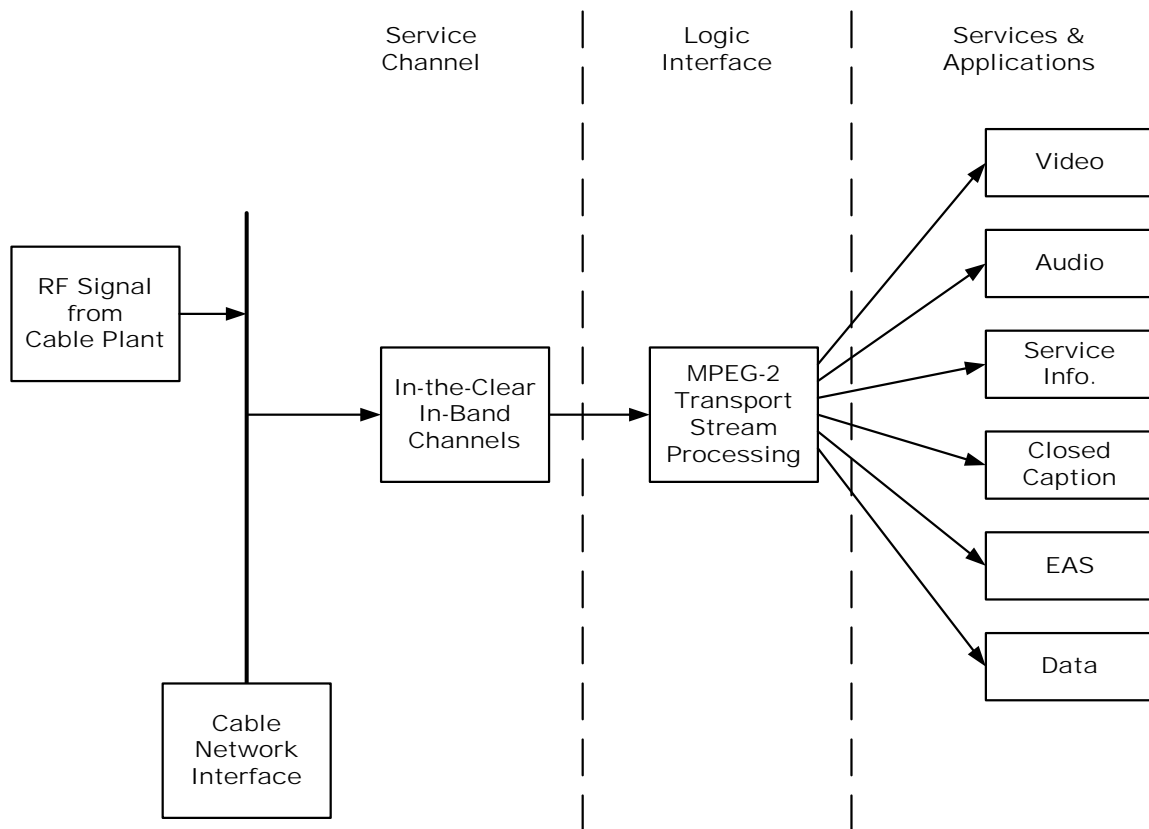


Figure 8 Interrelation of Service Channels, Logic Interfaces and Applications for Unscrambled Programming

8.1 Audio-Visual Services

Audio-Visual services may be provided on either or both the analog channels and the FAT channels. These services include analog and digital broadcast, impulse pay-per-view services, premium, tiered, and basic video services. Analog video and audio shall be NTSC in accordance with current cable-system practice and applicable FCC rules. The analog service may include both clear and scrambled services (although any scrambled analog service may also be simultaneously carried as a scrambled digital service). Along with the analog service, data may be sent in the NTSC Vertical Blanking Interval (VBI) lines that are then processed by the terminal device in compliance with FCC 47 CFR part 15.119. The demodulated NTSC signal is the Composite signal defined in SMPTE-170M.

The digital Audio-Visual services provide MPEG-2 compressed video (ISO/IEC 13818-2:2000) and AC-3 audio (ATSC A/52A as constrained per Annex B of ATSC A/53B), broadcast data, and systems information. A modified protocol stack for both analog and digital Audio-Visual services is shown in Figure 9. The Video formats that shall be allowed are specified in ANSI/SCTE 43 2003 (formerly DVS 258). The constraints and extensions that apply to video shall be those specified in ANSI/SCTE 43 2003 (formerly DVS 258). When audio is present, at least one Complete Main audio service shall 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 (EIA/CEA-542-A) | | | | | |

Figure 9 Modified Protocol Stack for Audio-Visual Services

8.2 Data Services

Broadcast data services may be provided via FAT channels and out-of-band FDCs. Standards for data services are in development and may be included in future revisions of this document.

8.3 In-Band Service/System Information

Transport streams containing one or more unscrambled programs that include navigation data shall include service information defined in 5.7.1 of ANSI/SCTE 54 2003 (formerly DVS 241). System and Service information, when present in a Transport Stream, may describe both scrambled and in-the-clear programming.

| | | | | | |
|-------------|-----|-----|-----|---------|---------|
| STT | MGT | VCT | RRT | EIT | ETT |
| SI_base_PID | | | | EIT_PID | ETT_PID |
| MPEG-2 TS | | | | | |

Figure 10 Layout of In-Band System Information

8.4 In-Band Entitlement Control Messages

To avoid renumbering subsequent sections, the material in this section, including Figure 11, has been deleted.

Figure 11 Deleted

8.5 Out-of-Band Service/System Information

When one or more scrambled services are offered on the cable system, System and Service Information for all services (both scrambled and in-the-clear) shall be 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 2002 (formerly DVS 234) (see *Note 9* below). This information is carried in MPEG-2 private sections mapped into either MPEG-TS packets in ANSI/SCTE 55-1 2002 (formerly DVS 178) or IP/AAL5 packets in ANSI/SCTE 55-2 2002 (formerly DVS 167). Figure 12 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 2002 (formerly DVS 234). The System and Service Information provided shall conform to one or more of the profiles specified in ANSI/SCTE 65 2002 (formerly DVS 234).

Note:

9. (Informative) Profiles 1 through 5 are compatible with terminal devices deployed as of Jan 1, 2000. Terminal devices that are intended to be portable across the US will need to function with any of the six profiles of ANSI/SCTE 65 2002 (formerly DVS 234). For operational considerations of various profiles, see section A.3 in ANSI/SCTE 65 2002 (formerly DVS 234).

| ANSI/SCTE 55-2 2002 (formerly DVS 167) | ANSI/SCTE 55-1 2002 (formerly DVS 178) |
|---|---|
| OOB-SI ANSI/SCTE 65 2002 (formerly DVS 234) | OOB-SI ANSI/SCTE 65 2002 (formerly DVS 234) |
| MPEG-2 private section | MPEG-2 private section |
| AAL5 | |
| ATM cell Format | MPEG-2 TS |
| ANSI/SCTE 55-2 2002 (formerly DVS 167) PHY | ANSI/SCTE 55-1 2002 (formerly DVS 178) PHY |

Figure 12 Protocol Stack for Out-of-Band Service/System Information

8.6 Out-of-Band Entitlement Management Messages

Entitlement Management Messages (EMMs) for each POD module deployed by the cable operator shall be carried in the out-of-band Forward Data Channel. EMMs addressed to each POD Module are carried in a well-known VCI/VPI for systems using ANSI/SCTE 55-2 2002 (formerly DVS 167), or the EMM PID described by the Conditional Access Table (CAT) for systems using ANSI/SCTE 55-1 2002 (formerly DVS 178).

EMMs shall be carried in the out-of-band Forward Data Channel and shall be made available to the POD module for processing. Figure 13 shows the protocol stack for Out-of-Band EMMs.

| ANSI/SCTE 55-2 2002 (formerly DVS 167) | ANSI/SCTE 55-1 2002 (formerly DVS 178) |
|---|---|
| EMM message | EMM message |
| MPEG-2 private section | MPEG-2 private section |
| AAL5 | EMM PID |
| ATM cell format | MPEG2-TS |
| ANSI/SCTE 55-2 2002 (formerly DVS 167) PHY | ANSI/SCTE 55-1 2002 (formerly DVS 178) PHY |

Figure 13 Protocol Stack for Out-of-Band EMMs

8.7 Emergency Alert System (EAS)

Emergency Alert System (EAS) is used to alert all viewers of any 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.

The EAS message syntax is compatible with MPEG-2 transport and is defined in SCTE 18 2001 (formerly DVS 208). For inband transmission, messages conforming to SCTE 18 2001 (formerly DVS 208) 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 SCTE 18 2001 (formerly DVS 208). The protocol stack is shown in Figure 14. For out-of-band (OOB) transmission, the EAS message shall be transmitted according to SCTE 18 2001 (formerly DVS 208).

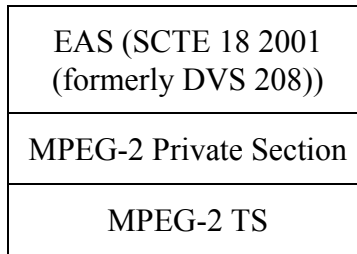


Figure 14 Protocol Stack for Inband EAS

8.8 Closed Caption

Closed caption 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.

8.8.1 Analog Television Programs

For analog television programs, the encoding of the closed caption data shall be in accordance with FCC part 15.119 and EIA/CEA-608-B. For NTSC, closed caption data, when present, is carried in line 21 of the vertical blanking interval (VBI).

8.8.2 Digital Television Programs

For digital television programs, when closed caption data is provided, it shall be provided in accordance with one or both of two closed caption data formats and in accordance with one or both of two transport mechanisms as defined in sections 5.2.1 and 5.2.2 of ANSI/SCTE 43 2003 (formerly DVS 258). Changes to closed caption encoding and transport format may occur at any time within a given service.

8.9 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 2003 (formerly DVS 241).