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**Stream Conditioning For Switching Of
Addressable Content In Digital Television
Receivers**

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Table of Contents

Title	Page Number
NOTICE	1
Table of Contents	2
1. Introduction	4
1.1. Executive Summary	4
1.2. Scope	4
1.2.1. Supported video and audio codecs	4
1.3. Benefits	4
1.4. Intended Audience	5
1.5. Areas for Further Investigation or to be Added in Future Versions	5
2. Normative References	5
2.1. SCTE References	5
2.2. Standards from Other Organizations	6
2.3. Published Materials	6
3. Informative References	6
3.1. SCTE References	7
3.2. Standards from Other Organizations	7
3.3. Published Materials	7
4. Compliance Notation	7
5. Abbreviations and Definitions	7
5.1. Abbreviations	7
5.2. Definitions	8
6. Standards Compliance	9
7. The PMT	10
8. Level 0 Requirements	10
8.1. Use of Transport Streams and Services	10
8.2. Video and Audio Elementary Stream Presentation Duration Differences	10
8.3. Conditioning of Primary Channel Streams	11
8.4. Filler	11
8.4.1. MPEG-2 Video Filler	11
8.4.2. AVC Video Filler	12
8.4.3. HEVC Video Filler	12
8.4.4. AC-3 or E-AC-3 Audio Filler	12
8.4.5. AAC Audio Filler	12
8.4.6. AC-4 Audio Filler	13
8.4.7. MPEG-H Audio Filler	13
8.4.8. DTS-HD Audio Filler	13
8.4.9. DTS-UHD Audio Filler	13
8.5. Filler Alignment	14
8.6. Filler Presentation Duration	14
8.7. Addressable Content Set Duration	14
8.8. MPEG-2 Video Coding Requirements	15
8.9. AVC Video Coding Requirements	15
8.10. HEVC Video Coding Requirements	15
8.11. DTS-UHD Audio Coding Requirements	15
8.12. Level 0 Special Cases	15
8.12.1. DVR-Based	15
8.12.2. Media Gateway/IP Client	16
8.12.3. Connected TV/IP Devices	17
9. Level 1 Requirements	18
9.1. Use of Transport Streams	18
9.2. Use of Services	18

9.3.	The Gap	18
9.4.	MPEG Coding Requirements	18
9.4.1.	The System Clock and Program Clock Reference	18
9.4.2.	MPEG Syntax	18
9.4.3.	Constraints on MPEG-2 Video Streams Adjacent to a Gap	19
9.4.4.	Constraints on AVC Video Streams Adjacent to a Gap	19
9.4.5.	Constraints on HEVC Video Streams Adjacent to a Gap	20
9.4.6.	Constraints on AC-3 or E-AC-3 Audio Streams Adjacent to a Gap	21
9.4.7.	Constraints on AAC Audio Streams Adjacent to a Gap	21
9.4.8.	Constraints on AC-4 Audio Streams Adjacent to a Gap	22
9.4.9.	Constraints on MPEG-H Audio Streams Adjacent to a Gap	22
9.4.10.	Constraints on DTS-HD Audio Streams Adjacent to a Gap	22
9.4.11.	Constraints on DTS-UHD Audio Streams Adjacent to a Gap	22
9.5.	Buffer Management	23
	Appendix A: System Overview (Informative)	24
	Appendix B: Bound on A/V Presentation Time Mismatch Due to Splicing	34

List of Figures

Title	Page Number
Figure 1 – Media Gateway IP Client Communications	17
Figure 2 - Example Level 0 Transport Multiplex	25
Figure 3 - Back to Back Level 0 Addressable Insertions	26
Figure 4 - Example Level 0 Head-End Configuration #1	27
Figure 5 - Example Level 0 Head-End Configuration #2	27
Figure 6 - Example Level 0 Set-Top Decoder Architecture	28
Figure 7 - Example Level 1 Transport Multiplex	29
Figure 8 - Example Level 1 Head-End Configuration	30
Figure 9 - Example Level 1 Set-Top Decoder Architecture	32
Figure 10 Illustration of A/V presentation time mismatch introduced by splicing a perfectly synchronized ad after a perfectly synchronized Filler.	34
Figure 11 : A/V presentation time mismatch introduced under different audio and video frame durations	35
Figure 12 : Bound on presentation time mismatch introduced by splicing ad with Filler in the front when Filler and ad are created with either MPEG-2 or AVC video and AC-3 audio	36
Figure 13 : Bound on presentation time mismatch introduced by splicing ad with Filler in the front when Filler and ad are created with HEVC video and AC-3 audio.	36
Figure 14: Lip Sync Detectability Limits	37

1. Introduction

1.1. Executive Summary

This standard supports the delivery of household addressable advertising in linear programs. This document also describes the stream Conditioning required to enable Client-DPI Devices to implement Switching of compressed video streams with associated compressed audio streams. This standard enables Client-DPI Devices to support addressable advertising where the Addressable Content Set appears in an MPEG program outside the Primary Channel.

1.2. Scope

The Switch from the Primary Channel to the Addressable Content Set and back to the Primary Channel is defined by several levels.

For “Level 0”, or “L0” systems, it defines Switching among compressed video and compressed audio streams in a non-seamless fashion (similar to a channel change).

For “Level 1”, or “L1” systems, it defines Switching among compressed video and compressed audio streams in a seamless fashion.

All L0 or L1 Switches *shall* occur from a video stream to another video stream compressed using the same video codec. All L0 or L1 Switches *shall* occur from an audio stream to another audio stream compressed using the same audio codec.

1.2.1. Supported video and audio codecs

This standard supports the following video and audio codecs:

- Video: MPEG-2, AVC, and HEVC.
- Audio: AC-3, E-AC-3, AAC, AC-4, MPEG-H Audio, DTS-HD, and DTS-UHD.

Readers of this standard will find references to other relevant standards in later sections of this document. Section 2.1 SCTE References, section 2.2 Standards from Other Organizations and section 6 Standards Compliance describe specific requirements for each of these codecs.

Codecs referred to in requirements defined by this standard are specified in other sections of this document. For example, video Filler requirements and related standards for the AVC video codec can be found in section 8.4.1 AVC Video Filler.

Triggers and signaling are out of scope for this standard.

Note: Client-DPI Devices include Receivers conforming to OCAP as well as other cable-compatible Receivers.

1.3. Benefits

Client-DPI Devices will Switch to Addressable Content Sets either in the same multiplex as the primary Channel or in a new multiplex depending on the level. This standard ensures that conditioning occurs to properly formatted picture data and audio data in the transmitted Primary Channels and the Addressable

Content Sets. This ensures that the Client-DPI Device will be able to acquire and begin decoding the new content without displaying any artifacts or losing any significant video or audio data. Without this conditioning, there would be visible artifacts during an addressable Client-DPI Device Switch.

1.4. Intended Audience

The intended audience for this standard is MVPDs, ad insertion equipment manufacturers, Client-DPI Device manufacturers, and addressable advertisement companies.

1.5. Areas for Further Investigation or to be Added in Future Versions

Areas for future consideration might include:

- Support for additional codecs beyond the ones included in this standard.
- Switches where there is a codec change in a Client-DPI Device implementation.
- Further consideration for C3/C7 rating periods.

2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. All documents are subject to revision; and while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

1. [SCTE 30] ANSI/SCTE 30 2017: Digital Program Insertion Splicing API.
2. [SCTE 43] ANSI/SCTE 43 2015: Digital Video Systems Characteristics Standard for Cable Television.
3. [SCTE 54] ANSI/SCTE 54 2015: Digital Video Service Multiplex and Transport System for Cable Television
4. [SCTE 128-1] ANSI/SCTE 128-1 2018: AVC Video Constraints for Cable Television Part 1: Coding
5. [SCTE 128-2] ANSI/SCTE 128-2 2018: AVC Video Constraints for Cable Television Part 2: Transport
6. [SCTE 172] ANSI/SCTE 172 2017: Constraints On AVC and HEVC Structured Video Coding for Digital Program Insertion
7. [SCTE 193-1] SCTE 193-1 2014: MPEG-4 AAC Family Audio System - Part 1 Coding Constraints For Cable Television
8. [SCTE 193-2] SCTE 193-2: 2014: MPEG-4 AAC Family Audio System - Part 2 Constraints For Carriage Over MPEG-2 Transport
9. [SCTE 194-1] SCTE 194-1 2018: DTS-HD AUDIO SYSTEM – Part 1: Coding Constraints for Cable Television
10. [SCTE 194-2] SCTE 194-2: 2018 DTS-HD AUDIO SYSTEM – Part 2: Constraints for Carriage over MPEG-2 Transport
11. [SCTE 215-1] SCTE 215-1 2018: HEVC Video Constraints for Cable Television Part 1- Coding
12. [SCTE 215-2] SCTE 215-2 2018: HEVC Video Constraints for Cable Television Part 2-Transport
13. [SCTE 242-1] ANSI/SCTE 242-1 2017: Next Generation Audio Coding Constraints for Cable Systems: Part 1 – Introduction and Common Constraints

14. [SCTE 243-1] ANSI/SCTE 243-1 2017: Next Generation Audio Carriage Constraints For Cable Systems: Part 1 – Common Transport Signaling
15. [SCTE 242-2] ANSI/SCTE 242-2 2017: Next Generation Audio Coding Constraints for Cable Systems: Part 2 – AC-4 Audio Coding Constraints
16. [SCTE 243-2] ANSI/SCTE 243-2 2017: Next Generation Audio Carriage Constraints For Cable Systems: Part 2 – AC-4 Audio Carriage Constraints
17. [SCTE 242-3] ANSI/SCTE 242-3 2017: Next Generation Audio Coding Constraints for Cable Systems: Part 3 – MPEG-H Audio Coding Constraints
18. [SCTE 243-3] ANSI/SCTE 243-3 2017: Next Generation Audio Carriage Constraints For Cable Systems: Part 3 – MPEG-H Audio Carriage Constraints
19. [SCTE 242-4] ANSI/SCTE 242-4 2018: Next Generation Audio Coding Constraints for Cable Systems: Part 3 – DTS-UHD Audio Coding Constraints
20. [SCTE 243-4] ANSI/SCTE 243-4 2018: Next Generation Audio Carriage Constraints for Cable Systems: Part 3 –DTS-UHD Audio Carriage Constraints

2.2. Standards from Other Organizations

21. [13818-1] ISO/IEC 13818-1 (2018): International Standard, Information Technology – Generic coding of moving pictures and associated audio information: Systems.
22. [13818-2] ISO/IEC 13818-2 (2013): International Standard, Information Technology – Generic coding of moving pictures and associated audio information: Video
23. [14496-3] ISO/IEC 14496-3 (2009):Information technology – Coding of audio-visual objects – Part 3: Audio
24. [14496-10] ISO/IEC 14496-10 (ITU-T H.264): International Standard (2014), Advanced video coding for generic audiovisual services.
25. [23008-2] ISO/IEC 23008-2 (ITU H.265): International Standard (2017), Information technology -- High efficiency coding and media delivery in heterogeneous environments -- Part 2: High efficiency video coding
26. [A/52] ATSC A/52 (2018): Digital Audio Compression Standard (AC-3, E-AC-3)
27. [A/53] ATSC A/53 Part 5 (2014): AC-3 Audio System Characteristics
28. [A/342-1]“ATSC Standard: A/342 Part 1, Audio Common Elements,” Doc. A/342-1:2017
29. [A/342-2]“ATSC Standard: A/342 Part 2, AC-4 System,” Doc. A/342-2:2017
30. [A/342-3] “ATSC Standard: A/342 Part 3, MPEG-H System,” Doc. A/342-3:2017
31. [TS 102 114] ETSI TS 102 114 V1.5.1 (2018-05) DTS Coherent Acoustics; Core and Extensions with Additional Profiles
32. [TS 103 491] ETSI TS 103 491 V1.1.1 (2017-04) DTS - UHD Audio Format; Delivery of Channels, Objects and Ambisonic Sound Fields
33. [ITU-R BT.1359-1] Recommendation ITU-R BT.1359-1 Relative Timing Of Sound and Vision for Broadcasting.

2.3. Published Materials

- No normative references are applicable.

3. Informative References

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

3.1. SCTE References

34. [SCTE 67] ANSI/SCTE 67 2017, Recommended Practice for Digital Program Insertion for Cable

3.2. Standards from Other Organizations

- No informative references are applicable.

3.3. Published Materials

- No informative references are applicable.

4. Compliance Notation

<i>shall</i>	This word or the adjective “ required ” means that the item is an absolute requirement of this document.
<i>shall not</i>	This phrase means that the item is an absolute prohibition of this document.
<i>forbidden</i>	This word means the value specified shall never be used.
<i>should</i>	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.
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<i>deprecated</i>	Use is permissible for legacy purposes only. Deprecated features may be removed from future versions of this document. Implementations should avoid use of deprecated features.

5. Abbreviations and Definitions

5.1. Abbreviations

AFD	active format descriptor
ATSC	Advanced Television Systems Committee
AVC	advanced video coding
CAT	Conditional Access Table. [13818-1]
DPB	decoded picture buffer
DPI	Digital Program Insertion.
FPP	forward predicted picture [SCTE 128-1]
GOP	group of pictures [13818-2]
HDR	High Dynamic Range
HEVC	High Efficiency Video Coding
I	intraframe
IDR	instantaneous decoding refresh

IP	internet protocol
MPEG	Moving Picture Experts Group
MPTS	Multiprogram Transport Stream. [13818-1]
MVPD	Multichannel Video Programming Distributor
NAL	network abstraction layer as defined in [14496-10].
OCAP	Open Cable Application Platform
P	predictive frame
PAT	program association table [13818-1]
PCR	program clock reference 13818-1
PES	packetized elementary stream 13818-1
PID	packet identifier 13818-1
PMT	program map table 13818-1
PSI	program specific information 13818-1
PTS	presentation time stamp 13818-1
QAM	quadrature amplitude modulation
SCTE	Society of Cable Telecommunications Engineers
SDR	Standard Dynamic Range
SRAP	SCTE (AVC) Random Access Point as defined in [SCTE 128-2]
T-STD	Transport Stream System Target Decoder 13818-1
TRAIL_N	Non-reference trailing picture in HEVC [SCTE 215-1]
SHRAP	SCTE HEVC Random Access Point as defined in [SCTE 215-1]

5.2. Definitions

Addressable Content Set	A collection of simultaneously transmitted elementary streams of equal presentation duration typically containing appropriate combinations of media streams (video, audio and data) that may be selected as the result of a Switch.
Advanced Video Coding	Refers specifically to video compression standardized in [14496-10]
C3	A metric for the ratings for average commercial minutes in live programming plus total playback by digital video recorder out to three days after live playback.
C7	A metric for the ratings for average commercial minutes in live programming plus total playback by digital video recorder out to seven days after live playback.
Client-DPI Device	A Receiver or other device that is able to select among elementary streams from within an Addressable Content Set.
Conditioning	This term refers to the set of rules that specify constraints on transport, video and audio that enable both a seamless and a non-seamless Switch within Client-DPI Devices.
Decision Engine	The algorithm in a Client-DPI Device that selects which particular content should be selected from an Addressable Content Set and presented to the viewer.
Filler	Used in Level 0 Streams, this is the region within which the Client-DPI Device begins and completes a Switch. Filler is inserted into all video and audio elementary streams that comprise an Addressable Content Set.
Gap	Used in Level 1 Streams, this is the region within which the Client-DPI Device begins and completes a Switch. The Gap is inserted into

	all video and audio elementary streams that comprise an Addressable Content Set.
Instantaneous Decoding Refresh	A picture type defined in [14496-10]
IDR NAL unit	An IDR slice [14496-10]. (A NAL unit with nal_unit_type = 5.)
Insertion Channel	The MPEG Programs comprising the Addressable Content Set that replaces the Primary Channel in whole or in part for the duration of a Switch Event.
Insertion Sequence	A set of back-to-back Switch Events.
Level 0 / L0	Streams or Switches resulting in non-seamless transitions.
Level 1 / L1	Streams or Switches resulting in seamless transitions.
Level 0 Stream	A Primary Channel or Insertion Channel that has been conditioned in order to enable a Level 0 Switch. [SCTE 67]
Level 1 Stream	A Primary Channel or Insertion Channel that has been conditioned in order to enable a Level 1 Switch. [SCTE 67]
Level 0 Switch	This term refers to a Switch from one video elementary stream to another video elementary stream and one audio elementary stream to another audio elementary stream without any perceptible audio or video artifacts, but which <i>may</i> include the use of black pictures and audio silence to mask any artifacts during the latency of the Switch.
Level 1 Switch	This term refers to a Switch from one video elementary stream to another video elementary stream of the same stream_type and/or one audio elementary stream to another audio elementary stream without any perceptible delay, or audio or video artifacts.
Primary Channel	The MPEG Program that is replaced in whole or in part by members of the Addressable Content Set during a Switch Event.
Receiver	A cable television receiving device which is typically a set-top box or other digital video device .
Seamless	A transition from one content set to another (either video or audio, or both) without any artifacts or discontinuities. This transition is usually invisible and inaudible to the viewer.
Signaled Switch Point	The point within the MPEG-2 transport stream where the Switching Engine <i>may</i> initiate a Switch.
Switch	The action performed by a Client-DPI Device, which chooses certain elementary streams out of an Addressable Content Set. Note: switch and splice are typically used interchangeably.
Switch Event	The time between two adjacent switches during which Client-DPI Devices present an Insertion Channel.
Switching Engine	The functionality that executes a Switch in a Client-DPI Device.
Trigger Signal	An element within the MPEG-2 transport stream multiplex which indicates the location of a Signaled Switch Point.

6. Standards Compliance

All transport streams (with video and audio components) delivered to Client-DPI Devices **shall** be compliant with [SCTE 54]. In addition:

- MPEG-2 video coding shall be compliant with [SCTE 43].
- AVC video coding shall be compliant with [SCTE 128-1] and carriage shall be compliant with [SCTE 128-2].

- HEVC video coding shall be compliant with [SCTE 215-1] and carriage shall be compliant with [SCTE 215-2].
- AC-3 audio coding shall be compliant with ATSC [A/52] as constrained by [A/53] Part 5.
- E-AC-3 audio coding shall be compliant with ATSC [A/52] as constrained by SCTE 54.
- AC-4 audio coding shall be compliant with [SCTE 242-2] and carriage shall be compliant with [SCTE 243-2]
- DTS-HD audio coding shall be compliant with [SCTE 194-1] and carriage shall be compliant with [SCTE 194-2].
- DTS-UHD coding shall be compliant with [SCTE 242-4] and carriage shall be compliant with [SCTE 243-4].
- MPEG-H audio coding shall be compliant with [SCTE 242-3] and carriage shall be compliant with [SCTE 243-3].

7. The PMT

SCTE 54 constrains each PMT PID to contain a single TS_program_map_section. Any PMT structures used by Addressable Content *should* conform to this constraint. [SCTE 54]

In systems where addressable content is present in the same transport stream as the Primary Channel, all of the PMTs *shall* be present in the transport stream at all times. Changes to any PMT in the vicinity of a Filler or Gap *should* be avoided.

Notes:

- The preceding requirement will result in one or more PMTs being present in the transport stream that describe PIDs for which data will be present only when addressable content is present.
- It may be necessary to transmit PAT, CAT and PMT more frequently than required by SCTE 54 during the Filler in Level 0 Streams. The aggregate of PAT, PMT and CAT transmitted in this interval should not exceed 80,000 bits/second.

8. Level 0 Requirements

Level 0 Conditioning consists of a Filler, as defined in section 8.4, and video coding requirements defined in sections 8.8, 8.9, and 8.10. The Conditioning described in this section *shall* be present in the transport stream at the input to a Client-DPI Device when a Level 0 Switch is enabled. In this context, “enabled” means that a Client-DPI Device *may*, as determined by its Decision Engine, perform a Level 0 Switch. The following requirements for Level 0 apply to both standard definition and high definition formats in coded video streams.

8.1. Use of Transport Streams and Services

In Level 0 systems, one or more transport streams *may* be used to convey the elementary streams comprising an Addressable Content Set. All elementary streams selected as the result of a Level 0 Switch *shall* reside in the same transport stream and in the same service.

8.2. Video and Audio Elementary Stream Presentation Duration Differences

Due to the fact that addressable content is preceded by Filler, a time difference (positive or negative) is introduced between corresponding audio and video presentation time stamps (PTS). This difference is introduced even when the original addressable content has been created with perfect synchronization. However, it can be shown (see Appendix B: Bound on A/V Presentation Time Mismatch Due to Splicing)

that under the following assumptions, the absolute value of the PTS difference introduced is bounded. Hence, the PTS difference between audio and video introduced by any technique under the following assumptions **shall** be less than or equal to one-half of the audio frame duration.

The presentation duration variance value calculations can be found in Appendix B: Bound on A/V Presentation Time Mismatch Due to Splicing. Those calculations **shall** be based on the following:

- A/V Filler (black video, muted audio) is precomputed with a target duration (e.g., 0.5 sec)
- Ad is spliced in after Filler, and PTS values are restamped to be continuous with Filler
- Video and audio frame periods are fixed and remain constant throughout Filler and ad
- PES packets contain one video or audio access unit (AU)
- The duration of the video Filler is calculated first. The duration of audio Filler is calculated to match the video Filler.

8.3. Conditioning of Primary Channel Streams

All of the video and audio elementary streams comprising the Primary Channel **shall** be Level 0 conditioned, as defined in section 8.0 of this standard, when a Level 0 Switch is enabled.

8.4. Filler

Filler **shall** be present in all of the audio and video elementary streams which comprise an Addressable Content Set when a Level 0 Switch is enabled. Filler in video elementary streams **shall** consist of picture data that will be decoded as black pictures. Filler in audio elementary streams **shall** consist of audio data that will be decoded as silence.

Filler **shall** be comprised of compressed video and compressed audio matching the video and audio codecs used to compress the Primary Channel and the addressable ads.

All Filler, Primary Channel and the addressable ad content **shall not** change PMTs during an Insertion Sequence.

Picture format changes during an Insertion Sequence **shall** be restricted to changes in horizontal resolution and **shall** be compliant with either [SCTE 43], [SCTE 128-1], or [SCTE 215-1].

The transition from Filler to subsequent non-Filler content and non-Filler content to subsequent Filler in both video and audio streams **should not** introduce any visible or audible artifacts.

Notes:

- There is no requirement that the codec used on any Insertion Channel be the same as any other Insertion Channel or Primary Channel.
- Filler may be produced at any point in the signal processing chain. For example, it could be included in stored advertising content or inserted by a splicing device.
- Client-DPI Devices may utilize any appropriate methods to minimize the time required to perform a Level 0 Switch, including communicating PID values in a manner that eliminates the need to parse the PSI (See section 7.0).

8.4.1. MPEG-2 Video Filler

The following requirements apply when performing an L0 Switch when MPEG-2 video content is present: