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ATSC Standard A/72 Part 1 – Video System Characteristics of AVC in the ATSC Digital Television System

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ATSC Standard A/72 Part 1 – Video System Characteristics of AVC in the ATSC Digital Television System

1. SCOPE

This Part describes the video coding constraints on ITU-T Rec. H.264 | ISO/IEC 14496-10 [4] (“AVC”) video compression in the ATSC Digital Television System. The Transport Stream constraints for AVC are described in Part 2 of this standard.

2. REFERENCES

All referenced documents are subject to revision. Users of this Standard are cautioned that newer editions might or might not be compatible.

2.1 Normative References

The following documents, in whole or in part, as referenced in this document, contain specific provisions that are to be followed strictly in order to implement a provision of this Standard.

- [1] ATSC: “ATSC Digital Television Standard, Part 1 – Digital Television System,” Doc. A/53 Part 1:2013, Advanced Television Systems Committee, Washington, D.C., 7 August 2013.
- [2] ATSC: “ATSC Digital Television Standard, Part 4 – MPEG-2 Video System Characteristics,” Doc. A/53 Part 4:2009, Advanced Television Systems Committee, Washington, D.C., 7 August 2009.
- [3] SCTE: “AVC Video Constraints for Cable Television, Part 1 – Coding,” Doc. ANSI/SCTE 128-1 2013, Society of Cable Telecommunications Engineers, Exton, PA.
- [4] ISO/IEC: “Information technology — Coding of audio-visual objects – Part 10: Advanced Video Coding,” Doc. ISO/IEC 14496-10¹, International Standard (2012), Advanced video coding for generic audiovisual services.
- [5] SMPTE: “Standard for Television—1920 x 1080 Scanning and Analog and Parallel Digital Interfaces for Multiple Picture Rates,” Doc. SMPTE ST 274 (2008), Society of Motion Picture and Television Engineers, White Plains, N.Y.
- [6] SMPTE: “SDTV Component Video Signal Coding 4:4:4 and 4:2:2, for 13.5 MHz and 18 MHz Systems,” Doc. SMPTE ST 125 (2013), Society of Motion Picture and Television Engineers, White Plains, N.Y.
- [7] SMPTE: “Standard for Television—1280 x 720 Progressive Image Sample Structure, Analog and Digital Representation and Analog Interface,” Doc. SMPTE ST 296 (2012), Society of Motion Picture and Television Engineers, White Plains, N.Y.
- [8] ITU: “ITU-R Recommendation BT.601-6 (2007), Encoding Parameters of Digital Television for Studios,” International Telecommunications Union, Geneva.
- [9] SCTE: “Constraints on AVC Video Coding for Digital Program Insertion,” Doc. ANSI/SCTE 172 2011, Society of Cable Telecommunications Engineers, Exton, PA.
- [10] SMPTE: “Format for Active Format Description and Bar Data,” Doc. SMPTE ST 2016-1:2009, Society of Motion Picture and Television Engineers, White Plains, N.Y.

¹ Also published by ITU as ITU-T Recommendation H.264. A/72 Part 1 does not implement Annexes G and H of [4].

2.2 Informative References

The following documents contain information that may be helpful in applying this Standard.

- [10] CEA: “Digital Television (DTV) Closed Captioning,” Doc. CEA-708-E, Consumer Electronics Association, Arlington, VA, June 2013.
- [11] CEA: “Line 21 Data Services,” Doc. CEA-608-E, Consumer Electronics Association, Arlington, VA, April 2008.
- [12] ETSI: “Digital Video Broadcasting (DVB) – Implementation Guidelines for the use of MPEG-2 Systems, Video and Audio in Satellite, Cable and Terrestrial Broadcasting Applications, Annex B,” Doc. ETSI TS 101 154 V1.11.1, November 2012.
- [13] Digital TV Group: “Digital Receiver Implementation Guidelines and Recommended Receiver Reaction to Aspect Ratio Signaling in Digital Video Broadcasting, Issue 1.2”, August 2000.
- [14] ITU: “International Standard (2000), Procedure for the allocation of ITU-T defined codes for non-standard facilities,” Recommendation ITU-T T.35, International Telecommunications Union, Geneva.
- [15] ITU: “Video Codec for Audiovisual Services at p x 64 kbits,” Recommendation ITU-T H.261 (1993), International Telecommunications Union, Geneva.
- [16] ATSC: “Use of AVC in the ATSC Digital Television System, Part 2 – Transport Subsystem Characteristics,” Doc. A/72 Part 2:2014, Advanced Television Systems Committee, Washington, D.C., 18 February 2014.
- [17] CEA: “Active Format Description (AFD) and Bar Data Recommended Practice,” Doc. CEB16,,Consumer Electronics Association, Arlington, VA, 31 July 2006.
- [18] SCTE: “AVC Video Constraints for Cable Television, Part 2 – Transport,” Doc. ANSI/SCTE 128-2 2013, Society of Cable Telecommunications Engineers, Exton, PA.
- [19] SCTE:, “Digital Program Insertion Cueing Message for Cable,” Doc. ANSI/SCTE 35 2013, Society of Cable Telecommunications Engineers, Exton, PA.

3. COMPLIANCE NOTATION

This section defines compliance terms for use by this document:

shall – This word indicates specific provisions that are to be followed strictly (no deviation is permitted).

shall not – This phrase indicates specific provisions that are absolutely prohibited.

should – This word indicates that a certain course of action is preferred but not necessarily required.

should not – This phrase means a certain possibility or course of action is undesirable but not prohibited.

3.1 Treatment of Syntactic Elements

This document contains symbolic references to syntactic elements used in the audio, video, and transport coding subsystems. These references are typographically distinguished by the use of a different font (e.g., `restricted`), may contain the underscore character (e.g., `sequence_end_code`) and may consist of character strings that are not English words (e.g., `dynrng`).

3.1.1 Reserved Elements

One or more reserved bits, symbols, fields, or ranges of values (i.e., elements) may be present in this document. These are used primarily to enable adding new values to a syntactical structure

without altering its syntax or causing a problem with backwards compatibility, but they also can be used for other reasons.

The ATSC default value for reserved bits is ‘1.’ There is no default value for other reserved elements. Use of reserved elements except as defined in ATSC Standards or by an industry standards setting body is not permitted. See individual element semantics for mandatory settings and any additional use constraints. As currently-reserved elements may be assigned values and meanings in future versions of this Standard, receiving devices built to this version are expected to ignore all values appearing in currently-reserved elements to avoid possible future failure to function as intended.

3.2 Symbols, Abbreviations, and Mathematical Operators

The symbols, abbreviations, and mathematical operators used herein are as found in Section 3.4 of ATSC A/53 Part 1 [1] and as herein specified.

one_bits – Each bit in fields marked, one_bits, shall be set to ‘1’.

3.3 Terms

The following terms are used within this document.

Digital Program Insertion – A term (sometimes called “DPI”) that refers to the splicing of MPEG-2 transport streams for the purpose of insertion of advertisements and other content types using an in-stream messaging mechanism. See ANSI/SCTE 35 [19].

HDTV –High Definition Television.

reserved – Set aside for future use by a Standard.

SDTV – Standard Definition Television.

4. SYSTEM OVERVIEW (INFORMATIVE)

Please see the A/53 Part 4 Section titled “System Overview” [2].

5. POSSIBLE VIDEO INPUTS

Please see the A/53 Part 4 Section titled “Possible Video Inputs” [2] for information regarding television production standards. Television production standards supported by this standard include 25 and 50 Hz inputs as well as 29.97 and 59.94 Hz inputs.

6. VIDEO PROCESSING BEFORE AVC COMPRESSION

The image formats for AVC compression may be derived from the production video formats as follows:

6.1 16:9 Aspect Ratio Source Images

In order to maintain square pixels and simple-ratio scaling factors, identical cropping from both left and right sides of the image should be done. If uneven cropping is required for some reason, the output image should be left justified in the result. Cropping should be performed prior to de-interlacing when required.

6.2 4:3 Aspect Ratio Source Images

In order to maintain square pixels and simple-ratio scaling factors, identical cropping from both left and right sides of the image should be done. If uneven cropping is required for some reason,

the output image should be left justified in the result. Cropping should be performed prior to de-interlacing.

6.3 Active Format Description

When the active image area in a 16:9 video signal does not fill the full 16:9 frame, Active Format Description (AFD) and (optionally) Bar Data information in accordance with SMPTE ST 2016-1 [10] should be present in the source video signal. It is expected that such AFD information, and (optional) Bar Data, will be included in the compressed bit stream and used by a receiver to optimize the display of images that do not fill the coded frame.

Bar Data values are specific to a given video format and, if used, will have to be recalculated when an incoming video signal is decimated (as above) and compressed to the AVC compression format. Formats without controlling source documents, as specified for compression in this standard, shall use the compressed domain line and pixel numbering.

7. SOURCE CODING SPECIFICATION

This section establishes a specific subset of the AVC video compression standard [4]. The AVC video compression algorithm shall conform to either the Constrained Baseline Profile, the Main Profile, or the High Profile syntax of AVC video (ISO/IEC 14496-10) [4].

The constraints and specifications applicable to bit streams are listed in Section 7.1 (including subsections 7.1.1 through 7.1.6), 7.3 and 7.4. Bounds on allowed picture sizes and other compression format constraints are shown in Table 7.3.

Main and High Profile bit streams meet the constraints and specifications specified in ANSI/SCTE 128-1 [3] Sections 7.2 (“Source coding specification”) and 8.0 (“Carriage of Captioning, AFD, and Bar Data”).

Constrained Baseline Profile AVC bit streams shall meet the constraints and specifications specified in Table 7.3 and as further described in Sections 7.1, 7.2, and 7.4 of this document.

AVC bit streams shall utilize both the “Supplemental enhancement information (SEI)” and the “Video usability information (VUI)” syntactic elements defined in ISO/IEC 14496-10 Annexes D and E [4]. Decoder design should be made under the assumption that any legal structure as permitted by ISO/IEC 14496-10 [4] may occur in the broadcast stream even if presently reserved or unused.

7.1 Constraints with Respect to AVC (ISO/IEC 14496-10)

The tables in section 7.2.1 (“Constraints with respect to AVC”) of ANSI/SCTE 128-1 [3] list the allowed values for each of the ISO/IEC 14496-10 [4] syntactic elements which are constrained.

7.1.1 Constraints with Respect to AVC Main and High Profiles

Picture coding shall not use the High Profile tools unless required by the picture format. See Section 7.2.1.5 (“Compression format constraints”) of ANSI/SCTE 128-1 [3].

7.1.2 Constraints with Respect to AVC Baseline Profile

When used for image formats where Baseline profile is permitted, the picture coding shall use the Constrained Baseline profile, which means that only the subset of Baseline tools that are also present in the Main profile are used.

7.1.3 AVC Access Point

An Access Point is defined as an access unit in an AVC bit stream at which a decoder can begin decoding video successfully. The access unit must contain one Sequence Parameter Set NAL unit and one Picture Parameter Set NAL unit that are active or being activated when decoding the primary coded picture in this access unit. The access unit must contain an IDR picture or an I picture.

7.1.4 Sequence Parameter Set Constraints

The Sequence Parameter Set constraints shall be the same as those in Section 7.2.1.1 (“Sequence Parameter Set (SPS) constraints”) of ANSI/SCTE 128-1 [3].

7.1.5 Picture Parameter Set Constraints

The Picture Parameter Set constraints shall be the same as those in Section 7.2.1.3 (“Picture Parameter Constraints and Level Limits”) of ANSI/SCTE 128-1 [3].

7.1.6 Video Usability Information (VUI) Parameter Constraints

The Video Usability Information (VUI) constraints shall be the same as those in Section 7.2.1.2 (“Video Usability Information (VUI) Constraints”) of ANSI/SCTE 128-1 [3].

7.2 Compression Format Constraints

Section 7.2.1.5 (“Compression format constraints”) of ANSI/SCTE 128-1 [3] includes detailed constraints on picture sizes and related parameters. Those constraints are relaxed in this standard to allow other coded image sizes to be used for broadcast stream optimization. The fixed image size rows are intended as format interoperation points and their use is encouraged. For images subsampled from 1920x1080 source image formats (HDTV per SMPTE ST 274 [5]), the maximum number of horizontal and vertical macroblocks is 120 and 68, respectively, with an image aspect ratio as close to 16:9 as possible. For images subsampled from 1280x720 source image formats (HDTV per SMPTE ST 296 [7]), the maximum number of horizontal and vertical macroblocks is 80 and 45, respectively, with an image aspect ratio as close to 16:9 as possible. For images subsampled from 720x480 or 720x576 source image formats (SDTV per either SMPTE ST 125 [6] or ITU-R BT.601 [8]), the maximum number of horizontal and vertical macroblocks is 45 and 30, respectively, with an image aspect ratio as close to 4:3 or 16:9 as possible.

The AVC video compression standard [4] requires that coded vertical size be a multiple of 16 (progressive scan) or 32 (interlaced scan). While many possible compression formats use square pixels and complete macroblocks, should the compression format require “padding out” of the coded frame (such as 1080 lines requires 1088 to be actually coded), those extra macroblocks shall be placed at the bottom and/or right edge of the coded frame.

Table 7.1 Recommended Compression Formats

Vertical Size	Horizontal Size	PicWidth InMbs	PicHeight InMbs	Prod Format	aspect_ratio_idc	profile_idc ¹	level_idc	Display Aspect Ratio	Allowed Frame Rates	Progressive/interlaced
1080	1920	120	68	HDTV	1	100	40	16:9	1,2,3,4,5,6,7,8	I or P
720	1280	80	45	HDTV	1	100	40	16:9	1, 2, 5, 6, 8	P
480	720	45	30	SDTV	3 or 5	77 or 100	31, 40	4:3 or 16:9	1,2,3,4,5,6,7,8	I
480	640	40	30	SDTV	1	100	31, 40	4:3	1,2,3,4,5,6,7,8	I
576	720	45	30	SDTV	2 or 4	77 or 100	31, 40	4:3 or 16:9	7 or 8	I

Legend:
frame rate: 1 = 23.976 Hz, 2 = 24 Hz, 3 = 29.97 Hz, 4 = 30 Hz, 5 = 59.94 Hz, 6 = 60 Hz, 7 = 25 Hz, 8 = 50 Hz
aspect_ratio_idc: 1 = 1:1 [square samples], 2 = 12:11, 3 = 10:11, 4 = 16:11, 5 = 40:33, 7 = 20:11, 14 = 4:3

Footnotes:
1 A compliant bitstream may have a profile_idc value of either 66, 77, or 100.
2 The use of aspect_ratio_idc = 4 in this case is intended for 16:9 display aspect ratio images.

Note: aspect_ratio_idc, profile_idc, level_idc are parameters in the Sequence Parameter Set (SPS) of the AVC bit stream.

7.3 Low Delay Mode and Still Picture Mode

The Low Delay Mode and Still Picture Mode constraints shall be the same as Section 7.2.1.6 (“Low Delay Mode”) and Section 9.0 (“Support For AVC Still Pictures”) of ANSI/SCTE 128-1 [3].

7.4 Bit Stream Specifications Beyond AVC (ISO/IEC 14496-10)

This section covers the specific data carried in the SEI RBSP and VUI sections of the video syntax. The syntax used for the insertion of closed captioning, AFD, and bar data in the SEI payload shall be as specified in the following sections.

7.4.1 Transport of Caption, Active Format Description (AFD) and Bar Data

Captions, AFD and bar data, when present, shall be carried according to A/53, Part 4 [2], Section 6.2 as further constrained and described in 7.4.2 of this document.

Note: CEA-708 [10] requires a fixed bandwidth of 9600 bits per second for the closed caption payload data when AVC is used for Terrestrial Fixed Broadcast applications. Bandwidth calculations should anticipate this requirement. CEA-708 [10] also provides carriage for CEA-608 [11] Line 21 caption data.

Note: Additional background on AFD and bar data may be found in ETSI TS 101 154 V1.11.1 [12], the Digital Receiver Implementation Guidelines [13], and CEA CEB16 [17].

7.4.2 Caption, AFD and Bar Data

Closed Captions, AFD and Bar Data shall be as specified by Section 8.1 (“Caption, AFD and Bar Data Syntax”) of ANSI/SCTE 128-1 [3].

7.4.3 Constraints for Digital Program Insertion

Where Digital Program Insertion is to be used, the video syntax shall follow the constraints of ANSI/SCTE 172 [9].

Note: See also Section 7.2.1.7 (“Program Splicing Constraint”) of ANSI/SCTE 128-1 [3] and ANSI/SCTE 35 [19].

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