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Candidate Standard:
Part 1 of Proposed Doc. A/73,
"Video System Characteristics of VC-1 in the ATSC Digital Television System"

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The Advanced Television Systems Committee, Inc. is an international, non-profit organization developing voluntary standards for digital television. The ATSC member organizations represent the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

Specifically, ATSC is working to coordinate television standards among different communications media focusing on digital television, interactive systems, and broadband multimedia communications. ATSC is also developing digital television implementation strategies and presenting educational seminars on the ATSC standards.

ATSC was formed in 1982 by the member organizations of the Joint Committee on InterSociety Coordination (JCIC): the Electronic Industries Association (EIA), the Institute of Electrical and Electronic Engineers (IEEE), the National Association of Broadcasters (NAB), the National Cable Television Association (NCTA), and the Society of Motion Picture and Television Engineers (SMPTE). Currently, there are approximately 140 members representing the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

ATSC Digital TV Standards include digital high definition television (HDTV), standard definition television (SDTV), data broadcasting, multichannel surround-sound audio, and satellite direct-to-home broadcasting.

About the Candidate Standard

This specification is being put forth as a Candidate Standard by the TSG/S6 Specialist Group on Audio and Video Coding. ATSC members and non-members are encouraged to review and implement this specification and return comments to cs_amend_editor@atsc.org. ATSC Members can also send comments directly to the TSG/S6 Specialist Group. The ATSC believes this specification is stable. It is expected to progress to Proposed Standard within a period of time ending 31 December 2007.

Advisory Notice

In issuing this standard, the ATSC recognizes that it includes encoding and decoding techniques for digital television transmission which are not backwards compatible with existing MPEG-2-based ATSC DTV deployments. Transitional issues associated with continuing service to existing receivers, how and when to deploy advanced-capability receivers, allocation of channel bit capacity, and related issues should be considered. ATSC recognizes that this standard will be utilized more readily in countries that have not yet implemented digital terrestrial television broadcasting systems, or in countries that have achieved internal agreement on a transition plan.

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1. SCOPE

This Part describes the video coding constraints on SMPTE 421M [3] ("VC-1") video compression of the ATSC Digital Television System. The Transport Stream constraints for VC-1 are described in Part 2 of this Standard.

2. REFERENCES

2.1 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.

[1] ATSC: A/53 Part 1:2007, "ATSC Digital Television Standard, Part 1 – Digital Television System," Advanced Television Systems Committee, Washington, D.C., 3 January 2007.

[2] ATSC: A/53 Part 4:2007, "ATSC Digital Television Standard, Part 4 – MPEG-2 Video System Characteristics with Amendment No. 1," Advanced Television Systems Committee, Washington, D.C. (Amendment No. 1, CS/TSG-744r1, is currently at Candidate Standard).

[3] SMPTE: SMPTE 421M (2006), "Standard for Television—VC-1 Compressed Video Bitstream Format and Decoding Process," Society of Motion Picture and Television Engineers, White Plains, N.Y.

[4] SMPTE: SMPTE RP227 (2006), "Recommended Practice—VC-1 Bitstream Transport Encodings with Amendment 1," Society of Motion Picture and Television Engineers, White Plains, N.Y.

3. COMPLIANCE NOTATION

As used in this document, "shall" 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.

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).

3.2 Symbols, Abbreviations, and Mathematical Operators

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

4. SYSTEM OVERVIEW (INFORMATIVE)

Please see A/53 Part 4, Section 4 titled "System Overview" [2].

5. POSSIBLE VIDEO INPUTS (INFORMATIVE)

Please see A/53 Part 4, Section titled "Possible Video Inputs" [2] for information regarding television production standards.

6. SOURCE CODING SPECIFICATION

The VC-1 video compression algorithm shall conform to the Advanced Profile syntax. The allowable parameters shall be bounded by the upper limits set forth in Level 4. See VC-1 [3], Annex D for more information regarding profiles and levels.

Additionally, VC-1 bit streams shall meet the constraints and specifications described in this Section.

Decoder designs are encouraged to parse any legal structure as permitted by VC-1 [3] even if presently reserved or unused.

6.1 Constraints with Respect to SMPTE 421M Advanced Profile

The following tables list the allowed values for each of the VC-1 [3] syntactic elements which are restricted beyond the limits imposed by Advanced Profile at Level 4 (AP@L4).

6.1.1 Access Points

An Access Point is defined as an Access Unit in an Advanced Profile VC-1 bit stream at which a decoder can begin decoding video successfully. The Access Unit associated with an Access Point contains a Sequence Header followed by an Entry Point Header structure as defined in VC-1.

6.1.2 Sequence Header Parameter Set Constraints

The constraints for the fields in a Sequence Header are listed in Table 6.1.

Table 6.1 Sequence Header Parameter Set Constraints

Sequence Parameter Set Syntactic Element	Allowed Value
PROFILE	See Table 6.2
LEVEL	See Table 6.2
COLORDIFF_FORMAT	'1'
MAX_CODED_WIDTH	See Table 6.2
MAX_CODED_HEIGHT	See Table 6.2
TFCNTRFLAG	'1'
DISPLAY_EXT	'1'
ASPECT_RATIO_FLAG	'1'
ASPECT_RATIO	See Table 6.2
FRAMERATE_FLAG	'1'
FRAMERATEIND	'0'
FRAMERATENR	See Table 6.2
FRAMERATEDR	See Table 6.2
COLOR_FORMAT_FLAG	'1'
HRD_PARAM_FLAG	See text below

The maximum size of the video elementary stream buffer shall comply with the value Rmax listed in Table 253 of VC-1 [3]. The sequence header may include zero, one or more Hypothetical Reference Decoder buffer model parameters in the form of a HRD_PARAM() structure in the sequence header and a HRD_FULLNESS() field in the Entry Point header. The HRD_PARAM_FLAG and HRD_NUM_LEAKY_BUCKETS shall be set accordingly, as specified in VC-1 [3].

6.1.3 Compression Format Constraints

Table 6.2 lists the allowed compression formats.

Table 6.2 Compression Format Constraints

Vertical Size	Horizontal Size	PROFILE	LEVEL	MAX_ CODED_ WIDTH	MAX_ CODED_ HEIGHT	ASPECT_ RATIO	Display Aspect Ratio	Allowed Frame Rates	Progressive / Interlaced
1080	1920	3	3	959	539	1	16:9	1,2,3,4	P
1080	1920	3	4 [1]	959	539	1	16:9	5,6,8	P
1080	1920	3	3	959	539	1	16:9	3,4,7	I
1080	1440	3	3	959	719	15 [2]	16:9	1,2,3,4	P
1080	1440	3	3	959	719	15 [2]	16:9	3,4,7	I
720	1280	3	2	359	639	1	16:9	1,2,3,4	P
720	1280	3	3	359	639	1	16:9	5,6,8	P
480	720	3	1	239	359	3	4:3	1,2,3,4	P
480	720	3	2	239	359	3	4:3	5,6,8	P
480	720	3	1	239	359	5	16:9	1,2,3,4	P
480	720	3	2	239	359	5	16:9	5,6,8	P
480	720	3	1	239	359	3	4:3	3,4,7	I
480	720	3	1	239	359	5	16:9	3,4,7	I
480	704	3	1	239	351	3	4:3	1,2,3,4	P
480	704	3	2	239	351	3	4:3	5,6,8	P
480	704	3	1	239	351	5	16:9	1,2,3,4	P
480	704	3	2	239	351	5	16:9	5,6,8	P
480	704	3	1	239	351	3	4:3	3,4,7	I
480	704	3	1	239	351	5	16:9	3,4,7	I
480	640	3	1	239	319	1	4:3	1,2,3,4	P
480	640	3	2	239	319	1	4:3	5,6,8	P
480	640	3	1	239	319	1	4:3	3,4,7	I
480	544	3	1	239	271	5	4:3	1,7	P
480	544	3	1	239	271	5	4:3	3,7	I
480	528	3	1	239	263	5	4:3	1,7	P
480	528	3	1	239	263	5	4:3	3,7	I
480	352	3	1	239	175	7	4:3	1,7	P
480	352	3	1	239	175	7	4:3	3,7	I
240	352	3	0	119	175	3	4:3	1,7	P
120	176	3	0	59	87	3	4:3	1,7	P

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: 1 = 1:1 [square samples], 3 = 10:11, 5 = 40:33, 7 = 20:11, 15 = aspect width and height transmitted.

Note:
For vertical sizes of 1080 and 120, 1088 and 128 lines (respectively) are actually coded in order to satisfy the VC-1 requirement that the coded vertical size be a multiple of 16 (progressive scan) or 32 (interlaced scan).

Footnotes:
[1] Use of this format may be constrained by service_type (see A/53 Part 1 [1] Section 4.2).
[2] In addition, ASPECT_HORIZ_SIZE shall be equal to 4 and ASPECT_VERT_SIZE shall be equal to 3.

For each frame rate shown in Table 6.2, the values for FRAMERATENR and FRAMERATEDR shall be as shown in Table 6.3.

Table 6.3 Frame Rate Parameter Constraints

frame rate	FRAMERATENR	FRAMERATEDR
23.98 Hz	1	2
24 Hz	1	1
25 Hz	2	1
29.97 Hz	3	2
30 Hz	3	1
50 Hz	4	1
59.94 Hz	5	2
60 Hz	5	1
Legend: FRAMERATENR: 1 = 24*1000, 2=25*1000, 3 = 30*1000, 4=50*1000, 5 = 60*1000 FRAMERATEDR: 1 = 1000, 2 = 1001		

6.2 Low Delay and Still Picture Modes

6.2.1 Low Delay Mode

Low delay mode shall follow the variable-delay mode of the VC-1 Hypothetical Reference Decoder (HRD) model as defined in VC-1 [3], Annex C. This mode of operation is signaled when there is no HRD parameter signaled in the sequence header; i.e., when HRD_PARAM_FLAG is equal to '0'.

6.2.2 Still Picture Mode

Still Picture Mode is supported and is governed by the conventional MPEG-2 Systems principles designed to support this mechanism. In particular, still picture mode is characterized by:

- A Still Picture Mode sequence shall begin with a VC-1 sequence header followed by an Entry Point header followed by an I-frame (in the case of progressive or frame interlaced mode) or by an I-I frame (in the case of field interlaced mode) followed by an End-Of-Sequence code.
- Still pictures shall comply with the Still Picture Mode elementary stream coding requirements and constraints in SMPTE RP227:2006 with Amendment 1 [4].

6.3 Bit Stream Specifications Beyond VC-1 (User Data)

This section covers the syntax of data carried in the User Data defined in VC-1 [3], Annex F. Closed captioning, active format description (AFD), and bar data, when present, shall be encoded in User Data according to ATSC A/53, Part 4 with Amendment 1 [2], Section 6.2 as follows:

The VC-1 User_data_identifier field shall be set to the ATSC user_data_identifier; and the VC-1 User_data[n] field shall be set to the ATSC user_structure(). This illustrated in Table 6.4.

Table 6.4 VC-1 User Data Parameters

VC1_User_data_parameters( )	No. of bits	Description
{		
user_data_identifier	32	uimsbf
user_structure()	var	
}		
Flushing_byte (0x80)	8	uimsbf

6.3.1 Closed Captions

When the User Data contains closed captions it shall be encoded at the frame layer.

6.3.2 AFD and Bar Data

AFD and Bar Data may be inserted in the video elementary stream at the sequence layer, entry-point layer or frame layer user data. After each sequence start (and repeat sequence start) the default aspect ratio of the area of interest is that signalled by the VC-1 sequence header and sequence display extension parameters. When present, after introduction, AFD and Bar Data settings persist until the next VC-1 sequence start or until another AFD or Bar Data is encountered.

The active_format is used by the decoder in conjunction with the sample aspect ratio signaled in a VC-1 elementary stream by means of the ASPECT_RATIO field in the sequence header as defined in VC-1 [3]. The combination of sample aspect ratio and active_format allows the decoder to identify whether the "area of interest" is the whole of the frame (e.g. source aspect ratio 16:9, active_format 16:9 centre), a letterbox within the frame (e.g. source aspect ratio 4:3, active_format 16:9 centre), or a "pillar-box" within the frame (e.g. source aspect ratio 16:9, active_format 4:3 centre).

When present, Bar Data shall override the signaling of pan scan information in the VC-1 bitstream.

As prescribed in VC-1, the PANSCAN_FLAG value '1' in the entry point header indicates bar data is present in the VC-1 bitstream. The set of pan scan values, PS_HOFFSET, PS_VOFFSET, PS_WIDTH, and PS_HEIGHT, remains in effect until the PS_PRESENT flag in a subsequent picture header is '1' or until the PANSCAN_FLAG value in a subsequent entry point header is reset to '0', whichever comes first.

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