ATSC Standard: A/335:2016 Amendment No. 2, Expanded Range of Encoding Values

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Advanced Television Systems Committee
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Revision History

Version	Date
Amendment approved	2 February 2021

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1. OVERVIEW

1.1 Definition

An Amendment is generated to document an enhancement, an addition or a deletion of functionality to previously agreed technical provisions in an existing ATSC document. Amendments shall be published as attachments to the original ATSC document. Distribution by ATSC of existing documents shall include any approved Amendments.

1.2 Scope

This document describes how video watermarking can achieve compatibility with a wider range of content and formats and improved video quality through use of revised values for watermark symbol encoding.

1.3 Rationale for Changes

The A/335:2016 specification includes constraints on the pixel component values employed for video watermark embedding.

Some of these constraints require use of component values that are defined as “prohibited” or “undershoot” by commonly used video formats. An example of this is the requirement in Section 5 of A/335:2016 that the chroma values for watermarked samples to be set to value zero, which is specified as a “prohibited” value in SMPTE ST 274 [3]. Another example of this is bit value "0" in the 1X version of the video watermark for 8-bit video, which is required by A/335:2016 (Table 5.2) to be encoded with luma value 4. This is specified as an “undershoot” luma value by SMPTE ST 274 [3]. These requirements have been observed in field trials to cause video signals containing video watermarks conforming to A/335:2016 to be incompatible with commercially-deployed broadcast equipment. The present document proposes to expand the range of permitted luma and chroma values so that video watermarks can be embedded without using any video values outside the normal operating ranges of commonly used video formats.

Additionally, some of these constraints require use of luma values that could unnecessarily reduce perceived video quality on display devices that do not employ overscan or that do not otherwise avoid displaying the video watermark as discussed in Section 4 of A/335:2016. An example of this is the bit value "1" in the 1X version of the video watermark for 8-bit video, which is required by A/335:2016 to be encoded with a luma value in the range of 40-100. For some content types, such as “credit sequences” with a black background, the lowest permitted luma value will be visible and obtrusive to some viewers, potentially impairing acceptance of the technology. Permitting the use of a lower luma value for bit value “1” in such instances would enable perceived video quality to be maintained without reducing the reliability of watermark recovery. The present document proposes to expand the range of permitted luma values in the 1X format to allow reduced luma values to be used for bit value “1” when appropriate, to enable video quality to be preserved in environments where the video watermark is displayed on-screen.

1.4 Compatibility Considerations

The changes described in this document are backward-compatible relative to the currently published version of the standard to which this Amendment pertains and the previously approved Amendment.

The revised range of permitted luma encoding values is a superset of the previously permitted values, so any embedded video watermarks that conform with the prior version will also conform with this version, and is contiguous with the previously permitted value so, to video watermark detectors designed in accordance with prior versions of the specification (see Appendix A of A/335:2016), embedded video watermarks that conform with this proposed amendment will appear to be video watermarks embedded in conformance with prior versions of the specification that have been degraded in accordance with typical redistribution video processing transformations (e.g. encoding, transcoding, etc.).

The change to the encoded chroma value is unrelated to watermark data transmission and solely for interoperability with other broadcast equipment. It is not expected to impact watermark detectors built to prior versions of the specification in any way.

2. LIST OF CHANGES

Change instructions are given below in *italics*. Unless otherwise noted, inserted text, tables, and drawings are shown in blue; deletions of existing text are shown in ~~red strikeout~~. The text "[ref]" indicates that a cross reference to a cited referenced document should be inserted.

2.1 Change Instructions

In Section 2.2, change references [2] and [3] as follows:

[2] ATSC: "ATSC Standard: Content Recovery in Redistribution Scenarios, with Amendment 1" Doc. A/336:~~2017~~2019, Advanced Television Systems Committee, Washington, D.C., ~~24 February 2017~~3 October 2019, Amendment No. 1 dated 4 June 2020.

[3] SMPTE: "1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates," Doc. SMPTE ST 274~~M~~ :2008, Society of Motion Picture and Television Engineers, White Plains, NY, 29 January 2008.

In Section 4, strike the fourth paragraph:

~~Visibility of this video watermark is not anticipated to be an issue because ATSC 3.0-aware receivers are expected to be designed with the knowledge that the top two lines of active video may include this watermark, and will thus avoid displaying (by any means desired). The majority of HDTV display systems in use at the time of publication operate by default in an "overscan" mode in which only the central ~95% of video lines are displayed. Thus, if watermarked video is delivered to a non-ATSC 3.0-aware receiver, the watermark would not normally be seen.~~

In Section 4, change the sixth paragraph as follows:

Figure 4.2 shows the full range of luma values on the Y-axis for 8-bit video encoding and the range of black to white as defined in SMPTE ST 274~~M~~ [3] of 16 to 235. As shown, for the 2X system, four levels of luma are used for the encoding, the black and white levels as well as two intermediate shades of gray (levels 89 and 162). Because the 2X system always employs the full

luma range for encoding of the watermark, broadcasters are advised to use it only in distribution paths where receivers of the service are known to either have overscan activated or are capable of masking the watermark when present.

In Section 4, change the last two paragraphs as follows:

Modulation levels for the 1X system are flexible to allow the broadcaster to set the desired balance between visibility and robustness. The luma level for the "0" value of the symbol may be set to any value in the range 4 to 16 ~~is set at 4~~ (for 8-bit video encoding), while ~~but~~ the luma value used for the "1" value may be set to any value in the range 20~~40~~ to 100.

The receiver is expected to take note of the modulation values in use and set a slicing level as appropriate. Figure 4.3 depicts ~~the~~ two cases ~~on the extremes~~ of this range. On the left, the modulation levels are 4 and 40, and the receiver sets an optimum slicing level of 22. On the right, the modulation levels are 4 and 100, and the receiver sets an optimum slicing level of 52. An algorithm receivers may use to determine the optimum slicing level is given in Annex A.

In Section 4, insert text after the last paragraph as follows:

Selection of luma levels for the 1X system appropriate to a particular service environment is dependent on a number of factors, including: the number of viewers of the service whose receivers are expected to present the watermarked lines on-screen, the video resolution and formats used for the service, the video processing technologies (e.g., encoders and their associated bit-rates) in the distribution path, and the rate of watermark message data transmission required. Broadcasters are advised to take local market conditions into account in their selection of luma levels. In general, the greater the separation between luma values used to transmit the "0" and "1" symbol values, the more likely the message is to be detected after video processing present in the distribution path is applied. However, the higher the luma values of watermark symbols displayed to the viewer relative to program content, the more likely the watermark is to be visually obtrusive to viewers for whom it is presented on-screen. If on-screen display is expected to occur for a substantial number of viewers, broadcasters can minimize impact on perceived video quality by encoding the watermark at luma levels sufficiently low to preserve commercially acceptable subjective video quality and may need to transmit watermark messages with error correction coding and/or temporal redundancy to ensure reliable reception of the watermark data by receivers. Where necessary, watermark embedding implementations may adjust the luma levels employed based on characteristics of the video content to optimize robustness while ensuring that a target video quality level is maintained.

In Section 5, change the last sentence prior to the Section 5.1 heading as follows:

The watermark payload is delivered within luma values. ~~; for all~~ For marked content, the chroma values for ~~all~~ video samples in lines 1 and 2 ~~shall be set to zero~~are not constrained by this specification and are expected to be ignored by watermark detectors.[1]

[1] Note that color system components can interact in unexpected ways as a result of clipping during conversions between color spaces (e.g., between YCbCr and RGB or vice versa). Implementers are advised to consider the potential impact of color space conversion when selecting values for the chroma channels of video samples that contain watermark payload data. It is further noted that such interactions can be avoided entirely if chroma channel values in the YCbCr color space are set to the midpoints of their ranges (i.e., 0x80 for 8-bit, 0x200 for 10-bit, and 0x800 for 12-bit video) or, in the RGB color space, if R, G, and B values are set to be equal to one another.

In Section 5.2, change the last paragraph as follows:

For example, for encodings of 1280 pixels, 5⅓ pixels will encode one symbol. Figure 5.1 illustrates the mapping of symbols to pixels and the resulting luma values for 32 pixels in the payload of a 1280-pixel-wide video frame, using 1X and modulation level 4 for symbol value "0" and 40 for symbol value "1". In this example, the luma values for each pixel (abbreviated as "px" below) shared by two symbols are:

- px *i*+5: (⅓ * 40) + (⅔ * 40) = 40
- px *i*+10: (⅔ * 40) + (⅓ * 4) = 28
- px *i*+21: (⅓ * 40) + (⅔ * 4) = 16
- px *i*+26: (⅔ * 4) + (⅓ * 4) = 4

In Section 5.4, change Table 5.2 and the wording of the second paragraph as follows:

Table 5.1 Luma Value Encodings for 1X System

Bits per symbol	Encoded Data	Luma Value		
		8-bit	10-bit	12-bit
1	0	0x04 (4) to 0x10 (16)	0x010 (16) to 0x040 (64)	0x40 (64) to 0x100 (256)
	1	0x14 (20) ~~0x28 (40)~~ to 0x64 (100)	0x050 (80) ~~0x0A0 (160)~~ to 0x190 (400)	0x140 (320) ~~0x280 (640)~~ to 0x640 (1600)
Minimum Level Difference		0x10 (16)	0x40 (64)	0x100 (256)

Note that in the 1X system a range of luma values is allowable for the "0" and "1" encoded data values. Higher luma values for the encoded data value "0" enable an increased range of overshoot protection in subsequent video processing and the ability to produce watermarks that remain fully within the normal range of luma specified by SMPTE ST 274 [ref] at the cost of lower robustness against watermark decoding errors introduced by video compression or transcoding. Lower luma values for the encoded data value "1" result in less visibility at the cost of lower robustness against errors introduced by video compression or transcoding. Higher values can be used if greater robustness is desired. The receiver is expected to determine an appropriate slice point[1] for recovery of the watermark based on the observed luma values. To assist receivers in this, a minimum level difference is specified between the luma values used to encode data symbol values "0" and "1" within a video frame. Guidance for receiver manufacturers regarding how to determine the optimum slice point is given in Annex A.

In Section A.1, change the first paragraph as follows:

In the 1X system, the luma value usable to modulate the "0" value of the symbol is specified to lie within the range 4 to 16 and the "1" value of the symbol is specified to lie within the range 20 ~~40~~ to 100 (8-bit video). For optimal recovery of the watermark, the receiver should set the slice point halfway between the value used to modulate "0" and the value used to modulate "1". This annex describes a simple algorithm a receiver can use to determine the best slice point when the 1X system is in use.

In Section A.2, change the second-to-last paragraph as follows:

This bin accumulation and peak detection process can be similarly applied within the luma range of 1 to 20 to establish an estimate for the encoding level for encoded data value "0". For a 2-level encoding where the luma value used to encode "0" is estimated ~~known~~ to be Z, the proper splice point would be Z + (peak - Z)/2.

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