

SMPTE RECOMMENDED PRACTICE

VC-2 Level 65 Compression of High Definition Video Sources for Use with a Standard Definition Infrastructure



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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual.

SMPTE RP 2047-3 was prepared by Technology Committee 10E.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Document. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

The transition from standard definition to high definition television production is well advanced. Yet many television production facilities still have a substantial legacy of a standard definition infrastructure that is impractical, or uneconomic, to immediately upgrade to a high definition infrastructure. There is therefore a need to compress high definition signals so that high definition production can continue to use a standard definition infrastructure. Standard definition infrastructure components that have the potential to be re-used by such compression include cabling, routers, uncompressed video links and uncompressed video recorders.

This Recommended Practice defines constraints on the VC-2 specification (SMPTE ST 2042-1) such that high definition source video images can be compressed to standard definition data rates. The bit rate of the resulting VC-2 stream is such that it can be carried over a standard definition serial digital interface (SDI) operating at 270Mbit/s. This document defines constraints on the coding and syntax. It does not define a mapping to any specific transport layer. The constraints defined herein are designed to support low latency, low complexity implementations suitable for television production environments.

1 Scope

This Recommended Practice defines constraints on the VC-2 video compression specification such that 10-bit high definition video signals can be compressed to only occupy the bit rate of 8-bit standard definition signals. Specifically, it defines constraints for compressing interlaced source video having 1920 or 1440 pixels/line by 1080 lines/frame at 25 or 30/1.001 frames/s, or progressive source video having 1280 pixels/line by 720 lines/frame at 50 or 60/1.001 frames/s, using 4:2:2 sampling in all cases.

This document defines a VC-2 bit-stream for video compressed according to this Recommended Practice. It also defines an application specific level for VC-2 compression.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; then formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this engineering document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this engineering document are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE ST 274:2008, Television — 1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates

SMPTE ST 296:2012, 1280 × 720 Progressive 4:2:2 and 4:4:4 Image Sample Structure — Analog and Digital Representation and Analog Interface

SMPTE ST 2042-1:2012, VC-2 Video Compression

4 Terms and Definitions

For the purposes of this document, the terms and definitions of SMPTE ST 2042-1 apply.

5 General Description

The VC-2 compression standard defines a compression system that uses Wavelet coding as the basis for image de-correlation with a number of compression tools including:

- A choice of Wavelet transform filters,
- A choice in the number of levels of Wavelet decimation,
- A choice between standard and low-delay operation,
- A choice of entropy coding.

The VC-2 compression standard defines various coding parameters that are needed by a decoder to successfully decode and present the output video signal. This Recommended Practice defines coding constraints to provide the interoperability of VC-2 streams coded for compatibility with a standard definition infrastructure. It also constrains the stream syntax to ensure that coded streams can be mapped in an interoperable fashion onto a transport layer.

The constraints defined here are signaled in the stream as the specialized VC-2 level number 65 (as indicated below in Section 6.3.1.1). That is, VC-2 streams conformant to this Recommended Practice ensure compliance by specifying specialized level 65 in the stream. This Recommended Practice does not define how the VC-2 stream is mapped to any specific transport layer.

Note: Such VC-2 stream transport specifications are defined in other SMPTE documents, such as SMPTE ST 2047-4 for the Carriage of Level 65 VC-2 Compressed Video Over the SDTV SDI.

6 Coding Constraints

This section defines the VC-2 coding constraints that ensure conformance to this application.

6.1 Overview (Informative)

In summary, this application has the following key coding constraints:

1. The video sources are limited to 4:2:2 sampling with the following picture formats:
 - 1920 pixels by 1080 interlaced lines with frame rates of 25 frames/sec or 30/1.001 frames/sec,
 - 1440 pixels by 1080 interlaced lines with frame rates of 25 frames/sec or 30/1.001 frames/sec,
 - 1280 pixels by 720 progressive lines with frame rates of 50 frames/sec or 60/1.001 frames/sec.
2. The codec uses only the low delay profile.
3. The codec uses only the LeGall (5,3) wavelet kernel.
4. The wavelet depth is exactly 3.
5. Slices are kept as small as possible, consistent with the wavelet depth, to minimize latency and implementation complexity.

6.2 Video Source Parameters

The video source shall be:

- as defined by SMPTE ST 274 for the field rates of 50 fields/sec and 60/1.001 field/sec only
- or
- as defined by SMPTE ST 296 for the frame rates of 50 frames/sec and 60/1.001 frames/sec only

The image sampling for a SMPTE ST 274 video source shall be:

- as defined by SMPTE ST 274 systems 5 and 6 only
- or
- as defined by SMPTE ST 274 systems 5 and 6 only, in which the horizontal sample rate has been reduced to 1440 pixels

The image sampling for a SMPTE ST 296 video source shall be:

- as defined by SMPTE ST 296 systems 2 and 3 only

Note: In the second case, the horizontal sampling structure of SMPTE ST 274 systems 5 and 6 is reduced in the ratio 3 output pixels for every 4 input pixels prior to compression. The sampling structure needs to be restored in a complementary fashion after decompression. Thus the overall system (sample rate changing plus compression) can maintain compatibility with SMPTE ST 274. The provision to support 1440 pixel video is provided for compatibility with other video compression systems that use 1440 pixel video sub-sampling (such as Type D-11, SMPTE ST 367). Failure to support 1440 pixel video compression would result in increased compression artifacts and noise in systems with concatenated compression. To summarize, the text in this section normatively provides for the sub-sampling of 1920 pixels to 1440 pixels for the purpose of compression coding. Since the sub-sampling is a part of the compression process, there is no externally accessible presence of the 1440-pixel format so there is no requirement to document a standardized method for the down and up conversions. Filter coefficients suitable for sample rate changing using FIR filters are provided in informative Annex B.

The bit depth shall be limited to the 10 most significant bits.

The video sampling format shall be 4:2:2 as defined by SMPTE ST 274.

Only the active picture area shall be coded. For the 1080 line video formats only, each field of 540 lines shall be padded to 544 lines as part of the compression process, as defined in SMPTE ST 2042-1, Section 13.1.2. These extra four lines shall be added to the end of the picture and shall be removed as part of the VC-2 decoding process.

Note: These extra 4 lines are needed to pad the number of lines to be divisible by 8 in order to support the transform depth value of 3.

6.3 Coding Parameters

The codec shall use only the low delay syntax. The coding syntax structure shall be as defined in SMPTE ST 2042-1.

6.3.1 Sequence Header

The Sequence Header comprises the parse parameters, base video format, source parameters and picture coding mode and is defined as follows.

6.3.1.1 Parse parameters

The major version and minor version numbers shall be as defined in SMPTE ST 2042-1.

The profile value shall be the low delay profile as defined in SMPTE ST 2042-1.

The level value shall be a specialized level value with the value of 65. This level value shall be used only for the VC-2 coding constraints that comply with this Recommended Practice.

6.3.1.2 Base video format

The base video format shall be one of format numbers 9, 10, 11 or 12 (HD 720P-60, HD 720P-50, HD 1080I-60 or HD-1080I-50) as defined in SMPTE ST 2042-1.

Note: Per SMPTE ST 2042-1, the format names for 30 and 60 frames/sec systems ignore the 1.001 divisor for simplicity. Thus HD 1080I-60 means that the default field rate is 60/1.001 fields/sec, not 60 fields/sec.

Note: The format is thus defined as follows:

- The picture size is one of 1920 x 1080, 1440 x 1080 or 1280 x 720.
- The sampling format is 4:2:2.
- The scanning is interlaced for 1920 x 1080 and 1440 x 1080 video sources, and progressive for 1280 x 720 video sources.
- The frame rate is 30/1.001 Hz or 25 Hz for 1920 x 1080 and 1440 x 1080 video sources, and 60/1.001 Hz or 50 Hz (for 1280 x 720 video sources).
- The pixel aspect ratio is 1:1 for 1920 x 1080 and 1280 x 720 video sources (aspect ratio index 1) or 4:3 for 1440 x 1080 video sources (aspect ratio index 6, reduced horizontal resolution systems).
- The clean picture area is the same as the picture size, i.e. 1920 x 1080, 1440 x 1080 or 1280 x 720.
- The video depth is 10 bits.
- The color primaries and color matrix are as defined in ITU-R BT.709.
- The transfer function is as defined in ITU-R BT.709.

6.3.1.3 Source parameters

The source parameters allow the video parameters pre-defined by the base video format to be overridden with custom values. To comply with this document, the pre-defined video parameters shall not be overridden except in the following case:

Source video formats with 1440 horizontal pixels shall use base video format 11 or 12 and shall override:

- The frame width to be 1440 as specified in SMPTE ST 2042-1, Section 11.3.2.
- The aspect ratio to be aspect ratio 6 (4:3 (reduced horizontal resolution systems)) as specified in SMPTE ST 2042-1, Section 11.3.6.
- The clean area to be 1440 by 1080 with zero offset from top left as specified in SMPTE ST 2042-1, Section 11.3.7.