

SMPTE RECOMMENDED PRACTICE

VC-2 Conformance Specification



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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 Part XIII of its Administrative Practices.

SMPTE Recommended Practice RP 2042-3 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 Standard. 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 document.

VC-2 is a wavelet-based, intra-frame video compression system aimed at professional applications that provides efficient coding at many resolutions including various flavors of CIF, SDTV and HDTV. The VC-2 standard defines a bit-stream syntax and a reference decoder specification. To aid the creation of new VC-2 streams, this recommended practice also provides details for the operation of a sample VC-2 stream generator.

This recommended practice includes a list of VC-2 compliant streams that can be used to test various aspects of VC-2 decoder compliance. This recommended practice also includes a reference decoder for comparison-testing of decoder implementations. The reference decoder may also be used to establish the compliance of arbitrary streams.

1 Scope

The VC-2 video compression standard is an intra-frame video compression system defined through the VC-2 stream syntax, entropy coding, a coefficient unpacking process and a picture decoding process. The decoder operations are defined by means of a mixture of pseudo-code and mathematical operations.

This recommended practice defines the materials, procedures, and criteria for verifying conformance of SMPTE VC-2 video decoders. The documents that form this specification include this document, a register of test streams, a sample VC-2 stream generator and a reference decoder.

The reference decoder and the sample stream generator are both software written in the C++ programming language and capable of being compiled to executable code on a variety of computer platforms. The reference decoder can be used to verify conformance of VC-2 decoder implementations against a register of test streams, and the conformance of arbitrary streams to the VC-2 specification.

This conformance practice defines both the format for the register of test streams and the lists of test streams.

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.

3 Normative Reference

Normative references are external documents referenced in normative text that are indispensable to the user. Bibliographic references are references made in informative text or are those otherwise not indispensable to the user.

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

SMPTE ST 2042-1:2009, VC2 Video Compression

ISO/IEC 646:1991, Information Technology — ISO 7-Bit Coded Character Set for Information Interchange

4 Description of Materials

The VC-2 conformance specification shall comprise the following components:

1. VC-2 encoded video Files,
2. Reference decoder software,
3. Sample VC-2 stream generator software, and
4. Procedures for testing VC-2 streams and the reference decoder.

These components of the conformance specification shall be as defined in the following sections.

5 File Formats

This section defines the file formats used by this conformance specification. The specification defines two file formats:

- the file format for the storage of the coding parameters, and
- the file format for the storage of uncompressed video data.

The data pertaining to each frame in a VC-2 stream shall be stored as separate files to simplify data management.

A file belonging to a VC-2 stream basename shall have a filename of the form:

basename-frame_number.extension

where frame_number shall be the frame number in the VC-2 stream, and extension shall be a defined extension name that identifies the file storage format. The base name may be null, in which case the file name would be of the form frame_number.extension.

5.1 Coding Parameters File Format

All coding parameters for a given frame number shall be stored in a file whose format is defined as per Annex A. The extension part of the filename is recommended to end with ".cparams".

Note: The extension name is not required by the reference software.

5.2 Video Data File Format

The video data file format shall be used to store uncompressed video data.

Interlaced frames shall be stored in a pseudo-progressive manner, i.e., fields shall be interleaved such that a frame comprising two fields with no intermediate motion shall appear indistinguishable from a progressive frame.

The color difference format used for each frame shall be either 4:4:4, 4:2:2 or 4:2:0.

Each frame of Y, C1, C2 (as per the color model of Section 6.1 of the VC-2 specification) image data shall be stored as raw video data in a headerless planar format.

Data shall be serialized by raster scanning each component separately for each frame (i.e. a frame of Y, followed by a frame of C1, then a frame of C2).

Each sample of video data shall be stored as a 16 bit Big-Endian word, MSB justified and zero-padded. For example, an 8 bit sample of value 0x35, would be stored in a 16 bit word as 0x3500.

The extension part of the filename shall be used by the reference software to determine the desired input/output format. The extension value shall be the FOURCCCode value that correctly represents the color difference format as defined in the table below:

Color difference Format	FOURCCCode
4:4:4	16P4
4:2:2	16P2
4:2:0	16P0

Annex C illustrates the storage format for FOURCCCode values 16P4, 16P2 and 16P0.

In this practice, required components of the command line application wrap the component with the angle bracket symbols < > and optional components of the command line application wrap the component with the square bracket symbols [].

6 Reference Decoder Software

The reference decoder shall be used for testing VC-2 stream conformance and shall implement the decoding processes defined in SMPTE ST 2042-1 [VC-2].

The reference decoder, in the form of platform independent C++ source code and associated documentation (instructions for building, installing and running the software), is available at <http://store.smpte.org>.

The decoder is a command line application that shall have the following invocation format:

```
vc2decoder <inputstream> <outputvideo> [codingparams]
```

where:

- 'inputstream' is the VC-2 stream filename to decode.
- 'outputvideo' is the base of the filename to be used for storing decoded output video frames.

Note: The actual name of the output file will comprise the base name concatenated with a frame number plus an appropriate file extension

- 'codingparams' is an optional base file specification, as per annex A, to be used for storage of the coding parameters associated with each video frame as determined from the input stream. If this argument is not specified, no coding parameters files shall be produced.

Note: The actual name of the file generated, if any, will comprise the base file name concatenated with a frame number plus "cparams" as a file extension

The decoder decoding the input VC-2 stream, shall produce one video frame and coding parameters file for each frame decoded.

The frame number for each output file shall start with frame number of the first file. The arguments 'outputvideo' and 'codingparams' shall use identical frame numbers.

Note: There is no implicit relationship between the output frame numbers and the stream parameter, picture_number.

The reference decoder shall handle multiple VC-2 sequences within a VC-2 stream by storing all frames from each sequence as presented in the VC-2 stream. The output frame numbers shall not be reset between sequences within a decoded VC-2 stream.

7 Sample VC-2 Stream Generator

The sample VC-2 stream generator may be used for the creation of VC-2 streams. The sample VC-2 stream generator provided with this conformance specification provides compliant VC-2 streams that may be used by VC-2 decoders for testing purposes but this generator does not represent a full implementation of a VC-2 encoder.

The sample VC-2 stream generator, in the form of platform independent C++ source code and associated documentation (instructions for installing, building and running the software), is available at <http://store.smpte.org>.

The sample VC-2 stream generator is a command line application that shall have the following invocation format:

vc2streamgen <inputvideo> <codingparams> <outputstream>, where:

- <inputvideo> shall be the base of the filename, as per Section 4, to be used for input video frames,
- <codingparams> shall be the base of the filename, as per Section 8, providing the coding parameters associated with each input video frame and
- <outputstream> shall be the required filename of the output VC-2 stream.

The sample stream generator encodes the input video and coding parameters using one video and one coding parameters file per frame to produce a VC-2 output stream.

The frame number shall start from zero for both types of input file.

Note: There is no implicit relation between the output frame numbers and the stream parameter picture_number since the picture_number value is determined from the coding parameters file.

Multiple VC-2 sequences may be encoded with a VC-2 stream by varying any value in the sequence parameter section in the relevant coding parameters file where the new sequence is desired. It is not permitted to change the sequence parameter section and not set "signalled: true" on the encoded frame with the first change.

8 Test VC-2 Streams

The register of VC-2 streams to be used for testing target decoder conformance is identified in Annex C. The set of test VC-2 streams is comprehensive but not intended to represent every possible combination of encoding parameters and tools specified in SMPTE ST 2042-1.

9 Conformance Testing Procedure

The following sub-sections define the normative tests for verifying conformance of a candidate VC-2 stream and decoder to SMPTE ST 2042-1, and provide an informative description of how an encoder implementation can be tested with the conformance tools provided.

9.1 Conformance Testing of A Candidate VC-2 Stream

Bit stream testing is a process intended to verify that a candidate bit stream is a valid VC-2 stream in accordance to SMPTE ST 2042-1.

A candidate bit stream shall be deemed a valid VC-2 stream if no fatal errors occur in the decoding of the bit stream with the reference decoder (Section 6).

Note: The video files output by the reference decoder do not form part of this test, however they can be used to check that the stream decompresses as intended. If the video output is different from that intended, the encoder implementation can be tested according to the procedure described in Section 9.3.

9.2 Conformance Testing of A Candidate Decoder

Decoder testing is a process intended to verify that a candidate decoder implementation conforms to the decoding process as specified in SMPTE ST 2042-1. Decoder testing uses the register of test VC-2 streams (Section 8).

It shall be noted that:

- A candidate decoder need not support all possible profiles and levels.
- Failure of any test is sufficient to identify the candidate decoder as non-conformant to a particular level and profile.
- Successful completion of all tests only represents a high confidence of conformance to a particular level and profile and cannot guarantee 100% conformance.

Decoder implementations shall specify which profiles and levels are supported and shall declare conformance only when all the test VC-2 streams for those specified profiles and levels have been successfully decoded.

Decoder conformance testing shall be conducted as follows:

For each VC-2 stream in the register:

- 1) Verify the VC-2 stream is valid as per Section 9.1. The video files output by this step shall be used in step 3. The coding parameter file output by this step shall be used in step 4, if applicable.
- 2) Decode the VC-2 stream with the decoder under test. The video files output by this step shall be used in step 3.
- 3) Compare the two sets of video files. If, after taking into account differences in output file formatting, the two sets are not identical, the test shall be failed.
- 4) Compare the output coding parameters (if available). The decoder under test may be able to produce metadata containing some or all of the coding parameters extracted from the stream (but is not required to do so). This metadata must be identical to the coding parameters produced by the reference decoder, after taking into account differences in output and any omissions by the decoder under test. If not, the test shall be considered failed.

9.3 Encoder Testing (Informative)

A candidate stream can be verified by the procedure set out in Section 9.1 as a valid VC-2 stream, yet the decoded video output might not match what was intended. This will arise from an error in the encoder which generated the stream.

Verification that an encoder is producing a correct VC-2 stream, given the coding parameters it has selected or been given, is possible using the stream generator. Developers ought to use the following procedure to verify that an encoder is producing the intended results:

- 1) Use the sample stream generator (Section 7) to produce a new VC-2 stream using identical input video and coding parameters to those used to generate the candidate VC-2 stream.
- 2) Decode the candidate VC-2 stream using the reference decoder (Section 6).
- 3) Decode the new VC-2 stream using the reference decoder.
- 4) Compare the two sets of coding parameters (steps 2 and 3). If the two sets differ, there is a fault in the candidate VC-2 stream produced by the encoder under test.
- 5) Compare the two sets of video files (steps 2 and 3). If the two sets differ, there is a fault in the candidate stream produced by the encoder under test.

Annex A Coding Parameters File (Normative)

The file as a whole shall indicate the metadata values sent in the VC-2 stream. The file is intended to be human readable with clear interpretation. The following rules shall apply:

- Indentation shall use the ASCII space character only. Indentation shall be considered significant.
- Numeric values shall be represented as ISO/IEC 646 numerals.
- String values shall be represented as ISO/IEC 646 printing characters encapsulated in double quotes; e.g., "string literal".
- Boolean values shall be represented using the words "**True**" and "**False**" as defined by SMPTE ST 2042-1.
- A single file shall correspond to the parameters used to decode/encode either a single video frame or a pair of video fields.
- Each coding parameters file shall contain the following two sections for each picture in the frame:
 1. a sequence parameter section, and
 2. a picture parameter section.

Note: If the frame contains two pictures, then these two sections will define respectively the parameters of the first picture, followed immediately by a second pair of sequence and picture parameter sections defining the parameters of the second picture.

The individual sections shall be as defined below.

A.1 Sequence Parameter Section

The Sequence parameter section shall start with the text string: " - - - !SequenceParameters".

This section shall comprise the parameters extracted from the sequence parameters in force at the point of encoding or decoding the frame (see signalled parameter in Table A.1).

The parameters in this section shall be as defined below. Unless otherwise specified, all references to section numbers in the tables below shall refer to SMPTE ST 2042-1.

Table A.1 – Sequence Parameters Structure

Key	Meaning
signaled	This parameter does not correspond to an individual flag in the stream. When True, this sequence parameters section was present in the VC-2 stream prior to the following picture. When False, this sequence parameters section was inferred from a previously signaled section. This parameter shall be True at the start point of a new sequence.
version	In the form "major aa, minor bb", representing the version number of the VC-2 stream as per Section 11.1.1.
profile	Numeric values as per 11.1 and Annex D.1.
level	Numeric values as per 11.1 and Annex D.2.
picture_coding_mode	Numeric values as per 11.4
video_format	A structure containing the parameters defined in Table A.2.