SMPTE STANDARD

MXF — Mapping VC-5 Video Essence into the MXF Generic Container

Table of Contents

Approved
February 17, 2017

Table of Tables

Page

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 ST 2073-10 was prepared by Technology Committee TC-31FS.

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.

This standard specifies the mapping from VC-5 image essence into an MXF generic container.

Each picture is encoded according to SMPTE ST 2073-3 or SMPTE ST 2073-4.

VC-5 is a picture-by-picture coding scheme where each picture is entirely independent and can be extracted as an independent entity. SMPTE ST 2073-1 defines the VC-5 bitstream. SMPTE ST 2073-3 specifies the encoding of common image formats that do not have subsampled color difference components such as RGB(A), $Y'C'_1C'_2$(A), and Bayer. SMPTE ST 2073-4 specifies the encoding of images with subsampled color difference components.

1 Scope

This standard specifies the mapping of VC-5 image essence as a picture essence track of the MXF generic container in frame-wrapped, clip-wrapped, or custom-wrapped form.

This standard includes the KLV coding, essence container label values, and compression label values. This standard also defines the subdescriptors for CDCI and Bayer images.

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 377-1:2011, Material Exchange Format (MXF) — File Format Specification

Amendment 1:2012 to SMPTE ST 377-1:2011

Amendment 2:2012 to SMPTE ST 377-1:2011

SMPTE ST 379-2:2010, Material Exchange Format (MXF) — MXF Constrained Generic Container

SMPTE ST 2073-3:2015 VC-5 Video Essence. — Part 3: Image Formats

SMPTE ST 2073-4:2015 VC-5 Video Essence. — Part 4: Subsampled Color Difference Components

4 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

4.1 VC-5 Image Essence

Single image encoded as specified in SMPTE ST 2073-3 or SMPTE ST 2073-4.

5 Mapping VC-5 Image Essence to the MXF Constrained Generic Container

5.1 Compliance

Except for custom-wrapping, this specification is compliant with both SMPTE ST 379-1 and SMPTE ST 379-2 and uses only provisions that are common to both. Custom-wrapping is specified only in SMPTE ST 379-2.

Except for custom-wrapping, an essence container compliant with this specification can be used with applications that require compliance with SMPTE ST 379-1 and applications that require compliance with SMPTE ST 379-2.

5.2 Using MXF Constrained Generic Container

The VC-5 image essence shall be stored as a picture element in an MXF file as specified in SMPTE ST 377-1 using the MXF Constrained Generic Container defined in SMPTE ST 379-2.

The mapping from VC-5 image essence to the MXF Constrained Generic Container shall be one of:

- Frame-based wrapping,
- Clip-based wrapping,
- Custom wrapping.

5.3 Essence Container Label

The value of the Essence Container Label, defined in SMPTE ST 379-2, shall be as listed in Table 1.

Table 1 – MXF GC VC-5 Essence Container Label

Essence Container Label	Symbol
06.0E.2B.34.04.01.01.0D.0D.01.03.01.02.1B.01.00	MXFGCVC5FrameWrapped
06.0E.2B.34.04.01.01.0D.0D.01.03.01.02.1B.02.00	MXFGCVC5ClipWrapped
06.0E.2B.34.04.01.01.0D.0D.01.03.01.02.1B.03.00	MXFGCVC5CustomWrapped

5.4 Codec State Parameters

Codec state parameters describe the image represented by a VC-5 bitstream as described in SMPTE ST 2073-1, SMPTE ST 2073-3, and SMPTE ST 2073-4.

The codec state parameters that describe the bitstreams in the MXF Generic Container and are used in this standard are listed in Table 2.

Table 2 — Codec state parameters and chunk elements used in this standard

Codec State Parameter	Description	Reference
ImageWidth	Number of samples per row in the image	SMPTE ST 2073-1 Section B.1.1
ImageHeight	Number of rows of samples in the image	SMPTE ST 2073-1 Section B.1.2
ImageFormat	Format of the image	SMPTE ST 2073-3 Section A.2.4
ChannelCount	Number of component arrays	SMPTE ST 2073-1 Section B.1.4
BitsPerComponent	Number of bits in the values in a component array	SMPTE ST 2073-1 Section B.1.3
PatternWidth	Number of samples per row in a pattern element	SMPTE ST 2073-3 Section A.2.1
PatternHeight	Number of rows of samples in a pattern element	SMPTE ST 2073-3 Section A.2.2
ComponentsPerSample	Number of component values in a sample	SMPTE ST 2073-3 Section A.2.3
MaxBitsPerComponent	Upper bound on the value of **BitsPerComponent** for all component arrays	SMPTE ST 2073-3 Section A.2.5
AlphaSampling	Indicates whether the color difference component in a $Y'C'_1C'_2(A)$ image is subsampled	SMPTE ST 2073-4 Section A.2.1
Inverse Component Transform Chunk	Inverse affine transform that inverts the transform applied to the color components	SMPTE ST 2073-3 Section 11.1.3
Inverse Component Permutation Chunk	Inverse permutation that restores the components to the same order as in the source image	SMPTE ST 2073-3 Section 11.1.4

6 KLV Encoding of the VC-5 Image Essence

6.1 Picture Element Coding

The picture element coding shall be as defined in SMPTE ST 379-2.

6.2 Picture Essence Element

The value of the Picture Essence Element Key shall be as defined in Table 3 where byte 14 shall be the Essence Element Count (SMPTE ST 379-2) and byte 16 shall be the Essence Element Number (SMPTE ST 379-2).

The track number for the picture element shall be derived from the key as defined in SMPTE ST 379-2.

Table 3 – VC-5 Picture Essence Element Key

Essence Element Key	Name
06.0E.2B.34.01.02.01.01.0D.01.03.01.15.cc.14.nn	Frame-wrapped VC-5 Picture Element
06.0E.2B.34.01.02.01.01.0D.01.03.01.15.cc.15.nn	Clip-wrapped VC-5 Picture Element
06.0E.2B.34.01.02.01.01.0D.01.03.01.15.cc.16.nn	Custom-wrapped VC-5 Picture Element

6.3 Picture Element Value

The value field shall consist of at least one picture element.

Each picture element shall be encoded as VC-5 image essence.

The presence and values of the VC-5 codec state parameters listed in Table 2 shall be constant for all VC-5 image essence elements in the same track.

Note: The VC-5 inverse component transform and the VC-5 inverse component permutation can be implicitly specified as default values.

The picture element length may be constant or variable within the essence container.

7 Picture Essence Descriptors

7.1 Picture Essence Cases

Depending on the value of the **ImageFormat** codec state parameter, the VC-5 image essence can be described using the RGBA Picture Essence Descriptor, CDCI Picture Essence Descriptor, or Generic Picture Essence Descriptor as defined in SMPTE ST 377-1.

The mapping between the **ImageFormat** codec state parameter in the VC-5 image essence and the picture essence descriptor for the VC-5 image essence shall be as follows:

1. If the **ImageFormat** codec state parameter is 1, then the picture essence descriptor shall be the RGBA Picture Essence Descriptor.

2. If the **ImageFormat** codec state parameter is 2, then:

    a. The picture essence descriptor shall be the CDCI Picture Essence Descriptor and

    b. If the **ChannelCount** codec state parameter is equal to 4, then the VC-5 CDCI Picture Essence SubDescriptor shall be present.

3. If the **ImageFormat** codec state parameter is 3, then the picture essence descriptor shall be the Generic Picture Essence Descriptor and the VC-5 Bayer Picture Essence SubDescriptor shall be present.

4. Any other value for the **ImageFormat** codec state parameter is out of scope.

Note: The picture essence descriptor describes the stored image. The format of the image returned by the decoder can differ significantly from the stored image described by the picture essence descriptor.

7.2 Frame Layout

The Frame Layout is an item in the Generic Picture Descriptor.

The Frame Layout shall be 0.

Note: Frame Layout equal to 0 is full frame.

7.3 Picture Essence Coding Label

The value for the Picture Essence Coding Label as defined in SMPTE ST 377-1 shall be as listed in Table 4.

Note: The Picture Essence Coding label indicates the type of image format encoding of the VC-5 image essence.

Table 4 – Specification of the Picture Essence Coding Label

Picture Essence Coding Label	Symbol	Name
06.0E.2B.34.04.01.01.0D.04.01.02.02.03.05.03.01	VC5Part3RGBAPicture	VC-5 Part 3 RGB(A) Picture
06.0E.2B.34.04.01.01.0D.04.01.02.02.03.05.03.02	VC5Part3YCCAPicture	VC-5 Part 3 YCC(A) Picture
06.0E.2B.34.04.01.01.0D.04.01.02.02.03.05.03.03	VC5Part3BayerPicture	VC-5 Part 3 Bayer Picture
06.0E.2B.34.04.01.01.0D.04.01.02.02.03.05.04.02	VC5Part4YCCAPicture	VC-5 Part 4 YCC(A) Picture

Note : The values for byte 14 in Table 4 correspond to the SMPTE ST 2073 part number (3 or 4), and the values for byte 16 in Table 4 correspond to the values of the **ImageFormat** codec state parameter as defined in SMPTE ST 2073-3.

Note: SMPTE ST 2073-4 only supports the $Y'C'_1C'_2$(A) essence image format.

The correspondence between the Picture Essence Coding Label and the VC-5 essence as defined in SMPTE ST 2073-3 and ST 2073-4 shall be as listed in Table 5.

Table 5 – Correspondence between the symbol for the Picture Essence Coding Label and the VC-5 Image Format

Symbol	VC-5 Image Format
VC5Part3RGBAPicture	VC-5 Part 3 RGB(A) Picture
VC5Part3YCCAPicture	VC-5 Part 3 $Y'C'_1C'_2$(A) Picture
VC5Part3BayerPicture	VC-5 Part 3 Bayer Picture
VC5Part4YCCAPicture	VC-5 Part 4 $Y'C'_1C'_2$(A) Picture

7.4 VC5CDCIPictureEssenceSubDescriptor

The subdescriptor referred to by the symbol VC5CDCIPictureEssenceSubDescriptor shall be a subclass of SubDescriptor. This subdescriptor shall be referenced in the SubDescriptors item of the Descriptor as specified in SMPTE ST 377-1. The SubDescriptors item, an array of strong references, is inherited from and defined in the Generic Descriptor.

The value of the VC5CDCIPictureEssenceSubDescriptor key shall be 06.0E.2B.34.02.53.01.01.0D.01.01.01.01.01.77.00, where byte 6 is as defined in SMPTE ST 377-1.

Note: VC-5 $Y'C'_1C'_2$(A) image essence with subsampled color difference components can have an alpha channel that is same size as the luma array or the same size as either color difference component array.

VC5CDCIPictureEssenceSubDescriptor shall include the elements defined in Table 6 in addition to the elements inherited from SubDescriptor.

Table 6 – Items in VC5CDCIPictureEssenceSubDescriptor

Item Name	Type	Len	Item UL	Req?	Meaning	Default
VC-5 Alpha Sampling	UInt16	2	06.0E.2B.34 01.01.01.0E 04.01.06.08 01.00.00.00	Req	VC-5 **AlphaSampling** codec state parameter defined in SMPTE ST 2073-4	

Note: The subdescriptor conveys color component siting metadata for VC-5 essence that has color difference components (SMPTE ST 2073-4) as described in SMPTE ST 377-1 Annexes F.4.2 and G.2.29.

Note: The symbol for VC-5 Alpha Sampling is VC5AlphaSampling.

7.5 VC5BayerPictureEssenceSubDescriptor

The subdescriptor referred to by the symbol VC5BayerPictureEssenceSubDescriptor shall be a subclass of SubDescriptor. This subdescriptor shall be referenced in the SubDescriptors item of the Descriptor as specified in SMPTE ST 377-1. The SubDescriptors item, an array of strong references, is inherited from and defined in the Generic Descriptor.

The value of the VC5BayerPictureEssenceSubDescriptor key shall be 06.0E.2B.34.02.53.01.01.0D.01.01.01.01.01.76.00, where byte 6 is as defined in SMPTE ST 377-1.

VC5BayerPictureEssenceSubDescriptor shall include the elements defined in Table 7 in addition to the elements inherited from SubDescriptor.

Table 7 – Items in VC5BayerPictureEssenceSubDescriptor

Item Name	Type	Len	Item UL	Req?	Meaning	Default
VC-5 Bayer Component Pattern	RGBALayout	16	06.0E.2B.34 01.01.01.0E 04.01.06.08 02.00.00.00	Req	Bayer component order and bit depth of each component (See SMPTE ST 377-1)	
VC-5 Bayer Component Black Level	UInt32	4	06.0E.2B.34 01.01.01.0E 04.01.06.08 03.00.00.00	Opt	Value of each Bayer component that corresponds to black	0
VC-5 Bayer Component White Level	UInt32	4	06.0E.2B.34 01.01.01.0E 04.01.06.08 04.00.00.00	Opt	Value of each Bayer component that corresponds to the white clipping point	4095

The VC-5 Bayer Component Pattern shall describe the Bayer pattern in raster-scan order.

Example: 'R', 12, 'G', 12, 'G', 12, 'B', 12, 0, 0, 0, 0, 0, 0, 0, 0.

Note: As there are two G elements in a Bayer pattern, the VC-5 Bayer Component Pattern contains two instances of G. In the VC-5 standards, the first G component is G_1 and the second G component is G_2.

Note: The symbols for the individual items are VC5BayerComponentPattern, VC5BayerComponentBlackLevel, and VC5BayerComponentWhiteLevel, respectively.

Annex A Application Notes (Informative)

A.1 VC-5 Codec Standards

A VC-5 bitstream encodes a single image as specified in SMPTE ST 2073-1. A VC-5 bitstream can represent any image that corresponds to an ordered set of component arrays with values that are integers with precision in the range 8-24 bits.

SMPTE ST 2073-3 specifies how common image formats are represented as VC-5 bitstreams. Image formats that are in scope for SMPTE ST 2073-3 are RGB(A), $Y'C'_1C'_2$(A), Bayer, and generic Color Filter Array (CFA).

SMPTE ST 2073-4 extends SMPTE ST 2073-3 to specify how subsampled color difference components in $Y'C'_1C'_2$(A) images are represented as VC-5 bitstreams.

A.2 Populating the Picture Essence Descriptors

The parameters that describe characteristics of the encoded image, such as the width and height, are called codec state parameters. Codec state parameters can be represented explicitly in the VC-5 bitstream. If omitted from the VC-5 bitstream, items in the MXF picture descriptors can provide values for the codec state parameters.

The correspondence between items in the Picture Essence Descriptors and the VC-5 codec state parameters are listed in Table A.1.

Table A.1 – Mapping between VC-5 Codec State Parameters and Picture Essence Descriptor items

Codec State Parameter	Picture Essence Descriptor Item
ImageWidth	Stored Width
ImageHeight	Stored Height
ImageFormat	PixelLayout
ChannelCount	PixelLayout
BitsPerComponent	PixelLayout
AlphaSampling	VC-5 Alpha Sampling
PatternWidth	Horizontal Sampling
PatternHeight	Vertical Sampling
MaxBitsPerComponent	ComponentMaxRef
MaxBitsPerComponent	AlphaMaxRef

Bibliography (Informative)

SMPTE ST 336:2007, Data Encoding Protocol Using Key-Length-Value

SMPTE ST 379-1:2009, Material Exchange Format (MXF) – MXF Generic Container