SMPTE RECOMMENDED PRACTICE

VC-4 Decoder and Bitstream Conformance

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Foreword

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SMPTE Engineering Documents are drafted in accordance with the rules given in Part XIII of its Administrative Practices.

SMPTE RP 2058-2 was prepared by Technology Committee 10E on Essence.

Intellectual Property

SMPTE draws attention to the fact that it is claimed that compliance with this Standard may involve the use of one or more patents or other intellectual property rights (collectively, "IPR"). The Society takes no position concerning the evidence, validity, or scope of this IPR.

Each holder of claimed IPR has assured the Society that it is willing to License all IPR it owns, and any third party IPR it has the right to sublicense, that is essential to the implementation of this Standard to those (Members and non-Members alike) desiring to implement this Standard under reasonable terms and conditions, demonstrably free of discrimination. Each holder of claimed IPR has filed a statement to such effect with SMPTE. Information may be obtained from the Director, Standards & Engineering at SMPTE Headquarters.

Attention is also drawn to the possibility that elements of this Standard may be subject to IPR other than those identified above. The Society shall not be responsible for identifying any or all such IPR.

Introduction

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

The purpose of this document is to test conformance to the VC-4 bitstream syntax and for reference software and test bitstreams to ensure proper interpretation of the SMPTE ST 2058-1 standard.

1 Scope

This document specifies the material, procedures and criteria for verifying conformance of SMPTE VC-4 video decoders and bitstreams.

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.

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; followed by formal languages; then figures; and then any other language forms.

3 Normative References

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 421:2006) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 421M-2006). Documents with the same root number (e.g. 421) and publication year (e.g. 2006) are functionally identical.

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 421:2006, Television — VC-1 Compressed Video Bitstream Format and Decoding Process

Amendment 1:2007 to SMPTE ST 421:2006

Amendment 2:2011 to SMPTE ST 421:2006

SMPTE ST 2058-1:2011, VC-4 Layered Video Extension Bitstream Format and Decoding Process

SMPTE VC-4 Reference Decoder Software Material

SMPTE VC-4 Test Bitstream Material

4 Description of Materials

4.1 Reference Decoder Software

The reference decoder shall be used for testing bitstream conformance and shall implement the complete decoding process specified in SMPTE ST 2058-1. The reference decoder in the form of Microsoft Visual C/C++ together with associated tools (Microsoft Visual Studio files for building running file, batch file for running the VC-4 codec and the execution file of a sample base layer codec (H.264)) are available on the SMPTE ftp site ftp://smpte-ra.org/Bitstreams. Here any other codec specified by other video coding standard shall be employed as the base layer codec. The ftp site of SMPTE provides the H.264 decoder in binary file form. The output format for the reference decoder is a head-less binary file of YCbCr 4:2:0, YCbCr 4:2:2 or YCbCr 4:4:4 with the separate planes written in N-bit sample order (Y, then Cb, then Cr). The color difference format of the output and the bit depth (expressed by N) are specified at the sequence header of each enhancement layer bitstream, while the color difference and the bit-depth of the base layer are specified by the corresponding base layer bitstream. For interlaced decoded frames, the output consists of full-height frames with interleaved fields.

Because the decoding process itself is lossless, the output data from the reference decoder shall be the reference output for any given input bitstream.

4.2 Test Bitstream

The set of bitstreams to be used for testing decoder conformance is specified in Annex A and is available from SMPTE. All of the bitstreams shall conform to SMPTE ST 2058-1 as defined in Section 5.2 below. The encoding parameters shown in Section A.1 through Section A.5 are defined in SMPTE ST 2058-1. The set of test bitstream is not intended to represent all possible combinations of encoding parameters and tools specified in SMPTE ST 2058-1. Rather, the set of bitstream was developed according to the following guidelines:

- Encoding parameters and tools normative to the decoding process are tested.
- The conformance of the base layer bitstream is not tested, as the base layer is outside of the scope of the SMPTE ST 2058-1 and the reconstruction from the base layer is related to make the output. The test bitstream set includes the base layer bitstream encoded by H.264 to test the VC-4 bitstream. The base layer bitstreams are identified by the suffix L0 of the bitstream name. For example, if the name of bitstream is LCHFMC_1_L0, this bitstream is the base layer bitstream.
- Parameters and tools are tested in isolation to allow for error diagnosis.
- Combinations of parameters and tools that represent edge conditions for the decoder are tested.
- Parameters and tools that have been thoroughly tested at lower levels of a particular profile are not tested as conformance is already guaranteed by the testing at the lower level of the profile.
- Parameters and tools specific to the display process are not tested, as the display process is outside the scope of the SMPTE ST 2058-1.

All profile bitstreams are provided as elementary bitstreams as defined in SMPTE ST 2058-1. The suffix of the bitstream name listed in Section A.1 through Section A.5 indicates the layer number. For example, if the bitstream name is LCHFMM_2_L1, this bitstream is corresponding to the first enhancement layer while if the

bitstream name is LCHFMM_2_L1L2, this bitstream includes the first enhancement layer and the second enhancement layer.

4.3 Sample Encoder Software (Informative)

A sample encoder in the form of Microsoft Visual C/C++ together with associated tools. The sample encoder is included with the test materials described above for informational purposes only and is not used for any of the normative conformance tests described in the document.

5 Conformance Testing Procedure

The following sub-sections describe the normative tests for verifying conformance of a VC-4 video stream or decoder to SMPTE ST 2058-1. These conformance tests utilize the bitstream test suites (specified in Annex A of this document) and the reference software decoder available from SMPTE.

5.1 Decoder Testing Procedure

Decoder testing procedure is to verify that a candidate decoder implementation is conformant to the decoding process as specified in SMPTE ST 2058-1. Although a failure of any of the following tests is sufficient to identify the candidate decoder as non-conformant, successful completion of all tests represents a high confidence of conformance but not absolute certainty.

5.1.1 Order Conformance Testing

The purpose of order conformance testing is to the algorithmic correctness of a candidate decoder. Because VC-4 is specified as a bit-exact decoding process, full binary matching of the outputs of the candidate decoder and the reference decoder provides both highest possible confidence in the comparison and useful troubleshooting information in the event of failure.

When processing the set of test bitstreams specified in Annex A, a decoder that outputs reconstructed samples identical to outputs by the reference software decoder will be considered order conformant (as specified in Section 9.4 or Section 11.4 of SMPTE ST 2058-1). Order conformance testing is performed on the candidate implementation with no time restriction. Testing is performed by binary comparison of the data output by the candidate decoder at the conformance point to the data output by the reference decoder. Any binary mismatch is considered a failure.

5.1.2 Time Conformance Testing

When processing the set of test bitstreams specified in Annex A, a decoder that conforms to the specification of Annex A of SMPTE ST 2058-1 or Annex C.6 of SMPTE ST 421 will be considered time-conformant. Because the VC-4 uses the reconstruction outputs of the base layer, the outputs of the base layer to be used for making the output of the VC-4 shall be reconstructed before the reconstructed residuals are added to the output of the base layer (Section 12 of SMPTE ST 2058-1). Since the VC-4 bitstreams represent enhancement layers, the outputs of a VC-4 decoder shall have the same PTS (presentation time stamp) as the output of the base layer.

Since most digital video systems implement timing and synchronization at the transport level and elementary bitstreams have no intrinsic timing information, the constraints such as the time deadline for decoding process are outside the scope of the conformance testing process described in this document.

5.1.3 Recommendations (Informative)

When the loss or corruption of part of bitstream happens, it is recommended that a conformant decoder resumes the decoding process as soon as possible, for example at the following start code. When all coded data for a macroblock or video packet is not received, it is recommended that a conformant decoder perform concealment.

5.2 Bitstream Testing Procedure

A bitstream shall be conformant if and only if all three of the conditions below are satisfied:

- The bitstream conforms to the syntax and semantics specified in SMPTE ST 2058-1 and
- The reference software decoder completes the decoding process for the bitstream without reporting and warning and / or errors and
- The reference software decoder successfully and completely produces the following items for the bitstream:

  a) Output pictures with the color difference format which is defined at the sequence header of the highest enhancement layer when the base layer and all enhancement layers are decoded completely or

  b) Output pictures with the color difference format which is defined at the sequence header of the highest enhancement layer in the decoded bitstream when the base layer and the lowest one or few enhancement layers are decoded completely, and other higher layers are ignored or not received at decoder.

Note: When a conformant decoder receives the base layer bitstream and one VC-4 enhancement layer bitstream, the highest enhancement layer at the decoder is the first enhancement layer.

Annex A Test Bitstream Summary (Normative)

A.1 Main Profile with Coarse Grain Scalability (CGS), Median Grain Scalability (MGS) and Spatial Scalability

Bitstream Name	Scalability Type	PROFILE	LEVEL	Source Width	Source Height	Frame Rate	Number of Frames	Layer ID	Quality Layer ID	I Picture	P Picture	B Picture	Intra Prediction	4-MV (Motion Vector)	Quarter-pel Motion Compensation	4:2:0 Color Difference Format	Adaptive Coefficient Scanning	Bit-depth	Interlaced Pictures	PAFF (Picture-Adaptive Field/Frame)	P2I_METHOD	Quantized-Matrix	Multiple Reference	Smoothing	1-D Filtered Prediction	4:2:2 Color Difference Format	4:4:4 Color Difference Format	Lossless Coding	Number of Slices	Number of Entry Point Pictures
LCHFMC_1_L1	**CGS**	1	L1	832	480	29.97	200	1	-	1	1	0	0	1	1	1	0	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMC_1_L0	**Base**	-	-	832	480	29.97	200	0	-	-	-	-	-	-	-	1	-	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMC_2_L1L2	**CGS**	1	L2	1280	720	30	200	2	-	1	1	1	1	1	1	1	0	8	-	-	-	-	-	-	-	-	-	-	1	1
(*)	**CGS**	1	L2	1280	720	30	200	1	-	1	1	1	1	1	1	1	0	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMC_2_L0	**Base**	-	-	1280	720	30	200	0	-	-	-	-	-	-	-	1	-	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMM_1_L1	**MGS**	1	L1	832	480	29.97	200	1	1	1	1	1	1	1	1	1	0	8	-	-	-	-	-	-	-	-	-	-	1	1
(*)	**MGS**	1	L1	832	480	29.97	200	1	0	1	1	1	1	1	1	1	0	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMM_1_L0	**Base**	-	-	832	480	29.97	200	0	-	-	-	-	-	-	-	1	-	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMM_2_L1	**MGS**	1	L2	1280	720	30	200	1	1	1	1	1	1	1	1	1	0	8	-	-	-	-	-	-	-	-	-	-	1	1
(*)	**MGS**	1	L2	1280	720	30	200	1	0	1	1	1	1	1	1	1	0	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMM_2_L0	**Base**	-	-	1280	720	30	200	0	-	-	-	-	-	-	-	1	-	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMS_1_L1	**Spatial**	1	L1	832	480	29.97	200	1	-	1	1	0	1	1	1	1	0	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMS_1_L0	**Base**	-	-	416	240	29.97	200	0	-	-	-	-	-	-	-	1	-	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMS_2_L1L2	**Spatial**	1	L2	1280	720	30	200	2	-	1	1	1	1	1	1	1	0	8	-	-	-	-	-	-	-	-	-	-	1	1
(*)	**Spatial**	1	L1	832	480	30	200	1	-	1	1	1	1	1	1	1	0	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMS_2_L0	**Base**	-	-	416	240	30	200	0	-	-	-	-	-	-	-	1	-	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMS_3_L1	**Spatial**	1	L2	1280	720	30	200	1	-	1	1	1	1	1	1	1	1	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFMS_3_L0	**Base**	-	-	832	480	30	200	0	-	-	-	-	-	-	-	1	-	8	-	-	-	-	-	-	-	-	-	-	1	1

(*) indicates the lower layer or lower quality layer bitstream embedded in the above bitstream of (*) row

A.2 High Profile with Coarse Grain Scalability (CGS), Median Grain Scalability (MGS) and Spatial Scalability

Bitstream Name	Scalability Type	PROFILE	LEVEL	Source Width	Source Height	Frame Rate	Number of Frames	Layer ID	Quality Layer ID	I Picture	P Picture	B Picture	Intra Prediction	4-MV (Motion Vector)	Quarter-pel Motion Compensation	4:2:0 Color Difference Format	Adaptive Coefficient Scanning	Bit-depth	Interlaced Pictures	PAFF (Picture-Adaptive Field/Frame)	P2I_METHOD	Quantized-Matrix	Multiple Reference	Smoothing	1-D Filtered Prediction	4:2:2 Color Difference Format	4:4:4 Color Difference Format	Lossless Coding	Number of Slices	Number of Entry Point Pictures
LCHFHC_1_L1	**CGS**	2	L3	1280	720	30	200	1	-	1	1	0	1	1	1	1	0	8	0	-	-	1	1(2)	0	0	-	-	-	1	1
LCHFHC_1_L0	**Base**	-	-	1280	720	30	200	0	-	-	-	-	-	-	-	1	-	8	-	-	-	-	-	-	-	-	-	-	1	1
LCHFHC_2_L1	**CGS**	2	L5	1920	1088	30	60	1	-	1	1	1	1	1	1	1	0	8	0	-	-	0	0	0	1	-	-	-	> 1	1
LCHFHC_2_L0	**Base**	-	-	1920	1088	30	60	0	-	-	-	-	-	-	-	1	-	8	-	-	-	-	-	-	-	-	-	-	> 1	1
LCHFHM_1_L1	**MGS**	2	L2	832	480	29.97	200	1	1	1	1	1	1	1	1	1	0	8	0	-	-	0	0	0	1	-	-	-	1	1
(*)	**MGS**	2	L2	832	480	29.97	200	1	0	1	1	1	1	1	1	1	0	8	0	-	-	0	0	0	1	-	-	-	1	1
LCHFHM_1_L0	**Base**	-	-	832	480	29.97	200	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	-	-	-	1	1
LCHFHS_1_L1	**Spatial**	2	L3	1280	720	30	200	1	-	1	1	0	1	1	1	1	0	8	0	-	-	0	1(2)	0	0	-	-	-	1	1
LCHFHS_1_L0	**Base**	-	-	832	480	15	100	0	-	-	-	-	-	-	-	1	-	8	1	-	-	-	-	-	-	-	-	-	1	1
LCHFHS_2_L1	**Spatial**	2	L3	1280	720	30	60	1	-	1	1	1	1	1	1	1	0	8	1	1	-	0	0	0	0	-	-	-	1	1
LCHFHS_2_L0	**Base**	-	-	832	480	30	60	0	-	-	-	-	-	-	-	1	-	8	1	-	-	-	-	-	-	-	-	-	1	1
LCHFHS_3_L1	**Spatial**	2	L3	1280	720	30	60	1	-	1	1	1	1	1	1	1	0	8	1	0	0	0	0	0	0	-	-	-	1	1
LCHFHS_3_L0	**Base**	-	-	832	480	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	-	-	-	1	1
LCHFHS_4_L1	**Spatial**	2	L5	1920	1088	30	60	1	-	1	1	0	1	1	1	1	0	8	1	0	1	0	0	0	0	-	-	-	1	1
LCHFHS_4_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	-	-	-	1	1

(*) indicates the lower quality layer bitstream embedded in the above bitstream of (*) row

A.3 High 4:2:2 Profile with Spatial Scalability

Bitstream Name	Scalability Type	PROFILE	LEVEL	Source Width	Source Height	Frame Rate	Number of Frames	Layer ID	Quality Layer ID	I Picture	P Picture	B Picture	Intra Prediction	4-MV (Motion Vector)	Quarter-pel Motion Compensation	4:2:0 Color Difference Format	Adaptive Coefficient Scanning	Bit-depth	Interlaced Pictures	PAFF (Picture-Adaptive Field/Frame)	P2I_METHOD	Quantized-Matrix	Multiple Reference	Smoothing	1-D Filtered Prediction	4:2:2 Color Difference Format	4:4:4 Color Difference Format	Lossless Coding	Number of Slices	Number of Entry Point Pictures
LCHFH2S_1_L1	**Spatial**	3	L5	1920	1088	30	60	1	-	1	1	0	1	1	1	0	0	10	0	-	-	0	0	0	0	1	-	-	1	1
LCHFH2S_1_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	-	-	1	1
LCHFH2S_2_L1	**Spatial**	3	L5	1920	1088	30	60	1	-	1	1	1	1	1	1	0	0	8	0	-	-	0	0	0	0	1	-	-	1	1
LCHFH2S_2_L0	**Base**	-	-	1280	720	15	30	0	-	-	-	-	-	-	-	1	-	8	1	-	-	-	-	-	-	0	-	-	1	1
LCHFH2S_3_L1	**Spatial**	3	L5	1920	1088	30	60	1	-	1	1	1	1	1	1	0	0	8	1	0	-	0	0	0	0	1	-	-	1	1
LCHFH2S_3_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	1	-	-	-	-	-	-	0	-	-	1	1
LCHFH2S_4_L1	**Spatial**	3	L5	1920	1088	30	60	1	-	1	1	1	1	1	1	0	0	8	1	0	0	0	0	0	0	1	-	-	1	1
LCHFH2S_4_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	-	-	1	1
LCHFH2S_5_L1	**Spatial**	3	L5	1920	1088	30	60	1	-	1	1	0	1	1	1	0	0	8	1	0	1	0	0	0	0	1	-	-	1	1
LCHFH2S_5_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	-	-	1	1

A.4 High 4:4:4 Profile with Spatial Scalability

Bitstream Name	Scalability Type	PROFILE	LEVEL	Source Width	Source Height	Frame Rate	Number of Frames	Layer ID	Quality Layer ID	I Picture	P Picture	B Picture	Intra Prediction	4-MV (Motion Vector)	Quarter-pel Motion Compensation	4:2:0 Color Difference Format	Adaptive Coefficient Scanning	Bit-depth	Interlaced Pictures	PAFF (Picture-Adaptive Field/Frame)	P2I_METHOD	Quantized-Matrix	Multiple Reference	Smoothing	1-D Filtered Prediction	4:2:2 Color Difference Format	4:4:4 Color Difference Format	Lossless Coding	Number of Slices	Number of Entry Point Pictures
LCHFH4S_1_L1	**Spatial**	4	L5	1920	1088	30	60	1	-	1	1	0	1	1	1	0	0	8	0	-	-	0	0	0	0	0	1	-	1	1
LCHFH4S_1_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	0	-	1	1
LCHFH4S_2_L1	**Spatial**	4	L5	1920	1088	30	60	1	-	1	1	0	1	1	1	0	0	10	0	-	-	0	0	0	0	0	1	-	1	1
LCHFH4S_2_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	0	-	1	1
LCHFH4S_3_L1	**Spatial**	4	L5	1920	1088	30	60	1	-	1	1	0	1	1	1	0	0	10	0	-	-	0	0	1	0	0	1	-	1	1
LCHFH4S_3_L0	**Base**	-	-	1920	1088	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	0	-	1	1
LCHFH4S_4_L1	**Spatial**	4	L5	1920	1088	30	60	1	-	1	1	1	1	1	1	0	0	10	0	-	-	0	0	0	0	0	1	-	1	1
LCHFH4S_4_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	0	-	1	1

A.5 High Intra 4:4:4 Profile with Coarse Grain Scalability (CGS) and Spatial Scalability

Bitstream Name	Scalability Type	PROFILE	LEVEL	Source Width	Source Height	Frame Rate	Number of Frames	Layer ID	Quality Layer ID	I Picture	P Picture	B Picture	Intra Prediction	4-MV (Motion Vector)	Quarter-pel Motion Compensation	4:2:0 Color Difference Format	Adaptive Coefficient Scanning	Bit-depth	Interlaced Pictures	PAFF (Picture-Adaptive Field/Frame)	P2I_METHOD	Quantized-Matrix	Multiple Reference	Smoothing	1-D Filtered Prediction	4:2:2 Color Difference Format	4:4:4 Color Difference Format	Lossless Coding	Number of Slices	Number of Entry Point Pictures
LCHFHI4C_1_L1	**CGS**	5	L2	832	480	29.97	200	1	-	1	-	-	-	-	-	1	0	8	0	-	-	0	-	0	0	0	0	0	1	1
LCHFHI4C_1_L0	**Base**	-	-	832	480	29.97	200	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	0	-	1	1
LCHFHI4C_2_L1	**CGS**	5	L3	1280	720	30	200	1	-	1	-	-	-	-	-	1	0	8	0	-	-	0	-	0	1	0	0	0	1	1
LCHFHI4C_2_L0	**Base**	-	-	1280	720	30	200	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	0	-	1	1
LCHFHI4C_3_L1	**CGS**	5	L5	1920	1088	30	60	1	-	1	-	-	-	-	-	0	0	10	0	-	-	0	-	0	0	1	0	0	1	1
LCHFHI4C_3_L0	**Base**	-	-	1920	1088	30	60	0	-	-	-	-	-	-	-	0	-	10	0	-	-	-	-	-	-	1	0	-	1	1
LCHFHI4C_4_L1	**CGS**	5	L9	1920	1088	30	60	1	-	1	-	-	-	-	-	0	0	10	0	-	-	0	-	0	0	0	1	1	> 1	> 1
LCHFHI4C_4_L0	**Base**	-	-	1920	1088	30	60	0	-	-	-	-	-	-	-	0	-	10	0	-	-	-	-	-	-	0	1	-	> 1	> 1
LCHFHI4S_1_L1	**Spatial**	5	L3	1280	720	30	200	1	-	1	-	-	-	-	-	1	0	8	0	-	-	0	-	0	0	0	0	0	1	1
LCHFHI4S_1_L0	**Base**	-	-	832	480	30	200	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	0	-	1	1
LCHFHI4S_2_L1	**Spatial**	5	L5	1920	1088	30	60	1	-	1	-	-	-	-	-	1	0	8	1	0	-	0	-	0	0	0	0	0	1	1
LCHFHI4S_2_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	1	-	-	-	-	-	-	0	0	-	1	1
LCHFHI4S_3_L1	**Spatial**	5	L5	1920	1088	30	60	1	-	1	-	-	-	-	-	1	0	8	1	1	-	0	-	0	0	0	0	0	1	1
LCHFHI4S_3_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	1	-	-	-	-	-	-	0	0	-	1	1
LCHFHI4S_4_L1	**Spatial**	5	L5	1920	1088	30	60	1	-	1	-	-	-	-	-	0	0	8	0	-	-	0	-	0	0	1	0	0	1	1
LCHFHI4S_4_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	0	-	1	1
LCHFHI4S_5_L1	**Spatial**	5	L5	1920	1088	30	60	1	-	1	-	-	-	-	-	0	0	10	0	-	-	0	-	0	0	0	1	0	1	1
LCHFHI4S_5_L0	**Base**	-	-	1280	720	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	0	-	1	1
LCHFHI4S_6_L1	**Spatial**	5	L5	1920	1088	30	60	1	-	1	-	-	-	-	-	0	0	10	0	-	-	0	-	1	0	0	1	0	1	1
LCHFHI4S_6_L0	**Base**	-	-	1920	1088	30	60	0	-	-	-	-	-	-	-	1	-	8	0	-	-	-	-	-	-	0	0	-	1	1

Annex B Test Materials Inventory (Informative)

This annex contains a list of the test materials available from SMPTE. The following is a list of the test materials in the “VC-4_Conformance_Suite.tar” file. This file has sub-directory structure. “bin” directory has binary files for the base layer decoder and VC-4 decoder for conformance test. Each directory in “Bitstreams” directory has a base layer bitstream (XXX.264) and a VC-4 bitstream (XXXX.vc4). The base layer bitstreams in these test materials are coded by H.264 and it can be decoded using “ldecode.exe” in the “bin” directory. The VC-4 bistreams in these test materials can be decoded by “VC4_Decoder.exe” in the “bin” directory or the execution files generated by “VC-4_SourceCode_201012.zip” which includes the reference decoder S/W and sample encoder software.

Note: TAR file (*.tar) is a kind of archive file format. Detailed information is found at Tar Project web page http://www.gnu.org/software/tar.

```
 Directory of F:\VC-4_Conformance_Suite

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   02:24 PM   <DIR>          Bitstreams
2010-11-25   01:24 PM           545,391 VC-4_SourceCode_201012.zip
               1 File(s)            545,391 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   02:23 PM   <DIR>          01_Main_CGS_LCHFMC_1
2010-11-25   02:23 PM   <DIR>          02_Main_CGS_LCHFMC_2
2010-11-25   02:23 PM   <DIR>          03_Main_MGS_LCHFMM_1
2010-11-25   02:23 PM   <DIR>          04_Main_MGS_LCHFMM_2
2010-11-25   02:23 PM   <DIR>          05_Main_Spatial_LCHFMS_1
2010-11-25   02:23 PM   <DIR>          06_Main_Spatial_LCHFMS_2
2010-11-25   02:23 PM   <DIR>          07_Main_Spatial_LCHFMS_3
2010-11-25   02:23 PM   <DIR>          08_High_CGS_LCHFHC_1
2010-11-25   02:23 PM   <DIR>          09_High_CGS_LCHFHC_2
2010-11-25   02:23 PM   <DIR>          10_High_MGS_LCHFHM_1
2010-11-25   02:23 PM   <DIR>          11_High_Spatial_LCHFHS_1
2010-11-25   02:23 PM   <DIR>          12_High_Spatial_LCHFHS_2
2010-11-25   02:23 PM   <DIR>          13_High_Spatial_LCHFHS_3
2010-11-25   02:23 PM   <DIR>          14_High_Spatial_LCHFHS_4
2010-11-25   02:23 PM   <DIR>          15_High422_Spatial_LCHFH2S_1
2010-11-25   02:23 PM   <DIR>          16_High422_Spatial_LCHFH2S_2
2010-11-25   02:23 PM   <DIR>          17_High422_Spatial_LCHFH2S_3
2010-11-25   02:23 PM   <DIR>          18_High422_Spatial_LCHFH2S_4
2010-11-25   02:23 PM   <DIR>          19_High422_Spatial_LCHFH2S_5
2010-11-25   02:23 PM   <DIR>          20_High444_Spatial_LCHFH4S_1
2010-11-25   02:24 PM   <DIR>          21_High444_Spatial_LCHFH4S_2
2010-11-25   02:24 PM   <DIR>          22_High444_Spatial_LCHFH4S_3
2010-11-25   02:24 PM   <DIR>          23_High444_Spatial_LCHFH4S_4
2010-11-25   02:24 PM   <DIR>          24_HighIntra444_CGS_LCHFHI4C_1
2010-11-25   02:24 PM   <DIR>          25_HighIntra444_CGS_LCHFHI4C_2
2010-11-25   02:24 PM   <DIR>          26_HighIntra444_CGS_LCHFHI4C_3
2010-11-25   02:24 PM   <DIR>          27_HighIntra444_CGS_LCHFHI4C_4
2010-11-25   02:24 PM   <DIR>          28_HighIntra444_Spatial_LCHFHI4S_1
2010-11-25   02:24 PM   <DIR>          29_HighIntra444_Spatial_LCHFHI4S_2
2010-11-25   02:24 PM   <DIR>          30_HighIntra444_Spatial_LCHFHI4S_3
2010-11-25   02:24 PM   <DIR>          31_HighIntra444_Spatial_LCHFHI4S_4
2010-11-25   02:24 PM   <DIR>          32_HighIntra444_Spatial_LCHFHI4S_5
2010-11-25   02:24 PM   <DIR>          33_HighIntra444_Spatial_LCHFHI4S_6
2010-11-25   02:24 PM   <DIR>          bin
               0 File(s)                  0 bytes
```

```
 Directory of F:\VC-4_Conformance_Suite\Bitstreams\01_Main_CGS_LCHFMC_1

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-23   11:16 AM           645,362 LCHFMC_1_L0.264
2010-11-23   11:27 AM         1,061,890 LCHFMC_1_L1.vc4
               3 File(s)          1,707,380 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\02_Main_CGS_LCHFMC_2

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               140 decode.bat
2010-11-15   05:07 PM           476,908 LCHFMC_2_L0.264
2010-11-15   06:21 PM         5,006,420 LCHFMC_2_L1L2.vc4
               3 File(s)          5,483,468 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\03_Main_MGS_LCHFMM_1

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-23   05:37 PM           604,749 LCHFMM_1_L0.264
2010-11-23   05:59 PM         1,333,743 LCHFMM_1_L1.vc4
               3 File(s)          1,938,620 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\04_Main_MGS_LCHFMM_2

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-16   09:44 PM           641,379 LCHFMM_2_L0.264
2010-11-16   10:35 PM         7,541,992 LCHFMM_2_L1.vc4
               3 File(s)          8,183,499 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\05_Main_Spatial_LCHFMS_1

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-23   10:14 AM           239,216 LCHFMS_1_L0.264
2010-11-23   10:24 AM         1,023,878 LCHFMS_1_L1.vc4
               3 File(s)          1,263,222 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\06_Main_Spatial_LCHFMS_2

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               140 decode.bat
2010-11-15   06:20 PM           146,182 LCHFMS_2_L0.264
2010-11-15   07:14 PM         4,017,226 LCHFMS_2_L1L2.vc4
               3 File(s)          4,163,548 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\07_Main_Spatial_LCHFMS_3

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-16   07:05 PM           554,489 LCHFMS_3_L0.264
2010-11-16   07:43 PM         6,136,126 LCHFMS_3_L1.vc4
               3 File(s)          6,690,743 bytes
```

```
 Directory of F:\VC-4_Conformance_Suite\Bitstreams\08_High_CGS_LCHFHC_1

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-16   07:29 PM           858,609 LCHFHC_1_L0.264
2010-11-16   08:19 PM         2,250,496 LCHFHC_1_L1.vc4
               3 File(s)          3,109,233 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\09_High_CGS_LCHFHC_2

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-24   05:42 PM           261,940 LCHFHC_2_L0.264
2010-11-24   06:08 PM           358,194 LCHFHC_2_L1.vc4
               3 File(s)            620,262 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\10_High_MGS_LCHFHM_1

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-23   05:35 PM           958,511 LCHFHM_1_L0.264
2010-11-23   05:57 PM         3,474,807 LCHFHM_1_L1.vc4
               3 File(s)          4,433,446 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\11_High_Spatial_LCHFHS_1

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-19   11:43 AM           310,912 LCHFHS_1_L0.264
2010-11-19   12:33 PM         3,416,032 LCHFHS_1_L1.vc4
               3 File(s)          3,727,072 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\12_High_Spatial_LCHFHS_2

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-18   12:55 PM           109,518 LCHFHS_2_L0.264
2010-11-18   01:57 PM           610,419 LCHFHS_2_L1.vc4
               3 File(s)            720,065 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\13_High_Spatial_LCHFHS_3

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-18   12:20 PM           131,478 LCHFHS_3_L0.264
2010-11-18   01:11 PM           641,062 LCHFHS_3_L1.vc4
               3 File(s)            772,668 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\14_High_Spatial_LCHFHS_4

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               128 decode.bat
2010-11-18   04:38 PM           255,886 LCHFHS_4_L0.264
2010-11-18   05:21 PM         2,068,634 LCHFHS_4_L1.vc4
               3 File(s)          2,324,648 bytes
```

```
 Directory of F:\VC-4_Conformance_Suite\Bitstreams\15_High422_Spatial_LCHFH2S_1

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               130 decode.bat
2010-11-18   09:12 PM           914,944 LCHFH2S_1_L0.264
2010-11-18   09:32 PM        10,434,276 LCHFH2S_1_L1.vc4
               3 File(s)         11,349,350 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\16_High422_Spatial_LCHFH2S_2

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               130 decode.bat
2010-11-17   10:41 AM           486,567 LCHFH2S_2_L0.264
2010-11-17   11:07 AM         8,965,358 LCHFH2S_2_L1.vc4
               3 File(s)          9,452,055 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\17_High422_Spatial_LCHFH2S_3

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               130 decode.bat
2010-11-19   01:58 PM           945,773 LCHFH2S_3_L0.264
2010-11-19   04:18 PM         6,279,077 LCHFH2S_3_L1.vc4
               3 File(s)          7,224,980 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\18_High422_Spatial_LCHFH2S_4

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               130 decode.bat
2010-11-19   05:01 PM           816,804 LCHFH2S_4_L0.264
2010-11-19   07:25 PM        10,333,226 LCHFH2S_4_L1.vc4
               3 File(s)         11,150,160 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\19_High422_Spatial_LCHFH2S_5

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               130 decode.bat
2010-11-19   06:10 PM           949,594 LCHFH2S_5_L0.264
2010-11-19   07:01 PM         8,007,501 LCHFH2S_5_L1.vc4
               3 File(s)          8,957,225 bytes

Directory of F:\VC-4_Conformance_Suite\Bitstreams\20_High444_Spatial_LCHFH4S_1

2010-11-25   02:23 PM   <DIR>          .
2010-11-25   02:23 PM   <DIR>          ..
2010-11-25   01:43 PM               130 decode.bat
2010-11-17   06:23 PM           923,890 LCHFH4S_1_L0.264
2010-11-17   06:41 PM        15,120,093 LCHFH4S_1_L1.vc4
               3 File(s)         16,044,113 bytes

Directory of F:\VC-4_Conformance_Suite\Bitstreams\21_High444_Spatial_LCHFH4S_2

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               130 decode.bat
2010-11-16   10:47 AM           921,040 LCHFH4S_2_L0.264
2010-11-16   11:11 AM        17,193,343 LCHFH4S_2_L1.vc4
               3 File(s)         18,114,513 bytes
```

```
 Directory of F:\VC-4_Conformance_Suite\Bitstreams\22_High444_Spatial_LCHFH4S_3

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               130 decode.bat
2010-11-17   03:21 PM           916,997 LCHFH4S_3_L0.264
2010-11-17   03:39 PM        17,106,510 LCHFH4S_3_L1.vc4
               3 File(s)          18,023,637 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\23_High444_Spatial_LCHFH4S_4

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               130 decode.bat
2010-11-17   10:50 AM           967,861 LCHFH4S_4_L0.264
2010-11-17   11:17 AM        16,960,839 LCHFH4S_4_L1.vc4
               3 File(s)          17,928,830 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\24_HighIntra444_CGS_LCHFHI4C_1

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               132 decode.bat
2010-11-24   02:42 PM         3,493,656 LCHFHI4C_1_L0.264
2010-11-24   02:42 PM         3,081,567 LCHFHI4C_1_L1.vc4
               3 File(s)           6,575,355 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\25_HighIntra444_CGS_LCHFHI4C_2

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               132 decode.bat
2010-11-15   11:22 AM         9,082,434 LCHFHI4C_2_L0.264
2010-11-15   11:24 AM        13,910,423 LCHFHI4C_2_L1.vc4
               3 File(s)          22,992,989 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\26_HighIntra444_CGS_LCHFHI4C_3

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               132 decode.bat
2010-11-15   07:11 PM         5,136,423 LCHFHI4C_3_L0.264
2010-11-15   07:12 PM         8,977,691 LCHFHI4C_3_L1.vc4
               3 File(s)          14,114,246 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\27_HighIntra444_CGS_LCHFHI4C_4

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               132 decode.bat
2010-11-19   11:14 AM        44,305,944 LCHFHI4C_4_L0.264
2010-11-19   11:16 AM       211,443,084 LCHFHI4C_4_L1.vc4
               3 File(s)         255,749,160 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\28_HighIntra444_Spatial_LCHFHI4S_1

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               132 decode.bat
2010-11-15   11:29 AM         3,963,321 LCHFHI4S_1_L0.264
2010-11-15   11:31 AM        14,261,317 LCHFHI4S_1_L1.vc4
               3 File(s)          18,224,770 bytes
```

```
 Directory of F:\VC-4_Conformance_Suite\Bitstreams\29_HighIntra444_Spatial_LCHFHI4S_2

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               132 decode.bat
2010-11-15   11:51 AM         2,982,609 LCHFHI4S_2_L0.264
2010-11-15   11:52 AM         6,507,514 LCHFHI4S_2_L1.vc4
               3 File(s)          9,490,255 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\30_HighIntra444_Spatial_LCHFHI4S_3

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               132 decode.bat
2010-11-15   11:52 AM         2,982,609 LCHFHI4S_3_L0.264
2010-11-15   11:53 AM         6,428,452 LCHFHI4S_3_L1.vc4
               3 File(s)          9,411,193 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\31_HighIntra444_Spatial_LCHFHI4S_4

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               132 decode.bat
2010-11-15   01:21 PM         2,785,396 LCHFHI4S_4_L0.264
2010-11-15   01:23 PM         8,259,993 LCHFHI4S_4_L1.vc4
               3 File(s)         11,045,521 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\32_HighIntra444_Spatial_LCHFHI4S_5

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               132 decode.bat
2010-11-16   10:51 AM         2,304,734 LCHFHI4S_5_L0.264
2010-11-16   10:53 AM        17,521,627 LCHFHI4S_5_L1.vc4
               3 File(s)         19,826,493 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\33_HighIntra444_Spatial_LCHFHI4S_6

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-25   01:43 PM               132 decode.bat
2010-11-17   11:30 AM         2,223,061 LCHFHI4S_6_L0.264
2010-11-17   11:31 AM        17,390,043 LCHFHI4S_6_L1.vc4
               3 File(s)         19,613,236 bytes

 Directory of F:\VC-4_Conformance_Suite\Bitstreams\bin

2010-11-25   02:24 PM   <DIR>          .
2010-11-25   02:24 PM   <DIR>          ..
2010-11-05   11:48 AM           638,976 ldecod.exe
2010-11-25   09:32 AM           233,472 VC4_Decoder.exe
               2 File(s)            872,448 bytes

     Total Files Listed:
               102 File(s)        551,843,794 bytes
```

Annex C Bibliography (Informative)

ISO/IEC 13818-1:2007, Information Technology – Generic Coding of Moving Pictures and Associated Audio Information: Systems" (3r^{d} Edition)

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ISO/IEC 14496-2:2004 Information technology - Coding of Audio-Visual Objects - Part 2: Visual

Recommendation ITU-T H.262, ISO/IEC 13818-2, Information Technology – Generic Coding of Moving Pictures and Associated Audio Information: Video, Feburary 2000

Recommendation ITU-T H.264, Advanced Video Coding for Generic Audiovisual Services, November 2007

J. Ribas-Corbera, P.A. Chou, and S.L. Regunathan, "A generalized hypothetical reference decoder for H.264/AVC," IEEE Transactions on Circuits and Systems for Video Technology, Aug. 2003.