SMPTE STANDARD

VC-3 Picture Compression and Data Stream Format

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Approved
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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 Standard 2019-1 was prepared by Technology Committee C24.

1 Scope

This standard specifies the compressed data format and decoding process for VC-3 compressed video data. VC-3 supports high definition YCbCr video data in both 8-bit and 10-bit sampling depths for 4:2:2 sampling of 1920x1080 and 1280x720 video rasters.

VC-3 is an intra-frame compression format, with compressed bitrates from 36 Mbps (at 1080/24p) to 220 Mbps (at 1080/60i). The standard does not specify the encoding process.

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 References

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

SMPTE 274M-2005, Television – 1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates

SMPTE 296M-2001, Television – 1280 x 720 Progressive Image Sample Structure – Analog and Digital Representation and Analog Interface

4 Overview (Informative)

This section provides a brief overview of the VC-3 decoding process. Annex E: System Overview is an informative annex where one can find a description of the system and encoding process for VC-3.

The decoding process is depicted in Figure 1. The VC-3 bitstream contains a header region followed by entropy codes which encode quantized Discrete Cosine Transform (DCT) coefficients. As shown in the figure, the header region of the VC-3 compressed bitstream is parsed to determine information about the compressed bit-stream. Then entropy decoding is performed followed by inverse quantization. The inverse quantized coefficients are then transformed to the spatial domain via the Inverse Discrete Transform (IDCT). This produces an output picture. The VC-3 bitstream is intra-frame encoded, meaning that each compressed frame is independent of all other frames in the encoded bitstream.

The remainder of this standard describes the video sampling structure (Section 6), the compressed frame format (Section 7), and the decoding process (Section 8). In addition there are annexes that provide details regarding the entropy codeword format (Annex A), a suggested usage of the User Data Payload area(Annex B), the quantization tables (Annex C), the Variable Length Codeword (VLC) tables (Annex D), and compressed frame bitrates (Annex F).

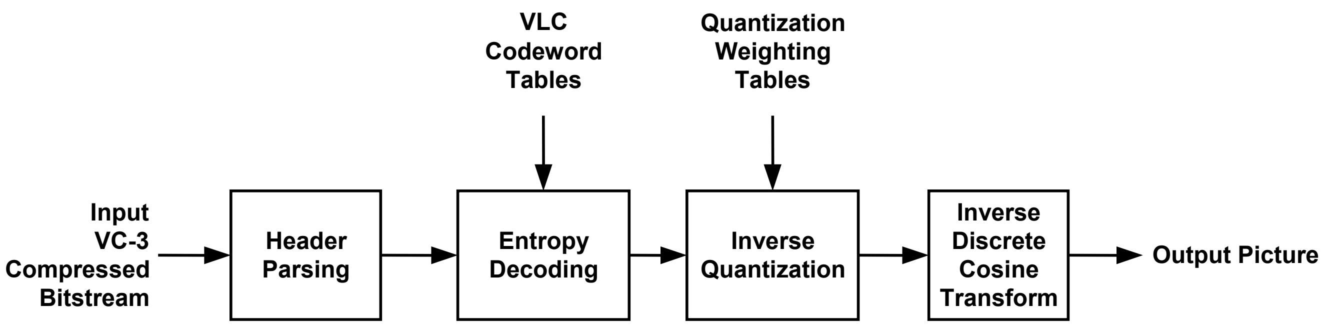

Figure 1 – Overview of the decompression process

5 Notation

The following notation is used in this document.

5.1 Arithmetic Operators

$+$ Addition.

$-$ Subtraction (as a binary operator) or negation (as a unary operator).

$++$ Increment.

$*$ or $\bullet$ Multiplication.

– Division .

$|\ |$ Absolute value:

$|x| = x,$ when $x > 0$

$|x| = 0,$ when $x == 0$

$|x| = -x,$ when $x < 0$.

$\mathrm{sgn}()$ Sign:

$\mathrm{sgn}(x) = 1,$ when $x \geq 0$

$\mathrm{sgn}(x) = -1,$ when $x < 0$.

$\lfloor \ \rfloor$ Floor:

$\lfloor x \rfloor$ returns the largest integral value $\leq x$.

5.2 Logical Operators

TRUE/FALSE Convention: This document uses the convention that a variable or expression evaluating to a nonzero value is equivalent to a condition that is TRUE and a variable or expression evaluating to a zero value is equivalent to a condition that is FALSE.

5.3 Relational Operators

$>$ Greater than.

$\geq$ Greater than or equal to.

$<$ Less than.

$\leq$ Less than or equal to.

$==$ Equal to.

$!=$ Not equal to.

5.4 Bitwise Operators

A twos complement number representation is assumed where the bitwise operators are used.

$>>$ Shift right with sign extension.

$<<$ Shift left with zero fill.

5.5 Assignment

$=$ Assignment operator.

5.6 Precedence Order of Operators

The precedence order of operators is defined as follows:

Operators	Type of operation	Associativity
$(\ )$	Expression	Left to Right
$++$	Postfix operator	Right to Left
$-$	Unary	Left to Right
$*$, $/$	Multiplicative	Left to Right

$+ , -$	Additive, Subtractive	Left to Right
$<< >>$	Shift	Left to Right.
$> , \geq , < , \leq$	Relational	Left to Right
$==$	Equality	Left to Right
$=$	Assignment operator	Right to Left

Operators are listed in descending order of precedence. If several operators appear in the same line, they have equal precedence. When several operators of equal precedence appear at the same level in an expression, evaluation proceeds according to the associativity of the operator either from right to left or from left to right.

5.7 Pseudocode Operations

The following operations are used in the pseudocode to define the decoding process.

• // is a comment to the line end

• A group of statements enclosed in curly brackets is a compound statement and is treated functionally as a single statement.

• while (condition)

(statement)

specifies repeated execution of statement until condition is no longer true.

• for(initial statement; condition; subsequent statement)

(primary statement)

specifies evaluation of intial statement followed by evaluation of condition, and if condition is true, specifies repeated execution of primary statement followed by subsequent statement until condition is no longer true

• if(condition)

(statement)

Else

(alternate statement)

statement is executed if condition is true, alternate statement is executed otherwise

5.8 Definition of Terminology

For the purposes of this standard, the following definitions apply:

AC coefficient: Any DCT coefficient for which the frequency in one or both dimensions is non-zero.

amplitude: The absolute value of a DCT coefficient.

bitstream: An ordered series of bits that forms the coded representation of the data.

bitrate: The data rate at which the decoder consumes and decodes the input VC-3 bitstream.

block: An 8-row by 8-column matrix of samples, or 64 transform coefficients.

byte-aligned: A bit in a coded bitstream is byte-aligned if its position is a multiple of 8 bits from the first bit in the stream.

byte: A sequence of 8 bits.

coding unit: A self contained VC-3 data segment. A coding unit is comprised of a Header, a Compressed Payload, and an End of Frame signature data sections. Progressive frames require a single coding unit, while interlaced frames require two coding units, one for each field.

component: A matrix, block or single sample from one of the three matrices (luma and two color-difference) that make up a picture.

compressed payload: The section of data which contains the compressed data of a coding unit.

compression: Reduction in the number of bits used to represent an item of data.

compression ID: A unique identifier associated with a particular raster size, sample bit depth, compressed frame size, and decoding parameters such as variable length codeword tables and quantization weights.

DC coefficient: The DCT coefficient for which the frequency is zero in both dimensions.

decoder: An embodiment of a decoding process.

decoding process: The process defined whereby a serialized bitstream is converted to an array of 8 or 10 bit Y, Cb, Cr samples with 4:2:2 color subsampling. The decoding process does not include the display rendering process, which may convert these samples to images in another color space (such as RGB), may apply format specific black and white levels, color primaries, Y, Cb, Cr matrix coefficients, sample aspect ratios, etc., and may display the images with frequency and timing different from the sampled rate.

dequantization: The process of rescaling the quantized transform coefficients after their representation in the bitstream has been decoded and before they are presented to the inverse transform.

display process: The (non-normative) process by which reconstructed frames are displayed.

encoder: An embodiment of an encoding process.

encoding (process): A process which reads a stream of input pictures and produces a valid coded bitstream.

field: For an interlaced video signal, a "field" is the assembly of alternate lines of a frame. Therefore an interlaced frame is composed of two fields, a top field and a bottom field.

frame: A frame contains lines of spatial information of a video signal. For progressive video, these lines contain samples starting from one time instant and continuing through successive lines to the bottom of the frame. For interlaced video, a frame consists of two fields, a top field and a bottom field. One of these fields will commence one field period later than the other.

frame rate: The rate at which frames are output from the decoding process.

header: A block of data in the coded bitstream containing the coded representation of a number of data elements pertaining to the coded data that follow the header in the bitstream.

macroblock: The four 8 by 8 blocks of luma data and the four corresponding 8 by 8 blocks of color-difference data coming from a 16 by 16 section of the luma component of the picture.

macroblock scan line: A row of macroblocks running the entire width of the video raster.

parameter: A variable within the syntax which may take one of a range of values. A variable which may take one of only two values is called a flag.

picture: Source, coded or reconstructed image data. A source or reconstructed picture consists of three rectangular matrices of 8 or 10 bit numbers representing the luma and two color-difference signals.

progressive: The property of frames where all the samples of the frame represent the same instance in time.

quantize, quantization: A process in which the continuous range of values of an input signal is divided into nonoverlapping (but not necessarily equal) subranges, and a discrete, unique value is assigned to each subrange. A unique index is generated to represent this value.

run: The number of zero coefficients preceding a non-zero coefficient, in the scan order.

variable length coding (VLC): A reversible procedure for coding that assigns shorter code-words to symbols of higher probability and longer code-words to symbols of lower probability. The acronym VLC also indicates a variable length code.

Video Codec 3 (VC-3): This is the name of the standard described here.

zigzag scanning order: A specific sequential ordering of the transform coefficients from (approximately) the lowest spatial frequency to the highest.

5.9 Acronym Definitions

The following acronyms are commonly used:

DCT: Discrete Cosine Transform

IDCT: Inverse Discrete Cosine Transform

LSB: Least Significant Bit.

MB: MacroBlock.

MSB: Most Significant Bit.

VLC: Variable Length Code.

VLD: Variable Length Decoding.

6 Video Sampling Structure

The VC-3 compression standard shall support the following HD video signals:

- 1080 line interlaced video at the following frame rates: 30, 30/1.001 and 25 Hz.

- 1080 line progressive video at the following frame rates: 60, 60/1.001, 50, 30, 30/1.001, 25, 24, 24/1.001 Hz.

- 720 line progressive video at the following frames rates: 60, 60/1.001, 50, 30, 30/1.001, 25, 24, 24/1.001 Hz.

The video sampling structure shall be defined by SMPTE 274M for 1080 line video rasters and SMPTE 296M for 720 line rasters. The decoder's video output signal shall consist of Luminance (Y) and color-difference components (Cb and Cr) with a 4:2:2 sampling ratio. The sample levels for 8 and 10-bit depth source sampling is tabulated in Table 1.

Table 1 – Video sample levels for 8-bit and 10-bit source sampling bit-depth

Sampling bit depth			8-bit (0 … 255)	10-bit (0 … 1023)
Sample levels	Y	Peak Range	1 … 254	4 … 1019
		White Level	235	940
		Black Level	16	64
		Number of levels between white and black (inclusive)	220	877
	Cb, Cr	Gray Level	128	512
		Excursion	+/- 112	+/- 448

As shown in Figure 2, the active video raster shall be subdivided into macroblocks, which are 16x16 blocks of spatially adjacent samples. A macroblock scan line shall be defined as a row of macroblocks running the entire width of the video raster. The following variables are defined to specify the video raster subdivision into macroblocks:

N_W = the number of macroblocks per macroblock scan line; that is, the *width* of the macroblock scan line.

N_S = the number of macroblock scan lines in a frame or field.

N_T = the total number of macroblocks in a frame or field. Note that $N_T = N_W * N_S$.

l = macroblock index; $l = 0,1,2,..., N_T$

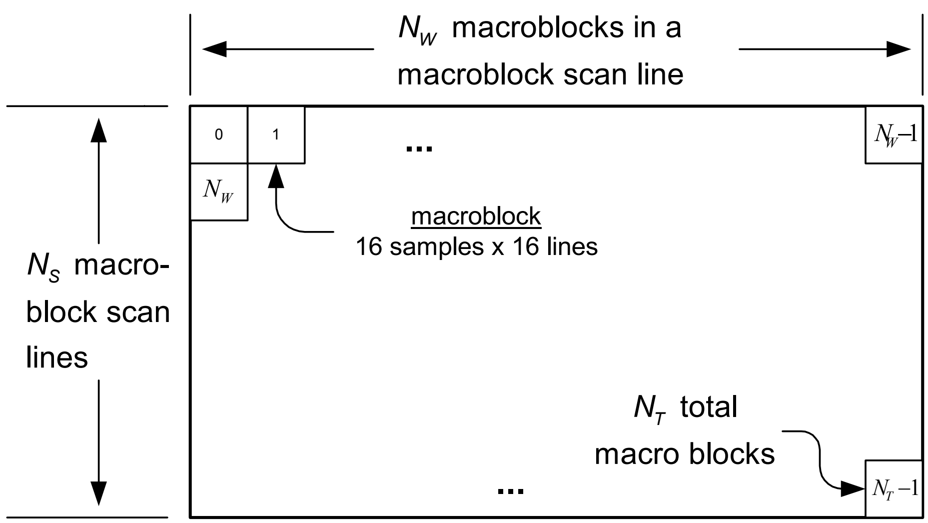

Figure 2 – Macroblock subdivision of the video raster

The macroblock subdivisions for the raster sizes supported by VC-3 shall be as shown in Figure 3, Figure 4, and Figure 5 and tabulated in Table 2. These figures specify how to map individual macroblocks to a specific range of sample locations in the video raster. Note that interlaced video shall be subdivided on a field basis so that macroblocks consist of lines from the same field. Rasters with 1080 lines shall require additional augmentation lines to increase the total number of lines to 1088, which is evenly divisible by 16. During decoding, the data contained in these augmentation lines shall be discarded.

Table 2 – Macroblock related parameters for the subdivision of the video raster

Source scan type	Lines per frame	Number of macroblocks per scan line: N_W	Number of macroblock scan lines per frame or field: N_S	Number of macroblocks per frame or field: N_T
Progressive	1080	120	68 (frame)	8160 (frame)
Interlaced	1080	120	34 (field)	4080 (field)
Progressive	720	80	45 (frame)	3600 (frame)

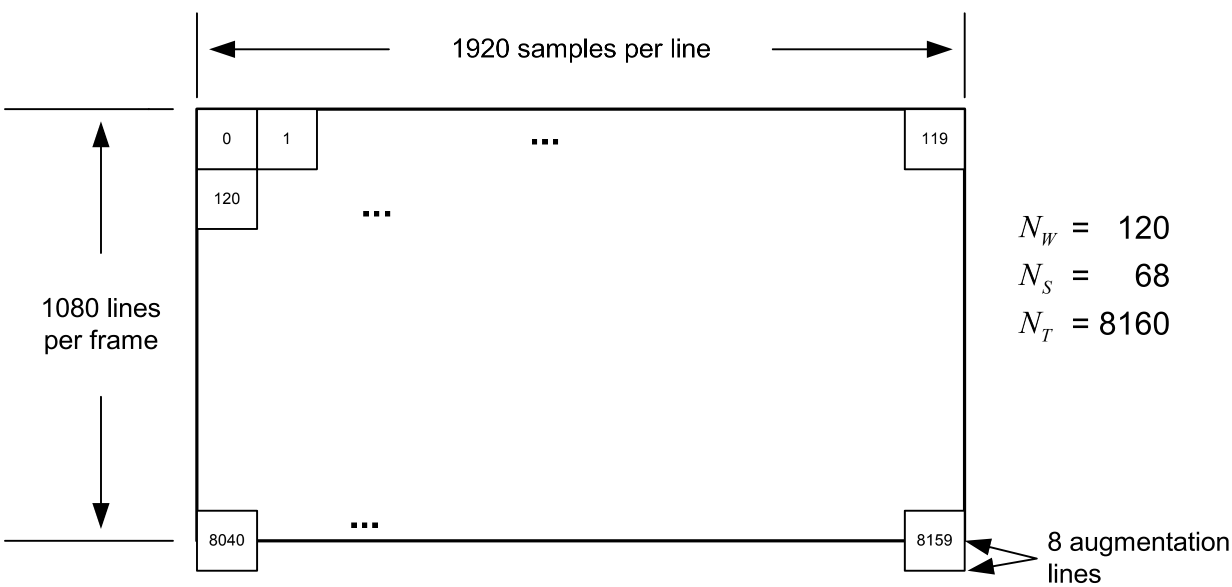

Figure 3 – 1080p raster subdivision into macroblocks

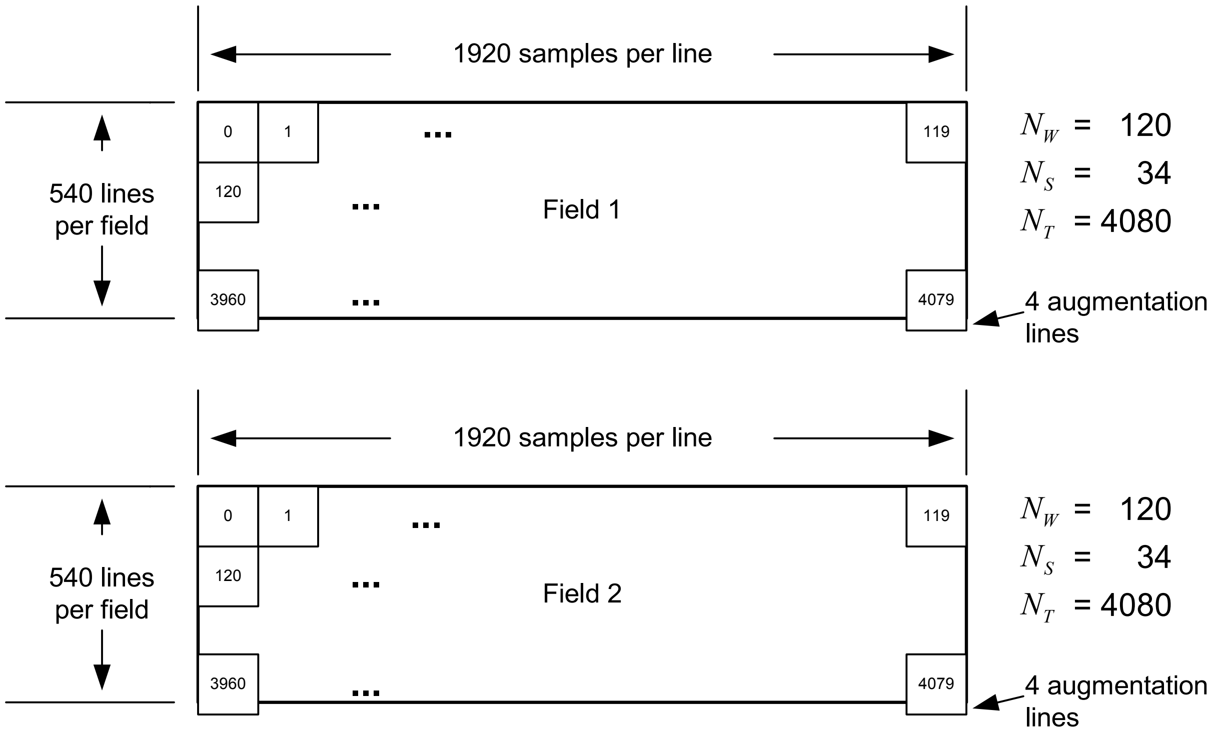

Figure 4 – 1080i raster sub-division into macroblocks

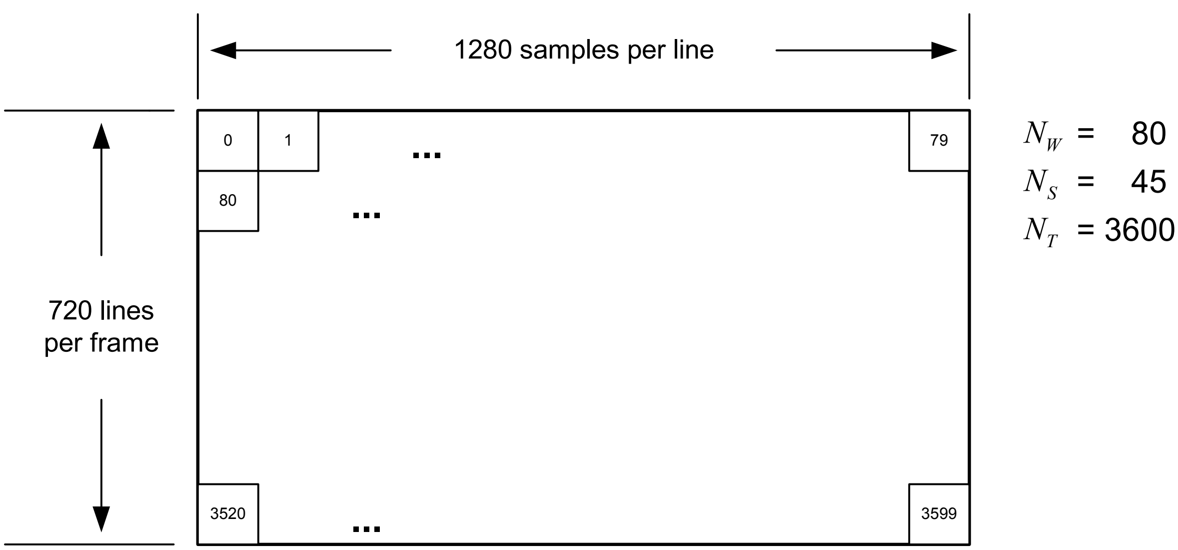

Figure 5 – 720p raster subdivision into macroblocks

Each macroblock shall be further subdivided into 8x8 pixel DCT blocks, as shown in Figure 6. Each DCT block shall consist of 8 pixels x 8 lines. Due to the 2:1 sampling ratio between luma and chroma, a chroma DCT block shall span 16 samples x 8 lines. The DCT blocks shall be ordered according to the indices listed in Table 3. The variable k denotes the DCT block index number, which ranges from 0 to 7. Figure 7 depicts the 8x8 block of video samples, $x_k^l(i, j)$, which comprises a DCT block. The range of the sample index, i, and line index j are from 0 to 7.

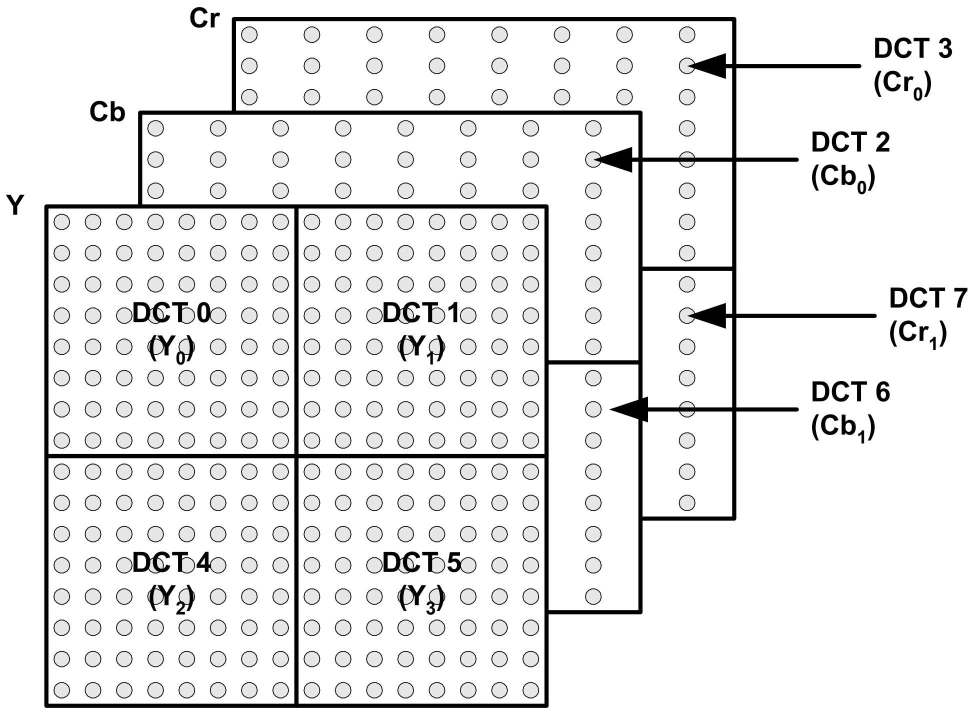

Figure 6 – Macroblock subdivision into 8x8 DCT blocks

Table 3 – DCT Block and DCT Index Correspondence

DCT Index k	DCT Block
0	Y_0
1	Y_1
2	Cb_0
3	Cr_0
4	Y_2
5	Y_3
6	Cb_1
7	Cr_1

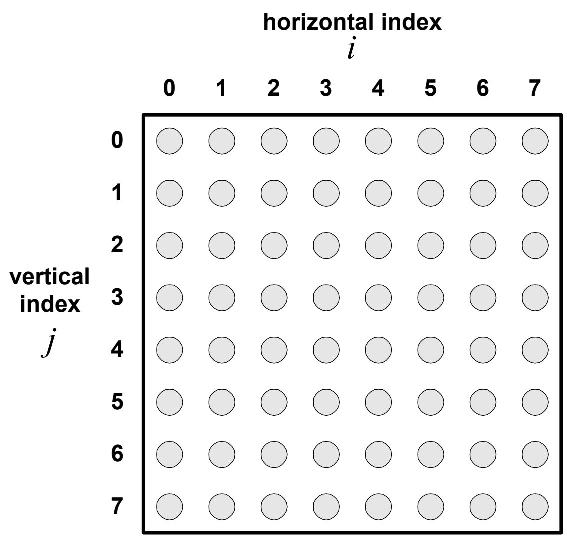

Figure 7 – $x_k^l(i, j)$: a block of 8x8 video sample data

7 Compressed Frame Format

A VC-3 compressed bitstream shall be comprised of continuously concatenated coding units (Figure 8). A coding unit shall consist of a Header of 640 bytes, a Compressed Payload, and an End-Of-Frame (EOF) signature of 4 bytes. Table 4 specifies the Compressed Frame, Coding Unit, and Compressed Payload sizes for the range of VC-3 bitstreams. Table 4 also lists the set of Compression IDs. A Compression ID shall be a unique identifier associated with a particular raster size, sample bit depth, compressed frame size, and decoding parameters such as variable length codeword tables and quantization weights.

The 640 byte Header shall be as described in Section 7.1. It shall contain parameters required to decode Compressed Data contained in the Compressed Payload, which is described in Section 7.2. The Compressed Payload shall contain the Coding Unit's compressed data. See Section 7.2.1. If the length of the Compressed Data is less than the Compressed Payload Size, then the remainder of the Compressed Payload Area shall be filled with padding bytes as detailed in Section 7.2.2. The padding bytes shall be stored in the Compressed Payload Padding area.

The compressed data for a single video frame shall require either one or two coding units. Progressive video shall require one coding unit, while interlaced video shall require two coding units (Figure 9). In the case of progressive video, a single coding unit shall contain the compressed data representing all the video data of a single frame. In the case of the interlaced video, two coding units shall hold the compressed data for a single frame. The first coding unit shall contain the compressed representation of the first video field, while the second coding unit shall contain the representation of the second video field. The second coding unit shall be concatenated onto the end of the first to create a compressed frame.

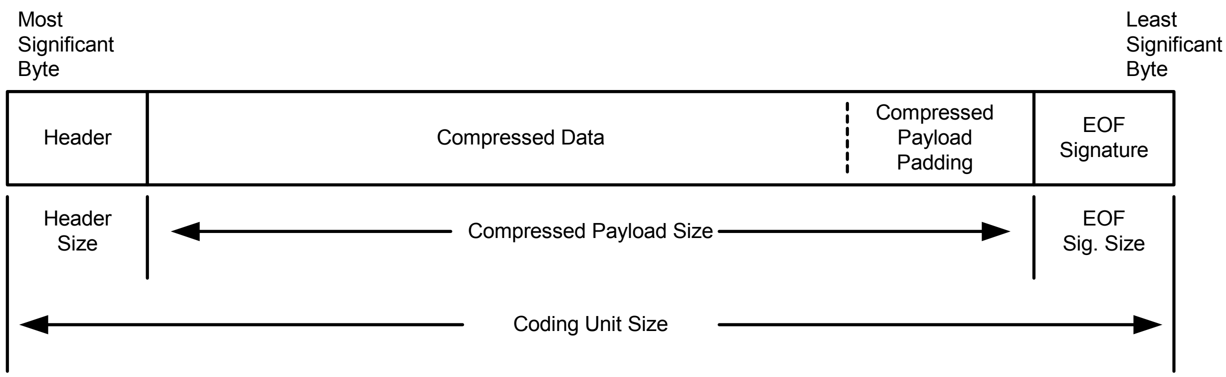

Figure 8 – Coding unit data structure

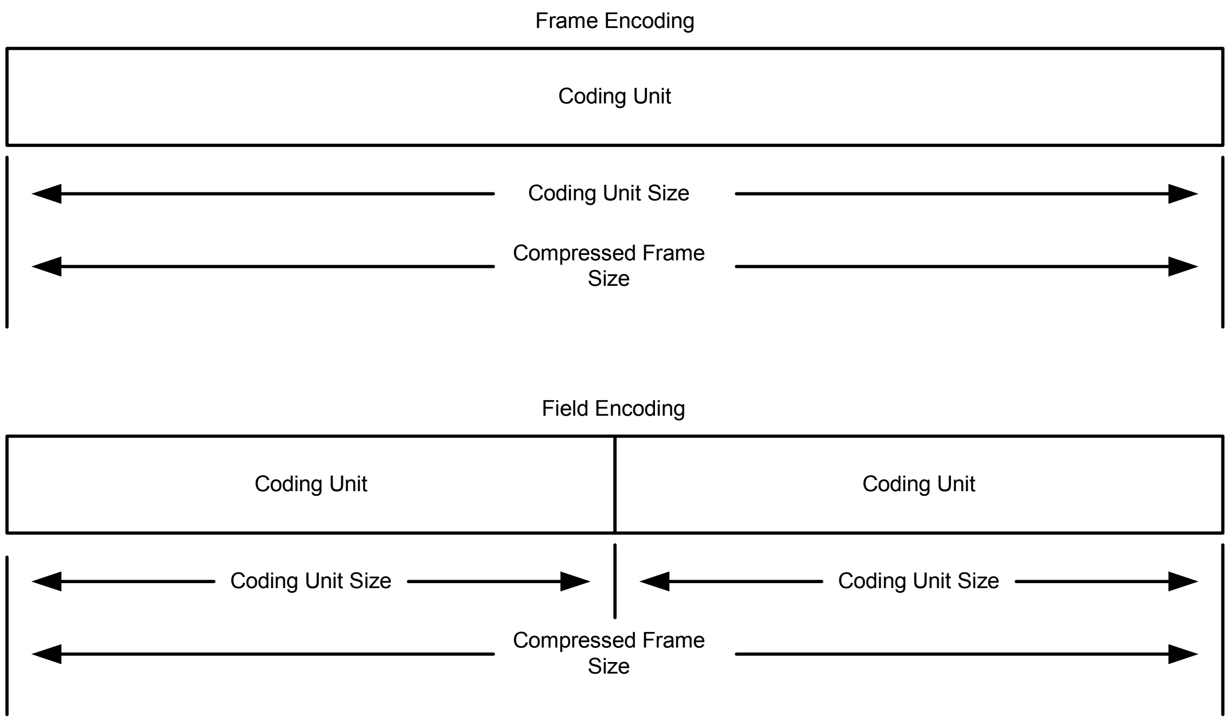

Figure 9 – Compressed frame data structure

The number of compressed bytes per frame for a particular Compression ID shall be as specified in Table 4. The video frame rate at which the compression is applied shall determine the compressed video bitrate.

Note: For example, the Compressed Frame Size of Compression ID 1241 is 917504 bytes. At a video frame rate of 29.97 frames per second, the compressed bitrate is 8*29.97*917504 = 219.98 Mbps. The informative Annex F, "Compressed Bitrates," provides examples of bitrates as a function of Compression ID and video frame rate.

Table 4 – VC-3 compression parameters

Compression ID	Source scan type	Samples per line	Active lines	Sample bit depth	Compressed Frame Size (bytes)	Coding Unit Size (bytes)	Compressed Payload Size (bytes)
1235	progressive	1920	1080 (frame)	10	917504	917504	916860
1237	progressive			8	606208	606208	605564
1238	progressive			8	917504	917504	916860
1241	interlaced	1920	540 (field)	10	917504	458752	458108
1242	interlaced			8	606208	303104	302460
1243	interlaced			8	917504	458752	458108
1250	progressive	1280	720 (frame)	10	458752	458752	458108
1251	progressive			8	458752	458752	458108
1252	progressive			8	303104	303104	302460
1253	progressive	1920	1080 (frame)	8	188416	188416	187772

7.1 Header Definition

The contents of the 640 byte Header area shall be as summarized in Table 5. The following subsections define the header data regions. The byte offsets shown in Table 5 and the figures of this section shall be relative to the start of the coding unit. The content of the reserved areas shall be 0b. Decoder implementations should not process these regions.

Table 5 – Content of header data regions

Starting Offset	Data Region Length (bytes)	Header Data Region Contents	Subsection
0x000	0x005	Header Prefix	7.1.1
0x005	0x003	Coding Control A	7.1.2
0x008	0x010	Reserved	–
0x018	0x00B	Image Geometry	7.1.3
0x023	0x005	Reserved	–
0x028	0x004	Compression ID	7.1.4
0x02C	0x001	Coding Control B	7.1.5
0x02D	0x003	Reserved	–
0x030	0x001	Time Code Control	7.1.6
0x031	0x008	Time Code	7.1.7
0x039	0x026	Reserved	–
0x05F	0x001	User Data Control	7.1.8
0x060	0x104	User Data Payload	7.1.9
0x164	0x003	Reserved	–
0x167	0x009	Macroblock Scan Indices Control	7.1.10
0x170	0x110	Macroblock Scan Indices Payload	7.1.11

7.1.1 Header Prefix

The header prefix shall consist of the five bytes given in Table 6.

Table 6 –Header Prefix data area contents

Byte Offset	Contents
0x000	0x00
0x001	0x00
0x002	0x02
0x003	0x80
0x004	0x01

7.1.2 Coding Control A

Coding Control A area shall hold the following data fields as shown in Figure 10.

FFC: Field/Frame Count

01 b: Progressive frame

10 b: Field 1 of interlaced frame

11 b: Field 2 of interlaced frame

CRCF: CRC flag

0 b: CRC shall not be present in EOF signature

1b: CRC shall be present in EOF signature

Byte Offset	msb							lsb
0x005	0	0	0	0	0	0	FFC_1	FFC_0
0x006	1	0	0	CRCF	0	0	0	0
0x007	1	0	1	0	0	0	0	0

Figure 10 – Coding Control A data area

7.1.3 Image Geometry

The Image Geometry area shall hold the following data fields as shown in Figure 11:

ALPF: The active lines-per-frame value shall vary according to the compression ID. The range of permissible values shall be as listed in the “Active lines” column of Table 4 on page 15. ALPF = ($ALPF_1$ << 8) + $ALPF_0$.

SPL: The samples-per-line value shall vary according to the compression ID. The range of permissible values shall be as listed in the “Samples per line” column of Table 4. SPL = (SPL_1 << 8) + SPL_0.

NAL: Number of active lines shall have the same value as ALPF.

SBD: Sample bit depth – shall correspond to the “Sample bit depth” column of Table 4.

010 b: 10-bits per sample

001 b: 8-bits per sample

SST: Source scan type – shall correspond to “Source scan type” column of Table 4.

0 b: Progressive scan

1 b: Interlaced scan

<table>
<tr><th>Byte Offset</th><th colspan="4">msb</th><th colspan="4">lsb</th></tr>
<tr><td>0x018</td><td colspan="8">$ALPF_1$</td></tr>
<tr><td>0x019</td><td colspan="8">$ALPF_0$</td></tr>
<tr><td>0x01A</td><td colspan="8">SPL_1</td></tr>
<tr><td>0x01B</td><td colspan="8">SPL_0</td></tr>
<tr><td>0x01C</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0x01D</td><td colspan="8">NAL_1</td></tr>
<tr><td>0x01E</td><td colspan="8">NAL_0</td></tr>
<tr><td>0x01F</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0x020</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0x021</td><td colspan="3">SBD</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0x022</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>SST</td><td>0</td><td>0</td></tr>
</table>

Figure 11 – Image Geometry data area

7.1.4 Compression ID

The Compression ID area is depicted in Figure 12. This four-byte area shall hold a binary representation of the Compression ID values listed in the “Compression ID” column of Table 4 on page 15.

Byte Offset	msb ... lsb
0x028	CID_3
0x029	CID_2
0x02A	CID_1
0x02B	CID_0

Figure 12 – Compression ID data area

7.1.4.1 Compression ID Example (Informative)

Compression ID 1250 has a hexadecimal representation of 0x000004E2. In this case, CID_3 = 0x00, CID_2= 0x00, CID_1 = 0x04, and CID_0 = 0xE2.

7.1.5 Coding Control B

The Coding Control B data area fields shall be as shown in Figure 13. It shall contain the following field:

FFE: Field or Frame Encoding

0 b: Field Encoding

1 b: Frame Encoding

If SST = 0 (progressive), then FFE = 1b, frame encoding

If SST = 1 (interlaced), the FFE = 0b, field encoding

Byte Offset	msb							lsb
0x02C	FFE	0	0	0	0	0	0	0

Figure 13– Coding Control B data area

7.1.6 Time Code Control

The Time Code Control data area shall be as shown in Figure 14.

TCP: Time Code Present:

0 b: Time code not present

1 b: Time code present

Byte Offset	msb							lsb
0x030	TCP	0	0	0	0	0	0	0

Figure 14– Time Code Control data area

7.1.7 Time Code Data Area

If the TCP flag of Section 7.1.6 is set, then the 8 bytes of the Time Code data area shall be filled with time code conforming to SMPTE 12M as specified in Table 7.

Table 7 – Time Code data area

Byte\bit	7	6	5	4	3	2	1	0
0x031	Binary Group 1 - BG1				Units of Frames			
	3	2	1	0	8	4	2	1
0x032	Binary Group 2 - BG2				Tens of Frames			
	3	2	1	0	Color Frame	Drop Frame	20	10
0x033	Binary Group 3 - BG3				Units of Seconds			
	3	2	1	0	8	4	2	1
0x034	Binary Group 4 - BG4				Tens of Seconds			
	3	2	1	0	Field ID	40	20	10
0x035	Binary Group 5 - BG5				Units of Minutes			
	3	2	1	0	8	4	2	1
0x036	Binary Group 6 - BG6				Tens of Minutes			
	3	2	1	0	X	40	20	10
0x037	Binary Group 7 - BG7				Units of Hours			
	3	2	1	0	8	4	2	1
0x38	Binary Group 8 - BG8				Tens of Hours			
	3	2	1	0	X	X	20	10

7.1.8 User Data Control

Figure 15 depicts the contents of the User Data Control area, which shall contain the User Data Label (UDL) UDL: User Data Label: a 4-bit field indicating the type of user data in the User Data Payload (Section 7.1.9).

The value of UDL shall be 0000 b which indicates that no user data shall be contained in the User Data Payload. No other UDL values are defined by this document. They are reserved for future use.

See informative Annex B for a description of the intended future use of the UDL field.

Byte Offset	msb							lsb
0x05F	UDL_3	UDL_2	UDL_1	UDL_0	0	0	0	1

Figure 15 – User Data Control data area

7.1.9 User Data Payload

The User Data Payload contains user data as indicated by the User Data Label of Section 7.1.8. When the value of UDL is 0000b, the entire contents of the User Data Payload shall be reserved and set to 0 b.

7.1.10 Macroblock Scan Indices Control

As shown in Figure 16, the Macroblock Scan Indices Control data area shall contain an 8-bit representation of the value N_S from Table 2 on page 10. The value of N_S shall specify how many macroblock scan indices are present in the Macroblock Scan Indices Payload area (Section 7.1.11).

MSIPS shall be a two byte field indicating the size of the Macroblock Scan Indices Payload area in bytes. MSIPS = ($MSIPS_1$ << 8) + $MSIPS_0$ – 4.

Byte Offset	msb							lsb
0x167	0	0	0	0	0	0	1	0
0x168	0	0	0	0	0	0	0	0
0x169	0	0	0	0	0	0	0	0
0x16A	$MSIPS_1$							
0x16B	$MSIPS_0$							
0x16C	0	0	0	0	0	0	0	0
0x16D	N_s							
0x16E	0	0	0	0	0	0	0	0
0x16F	0	0	0	1	0	0	0	0

Figure 16 – Macroblock Scan Indices Control data area

7.1.11 Macroblock Scan Indices Payload

The Macroblock Scan Indices Payload area shall contain a set of indices, one index for each macroblock scan line. The value of the index shall contain the starting byte offset of the Compressed Macroblock Data (Section 7.2.1.1) for the first macroblock in the macroblock scan line. The index offset value shall be relative to the start of the Compressed Payload at address 0x280.

The Macroblock Scan Indices Payload area shall be located at byte offsets 0x170 to 0x27F. The locations shall contain the four-byte macroblock scan indices. The indices shall be placed in this area in big-endian order, starting with the first macroblock scan line through the last macroblock scan line. The interlaced and 720p video formats do not require the full area since they have fewer macroblock scan lines than the 1080p video formats. In these cases, the remaining bytes of the data area shall be padded with 0x00.

An informative example of how macroblock scan indices are used is given in Section 7.4.

7.2 Compressed Payload

As shown in Figure 8, the Compressed Payload area shall consist of Compressed Data (Section 7.2.1) and Compressed Payload Padding (Section 7.2.2). This Compressed Payload area shall immediately follow the 640 byte Header field shown in Figure 8.

7.2.1 Compressed Data

The Compressed Data shall consist of Compressed Macroblock Data and Macroblock Scan-line Padding as shown in Figure 17. The starting address of each compressed macroblock scan line shall be a multiple of 4-bytes. The compressed macroblock data from the first macroblock shall be located at byte offset 0x280, followed by the compressed data of the succeeding macroblocks. At the end of a macroblock scan line (that is, after N_W compressed macroblock data regions) a section of Macroblock Scan-line Padding shall occur. This padding shall ensure that the start of the next compressed macroblock scan line occurs on a four-byte alignment boundary.

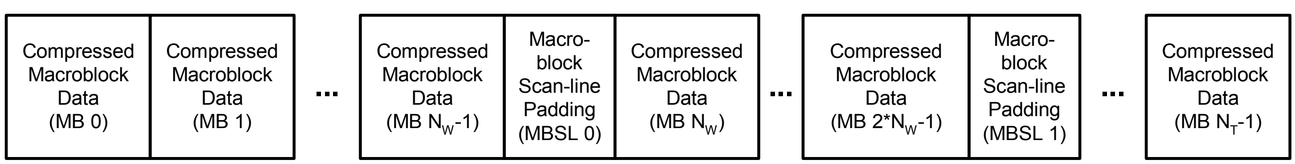

Figure 17 – Compressed Macroblock Data and padding format

7.2.1.1 Compressed Macroblock Data

The Compressed Macroblock Data shall contain a 12-bit Macroblock Header, followed by the entropy codewords for each DCT block as diagrammed in Figure 18. Each DCT's entropy codeword bitstream shall be terminated by an End Of Block (EOB) codeword. At a minimum, a DCT's entropy codewords shall consist of a DC coefficient codeword and zero or more AC coefficient codewords.

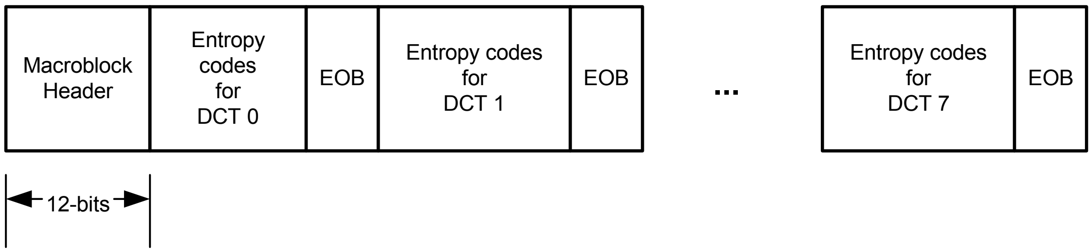

Figure 18 – Compressed Macroblock Data format

Figure 19 depicts the macroblock header, which shall consist of an 11-bit value representing the quantization scale factor (QSF) and a 1-bit fixed value of 0b. Section 8.4 defines the application of the QSF.

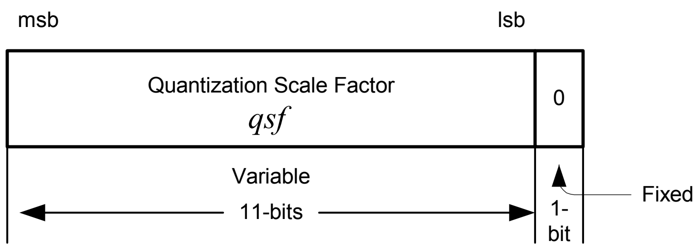

Figure 19 – Macroblock header format

7.2.1.2 Macroblock Scan-Line Padding

Macroblock scan-line padding shall occur at the end of macroblock scan-line row. Since the starting address of each compressed macroblock scan line shall be a multiple of four bytes, the length of padding can vary between 0 and 31 bits. In the case where a compressed macroblock scan line ends on a four-byte multiple address, no padding shall be required. The padding value shall be 0 b, for each padding bit.

Note: The amount of padding may be variable, depending on the total length of the compressed macroblock data sections.

7.2.2 Compressed Payload Padding

Compressed Payload Padding shall fill the Compressed Payload Area that is not consumed by the Compressed Data. The compressed payload padding shall be filled with byte values 0x00.

Note: The number of bytes of Compressed Payload Padding may be variable, since the number of compressed bytes depends on video content and visual quality requirements.

7.3 EOF Signature

The contents of the four-byte EOF signature region shall depend on the value of the CRC flag (CRCF), as defined in Section 7.1.2.

If CRCF = 0, then the EOF signature region shall contain the value shown in Table 8. If CRCF = 1, then the region shall contain the value shown in Figure 20.

Table 8 – EOF Signature When CRCF = 0

EOF Byte Offset	Contents
CRC_3	0x60
CRC_2	0x0D
CRC_1	0xC0
CRC_0	0xDE

The CRC algorithm for the EOF signature shall be the 32-bit CRC (CRC-32-IEEE 802.3) defined by the polynomial:

$x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$, with an initial seed of 0x0000 0000.

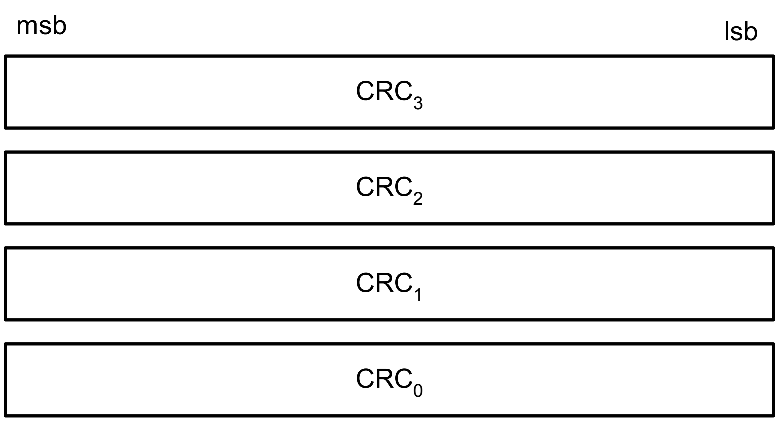

Figure 20 – EOF Signature contents when CRCF = 1

7.3.1 Verification of Data Integrity (Informative)

To verify the integrity of the data in the coding unit, the CRC computation is initialized with the value of 0x0000 0000. The data contained in the coding unit, including the four bytes in the EOF signature area, is presented to the CRC computation. Each data presentation consists for four sequential bytes in big-endian order. Upon completion of the last CRC calculation, a CRC output value other than 0x0000 0000 indicates data corruption.

7.4 Illustrative Example (Informative)

The following example provides the contents of the macroblock scan indices and the compressed macroblock starting addresses for a hypothetical coding unit. It also computes the size of the Compressed Payload Padding. The coding unit represents a field of interlaced 1920x1080 encoding using Compression ID 1242. The columns in Table 9 list pertinent information.

In this example, the first compressed macroblock scan line requires 7985 bits to encode. A total of 15 padding bits are present at the end of the compressed macroblock scan line, so that the end of the compressed data is a multiple of four bytes. The length of the compressed macroblock and padding is 1000 bytes. The first macroblock scan-line index payload area is at location 0x170. It contains the value 0 to indicate that the first macroblock scan area starts at byte location 640 (0x0280).

The second macroblock scan line index payload area is located at byte location 0x174. It contains the value 1000 which indicates that the start of the second macroblock scan line is at byte location 1640 (0x0668).

Since this example compression involves interlaced video, Table 2 on page 10 indicates that N_S = 34. Thus, the last value specified in the macroblock scan line index payload is location 0x1F4. The unused locations 0x1F8 through 0x27F are filled with padding.

The total compressed data consumes 300400 + 1600 = 302000 bytes. As listed in Table 4 on page 15, the compressed payload size is 302460 bytes. The remainder of the compressed payload consists of compressed payload padding, which means that 302460 – 302000 = 460 bytes of compressed payload padding are present in the coding unit.

Table 9 – Contents of Macroblock scan-line indices for the illustrative example

Macro block scan line	Length of compressed macroblock scan line (bits)	Length of macroblock scan-line padding (bits)	Length of compressed macroblock scan-line and padding (bytes)	Macroblock scan line index location	Contents of Macroblock scan-line index	Starting address of compressed macroblock scan line
0	7985	15	1000	0x170	0x0000 0000 (0)	0x0000 0280 (640)
1	9569	31	1200	0x174	0x0000 03E8 (1000)	0x0000 0668 (1640)
2	…	…	…	0x178	0x0000 0898 (2200)	0x0000 0B18 (2840)
…	…	…	…	…	…	…
32	6400	0	800	0x1F0	0x0004 9250 (299600)	0x0004 9368 (299880)
33	12789	11	1600	0x1F4	0x0004 9570 (300400)	0x0004 97F0 (301040)

8 Decoding

The decoding process shall convert the compressed macroblock data into video raster data. The process is summarized in the pseudo code listed in Figure 21. The range of the macroblock index shall be l = 0, 1, $\ldots, N_T - 1$, where N_T is defined in Table 2. The pseudo code listing contains two functions: decodeMacroblock( ) and skipMacroblockPadding( ). The decodeMacroblock( ) function is described in Section 8.1. The skipMacroblockPadding( ) function removes macroblock scan padding bits. This shall occur when $l = N_W - 1,\ 2N_W - 1, \ldots,\ (N_S - 1)(N_W) - 1$.

```
l=0; // Macroblock index
for (s = 0; s < N_S; s++)
{
  for(w = 0; w < N_W; w++)
  {
     decodeMacroblock(MB_l, l);
     l++;
  }
  skipMacroblockPadding( );
}
```

Figure 21 – Pseudo code for the decoding process

8.1 Macroblock Decoding

The macroblock decoding process shall convert the compressed macroblock data for MB_l to its corresponding video raster data. Figure 22 provides the pseudo code representation of the process.

```
decodeMacroblock(MB_l, l)
{
  for(k = 0; k < 7; k++) // k is the DCT index
  {
    x_k^l(i, j) = decodeDCTBlock(v_k^l, k, l); //returns all video
                                                // samples in DCT block
    switch(k)
    {
       case: 0,1, 4,5
         Y_k^l(i, j) = x_k^l(i, j); //Assign to Y for all i, j = 0,1,...,7
         break;
       case: 2,6
         Cb_k^l(i, j) = x_k^l(i, j); //Assign to Cb for all i, j = 0,1,...,7
         break;
      case: 3,7
         Cr_k^l(i, j) = x_k^l(i, j); //Assign to Cr for all i, j = 0,1,...,7
         break;
    }
  }
}
```

Figure 22 – Macroblock decoding pseudo code

The DCT decoding function, $\text{decodeDCTBlock}(v_k^l, k, l)$, converts the variable-length bitstream v_k^l into a set of 2-D, decompressed video samples $x_k^l(i, j),\ i, j = 0,1,...,7$. The decoding process is depicted in Figure 23. It should consist of the following steps:

1. Entropy decoding: Entropy decoding (Section 8.2) converts v_k^l into a set of quantized DCT coefficients $\hat{X}_k^l(r)$. The coefficients shall be ordered in bit-stream order, denoted by bitstream coefficient index, r.

2. Inverse Zig-zag: The inverse zig-zag process (Section 8.3) reorders the quantized DCT coefficients $\hat{X}_k^l(r)$ into a 2-D array $\hat{X}_k^l(u, v)$

3. Inverse quantization: During the inverse quantization process (Section 8.4), the quantization scaling factor, qsf, which shall be encoded in the macroblock header (Section 8.2.1), and the quantization weights, $W(u, v)$, shall be applied to compute a set of DCT coefficients $X_k^l(u, v)$

4. Inverse Discrete Cosine Transform: The Inverse DCT process (Section 8.5) transforms the 2-D DCT coefficients $X_k^l(u,v)$ to a set of 2-D, decompressed video samples $x_k^l(i,j)$.

5. Adjust the level of the IDCT output as described in Section 8.5.3.

The decoding process for a single DCT block is detailed in the following sub-sections. The subscript k (DCT index) and the superscript l (macroblock index) are dropped from the notation for readability.

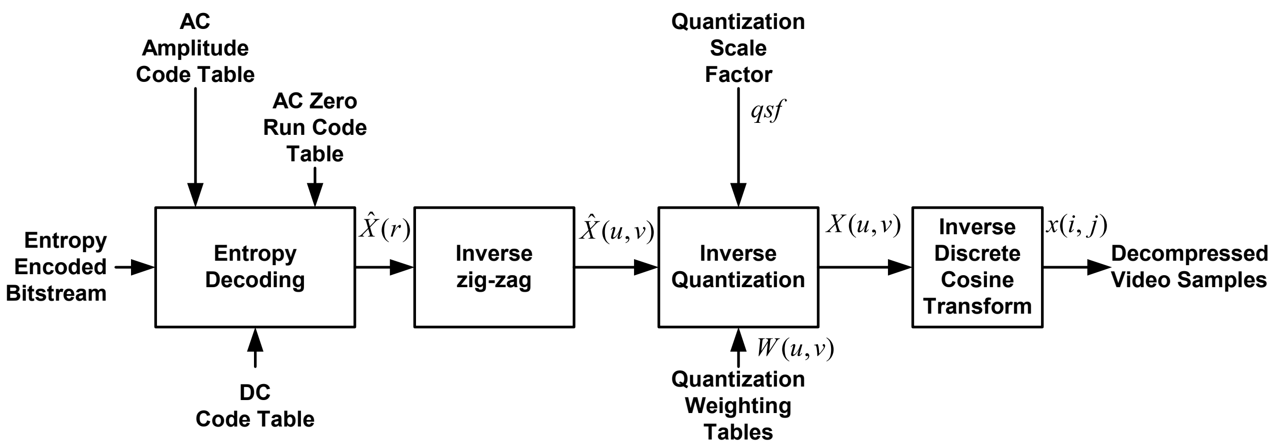

Figure 23 – Decoding block diagram for a single DCT block

8.2 DCT Block Entropy Decoding

As shown in Figure 24, the elements of a DCT block's encoded bitstream consist of a grouping of entropy codewords. The codeword types fall into three categories: DC DCT coefficient codewords (v_{DC}), AC DCT coefficient codewords ($\mathbf{v}_{AC}$), and EOB codewords (v_{EOB}). This is represented by the notation:

$$\mathbf{v} = \{v_{DC}, \mathbf{v}_{AC}, v_{EOB}\}$$

The following sub-sub sections describe the entropy decoding process.

v_{DC}	$\mathbf{v}_{AC}$	v_{EOB}

Figure 24 – A DCT block's entropy bitstream

8.2.1 Macroblock Header and Quantization Scale Factor

The macroblock header shall be a 12-bit data field that contains an 11-bit quantization scale factor, qsf.

Valid values of the qsf shall be [1 1024]. The format is shown in Figure 19.

8.2.2 VLC Codeword Tables

For each compression ID, three sets of variable-length codeword (VLC) tables shall be defined: the amplitude codeword table, V^A, the zero run-length table, V^R, and the DC VLC table, V^{DC}. The entries for these tables are listed in Annex D: VLC Tables, according to compression ID. The amplitude codeword tables are found in Table D.1, Table D.4, Table D.7, Table D.10, Table D.13, and Table D.16. The zero run-length tables are found in Table D.2, Table D.5, Table D.8, Table D.11, Table D.14, and Table D.17. The DC coefficient decoding process utilizes the DC VLC Tables, Table D.3, Table D.6, Table D.9, Table D.12, Table D.15, and Table D.18.

8.2.3 DC Coefficient Decoding

Computing the DC coefficient of a DCT block, $\hat{X}_k(0)$, shall follow a multi-step process. First, the DC coefficient codeword, v_{DC}, shall be decoded. The results of the decoding enable the computation of prediction correction term, ε. The prediction correction value shall be added to a DC coefficient prediction value, P_{ct}, to compute $\hat{X}_k(0)$. This process is further described below.

v_{DC} shall consist of two elements as shown in Figure 25. The first element shall be a variable-length codeword indicating the number of bits, η, required to decode the second. The second element, designated by ρ, shall be an intermediate binary value used to compute ε. The mapping from a variable-length codeword to a value of η shall be as defined in the DC VLC Tables listed in Annex D: VLC Tables.

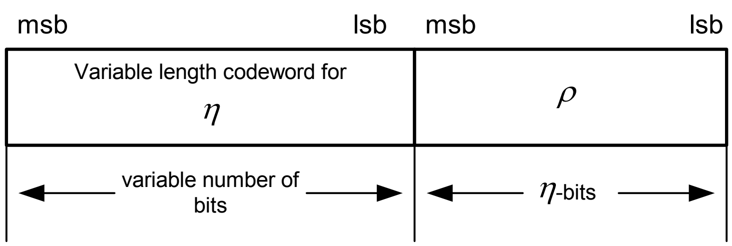

Figure 25 – Format for the DC codeword v_{DC}

The relationship between the range of ε and η shall be $\text{Range} = \pm(2^\eta - 1), \pm(2^n - 2), \ldots \pm(2^{\eta-1})$ as shown in Table 10. For 8-bit video sampling, the maximum value of η = 11 and for 10-bit video sampling, the maximum value of η = 13. Summarizing,

- ε shall be the prediction correction value.
- ρ shall be an intermediate binary value used to compute ε. It shall be an unsigned binary value with a length of η.
- η shall be the length of ρ in bits.
- The variable-length codewords for η shall be as listed in the DC VLC table given in Annex D: VLC Tables.
- ε shall be computed from ρ according to the pseudo code given in Figure 26.

Table 10 – Relationship between the range of the correction prediction value and the length of ρ

Range of prediction correction value ε	η: Length of ρ in bits
0	0
+/- 1	1
+/- 3, +/- 2	2
+/- 7, …, +/- 4	3
+/- 15, …, +/- 8	4
+/- 31, …, +/- 16	5
+/- 63, …, +/- 32	6
+/- 127, …, +/- 64	7
+/- 255, …, +/- 128	8
+/- 511, …, +/- 256	9
+/- 1023, …, +/- 512	10
+/- 2047, …, +/- 1024	11
+/- 4095, …, +/- 2048	12
+/- 8191, …, +/- 4096	13

```
if (η = 0)
    ε = 0
else
    if (ρ ≥ 2^(η-1))
        ε=ρ
    else
        ε=ρ+1-2^η
```

Figure 26 – Pseudo-code for computation of the prediction correction value ε

A separate prediction value, P_{ct}, shall be maintained for each component type (ct = Y, C_B, or C_R). P_{ct} shall be set to 0 at the beginning of a macroblock scan line for each component type. The DC coefficient for DCT block k (with component type ct) shall be computed by:

$$\hat{X}_k(0) = P_{ct} + \varepsilon_k$$

The prediction value shall be updated according to:

$$P_{ct} \leftarrow \hat{X}_k(0)$$

except at the beginning of a macroblock scan line.

8.2.4 AC Coefficient Entropy Decoding

The process of AC coefficient entropy decoding shall extract the quantized AC DCT coefficients from the entropy encoded bitstream. The entropy codewords shall represent the sign and amplitude of the non-zero values quantized AC coefficients and the run lengths of zero-valued AC coefficients. A description of the format of AC coefficient entropy codewords is given in Annex A.

The AC coefficient entropy codewords shall be a set defined by:

$$\mathbf{v}_{AC} = \begin{cases} \phi & \text{if no AC coefficients are encoded} \\ \{v_1, v_2, \ldots v_N\} & \text{otherwise} \end{cases}$$

where ϕ is the empty set and *N* is the number of non-zero AC coefficients in the quantized DCT.

8.2.4.1 AC Coefficient Codeword Tables

The amplitude codeword table, V^A, shall provide the following information for each unique codeword. The amplitude codeword tables shall be as listed in Annex D: VLC Tables.

- The length of the codeword in bits shall correspond to the “Length” column.
- The amplitude of the quantized DCT coefficient shall correspond to the “Amp” column.
- A flag, F_{run}, indicating if there are one or more zero-valued coefficients preceding the coefficient. This flag shall correspond to the “Run Flag F_{run}” column.
- A flag, F_{index}, which indicates that the amplitude of the coefficient must be adjusted by an offset. This flag shall correspond to the “Index Flag F_{index}” column.

8.2.4.2 AC Coefficient Decoding Pseudo Code

The AC coefficients shall be decoded in a manner which gives identical results to the process defined here.

The remainder of this section is designated informative.

The pseudo code shown in Figure 27 describes an algorithm for decoding the AC coefficients of one DCT block. This algorithm provides the quantized coefficients, $\hat{X}(r)$ for $r = 1,2,\ldots,63$ by decoding the codewords in $\mathbf{v}_{AC}$. The pseudo code makes use of three functions: decode_VLC_VA( ), decode_P( ), and decode_VLC_VR( ).

The function decode_VLC_VA( ) operates on the amplitude codeword table V^A to provide:

- A – the value from which the coefficient’s amplitude computed.
- S – the sign of the coefficient. If the one-bit sign field in v_i = 1, then S = -1, otherwise, S = 1.
- F_{run} – a flag, that if set to 1, indicates that one or more zero value coefficients precedes the current coefficient.

- F_{index} – a flag, that if set to 1, indicates that the coefficient amplitude must be adjusted by an offset, dependent on the amplitude index, P. The amplitude index is encoded later in the bitstream.

- F_{EOB} – a flag, that if set to 1, indicates that the EOB has occurred.

The function decode_P( ) is applied when F_{index} is true. It returns P, which is decoded from the bit-stream of v_i.

The function decode_VLC_VR( ) operates on the zero run-length table, V^R, to provide the number of zero-valued coefficients preceding the current coefficient. It is when F_{run} is true.

```
for (r = 1; r < 64; r++)
        X̂(r) = 0;

r = 1; // DCT coefficient index
i = 1; // Codeword index

while (r < 64)
{
   (A, S, F_run, F_index, F_EOB) = decode_vlc_VA(v_i);
   if (F_EOB)
        break;
   if (F_index)
        P  = decode_P(v_i);
        A = A + P*64;
   if (F_run)
        Run = decode_vlc_VR(v_i);
        r = r + Run;
   X̂(r) = sign(S)*A;
   r = r + 1;
   i = i + 1;
}
```

Figure 27 – Pseudo-code for AC coefficient entropy decoding of a single DCT block

8.3 Inverse Zig-zag

The conversion from bitstream order index r to 2-D DCT array indices (u,v) shall be as shown in Figure 28. This conversion remaps the quantized coefficients $\hat{X}(r)$ to $\hat{X}(u,v)$.

horizontal index (u)

vertical index (v)	0	1	2	3	4	5	6	7
0	0	1	5	6	14	15	27	28
1	2	4	7	13	16	26	29	42
2	3	8	12	17	25	30	41	43
3	9	11	18	24	31	40	44	53
4	10	19	23	32	39	45	52	54
5	20	22	33	38	46	51	55	60
6	21	34	37	47	50	56	59	61
7	35	36	48	49	57	58	62	63

Figure 28 – Zig-zag ordering $\mathrm{r} \rightarrow (\mathrm{u,v})$

8.4 Inverse Quantization

Computation of the inverse quantization of a set of quantized DCT values $\hat{X}(u,v)$ shall utilize the quantization scale factor (qsf) present in the macroblock header and a set of quantization weights $W(u,v)$. The weights for each Compression ID shall be as listed in Annex C: Quantization Weights. The luma and chroma components shall each have their own set of quantization weights.

Inverse quantization shall not be applied to the DC coefficient $\hat{X}(0,0)$, since it is not quantized during the encoding process. In other words:

$$X(0,0) = \hat{X}(0,0).$$

The inverse quantization process for AC coefficients shall be as shown in **Eq. 1** below, where the inverse quantization parameter p shall be dependent on the video sampling bit-depth, as detailed in Table 11. The notation $\lfloor t \rfloor$ denotes the floor operation, which returns the largest integral value less than or equal to t.

Eq. 1

$$
\begin{aligned}
&\text{if } \hat{X}(u,v)=0\\
&\qquad X(u,v)=0\\
&\text{else if } W(u,v)\,!=p\\
&\qquad X(u,v)=\operatorname{sgn}(\hat{X}(u,v))\left\lfloor \frac{\left|\hat{X}(u,v)\right|\cdot W(u,v)\cdot qsf+\left\lfloor \frac{W(u,v)\cdot qsf}{2}\right\rfloor+\frac{p}{2}}{p}\right\rfloor\\
&\text{else}\\
&\qquad X(u,v)=\operatorname{sgn}(\hat{X}(u,v))\left\lfloor \frac{\left|\hat{X}(u,v)\right|\cdot W(u,v)\cdot qsf+\left\lfloor \frac{W(u,v)\cdot qsf}{2}\right\rfloor}{p}\right\rfloor
\end{aligned}
$$

Table 11 – The inverse quantization parameter shall be dependent upon video sampling bit depth

Video sampling bit-depth	Inverse quantization parameter p
8	32
10	8

Note: For informative reference, the quantization function is shown in **Eq. 2**

Eq. 2 $$\hat{X}(u,v)=\operatorname{sgn}(X(u,v))\left\lfloor \frac{\left|X(u,v)\right|\cdot p}{qsf\cdot W(u,v)}\right\rfloor$$

8.5 Discrete Cosine Transform

8.5.1 8x8 Inverse DCT

The IDCT shall produce a set of 8x8 video pixels from the DCT coefficients, $X(u,v)$. The 8x8 Inverse DCT of DCT coefficients $X(u,v), u,v=0,...,7$ shall be defined according to:

Eq. 3 $$x(i,j)=(1/4)\sum_{u=0}^{7}\sum_{v=0}^{7}C(u)C(v)X(u,v)\cos\left(\frac{(2i+1)\pi u}{16}\right)\cos\left(\frac{(2j+1)\pi v}{16}\right)$$

8.5.2 8x8 Forward DCT (informative)

For reference the Forward Discrete CosineTransform (FDCT) is given below. The 8x8 Forward DCT of pixel data $x(i,j), i,j=0,...,7$ produces an 8x8 array of DCT coefficients:

$$X(u,v) = (1/4)C(u)C(v)\sum_{i=0}^{7}\sum_{j=0}^{7} x(i,j)\cos\left(\frac{(2i+1)\pi u}{16}\right)\cos\left(\frac{(2j+1)\pi v}{16}\right)$$

Eq. 4 where

$$C(0) = 1/\sqrt{2} \text{ and } C(u) = C(v) = 1, \text{ for } u, v = 1,...7$$

8.5.3 Video Sample Level Adjustment

As shown in Table 12, when pixel data passes through the FDCT, the dynamic range of the data increases by 3 bits. When DCT coefficients are transformed via the IDCT, the dynamic range decreases by 3 bits.

Table 12 –Dynamic ranges of FDCT and IDCT for 8-bit and 10-bit video sampling depth

	FDCT Range		IDCT Range	
	Input	Output	Input	Output
8-bit sampling depth	-128 to 127 (8 bits)	-1024 to 1023 (11 bits)	-1024 to 1023 (11 bits)	-128 to 127 (8 bits)
10-bit sampling depth	-512 to 511 (10 bits)	-4096 to 4095 (13 bits)	-4096 to 4095, (13 bits)	-512 to 511 (10 bits)

The last stage of DCT decoding should be to adjust the levels of the video data. The adjustment value, d, shall be $d = 2^{b-1}$, where b is the sample bit depth value determined from SBD field in the Image Geometry header data area described in Section 7.1.3. The adjustment process is described by the pseudo code given in Figure 29.

```
for(i=0; i< 8; i++)
  for(j=0; j< 8; j++)
    x(i, j) = x(i, j) + d
```

Figure 29 – Level adjustment for a DCT block.

8.6 Recommendations (Informative)

Following the loss or corruption of part of a bitstream, it is recommended that a conformant decoder resume the decoding process as soon as possible. It is practical to resynchronize the decoder on a subsequent frame boundary.

In order to preserve color fidelity, video processing systems which interface to a VC-3 decoder, should take special precautions when converting 10-bit video samples to 8-bit samples, by applying a suitable rounding or dithering algorithm.

Annex A (Normative)
AC Coefficient Entropy Codeword Format

This annex pertains to the format of quantized AC coefficient entropy codewords. For the remainder of this annex, the term coefficient means quantized AC coefficient.

Entropy Codeword Symbol Set Definitions:

VC-3 shall utilize six types of symbol sets to represent coefficients: four for non-zero coefficient amplitudes, one for run lengths of zero-valued coefficients, and one for the End of Block condition. A coefficient's codeword format shall depend upon which symbol set is used to represent the coefficient. In order to describe the symbol sets, the following definitions are given.

- Coefficients residing in the "base range" of amplitude shall have amplitudes between 1 and 64 inclusive.
- Coefficients residing in the "index range" of amplitude shall have amplitudes between 65 and 4096 inclusive.
- The index range shall be partitioned into a number of segments, each of length 64.
- The index value, P, shall indicate from which segment a coefficient in the index range originates. The relationship between P and the coefficient amplitude, A, shall be: $P = ((A-1) >> 6)\ for\ 65 <= A <= 4096$.
- If the video sampling depth is 10-bits, then P shall be a 6-bit binary value indicating the amplitude offset value. P shall be a 4-bits binary value, when the video sampling is 8-bits.

The six symbol sets shall be defined as follows:

1. $A^{nrb} = \{A_1^{nrb}, A_2^{nrb}, ..., A_{64}^{nrb}\}$: Non-zero coefficient amplitudes in the base range, with *no* preceding run of zero-valued coefficients. The superscript nrb represents no-run, base amplitude. The amplitudes shall vary from $A_1^{nrb} = 1$ to $A_{64}^{nrb} = 64$.
2. $A^{wrb} = \{A_1^{wrb}, A_2^{wrb}, ..., A_{64}^{wrb}\}$: Non-zero coefficient amplitudes in the base range, *with* preceding run of zero-valued coefficients. The superscript wrb represents with-run, base amplitude. The amplitudes shall vary from $A_1^{wrb} = 1$ to $A_{64}^{wrb} = 64$.
3. $A^{nri} = \{A_1^{nri}, A_2^{nri}, ..., A_{64}^{nri}\}$: Non-zero coefficient amplitudes in the index range, with *no* preceding run of zero-valued coefficients. The superscript nri represents no-run, index amplitude. The amplitudes shall vary from 65 to 4096.
4. $A^{wri} = \{A_1^{wri}, A_2^{wri}, ..., A_{64}^{wri}\}$: Non-zero coefficient amplitudes in the index range, *with* preceding run of zero-valued coefficients. The superscript wri represents with-run, index amplitude. The amplitudes shall vary from 65 to 4096.
5. $R = \{R_1, R_2, ..., R_{max}\}$: a run of 1 or more zero-valued coefficients. $R_1 = 1$ and $R_{max} = 62$.
6. $E = \{EOB\}$: the end of block symbol.

Figure A.1 shows the mapping between coefficients and the sets A^{nrb}, A^{nri}, A^{wrb}, A^{wri} and R.

The symbols in the five sets of $A^{nrb}, A^{nri}, A^{wrb}, A^{wri}, E$ shall be grouped together represented by a set of variable-length code words $V^A = \{V^{nrb}, V^{nri,} V^{wrb}, V^{wri}, V^E\}$. There shall be $4*64+1=129$ code words in V^A. The remaining symbol set, R, shall be represented by its own set variable-length, zero-run code words V^R. There shall be 62 codewords in V^R.

AC Coefficient Entropy Codeword Format

If a coefficient is an element of the set A^{nrb} (that is., the dotted region of Figure A.1), it shall be represented by a single code word taken from $\boldsymbol{V^{nrb}}$ followed by a 1-bit sign flag indicating the coefficient's sign value. The entropy encoding format for this case is shown at the top of Figure A.2.

If a coefficient resides in the set A^{wrb}, it shall be represented by a codeword taken from V^{wrb}, followed by a 1-bit sign flag, followed by a codeword taken from V^R. This case is depicted in the drawing that is second from the top of Figure A.2.

If a coefficient has no preceding run of zeros and lies in the index range, it shall be an element of A^{nri}. In this case, the coefficient shall be represented by a codeword taken from V^{nri}, followed by a 1-bit sign flag, followed by the index value P as shown in the middle drawing of Figure A.2.

A coefficient that is a member of the set A^{wri} shall be represented by a codeword taken from V^{wri}, followed by a 1-bit sign flag, followed by the index value P, followed by a codeword taken from V^R to represent the number of preceding zero runs. This format is shown in the drawing that is third from the top of Figure A.2.

Finally, the end of block case shall be represented as shown at the bottom of Figure A.2.

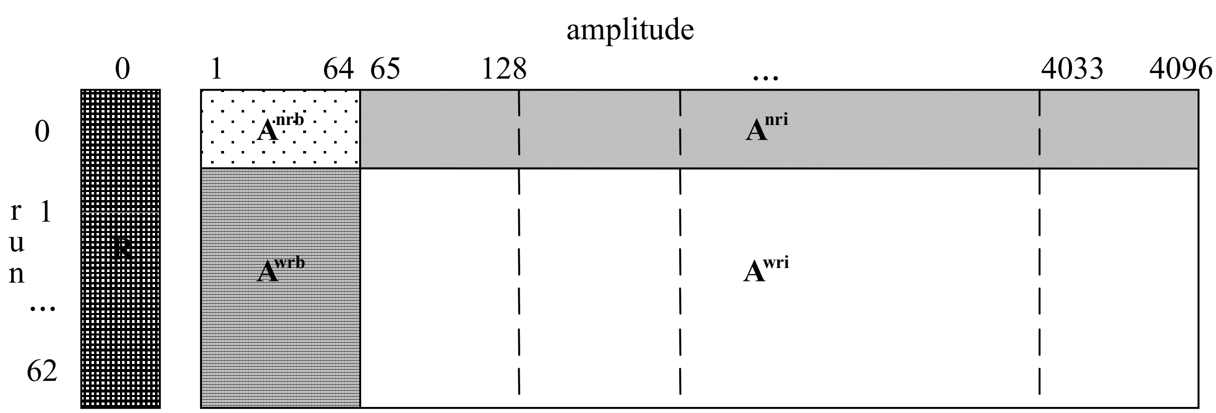

Figure A.1 – Mapping of Zero Run/Amplitude Combinations to Symbol Sets

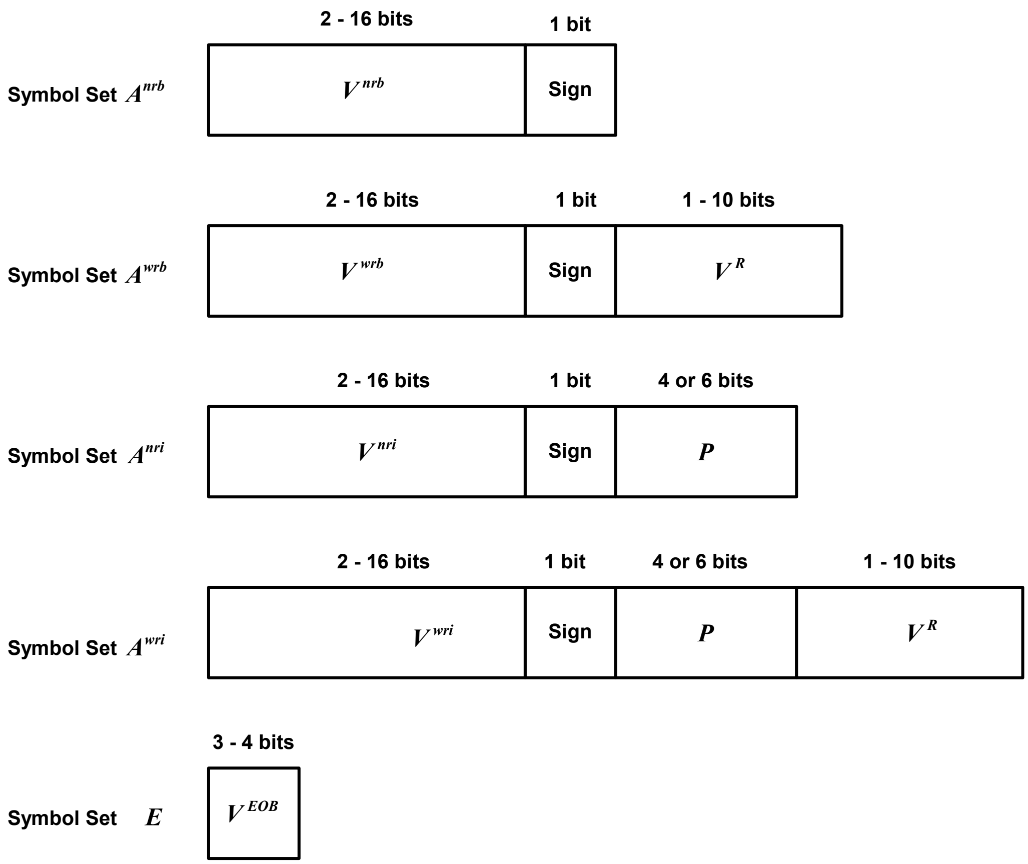

Figure A.2 – Variable-length code word bit lengths and format

Informative Description of the Entropy Codeword Format

Note: The remainder of this annex is an informative description.

The categorization of non-zero coefficient amplitudes into one of the four possible sets depends on the amplitude value (A) and the absence or presence of preceding zero-valued coefficients.

The range of A is partitioned into two sub-ranges: a base range for amplitudes between 1 and 64 and an index range for amplitudes between 65 and 4096. The index range is broken down into a number of segments, each of length 64. Amplitudes in the index range are encoded with a variable-length codeword and an index value, P . On the other hand, amplitudes in the base range do not require an index value.

For video sampled with a bit-depth of 10, P requires 6 bits. P requires 4 bits when 8-bit video sampling is used.

Coefficients with no preceding run of zeros are considered a different type of symbol from those that have one or more preceding zero-valued coefficients. If there is one or more preceding zero-valued coefficients, the amplitude is encoded with a variable-length codeword (and, possibly an index value) and followed by another variable-length codeword representing the length of the preceding run of zeros. If there is no preceding run of zeros, the amplitude is encoded with a single variable-length codeword (and, possibly an index value). The codeword for a coefficient with a given amplitude and no preceding run of zeros is different than the codeword with the same amplitude which does have a preceding run of zeros. This enables the decoder to differentiate between the presence or absence of preceding zeros.

Annex B (Informative)
User Data Control and Payload Field Usage

The UDL field and 260B User Data Payload area (See Sections 7.1.8 and 7.1.9) are used to respectively carry user data type-IDs and payloads. This standard does not specifically define data types or payload mappings. However, it does provide for future mappings using the 4 bit UDL field. Each bit of this field will be associated with a distinct data type. A UDL bit value of 0b will indicate that the defined data type is not present as payload data and a value of 1b will indicate that the corresponding data type is present. Additional SMPTE documentation will be written to define the data type and exact mapping formula for the payload data.

As an example, carriage of SMPTE 291M Ancillary Data fields in the payload area could be defined as one of the four permissible payloads. It is anticipated that UDL mappings to distinct data types and their corresponding payload definitions will be done outside this document at some future date through the SMPTE standardization process.

Annex C (Normative)
Quantization Weighting Tables

Compression ID 1235

Luma Quantization Weighting Table							
-	32	32	32	33	35	38	39
32	33	32	33	36	36	39	42
32	32	33	36	35	37	41	43
31	33	34	36	36	40	42	48
32	34	36	37	39	42	46	51
36	37	37	39	41	46	51	55
37	39	41	41	47	50	55	56
41	42	41	44	50	53	60	60

Chroma Quantization Weighting Table							
-	32	33	34	39	41	54	59
33	34	35	38	43	49	58	84
34	37	39	44	46	55	74	87
40	42	47	48	58	70	87	86
43	50	56	63	72	94	91	82
55	63	65	75	93	89	85	73
61	67	82	81	83	90	79	73
74	84	75	78	90	85	73	73

Compression ID 1237 and 1253

Luma Quantization Weighting Table							
-	32	36	37	41	44	54	60
33	34	36	39	43	51	62	78
34	36	38	41	49	59	73	79
37	38	40	47	55	66	80	95
38	41	46	54	63	79	93	96
46	47	56	64	78	90	97	98
49	58	66	78	89	97	102	98
61	65	82	87	100	104	99	99

Chroma Quantization Weighting Table							
-	32	38	39	47	51	77	83
36	39	41	48	55	74	85	95
39	45	53	58	72	83	105	89
51	58	66	73	82	109	92	95
57	75	78	89	105	95	93	96
81	82	99	99	94	90	97	98
83	96	97	93	89	97	102	98
90	94	92	88	100	104	99	99

Compression ID 1238

Luma Quantization Weighting Table							
-	32	33	33	37	37	41	42
32	34	33	35	36	38	41	43
33	33	33	36	37	39	41	44
33	33	35	36	38	40	44	50
33	36	35	38	39	44	49	51
38	36	38	39	44	47	51	58
38	39	41	44	47	51	57	59
41	42	45	47	53	55	57	57

Chroma Quantization Weighting Table							
-	32	34	34	40	41	55	61
35	35	35	39	42	52	62	75
35	39	41	44	52	58	68	77
43	45	48	53	58	65	74	80
45	55	59	63	66	74	76	89
59	65	66	70	77	73	90	84
63	66	74	76	73	82	86	82
65	70	73	73	77	80	82	82

Compression ID 1241

Luma Quantization Weighting Table							
-	32	35	36	39	40	45	45
33	34	37	39	40	43	46	46
34	36	38	38	42	47	46	46
37	38	38	41	46	45	47	49
38	39	41	45	45	47	48	50
38	39	43	44	46	47	49	48
37	39	40	44	45	48	48	49
37	37	42	43	46	47	49	49

Chroma Quantization Weighting Table							
-	32	37	40	41	41	45	45
36	37	41	41	42	45	46	48
38	40	41	43	45	47	48	46
40	42	44	44	46	48	47	49
42	44	45	45	47	47	48	50
45	46	44	45	46	47	49	48
46	42	45	47	45	48	49	49
41	43	46	45	46	48	49	49

Compression ID 1242

Luma Quantization Weighting Table							
-	32	35	36	38	37	40	42
33	34	35	37	37	37	45	49
33	33	37	37	36	46	48	50
33	36	36	37	44	46	52	51
35	37	39	41	48	52	51	50
37	38	42	50	50	50	49	49
37	44	49	49	50	49	51	47
45	47	47	48	51	52	47	47

Chroma Quantization Weighting Table							
-	32	45	45	51	47	45	47
37	45	44	49	41	47	50	51
42	38	44	40	47	51	49	51
37	42	43	51	49	48	52	54
40	44	54	46	51	52	54	53
46	51	47	55	54	53	53	60
48	49	55	54	52	55	62	60
47	50	49	49	59	63	60	60

Compression ID 1243

Luma Quantization Weighting Table							
-	32	35	35	38	40	44	45
32	33	35	35	39	42	44	45
33	35	34	37	41	42	45	45
35	35	37	40	41	44	45	48
35	37	38	40	43	45	47	48
36	36	38	40	45	47	48	47
35	36	38	41	45	46	47	48
36	37	39	41	44	45	47	47

Chroma Quantization Weighting Table							
-	32	37	39	41	42	45	45
36	36	39	41	43	45	46	45
37	41	41	43	45	44	45	46
43	42	43	46	44	45	46	48
43	44	47	45	44	46	47	49
44	46	44	45	45	47	48	47
44	42	46	44	45	46	47	48
41	43	45	44	45	46	47	47

Compression ID 1250

Luma Quantization Weighting Table							
-	32	35	35	36	36	41	43
32	34	35	36	37	39	43	47
33	34	36	38	38	42	42	50
34	36	38	38	41	40	47	54
35	38	39	40	39	45	49	58
38	39	40	39	46	47	54	60
38	39	41	46	46	48	57	62
40	41	44	45	49	54	63	63

Chroma Quantization Weighting Table							
-	32	35	36	40	42	51	51
35	36	39	39	43	51	52	55
36	41	41	43	51	53	54	56
43	44	45	50	54	54	55	57
45	48	50	51	55	58	59	58
49	52	49	57	58	62	58	60
51	51	56	58	62	61	59	62
52	52	60	61	59	59	63	63

Compression ID 1251

Luma Quantization Weighting Table							
-	32	34	34	35	36	41	44
32	34	35	36	38	39	43	46
34	35	36	38	38	41	43	46
35	37	38	38	40	40	44	55
36	38	38	40	39	44	50	58
38	38	40	40	44	48	53	61
38	40	41	42	46	48	58	62
39	40	41	43	50	55	62	62

Chroma Quantization Weighting Table							
-	32	35	36	40	42	51	51
35	36	39	39	43	51	52	55
36	41	41	43	51	53	54	56
43	44	45	50	54	54	55	57
45	48	50	51	55	58	59	58
48	50	49	57	58	62	58	61
48	51	56	58	62	61	59	62
52	52	60	61	59	59	62	62

Compression ID 1252

Luma Quantization Weighting Table							
-	32	36	36	40	40	55	60
34	36	37	40	41	48	57	82
35	36	41	41	46	52	73	82
37	40	42	45	50	65	80	87
39	41	44	49	62	78	88	90
41	44	49	58	73	90	95	95
43	52	55	68	90	100	97	93
52	53	71	82	107	103	99	99

Chroma Quantization Weighting Table							
-	32	37	38	49	53	65	66
35	37	40	49	56	64	65	82
36	42	50	56	64	67	73	85
46	50	57	63	71	72	89	87
49	58	65	72	78	88	88	90
60	64	74	81	84	90	95	134
62	74	77	80	90	114	129	125
74	74	90	100	128	125	116	116

Annex D (Normative)
VLC Tables

Compression ID 1235, 1241

Table D.1 – Amplitude VLC Table for Compression ID 1235 and 1241

Codeword	Length	Amp	Run Flag F_{run}	Index Flag F_{index}
00	2	1	0	0
01	2	1	1	0
100	3	2	0	0
1010	4	3	0	0
1011	4	eob	0	0
11000	5	4	0	0
11001	5	5	0	0
11010	5	2	1	0
110110	6	6	0	0
110111	6	7	0	0
111000	6	8	0	0
111001	6	3	1	0
1110100	7	9	0	0
1110101	7	10	0	0
1110110	7	11	0	0
1110111	7	4	1	0
11110000	8	12	0	0
11110001	8	13	0	0
11110010	8	14	0	0
11110011	8	15	0	0
11110100	8	16	0	0
11110101	8	5	1	0
111101100	9	17	0	0
111101101	9	18	0	0
111101110	9	19	0	0
111101111	9	20	0	0
111110000	9	21	0	0
111110001	9	6	1	0
111110010	9	7	1	0
1111100110	10	22	0	0
1111100111	10	23	0	0
1111101000	10	24	0	0
1111101001	10	25	0	0
1111101010	10	26	0	0
1111101011	10	27	0	0
1111101100	10	28	0	0
1111101101	10	29	0	0
1111101110	10	8	1	0
1111101111	10	9	1	0
11111100000	11	30	0	0
11111100001	11	31	0	0
11111100010	11	32	0	0
11111100011	11	33	0	0
11111100100	11	34	0	0
11111100101	11	35	0	0
11111100110	11	36	0	0
11111100111	11	37	0	0
11111101000	11	38	0	0
11111101001	11	10	1	0
11111101010	11	11	1	0
111111010110	12	39	0	0
111111010111	12	40	0	0
111111011000	12	41	0	0
111111011001	12	42	0	0
111111011010	12	43	0	0
111111011011	12	44	0	0
111111011100	12	45	0	0
111111011101	12	46	0	0
111111011110	12	47	0	0
111111011111	12	48	0	0
111111100000	12	49	0	0
111111100001	12	50	0	0
111111100010	12	12	1	0
111111100011	12	13	1	0
111111100100	12	14	1	0
111111100101	12	15	1	0

1111111001100	13	51	0	0
1111111001101	13	52	0	0
1111111001110	13	53	0	0
1111111001111	13	54	0	0
1111111010000	13	55	0	0
1111111010001	13	56	0	0
1111111010010	13	57	0	0
1111111010011	13	58	0	0
1111111010100	13	59	0	0
1111111010101	13	60	0	0
1111111010110	13	61	0	0
1111111010111	13	62	0	0
1111111011000	13	63	0	0
1111111011001	13	1	0	1
1111111011010	13	16	1	0
1111111011011	13	17	1	0
1111111011100	13	18	1	0
1111111011101	13	19	1	0
11111110111100	14	64	0	0
11111110111101	14	2	0	1
11111110111110	14	3	0	1
11111110111111	14	4	0	1
11111111000000	14	5	0	1
11111111000001	14	6	0	1
11111111000010	14	7	0	1
11111111000011	14	8	0	1
11111111000100	14	9	0	1
11111111000101	14	10	0	1
11111111000110	14	11	0	1
11111111000111	14	12	0	1
11111111001000	14	13	0	1
11111111001001	14	14	0	1
11111111001010	14	15	0	1
11111111001011	14	16	0	1
11111111001100	14	17	0	1
11111111001101	14	20	1	0
11111111001110	14	21	1	0
11111111001111	14	22	1	0
11111111010000	14	23	1	0
11111111010001	14	24	1	0
111111110100100	15	18	0	1
111111110100101	15	19	0	1
111111110100110	15	20	0	1
111111110100111	15	21	0	1
111111110101000	15	22	0	1
111111110101001	15	23	0	1
111111110101010	15	24	0	1
111111110101011	15	25	0	1
111111110101100	15	26	0	1
111111110101101	15	27	0	1
111111110101110	15	28	0	1
111111110101111	15	29	0	1
111111110110000	15	30	0	1

111111110110001	15	31	0	1
111111110110010	15	32	0	1
111111110110011	15	33	0	1
111111110110100	15	34	0	1
111111110110101	15	35	0	1
111111110110110	15	36	0	1
111111110110111	15	37	0	1
111111110111000	15	38	0	1
111111110111001	15	39	0	1
111111110111010	15	40	0	1
111111110111011	15	41	0	1
111111110111100	15	42	0	1
111111110111101	15	25	1	0
111111110111110	15	26	1	0
111111110111111	15	27	1	0
111111111000000	15	28	1	0
111111111000001	15	29	1	0
111111111000010	15	30	1	0
111111111000011	15	31	1	0
111111111000100	15	32	1	0
1111111110001010	16	43	0	1
1111111110001011	16	44	0	1
1111111110001100	16	45	0	1
1111111110001101	16	46	0	1
1111111110001110	16	47	0	1
1111111110001111	16	48	0	1
1111111110010000	16	49	0	1
1111111110010001	16	50	0	1
1111111110010010	16	51	0	1
1111111110010011	16	52	0	1
1111111110010100	16	53	0	1
1111111110010101	16	54	0	1
1111111110010110	16	55	0	1
1111111110010111	16	56	0	1
1111111110011000	16	57	0	1
1111111110011001	16	58	0	1
1111111110011010	16	59	0	1
1111111110011011	16	60	0	1
1111111110011100	16	61	0	1
1111111110011101	16	62	0	1
1111111110011110	16	63	0	1
1111111110011111	16	64	0	1
1111111110100000	16	33	1	0
1111111110100001	16	34	1	0
1111111110100010	16	35	1	0
1111111110100011	16	36	1	0
1111111110100100	16	37	1	0
1111111110100101	16	38	1	0
1111111110100110	16	39	1	0
1111111110100111	16	40	1	0
1111111110101000	16	41	1	0
1111111110101001	16	42	1	0
1111111110101010	16	43	1	0

1111111110101011	16	44	1	0
1111111110101100	16	45	1	0
1111111110101101	16	46	1	0
1111111110101110	16	47	1	0
1111111110101111	16	48	1	0
1111111110110000	16	49	1	0
1111111110110001	16	50	1	0
1111111110110010	16	51	1	0
1111111110110011	16	52	1	0
1111111110110100	16	53	1	0
1111111110110101	16	54	1	0
1111111110110110	16	55	1	0
1111111110110111	16	56	1	0
1111111110111000	16	57	1	0
1111111110111001	16	58	1	0
1111111110111010	16	59	1	0
1111111110111011	16	60	1	0
1111111110111100	16	61	1	0
1111111110111101	16	62	1	0
1111111110111110	16	63	1	0
1111111110111111	16	64	1	0
1111111111000000	16	1	1	1
1111111111000001	16	2	1	1
1111111111000010	16	3	1	1
1111111111000011	16	4	1	1
1111111111000100	16	5	1	1
1111111111000101	16	6	1	1
1111111111000110	16	7	1	1
1111111111000111	16	8	1	1
1111111111001000	16	9	1	1
1111111111001001	16	10	1	1
1111111111001010	16	11	1	1
1111111111001011	16	12	1	1
1111111111001100	16	13	1	1
1111111111001101	16	14	1	1
1111111111001110	16	15	1	1
1111111111001111	16	16	1	1
1111111111010000	16	17	1	1
1111111111010001	16	18	1	1
1111111111010010	16	19	1	1
1111111111010011	16	20	1	1
1111111111010100	16	21	1	1
1111111111010101	16	22	1	1

1111111111010110	16	23	1	1
1111111111010111	16	24	1	1
1111111111011000	16	25	1	1
1111111111011001	16	26	1	1
1111111111011010	16	27	1	1
1111111111011011	16	28	1	1
1111111111011100	16	29	1	1
1111111111011101	16	30	1	1
1111111111011110	16	31	1	1
1111111111011111	16	32	1	1
1111111111100000	16	33	1	1
1111111111100001	16	34	1	1
1111111111100010	16	35	1	1
1111111111100011	16	36	1	1
1111111111100100	16	37	1	1
1111111111100101	16	38	1	1
1111111111100110	16	39	1	1
1111111111100111	16	40	1	1
1111111111101000	16	41	1	1
1111111111101001	16	42	1	1
1111111111101010	16	43	1	1
1111111111101011	16	44	1	1
1111111111101100	16	45	1	1
1111111111101101	16	46	1	1
1111111111101110	16	47	1	1
1111111111101111	16	48	1	1
1111111111110000	16	49	1	1
1111111111110001	16	50	1	1
1111111111110010	16	51	1	1
1111111111110011	16	52	1	1
1111111111110100	16	53	1	1
1111111111110101	16	54	1	1
1111111111110110	16	55	1	1
1111111111110111	16	56	1	1
1111111111111000	16	57	1	1
1111111111111001	16	58	1	1
1111111111111010	16	59	1	1
1111111111111011	16	60	1	1
1111111111111100	16	61	1	1
1111111111111101	16	62	1	1
1111111111111110	16	63	1	1
1111111111111111	16	64	1	1

Table D.2 – Run VLC Table for Compression IDs 1235 and 1241

Codeword	Length	Run
0	1	1
100	3	2
1010	4	3
1011	4	4
11000	5	5
11001	5	6
11010	5	7
11011	5	8
111000	6	9
111001	6	10
111010	6	11
111011	6	12
1111000	7	13
11110010	8	14
111100110	9	15
111100111	9	16
111101000	9	18
111101001	9	20
1111010100	10	17
1111010101	10	19
1111010110	10	21
1111010111	10	22
1111011000	10	23
1111011001	10	24
1111011010	10	25
1111011011	10	26
1111011100	10	27
1111011101	10	28
1111011110	10	29
1111011111	10	30
1111100000	10	31

Codeword	Length	Run
1111100001	10	32
1111100010	10	33
1111100011	10	34
1111100100	10	35
1111100101	10	36
1111100110	10	37
1111100111	10	38
1111101000	10	39
1111101001	10	40
1111101010	10	41
1111101011	10	42
1111101100	10	43
1111101101	10	44
1111101110	10	45
1111101111	10	46
1111110000	10	47
1111110001	10	48
1111110010	10	49
1111110011	10	50
1111110100	10	51
1111110101	10	52
1111110110	10	53
1111110111	10	54
1111111000	10	55
1111111001	10	56
1111111010	10	57
1111111011	10	58
1111111100	10	59
1111111101	10	60
1111111110	10	61
1111111111	10	62

Table D.3 – DC VLC Table for Compression IDs 1235 and 1241

Codeword	η
1010	0
111110	1
1011	2
1100	3
1101	4
000	5
001	6
010	7
011	8
100	9
1110	10
11110	11
1111110	12
1111111	13

VCL Tables for Compression ID 1237, 1242 and 1253

Table D.4 – Amplitude VLC Table for Compression ID 1237, 1242 and 1253

Codeword	Length	Amp	Run Flag F_{run}	Index Flag F_{index}
00	2	1	0	0
01	2	1	1	0
100	3	2	0	0
101	3	eob	0	0
1100	4	3	0	0
11010	5	4	0	0
11011	5	2	1	0
111000	6	5	0	0
111001	6	6	0	0
111010	6	7	0	0
111011	6	3	1	0
1111000	7	8	0	0
1111001	7	9	0	0
11110100	8	10	0	0
11110101	8	11	0	0
11110110	8	12	0	0
11110111	8	4	1	0
11111000	8	5	1	0
111110010	9	13	0	0
111110011	9	14	0	0
111110100	9	15	0	0
111110101	9	16	0	0
111110110	9	6	1	0
1111101110	10	17	0	0
1111101111	10	18	0	0
1111110000	10	19	0	0
1111110001	10	20	0	0
1111110010	10	21	0	0
1111110011	10	7	1	0
11111101000	11	22	0	0
11111101001	11	23	0	0
11111101010	11	24	0	0
11111101011	11	25	0	0
11111101100	11	26	0	0
11111101101	11	27	0	0
11111101110	11	8	1	0
11111101111	11	9	1	0
111111100000	12	28	0	0
111111100001	12	29	0	0
111111100010	12	30	0	0
111111100011	12	31	0	0
111111100100	12	32	0	0
111111100101	12	33	0	0
111111100110	12	34	0	0
111111100111	12	10	1	0
111111101000	12	11	1	0
111111101001	12	12	1	0
1111111010100	13	35	0	0
1111111010101	13	36	0	0
1111111010110	13	37	0	0
1111111010111	13	38	0	0
1111111011000	13	39	0	0
1111111011001	13	40	0	0
1111111011010	13	41	0	0
1111111011011	13	13	1	0
1111111011100	13	14	1	0
1111111011101	13	15	1	0
1111111011110	13	16	1	0
11111110111110	14	42	0	0
11111110111111	14	43	0	0
11111111000000	14	44	0	0
11111111000001	14	45	0	0
11111111000010	14	46	0	0
11111111000011	14	47	0	0
11111111000100	14	48	0	0
11111111000101	14	49	0	0
11111111000110	14	50	0	0
11111111000111	14	51	0	0
11111111001000	14	52	0	0
11111111001001	14	17	1	0
11111111001010	14	18	1	0
11111111001011	14	19	1	0
11111111001100	14	20	1	0
11111111001101	14	21	1	0
111111110011100	15	53	0	0
111111110011101	15	54	0	0
111111110011110	15	55	0	0
111111110011111	15	56	0	0
111111110100000	15	57	0	0
111111110100001	15	58	0	0
111111110100010	15	59	0	0
111111110100011	15	60	0	0
111111110100100	15	61	0	0
111111110100101	15	64	0	0
111111110100110	15	1	0	1
111111110100111	15	22	1	0
111111110101000	15	23	1	0
111111110101001	15	24	1	0

111111110101010	15	25	1	0
111111110101011	15	26	1	0
111111110101100	15	27	1	0
1111111101011010	16	62	0	0
1111111101011011	16	63	0	0
1111111101011100	16	2	0	1
1111111101011101	16	3	0	1
1111111101011110	16	4	0	1
1111111101011111	16	5	0	1
1111111101100000	16	6	0	1
1111111101100001	16	7	0	1
1111111101100010	16	8	0	1
1111111101100011	16	9	0	1
1111111101100100	16	10	0	1
1111111101100101	16	11	0	1
1111111101100110	16	12	0	1
1111111101100111	16	13	0	1
1111111101101000	16	14	0	1
1111111101101001	16	15	0	1
1111111101101010	16	16	0	1
1111111101101011	16	17	0	1
1111111101101100	16	18	0	1
1111111101101101	16	19	0	1
1111111101101110	16	20	0	1
1111111101101111	16	21	0	1
1111111101110000	16	22	0	1
1111111101110001	16	23	0	1
1111111101110010	16	24	0	1
1111111101110011	16	25	0	1
1111111101110100	16	26	0	1
1111111101110101	16	27	0	1
1111111101110110	16	28	0	1
1111111101110111	16	29	0	1
1111111101111000	16	30	0	1
1111111101111001	16	31	0	1
1111111101111010	16	32	0	1
1111111101111011	16	33	0	1
1111111101111100	16	34	0	1
1111111101111101	16	35	0	1
1111111101111110	16	36	0	1
1111111101111111	16	37	0	1
1111111110000000	16	38	0	1
1111111110000001	16	39	0	1
1111111110000010	16	40	0	1
1111111110000011	16	41	0	1
1111111110000100	16	42	0	1
1111111110000101	16	43	0	1
1111111110000110	16	44	0	1
1111111110000111	16	45	0	1
1111111110001000	16	46	0	1
1111111110001001	16	47	0	1
1111111110001010	16	48	0	1
1111111110001011	16	49	0	1

1111111110001100	16	50	0	1
1111111110001101	16	51	0	1
1111111110001110	16	52	0	1
1111111110001111	16	53	0	1
1111111110010000	16	54	0	1
1111111110010001	16	55	0	1
1111111110010010	16	56	0	1
1111111110010011	16	57	0	1
1111111110010100	16	58	0	1
1111111110010101	16	59	0	1
1111111110010110	16	60	0	1
1111111110010111	16	61	0	1
1111111110011000	16	62	0	1
1111111110011001	16	63	0	1
1111111110011010	16	64	0	1
1111111110011011	16	28	1	0
1111111110011100	16	29	1	0
1111111110011101	16	30	1	0
1111111110011110	16	31	1	0
1111111110011111	16	32	1	0
1111111110100000	16	33	1	0
1111111110100001	16	34	1	0
1111111110100010	16	35	1	0
1111111110100011	16	36	1	0
1111111110100100	16	37	1	0
1111111110100101	16	38	1	0
1111111110100110	16	39	1	0
1111111110100111	16	40	1	0
1111111110101000	16	41	1	0
1111111110101001	16	42	1	0
1111111110101010	16	43	1	0
1111111110101011	16	44	1	0
1111111110101100	16	45	1	0
1111111110101101	16	46	1	0
1111111110101110	16	47	1	0
1111111110101111	16	48	1	0
1111111110110000	16	49	1	0
1111111110110001	16	50	1	0
1111111110110010	16	51	1	0
1111111110110011	16	52	1	0
1111111110110100	16	53	1	0
1111111110110101	16	54	1	0
1111111110110110	16	55	1	0
1111111110110111	16	56	1	0
1111111110111000	16	57	1	0
1111111110111001	16	58	1	0
1111111110111010	16	59	1	0
1111111110111011	16	60	1	0
1111111110111100	16	61	1	0
1111111110111101	16	62	1	0
1111111110111110	16	63	1	0
1111111110111111	16	64	1	0
1111111111000000	16	1	1	1

1111111111000001	16	2	1	1
1111111111000010	16	3	1	1
1111111111000011	16	4	1	1
1111111111000100	16	5	1	1
1111111111000101	16	6	1	1
1111111111000110	16	7	1	1
1111111111000111	16	8	1	1
1111111111001000	16	9	1	1
1111111111001001	16	10	1	1
1111111111001010	16	11	1	1
1111111111001011	16	12	1	1
1111111111001100	16	13	1	1
1111111111001101	16	14	1	1
1111111111001110	16	15	1	1
1111111111001111	16	16	1	1
1111111111010000	16	17	1	1
1111111111010001	16	18	1	1
1111111111010010	16	19	1	1
1111111111010011	16	20	1	1
1111111111010100	16	21	1	1
1111111111010101	16	22	1	1
1111111111010110	16	23	1	1
1111111111010111	16	24	1	1
1111111111011000	16	25	1	1
1111111111011001	16	26	1	1
1111111111011010	16	27	1	1
1111111111011011	16	28	1	1
1111111111011100	16	29	1	1
1111111111011101	16	30	1	1
1111111111011110	16	31	1	1
1111111111011111	16	32	1	1
1111111111100000	16	33	1	1

1111111111100001	16	34	1	1
1111111111100010	16	35	1	1
1111111111100011	16	36	1	1
1111111111100100	16	37	1	1
1111111111100101	16	38	1	1
1111111111100110	16	39	1	1
1111111111100111	16	40	1	1
1111111111101000	16	41	1	1
1111111111101001	16	42	1	1
1111111111101010	16	43	1	1
1111111111101011	16	44	1	1
1111111111101100	16	45	1	1
1111111111101101	16	46	1	1
1111111111101110	16	47	1	1
1111111111101111	16	48	1	1
1111111111110000	16	49	1	1
1111111111110001	16	50	1	1
1111111111110010	16	51	1	1
1111111111110011	16	52	1	1
1111111111110100	16	53	1	1
1111111111110101	16	54	1	1
1111111111110110	16	55	1	1
1111111111110111	16	56	1	1
1111111111111000	16	57	1	1
1111111111111001	16	58	1	1
1111111111111010	16	59	1	1
1111111111111011	16	60	1	1
1111111111111100	16	61	1	1
1111111111111101	16	62	1	1
1111111111111110	16	63	1	1
1111111111111111	16	64	1	1

Table D.5 – Run VLC Table for Compression ID 1237, 1242 and 1253

Codeword	Length	Run
0	1	1
100	3	2
1010	4	3
1011	4	4
11000	5	5
11001	5	6
11010	5	7
110110	6	8
110111	6	9
111000	6	10
111001	6	11
111010	6	12
1110110	7	13
1110111	7	14
11110000	8	15
111100010	9	16
111100011	9	17
111100100	9	18
111100101	9	19
111100110	9	20
111100111	9	21
111101000	9	53
111101001	9	57
111101010	9	58
111101011	9	59
111101100	9	60
111101101	9	61
111101110	9	62
1111011110	10	22
1111011111	10	23
1111100000	10	24

Codeword	Length	Run
1111100001	10	25
1111100010	10	26
1111100011	10	27
1111100100	10	28
1111100101	10	29
1111100110	10	30
1111100111	10	31
1111101000	10	32
1111101001	10	33
1111101010	10	34
1111101011	10	35
1111101100	10	36
1111101101	10	37
1111101110	10	38
1111101111	10	39
1111110000	10	40
1111110001	10	41
1111110010	10	42
1111110011	10	43
1111110100	10	44
1111110101	10	45
1111110110	10	46
1111110111	10	47
1111111000	10	48
1111111001	10	49
1111111010	10	50
1111111011	10	51
1111111100	10	52
1111111101	10	54
1111111110	10	55
1111111111	10	56

Table D.6 – DC Differential VLC Table for Compression ID 1237, 1242 and 1253

Codeword	η
000	0
1100	1
1101	2
001	3
010	4
011	5
100	6
101	7
1110	8
11110	9
111110	10
111111	11

VCL Tables for Compression ID 1238 and 1243

Table D.7 – Amplitude VLC Table for Compression ID 1238 and 1243

Codeword	Length	Amp	Run Flag F_{run}	Index Flag F_{index}
00	2	1	0	0
01	2	1	1	0
100	3	2	0	0
1010	4	3	0	0
1011	4	eob	0	0
11000	5	4	0	0
11001	5	5	0	0
11010	5	2	1	0
110110	6	6	0	0
110111	6	7	0	0
111000	6	8	0	0
111001	6	3	1	0
1110100	7	9	0	0
1110101	7	10	0	0
1110110	7	11	0	0
1110111	7	4	1	0
11110000	8	12	0	0
11110001	8	13	0	0
11110010	8	14	0	0
11110011	8	15	0	0
11110100	8	16	0	0
11110101	8	5	1	0
111101100	9	17	0	0
111101101	9	18	0	0
111101110	9	19	0	0
111101111	9	20	0	0
111110000	9	21	0	0
111110001	9	22	0	0
111110010	9	6	1	0
111110011	9	7	1	0
1111101000	10	23	0	0
1111101001	10	24	0	0
1111101010	10	25	0	0
1111101011	10	26	0	0
1111101100	10	27	0	0
1111101101	10	28	0	0
1111101110	10	29	0	0
1111101111	10	8	1	0
1111110000	10	9	1	0
11111100010	11	30	0	0
11111100011	11	31	0	0
11111100100	11	32	0	0
11111100101	11	33	0	0
11111100110	11	34	0	0
11111100111	11	35	0	0
11111101000	11	36	0	0
11111101001	11	37	0	0
11111101010	11	10	1	0
11111101011	11	11	1	0
111111011000	12	38	0	0
111111011001	12	39	0	0
111111011010	12	40	0	0
111111011011	12	41	0	0
111111011100	12	42	0	0
111111011101	12	43	0	0
111111011110	12	44	0	0
111111011111	12	45	0	0
111111100000	12	46	0	0
111111100001	12	47	0	0
111111100010	12	48	0	0
111111100011	12	12	1	0
111111100100	12	13	1	0
111111100101	12	14	1	0
1111111001100	13	49	0	0
1111111001101	13	50	0	0
1111111001110	13	51	0	0
1111111001111	13	52	0	0
1111111010000	13	53	0	0
1111111010001	13	54	0	0
1111111010010	13	55	0	0
1111111010011	13	56	0	0
1111111010100	13	57	0	0
1111111010101	13	58	0	0
1111111010110	13	59	0	0
1111111010111	13	60	0	0
1111111011000	13	61	0	0
1111111011001	13	15	1	0
1111111011010	13	16	1	0
1111111011011	13	17	1	0
1111111011100	13	18	1	0
11111110111010	14	62	0	0
11111110111011	14	63	0	0
11111110111100	14	64	0	0
11111110111101	14	1	0	1
11111110111110	14	2	0	1
11111110111111	14	3	0	1
11111111000000	14	4	0	1
11111111000001	14	5	0	1
11111111000010	14	6	0	1
11111111000011	14	7	0	1
11111111000100	14	8	0	1
11111111000101	14	9	0	1
11111111000110	14	10	0	1
11111111000111	14	11	0	1
11111111001000	14	12	0	1
11111111001001	14	13	0	1

11111111001010	14	14	0	1
11111111001011	14	15	0	1
11111111001100	14	16	0	1
11111111001101	14	19	1	0
11111111001110	14	20	1	0
11111111001111	14	21	1	0
11111111010000	14	22	1	0
11111111010001	14	23	1	0
11111111010010	14	24	1	0
111111110100110	15	17	0	1
111111110100111	15	18	0	1
111111110101000	15	19	0	1
111111110101001	15	20	0	1
111111110101010	15	21	0	1
111111110101011	15	22	0	1
111111110101100	15	23	0	1
111111110101101	15	24	0	1
111111110101110	15	25	0	1
111111110101111	15	26	0	1
111111110110000	15	27	0	1
111111110110001	15	28	0	1
111111110110010	15	29	0	1
111111110110011	15	30	0	1
111111110110100	15	31	0	1
111111110110101	15	32	0	1
111111110110110	15	33	0	1
111111110110111	15	34	0	1
111111110111000	15	35	0	1
111111110111001	15	36	0	1
111111110111010	15	37	0	1
111111110111011	15	40	0	1
111111110111100	15	25	1	0
111111110111101	15	26	1	0
111111110111110	15	27	1	0
111111110111111	15	28	1	0
111111111000000	15	29	1	0
111111111000001	15	30	1	0
1111111110000100	16	38	0	1
1111111110000101	16	39	0	1
1111111110000110	16	41	0	1
1111111110000111	16	42	0	1
1111111110001000	16	43	0	1
1111111110001001	16	44	0	1
1111111110001010	16	45	0	1
1111111110001011	16	46	0	1
1111111110001100	16	47	0	1
1111111110001101	16	48	0	1
1111111110001110	16	49	0	1
1111111110001111	16	50	0	1
1111111110010000	16	51	0	1
1111111110010001	16	52	0	1
1111111110010010	16	53	0	1
1111111110010011	16	54	0	1
1111111110010100	16	55	0	1
1111111110010101	16	56	0	1
1111111110010110	16	57	0	1

1111111110010111	16	58	0	1
1111111110011000	16	59	0	1
1111111110011001	16	60	0	1
1111111110011010	16	61	0	1
1111111110011011	16	62	0	1
1111111110011100	16	63	0	1
1111111110011101	16	64	0	1
1111111110011110	16	31	1	0
1111111110011111	16	32	1	0
1111111110100000	16	33	1	0
1111111110100001	16	34	1	0
1111111110100010	16	35	1	0
1111111110100011	16	36	1	0
1111111110100100	16	37	1	0
1111111110100101	16	38	1	0
1111111110100110	16	39	1	0
1111111110100111	16	40	1	0
1111111110101000	16	41	1	0
1111111110101001	16	42	1	0
1111111110101010	16	43	1	0
1111111110101011	16	44	1	0
1111111110101100	16	45	1	0
1111111110101101	16	46	1	0
1111111110101110	16	47	1	0
1111111110101111	16	48	1	0
1111111110110000	16	49	1	0
1111111110110001	16	50	1	0
1111111110110010	16	51	1	0
1111111110110011	16	52	1	0
1111111110110100	16	53	1	0
1111111110110101	16	54	1	0
1111111110110110	16	55	1	0
1111111110110111	16	56	1	0
1111111110111000	16	57	1	0
1111111110111001	16	58	1	0
1111111110111010	16	59	1	0
1111111110111011	16	60	1	0
1111111110111100	16	61	1	0
1111111110111101	16	62	1	0
1111111110111110	16	63	1	0
1111111110111111	16	64	1	0
1111111111000000	16	1	1	1
1111111111000001	16	2	1	1
1111111111000010	16	3	1	1
1111111111000011	16	4	1	1
1111111111000100	16	5	1	1
1111111111000101	16	6	1	1
1111111111000110	16	7	1	1
1111111111000111	16	8	1	1
1111111111001000	16	9	1	1
1111111111001001	16	10	1	1
1111111111001010	16	11	1	1
1111111111001011	16	12	1	1
1111111111001100	16	13	1	1
1111111111001101	16	14	1	1
1111111111001110	16	15	1	1

1111111111001111	16	16	1	1
1111111111010000	16	17	1	1
1111111111010001	16	18	1	1
1111111111010010	16	19	1	1
1111111111010011	16	20	1	1
1111111111010100	16	21	1	1
1111111111010101	16	22	1	1
1111111111010110	16	23	1	1
1111111111010111	16	24	1	1
1111111111011000	16	25	1	1
1111111111011001	16	26	1	1
1111111111011010	16	27	1	1
1111111111011011	16	28	1	1
1111111111011100	16	29	1	1
1111111111011101	16	30	1	1
1111111111011110	16	31	1	1
1111111111011111	16	32	1	1
1111111111100000	16	33	1	1
1111111111100001	16	34	1	1
1111111111100010	16	35	1	1
1111111111100011	16	36	1	1
1111111111100100	16	37	1	1
1111111111100101	16	38	1	1
1111111111100110	16	39	1	1
1111111111100111	16	40	1	1

1111111111101000	16	41	1	1
1111111111101001	16	42	1	1
1111111111101010	16	43	1	1
1111111111101011	16	44	1	1
1111111111101100	16	45	1	1
1111111111101101	16	46	1	1
1111111111101110	16	47	1	1
1111111111101111	16	48	1	1
1111111111110000	16	49	1	1
1111111111110001	16	50	1	1
1111111111110010	16	51	1	1
1111111111110011	16	52	1	1
1111111111110100	16	53	1	1
1111111111110101	16	54	1	1
1111111111110110	16	55	1	1
1111111111110111	16	56	1	1
1111111111111000	16	57	1	1
1111111111111001	16	58	1	1
1111111111111010	16	59	1	1
1111111111111011	16	60	1	1
1111111111111100	16	61	1	1
1111111111111101	16	62	1	1
1111111111111110	16	63	1	1
1111111111111111	16	64	1	1

Table D.8 – Run VLC Table for Compression ID 1238 and 1243

Codeword	Length	Run
0	1	1
100	3	2
1010	4	3
1011	4	4
11000	5	5
11001	5	6
11010	5	7
11011	5	8
111000	6	9
111001	6	10
111010	6	11
111011	6	12
1111000	7	13
11110010	8	14
111100110	9	15
111100111	9	16
111101000	9	20
111101001	9	21
1111010100	10	17
1111010101	10	18
1111010110	10	19
1111010111	10	22
1111011000	10	23
1111011001	10	24
1111011010	10	25
1111011011	10	26
1111011100	10	27
1111011101	10	28
1111011110	10	29
1111011111	10	30
1111100000	10	31
1111100001	10	32
1111100010	10	33
1111100011	10	34
1111100100	10	35
1111100101	10	36
1111100110	10	37
1111100111	10	38
1111101000	10	39
1111101001	10	40
1111101010	10	41
1111101011	10	42
1111101100	10	43
1111101101	10	44
1111101110	10	45
1111101111	10	46
1111110000	10	47
1111110001	10	48
1111110010	10	49
1111110011	10	50
1111110100	10	51
1111110101	10	52
1111110110	10	53
1111110111	10	54
1111111000	10	55
1111111001	10	56
1111111010	10	57
1111111011	10	58
1111111100	10	59
1111111101	10	60
1111111110	10	61
1111111111	10	62

Table D.9 – DC Differential VLC Table for Compression ID 1238 and 1243

Codeword	η
000	0
1100	1
1101	2
001	3
010	4
011	5
100	6
101	7
1110	8
11110	9
111110	10
111111	11

VCL Tables for Compression ID 1250

Table D.10 – Amplitude VLC Table for Compression ID 1250

Codeword	Length	Amp	Run Flag F_{run}	Index Flag F_{index}
00	2	1	0	0
01	2	1	1	0
100	3	2	0	0
1010	4	3	0	0
1011	4	eob	0	0
11000	5	4	0	0
11001	5	5	0	0
11010	5	2	1	0
110110	6	6	0	0
110111	6	7	0	0
111000	6	8	0	0
111001	6	3	1	0
1110100	7	9	0	0
1110101	7	10	0	0
1110110	7	11	0	0
1110111	7	4	1	0
11110000	8	12	0	0
11110001	8	13	0	0
11110010	8	14	0	0
11110011	8	15	0	0
11110100	8	16	0	0
11110101	8	5	1	0
111101100	9	17	0	0
111101101	9	18	0	0
111101110	9	19	0	0
111101111	9	20	0	0
111110000	9	21	0	0
111110001	9	22	0	0
111110010	9	6	1	0
1111100110	10	23	0	0
1111100111	10	24	0	0
1111101000	10	25	0	0
1111101001	10	26	0	0
1111101010	10	27	0	0
1111101011	10	28	0	0
1111101100	10	29	0	0
1111101101	10	7	1	0
1111101110	10	8	1	0
11111011110	11	30	0	0
11111011111	11	31	0	0
11111100000	11	32	0	0
11111100001	11	33	0	0
11111100010	11	34	0	0
11111100011	11	35	0	0

Codeword	Length	Amp	Run Flag F_{run}	Index Flag F_{index}
11111100100	11	36	0	0
11111100101	11	37	0	0
11111100110	11	38	0	0
11111100111	11	39	0	0
11111101000	11	9	1	0
11111101001	11	10	1	0
111111010100	12	40	0	0
111111010101	12	41	0	0
111111010110	12	42	0	0
111111010111	12	43	0	0
111111011000	12	44	0	0
111111011001	12	45	0	0
111111011010	12	46	0	0
111111011011	12	47	0	0
111111011100	12	48	0	0
111111011101	12	49	0	0
111111011110	12	50	0	0
111111011111	12	51	0	0
111111100000	12	52	0	0
111111100001	12	11	1	0
111111100010	12	12	1	0
111111100011	12	13	1	0
1111111001000	13	53	0	0
1111111001001	13	54	0	0
1111111001010	13	55	0	0
1111111001011	13	56	0	0
1111111001100	13	57	0	0
1111111001101	13	58	0	0
1111111001110	13	59	0	0
1111111001111	13	60	0	0
1111111010000	13	61	0	0
1111111010001	13	62	0	0
1111111010010	13	63	0	0
1111111010011	13	64	0	0
1111111010100	13	1	0	1
1111111010101	13	2	0	1
1111111010110	13	3	0	1
1111111010111	13	4	0	1
1111111011000	13	5	0	1
1111111011001	13	14	1	0
1111111011010	13	15	1	0
1111111011011	13	16	1	0
1111111011100	13	17	1	0
11111110111010	14	6	0	1

11111110111011	14	7	0	1
11111110111100	14	8	0	1
11111110111101	14	9	0	1
11111110111110	14	10	0	1
11111110111111	14	11	0	1
11111111000000	14	12	0	1
11111111000001	14	13	0	1
11111111000010	14	14	0	1
11111111000011	14	15	0	1
11111111000100	14	16	0	1
11111111000101	14	17	0	1
11111111000110	14	18	0	1
11111111000111	14	19	0	1
11111111001000	14	20	0	1
11111111001001	14	21	0	1
11111111001010	14	22	0	1
11111111001011	14	23	0	1
11111111001100	14	24	0	1
11111111001101	14	25	0	1
11111111001110	14	26	0	1
11111111001111	14	18	1	0
11111111010000	14	19	1	0
11111111010001	14	20	1	0
11111111010010	14	21	1	0
111111110100110	15	27	0	1
111111110100111	15	28	0	1
111111110101000	15	29	0	1
111111110101001	15	30	0	1
111111110101010	15	31	0	1
111111110101011	15	32	0	1
111111110101100	15	33	0	1
111111110101101	15	34	0	1
111111110101110	15	35	0	1
111111110101111	15	36	0	1
111111110110000	15	37	0	1
111111110110001	15	38	0	1
111111110110010	15	39	0	1
111111110110011	15	40	0	1
111111110110100	15	41	0	1
111111110110101	15	42	0	1
111111110110110	15	43	0	1
111111110110111	15	44	0	1
111111110111000	15	45	0	1
111111110111001	15	46	0	1
111111110111010	15	47	0	1
111111110111011	15	48	0	1
111111110111100	15	49	0	1
111111110111101	15	50	0	1
111111110111110	15	51	0	1
111111110111111	15	52	0	1
111111111000000	15	53	0	1
111111111000001	15	55	0	1
111111111000010	15	56	0	1

111111111000011	15	22	1	0
111111111000100	15	23	1	0
111111111000101	15	24	1	0
111111111000110	15	25	1	0
111111111000111	15	26	1	0
111111111001000	15	27	1	0
1111111110010010	16	54	0	1
1111111110010011	16	57	0	1
1111111110010100	16	58	0	1
1111111110010101	16	59	0	1
1111111110010110	16	60	0	1
1111111110010111	16	61	0	1
1111111110011000	16	62	0	1
1111111110011001	16	63	0	1
1111111110011010	16	64	0	1
1111111110011011	16	28	1	0
1111111110011100	16	29	1	0
1111111110011101	16	30	1	0
1111111110011110	16	31	1	0
1111111110011111	16	32	1	0
1111111110100000	16	33	1	0
1111111110100001	16	34	1	0
1111111110100010	16	35	1	0
1111111110100011	16	36	1	0
1111111110100100	16	37	1	0
1111111110100101	16	38	1	0
1111111110100110	16	39	1	0
1111111110100111	16	40	1	0
1111111110101000	16	41	1	0
1111111110101001	16	42	1	0
1111111110101010	16	43	1	0
1111111110101011	16	44	1	0
1111111110101100	16	45	1	0
1111111110101101	16	46	1	0
1111111110101110	16	47	1	0
1111111110101111	16	48	1	0
1111111110110000	16	49	1	0
1111111110110001	16	50	1	0
1111111110110010	16	51	1	0
1111111110110011	16	52	1	0
1111111110110100	16	53	1	0
1111111110110101	16	54	1	0
1111111110110110	16	55	1	0
1111111110110111	16	56	1	0
1111111110111000	16	57	1	0
1111111110111001	16	58	1	0
1111111110111010	16	59	1	0
1111111110111011	16	60	1	0
1111111110111100	16	61	1	0
1111111110111101	16	62	1	0
1111111110111110	16	63	1	0
1111111110111111	16	64	1	0
1111111111000000	16	1	1	1

1111111111000001	16	2	1	1
1111111111000010	16	3	1	1
1111111111000011	16	4	1	1
1111111111000100	16	5	1	1
1111111111000101	16	6	1	1
1111111111000110	16	7	1	1
1111111111000111	16	8	1	1
1111111111001000	16	9	1	1
1111111111001001	16	10	1	1
1111111111001010	16	11	1	1
1111111111001011	16	12	1	1
1111111111001100	16	13	1	1
1111111111001101	16	14	1	1
1111111111001110	16	15	1	1
1111111111001111	16	16	1	1
1111111111010000	16	17	1	1
1111111111010001	16	18	1	1
1111111111010010	16	19	1	1
1111111111010011	16	20	1	1
1111111111010100	16	21	1	1
1111111111010101	16	22	1	1
1111111111010110	16	23	1	1
1111111111010111	16	24	1	1
1111111111011000	16	25	1	1
1111111111011001	16	26	1	1
1111111111011010	16	27	1	1
1111111111011011	16	28	1	1
1111111111011100	16	29	1	1
1111111111011101	16	30	1	1
1111111111011110	16	31	1	1
1111111111011111	16	32	1	1
1111111111100000	16	33	1	1

1111111111100001	16	34	1	1
1111111111100010	16	35	1	1
1111111111100011	16	36	1	1
1111111111100100	16	37	1	1
1111111111100101	16	38	1	1
1111111111100110	16	39	1	1
1111111111100111	16	40	1	1
1111111111101000	16	41	1	1
1111111111101001	16	42	1	1
1111111111101010	16	43	1	1
1111111111101011	16	44	1	1
1111111111101100	16	45	1	1
1111111111101101	16	46	1	1
1111111111101110	16	47	1	1
1111111111101111	16	48	1	1
1111111111110000	16	49	1	1
1111111111110001	16	50	1	1
1111111111110010	16	51	1	1
1111111111110011	16	52	1	1
1111111111110100	16	53	1	1
1111111111110101	16	54	1	1
1111111111110110	16	55	1	1
1111111111110111	16	56	1	1
1111111111111000	16	57	1	1
1111111111111001	16	58	1	1
1111111111111010	16	59	1	1
1111111111111011	16	60	1	1
1111111111111100	16	61	1	1
1111111111111101	16	62	1	1
1111111111111110	16	63	1	1
1111111111111111	16	64	1	1

Table D.11 – Run VLC Table for Compression ID 1250

Codeword	Length	Run
0	1	1
100	3	2
101	3	3
1100	4	4
11010	5	5
11011	5	6
11100	5	7
111010	6	8
1110110	7	9
1110111	7	10
1111000	7	11
11110010	8	12
111100110	9	13
111100111	9	14
1111010000	10	15
1111010001	10	16
1111010010	10	17
1111010011	10	18
1111010100	10	19
1111010101	10	20
1111010110	10	21
1111010111	10	22
1111011000	10	23
1111011001	10	24
1111011010	10	25
1111011011	10	26
1111011100	10	27
1111011101	10	28
1111011110	10	29
1111011111	10	30
1111100000	10	31
1111100001	10	32
1111100010	10	33
1111100011	10	34
1111100100	10	35
1111100101	10	36
1111100110	10	37
1111100111	10	38
1111101000	10	39
1111101001	10	40
1111101010	10	41
1111101011	10	42
1111101100	10	43
1111101101	10	44
1111101110	10	45
1111101111	10	46
1111110000	10	47
1111110001	10	48
1111110010	10	49
1111110011	10	50
1111110100	10	51
1111110101	10	52
1111110110	10	53
1111110111	10	54
1111111000	10	55
1111111001	10	56
1111111010	10	57
1111111011	10	58
1111111100	10	59
1111111101	10	60
1111111110	10	61
1111111111	10	62

Table D.12 – DC Differential VLC Table for Compression ID 1250

Codeword	η
1010	0
111110	1
1011	2
1100	3
1101	4
000	5
001	6
010	7
011	8
100	9
1110	10
11110	11
1111110	12
1111111	13

VLC Tables for Compression ID 1251

Table D.13 – Amplitude VLC Table for Compression ID 1251

Codeword	Length	Amp	Run Flag F_{run}	Index Flag F_{index}
00	2	1	0	0
01	2	1	1	0
100	3	2	0	0
1010	4	3	0	0
1011	4	eob	0	0
11000	5	4	0	0
11001	5	5	0	0
11010	5	2	1	0
110110	6	6	0	0
110111	6	7	0	0
111000	6	8	0	0
111001	6	3	1	0
1110100	7	9	0	0
1110101	7	10	0	0
1110110	7	11	0	0
1110111	7	4	1	0
11110000	8	12	0	0
11110001	8	13	0	0
11110010	8	14	0	0
11110011	8	15	0	0
11110100	8	16	0	0
11110101	8	5	1	0
111101100	9	17	0	0
111101101	9	18	0	0
111101110	9	19	0	0
111101111	9	20	0	0
111110000	9	21	0	0
111110001	9	6	1	0
1111100100	10	22	0	0
1111100101	10	23	0	0
1111100110	10	24	0	0
1111100111	10	25	0	0
1111101000	10	26	0	0
1111101001	10	27	0	0
1111101010	10	28	0	0
1111101011	10	29	0	0
1111101100	10	7	1	0
1111101101	10	8	1	0
11111011100	11	30	0	0
11111011101	11	31	0	0
11111011110	11	32	0	0
11111011111	11	33	0	0
11111100000	11	34	0	0
11111100001	11	35	0	0
11111100010	11	36	0	0
11111100011	11	37	0	0
11111100100	11	38	0	0
11111100101	11	39	0	0
11111100110	11	40	0	0
11111100111	11	9	1	0
11111101000	11	10	1	0
11111101001	11	11	1	0
111111010100	12	41	0	0
111111010101	12	42	0	0
111111010110	12	43	0	0
111111010111	12	44	0	0
111111011000	12	45	0	0
111111011001	12	46	0	0
111111011010	12	47	0	0
111111011011	12	48	0	0
111111011100	12	49	0	0
111111011101	12	50	0	0
111111011110	12	51	0	0
111111011111	12	52	0	0
111111100000	12	12	1	0
111111100001	12	13	1	0
111111100010	12	14	1	0
1111111000110	13	53	0	0
1111111000111	13	54	0	0
1111111001000	13	55	0	0
1111111001001	13	56	0	0
1111111001010	13	57	0	0
1111111001011	13	58	0	0
1111111001100	13	59	0	0
1111111001101	13	60	0	0
1111111001110	13	61	0	0
1111111001111	13	62	0	0
1111111010000	13	63	0	0
1111111010001	13	64	0	0
1111111010010	13	1	0	1
1111111010011	13	2	0	1
1111111010100	13	3	0	1
1111111010101	13	4	0	1
1111111010110	13	5	0	1
1111111010111	13	6	0	1
1111111011000	13	7	0	1

1111111011001	13	8	0	1
1111111011010	13	15	1	0
1111111011011	13	16	1	0
1111111011100	13	17	1	0
11111110111010	14	9	0	1
11111110111011	14	10	0	1
11111110111100	14	11	0	1
11111110111101	14	12	0	1
11111110111110	14	13	0	1
11111110111111	14	14	0	1
11111111000000	14	15	0	1
11111111000001	14	16	0	1
11111111000010	14	17	0	1
11111111000011	14	18	0	1
11111111000100	14	19	0	1
11111111000101	14	20	0	1
11111111000110	14	21	0	1
11111111000111	14	22	0	1
11111111001000	14	23	0	1
11111111001001	14	24	0	1
11111111001010	14	25	0	1
11111111001011	14	26	0	1
11111111001100	14	27	0	1
11111111001101	14	28	0	1
11111111001110	14	29	0	1
11111111001111	14	18	1	0
11111111010000	14	19	1	0
11111111010001	14	20	1	0
11111111010010	14	21	1	0
11111111010011	14	22	1	0
111111110101000	15	30	0	1
111111110101001	15	31	0	1
111111110101010	15	32	0	1
111111110101011	15	33	0	1
111111110101100	15	34	0	1
111111110101101	15	35	0	1
111111110101110	15	36	0	1
111111110101111	15	37	0	1
111111110110000	15	38	0	1
111111110110001	15	39	0	1
111111110110010	15	40	0	1
111111110110011	15	41	0	1
111111110110100	15	42	0	1
111111110110101	15	43	0	1
111111110110110	15	44	0	1
111111110110111	15	45	0	1
111111110111000	15	46	0	1
111111110111001	15	47	0	1
111111110111010	15	48	0	1
111111110111011	15	49	0	1
111111110111100	15	50	0	1
111111110111101	15	51	0	1
111111110111110	15	52	0	1

111111110111111	15	53	0	1
111111111000000	15	54	0	1
111111111000001	15	55	0	1
111111111000010	15	56	0	1
111111111000011	15	57	0	1
111111111000100	15	58	0	1
111111111000101	15	23	1	0
111111111000110	15	24	1	0
111111111000111	15	25	1	0
111111111001000	15	26	1	0
111111111001001	15	27	1	0
111111111001010	15	28	1	0
1111111110010110	16	59	0	1
1111111110010111	16	60	0	1
1111111110011000	16	61	0	1
1111111110011001	16	62	0	1
1111111110011010	16	63	0	1
1111111110011011	16	64	0	1
1111111110011100	16	29	1	0
1111111110011101	16	30	1	0
1111111110011110	16	31	1	0
1111111110011111	16	32	1	0
1111111110100000	16	33	1	0
1111111110100001	16	34	1	0
1111111110100010	16	35	1	0
1111111110100011	16	36	1	0
1111111110100100	16	37	1	0
1111111110100101	16	38	1	0
1111111110100110	16	39	1	0
1111111110100111	16	40	1	0
1111111110101000	16	41	1	0
1111111110101001	16	42	1	0
1111111110101010	16	43	1	0
1111111110101011	16	44	1	0
1111111110101100	16	45	1	0
1111111110101101	16	46	1	0
1111111110101110	16	47	1	0
1111111110101111	16	48	1	0
1111111110110000	16	49	1	0
1111111110110001	16	50	1	0
1111111110110010	16	51	1	0
1111111110110011	16	52	1	0
1111111110110100	16	53	1	0
1111111110110101	16	54	1	0
1111111110110110	16	55	1	0
1111111110110111	16	56	1	0
1111111110111000	16	57	1	0
1111111110111001	16	58	1	0
1111111110111010	16	59	1	0
1111111110111011	16	60	1	0
1111111110111100	16	61	1	0
1111111110111101	16	62	1	0
1111111110111110	16	63	1	0

1111111110111111	16	64	1	0
1111111111000000	16	1	1	1
1111111111000001	16	2	1	1
1111111111000010	16	3	1	1
1111111111000011	16	4	1	1
1111111111000100	16	5	1	1
1111111111000101	16	6	1	1
1111111111000110	16	7	1	1
1111111111000111	16	8	1	1
1111111111001000	16	9	1	1
1111111111001001	16	10	1	1
1111111111001010	16	11	1	1
1111111111001011	16	12	1	1
1111111111001100	16	13	1	1
1111111111001101	16	14	1	1
1111111111001110	16	15	1	1
1111111111001111	16	16	1	1
1111111111010000	16	17	1	1
1111111111010001	16	18	1	1
1111111111010010	16	19	1	1
1111111111010011	16	20	1	1
1111111111010100	16	21	1	1
1111111111010101	16	22	1	1
1111111111010110	16	23	1	1
1111111111010111	16	24	1	1
1111111111011000	16	25	1	1
1111111111011001	16	26	1	1
1111111111011010	16	27	1	1
1111111111011011	16	28	1	1
1111111111011100	16	29	1	1
1111111111011101	16	30	1	1
1111111111011110	16	31	1	1
1111111111011111	16	32	1	1

1111111111100000	16	33	1	1
1111111111100001	16	34	1	1
1111111111100010	16	35	1	1
1111111111100011	16	36	1	1
1111111111100100	16	37	1	1
1111111111100101	16	38	1	1
1111111111100110	16	39	1	1
1111111111100111	16	40	1	1
1111111111101000	16	41	1	1
1111111111101001	16	42	1	1
1111111111101010	16	43	1	1
1111111111101011	16	44	1	1
1111111111101100	16	45	1	1
1111111111101101	16	46	1	1
1111111111101110	16	47	1	1
1111111111101111	16	48	1	1
1111111111110000	16	49	1	1
1111111111110001	16	50	1	1
1111111111110010	16	51	1	1
1111111111110011	16	52	1	1
1111111111110100	16	53	1	1
1111111111110101	16	54	1	1
1111111111110110	16	55	1	1
1111111111110111	16	56	1	1
1111111111111000	16	57	1	1
1111111111111001	16	58	1	1
1111111111111010	16	59	1	1
1111111111111011	16	60	1	1
1111111111111100	16	61	1	1
1111111111111101	16	62	1	1
1111111111111110	16	63	1	1
1111111111111111	16	64	1	1

Table D.14 – Run VLC Table for Compression ID 1251

Codeword	Length	Run
0	1	1
100	3	2
101	3	3
1100	4	4
11010	5	5
11011	5	6
11100	5	7
111010	6	8
1110110	7	9
1110111	7	10
1111000	7	11
11110010	8	12
111100110	9	13
111100111	9	14
1111010000	10	15
1111010001	10	16
1111010010	10	17
1111010011	10	18
1111010100	10	19
1111010101	10	20
1111010110	10	21
1111010111	10	22
1111011000	10	23
1111011001	10	24
1111011010	10	25
1111011011	10	26
1111011100	10	27
1111011101	10	28
1111011110	10	29
1111011111	10	30
1111100000	10	31

Codeword	Length	Run
1111100001	10	32
1111100010	10	33
1111100011	10	34
1111100100	10	35
1111100101	10	36
1111100110	10	37
1111100111	10	38
1111101000	10	39
1111101001	10	40
1111101010	10	41
1111101011	10	42
1111101100	10	43
1111101101	10	44
1111101110	10	45
1111101111	10	46
1111110000	10	47
1111110001	10	48
1111110010	10	49
1111110011	10	50
1111110100	10	51
1111110101	10	52
1111110110	10	53
1111110111	10	54
1111111000	10	55
1111111001	10	56
1111111010	10	57
1111111011	10	58
1111111100	10	59
1111111101	10	60
1111111110	10	61
1111111111	10	62

Table D.15 – DC Differential VLC Table for Compression ID 1251

Codeword	η
000	0
1100	1
1101	2
001	3
010	4
011	5
100	6
101	7
1110	8
11110	9
111110	10
111111	11

Table D.16 – Amplitude VLC Tables for Compression ID 1252

Codeword	Length	Amp	Run Flag F_{run}	Index Flag F_{index}
00	2	1	0	0
01	2	1	1	0
100	3	2	0	0
1010	4	3	0	0
1011	4	2	1	0
1100	4	eob	0	0
11010	5	4	0	0
11011	5	5	0	0
111000	6	6	0	0
111001	6	7	0	0
111010	6	3	1	0
1110110	7	8	0	0
1110111	7	9	0	0
1111000	7	10	0	0
11110010	8	11	0	0
11110011	8	12	0	0
11110100	8	13	0	0
11110101	8	14	0	0
11110110	8	4	1	0
11110111	8	5	1	0
111110000	9	15	0	0
111110001	9	16	0	0
111110010	9	17	0	0
111110011	9	18	0	0
111110100	9	6	1	0
1111101010	10	19	0	0
1111101011	10	20	0	0
1111101100	10	21	0	0
1111101101	10	22	0	0
1111101110	10	23	0	0
1111101111	10	24	0	0
1111110000	10	7	1	0
1111110001	10	8	1	0
11111100100	11	25	0	0
11111100101	11	26	0	0
11111100110	11	27	0	0
11111100111	11	28	0	0
11111101000	11	29	0	0
11111101001	11	30	0	0
11111101010	11	31	0	0
11111101011	11	32	0	0
11111101100	11	9	1	0
11111101101	11	10	1	0
111111011100	12	33	0	0
111111011101	12	34	0	0
111111011110	12	35	0	0

Codeword	Length	Amp	Run Flag F_{run}	Index Flag F_{index}
111111011111	12	36	0	0
111111100000	12	37	0	0
111111100001	12	38	0	0
111111100010	12	39	0	0
111111100011	12	40	0	0
111111100100	12	41	0	0
111111100101	12	11	1	0
111111100110	12	12	1	0
111111100111	12	13	1	0
1111111010000	13	42	0	0
1111111010001	13	43	0	0
1111111010010	13	44	0	0
1111111010011	13	45	0	0
1111111010100	13	46	0	0
1111111010101	13	47	0	0
1111111010110	13	48	0	0
1111111010111	13	49	0	0
1111111011000	13	50	0	0
1111111011001	13	51	0	0
1111111011010	13	52	0	0
1111111011011	13	53	0	0
1111111011100	13	14	1	0
1111111011101	13	15	1	0
1111111011110	13	16	1	0
11111110111110	14	54	0	0
11111110111111	14	55	0	0
11111111000000	14	56	0	0
11111111000001	14	57	0	0
11111111000010	14	58	0	0
11111111000011	14	59	0	0
11111111000100	14	60	0	0
11111111000101	14	61	0	0
11111111000110	14	62	0	0
11111111000111	14	63	0	0
11111111001000	14	64	0	0
11111111001001	14	1	0	1
11111111001010	14	2	0	1
11111111001011	14	3	0	1
11111111001100	14	17	1	0
11111111001101	14	18	1	0
11111111001110	14	19	1	0
11111111001111	14	20	1	0
111111110100000	15	4	0	1
111111110100001	15	5	0	1
111111110100010	15	6	0	1
111111110100011	15	7	0	1

111111110100100	15	8	0	1
111111110100101	15	9	0	1
111111110100110	15	10	0	1
111111110100111	15	11	0	1
111111110101000	15	12	0	1
111111110101001	15	13	0	1
111111110101010	15	14	0	1
111111110101011	15	15	0	1
111111110101100	15	16	0	1
111111110101101	15	17	0	1
111111110101110	15	18	0	1
111111110101111	15	19	0	1
111111110110000	15	20	0	1
111111110110001	15	21	0	1
111111110110010	15	21	1	0
111111110110011	15	22	1	0
111111110110100	15	23	1	0
111111110110101	15	24	1	0
111111110110110	15	25	1	0
1111111101101110	16	22	0	1
1111111101101111	16	23	0	1
1111111101110000	16	24	0	1
1111111101110001	16	25	0	1
1111111101110010	16	26	0	1
1111111101110011	16	27	0	1
1111111101110100	16	28	0	1
1111111101110101	16	29	0	1
1111111101110110	16	30	0	1
1111111101110111	16	31	0	1
1111111101111000	16	32	0	1
1111111101111001	16	33	0	1
1111111101111010	16	34	0	1
1111111101111011	16	35	0	1
1111111101111100	16	36	0	1
1111111101111101	16	37	0	1
1111111101111110	16	38	0	1
1111111101111111	16	39	0	1
1111111110000000	16	40	0	1
1111111110000001	16	41	0	1
1111111110000010	16	42	0	1
1111111110000011	16	43	0	1
1111111110000100	16	44	0	1
1111111110000101	16	45	0	1
1111111110000110	16	46	0	1
1111111110000111	16	47	0	1
1111111110001000	16	48	0	1
1111111110001001	16	49	0	1
1111111110001010	16	50	0	1
1111111110001011	16	51	0	1
1111111110001100	16	52	0	1
1111111110001101	16	53	0	1
1111111110001110	16	54	0	1
1111111110001111	16	55	0	1

1111111110010000	16	56	0	1
1111111110010001	16	57	0	1
1111111110010010	16	58	0	1
1111111110010011	16	59	0	1
1111111110010100	16	60	0	1
1111111110010101	16	61	0	1
1111111110010110	16	62	0	1
1111111110010111	16	63	0	1
1111111110011000	16	64	0	1
1111111110011001	16	26	1	0
1111111110011010	16	27	1	0
1111111110011011	16	28	1	0
1111111110011100	16	29	1	0
1111111110011101	16	30	1	0
1111111110011110	16	31	1	0
1111111110011111	16	32	1	0
1111111110100000	16	33	1	0
1111111110100001	16	34	1	0
1111111110100010	16	35	1	0
1111111110100011	16	36	1	0
1111111110100100	16	37	1	0
1111111110100101	16	38	1	0
1111111110100110	16	39	1	0
1111111110100111	16	40	1	0
1111111110101000	16	41	1	0
1111111110101001	16	42	1	0
1111111110101010	16	43	1	0
1111111110101011	16	44	1	0
1111111110101100	16	45	1	0
1111111110101101	16	46	1	0
1111111110101110	16	47	1	0
1111111110101111	16	48	1	0
1111111110110000	16	49	1	0
1111111110110001	16	50	1	0
1111111110110010	16	51	1	0
1111111110110011	16	52	1	0
1111111110110100	16	53	1	0
1111111110110101	16	54	1	0
1111111110110110	16	55	1	0
1111111110110111	16	56	1	0
1111111110111000	16	57	1	0
1111111110111001	16	58	1	0
1111111110111010	16	59	1	0
1111111110111011	16	60	1	0
1111111110111100	16	61	1	0
1111111110111101	16	62	1	0
1111111110111110	16	63	1	0
1111111110111111	16	64	1	0
1111111111000000	16	1	1	1
1111111111000001	16	2	1	1
1111111111000010	16	3	1	1
1111111111000011	16	4	1	1
1111111111000100	16	5	1	1

1111111111000101	16	6	1	1
1111111111000110	16	7	1	1
1111111111000111	16	8	1	1
1111111111001000	16	9	1	1
1111111111001001	16	10	1	1
1111111111001010	16	11	1	1
1111111111001011	16	12	1	1
1111111111001100	16	13	1	1
1111111111001101	16	14	1	1
1111111111001110	16	15	1	1
1111111111001111	16	16	1	1
1111111111010000	16	17	1	1
1111111111010001	16	18	1	1
1111111111010010	16	19	1	1
1111111111010011	16	20	1	1
1111111111010100	16	21	1	1
1111111111010101	16	22	1	1
1111111111010110	16	23	1	1
1111111111010111	16	24	1	1
1111111111011000	16	25	1	1
1111111111011001	16	26	1	1
1111111111011010	16	27	1	1
1111111111011011	16	28	1	1
1111111111011100	16	29	1	1
1111111111011101	16	30	1	1
1111111111011110	16	31	1	1
1111111111011111	16	32	1	1
1111111111100000	16	33	1	1
1111111111100001	16	34	1	1
1111111111100010	16	35	1	1
1111111111100011	16	36	1	1
1111111111100100	16	37	1	1
1111111111100101	16	38	1	1
1111111111100110	16	39	1	1
1111111111100111	16	40	1	1
1111111111101000	16	41	1	1
1111111111101001	16	42	1	1
1111111111101010	16	43	1	1
1111111111101011	16	44	1	1
1111111111101100	16	45	1	1
1111111111101101	16	46	1	1
1111111111101110	16	47	1	1
1111111111101111	16	48	1	1
1111111111110000	16	49	1	1
1111111111110001	16	50	1	1
1111111111110010	16	51	1	1
1111111111110011	16	52	1	1
1111111111110100	16	53	1	1
1111111111110101	16	54	1	1
1111111111110110	16	55	1	1
1111111111110111	16	56	1	1
1111111111111000	16	57	1	1
1111111111111001	16	58	1	1
1111111111111010	16	59	1	1
1111111111111011	16	60	1	1
1111111111111100	16	61	1	1
1111111111111101	16	62	1	1
1111111111111110	16	63	1	1
1111111111111111	16	64	1	1

Table D.17 – Run VLC Table for Compression ID 1252

Codeword	Length	Run
0	1	1
100	3	2
101	3	3
1100	4	4
11010	5	5
11011	5	6
11100	5	7
111010	6	8
1110110	7	9
1110111	7	10
1111000	7	11
11110010	8	12
111100110	9	13
111100111	9	14
1111010000	10	15
1111010001	10	16
1111010010	10	17
1111010011	10	18
1111010100	10	19
1111010101	10	20
1111010110	10	21
1111010111	10	22
1111011000	10	23
1111011001	10	24
1111011010	10	25
1111011011	10	26
1111011100	10	27
1111011101	10	28
1111011110	10	29
1111011111	10	30
1111100000	10	31

Codeword	Length	Run
1111100001	10	32
1111100010	10	33
1111100011	10	34
1111100100	10	35
1111100101	10	36
1111100110	10	37
1111100111	10	38
1111101000	10	39
1111101001	10	40
1111101010	10	41
1111101011	10	42
1111101100	10	43
1111101101	10	44
1111101110	10	45
1111101111	10	46
1111110000	10	47
1111110001	10	48
1111110010	10	49
1111110011	10	50
1111110100	10	51
1111110101	10	52
1111110110	10	53
1111110111	10	54
1111111000	10	55
1111111001	10	56
1111111010	10	57
1111111011	10	58
1111111100	10	59
1111111101	10	60
1111111110	10	61
1111111111	10	62

Table D.18 – DC Differential VLC Table for Compression ID 1252

Codeword	η
000	0
1100	1
1101	2
001	3
010	4
011	5
100	6
101	7
1110	8
11110	9
111110	10
111111	11

Annex E (Informative)
System Overview

This informative annex provides the context of how the VC-3 bitstream and decoding process relate to other system level aspects. Figure E.1 illustrates the scope of this standard and where the VC-3 decoding process lies within a typical application. SMPTE 2019-3 describes the mapping of VC-3 and AES3 data over SDTI. Compression IDs 1237, 1242, and 1252 are supported in SMPTE 2019-3.

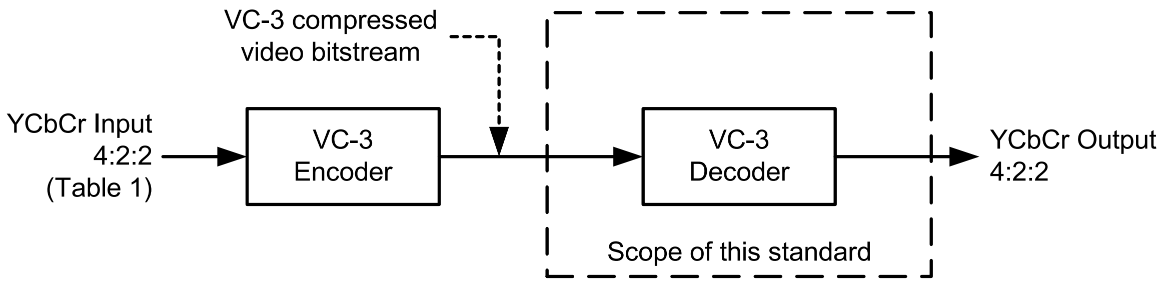

Figure E.1 – Scope of the VC-3 compression standard

The encoding process is not defined in this standard; however, Figure E.2 illustrates a typical encoder data flow. The process shown is not the only possible compression method but is representative of a typical encoding approach. The main elements of a VC-3 encoder are:

- The Forward Discrete Cosine Transform which converts an input picture to a DCT based, spatial frequency representation.
- The Zig-zag element which re-orders the DCT block transform elements into an order that is efficient for entropy encoding.
- The Rate-control element which ensures that the desired compression rate is achieved by controlling the quantization values applied to the DCT coefficients.
- The Quantization element which quantizes the DCT coefficients to reduce bandwidth required to represent the input picture.
- The Entropy Encoding element which losslessly encodes the quantized DCT coefficients.
- The Bitstream Formation element which formats the entropy codewords into a valid VC3 compressed bitstream.

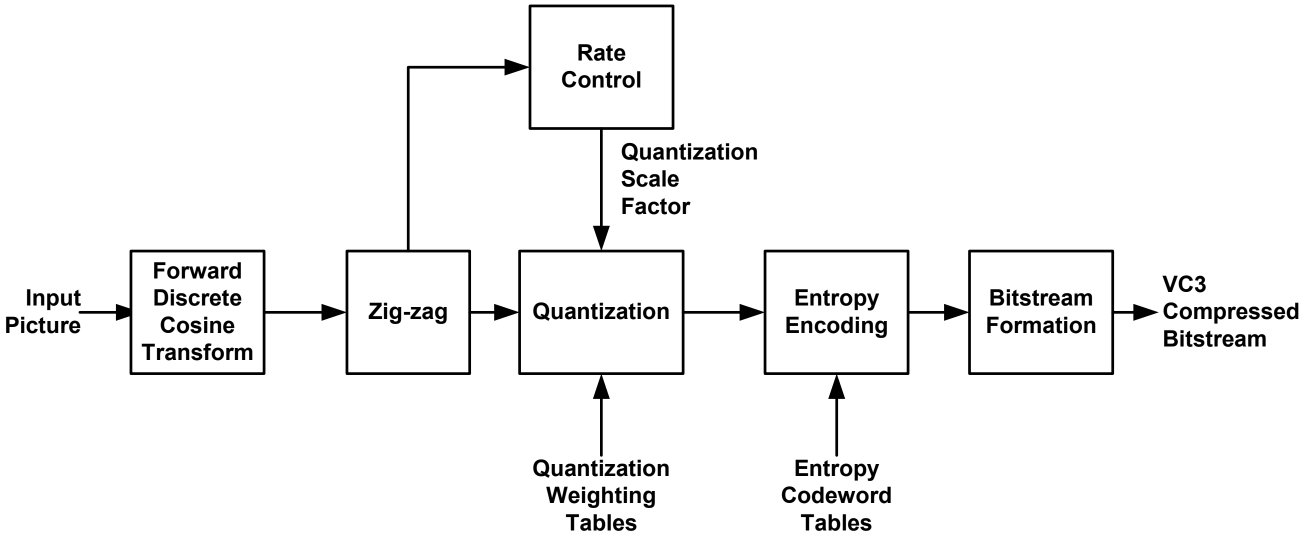

Figure E.2 – Overview of the compression process

SMPTE RP 2019-2 provides the details regarding VC-3 bitstream and decoder conformance testing.

Annex F (Informative)
Compressed Bitrates

Table F.1 below provides examples of compressed bitrates by Compression ID and a variety of video frame rates. The bitrate is rounded to the nearest 5 Mbps.

Table F.1 – Compressed bitrates rounded to the nearest 5 Mbps

					Frame rate (fps)				
					23.976	25	29.97	50	59.94
Compression ID	Source scan type	Samples per line	Active lines per frame	Compressed bytes per frame	Mbps	Mbps	Mbps	Mbps	Mbps
1235	progressive	1920	1080	917504	175	185		365	440
1237	progressive			606208	115	120		240	290
1238	progressive			917504	175	185		365	440
1241	interlaced			917504		185	220		
1242	interlaced			606208		120	145		
1243	interlaced			917504		185	220		
1250	progressive	1280	720	458752	90	90		180	220
1251	progressive			458752	90	90		180	220
1252	progressive			303104	60	60		120	145
1253	Progressive	1920	1080	188416	35				

Annex G (Informative)
Bibliography

SMPTE 2019-3-2008, VC-3 Type Data Stream and Mapping over SDTI

SMPTE RP 2019-2-2008, VC-3 Decoder and Bitstream Conformance