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SMPTE STANDARD

for Television — Type D-11 Picture Compression and Data Stream Format

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1 Scope

This standard specifies the compression of a high-definition source format to a dual-channel packetized data stream format which is suitable for recording on disc and tape storage devices including type D-11 tape recorder. The specification includes a number of basic packetizing operations including the shuffling of the source data prior to compression both to aid compression performance and to allow error concealment processing in the decoder. The standard also includes the processes required to decode the compressed type D-11 packetized data format into a high-definition output signal.

This standard supports high-definition source formats using 1920*1080 pixels and the sampling structures specified in SMPTE 274M and SMPTE RP 211 at the following picture rates:

24÷1.001/PsF, 24/PsF, 25/PsF, 30÷1.001/PsF, 50/I and 60÷1.001/I
(where PsF indicates progressive segmented frame and I indicates interlaced).

The data packet format specified by this standard is used as the source data stream for the associated document which maps this type D-11 packetized data stream format together with AES3 data over SDTI.

2 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,

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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 12M-1999, Television, Audio and Film — Time and Control Code

SMPTE 274M-1998, Television — 1920 x 1080 Scanning and Analog and Parallel Digital Interfaces for Multiple Picture Rates

SMPTE 292M-1998, Television — Bit-Serial Digital Interface for High-Definition Television Systems

SMPTE RP 188-1999, Transmission of Time Code and Control Code in the Ancillary Data Space of a Digital Television Data Stream

SMPTE RP 211-2000, Implementation of 24P, 25P and 30P Segmented Frames for 1920 x 1080 Production Format

3 Introduction

This standard specifies the encoding and decoding of high-definition source formats via compression into a bit rate in the range 112~140 Mb/s for recording on a type D-11 digital tape recorder. The recorded bit rate is related to the source picture rate as given in table 1.

Table 1 – Data rates associated with source picture rates

Picture rate	Base data rate (Mb/s)
24÷1.001/PsF	111.863
24/PsF	111.975
25/PsF	116.640
30÷1.001/PsF	139.828
50/I	116.640
60÷1.001/I	139.828

Annex E gives the system overview of the documents which comprise the full type D-11 specification. This document specifies the parts identified by the number 1. The other documents identified as 2 and 3 specify, respectively, the following parts:

- The SDTI definition for direct data input and output from the type D-11 recorder.

- The mapping of the compressed data format from either this document or the data interface document onto the type D-11 helical tracks as the VTR format.

In common with other compression systems, the type D-11 encoding process uses intraframe coding (i.e., the coding is bound by the frame period) using the discrete cosine transform (DCT) to provide the data decorrelation required for efficient compression. The coefficients are quantized and variable length coded (VLC) to produce the basic output data format.

The source pictures are subsampled prior to compression coding. This reduces the number of coded pixels and allows the number of bits-per-pixel value to be raised in proportion. The luminance source sampling grid of 1920*1080 pixels is reduced to 1440*1080 pixels. For each chrominance channel, the source sampling grid of 960*1080 pixels is reduced to 480*1080 pixels. In the decoder, the output pixel sample grid is restored back to the source format of 1920*1080 pixels by interpolation following the compression decoding process.

The compressed data format specified by the output of the compression encoder is of a form which allows direct mapping into the basic block structure as defined in the type D-11 digital recorder document.

4 Encoding

4.1 Overview

The type D-11 source data for compression shall comprise only the production aperture area as defined by SMPTE 274M.

NOTE – The DCT coding uses a data block size which allows exactly 1080 lines to be coded.

The source formats comprise luminance (Y) and chrominance (C_B, C_R) component signals as defined by SMPTE 274M and SMPTE RP 211.

The type D-11 source picture rates for compression shall be constrained to the following values:

- 24÷1.001 frames per second in the segmented format as defined by SMPTE RP 211.
- 24 frames per second in the segmented format as defined by SMPTE RP 211.
- 25 frames per second in the segmented format as defined by SMPTE RP 211.
- 30÷1.001 frames per second in the segmented format as defined by SMPTE RP 211.
- 50 fields per second in the interlaced format (a.k.a. 50/I) as defined by SMPTE 274M.
- 60÷1.001 fields per second in the interlaced format (a.k.a. 60/I) as defined by SMPTE 274M.

The active picture data for compression shall be prefiltered and then subsampled from a source representation to a subsampled representation.

The reduced active data shall then be split into two identical channels for processing as shown in figure 1 and table 2.

The total picture data in each channel shall be divided into 20,250 8*8 blocks, each formed from 8 samples of 8 consecutive lines in a frame.

The 8*8 blocks for each channel shall then be shuffled within the frame boundary to produce 270 code blocks each comprising 45 luminance (Y) 8*8 blocks and 30 chrominance 8*8 blocks (15 C_B and 15 C_R).

The picture data in each code block shall be compressed by the application of the discrete cosine transform, quantization and VLC encoding. Each code block shall be separately encoded and there shall be no data sharing between code blocks. The data from the compression output shall be packed into the code block space of 1080 bytes.

Each code block shall be segmented into five basic blocks each comprising 216 compressed data bytes. Each basic block nominally contains the compressed data for 9 luminance 8*8 blocks and 6 chrominance 8*8 blocks (3 C_B and 3 C_R). Data overflow from one basic block can be shared with other basic blocks in the same code block.

NOTE – The 8*8 blocks may be coded by a single 8*8 DCT block, by two 8*4 DCT blocks, or by two 4*8 DCT blocks depending on the mode of operation (see 4.4).

The 270 code blocks for each channel shall be divided into six equal segments of 45 code blocks per segment. Each segment shall contain one auxiliary basic block prior to the compressed data basic blocks. All auxiliary basic blocks in one channel shall be identical with the exception of the segment identification

number. The auxiliary basic block shall contain utility data for the segment. The distribution of a channel into code blocks and basic blocks is illustrated in figure 2.

All basic blocks shall have a total length of 219 bytes. The data for the basic blocks in a code block shall be 216 bytes in length, allowing 3 bytes for the basic block header. The data for the auxiliary basic block in each segment shall be 217 bytes in length, allowing 2 bytes for the basic block header.

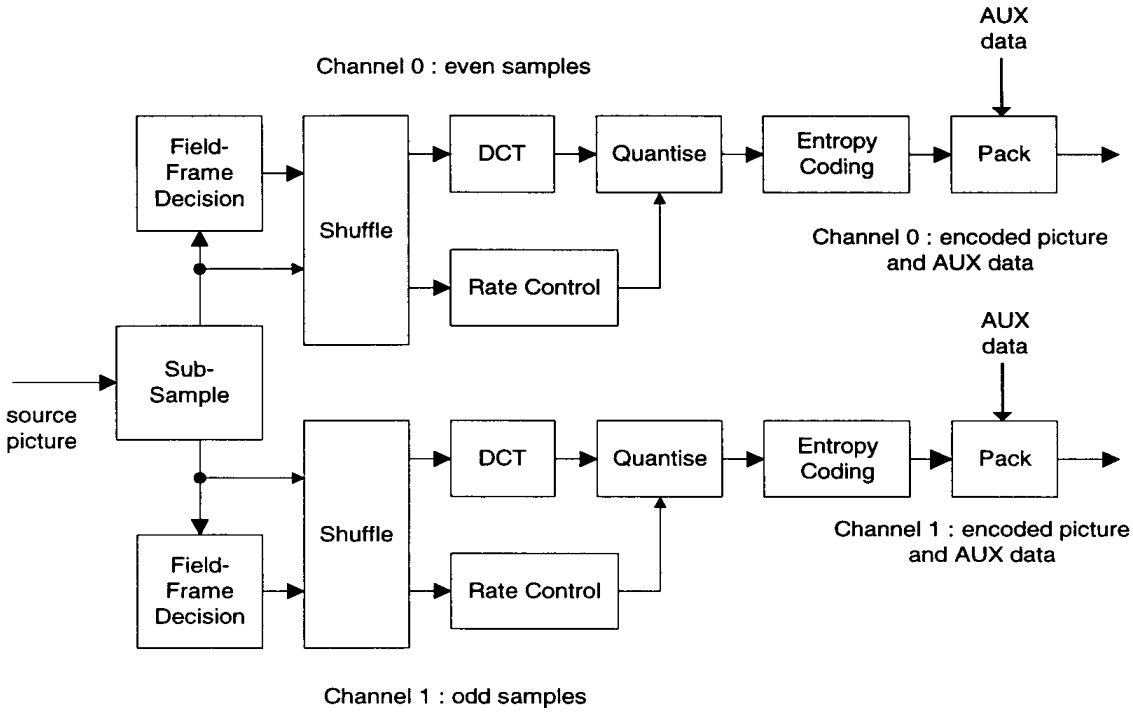

Figure 1 – Encoding block diagram

Table 2 – Definition of signal sampling parameters

Parameter		Source sampling	Subsampling	Channel division
Number of samples per line	Y	1920	1440	720
	C_B, C_R	960	480	240
Number of active lines per frame		1080	1080	1080
Quantization		10-bit (0..1023)	8-bit (0..255)	8-bit (0..255)
Sample levels	Peak range	4 to 1019	1 to 254	1 to 254
	Y	Peak white level: 940	Peak white level: 235	Peak white level: 235
		Black level: 64	Black level: 16	Black level: 16
		Total levels: 877	Total levels: 220	Total levels: 220
	C_B, C_R	Signal level: 512 ± 448	Signal level: 128 ± 112	Signal level: 128 ± 112
		Total levels: 897	Total levels: 225	Total levels: 225

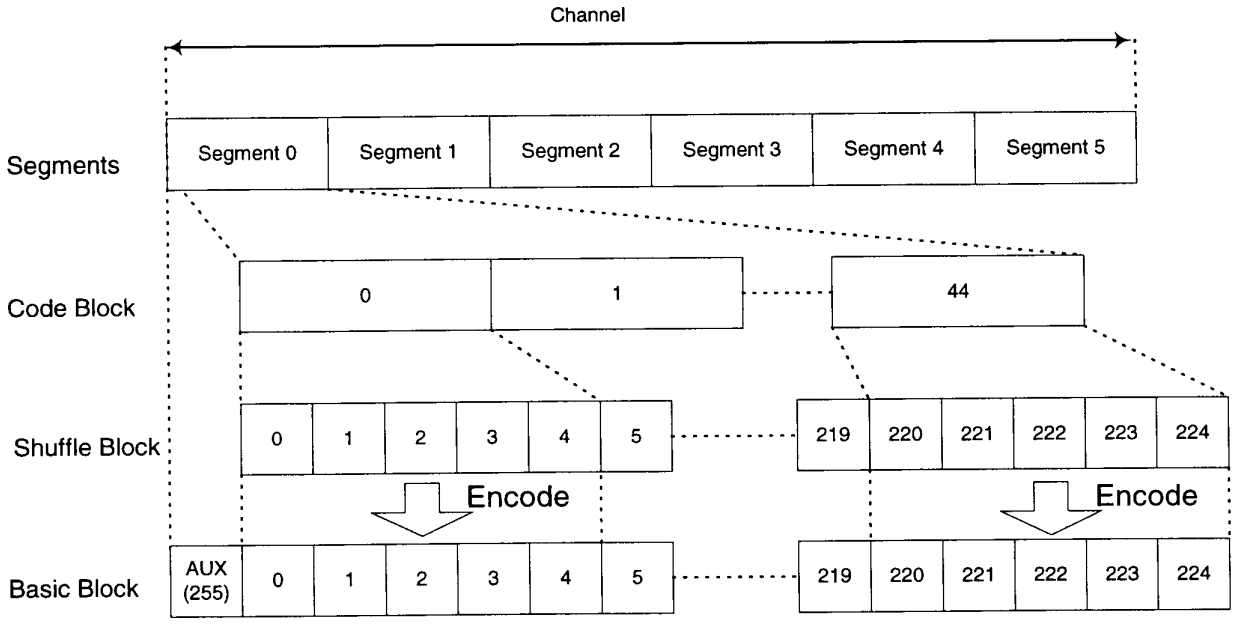

Figure 2 – Code blocks and basic blocks in channel

4.2 Preprocessing

The source picture shall be the production aperture as defined in SMPTE 274M having a luminance structure of 1920*1080 pixels and a multiplexed chrominance structure of 960*1080 pixels for each chrominance component.

The source interface has a sample resolution of 10 bits which shall be reduced to 8 bits after the horizontal subsampling process.

4.2.1 Vertical sampling process

For 1080/I systems, 540 lines for Y, C_B, C_R signals from each interlaced field shall be processed. The coding lines for each interlaced field are illustrated in figure 2.

For 1080/PsF systems, 1080 lines for Y, C_B, C_R signals from each whole frame shall be processed. The coding lines for the segmented frame are illustrated in figure 3.

4.2.2 Horizontal subsampling process

For the luminance component, all 1920 active samples per line shall be subsampled to 1440 samples per line after a bandwidth limitation filtering process.

For each of the two chrominance components, all 960 active samples per line shall be subsampled to 480 samples per line after a bandwidth limitation filtering process.

The basic sample parameters for luminance (Y) and the two chrominance signals (C_B, C_R) of the source and subsampled component signals are described in table 2.

Figure 3 depicts the resampled spatial positions of the subsampled components for 1080/I and 1080/PsF line scanning systems.