RECOMMENDATION ITU-R BR.1575

Guide to the selection of digital video tape recording formats for studio production in the standard definition television (SDTV) environment based on production requirements

(Question ITU-R 239/11)

(2002)

The ITU Radiocommunication Assembly,

considering

a) that digital video tape recording (VTR) formats for programme production are selected based on user requirements such as performance and operational requirements;

b) that Recommendation ITU-R BR.657 – Digital television tape recording, standards for the international exchange of television programmes on magnetic tape, describes user requirements for digital television tape recorders, and is the basis for the standardization of D-1 format;

c) that Recommendation ITU-R BR.1292 – Engineering guidelines for video recording in SDTV production and post-production chains, recommends engineering guidelines for television post-production;

d) that Recommendation ITU-R BR.1356 – User requirements for application of compression in television production, lists user requirements for application of compression in television production, for bit rates up to 50 Mbit/s in particular;

e) that Recommendation ITU-R BR.1376 – Compression families for use in recording and networked SDTV production, recommends compression based on intra-frame coding at a data rate close to 50 Mbit/s for mainstream applications which require high margin of quality overhead for post-production;

f) that Recommendation ITU-R BR.1376 specifies the two compression families which meet the requirements in *considering* e) above:

– DV-based 50 Mbit/s 4:2:2 intra-frame;

– MPEG-2 4:2:2P@ML 50 Mbit/s intra-frame;

g) that the two categories of programme production in standard definition television (SDTV) environment, the “high-end” and the “mainstream”, are identified based on the user’s requirements in Appendix 3 of Recommendation ITU-R BR.1376,

recommends

1 that for digital VTRs for studio production and post-production for SDTV, one of the following families of recorders should preferably be used according to required margin of quality overhead:

– uncompressed or loss-less compression recorders suitable for high-end production which requires highest margin of quality overhead for intensive post-production;

– slightly compressed recorders suitable for high-end production which requires higher margin of quality headroom for post-production;

– recorders at around 50 Mbit/s employing intra-frame coding, such as DV-based 4:2:2 or MPEG-2 4:2:2P@ML suitable for mainstream production which requires modest margin of quality overhead for post-production.

NOTE 1 – Digital VTRs for SDTV program production that use compression below 50 Mbit/s will be covered in a separate Recommendation.

APPENDIX 1

Features and specifications of digital tape recording formats for SDTV production

(Informative)

Tables 1 (SDTV digital VTR for 525/59.94) and 2 (SDTV digital VTR for 625/50) provide the major features and specifications of the commercially available tape-based storage devices for SDTV high-end and mainstream production.

TABLE 1

SDTV Digital VTR for 525/59.94

Category		High-end			Mainstream		
Manufacture specification		D1	D5	Digital BETACAM	DVCPRO 50	D-9 (Digital-S)	D10 (MPEG IMX)
Sampling frequency	Video (MHz)	13.5	13.5/18	13.5			
	Audio (kHz)	48					
Quantization	Video (bits)	8	10/8	10	8		
	Audio (bits)	20			16		24/16
Number of AES 3 channels(1)		2					2/4
Raster structure	Number of Y samples	720	720/960	720			
	Recorded lines	500	510	512	480		512
	Y/C sampling	4:2:2					
Compression (video)	Coding scheme	Uncompressed		Intra field DCT	Intra frame DCT		Intra frame DCT
					DV-based		MPEG-2(2) 4:2:2P@ML
Video rate (Mbit/s)		173	235	90	50		
ECC Video	Inner	64, 60	95, 87	178, 164	85, 77		162, 150
	Outer	32, 30	128, 120	106, 96	149, 138		60, 46
	Redundancy (%)	14	16	20	19		41
ECC Audio	Inner	64, 60	95, 87	178, 164	85, 77		117, 105
	Outer	10, 7	16, 8	10, 5	14, 9		18, 8
	Redundancy (%)	105	118	117	72		152
Channel coding		S-NRZ	8-14	S-NRZI	24-25 I-NRZI		S-NRZI
Total rate (Mbit/s)		225.3	300.6	128	84	99	97
Number of recording RF channels		4		2			
Drum diameter (mm)		75.0	76.0	81.4	21.7	62.0	81.4
Drum rotation (rps)		150	90	89.91	149.85	75	59.94
Number of tracks (/field)		10	12	6	20/Frame	10/Frame	8/Frame
Tape speed (mm/s)		286.6	167.228	96.7	67.640	57.737	64.5
Track pitch (µm)		45.0	20.0	21.7	18	20	21.7
Minimum wavelength (µm)		0.9	0.64	0.69	0.49	0.587	0.56
Width of tape (mm)		19.01	12.65		6.35	12.65	
Media substance		Oxide	Metal particle				
Tape Hc (kA/m)		68	143	125	184	143	120
Cassette size (mm)		S: 172 × 109 M: 254 × 150 L: 366 × 206	S: 161 × 98 M: 212 × 124 L: 296 × 167	S: 156 × 96 L: 254 × 145	M: 97.5 × 64.5 L: 125 × 78	188 × 104	S: 156 × 96 L: 254 × 145
Recording time (min)		13/41/94	23/63/124	40/124	33/92	124	60/184

(1) An AES 3 channel may carry two linear pulse code modulation audio channels or it may carry data as indicated by Status Channel bit 1.

(2) See Appendix 2.

TABLE 2

SDTV Digital VTR for 625/50

Category		High-end			Mainstream		
Manufacture specification		D1	D5	Digital BETACAM	DVCPRO 50	D-9 (Digital-S)	D10 (MPEG IMX)
Sampling frequency	Video (MHz)	13.5	13.5/18	13.5			
	Audio (kHz)	48					
Quantization	Video (bits)	8	10/8	10	8		
	Audio (bits)	20			16		24/16
Number of AES 3 channels		2					2/4
Raster structure	Number of Y samples	720	720/960	720			
	Recorded lines	600	608	608	576		608
	Y/C sampling	4:2:2					
Compression (video)	Coding scheme	Uncompressed		Intra field DCT	Intra frame DCT		Intra frame DCT
					DV-based		MPEG-2[1] 4:2:2P@ML
Video rate (Mbit/s)		173	233	89	50		
ECC Video	Inner	64, 60	86, 78	178, 164	85, 77		162, 150
	Outer	32, 30	128, 120	126, 114	149, 138		64, 54
	Redundancy (%)	14	18	20	19		28
ECC Audio	Inner	64, 60	86, 78	178, 164	85, 77		137, 125
	Outer	10, 7	16, 8	18, 9	14, 9		18, 8
	Redundancy (%)	105	121	117	72		147
Channel coding		S-NRZ	8-14	S-NRZI	24-25 I-NRZI		S-NRZI
Total rate (Mbit/s)		225.3	303	126	84	99	88
Number of recording RF channels		4		2			
Drum diameter (mm)		75.0	76.0	81.4	21.7	62.0	81.4
Drum rotation (rps)		150	100	75	150	75	50
Number of tracks (/field)		12	16	6	24/Frame	12/Frame	8/Frame
Tape speed (mm/s)		286.9	167.228	96.7	67.708	57.795	53.8
Track pitch (µm)		45.0	18.0	26	18	20	21.7
Minimum wavelength (µm)		0.9	0.70	0.59	0.49	0.587	0.56
Width of tape (mm)		19.01	12.65		6.35	12.65	
Media substance		Oxide	Metal particle				
Tape Hc (kA/m)		68	143	125	184	143	120
Cassette size (mm)		S: 172 × 109 M: 254 × 150 L: 366 × 206	S: 161 × 98 M: 212 × 124 L: 296 × 167	S: 156 × 96 L: 254 × 145	M: 97.5 × 64.5 L: 125 × 78	188 × 104	S: 156 × 96 L: 254 × 145
Recording time (min)		11/34/94	23/63/124	40/124	33/92	124	72/224

(1) See Appendix 2.

APPENDIX 2

Compression specifications of D10 MPEG IMX format

(Informative)

Introduction

The IMX-MPEG VTR is based upon a compliant MPEG elementary stream as its source of compressed data. MPEG-2 4:2:2P@ML is a very flexible standard. This contrasts with the unique requirements of a VTR.

In order to provide accurate editing, slow-motion and variable speed playback, and pictures in shuttle, a constrained bit stream is required. The following paragraphs define encoding parameters suitable for the Type D10-IMX recording format. The MPEG-2 4:2:2P@ML video elementary stream bit stream constrained to these parameters can be successfully decoded by a compliant MPEG-2 4:2:2 Profile@Main level decoder.

D-10 bit stream definition

This Appendix specifies the compression constraints and bit stream characteristics of an MPEG-2 4:2:2P@ML video elementary stream operating at bit rates up to 50 Mbit/s. The video compression format is fully compliant with the MPEG-2 video standard (ISO/IEC 13818-2: 2000) [4:2:2P@ML].

The video elementary stream bit stream shall comply with the syntax of SMPTE 328M – MPEG-2 video elementary stream editing information.

In order to provide accurate editing and playback in slow-motion and variable speed replay including pictures in shuttle, this clause defines encoding parameter specifications suitable for the Type D10 recording format capable of recording MPEG-2 4:2:2P@ML video elementary streams at bit rates up to 50 Mbit/s. The MPEG-2 4:2:2P@ML video elementary stream bit stream constrained to these parameter specifications is fully compliant with the MPEG-2 4:2:2P@ML video elementary stream syntax and can be successfully decoded by a compliant MPEG-2 4:2:2 Profile@Main level decoder.

General bit stream characteristics

TABLE 3

Basic bit stream constraints

Source format	SDTV 525/60/1.001 and 625/50
Bit rate	Up to 50 Mbit/s constrained bytes per GoP (CBG)
Group of pictures (GoP) structure	I-picture only
Maximum coded frame size	Up to 208 541 bytes net (30/1.001 I-frames/s)
	Up to 250 000 bytes net (25 I-frames/s)

Table 4 indicates recommended operating points to simplify studio operations and to provide users with a tool to be used in designing systems.

TABLE 4

Optional operating points (bit rates)

D-10 profile	Bit rate (Mbit/s)	Sequence header bit rate value	Comments
Operating Point **E**	50	1E848h	To be used when compliant with EBU statement D84/85 1999
Operating point **F**	40	186A0h	May be used for interfaces to T3 telco circuits and other content production
Operating point **G**	30	124F8h	May be used for E3 telco interfaces, and non critical content material

MPEG compression parameter constraints

The following defined constraints shall apply.

The bit_rate_value in sequence_header shall be set with a value up to 50 Mbit/s.

The sequence_extension parameter shall be set with the following value:

- sequence_extension: bit_rate_extension = 0h

Video buffering verifier (VBV) delay constraint

The VBV delay parameter shall be constrained to a 1-frame delay for each GoP by defining the following values:

525/60 systems

- picture_header: vbv_delay = 0BBBh

625/50 systems

- picture_header: vbv_delay = 0E10h

MPEG-2 4:2:2 Profile@Main Level

The sequence_extension parameters shall be constrained to the following values:

- sequence_extension: profile_and_level_indication = 85h (MPEG-2 4:2:2P@ML)
- sequence_extension: chroma_format = 2h (MPEG-2 4:2:2P@ML)

All I-picture encoding

The picture_header parameter shall be constrained to the following values:

- picture_header: temporal_reference = 0h (1 picture in a GoP)
- picture_header: picture_coding_type = 1h (I-picture only)

Picture structure is frame picture only

The picture_coding_extension parameter shall be set to constrain the picture coding to frame pictures only by constraining to the following value:

- picture_coding_extension:	picture_structure	= 3h	(frame picture)

Frame frequency

The sequence_header parameters shall be constrained to the following values:

 # 525/60 systems

- sequence_header:	frame_rate_code	= 4h	(30/1.001 Hz)

 # 625/50 systems

- sequence_header:	frame_rate_code	= 3h	(25 Hz)

Picture coding parameter constraints

The picture coding constraints shall be defined as follows:

- picture_coding_extension():	intra_dc_precision	= 2h	(10 bit DC)
- picture_coding_extension():	frame_pred_frame_dct	= 0h	(field/frame adaptive)
- picture_coding_extension():	q_scale_type	= 1h	(non-linear quantizer)
- picture_coding_extension():	intra_vlc_format	= 1h	(use intra-VLC table)
- picture_coding_extension():	alternate_scan	= 0h	(zig-zag scan)
- picture_coding_extension():	top_field_first	= 1h	(top field first only)
- picture_coding_extension():	repeat_first_field	= 0h	(no repeat first field)
- picture_coding_extension():	progressive_frame	= 0h	(interlace frames only)
- sequence_extension():	progressive_sequence	= 0h	(interlace frames only)

Slice structure

All slices shall contain only one macroblock. Each macroblock shall have a slice header as a sync-code. In case of any errors occurring during transmission/recording the error propagation will be less than one macroblock. The slice structure syntax shall be as follows:

```
slice(){                                                No.of bits Mnemonic
          slice_start_code                                    32     bslbf
          if (vertical_size > 2800)
              slice_vertical_position_extension               3      uimsbf
          if (<sequence_scalable_extension() is present in the bitstream>){
              if (scalable_mode == "data partitioning")
                  priority_breakpoint                         7      uimsbf
          }
```

```
    quantiser_scale_code                                    5       uimsbf
    if (nextbits() == '1'){
        intra_slice_flag                                    1       bslbf
        intra_slice                                         1       uimsbf
        reserved_bits                                       7       uimsbf
        while (nextbits() == '1'){
            extra_bit_slice  ( with the value '1' )         1       uimsbf
            extra_information_slice                         8       uimsbf
        }
    }
    extra_bit_slice  ( with the value '0' )                 1       uimsbf
    macroblock()
    next_start_code()
}
```

Sequence_header and sequence_extension

The sequence_header and sequence_extension shall be present for every picture [as per SMPTE 328M], specified as follows.

```
video_sequence(){                                           No.of bits Mnemonic
    next_start_code()
    sequence_header()
    if (nextbits() == extension_start_code){
        sequence_extension()
        do {
            extension_and_user_data(0)
            if (nextbits() == group_start_code){
                group_of_picture_header()
                extension_and_user_data(1)
            }
            picture_header()
            picture_coding_extension()
            extension_and_data(2)
            picture_data()
            if (nextbits() != sequence_end_code){
                sequence_header()
                sequence_extension()
            }
        } while (nextbits() != sequence_end_code)
    } else {
        ( ISO/IEC 11172-2 )
    }
    sequence_end_code                                       32      bslbf

}
```