SMPTE STANDARD

for Television —

Transporting MPEG-2 Recoding Information through 4:2:2 Component Digital Interfaces

Contents

1 Scope

This standard specifies an embedded transport mechanism for the MPEG-2 recoding data set as defined in SMPTE 327M for the representation of MPEG-2 recoding information in ITU-R BT.656, 4:2:2 component digital interfaces.

The recoding data set is derived from an ISO/IEC 13818-1 and 2 compliant MPEG bit stream during the decoding process, as described in ISO/IEC 13818-1 and -2.

For the minimum operation of this standard, the MPEG-2 recoding data set shall be spatially and temporally aligned to each decoded macroblock mapped into an ITU-R BT.656 interface.

This standard specifies the spatially and temporally aligned transport of the MPEG-2 recoding data set within the active picture area on ITU-R BT.656 interfaces for equipment that complies with ISO/IEC 13818-1 and -2, including 422P@ML and MP@ML for both the 625/50 and 525/60 video standards.

2 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, 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 327M-2000, Television — MPEG-2 Recoding Data Set

ITU-R BT.601-5 (1994), Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide-Screen 16:9 Aspect Ratios

ITU-R BT.656-4, Interfaces for Digital Component Video Signals in 525-Line and 625-Line Television Systems Operating at the 4:2:2 Level of Recommendation ITU-R BT.601 [Part A]

ITU-T H.222.0 with amend 1-2, ISO/IEC 13818-1:1996, Information Technology — Generic Coding of Moving Pictures and Associated Audio Information: Systems

ITU-T H.262 with amend 1/corr 1 and amend 2/corr 2, ISO/IEC 13818-2:1996, Information Technology — Generic Coding of Moving Pictures and Associated Audio Information: Video

3 General

The principal application of this standard is to preserve the quality of the video signal when cascading

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MPEG-2 decoders and coders for editing or transcoding purposes by feeding forward previous coding decisions.

The transport mechanism for the MPEG-2 recoding data set permits the simultaneous processing of both the video and the MPEG-2 recoding data set and, consequently, of the MPEG bit stream. This allows lossless cascading, frame accurate editing, and logo/caption insertion to be performed.

The information contained in the MPEG-2 recoding data set is defined in SMPTE 327M.

This recoding information shall be temporally locked to the decoded (or partially decoded) video to the nearest MPEG-2 frame or field depending on the picture structure of the coded MPEG-2 bit stream. It shall also be spatially locked with the decoded video to the nearest MPEG-2 macroblock within the decoded frame/field.

To accrue the full benefits of the recoding information when cascading via a 4:2:2 component digital interface, the following recommendations shall be adhered to:

– The transportation mechanism shall preserve at least the 8 most significant bits of active video. The mechanism outlined uses the least significant bit of each 10-bit chrominance sample to transmit the data through the ITU-R BT.656 interface.

– It is also necessary for the recoding information to be aligned with the decoded MPEG macroblocks in the decoded pictures, both spatially and temporally. This standard is based on producing an ITU-R BT.656 output and will cover MPEG bit streams up to and including 422P@ML and MP@ML for both 625/50 and 525/60 systems.

NOTE – Users should be aware that some existing equipment using ITU-R BT.656 interfaces alters or uses the tenth bit of the video samples for other (nonstandardized) purposes. Where this occurs, the recoder will be unable to benefit from the MPEG-2 recoding information.

4 Definitions

4.1 aligned: [Applied usually to recoding information] arranged so that information relating to a macroblock (or other region) is embedded within that region of the decoded signal.

4.2 bit stream: An ordered series of bits conforming to ISO/IEC 13818-2.

4.3 bottom field: One of two fields that comprise a frame. Each line of a bottom field is spatially located immediately below the corresponding line of the top field.

4.4 cascading: The process where video that has once been coded (compressed) is subsequently decoded and coded once more. This cascaded step could carry on for any number of generations.

4.5 chrominance: The color-difference samples defined in ITU-R BT.601.

4.6 coding: The process by which an uncompressed video sequence is compressed to a bit stream that conforms to ISO/IEC 13818-2.

4.7 column: A vertical column of macroblocks spanning the full height of the decoded picture (columns are numbered from left to right starting at zero).

4.8 CRC: Cyclic Redundancy Check. A class of error detecting codes used in this standard to detect errors when the recoding information and the decoded pictures are being edited or processed in an ITU-R BT.601 stream by external equipment.

4.9 decoded video, decoded picture: Output video generated by an ISO/IEC 13818-2 compliant decoder that complies with the ITU-R BT.656 interface standard.

4.10 decoder: A compressed bit stream decoder that complies with ISO/IEC 13818-2.

4.11 DTS: Decoder Time Stamp (see ISO/IEC 13818-1).

4.12 embedded: [Applied usually to recoding information] conveyed within a digital video signal so as to be capable of being passed through digital video equipment.

4.13 macroblock: Defined in ISO/IEC 13818-2 as a block of 16 $\times$ 16 luminance pixels.

4.14 macroblock rate information: This corresponds to the coding information from the ISO/IEC 13818-2 bit stream that relates to the individual macroblocks as defined in this standard.

4.15 MPEG profile/level: As defined in ISO/IEC 13818-2.

4.16 MPEG-2 recoding information: This comprises the elements defined in SMPTE 327M and the additional information described in this standard required for the practical transport and use of the MPEG-2 recoding data set.

4.17 picture: As defined in ISO/IEC 13818-2.

4.18 picture rate information: This corresponds to the coding information from the ISO/IEC 13818-2 bit stream that relates to the whole picture as defined in this standard.

4.19 PTS: Presentation Time Stamp (see ISO/IEC 13818-1).

4.20 recoding data set: The set of information defined in SMPTE 327M.

4.21 stripe: A horizontal row of macroblocks spanning the full width of the decoded picture (stripes are numbered from top to bottom starting at zero).

4.22 sufficient: [Applied usually to recoding data set] containing the necessary information to enable transparent recoding (in a mathematical sense) of the video signal.

4.23 top field: One of two fields that comprise a frame. Each line of a top field is spatially located immediately above the corresponding line of the bottom field.

4.24 transcoding: A conversion within the MPEG-2 stream domain, such as bit rate changing or changing the group of pictures (GOP) structure.

4.25 video: A signal conforming to ITU-R BT.601 in this standard.

5 MPEG-2 recoding information

MPEG-2 recoding information comprises:

– The elements defined in SMPTE 327M.

– Additional elements from both macroblock and picture rate information as described in this standard.

These additional elements are required to allow the video and the MPEG-2 recoding information to be edited in parallel using conventional ITU-R BT.601 based equipment.

The MPEG-2 recoding information is subsequently aligned within the macroblock as described in figure 1.

6 Macroblock rate information

The contents of the MPEG-2 recoding data set relating to each macroblock will be spatially as well as temporally aligned with the decoded video pixels relating to that macroblock.

The elements in table 1 are at picture rate in the MPEG-2 stream, but are inserted into MPEG-2 recoding information at both picture and macroblock level to create the alignment required to allow editing of the resultant ITU-R BT.601 signal.

The elements in table 2 are required in the transport mechanism to synchronize the video information and the MPEG-2 recoding information.

Where reference is made to elements in ISO/IEC 13818-2, these are indicated in the text in italics.

7 MPEG-2 recoding information transport mechanism

This comprises 256 bits of data per macroblock that shall be placed bit by bit onto the least significant bit of each 10-bit chrominance sample in the decoded video.

The decoded 4:2:2 component video macroblock corresponds to a matrix of 16×16 luminance components and two matrices of 8×16 color-difference components. Hence, in total there are 256 pixels of luminance and 256 pixels of chrominance in each macroblock. In ITU-R BT.656 video, the multiplexed order for these pixels is C_b,Y,C_r,Y, etc.

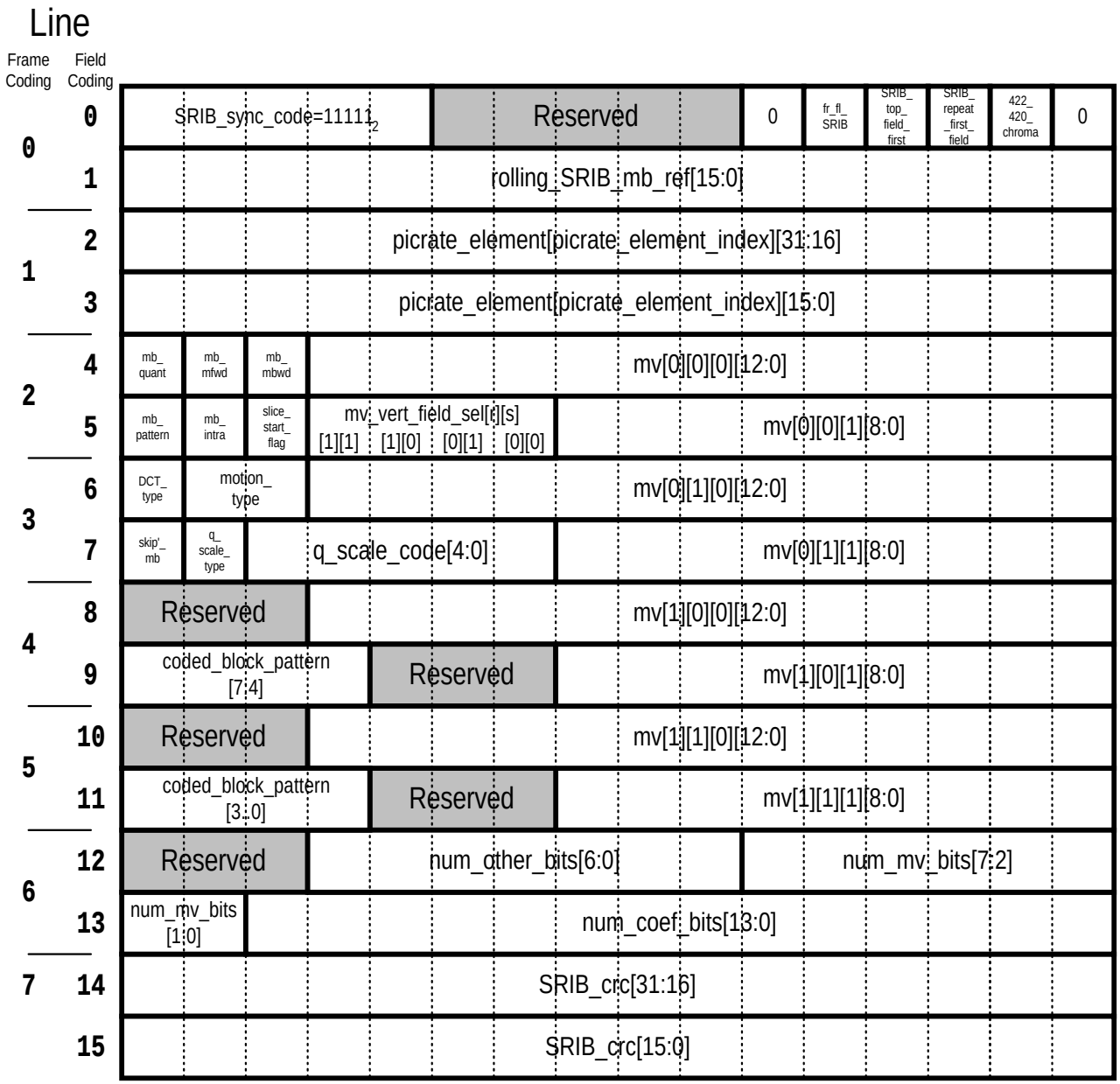

Figure 1 – Macroblock format of MPEG-2 recoding information

Table 1 – Additional macroblock rate information

Parameter	No. of bits	Definition
top_field_first	1-bit flag	Set to a value equal to *top_field_first* held in the original bit stream and also indicates, along with repeat_first_field, the temporal alignment of the recoding information with its associated video.
repeat_first_field	1-bit flag	Set to a value equal to *repeat_first_field* held in the original bit stream. The contents of the recoding information of the first field must also be repeated, as indicated by this flag.
422_420_chroma	1-bit flag	A value of 0 indicates the bit stream was 4:2:0 and chrominance up-sampling was performed to output 4:2:2 video. A value of 0 indicates the bit stream was 4:2:2 and no chrominance filtering was performed.
picrate_element picrate_element[31:16] picrate_element[15:0]	 16-bit ui 16-bit ui	Represents part of the picture rate information for the present picture and has its content dispersed within the decoded picture. This is defined in further detail in clause 8.
q_scale_type	1-bit flag	Set to a value equal to *q_scale_type* held in the original bit stream.
reserved		These blocks have no meaning and all the bits shall be set to 0.

Table 2 – Additional transport elements

Parameter	No. of bits	Definition
srib_sync_code	5-bit flag	This is a fixed bit-string, 11111, which shall be used to indicate the left alignment of the first row of each macroblock.
fr_fl_srib	1-bit flag	This flag shall be set to the value 1 when *picture_structure* is set to frame picture structure (value 11) and indicates that the MPEG-2 recoding information is distributed over 16 frame lines. If *picture_structure* is not set to frame (value 11), then the flag is set to 0 and the recoding information is distributed over 16 field lines. This mechanism ensures that the recoding information remains spatially and temporally locked to the corresponding pixels in the decoded video frames/fields. The distribution of the recoding information for frame pictures and field pictures is further shown in figures 2 and 3.
rolling_srib_mb_ref	16-bit ui	This is a 16-bit modulo 65521 rolling reference value (see note). This rolling reference increments on every macroblock of the transmitted picture. The count shall be continuous across transmitted picture boundaries. This value shall be initialized at start-up to a number selectable between 0 and 65520 inclusive. This is to allow systems of decoders to be built with unique recoding information identifiers.
srib_crc srib_crc[31:16] srib_crc[15:0]	 16-bit ui 16-bit ui	A 32-bit CRC to allow error detection for each macroblock of the MPEG-2 recoding information. A model for the operation of this 32-bit CRC is defined in annex A of ISO/IEC 13818-1. The CRC is calculated on the 224 data bits of the macroblock of MPEG-2 recoding information taken in raster order, using the following generator polynomial: $x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^8 + x^7 + x^5 + x^4 + x^2 + x + 1$
NOTE – The largest 16-bit derived prime number was chosen to ensure that there is a minimum coherence between the position of the macroblock and its equivalent address in subsequent pictures.		

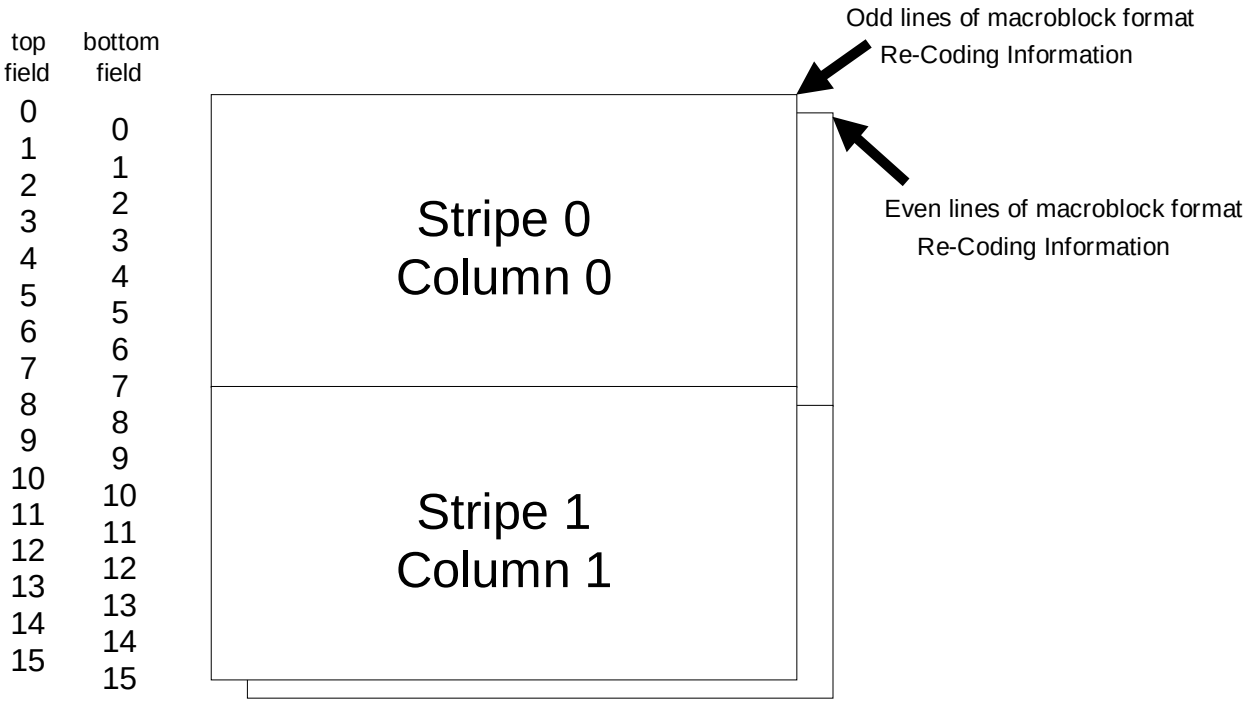

Figure 2 – Recoding information in frame coded pictures (fr_fl_srib=1)

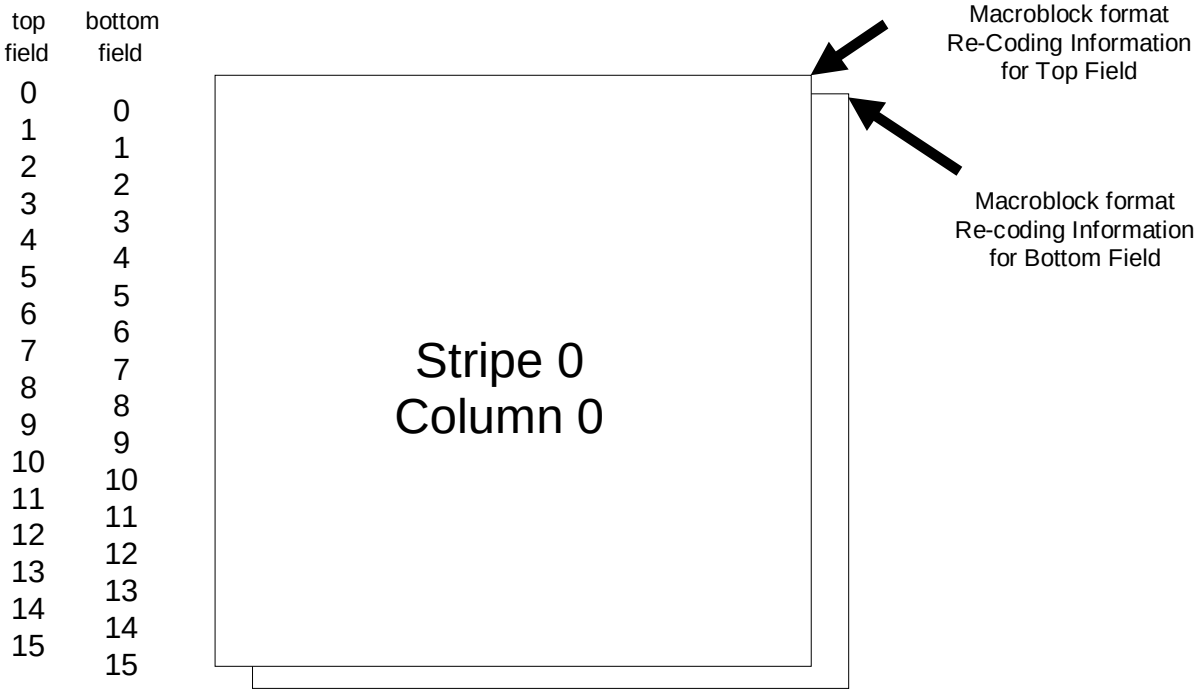

Figure 3 – Recoding information in field coded pictures (fr_fl_srib=0)

To increase the resilience of the detection of edits in the macroblock formatted recoding information, a form of parity scrambling is applied to the data before being placed in the least significant bit of the 10-bit chrominance samples.

The parity scrambling scheme used is shown in figure 4, where the bits represent the bits of 10-bit video (i.e., bits 2 through 9 correspond to the 8-bit video).

Consider the first few video samples in a stream as being C_b0, Y0, C_r0, Y1, C_b1, Y2, C_r1, Y3, etc. The parity for scrambling the macroblock formatted recoding information inserted into each chrominance sample is derived by combining the parity of the chrominance sample with the parity of the subsequent luminance sample in the video stream.

For example, the parity used to scramble the macroblock formatted recoding information for sample C_b0 above is the combined parity of C_b0 and Y0, the scrambling of data for C_r0 is taken from the combined parity of C_r0 and Y1, etc.

A detailed example of the macroblock formatted recoding information bits encoded into the ITU-R BT.656 samples for the first four luminance and associated chrominance samples is shown in table 3.

8 Picture rate information

This clause defines the picture rate information required in the recoding information. Table 4 shows the elements which must be included.

The picture rate information must all pass without error in order to achieve the best performance when recoding. Therefore, the picture rate information must be sent in a reasonably rugged way and it is for this reason that several copies are sent in the macroblock formatted recoding information distributed around the picture in the manner which will now be discussed.

In order to carry the full picture rate information, 4320 bits are required. Each macroblock of recoding information shall carry a 32-bit element of this picture rate information which will therefore require a total of 135 macroblocks in order to carry the full picture rate information. The number of copies which will then be distributed for the main picture types and video format is given in table 5.

Other formats also exist, for example, in 422P@ML, the formats 720 $\times$ 608 pels for 625/50 frame and 720 $\times$ 512 pels for 525/60 frame. For these and other picture formats where a noninteger number of copies is available, incomplete copies will exist in the lower stripes of each picture.

The content of the picture rate information is described in SMPTE 327M and in more detail as regards the transport mechanism in table 4.

The distribution of the picture rate information must be such that common video processes such as caption or logo insertion permit the full extraction of the picture rate information. The equation given below gives the optimal distribution of picture rate elements in each macroblock of the MPEG-2 recoding information, regardless of the picture type and video format used, given the stripe and column address of that macroblock:

picrate_element_index = [(stripe % 3) * 45 + column + (27 * (stripe / 3))] % 135

The mathematical symbols are as defined in ISO/IEC 13818-2.

8.1 Picture rate elements

Table 4 shows a listing of the elements taken from the bit stream which will be included in the MPEG-2 recoding information.

For each element of the picture rate information, a category can be defined according to the way the information should be conveyed within the MPEG-2 recoding information. These categories are defined and numbered in the list below, with a definition of how this information is conveyed:

1) Represents values that are taken directly from the bit stream when present in the current picture, otherwise these values are undefined.

2) Represents values which might not be present in the bit stream for each picture, but which are required in each picture where MPEG-2 recoding information is embedded. These elements must be repeated in each picture based on previous values encountered in the bit stream.

3) Represents values that are not directly present in the bit stream, but must be derived for every

picture where the recoding information is to be embedded.

The category of each picture rate information element is given for each element in table 4.

The 32-bit protection CRC to allow error detection for the picture rate information is defined by the model in annex A of ISO/IEC 13818-1. The CRC is calculated on the 4288 data bits of the embedded MPEG-2 recoding picture rate information taken in the order given in table 4.

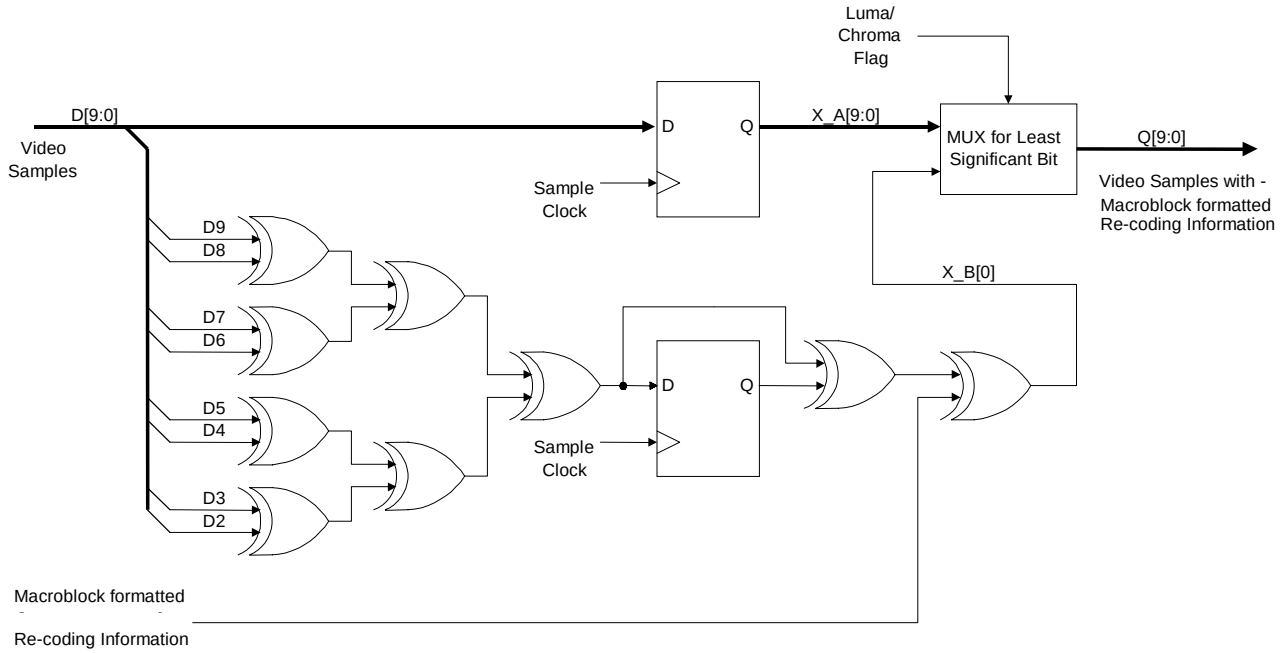

Figure 4 – Embedding of the macroblock formatted recoding information

Table 3 – Layout of the macroblock formatted recoding information within the video data

D9	C_b[0][9]	Y[0][9]	C_r[0][9]	Y[1][9]	C_b[1][9]	Y[2][9]	C_r[1][9]	Y[3][9]
D8	C_b[0][8]	Y[0][8]	C_r[0][8]	Y[1][8]	C_b[1][8]	Y[2][8]	C_r[1][8]	Y[3][8]
D7	C_b[0][7]	Y[0][7]	C_r[0][7]	Y[1][7]	C_b[1][7]	Y[2][7]	C_r[1][7]	Y[3][7]
D6	C_b[0][6]	Y[0][6]	C_r[0][6]	Y[1][6]	C_b[1][6]	Y[2][6]	C_r[1][6]	Y[3][6]
D5	C_b[0][5]	Y[0][5]	C_r[0][5]	Y[1][5]	C_b[1][5]	Y[2][5]	C_r[1][5]	Y[3][5]
D4	C_b[0][4]	Y[0][4]	C_r[0][4]	Y[1][4]	C_b[1][4]	Y[2][4]	C_r[1][4]	Y[3][4]
D3	C_b[0][3]	Y[0][3]	C_r[0][3]	Y[1][3]	C_b[1][3]	Y[2][3]	C_r[1][3]	Y[3][3]
D2	C_b[0][2]	Y[0][2]	C_r[0][2]	Y[1][2]	C_b[1][2]	Y[2][2]	C_r[1][2]	Y[3][2]
D1	C_b[0][1]	Y[0][1]	C_r[0][1]	Y[1][1]	C_b[1][1]	Y[2][1]	C_r[1][1]	Y[3][1]
D0	Macroblock formatted recoding information	Y[0][0]	Macroblock formatted recoding information	Y[1][0]	Macroblock formatted recoding information	Y[2][0]	Macroblock formatted recoding information	Y[3][0]

Table 4 – Picture rate elements

Parameter	Number format	No. of bits	Bit offset from	Bit offset to	Data category	Details
MPEG standard flag	1-bit flag	1	0	0	3	1=>MPEG1:0=>MPEG2
red_bw_flag	1-bit flag	1	1	1	3	Default = 0
red_bw_indicator	3-bit ui	3	2	4	3	Default = 000
header present flags	2 flags	2	5	6	3	Sequence header present flag, GOP header present flag
Extension start code flags	16 flags	16	7	22	3	Indicates if a given extension start code exists. The 16 flags correspond to the 16 entries in table 6.2 of ISO/IEC 13818-2 in the order they are listed.
Other start codes	3 flags	3	23	25	3	user_data_start_code sequence_error_code sequence_end_code
sequence header						
horizontal_size	14-bit uimsbf	14	26	39	2	Includes extension
vertical_size	14-bit uimsbf	14	40	53	2	Includes extension
aspect_ratio_information	4-bit uimsbf	4	54	57	2	
frame_rate_code	4-bit uimsbf	4	58	61	2	
bit_rate	30-bit uimsbf	30	62	91	2	Includes extension
vbv_buffer_size	18-bit uimsbf	18	92	109	2	Includes extension
constrained_parameter_flag	1-bit flag	1	110	110	2	
sequence extension						
profile_and_level_indication	8-bit uimsbf	8	111	118	2	
progressive_sequence	1-bit flag	1	119	119	2	
chroma_format	2-bit uimsbf	2	120	121	2	
low_delay	1-bit flag	1	122	122	2	
sequence display extension						
video_format	3-bit uimsbf	3	123	125	2	
color_description	1-bit flag	1	126	126	2	
color_primaries	8-bit uimsbf	8	127	134	2	
transfer_characteristics	8-bit uimsbf	8	135	142	2	
matrix_coefficients	8-bit uimsbf	8	143	150	2	
display_horizontal_size	14-bit uimsbf	14	151	164	2	
display_vertical_size	14-bit uimsbf	14	165	178	2	
group of pictures header						
time_code	25-bit field	25	179	203	2	
closed_gap	1-bit flag	1	204	204	2	
broken_link	1-bit flag	1	205	205	2	

(continued)

Table 4 – Picture rate elements (continued)

Parameter	Number format	No. of bits	Bit offset from	Bit offset to	Data category	Details
picture header						
temporal_reference	10-bit uimsbf	10	206	215	1	
picture_coding_type	3-bit uimsbf	3	216	218	1	
vbv_delay	16-bit uimsbf	16	219	234	1	To be calculated (see note 1)
full_pel_forward_vector	1-bit flag	1	235	235	1	
forward_f_code	3-bit uimsbf	3	236	236	1	
full_pel_backward_vector	1-bit flag	1	239	239	1	
backward_f_code	3-bit uimsbf	3	240	242	1	
picture coding extension						
forward_horizontal_f_code	4-bit uimsbf	4	243	246	1	
forward_vertical_f_code	4-bit uimsbf	4	247	250	1	
backward_horizontal_f_code	4-bit uimsbf	4	251	254	1	
backward_vertical_f_code	4-bit uimsbf	4	255	258	1	
intra_dc_precision	2-bit uimsbf	2	259	260	1	
picture_structure	2-bit uimsbf	2	261	262	1	
top_field_first	1-bit flag	1	263	263	1	
frame_pred_frame_dct	1-bit flag	1	264	264	1	
concealment_motion_vectors	1-bit flag	1	265	265	1	
q_scale_type	1-bit flag	1	266	266	1	
intra_vlc_format	1-bit flag	1	267	267	1	
alternate_scan	1-bit flag	1	268	268	1	
repeat_first_field	1-bit flag	1	269	269	1	
chroma_420_type	1-bit flag	1	270	270	1	
progressive frame	1-bit flag	1	271	271	1	
composite_display_flag	1-bit flag	1	272	272	1	
v-axis	1-bit flag	1	273	272	1	
field_sequence	3-bit uimsbf	3	274	276	1	
sub_carrier	1-bit flag	1	277	277	1	
burst_amplitude	7-bit uimsbf	7	278	284	1	
sub_carrier_phase	8-bit uimsbf	8	285	292	1	
quant matrix extension						See note 2.
load_intra_quantizer_matrix	1-bit flag	1	293	293	1	
load_non_intra_quantizer_matrix	1-bit flag	1	294	294	1	
load_chroma_intra_quantizer_matrix	1-bit flag	1	295	295	1	
load_chroma_non_intra_quantizer_matrix	1-bit flag	1	296	296	1	
intra_quantizer_matrix[64]	64* 0..255	512	297	808	2	
non_intra_quantizer_matrix[64]	64* 0..255	512	809	1320	2	
chroma_intra_quantizer_matrix[64]	64* 0..255	512	1321	1832	2	
chroma_non_intra_quantizer_matrix[64]	64* 0..255	512	1833	2344	2	

(continued)

Table 4 – Picture rate elements (concluded)

Parameter	Number format	No. of bits	Bit offset from	Bit offset to	Data category	Details
picture display extension						
frame_center_horizontal_offset_1	16-bit uimsbf	16	2345	2360	2	
frame_center_vertical_offset_1	16-bit uimsbf	16	2361	2376	2	
frame_center_horizontal_offset_2	16-bit uimsbf	16	2377	2392	2	
frame_center_vertical_offset_2	16-bit uimsbf	16	2393	2408	2	
frame_center_horizontal_offset_3	16-bit uimsbf	16	2409	2424	2	
frame_center_vertical_offset_3	16-bit uimsbf	16	2425	2440	2	
copyright extension						
Copyright flag	1-bit flag	1	2441	2441	2	
Copyright identifier	8-bit code	8	2442	2449	2	
Original or copy	1-bit flag	8	2450	2450	2	
Copyright number	64-bit uimsbf	64	2451	2514	2	
PTS/DTS						
PTS_DTS_flag	2-bit flag	2	2515	2516	1	
PTS value	33-bit uimsbf	33	2517	2549	2	
DTS value	33-bit uimsbf	33	2550	2582	2	
spare reserved bits						
Spare	41-bit uimsbf	41	2583	2623		
user data area						
User data		1664	2624	4287	2	
picture rate information CRC						
32-bit protection CRC	32-bit uimsbf	32	4288	4319		

NOTES
1 This value shall be calculated as defined in SMPTE 327M.
2 Refer to SMPTE 327M for further details.

Table 5 – Repetition of picture rate information

Video format	Pels	No. of MBs	No. of copies
625/50 frame	720 × 576	1620	12
625/50 field	720 × 288	810	6
525/60 frame	720 × 480	1350	10
525/60 field	720 × 240	675	5