

INTERNATIONAL
STANDARD

IEC
62330-2

First edition
2003-05

**Helical-scan digital video cassette recording
system using 12,65 mm (0,5 in) magnetic tape –
Format HD-D5 –**

**Part 2:
Compression format**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**HELICAL-SCAN DIGITAL VIDEO CASSETTE RECORDING SYSTEM
USING 12,65 mm (0,5 in) MAGNETIC TAPE – FORMAT HD-D5 –****Part 2: Compression format****FOREWORD**

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International Standard IEC 62330-2 has been prepared by Technical Area 6: Higher data rate storage media and equipment of IEC technical committee 100: Audio, video and multimedia systems and equipment.

It was submitted to the national committees for voting under the Fast Track Procedure as the following documents:

CDV	Report on voting
100/505/CDV	100/604/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until 2008. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

IEC 62330 consists of the following parts, under the general title *Helical-scan digital video cassette recording system using 12,65 mm (0,5 in) magnetic tape – Format HD-D5*.

Part 1: VTR specifications

Part 2: Compression format

Part 3: Data stream format

Part 1 describes the VTR specifications which are tape, magnetization, helical recording, modulation method and basic system data for high definition video compressed data on 29,97 or 59,94 frame rate.

This part 2 describes the specifications for encoding process and data format for 1080i and 720p systems.

Part 3 describes the specifications for transmission of HD-D5 compressed video and audio data stream over 360 Mb/s serial digital interface.

HELICAL-SCAN DIGITAL VIDEO CASSETTE RECORDING SYSTEM USING 12,65 mm (0,5 in) MAGNETIC TAPE – FORMAT HD-D5 –

Part 2 – Compression format

1 Scope

This part of IEC 62330 defines the encoding process of the HD-D5 video compression and its data format for the 1 080/59,94i system (hereinafter referred to as the 1 080i system) and the 720/59,94p system (hereinafter referred to as the 720p system).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ITU-R BT.1543, *1 280 × 720, 16 × 9 progressively-captured image format for production and international programme exchange in the 60 Hz*

ITU-R BT.709, *Parameter values for the HDTV standards for production and international programme exchange*

3 Acronyms

BUF	Buffer memory
C	Colour difference signal
C3RMB	Compressed data of 3 RMBs
C(t, u)	The value of the DCT coefficient at frequency (t, u)
C _B /C _R	Colour difference signal
CC0 ~ CC2	Categories for C DCT block
Ccoef()	C DCT CG
CG	Coefficient group
CGNR	CG number of one Y/C DCT coefficient block in one RMB
CGNS	CG number of one Y/C DCT coefficient block in one SMB
CN	C3RMB number in one RMBG
CRcoef()	Rearranged C DCT CG
CS	C DCT block number in one SMB
CY0 ~ CY3	Categories for Y DCT block
DCT	Discrete cosine transform
DIF	Digital interface
DIF(n)	DIF block numbered n
DN	DIF block number
EOB	“End of block” code
EOM	“End of 3 RMBs” code

exnor	Logical exclusive nor
f()	Offset value table for SMBG distribution
FCB	Category flag of C _B DCT block
FCB'	Category flag of C _B DCT block
FCR	Category flag of C _R DCT block
FCR'	Category flag of C _R DCT block
FFL	Field number flag
FMB	Category flag of the MB
FMB'	Category flag of the MB
FYa ~ FYd	Category flags of the four DCT blocks (Ya ~ Yd) of the MB
FYa' ~ FYd'	Category flags of the four DCT blocks (Ya ~ Yd) of the MB
H	The horizontal SMB position number in one video field (1 080i system) or one video frame (720p system)
HR	The column position number of RMB
HS	The column position number of SMB in one SMBG
IDCT	Inverse discrete cosine transform
int (A)	Integer part of A
LEN	The byte length of C3RMB
MB	Macro block
mod	Modulus operator
N.A.	Not applicable
Offset()	Offset value for RMB shuffling
P(r, s)	The value of the pixel at the position (r, s) in Y/C DCT block
Qno	Quantization number
Qstep	Quantization step value
r	The horizontal pixel position number in Y/C DCT block
Rg	The RMBG number within the RMBs
RMB	Rearranged macro block
RMBG	Rearranged macro block group
Rn	The number of RMB coding order in each RMBG
s	The vertical pixel position number in Y/C DCT block
SA	The starting address of the remainder data in buffer memory
SABM	One byte data of SA (two bytes)
Sg	The SMBG number in one video field (1 080i system) or one video frame (720p system)
SMB	Super macro block
SMBG	Super macro block group
t	The horizontal frequency number in Y/C DCT coefficient block
TableCY0 ~ 3	Set up value tables for Y weighting function
TableCC0 ~ 2	Set up value tables for C weighting function
u	The vertical frequency number in Y/C DCT coefficient block
V	The vertical position number of SMB in one video field (1 080i system) or one video frame (720p system)
VLC	Variable length coding

VR	The row position number of RMB
VS	The row position number of SMB in one SMBG
W(t, u)	Weighting value at frequency (t, u)
Y	Luminance signal
Ya ~ Yd	Four Y DCT blocks in one MB
Ycoef()	Y DCT CG
YR	The Y DCT coefficient block number in one RMB
YRcoef()	Rearranged Y DCT CG
YS	The Y DCT block number in one SMB
Z	The row position number of the RMB after RMB shuffling
ZRL	Code of 15 successive zero coefficients followed by a coefficient of zero amplitude

4 Video processing

4.1 Overview

Luminance (Y) and colour difference components (C_B and C_R) from 1 080i or 720p video signal are sampled by 74,25/1,001 MHz and 37,125/1,001 MHz respectively.

After discarding samples in vertical and horizontal blanking periods, active video samples are divided into four super macro block groups (SMBG) per field (1 080i) or per frame (720p). Each SMBG consists of 1 080 super macro blocks (SMB).

Each SMB consists of two MBs. Each MB consists of four luminance DCT blocks (8×4 pixel matrix) and one each of C_B DCT block (8×8 pixel matrix) and C_R DCT block (8×8 pixel matrix).

As described later, two horizontally adjacent luminance DCT blocks are overlapped by one pixel column at their junction. Two horizontally adjacent chrominance DCT blocks are overlapped by one pixel column at their junction when they are formed into SMB.

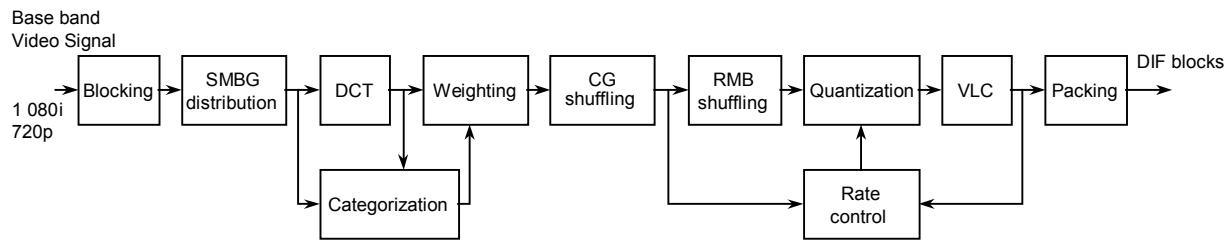
Each DCT block is transformed to represent DC and AC coefficients. Coefficients are weighted through the prearranged categories prior to shuffling, then formed into rearranged MBs (RMB).

DCT coefficients within one rearranged MB group (RMBG) are quantized, and made into a fixed length data set through VLC.

The VLC output code words from one RMBG are formed into 360 DIF blocks.

The compressed video data for one 1 080i field or one 720p frame consists of 5 760 DIF blocks.

The block diagram of the outline about video processing is shown in Figure 1.

**Figure 1 – Block diagram of outline about video processing**

4.2 Video signal

4.2.1 Sampling process

The sampling structure is defined in ITU-R BT.709 and ITU-R BT.1543. Sampling structures of the luminance (Y) and the two colour difference signals (C_B/C_R) are described in Table 1.

4.2.1.1 Line structure in one field (1 080i system) or frame (720p system)

For the 1 080i system, 540 lines for Y, C_B and C_R signals from each field shall be transmitted. For the 720p system, 720 lines for Y, C_R and C_B signals from each frame shall be transmitted. The transmitting lines on a television frame are defined in Table 1.

Table 1 – The construction of video signal sampling

		1 080i system		720p system			
Sampling frequency	Y	74,25 MHz / 1,001					
	C_B/C_R	37,125 MHz / 1,001					
Total number of pixels per line	Y	2 200		1 650			
	C_B/C_R	1 100		825			
The number of active pixels per line	Y	1 920		1 280			
	C_B/C_R	960		640			
Total number of lines per frame		1 125		750			
The number of active lines per frame		1 080		720			
The active line numbers		Field 1	21 to 560	Frame	26 to 745		
		Field 2	584 to 1 123				
Quantization		Each sample is linearly quantized to 10 bits for Y, C_B and C_R					
The relation between video signal level and quantized level	Scale	4 to 1 019					
	Y	Quantized level: 877 Video signal level of white: 940 Video signal level of black: 64					
	C_B/C_R	Quantized level: 897 Video signal level of gray: 512					

4.2.1.2 Pixel structure in one field (1 080i) / in one frame (720p)

- 1 080i system

All sampled pixels, 1 920 luminance pixels per line and 960 colour difference pixels, are retained for processing as shown in Figure 2. The sampling process starts simultaneously for both luminance and colour difference signals.

- 720p system

All sampled pixels, 1 280 pixels per line and 640 colour difference pixels, are retained for processing as shown in Figure 3. Sampling processes start simultaneously for both luminance and colour difference signals.

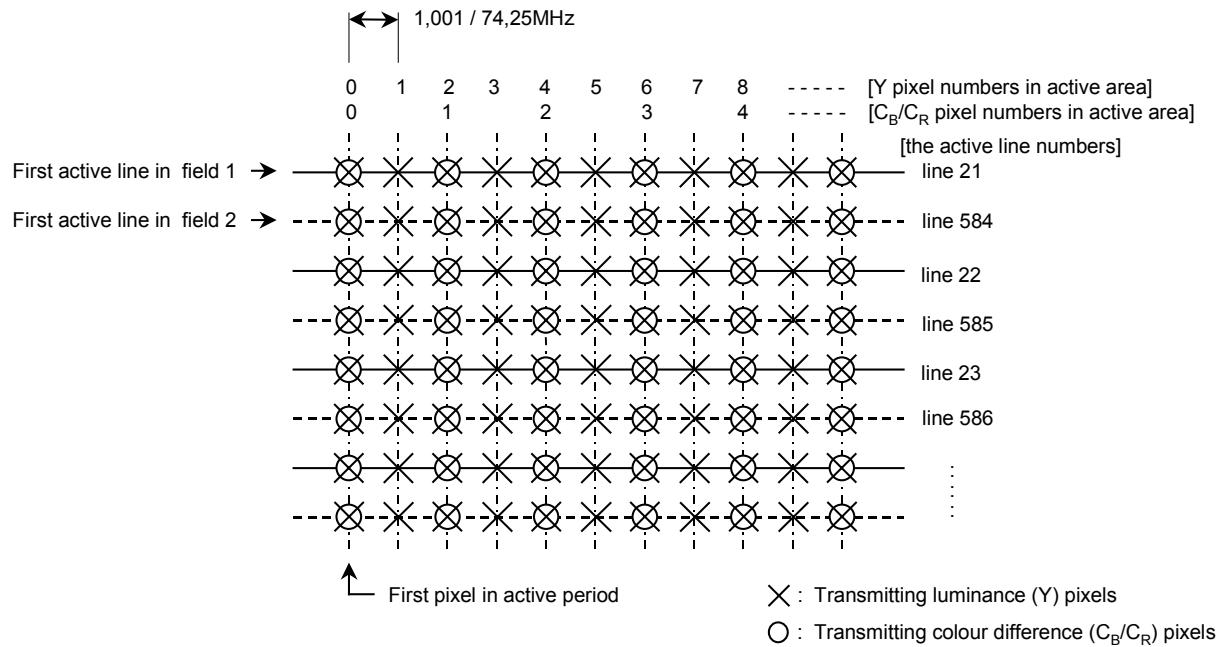


Figure 2 – Transmitting samples of 1 080i system

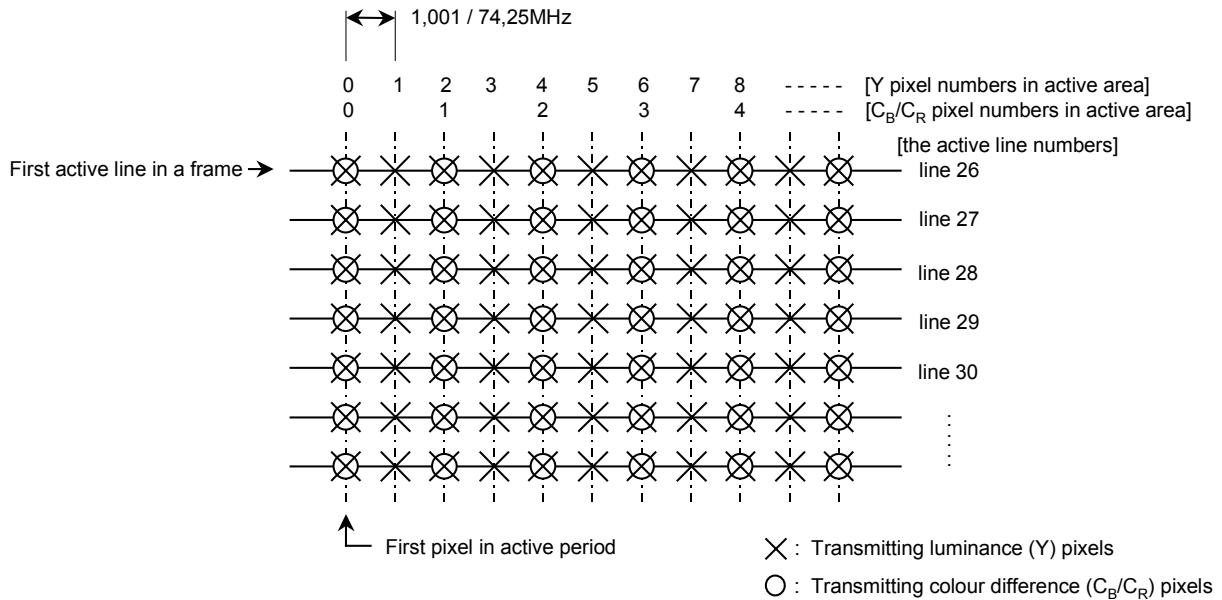


Figure 3 – Transmitting samples of 720p system

4.3 Block formation

4.3.1 DCT block, macro block (MB) and super macro block (SMB)

4.3.1.1 DCT block

The Y pixels in a field (1 080i system) and in a frame (720p system) shall be divided into rectangular areas of 15 horizontal pixels and 4 lines. Two Y DCT blocks (one Y DCT block pair) are made from each one of the rectangular areas as shown in Figure 4. In each Y DCT block pair, the rightmost pixel in the left DCT block is overlapped with the leftmost pixel in the right DCT block (overlapped blocking).

The C_B/C_R pixels in a field (1 080i) and in a frame (720p) shall be divided into rectangular areas of 15 horizontal pixels and 8 lines. Two C DCT blocks (one C DCT block pair) are made from each one of the rectangular areas as shown in Figure 5. In each C DCT block pair, the rightmost pixel in the left block is overlapped with the leftmost pixel in the right block (overlapped blocking). Overlapped blocking is used for the robustness of error (see Annex A).

Let r be the horizontal pixel position number in Y/C DCT block

$$r = 0, 1, 2, \dots, 7.$$

Let s be the vertical pixel position number in Y/C DCT block

For Y block s = 0, 1, 2, 3

For C block s = 0, 1, 2, ..., 7.

Let P(r, s) be the value of the pixel at the position (r, s)

4.3.1.2 Macro block (MB)

Each macro block (MB) in the 1 080i system and the 720p system consists of two Y DCT block pairs, one C_B DCT block and one C_R DCT block. Two Y DCT block pairs are vertically adjacent. C_B DCT block and C_R DCT block spatially correspond to the two Y DCT block pairs. Four Y DCT blocks (Y_a, Y_b, Y_c, Y_d), one C_B DCT block and one C_R DCT block are shown in Figure 6.

4.3.1.3 Super macro block (SMB)

As shown in Figure 7, each super macro block (SMB) in the 1 080i system and the 720p system consists of two macro blocks which are horizontally adjacent. Two C DCT blocks of C_B/C_R in one super macro block are one C DCT block pair of C_B/C_R .

Let YS be the Y DCT block number in each SMB as shown in Figure 7.

$$YS = 0, 1, 2, \dots, 7.$$

Let CS be the C DCT block number in each SMB as shown in Figure 7.

$$CS = 0, 1.$$

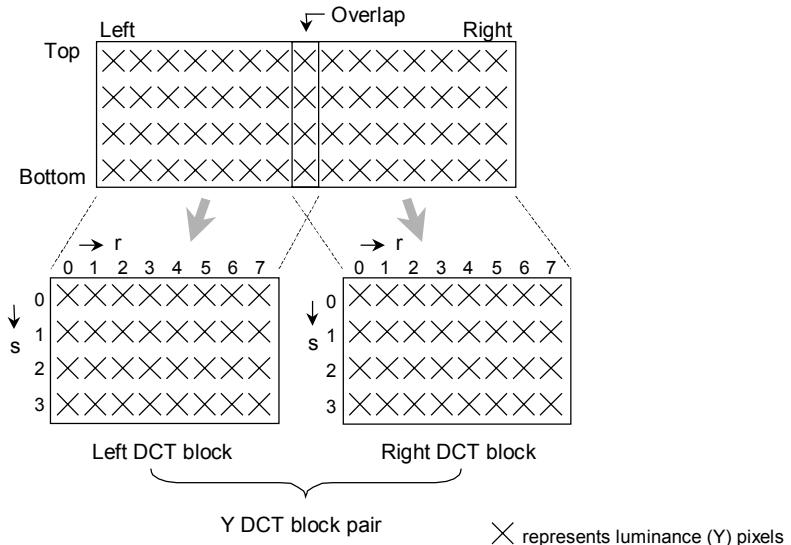


Figure 4 – Overlapped blocking of luminance (Y) pixels

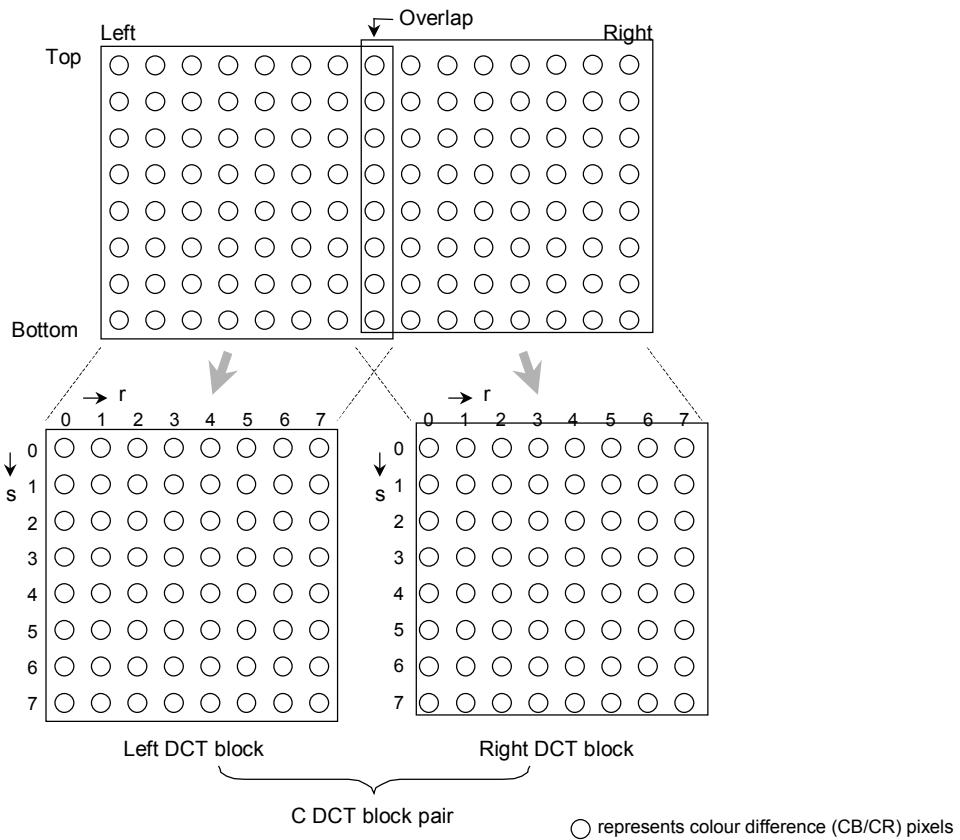


Figure 5 – Overlapped blocking of colour difference C_B/C_R pixels

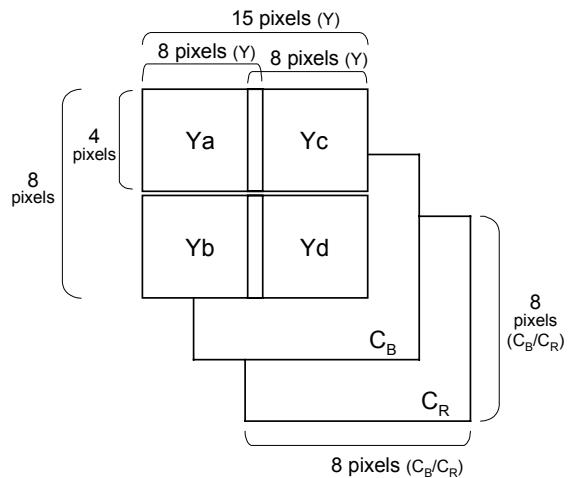


Figure 6 – Macro block structure in 1 080i system and 720p systems

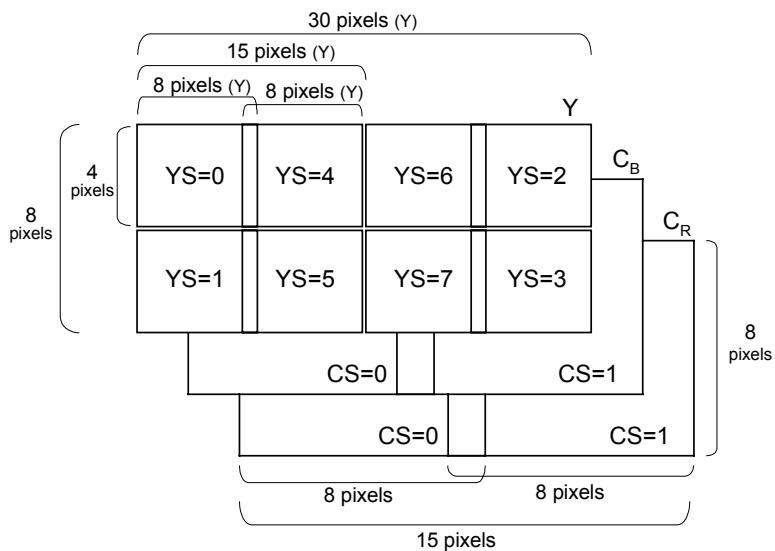


Figure 7 – Super macro block structure in 1 080i system and 720p systems

4.3.2 Super macro block arrangement

4.3.2.1 1 080i system

The vertical field dimension, 540 pixel long, is not divisible into an integer by the vertical dimension of the SMB, 8 pixels long.

In order to place all SMBs within the $1\ 920 \times 540$ pixel matrix of the 1 080i field, removal and attachments of half height SMBs are required as shown in Figure 8.

1) Y pixels

- Pixels in four rectangular areas of the horizontal pixel position number from $(480 \times N)$ to $(59 + 480 \times N)$ and from $(360 + 480 \times N)$ to $(419 + 480 \times N)$ in the active area and line position number from 536 to 539 in the active area shall be moved horizontally 1 020 pixel positions to the right, vertically 4 lines to the bottom ($N = 0, 1$).
- Pixels in two rectangular areas of the horizontal pixel position number from $(240 + 480 \times N)$ to $(359 + 480 \times N)$ in the active area and line position number from 536 to 539 in the active area shall be moved horizontally 840 pixel positions to the right, vertically 4 lines to the bottom ($N = 0, 1$).
- Pixels in four rectangular areas of the horizontal pixel position number from $(960 + 480 \times N)$ to $(1\ 019 + 480 \times N)$ and from $(1\ 320 + 480 \times N)$ to $(1\ 379 + 480 \times N)$ in the active area and line position number from 536 to 539 in the active area shall be moved horizontally 900 pixel positions to the left, vertically 4 lines to the bottom ($N = 0, 1$).
- Pixels in two rectangular areas of the horizontal pixel position number from $(1\ 200 + 480 \times N)$ to $(1\ 319 + 480 \times N)$ in the active area and line position number from 536 to 539 in the active area shall be moved horizontally 1 080 pixel positions to the left, vertically 4 lines to the bottom ($N = 0, 1$).

2) C_B/C_R pixels

C_B/C_R pixels occupy the positions held by the even numbered Y horizontal pixel numbers. The half height SMB replacement operation, identical to the Y pixels as described above, is performed for C_B/C_R pixels.

The arrangement of the SMBs in one field is shown in Figure 9. The same horizontal arrangement of 64 SMBs is repeated with 67 SMBs in the vertical direction from top, and there are 32 SMBs in the horizontal direction at the bottom. The number of SMBs in one field is 4 320 as described below:

$$(\text{vertical } 67 \text{ SMBs} \times \text{horizontal } 64 \text{ SMBs}) + 32 \text{ SMBs} = 4\,320 \text{ SMBs}$$

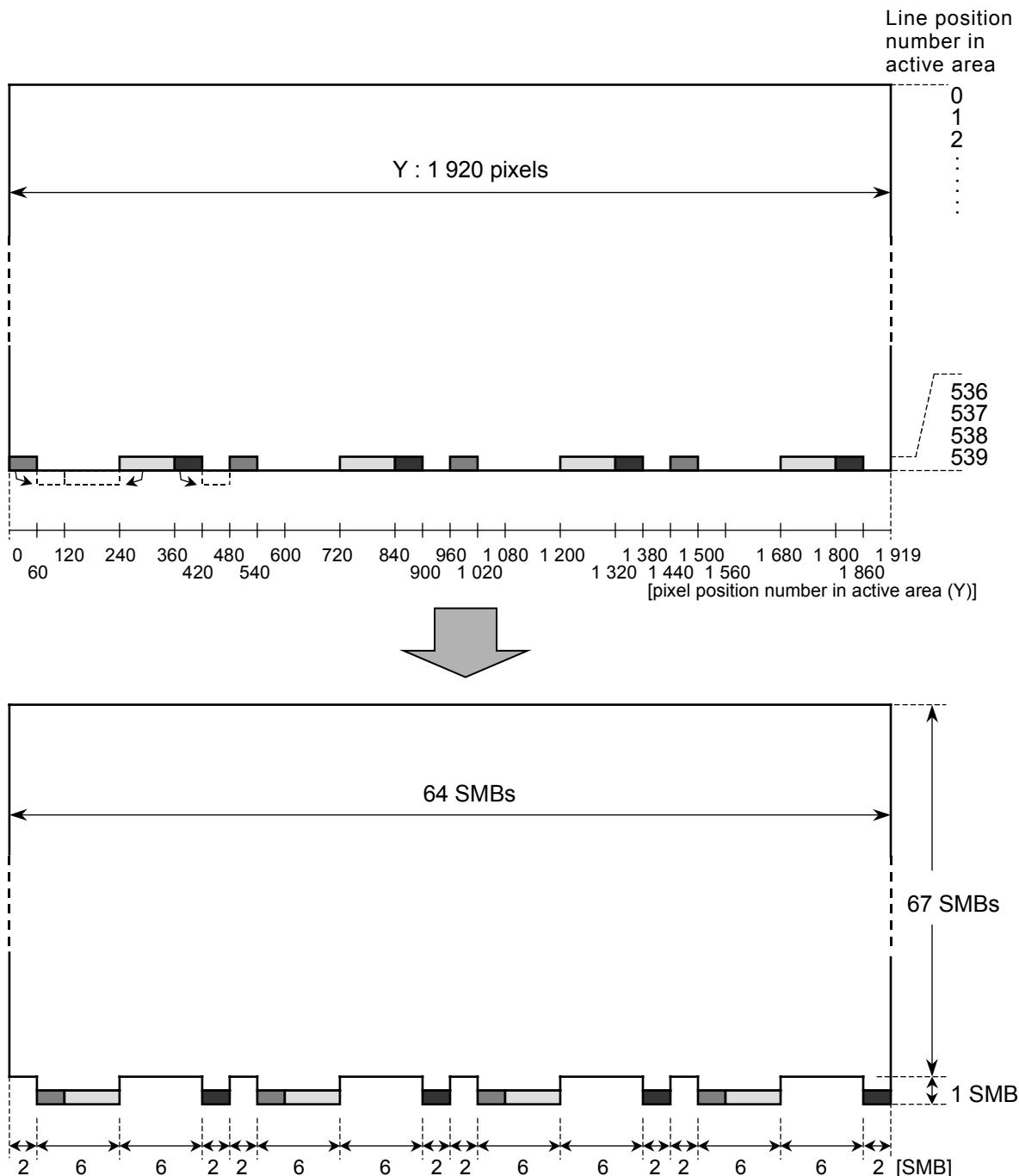


Figure 8 – Pixel arrangement for blocking of 1 080i system

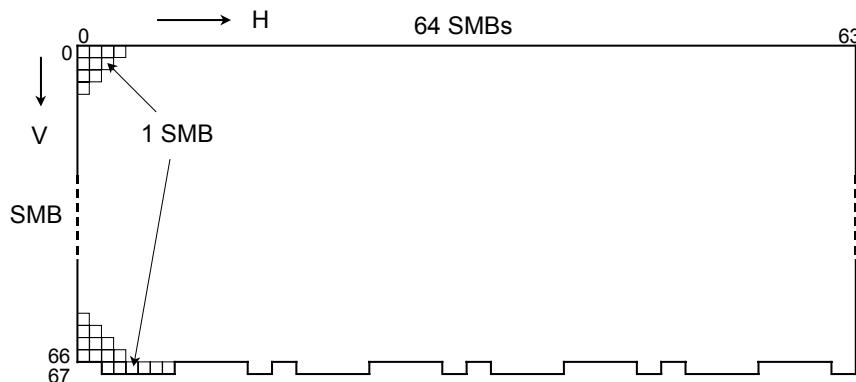


Figure 9 – The arrangement of SMBs in one field for 1 080i system

4.3.2.2 720p system

As the first step of block formation, 160 dummy of Y pixels and 80 dummy of C_B/C_R pixels are added as rightmost pixels in each line. The value of dummy shall be “040h” for Y and “200h” for C.

The arrangement of SMBs in one frame for the 720p system is shown in Figure 10. The same horizontal arrangement of 48 SMBs is repeated with 90 SMBs in the vertical direction from top to bottom. The number of SMBs in one frame is 4 320 as described below:

$$\text{vertical } 90 \text{ SMBs} \times \text{horizontal } 48 \text{ SMBs} = 4\,320 \text{ SMBs}$$

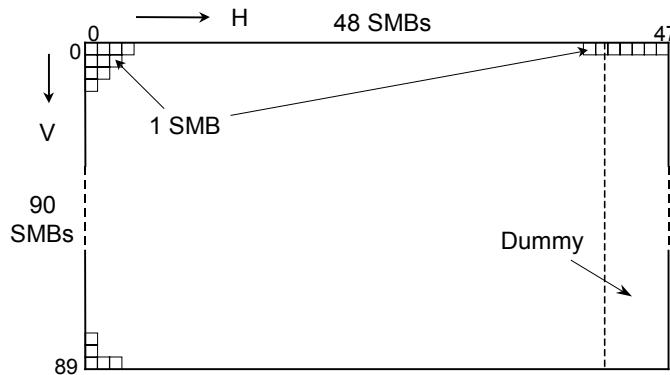


Figure 10 – The arrangement of SMBs in one frame for 720p system

4.4 SMBG distribution

4.4.1 1 080i system

4 320 SMBs in one field are divided into four SMBGs as shown in Figure 11.

Let H be the horizontal position number of SMB within the video field

$$H = 0, 1, 2, \dots, 63.$$

Let V be the vertical position number of SMB within the video field

$$V = 0, 1, 2, \dots, 67.$$

Let HS be the column position number of SMB within one SMBG

$$HS = 0, 1, 2, \dots, 5.$$

Let VS be the row position number of SMB within one SMBG

$$VS = 0, 1, 2, \dots, 179.$$

Let Sg be the SMBG number in one field

$$Sg = 0, 1, 2, 3.$$

The distribution method is described as follows:

$$V = (\text{int} (VS / 8)) \times 3 + \text{int} ((VS \bmod 8) \times 6 + HS) / 16$$

$$H = ((f(h, v) + ((\text{int}(VS / 8)) - Sg) \times 8) \bmod 32) \times 2 + ((\text{int}(VS / 8)) \bmod 2) \times \text{nor}(HS \bmod 2)$$

$$\text{where } v = \text{int} ((VS \bmod 8) \times 6 + HS) / 16$$

$$h = \text{int} (((VS \bmod 8) \times 6 + HS) \bmod 16) / 2$$

xnor: exclusive nor

Value of $f(h, v)$

v	0	1	2	3	4	5	6	7
0	1	2	0	19	20	21	15	14
1	15	10	9	11	30	29	28	24
2	24	25	5	7	6	20	19	18

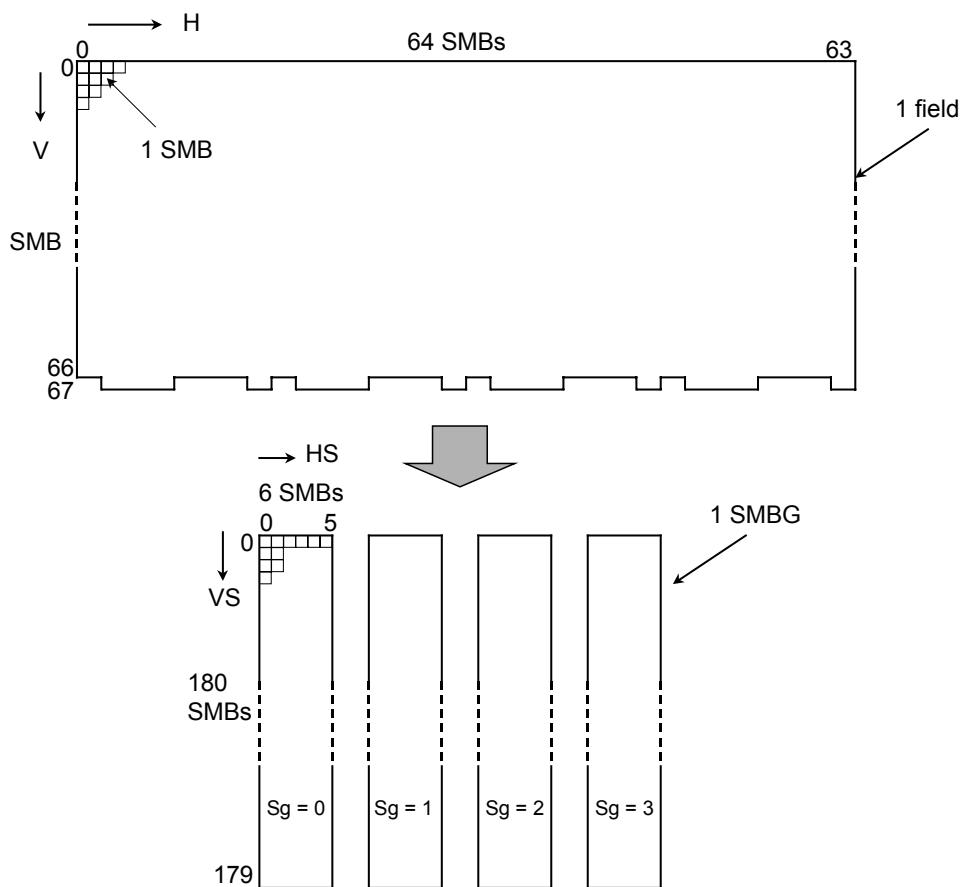


Figure 11 – SMBG distribution in 1 080i system

4.4.2 720p system

4 320 SMBs in one frame are divided into four SMBs as shown in Figure 12.

Let H be the horizontal position number of SMB within video frame

$$H = 0, 1, 2, \dots, 47.$$

Let V be the vertical position number of SMB within video frame

$$V = 0, 1, 2, \dots, 89.$$

Let HS be the column position number of SMB within one SMBG

$$HS = 0, 1, 2, \dots, 5.$$

Let VS be the row position number of SMB within one SMBG

$$VS = 0, 1, 2, \dots, 179.$$

Let Sg be the SMBG number in one frame

$$Sg = 0, 1, 2, 3.$$

The distribution method is described as follows:

$$V = \text{int} (VS / 2)$$

$$H = (VS \bmod 2) \times 24 + ((Sg + f((\text{int} (VS / 2)) \bmod 4)) \bmod 4) \times 6 + ((HS - \text{int} (VS / 2)) \bmod 6)$$

$$\text{where } f(0) = 0, f(1) = 1, f(2) = 3, f(3) = 2$$

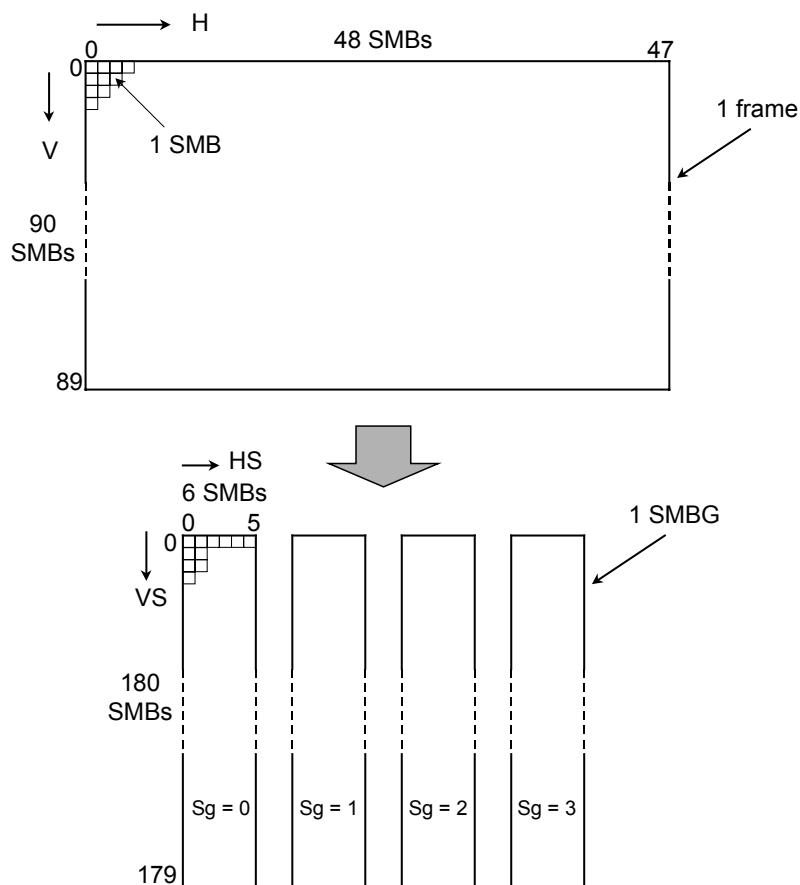


Figure 12 – SMBG distribution in 720p system

4.5 DCT

The maximum excursion of all pixel value is changed to fall between -511 and +511 by the subtraction of 512 from the original sampled value. 8×4 pixels $P(r, s)$ of each Y DCT block and 8×8 pixels $P(r, s)$ of each C_B/C_R DCT block are transformed into 8×4 Y DCT coefficients and 8×8 C DCT coefficients respectively.

Let t be the horizontal frequency number in Y/C DCT coefficient block as shown in Figure 13.

$$t = 0, 1, 2, \dots, 7.$$

Let u be the vertical frequency number in Y/C DCT coefficient block

$$\text{For Y DCT coefficient block } u = 0, 1, 2, 3$$

$$\text{For C DCT coefficient block } u = 0, 1, 2, \dots, 7.$$

Let $C(t, u)$ be the value of the DCT coefficient at frequency (t, u).

The coefficient of $t = 0$ and $u = 0$ is called as DC coefficient. Other coefficients are called as AC coefficients.

4.5.1 DCT/IDCT for Y

DCT/IDCT for the Y signal are defined as shown below:

DCT:

$$C(t, u) = \sqrt{2} \times C1(t) \times C2(u) \sum_{s=0}^3 \sum_{r=0}^7 (P(r, s) \times \cos(\pi u(2s+1)/8) \times \cos(\pi t(2r+1)/16))$$

IDCT:

$$P(r, s) = (1/\sqrt{2}) \sum_{u=0}^3 \sum_{t=0}^7 (C1(t) \times C2(u) \times C(t, u) \times \cos(\pi u(2s+1)/8) \times \cos(\pi t(2r+1)/16))$$

$$\text{where } C1(t) = 1/2\sqrt{2} \quad \text{for } t = 0$$

$$C1(t) = 1/2 \quad \text{for } t = 1 \text{ to } 7$$

$$C2(u) = 1/2 \quad \text{for } u = 0$$

$$C2(u) = 1/\sqrt{2} \quad \text{for } u = 1 \text{ to } 3$$

The structure of the Y DCT coefficient block is shown in Figure 13 a). DCT coefficients $C(t, u)$ of the Y DCT coefficient block are divided into 6 DCT coefficient groups (CGs).

Let CGNS be the CG number as shown in Figure 13 a)

$$\text{CGNS} = 0, 1, 2, 3, 4, 5.$$

4.5.2 DCT/IDCT for C

DCT/IDCT for C (C_B/C_R) signal are defined as shown below:

DCT:

$$C(t, u) = C3(t) \times C4(u) \sum_{s=0}^7 \sum_{r=0}^7 (P(r, s) \times \cos(\pi u(2s+1)/16) \times \cos(\pi t(2r+1)/16))$$

IDCT:

$$P(r, s) = \sum_{u=0}^7 \sum_{t=0}^7 (C_3(t) \times C_4(u) \times C(t, u) \times \cos(\pi u(2s+1)/16) \times \cos(\pi t(2r+1)/16))$$

where $C_3(t) = 1/\sqrt{2}$ for $t = 0$
 $C_3(t) = 1/2$ for $t = 1$ to 7
 $C_4(u) = 1/\sqrt{2}$ for $u = 0$
 $C_4(u) = 1/2$ for $u = 1$ to 7

The structure of the C DCT coefficient block is shown in Figure 13 b). DCT coefficients $C(t, u)$ of the C DCT coefficient block are divided into 6 DCT coefficient groups (CGs).

Let CGNS be the CG number as shown in Figure 13 b)

$$\text{CGNS} = 0, 1, 2, 3, 4, 5.$$

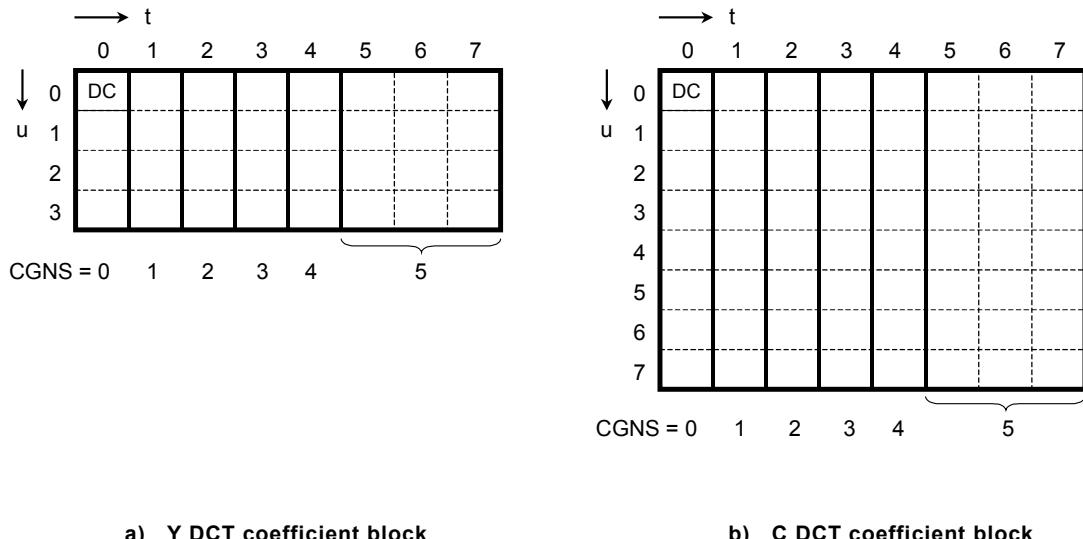


Figure 13 – The structure of DCT coefficient block

4.6 Categorization and weighting

Each MB is categorized into one of the categories and weighting is performed by multiplying all AC coefficients of the subject MB by a weighting function $W(t, u)$ selected by the category. The DC coefficient is not weighted.

There are four categories (CY0, CY1, CY2, CY3) for the Y DCT block, and three categories (CC0, CC1, CC2) for the C_B/C_R DCT block. Each category has its own weighting function. The weighting functions are selectively used to optimize the data compression process by categorization.

4.6.1 Categorization

MB categorization is identified by category flags of FMB, FYa, FYb, FYc, FYd, FCB and FCR. FYa, FYb, FYc, and FYd correspond to the Y DCT blocks of Ya, Yb, Yc, Yd in Figure 6 respectively. If the value of the quantized DC coefficient (-255, ..., 0, ..., 255, decimal) of C_B DCT block is less than 24, then FCB is set to 0, else FCB is set to 1. If the value of quantized DC coefficient (-255, ..., 0, ..., 255) of the C_R DCT block is less than 44, then FCR is set to 0, else FCR is set to 1.

Categories of CY0, CY1, CY2, and CY3 for the Y signal and categories of CC0, CC1, and CC2 for C signal are expressed by the flags as shown in Tables 2 to 4.

Table 2 – Categorization of Y signal

Flag				Category
FMB	FYa, FYb, FYc, FYd	FCB	FCR	
1	-	-	-	CY0
0	1	-	-	CY1
0	0	1	-	CY2
0	0	-	1	CY2
0	0	0	0	CY3

where -: arbitrary

Table 3 – Categorization of C_B signal

Flag		Category
FMB	FCB	
1	-	CC0
0	1	CC1
0	0	CC2

where -: arbitrary

Table 4 – Categorization of C_R signal

Flag		Category
FMB	FCR	
1	-	CC0
0	1	CC1
0	0	CC2

where -: arbitrary

4.6.2 Weighting

Weighting function W(t, u) in each category is defined below:

4.6.2.1 For Y signal

Category CY0

$$W(t, u) = \text{TableCY0}(t, u) \times \cos(0,045\pi t) \times \cos(0,060\pi u) / \sqrt{2}$$

Table 5 – Table CY0(t, u)

u	0	1	2	3	4	5	6	7
0	-	0,25	0,25	0,125	0,125	0,125	0,125	0,125
1	0,25	0,25	0,25	0,125	0,125	0,125	0,062 5	0,062 5
2	0,25	0,25	0,125	0,125	0,125	0,062 5	0,062 5	0,062 5
3	0,125	0,125	0,125	0,125	0,125	0,062 5	0,062 5	0,062 5

where -: N.A.

Category CY1

$$W(t, u) = \text{TableCY1}(t, u) \times \cos(0,045\pi t) \times \cos(0,0585\pi u) / \sqrt{2}$$

Table 6 – Table CY1(t, u)

u	t	0	1	2	3	4	5	6	7
0	-	0,5	0,5	$1/\sqrt{2}$	$1/\sqrt{2}$	$1/\sqrt{2}$	$1/\sqrt{2}$	$1/\sqrt{2}$	$1/\sqrt{2}$
1	0,5	0,5	0,5	$1/\sqrt{2}$	$1/\sqrt{2}$	$1/\sqrt{2}$	$1/\sqrt{2}$	$1/\sqrt{2}$	$1/\sqrt{2}$
2	0,5	0,5	$1/\sqrt{2}$						
3	$1/\sqrt{2}$								

where -: N.A.

Category CY2

$$W(t, u) = \text{TableCY2}(t, u) \times \cos(0,045\pi t) \times \cos(0,0585\pi u) / \sqrt{2}$$

Table 7 – Table CY2(t, u)

u	t	0	1	2	3	4	5	6	7
0	-	1	1	0,5	0,5	0,5	0,5	0,5	0,5
1	1	1	0,5	0,5	0,5	0,5	0,5	0,5	0,5
2	1	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
3	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5

where -: N.A.

Category CY3

$$W(t, u) = \text{TableCY3}(t, u) \times \cos(0,045\pi t) \times \cos(0,0585\pi u) / \sqrt{2}$$

Table 8 – Table CY3(t, u)

u	t	0	1	2	3	4	5	6	7
0	-	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
1	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
2	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
3	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5

where -: N.A.

4.6.2.2 For C_B/C_R signal

Category CC0

$$W(t, u) = \text{TableCC0}(t, u) \times \cos(0,065\pi t) \times \cos(0,065\pi u)$$

Table 9 – Table CC0(t, u)

t u	0	1	2	3	4	5	6	7
0	-	0,25	0,25	0,125	0,125	0,125	0,125	0,125
1	0,25	0,25	0,125	0,125	0,125	0,125	0,125	0,062 5
2	0,25	0,125	0,125	0,125	0,125	0,125	0,062 5	0,062 5
3	0,125	0,125	0,125	0,125	0,125	0,062 5	0,062 5	0,062 5
4	0,125	0,125	0,125	0,125	0,062 5	0,062 5	0,062 5	0,062 5
5	0,125	0,125	0,125	0,062 5	0,062 5	0,062 5	0,062 5	0,062 5
6	0,125	0,125	0,062 5	0,062 5	0,062 5	0,062 5	0,062 5	0,062 5
7	0,125	0,062 5	0,062 5	0,062 5	0,062 5	0,062 5	0,062 5	0,062 5

where -: N.A.

Category CC1

$$W(t, u) = \text{TableCC1}(t, u) \times \cos(0,065\pi t) \times \cos(0,065\pi u)$$

Table 10 – Table CC1(t, u)

t u	0	1	2	3	4	5	6	7
0	-	1	1	1/	1/ $\sqrt{2}$	1/ $\sqrt{2}$	1/ $\sqrt{2}$	1/ $\sqrt{2}$
1	1	1	1/ $\sqrt{2}$					
2	1	1/ $\sqrt{2}$						
3	1/ $\sqrt{2}$							
4	1/ $\sqrt{2}$							
5	1/ $\sqrt{2}$							
6	1/ $\sqrt{2}$							
7	1/ $\sqrt{2}$							

where -: N.A.

– Category CC2

$$W(t, u) = \text{TableCC2}(t, u) \times \cos(0,065\pi t) \times \cos(0,065\pi u)$$

Table 11 – Table CC2(t, u)

t u	0	1	2	3	4	5	6	7
0	-	0,5	0,5	0,5	0,5	0,5	0,5	0,5
1	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
2	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
3	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
4	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
6	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
7	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5

where -: N.A.

4.7 CG shuffling

In order to improve data robustness against error, weighted DCT CGs are shuffled within the same CGNSs of the 6 SMBs to 12 RMBs as shown in Figures 14 and 15. Each RMB comprises 4 Y shuffled DCT coefficient blocks, one shuffled C_B DCT coefficient block and one shuffled C_R DCT coefficient block.

Let $Ycoef(HS, VS, YS, CGNS)$ be the DCT CG which is referred by CGNS, YS, VS, and HS.

Let HR be the column position number of RMB

$$HR = 0, 1, 2, \dots, 11.$$

Let VR be the row position number of RMB

$$VR = 0, 1, 2, \dots, 179.$$

Let YR be the Y DCT coefficient block number within one RMB

$$YR = 0, 1, 2, 3.$$

Let CGNR be the DCT CG number of one Y DCT coefficient block or one C_B/C_R DCT coefficient block within one RMB

$$CGNR = 0, 1, 2, \dots, 5.$$

Let $YRcoef(HR, VR, YR, CGNR)$ be the DCT CG which is referred by CGNR, YR, VR, and HR.

The shuffling method of Y DCT CGs is described in the following equations.

For $HR = 0$ to 5

$$YRcoef(HR, VR, YR, CGNR) = Ycoef((CGNR - HR - \text{int}(VR / 32)) \bmod 6, VR, \\ VR + 4 \times \text{int}(((CGNR - HR) \bmod 6) / 3), CGNR)$$

For $HR = 6$ to 11

$$YRcoef(HR, VR, YR, CGNR) = Ycoef((1 - (CGNR + HR + \text{int}(VR / 32))) \bmod 6, VR, \\ VR + 4 \times \text{int}((4 - (CGNR + HR)) \bmod 6) / 3, CGNR)$$

Let $Ccoef(HS, VS, CS, CGNS)$ be the DCT CG which is referred by CGNS, CS, VS, and HS.

Let $CRcoef(HR, VR, CGNR)$ be the DCT CG which is referred by CGNR, VR, and HR.

The shuffling method of C_B/C_R DCT CGs is described in the following equations.

For $HR = 0$ to 5

$$CRcoef(HR, VR, CGNR) = Ccoef((CGNR - HR - \text{int}(VR / 32)) \bmod 6, VR, \\ \text{int}(((CGNR - HR) \bmod 6) / 3), CGNR)$$

For $HR = 6$ to 11

$$CRcoef(HR, VR, CGNR) = Ccoef((1 - (CGNR + HR + \text{int}(VR / 32))) \bmod 6, VR, \\ \text{int}((4 - (CGNR + HR)) \bmod 6) / 3, CGNR)$$

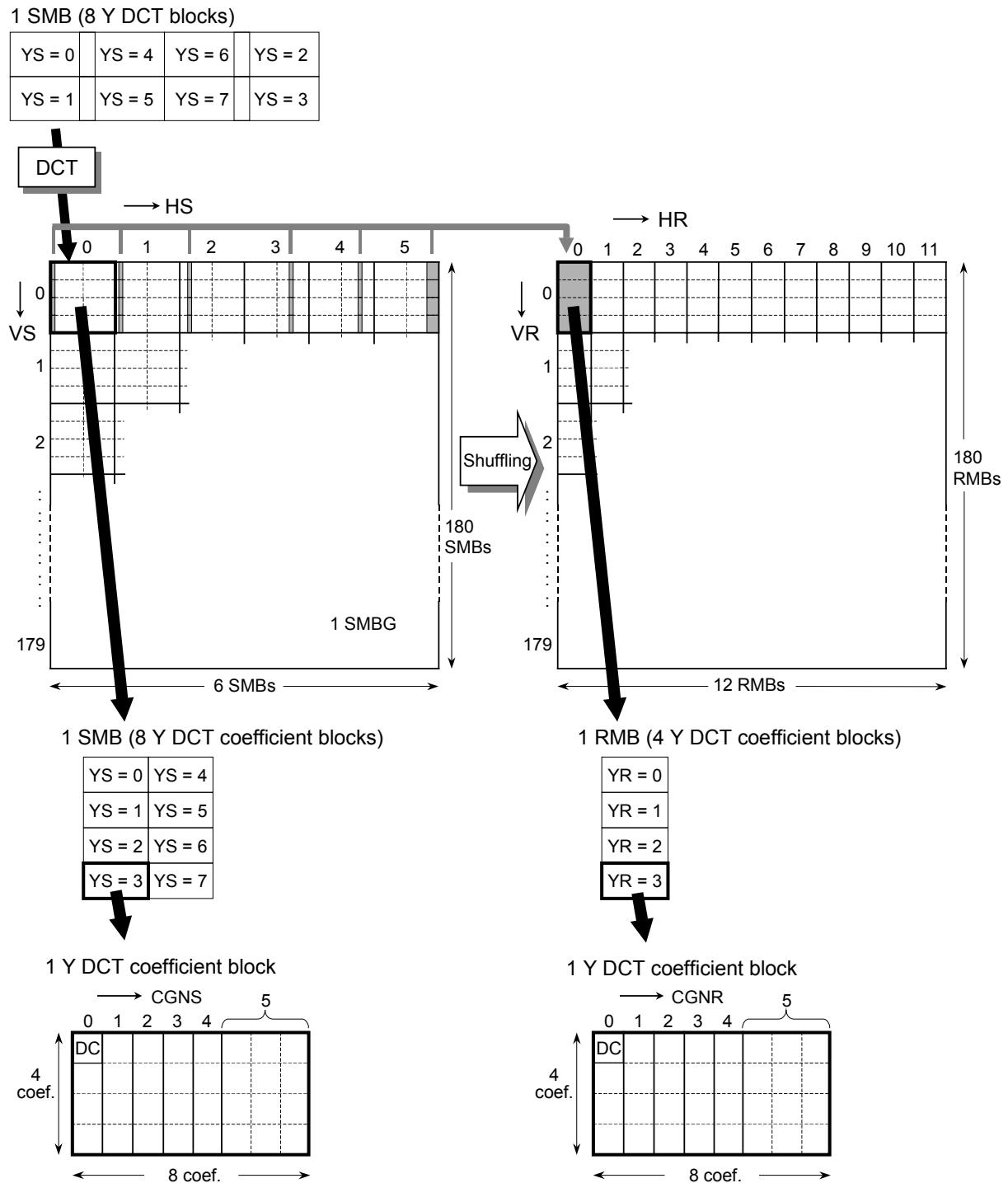
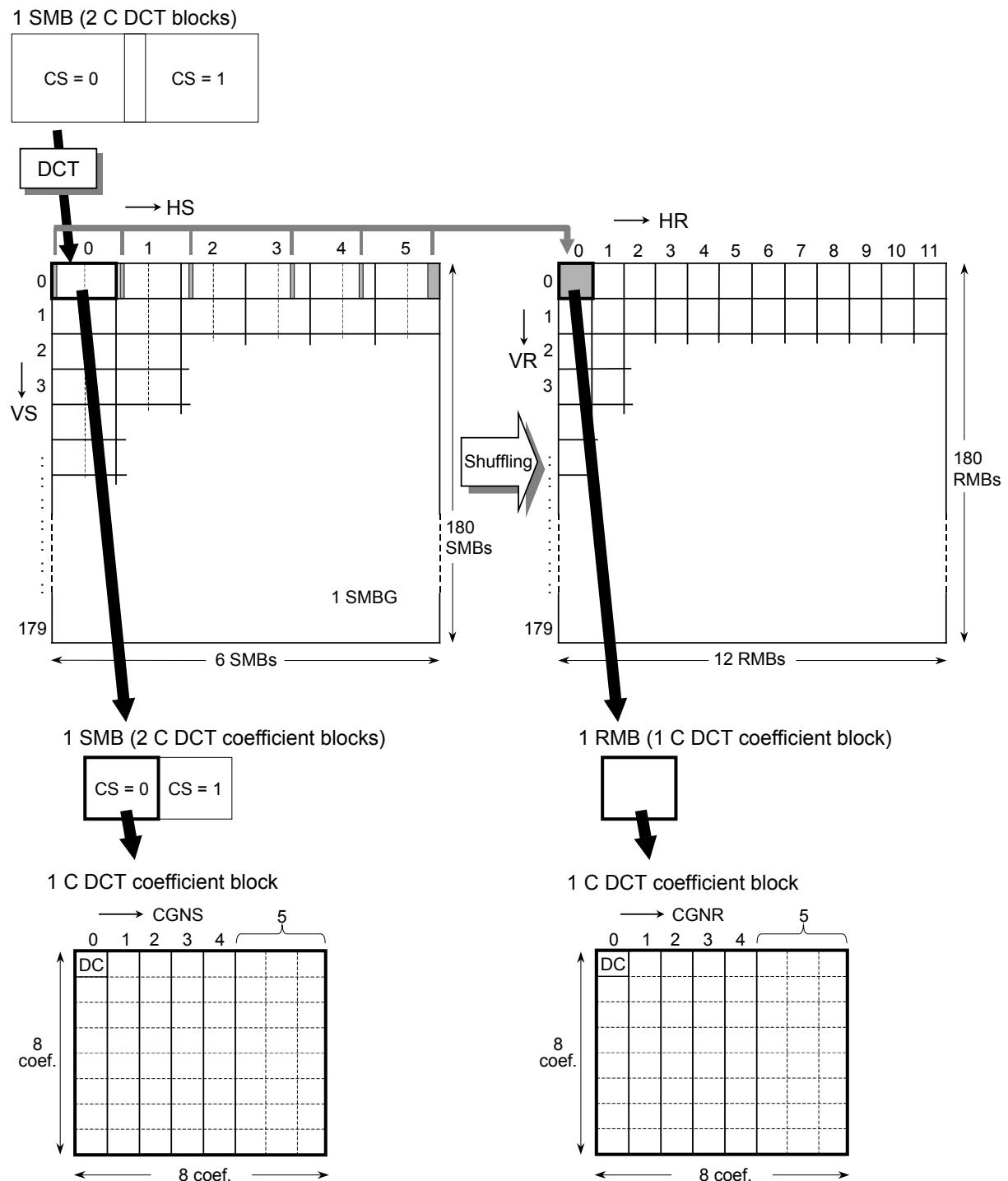


Figure 14 – CG shuffling for Y

**Figure 15 – CG shuffling for C**

4.8 RMB shuffling

In order to improve data robustness against error, RMBs are shuffled within the column of 180 RMBs as shown in Figure 16.

Let Z be the row position number of the RMB after RMB shuffling.

$$Z = 0, 1, 2, \dots, 179.$$

The method of RMB shuffling is described in the following equation:

$$Z = (17 \times (VR - \text{Offset(HR)})) \bmod 180$$

where value of Offset(HR)

HR	Offset(HR)
0	0
1	165
2	150
3	135
4	120
5	105
6	90
7	75
8	60
9	45
10	30
11	15

Then, the RMBs corresponding to one SMBG are divided into 4 RMB Groups (RMBGs). There are 540 RMBs in each RMBG.

Let Rg be the RMBG number within the RMBs as shown in Figure 16

$$Rg = 0, 1, 2, 3.$$

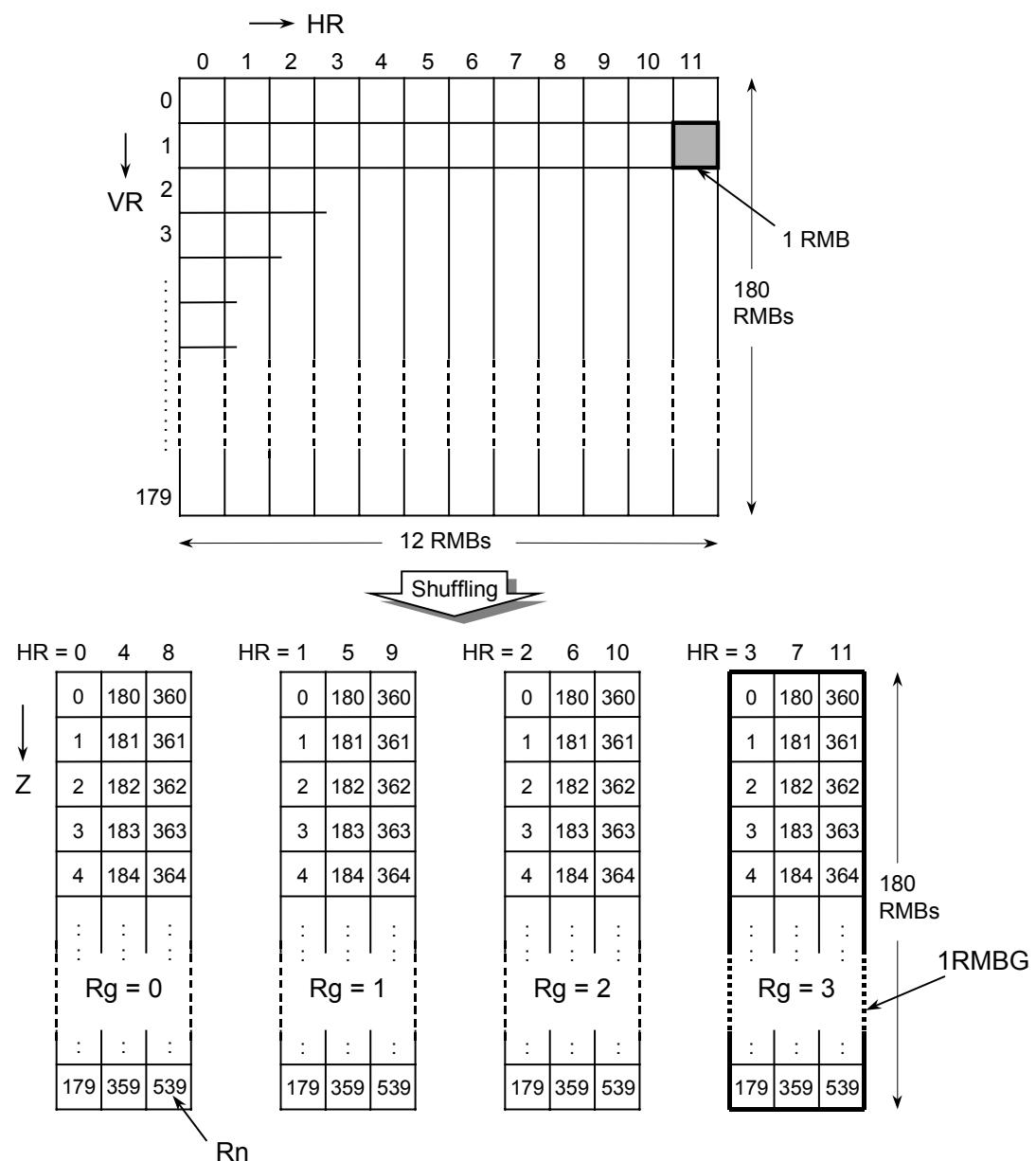
Let Rn be the number of RMB coding order in each RMBG

$$Rn = 0, 1, 2, \dots, 539.$$

The dividing method is described in the equation:

$$Rg = HR \bmod 4$$

$$Rn = Z + 180 \times \text{int} (HR / 4)$$

**Figure 16 – RMB shuffling**

4.9 Quantization

AC coefficient quantization step values (Qstep) are related to the quantization number (Qno) through a relationship as shown below:

$$\text{Qstep} = 2 (\text{Qno} \times 6 / 127 + 1)$$

where Qno = 0, 1, 2, ..., 127

Weighted AC coefficients are divided by Q step to be rounded into a signed value of 12 bits. The Q step for the DC coefficient is always 16. The DC coefficient is rounded into a signed integer value of 9 bits by quantization.

4.10 Rate control

The amount of the compressed data of one RMBG shall be controlled to 30 240 bytes or less. Qno is selected every three successive RMBs which are defined in 4.12.1.

4.11 VLC

Variable length coding (VLC) is an operation for transforming quantized AC coefficients in a DCT coefficient block into variable length codes using two-dimensional Huffman coding. One or some successive AC coefficients within a DCT coefficient block are coded into one variable length. The variable length coding process is as follows:

- 1) AC coefficients in a DCT coefficient block are arranged in order of AC coefficient number i ($i = 1$ to $31(Y), 63(C_B/C_R)$) as shown in Figure 17.
- 2) Each nonzero AC coefficient in the arranged AC coefficients is represented by the combination of size and level-codeword as shown in Table 12. The j-th nonzero AC coefficient is expressed as follows:

(Size(j), Level-codeword(j)) where $j = 1, 2, \dots$

- 3) Zero-run(j) gives the number of successive AC coefficients quantized to zero between (j-1)th nonzero AC coefficient and j-th nonzero AC coefficient.

The composite value of "Zero-run(j) / Size(j)" is Huffman coded to be the run_size-codeword(j) according to Table 13.

- 4) Each run_size-codeword(j) is followed by Level-codeword(j) to be one VLC codeword.

Since the number of successive zero coefficients may exceed 15, the codeword of ZRL (111111101100, shown in Table 13) is defined to represent 15 successive zero coefficients followed by a coefficient of zero amplitude (zero-run / size = 15 / 0).

The codeword of EOB (1010, shown in Table 13) is used to signal that all remaining AC coefficients in a DCT coefficient block are zero. If the AC coefficient numbered $31(Y), 63(C_B/C_R)$ in a DCT coefficient block is not zero, the EOB codeword is bypassed.

EOM (1111111111111111, shown in Table 13) codeword is used to terminate VLC coding of 3 RMBs compulsorily.

→ Horizontal frequency number

↓
Vertical frequency number

[DC]	4	8	12	16	20	24	28
1	5	9	13	17	21	25	29
2	6	10	14	18	22	26	30
3	7	11	15	19	23	27	31

→ Horizontal frequency number

↓
Vertical frequency number

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

b) C DCT coefficient block

Figure 17 – The order of VLC coding**Table 12 – Codewords for variable length coding (1)**

Coefficient (signed 12 bits)	Size	Level-codeword (0 bit – 11 bits)
0	0	–
-1, 1	1	0, 1
-3, -2, 2, 3	2	00, 01, 10, 11
-7, ..., -4, 4, ..., 7	3	000, ..., 011, 100, ..., 111
-15, ..., -8, 8, ..., 15	4	0000, ..., 0111, 1000, ..., 1111
-31, ..., -16, 16, ..., 31	5	00000, ..., 01111, 10000, ..., 11111
-63, ..., -32, 32, ..., 63	6	000000,, 111111
-127, ..., -64, 64, ..., 127	7	0000000,, 1111111
-255, ..., -128, 128, ..., 255	8	00000000,, 11111111
-511, ..., -256, 256, ..., 511	9	000000000,, 111111111
-1023, ..., -512, 512, ..., 1023	10	0000000000,, 1111111111
-2047, ..., -1024, 1024, ..., 2047	11	00000000000,, 11111111111

Table 13 – Codewords for variable length coding (2)

Zero-run / Size	Code length	Run_Size-codeword
0 / 0 (EOB)	4	1010
0 / 1	2	00
0 / 2	2	01
0 / 3	3	100
0 / 4	4	1011
0 / 5	5	11010
0 / 6	7	1111000
0 / 7	8	11111000
0 / 8	10	1111110101
0 / 9	13	1111111100010
0 / 10	13	1111111100011
0 / 11	17	1111111111011111
1 / 0 (EOM)	17	1111111111111111
1 / 1	4	1100
1 / 2	5	11011
1 / 3	7	1111001
1 / 4	9	111110110
1 / 5	11	11111110011
1 / 6	14	11111111001000
1 / 7	14	11111111001001
1 / 8	14	11111111001010
1 / 9	14	11111111001011
1 / 10	15	111111110011000
1 / 11	17	11111111111000011
2 / 1	5	11100
2 / 2	8	11111001
2 / 3	10	1111110110
2 / 4	12	111111101101
2 / 5	15	111111110011001
2 / 6	15	111111110011010
2 / 7	15	111111110011011
2 / 8	15	111111110011100
2 / 9	15	111111110011101
2 / 10	15	111111110011110
2 / 11	17	11111111111000111
3 / 1	6	111010
3 / 2	9	111110111
3 / 3	12	111111101110
3 / 4	15	111111110011111
3 / 5	15	111111110100000
3 / 6	15	111111110100001
3 / 7	15	111111110100010
3 / 8	15	111111110100011
3 / 9	15	111111110100100
3 / 10	15	111111110100101

Zero-run / Size	Code length	Run_Size-codeword
3 / 11	17	11111111111001011
4 / 1	6	111011
4 / 2	10	1111110111
4 / 3	15	111111110100110
4 / 4	15	111111110100111
4 / 5	15	111111110101000
4 / 6	15	111111110101001
4 / 7	15	111111110101010
4 / 8	15	111111110101011
4 / 9	15	111111110101100
4 / 10	15	111111110101101
4 / 11	17	11111111111001111
5 / 1	7	1111010
5 / 2	11	11111110100
5 / 3	15	111111110101110
5 / 4	15	111111110101111
5 / 5	15	111111110110000
5 / 6	15	111111110110001
5 / 7	15	111111110110010
5 / 8	15	111111110110011
5 / 9	15	111111110110100
5 / 10	15	111111110110101
5 / 11	17	11111111111010011
6 / 1	7	1111011
6 / 2	12	111111101111
6 / 3	15	111111110110110
6 / 4	15	111111110110111
6 / 5	15	111111110111000
6 / 6	15	111111110111001
6 / 7	15	111111110111010
6 / 8	15	111111110111011
6 / 9	15	111111110111100
6 / 10	15	111111110111101
6 / 11	17	11111111111010111
7 / 1	8	11111010
7 / 2	13	1111111100000
7 / 3	15	111111110111110
7 / 4	15	111111110111111
7 / 5	15	111111111100000
7 / 6	15	111111111100001
7 / 7	15	1111111111000010
7 / 8	15	1111111111000011
7 / 9	15	1111111111000100
7 / 10	15	1111111111000101
7 / 11	17	11111111111010111

Zero-run / Size	Code length	Run_Size-codeword
8 / 1	9	111111000
8 / 2	13	1111111100001
8 / 3	15	111111111000110
8 / 4	15	111111111000111
8 / 5	15	111111111000100
8 / 6	15	111111111001001
8 / 7	15	111111111001010
8 / 8	15	111111111001011
8 / 9	15	111111111001100
8 / 10	15	111111111001101
8 / 11	17	1111111111101111
9 / 1	9	111111001
9 / 2	15	111111111001110
9 / 3	15	111111111001111
9 / 4	15	111111111010000
9 / 5	16	1111111110100010
9 / 6	16	1111111110100011
9 / 7	16	1111111110100100
9 / 8	16	1111111110100101
9 / 9	16	1111111110100110
9 / 10	16	1111111110100111
9 / 11	17	1111111111100011
10 / 1	10	1111110100
10 / 2	16	1111111110101000
10 / 3	16	1111111110101001
10 / 4	16	1111111110101010
10 / 5	16	1111111110101011
10 / 6	16	1111111110101100
10 / 7	16	1111111110101101
10 / 8	16	1111111110101110
10 / 9	16	1111111110101111
10 / 10	16	1111111110110000
10 / 11	17	1111111111100111
11 / 1	10	1111111000
11 / 2	16	1111111110110001
11 / 3	16	1111111110110010
11 / 4	16	1111111110110011
11 / 5	16	1111111110110100
11 / 6	16	1111111110110101
11 / 7	16	1111111110110110
11 / 8	16	1111111110110111
11 / 9	16	1111111110111000
11 / 10	16	1111111110111001
11 / 11	17	1111111111101011
12 / 1	11	1111110010

Zero-run / Size	Code length	Run_Size-codeword
12 / 2	16	1111111110111010
12 / 3	16	11111111110111011
12 / 4	16	11111111110111100
12 / 5	16	11111111110111101
12 / 6	16	11111111110111110
12 / 7	16	11111111110111111
12 / 8	16	11111111111000000
12 / 9	16	11111111111000001
12 / 10	16	11111111111000010
12 / 11	17	111111111111101111
13 / 1	11	11111110101
13 / 2	16	11111111111000011
13 / 3	16	11111111111000100
13 / 4	16	11111111111000101
13 / 5	16	11111111111000110
13 / 6	16	11111111111000111
13 / 7	16	11111111111001000
13 / 8	16	11111111111001001
13 / 9	16	11111111111001010
13 / 10	16	11111111111001011
13 / 11	17	111111111111110011
14 / 1	16	11111111111001100
14 / 2	16	11111111111001101
14 / 3	16	11111111111001110
14 / 4	16	11111111111001111
14 / 5	16	11111111111010000
14 / 6	16	11111111111010001
14 / 7	16	11111111111010010
14 / 8	16	11111111111010011
14 / 9	16	11111111111010100
14 / 10	16	11111111111010101
14 / 11	17	111111111111110111
15 / 0 (ZRL)	12	111111101100
15 / 1	16	11111111111010110
15 / 2	16	11111111111010111
15 / 3	16	11111111111011000
15 / 4	16	11111111111011001
15 / 5	16	11111111111011010
15 / 6	16	11111111111011011
15 / 7	16	11111111111011100
15 / 8	16	11111111111011101
15 / 9	16	11111111111011110
15 / 10	17	111111111110111110
15 / 11	17	111111111111110111

4.12 Packing

4.12.1 Compressed data of 3 RMBs

As the first step in packing compressed data into DIF blocks, the compressed data (C3RMB) of every 3 RMBs are made.

Let CN be the C3RMB number in one RMBG.

CN = 0, 1, 2, ..., 179

Let C3RMB[Sg][Rg][CN] be the C3RMB numbered CN of RMBG numbered Rg in SMBG numbered Sg.

Let C3RMB[Sg][Rg][CN][i] be the i-th byte of data in the C3RMB [Sg][Rg][CN] (i = 0, 1, 2, ...).

Each C3RMB is composed of 3 RMBs which are numbered Rn = 3CN, 3CN+1, 3CN+2 in each RMBG.

The structure of the C3RMB is shown in Figure 18. The C3RMB is composed of a fixed length data portion and a variable length data portion. The fixed length data portion comprises side information and DC data. The variable length data portion comprises AC data.

4.12.1.1 Side information and DC data

The details of the fixed length data portion in Figure 18 are as follows:

- SABM: Upper or lower byte of the starting address (2 bytes) of the remainder data of the C3RMB stored in buffer memory. (See 4.12.3 for details)
- FFL: Field number flag
 - 0 = the 1st field, 1 = the 2nd field (1 080i system)
 - N.A. (720p system)
- Qno: 7-bit data of quantization number
- Category flag:
 - FMB -- FMB flag of the MB, to which the C_B/C_R DC coefficient of the RMB belongs before CG shuffling.
 - FMB' -- FMB flag of the other MB in the SMB, to which the MB mentioned above belongs.
 - FYa-d -- Flags of the four DCT blocks (Ya-Yd) of the MB, to which the C_B/C_R DC coefficient of the RMB belongs before CG shuffling.
 - FYa'-d' -- Flag of each DCT block (Ya-Yd) of the other MB in the SMB, to which the MB mentioned above belongs.
 - FCB' -- FCB flag of the C_B DCT block which overlaps the C_B DCT block, to which the C_B DC coefficient of the RMB belongs before CG shuffling.
 - FCR' -- FCR flag of the C_R DCT block which overlaps the C_R DCT block, to which the C_R DC coefficient of the RMB belongs before CG shuffling.
- DC data: 9-bit DC coefficient data of the 18 DCT coefficient blocks in 3 RMBs 9-bit DC coefficient data are separated into two groups of 8-MSB data and LSB data respectively. DC data is composed of one sign bit data (MSB, 0: plus or zero, 1: minus) and 8-bit binary data (absolute value).

NOTE The side information does not include FCB and FCR because they can be made from the DC data of the C_B/C_R DCT block.

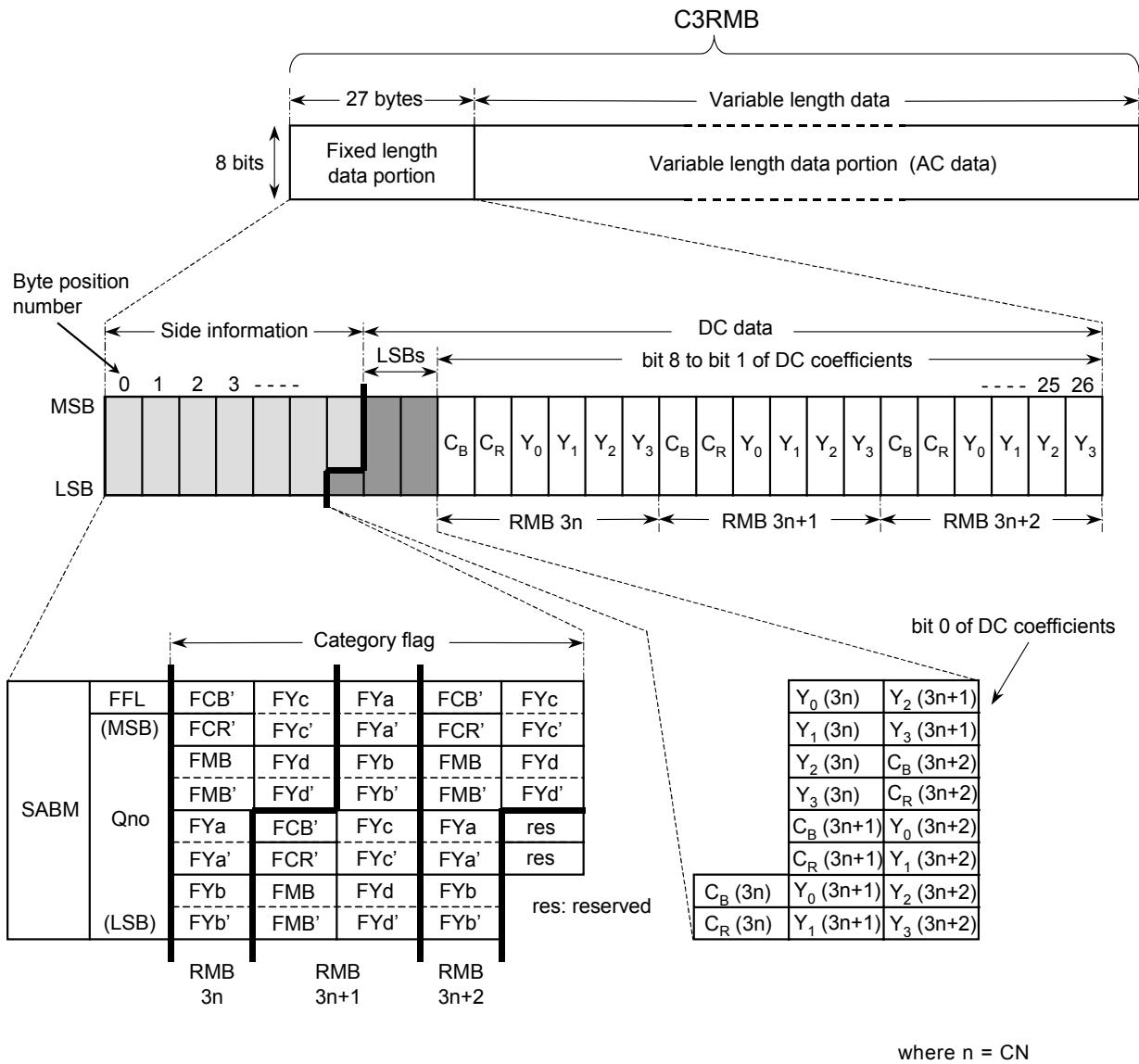


Figure 18 – Structure of C3RMB

4.12.1.2 AC data of 3 RMBs

To store the significant data of C3RMB in one DIF block, VLC code words of all DCT coefficient blocks within every 3 RMBs are rearranged.

The rearranging method is described below:

```
while( code_word_rearranging_not_finished_in_3_RMB ) {
    for ( blk_id=0; blk_id <6; blk_id++ ) {
        for ( rmb=0; rmb<3; rmb++ ) {
            if (block[rmb][blk_id]_is_not_empty ) { get_a_code_word_and_connect (see Figure 19) }
        }
    }
}
```

where blk_id = 0 (C_B – block)
 = 1 (C_R – block)
 = 2 (Y_0 – block)
 = 3 (Y_1 – block)
 = 4 (Y_2 – block)
 = 5 (Y_3 – block)

The rearranged code words are sequentially connected and divided into bytes, then stored in the AC variable length data portion of the C3RMB. The codewords are arranged from the upper-left part of the variable length data portion according to the order of rearranged VLC codewords as shown in Figure 19. After the codewords have been filled into the variable length data portion, there will be less than one byte of empty space remaining. Then the empty space must be filled with bit 0.

The byte length of AC data is

int ((the total bit amount of VLC codewords of 3RMBs + 7) / 8)

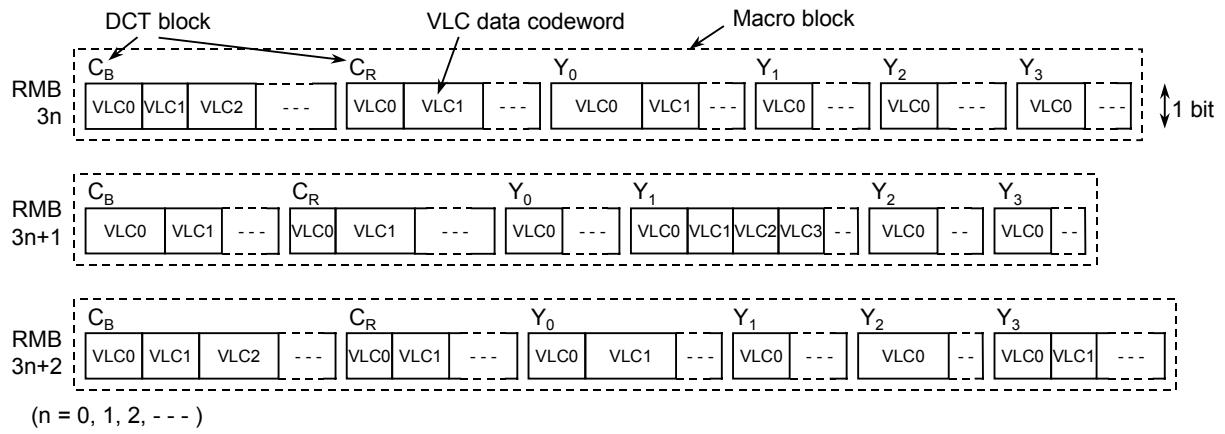
The byte length of C3RMB data is

int ((the total bit amount of VLC codewords of 3RMBs + 7) / 8) + 27

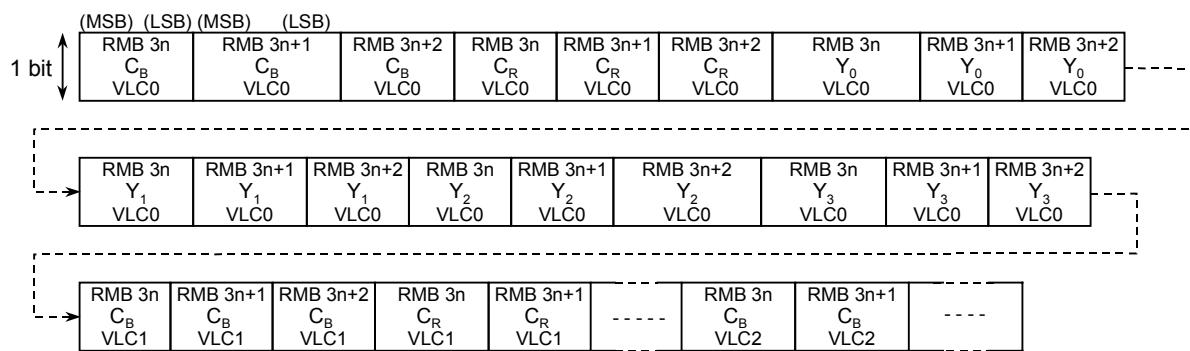
and its maximum value is 768 bytes.

Let LEN[Sg][Rg][CN] be the byte length of C3RMB[Sg][Rg][CN].

[Original VLC data codewords]



[Rearranged VLC data codewords]



[AC data]

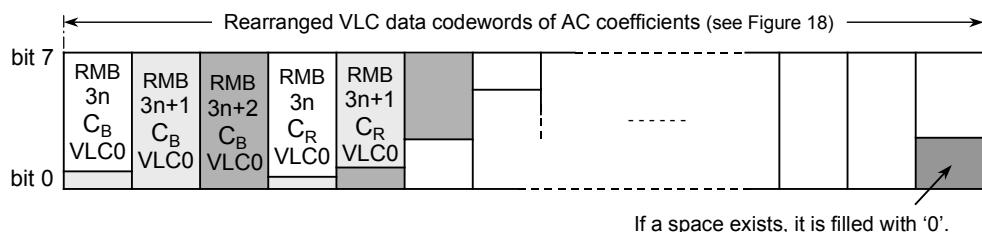


Figure 19 – Rearrangement of VLC data codewords

4.12.2 DIF block

The 5 760 DIF block data stream contains compressed video data for one 1 080i field, or one 720p frame. The data structure of the HD compressed video stream is shown in Figure 20. DIF blocks are numbered 0 to 5 759 in order. Each DIF block consists of 85 bytes of data. A 12 byte area in byte position numbers 0 to 11 of the 85 bytes in each DIF block numbered multiples of 12 (DIF block number DN is 0, 12, ..., 5 748) is reserved for data transmission.

The DIF blocks numbered $DN = 4xJ+2, 4xJ+3$ ($J=0, 1, 2, 3, \dots, 1439$) are called main data DIF blocks and are used to transmit significant data of C3RMB. One Main Data DIF Block has all or most of the data of one C3RMB. The DIF Blocks numbered $DN = 4xJ, 4xJ+1$ are called remainder data DIF Blocks and are used to transmit the remainder of the C3RMB.

Let $DIF[m]$ be the DIF block numbered m where $m = 0, 1, 2, 3, \dots, 5759$.

Let $DIF[m][i]$ be the i -th byte of data in $DIF[m]$ where $i = 0, 1, 2, \dots, 84$.

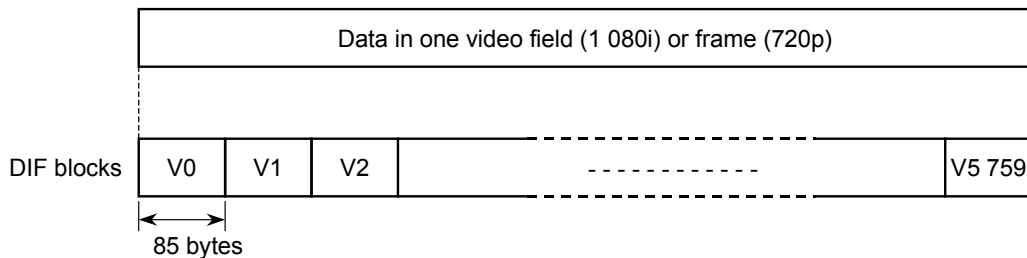


Figure 20 – Data structure of one 1 080i field/720p frame

4.12.3 Main data DIF block packing

A pair (packing pair) of compressed data, $C3RMB[Sg][Rg][2xK]$ and $C3RMB[Sg][Rg][2xK+1]$, are packed into a pair of main data DIF blocks, $DIF[4xJ+2]$ and $DIF[4xJ+3]$ respectively, where K is $0, 1, 2, \dots, 89$ in one RMBG. J is described as follows:

$$J = 360 \times Rg + 4 \times K + (Rg + Sg) \bmod 4$$

If the data of C3RMB overflow their own DIF block, the vacant space in the other DIF block of the pair and buffer memory are used for overflow data storing. The size of the buffer memory for one RMBG is 14 940 bytes.

Let $BUF[Sg][Rg]$ be the buffer memory for the RMBG numbered Rg in the SMBG numbered Sg .

Let $BUF[Sg][Rg][i]$ be the byte data addressed "i" in the $BUF[Sg][Rg]$, where $i=0, 1, \dots, 14939$.

The C3RMB data stored in main data DIF blocks are called main data and the C3RMB data stored in the buffer memory are called remainder data. After main data DIF block packing, the remainder data of one RMBG in buffer memory are packed into 180 Remainder Data DIF Blocks as described in 4.12.4.

Let $SA[Sg][Rg][K]$ be the starting address of the remainder data of $C3RMB[Sg][Rg][2xK]$ and/or $C3RMB[Sg][Rg][2xK+1]$ in the buffer memory.

So that the remainder data of $C3RMB[Sg][Rg][2xK]$ and/or $C3RMB[Sg][Rg][2xK+1]$ are stored at the addresses from $SA[Sg][Rg][K]$ to $(SA[Sg][Rg][K+1]-1)$ in the buffer memory. $SA[Sg][Rg][0]$ is always 0000h, and $SA[Sg][Rg][90]$ is the next address of the last remainder data of each RMBG in the buffer memory.

Before the main data packing in DIF[4xJ+2] and DIF[4xJ+3], the most significant byte and the least significant byte of the data SA[Sg][Rg][K](2 byte) are stored in C3RMB[Sg][Rg][2xK][0] and C3RMB[Sg][Rg][2xK+1][0] respectively as the SABM described in 4.12.1.

Let Set_SABM_of_C3RMB(Sg,Rg,K,SA[Sg][Rg][K]) be the SABM setting process mentioned above.

As an exception, the address data SA[Sg][Rg][90] are stored in C3RMB[Sg][Rg][0][0] and C3RMB[Sg][Rg][1][0], in other words, in DIF[4xJ+2][0] and DIF[4xJ+3][0], where K is 0, as SABM instead of SA[Sg][Rg][0].

Let Set_SA90(Sg,Rg,K,4xJ) be the process of SA[Sg][Rg][90] storing mentioned above.

There are four cases in the packing of C3RMB[Sg][Rg][2xK] and C3RMB[Sg][Rg][2xK+1] according to their byte length. The packing method of four cases is described below:

Case A

In the case that (LEN[Sg][Rg][2xK] =< 85) and (LEN[Sg][Rg][2xK+1] =< 85), all data of C3RMB[Sg][Rg][2xK] and C3RMB[Sg][Rg][2xK+1] are packed into DIF[4xJ+2] and DIF[4xJ+3] respectively. In this case, the vacant space is not used. The packing method of case A is described below and shown in Figure 21.

```
for(i=0; i<LEN[Sg][Rg][2xK]; i++)
DIF[4xJ+2][i] = C3RMB[Sg][Rg][2xK][i];

for(i=0; i<LEN[Sg][Rg][2xK+1]; i++)
DIF[4xJ+3][i] = C3RMB[Sg][Rg][2xK+1][i];

SA[Sg][Rg][K+1]=SA[Sg][Rg][K];
```

Case B

In the case that ((LEN[Sg][Rg][2xK] => 85) and (LEN[Sg][Rg][2xK+1] > 85)) or ((LEN[Sg][Rg][2xK] > 85) and (LEN[Sg][Rg][2xK+1] => 85)), the overflow data of C3RMB[Sg][Rg][2xK] and C3RMB[Sg][Rg][2xK+1] are stored in buffer memory as shown in Figure 21. The packing method of case B is described below:

```
for(i=0; i<85; i++)
DIF[4xJ+2][i] = C3RMB[Sg][Rg][2xK][i];
ra=SA[Sg][Rg][K];
for(i=0; i<(LEN[Sg][Rg][2xK]-85); i++)
BUF[Sg][Rg][ra+i] = C3RMB[Sg][Rg][2xK][85+i];

ra=ra+(LEN[Sg][Rg][2xK]-85);
for(i=0; i<85; i++)
DIF[4xJ+3][i] = C3RMB[Sg][Rg][2xK+1][i];
for(i=0; i<(LEN[Sg][Rg][2xK+1]-85); i++)
BUF[Sg][Rg][ra+i] = C3RMB[Sg][Rg][2xK+1][85+i];

SA[Sg][Rg][K+1]=SA[Sg][Rg][K]+LEN[Sg][Rg][2xK]+LEN[Sg][Rg][2xK+1]-170;
```

Case C

In the case that $(LEN[Sg][Rg][2xK] < 85)$ and $(LEN[Sg][Rg][2xK+1] > 85)$, the overflow data of $C3RMB[Sg][Rg][2xK]$ are packed into the vacant space of $DIF[4xJ+2]$, and in the case of $(LEN[Sg][Rg][2xK+1] - 85) > (85-LEN[Sg][Rg][2xK])$, stored in buffer memory as shown in Figure 21. The packing method of case C is described below:

```

for(i=0; i<LEN[Sg][Rg][2xK]; i++)
  DIF[4xJ+2][i] = C3RMB[Sg][Rg][2xK][i];

for(i=0; i<85; i++)
  DIF[4xJ+3][i] = C3RMB[Sg][Rg][i];
if((LEN[Sg][Rg][2xK+1] - 85) =< (85-LEN[Sg][Rg][2xK])) {
  for(i=0; i<(LEN[Sg][Rg][2xK+1]-85); i++)
    DIF[4xJ+2][LEN[Sg][Rg][2xK]+i] = C3RMB[Sg][Rg][85+i];
  SA[Sg][Rg][K+1]=SA[Sg][Rg][K];
}else {
  for(i=0; i<(85-LEN[Sg][Rg][2xK]); i++)
    DIF[4xJ+2][LEN[Sg][Rg][2xK]+i] = C3RMB[Sg][Rg][85+i];
  ra=SA[Sg][Rg][K];
  for(i=0; i<(LEN[Sg][Rg][2xK]+LEN[Sg][Rg][2xK+1]-170); i++)
    BUF[Sg][Rg][ra+i] = C3RMB[Sg][Rg][2xK+1][170-LEN[Sg][Rg][2xK]+i];
  SA[Sg][Rg][K+1] = SA[Sg][Rg][K]+LEN[Sg][Rg][2xK]+LEN[Sg][Rg][2xK+1]-170;
}

```

Case D

In the case that $(LEN[Sg][Rg][2xK] > 85)$ and $(LEN[Sg][Rg][2xK+1] < 85)$, the overflow data of $C3RMB[Sg][Rg][2xK]$ are packed into the vacant space of $DIF[4xJ+3]$, and in the case of $(LEN[Sg][Rg][2xK] - 85) > (85-LEN[Sg][Rg][2xK+1])$, stored in buffer memory as shown in Figure 21. The packing method of case D is described below:

```

for(i=0; i<LEN[Sg][Rg][2xK+1]; i++)
  DIF[4xJ+3][i] = C3RMB[Sg][Rg][2xK+1][i];

for(i=0; i<85; i++)
  DIF[4xJ+2][i] = C3RMB[Sg][Rg][2xK][i]
if((LEN[Sg][Rg][2xK]-85) =< (85-LEN[Sg][Rg][2xK+1])){
  for(i=0; i<(LEN[Sg][Rg][2xK]-85); i++)
    DIF[4xJ+3][84-i] = C3RMB[Sg][Rg][2xK][85+i];
  SA[Sg][Rg][K+1]=SA[Sg][Rg][K];
}else{
  for(i=0; i<(85-LEN[Sg][Rg][2xK+1]); i++)
    DIF[4xJ+3][84-i] =
      C3RMB[Sg][Rg][2xK][LEN[Sg][Rg][2xK]+LEN[Sg][Rg][2xK+1]-85+i];
  ra=SA[Sg][Rg][K];
  for(i=0; i<(LEN[Sg][Rg][2xK]+LEN[Sg][Rg][2xK+1]-170); i++)
    
```

```

BUF[Sg][Rg][ra+i] = C3RMB[Sg][Rg][2xK][85+i];
SA[Sg][Rg][K+1]=SA[Sg][Rg][K]+LEN[Sg][Rg][2xK]+LEN[Sg][Rg][2xK+1]-170;
}

```

Let `PACK_C3RMB_PAIR_IN_DIF(Sg,Rg,K,4xJ)` be the process of the four cases mentioned above.

The method of packing 90x16 pairs of C3RMBs of one 1 080i field or one 720p frame into 90x16 pairs of main data DIF blocks is described below:

```

for(Rg=0; Rg<4; Rg++){
  for(Sg=0; Sg<4; Sg++){
    SA[Sg][Rg][0] = 0;
    for(K=0; K<90; K++){
      J= 360 × Rg + 4 × K + (Rg+Sg)mod4;
      Set_SABM_of_C3RMB(Sg,Rg,K,SA[Sg][Rg][K]);
      PACK_C3RMB_PAIR_IN_DIF(Sg,Rg,K,4xJ);
      if(K==89){
        K = 0;
        J= 360 × Rg + 4 × K + (Rg+Sg)mod4;
        Set_SA90(Sg,Rg,K,4xJ);
      }
    }
  }
}

```

4.12.4 Remainder data DIF block packing

The method of packing the remainder data into one remainder data DIF block is described below:

```

if( ( (4xJ)mod12 )==0 ) { SIZE=73; SKIP=12;
}else{      SIZE=85; SKIP= 0;
}
for(i; i<SIZE; i++) DIF[4xJ][SKIP+i] = BUF[Sg][Rg][ra+i];
ra=ra+SIZE;

```

Let `PACK_REMAINDER_IN_DIF(Sg,Rg,4xJ,ra)` be the process mentioned above.

All remainder data in the buffer memory of one 1 080i field or one 720p frame are packed into 180x16 remainder data DIF blocks. The method of packing remainder data into remainder data DIF blocks is described below:

```

for(Rg=0; Rg<4; Rg++){
  for(Sg=0; Sg<4; Sg++){
    ra=0;
    for(K=0; K<90; K++){
      J = 360 × Rg + 4 × K + (Rg+Sg)mod4;

```

```
PACK_REMAINDER_IN_DIF(Sg,Rg,4xJ,ra);
PACK_REMAINDER_IN_DIF(Sg,Rg,4xJ+1,ra);
}
}
}
```

The result of packing all the compressed data C3RMBs of one 1 080i field or one 720p frame into 5 760 DIF blocks (2 880 main data DIF blocks and 2 880 remainder data DIF blocks) is shown in Figure 22.

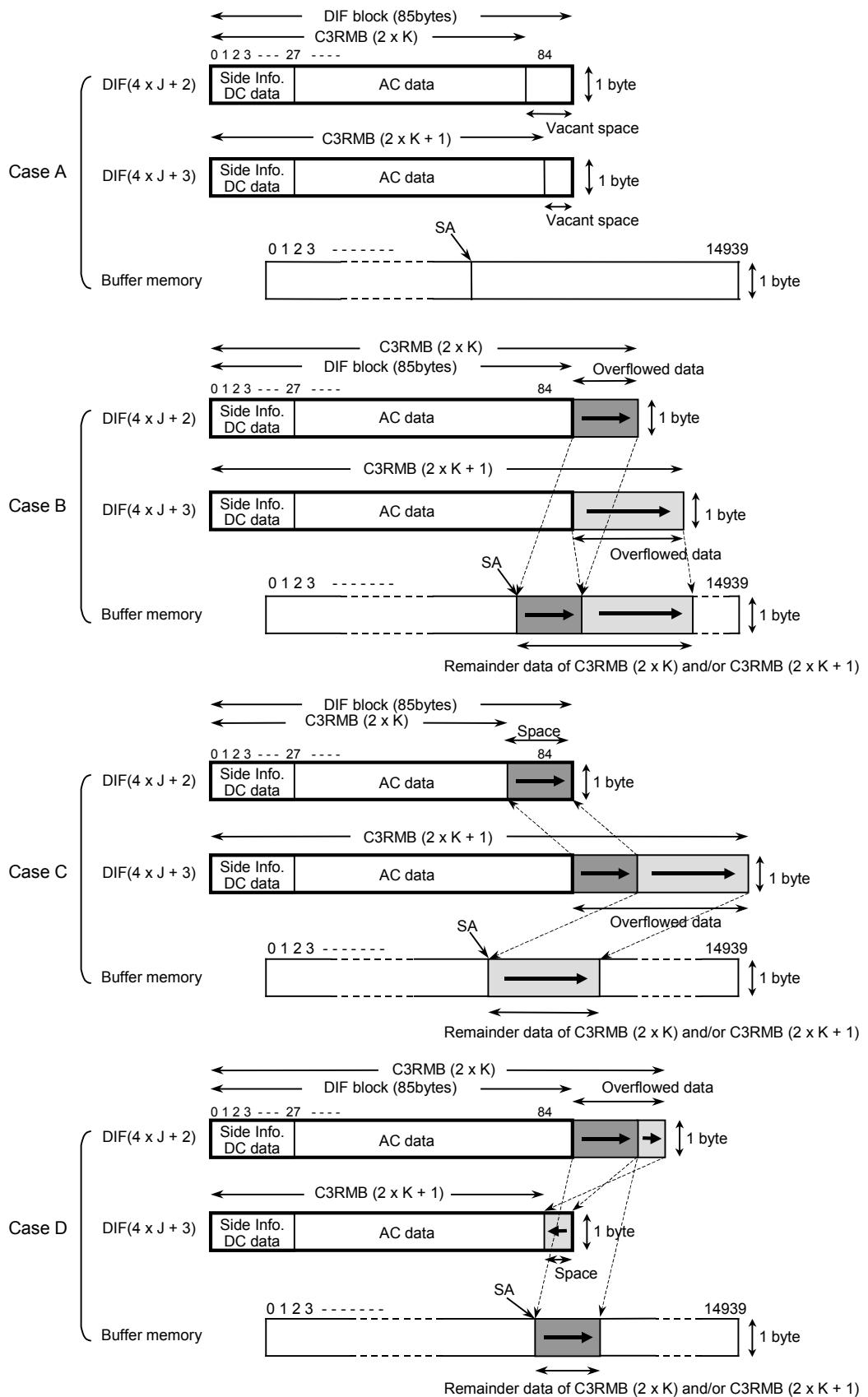


Figure 21 – Main data DIF block packing

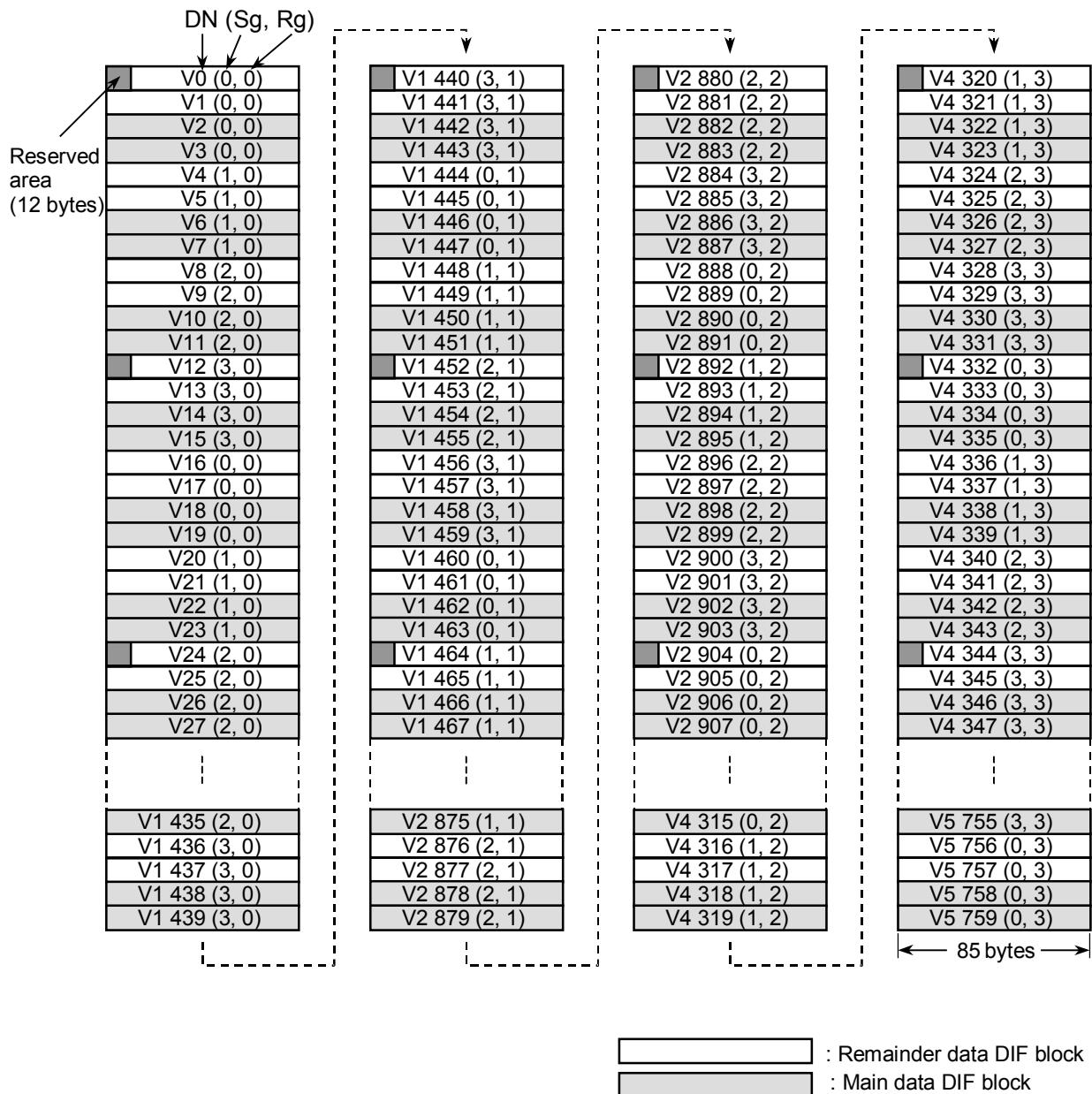


Figure 22 – Packing the compressed data in 5 760 DIF blocks

Annex A (normative)

Overlapped block DCT coding for robustness

The process of reproduction of missing (error-detected) coefficient in overlapped block DCT coding is shown in Figure A.1.

In the case of missing one column of data in a DCT coefficient block

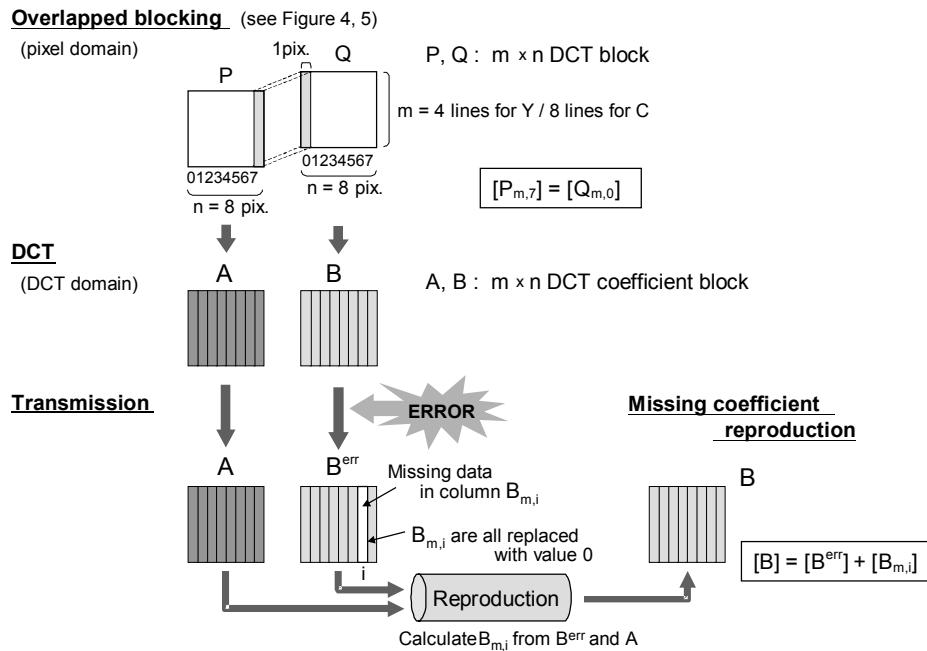


Figure A.1 – The process of missing coefficient reproduction

$$\text{IDCT: } [P_{m,n}] = [D_{m,m}]^T [A_{m,n}] [D_{n,n}], \quad [Q_{m,n}] = [D_{m,m}]^T [B_{m,n}] [D_{n,n}] \quad \text{where } [D]: \text{DCT basis matrix}$$

Pixel data in the most right side column of the DCT block "P": $[P_{m,7}] = [D_{m,m}]^T [A_{m,n}] [D_{n,7}]$

Pixel data in the most left side column of the DCT block "Q": $[B_{m,0}] = [D_{m,m}]^T [B_{m,n}] [D_{n,0}]$

By overlapped blocking: $[P_{m,7}] = [Q_{m,0}]$

From the equations mentioned above: $[A_{m,n}] [D_{n,7}] = [B_{m,n}] [D_{n,0}]$

The relationship of DCT coefficient between $[A_{m,n}]$ and $[B_{m,n}]$:

$$[A_{m,n}] [D_{n,7}] = [B_{m,n}] [D_{n,0}] + [B_{m,i}] [D_{i,0}]$$

where $i = 0$ to 7, $[B_{m,n}]$: $[B_{m,n}]$ in which coefficients of column $[B_{m,i}]$ are all replaced to value 0

Reproduced missing coefficient data $[B_{m,i}]$ (column i in the $[B_{m,n}]$):

$$[B_{m,i}] = ([A_{m,n}] [D_{n,7}] - [B_{m,n}] [D_{n,0}]) / [D_{i,0}]$$

Reproduced DCT coefficient $[B_{m,n}]$: $[B_{m,n}] = [B_{m,n}] + [B_{m,i}]$

In the case of missing more than one column of data in a DCT coefficient block

All data in error-detected columns are replaced with the value zero. Then the only lowest frequency column in the error-detected columns is reproduced by the same equations described above, supposing all other columns replaced with value zero are originally zero.

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<p>Q2 Please tell us in what capacity(ies) you bought the standard (<i>tick all that apply</i>). I am the/a:</p> <p>purchasing agent <input type="checkbox"/></p> <p>librarian <input type="checkbox"/></p> <p>researcher <input type="checkbox"/></p> <p>design engineer <input type="checkbox"/></p> <p>safety engineer <input type="checkbox"/></p> <p>testing engineer <input type="checkbox"/></p> <p>marketing specialist <input type="checkbox"/></p> <p>other <input type="checkbox"/></p>	<p>Q7 Please assess the standard in the following categories, using the numbers:</p> <p>(1) unacceptable, <input type="checkbox"/></p> <p>(2) below average, <input type="checkbox"/></p> <p>(3) average, <input type="checkbox"/></p> <p>(4) above average, <input type="checkbox"/></p> <p>(5) exceptional, <input type="checkbox"/></p> <p>(6) not applicable <input type="checkbox"/></p> <p>timeliness <input type="checkbox"/></p> <p>quality of writing <input type="checkbox"/></p> <p>technical contents <input type="checkbox"/></p> <p>logic of arrangement of contents <input type="checkbox"/></p> <p>tables, charts, graphs, figures <input type="checkbox"/></p> <p>other <input type="checkbox"/></p>
<p>Q3 I work for/in/as a: (<i>tick all that apply</i>)</p> <p>manufacturing <input type="checkbox"/></p> <p>consultant <input type="checkbox"/></p> <p>government <input type="checkbox"/></p> <p>test/certification facility <input type="checkbox"/></p> <p>public utility <input type="checkbox"/></p> <p>education <input type="checkbox"/></p> <p>military <input type="checkbox"/></p> <p>other <input type="checkbox"/></p>	<p>Q8 I read/use the: (<i>tick one</i>)</p> <p>French text only <input type="checkbox"/></p> <p>English text only <input type="checkbox"/></p> <p>both English and French texts <input type="checkbox"/></p>
<p>Q4 This standard will be used for: (<i>tick all that apply</i>)</p> <p>general reference <input type="checkbox"/></p> <p>product research <input type="checkbox"/></p> <p>product design/development <input type="checkbox"/></p> <p>specifications <input type="checkbox"/></p> <p>tenders <input type="checkbox"/></p> <p>quality assessment <input type="checkbox"/></p> <p>certification <input type="checkbox"/></p> <p>technical documentation <input type="checkbox"/></p> <p>thesis <input type="checkbox"/></p> <p>manufacturing <input type="checkbox"/></p> <p>other <input type="checkbox"/></p>	<p>Q9 Please share any comment on any aspect of the IEC that you would like us to know:</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>
<p>Q5 This standard meets my needs: (<i>tick one</i>)</p> <p>not at all <input type="checkbox"/></p> <p>nearly <input type="checkbox"/></p> <p>fairly well <input type="checkbox"/></p> <p>exactly <input type="checkbox"/></p>	<p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>

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