

INTERNATIONAL STANDARD

IEC
62071-2

First edition
2005-10

**Helical-scan compressed digital video
cassette system using 6,35 mm
magnetic tape – Format D-7 –**

**Part 2:
Compression format**



Reference number
IEC 62071-2:2005(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

Consolidated editions

The IEC is now publishing consolidated versions of its publications. For example, edition numbers 1.0, 1.1 and 1.2 refer, respectively, to the base publication, the base publication incorporating amendment 1 and the base publication incorporating amendments 1 and 2.

Further information on IEC publications

The technical content of IEC publications is kept under constant review by the IEC, thus ensuring that the content reflects current technology. Information relating to this publication, including its validity, is available in the IEC Catalogue of publications (see below) in addition to new editions, amendments and corrigenda. Information on the subjects under consideration and work in progress undertaken by the technical committee which has prepared this publication, as well as the list of publications issued, is also available from the following:

- **IEC Web Site** (www.iec.ch)

- **Catalogue of IEC publications**

The on-line catalogue on the IEC web site (www.iec.ch/searchpub) enables you to search by a variety of criteria including text searches, technical committees and date of publication. On-line information is also available on recently issued publications, withdrawn and replaced publications, as well as corrigenda.

- **IEC Just Published**

This summary of recently issued publications (www.iec.ch/online_news/justpub) is also available by email. Please contact the Customer Service Centre (see below) for further information.

- **Customer Service Centre**

If you have any questions regarding this publication or need further assistance, please contact the Customer Service Centre:

Email: custserv@iec.ch
Tel: +41 22 919 02 11
Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

IEC 62071-2

First edition
2005-10

Helical-scan compressed digital video cassette system using 6,35 mm magnetic tape – Format D-7 –

Part 2: Compression format

© IEC 2005 — Copyright - all rights reserved

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembe, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch



Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE

XB

For price, see current catalogue

CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references.....	7
3 Abbreviations and acronyms	7
4 Interface.....	8
4.1 Introduction	8
4.2 Data structure.....	9
4.3 Header section	12
4.4 Subcode section	15
4.5 VAUX section	20
4.6 Audio section.....	24
4.7 Video section.....	30
5 Video compression	32
5.1 Video structure	32
5.2 DCT processing.....	48
5.3 Quantization	51
5.4 Variable length coding (VLC)	53
5.5 The arrangement of a compressed macro block.....	56
5.6 The arrangement of a video segment.....	59
Annex A (informative) Differences between IEC 61834 and IEC 62071-2.....	64
Annex B (normative) Digital filter for sampling-rate conversion from 4:2:2 to 4:1:1 colour difference signals	65
Annex C (informative) Block diagram of D-7 recorder	66
Bibliography.....	67
Figure 1 – Block diagram on the digital interface.....	8
Figure 2 – Data structure of one video frame for 50 Mb/s structure	10
Figure 3 – Data structure of one video frame for 25 Mb/s structure	10
Figure 4 – Data structure of a DIF sequence.....	11
Figure 5 – Data in the subcode section.....	16
Figure 6 – Pack in SSYB	17
Figure 7 – Data in the VAUX section.....	21
Figure 8 – Data in the audio section	24
Figure 9 – conversion of audio sample to audio data bytes	26
Figure 10 – Arrangement of AAUX packs in audio auxiliary data	26
Figure 11 – Transmitting samples of 525/60 system for 4:2:2 compression	34
Figure 12 – Transmitting samples of 625/50 system for 4:2:2 compression	35
Figure 13 – Transmitting samples of 525/60 system for 4:1:1 compression	36
Figure 14 – Transmitting samples of 625/50 system for 4:1:1 compression	37
Figure 15 – DCT block and the pixel coordinates	38

Figure 16 – The rightmost DCT block in colour difference signal for 4:1:1 compression mode	38
Figure 17 – DCT block arrangement for 4:2:2 compression.....	39
Figure 18 – DCT block arrangement for 4:1:1 compression.....	40
Figure 19 – Macro block and DCT blocks for 4:2:2 compression	40
Figure 20 – Macro block and DCT blocks for 4:1:1 compression	40
Figure 21 – Super blocks and macro blocks in one TV frame for 525/60 system for 4:2:2 compression.....	42
Figure 22 – Super blocks and macro blocks in one TV frame for 525/60 system for 4:1:1 compression.....	43
Figure 23 – Super blocks and macro blocks in one TV frame for 625/50 system for 4:2:2 compression.....	44
Figure 24 – Super blocks and macro blocks in one TV frame for 625/50 system for 4:1:1 compression.....	45
Figure 25 – Macro block order in a super block for 4:2:2 compression	47
Figure 26 – Macro block order in a super block for 4:1:1 compression	47
Figure 27 – The output order of a weighted DCT block	50
Figure 28 – Area numbers	52
Figure 29 – Arrangement of a compressed macro block for 4:2:2 compression	56
Figure 30 – The arrangement of a compressed macro block for 4:1:1 compression.....	57
Figure 31 – The arrangement of a video segment after the bit rate reduction for 4:2:2 compression	62
Figure 32 – The arrangement of a video segment after the bit rate reduction for 4:1:1 compression	63
Figure 33 – The video error code.....	63
Figure B.1 – Template for insertion loss frequency characteristics	65
Figure B.2 – Passband ripple tolerance	65
Figure C.1 – Block diagram of D-7 recorder.....	66
Table 1 – ID data of a DIF block	12
Table 2 – Section type.....	13
Table 3 – DIF sequence number (525/60 system)	13
Table 4 – DIF sequence number (625/50 system)	14
Table 5 – DIF block number	14
Table 6 – Data (payload) in the Header DIF block.....	15
Table 7 – SSYB ID	17
Table 8 – Pack header table.....	18
Table 9 – Mapping of packet in SSYB data	18
Table 10 – Mapping of time code pack	19
Table 11 – Mapping of binary group pack	20
Table 12 – Mapping of VAUX pack in a DIF sequence	21
Table 13 – Mapping of VAUX source pack.....	21
Table 14 – Mapping of VAUX source control pack.....	23
Table 15 – Mapping of AAUX pack in a DIF sequence	26
Table 16 – Mapping of AAUX Source pack	27

Table 17 – Mapping of AAUX Source Control pack	28
Table 18 – Video DIF blocks and compressed macro blocks for 50 Mb/s structure – 4:2:2 compression.....	31
Table 19 – Video DIF blocks and compressed macro block for 25 Mb/s structure – 4:1:1 compression	32
Table 20 – Construction of video signal sampling (4:2:2)	33
Table 21 – Class number and the DCT block	51
Table 22 – An example of the Classification for reference.....	51
Table 23 – Quantization step	53
Table 24 – Length of codewords.....	54
Table 25 – Codewords for variable length coding	55
Table 26 – Definition of STA.....	57
Table 27 – Codewords of the QNO	58
Table A.1 – Abstract of differences between IEC 61834 and IEC 62071-2.....	64

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HELICAL-SCAN COMPRESSED DIGITAL VIDEO CASSETTE SYSTEM USING 6,35 mm MAGNETIC TAPE – FORMAT D-7 –

Part 2: Compression format

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62071-2 has been prepared by technical area 6: Higher data rate storage media, data structures and equipment of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this standard is based on the following documents:

CDV	Report on voting
100/901/CDV	100/985/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.

IEC 62071 consists of the following parts, under the general title *Helical-scan compressed digital video cassette system using 6,35 mm magnetic tape – Format D-7*:

Part 1: VTR specifications

Part 2: Compression format

Part 3: Data stream format

This part 2 describes the specifications for encoding process and data format for 525i and 625i systems.

Part 1 describes the VTR specifications which are tape, magnetization, helical recording, modulation method and basic system data for video compressed data.

Part 3 describes the specifications for transmission of DV-based compressed video and audio data stream over 270Mb/s and 360 Mb/s serial digital interface.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

A bilingual version of this publication may be issued at a later date.

HELICAL-SCAN COMPRESSED DIGITAL VIDEO CASSETTE SYSTEM USING 6,35 mm MAGNETIC TAPE – FORMAT D-7 –

Part 2: Compression format

1 Scope

This part of IEC 62071 defines the DV-based data structure for the interface of digital audio, subcode data and compressed video with the following parameters:

525/60 system – 4:1:1 image sampling structure, 25 Mb/s data rate;

525/60 system – 4:2:2 image sampling structure, 50 Mb/s data rate;

625/50 system – 4:1:1 image sampling structure, 25 Mb/s data rate;

625/50 system – 4:2:2 image sampling structure, 50 Mb/s data rate.

This standard does not define the DV compliant data structure for interface, of digital audio, subcode data and compressed video with the following parameters:

625/50 system – 4:2:0 image sampling structure, 25 Mb/s data rate

The compression algorithm and the DIF structure conform to the DV data structure as defined in IEC 61834. Differences between the DV-based data structure defined in this standard and IEC 61834 are shown in Annex A.

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.601-5: 1995, *Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios*

AES3-2003: *Serial transmission format for two-channel linearly represented digital audio data*

SMPTE 12M: 1999, *Television, Audio and Film – Time and Control Code*

3 Abbreviations and acronyms

AAUX	Audio auxiliary data
AP1	Audio application ID
AP2	Video application ID
AP3	Subcode application ID
APT	Track application ID
Arb	Arbitrary
AS	AAUX source pack
ASC	AAUX source control pack
B/W	Black and white flag
CGMS	Copy generation management system

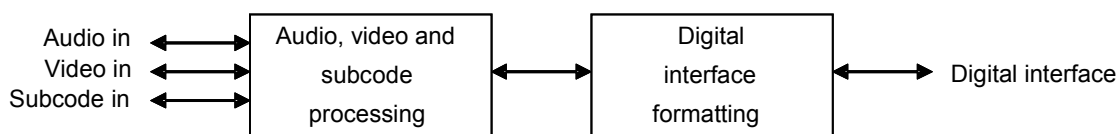
CM	Compressed macro block
DBN	DIF block number
DCT	Discrete cosine transform
DIF	Digital interface
DRF	Direction flag
Dseq	DIF sequence number
DSF	DIF sequence flag
DV	Identification of a compression family
EFC	Emphasis audio channel flag
EOB	End of block
FR	Identification for the first half or the second half of each channel
FSC	Identification of a DIF block in each channel
LF	Locked mode flag
QNO	Quantization number
QU	Quantization
Res	Reserved for future use
SCT	Section type
SMP	Sampling frequency
SSYB	Subcode sync block
STA	Status of the compressed macro block
STYPE (see Note)	Signal type
Syb	Subcode sync block number
TF	Transmitting flag
VAUX	Video auxiliary data
VLC	Variable length coding
VS	VAUX source pack
VSC	VAUX source control pack

NOTE STYPE as used in this standard is different from that in ANSI/IEEE 1394.

4 Interface

4.1 General

As shown in Figure 1, processed audio, video and subcode data, are output for different applications through a digital interface port.



IEC 1905/05

Figure 1 – Block diagram on the digital interface

4.2 Data structure

The data structure of the compressed stream at the digital interface is shown in Figures 2 and 3. Figure 2 shows the data structure for a 50 Mb/s structure, and Figure 3 shows the data structure for a 25 Mb/s structure.

In the 50 Mb/s structure, the data of one video frame are divided into two channels. Each channel is divided into 10 DIF sequences for the 525/60 system and 12 DIF sequences for the 625/50 system.

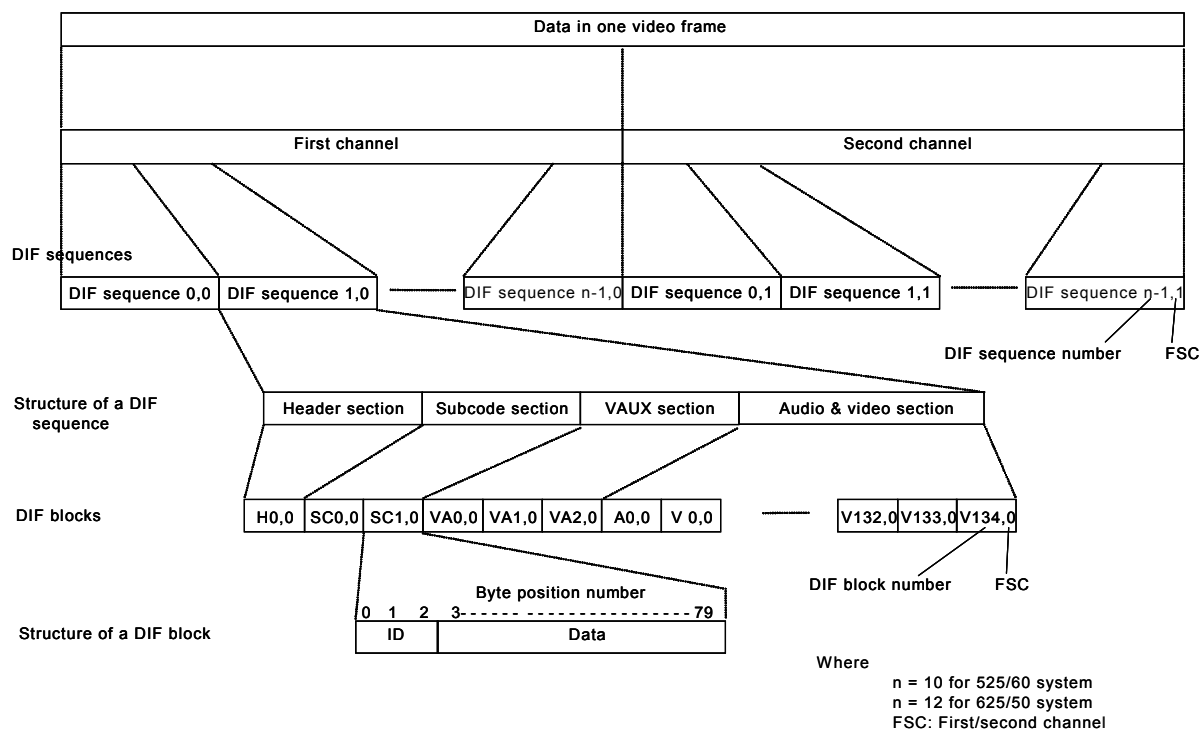
In the 25 Mb/s structure, the data of one video frame are divided into 10 DIF sequences for the 525/60 system and 12 DIF sequences for the 625/50 system.

Each DIF sequence consists of a header section, subcode section, VAUX section, audio section and video section with the following DIF blocks respectively:

Header section	: 1 DIF block,
Subcode section	: 2 DIF blocks,
VAUX section	: 3 DIF blocks,
Audio section	: 9 DIF blocks,
Video section	:135 DIF blocks.

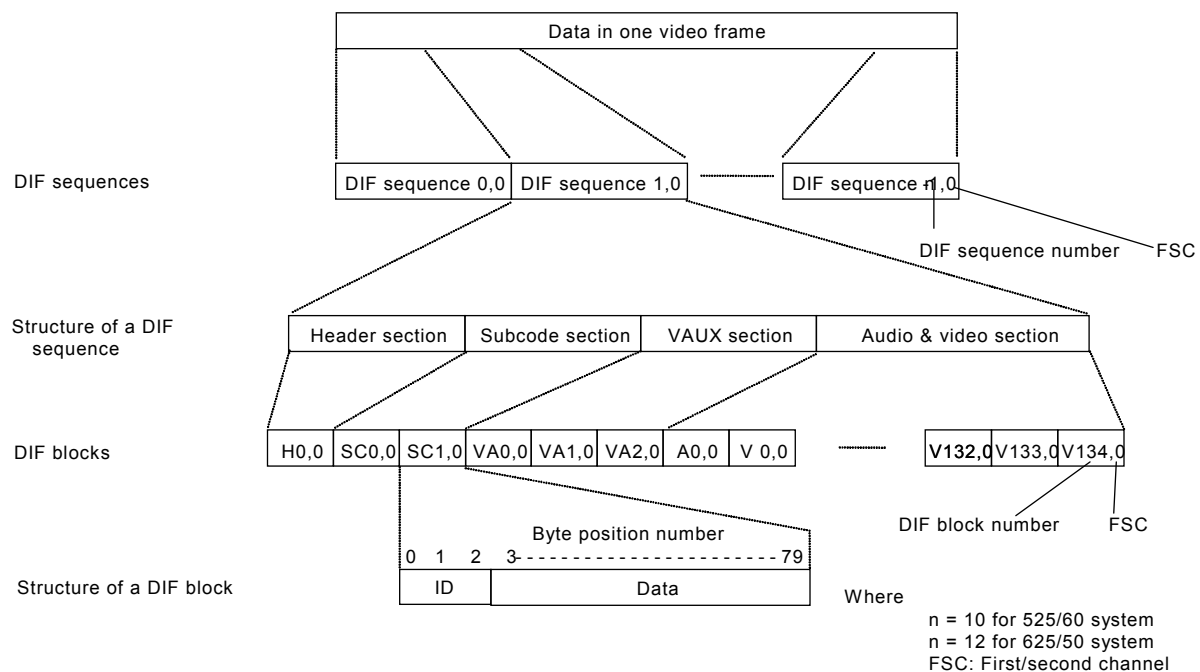
As shown in Figures 2 and 3, each DIF block consists of a 3-byte ID and 77 bytes of data. DIF data bytes are numbered 0 to 79.

Figure 4 shows the data structure of a DIF sequence for a 50 Mb/s or 25 Mb/s structure.



IEC 1906/05

Figure 2 – Data structure of one video frame for 50 Mb/s structure



IEC 1907/05

Figure 3 – Data structure of one video frame for 25 Mb/s structure

DIF blocks

H0,i	SC0,i	SC1,i	VA0,i	VA1,i	VA2,i
------	-------	-------	-------	-------	-------

A0,i	V0,i	V1,i	V2,i	V3,i	V4,i	V5,i	V6,i	V7,i	V8,i	V9,i	V10,i	V11,i	V12,i	V13,i	V14,i
------	------	------	------	------	------	------	------	------	------	------	-------	-------	-------	-------	-------

A1,i	V15,i	V16,i	V17,i	V18,i	V19,i	V20,i	V21,i	V22,i	V23,i	V24,i	V25,i	V26,i	V27,i	V28,i	V29,i
------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

A2,i	V30,i	V31,i	V32,i	V33,i	V34,i	V35,i	V36,i	V37,i	V38,i	V39,i	V40,i	V41,i	V42,i	V43,i	V44,i
------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

A3,i	V45,i	V46,i	V47,i	V48,i	V49,i	V50,i	V51,i	V52,i	V53,i	V54,i	V55,i	V56,i	V57,i	V58,i	V59,i
------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

A4,i	V60,i	V61,i	V62,i	V63,i	V64,i	V65,i	V66,i	V67,i	V68,i	V69,i	V70,i	V71,i	V72,i	V73,i	V74,i
------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

A5,i	V75,i	V76,i	V77,i	V78,i	V79,i	V80,i	V81,i	V82,i	V83,i	V84,i	V85,i	V86,i	V87,i	V88,i	V89,i
------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------

A6,i	V90,i	V91,i	V92,i	V93,i	V94,i	V95,i	V96,i	V97,i	V98,i	V99,i	V100,i	V101,i	V102,i	V103,i	V104,i
------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------	--------	--------	--------	--------

A7,i	V105,i	V106,i	V107,i	V108,i	V109,i	V110,i	V111,i	V112,i	V113,i	V114,i	V115,i	V116,i	V117,i	V118,i	V119,i
------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

A8,i	V120,i	V121,i	V122,i	V123,i	V124,i	V125,i	V126,i	V127,i	V128,i	V129,i	V130,i	V131,i	V132,i	V133,i	V134,i
------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

DIF block number

IEC 1908/05

where

i : FSC

i = 0 for 25 Mb/s structure

i = 0,1 for 50 Mb/s structure

H0,i : DIF block in header section

SC0,i to SC1,i : DIF blocks in subcode section

VA0,i to VA2,i : DIF blocks in VAUX section

A0,i to A8,i : DIF blocks in audio section

V0,i to V134,i : DIF blocks in video section

Figure 4 – Data structure of a DIF sequence

4.3 Header section

4.3.1 ID

The ID part of each DIF block in the header section, shown in Figures 2 and 3, consists of 3 bytes (ID0, ID1, ID2). Table 1 shows the ID content of a DIF block.

Table 1 – ID data of a DIF block

Byte position number			
	Byte 0 (ID0)	Byte 1 (ID1)	Byte 2 (ID2)
MSB	SCT ₂	Dseq ₃	DBN ₇
	SCT ₁	Dseq ₂	DBN ₆
	SCT ₀	Dseq ₁	DBN ₅
	Res	Dseq ₀	DBN ₄
	Arb	FSC	DBN ₃
	Arb	Res	DBN ₂
	Arb	Res	DBN ₁
LSB	Arb	Res	DBN ₀

The ID contains the following:

- SCT: Section type (see Table 2)
- Dseq: DIF sequence number (see Tables 3 and 4)
- FSC: Identification of a DIF block in each channel
 - 50 Mb/s structure
 - FSC = 0: first channel
 - FSC = 1: second channel
 - 25 Mb/s structure
 - FSC = 0
- DBN: DIF block number (see Table 5)
- Arb: Arbitrary bit
- Res: Reserved bit for future use
 - Default value shall be set to 1.

Table 2 – Section type

Section type bit			Section type
SCT ₂	SCT ₁	SCT ₀	
0	0	0	Header
0	0	1	Subcode
0	1	0	VAUX
0	1	1	Audio
1	0	0	Video
1	0	1	Reserved
1	1	0	
1	1	1	

Table 3 – DIF sequence number (525/60 system)

DIF sequence number bit				Meaning
Dseq ₃	Dseq ₂	Dseq ₁	Dseq ₀	
0	0	0	0	DIF sequence number 0
0	0	0	1	DIF sequence number 1
0	0	1	0	DIF sequence number 2
0	0	1	1	DIF sequence number 3
0	1	0	0	DIF sequence number 4
0	1	0	1	DIF sequence number 5
0	1	1	0	DIF sequence number 6
0	1	1	1	DIF sequence number 7
1	0	0	0	DIF sequence number 8
1	0	0	1	DIF sequence number 9
1	0	1	0	Not used
1	0	1	1	Not used
1	1	0	0	Not used
1	1	0	1	Not used
1	1	1	0	Not used
1	1	1	1	Not used

Table 4 – DIF sequence number (625/50 system)

DIF sequence number bit				Meaning
Dseq ₃	Dseq ₂	Dseq ₁	Dseq ₀	
0	0	0	0	DIF sequence number 0
0	0	0	1	DIF sequence number 1
0	0	1	0	DIF sequence number 2
0	0	1	1	DIF sequence number 3
0	1	0	0	DIF sequence number 4
0	1	0	1	DIF sequence number 5
0	1	1	0	DIF sequence number 6
0	1	1	1	DIF sequence number 7
1	0	0	0	DIF sequence number 8
1	0	0	1	DIF sequence number 9
1	0	1	0	DIF sequence number 10
1	0	1	1	DIF sequence number 11
1	1	0	0	Not used
1	1	0	1	Not used
1	1	1	0	Not used
1	1	1	1	Not used

Table 5 – DIF block number

DIF block number bit								Meaning
DBN ₇	DBN ₆	DBN ₅	DBN ₄	DBN ₃	DBN ₂	DBN ₁	DBN ₀	
0	0	0	0	0	0	0	0	DIF block number 0
0	0	0	0	0	0	0	1	DIF block number 1
0	0	0	0	0	0	1	0	DIF block number 2
0	0	0	0	0	0	1	1	DIF block number 3
:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:
1	0	0	0	0	1	1	0	DIF block number 134
1	0	0	0	0	1	1	1	Not used
:	:	:	:	:	:	:	:	:
1	1	1	1	1	1	1	1	Not used

4.3.2 Data

The data part (payload) of each DIF block in the header section is shown in Table 6, bytes 3 to 7 are active and bytes 8 to 79 are reserved.

Table 6 – Data (payload) in the Header DIF block

Byte position number of Header DIF block								
	3	4	5	6	7	8	-----	79
MSB	DSF	Res	TF1	TF2	TF3	Res	-----	Res
	0	Res	Res	Res	Res	Res	-----	Res
	Res	Res	Res	Res	Res	Res	-----	Res
	Res	Res	Res	Res	Res	Res	-----	Res
	Res	Res	Res	Res	Res	Res	-----	Res
	Res	APT2	AP12	AP22	AP32	Res	-----	Res
	Res	APT1	AP11	AP21	AP31	Res	-----	Res
	Res	APT0	AP10	AP20	AP30	Res	-----	Res
LSB								

DSF: DIF sequence flag

DSF = 0: 10 DIF sequences included in a channel (525/60 system)

DSF = 1: 12 DIF sequences included in a channel (625/50 system)

APT_n, AP1_n, AP2_n, AP3_n: These data shall be identical as track application IDs (APT_n = 001, AP1_n = 001, AP2_n = 001, AP3_n = 001), if the source signal comes from a digital VCR. If the signal source is unknown, all bits for these data shall be set to 1.

TF: Transmitting flag

TF1: Transmitting flag of audio DIF blocks

TF2: Transmitting flag of VAUX and video DIF blocks

TF3: Transmitting flag of subcode DIF blocks

TF_n = 0: Data shall be valid.

TF_n = 1: Data shall be invalid.

Res: Reserved bit for future use
Default value shall be set to 1.

4.4 Subcode section

4.4.1 ID

The ID part of each DIF block in the subcode section is described in 4.3.1. The section type shall be 001.

4.4.2 Data

The data part (payload) of each DIF block in the subcode section is shown in Figure 5. The subcode data consists of 6 SSYBs, each 48 bytes long, and a reserved area of 29 bytes in each DIF block. SSYBs in a DIF sequence are numbered 0 to 11. Each SSYB is composed of SSYB ID equal to 2 bytes, FFh, and an SSYB data payload of 5 bytes.

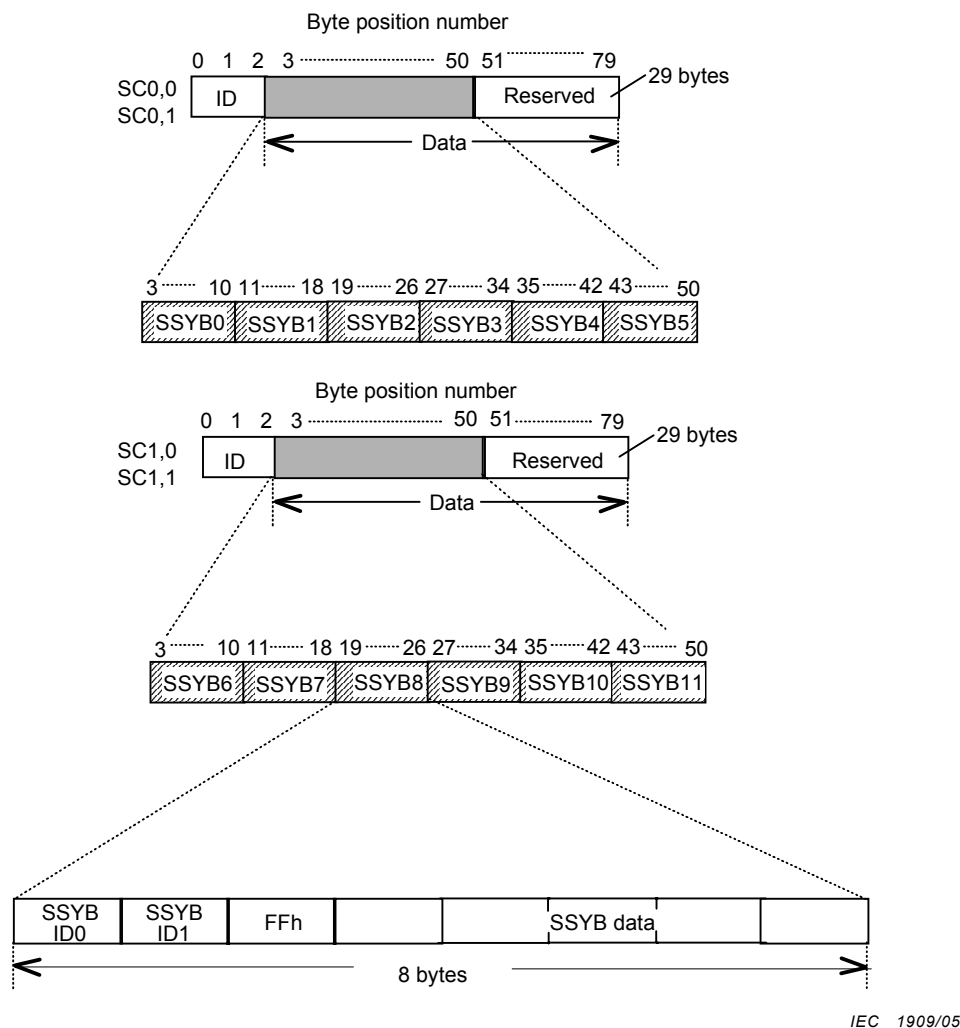


Figure 5 – Data in the subcode section

4.4.2.1 SSYB ID

Table 7 shows SSYB ID (ID0, ID1). These data contain FR ID, application ID (AP32, AP31, AP30), and SSYB number (Syb3, Syb2, Syb1, Syb0).

FR ID is an identification for the first or second half of each channel:

FR = 1: the first half of each channel
FR = 0: the second half of each channel

The first half of each channel

DIF sequence number 0, 1, 2, 3, 4	for 525/60 system
DIF sequence number 0, 1, 2, 3, 4, 5	for 625/50 system

The second half of each channel

DIF sequence number 5, 6, 7, 8, 9	for 525/60 system
DIF sequence number 6, 7, 8, 9, 10, 11	for 625/50 system

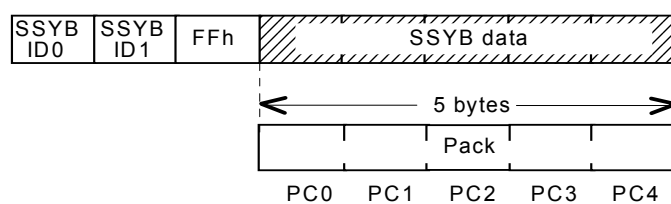
If information is not available, all bits shall be set to 1.

Table 7 – SSYB ID

Bit position	SSYB number 0 and 6		SSYB number 1 to 5 and 7 to 10		SSYB number 11	
	ID0	ID1	ID0	ID1	ID0	ID1
b7 (MSB)	FR	Arb	FR	Arb	FR	Arb
b6	AP3 ₂	Arb	Res	Arb	APT ₂	Arb
b5	AP3 ₁	Arb	Res	Arb	APT ₁	Arb
b4	AP3 ₀	Arb	Res	Arb	APT ₀	Arb
b3	Arb	Syb ₃	Arb	Syb ₃	Arb	Syb ₃
b2	Arb	Syb ₂	Arb	Syb ₂	Arb	Syb ₂
b1	Arb	Syb ₁	Arb	Syb ₁	Arb	Syb ₁
b0 (LSB)	Arb	Syb ₀	Arb	Syb ₀	Arb	Syb ₀
NOTE Arb: Arbitrary bit						

4.4.2.2 SSYB data

Each SSYB data payload consists of a pack of 5 bytes as shown in Figure 6. Table 8 shows pack header table (PC0 byte organization). Table 9 shows the pack arrangement in SSYB data for each channel.

**Figure 6 – Pack in SSYB**

IEC 1910/05

Table 8 – Pack header table

UPPER LOWER	0000	0001	0010	0011	0100	0101	0110	0111	-----	1111
0000						AUDIO SOURCE	VIDEO SOURCE			
0001						AUDIO SOURCE CONTROL	VIDEO SOURCE CONTROL			
0010										
0011		TIME CODE								
0100		BINARY GROUP								
0101										
I										
1111										NO INFO

Table 9 – Mapping of packet in SSYB data

SSYB number	The first half of each channel	The second half of each channel
0	Reserved	Reserved
1	Reserved	Reserved
2	Reserved	Reserved
3	TC	TC
4	BG	Reserved
5	TC	Reserved
6	Reserved	Reserved
7	Reserved	Reserved
8	Reserved	Reserved
9	TC	TC
10	BG	Reserved
11	TC	Reserved
<p>NOTE 1 TC: Time code pack.</p> <p>NOTE 2 BG: Binary group pack.</p> <p>NOTE 3 Reserved = default value of all bits is set to 1.</p> <p>NOTE 4 TC and BG data are the same within a single video frame. The time code data is an LCT type.</p>		

4.4.2.2.1 Time code pack (TC)

Table 10 shows a mapping of the time code pack. Time code data mapped to the time code packs remain the same within each video frame.

Table 10 – Mapping of time code pack

525/60 system

MSB					LSB			
PC0	0	0	0	1	0	0	1	1
PC1	CF	DF	TENS of FRAMES		UNITS of FRAMES			
PC2	PC	TENS of SECONDS			UNITS of SECONDS			
PC3	BGF0	TENS of MINUTES			UNITS of MINUTES			
PC4	BGF2	BGF1	TENS of HOURS		UNITS of HOURS			

625/50 system

MSB					LSB			
PC0	0	0	0	1	0	0	1	1
PC1	CF	Arb	TENS of FRAMES		UNITS of FRAMES			
PC2	BGF0	TENS of SECONDS			UNITS of SECONDS			
PC3	BGF2	TENS of MINUTES			UNITS of MINUTES			
PC4	PC	BGF1	TENS of HOURS		UNITS of HOURS			

NOTE Detailed information is given in ANSI/SMPTE 12M.

CF: Colour frame

0 = unsynchronized mode

1 = synchronized mode

DF: Drop frame flag

0 = Non-drop frame time code

1 = Drop frame time code

PC: Biphase mark polarity correction

0 = even

1 = odd

BGF: Binary group flag

Arb: Arbitrary bit

4.4.2.2.2 Binary group pack (BG)

Table 11 shows the mapping of the binary group pack. Binary group data mapped to the binary group packs remain the same within each video frame.

Table 11 – Mapping of binary group pack

	MSB				LSB			
PC0	0	0	0	1	0	1	0	0
PC1	BINARY GROUP2				BINARY GROUP1			
PC2	BINARY GROUP4				BINARY GROUP3			
PC3	BINARY GROUP6				BINARY GROUP5			
PC4	BINARY GROUP8				BINARY GROUP7			

4.5 VAUX section

4.5.1 ID

The ID part of each DIF block in the VAUX section is described in 4.3.1. The section type shall be 010.

4.5.2 Data

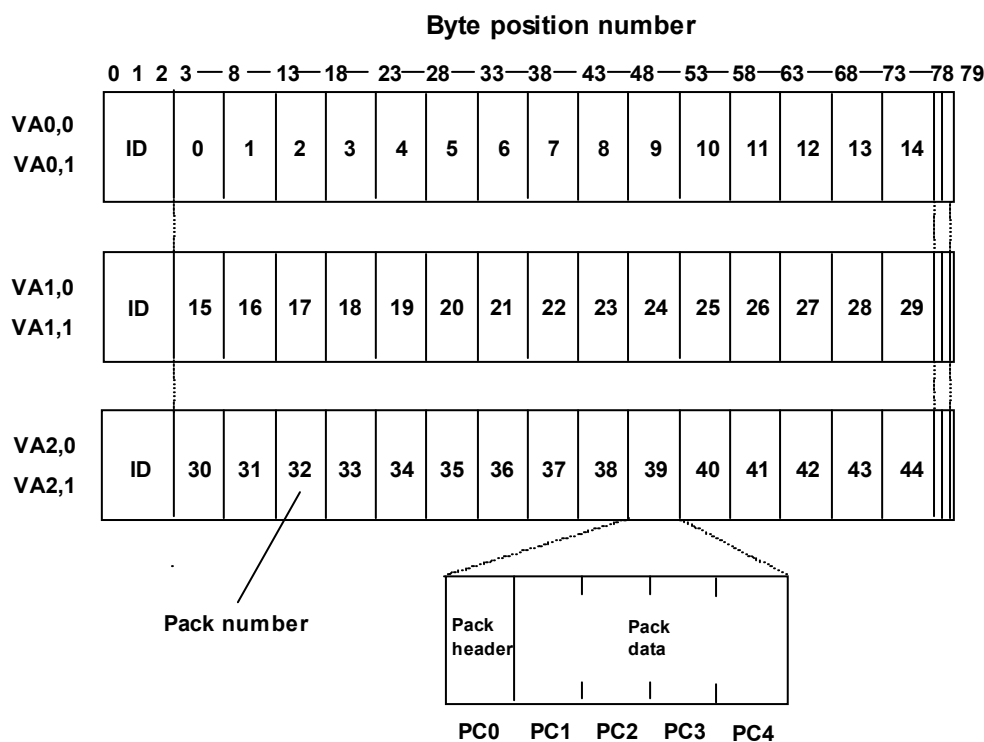
The data part (payload) of each DIF block in the VAUX section is shown in Figure 7. This figure shows the VAUX pack arrangement for each DIF sequence.

There are 15 packs, each 5 bytes long, and two reserved bytes in each VAUX DIF block payload. A default value for the reserved byte is set to FFh.

Therefore, there are 45 packs in a DIF sequence. VAUX packs of the DIF blocks are sequentially numbered 0 to 44. This number is called a video pack number.

Table 12 shows the mapping of the VAUX packs of the VAUX DIF blocks. A VAUX source pack (VS) and a VAUX source control pack (VSC) must be present in each of the video compressed frames. The remaining VAUX packs of the DIF blocks in a DIF sequence are reserved and the value of all reserved words is set to FFh.

If VAUX data are not transmitted, a NO INFO pack, which is filled up by FFh shall be transmitted.



IEC 1911/05

Figure 7 – Data in the VAUX section**Table 12 – Mapping of VAUX pack in a DIF sequence**

Pack		Number	Pack data
Even DIF sequence	Odd DIF sequence		
39	0		VS
40	1		VSC

Even DIF sequence:

DIF sequence number 0, 2, 4, 6, 8 for 525/60 system
 DIF sequence number 0, 2, 4, 6, 8, 10 for 625/50 system

Odd DIF sequence:

DIF sequence number 1, 3, 5, 7, 9 for 525/60 system
 DIF sequence number 1, 3, 5, 7, 9, 11 for 625/50 system

4.5.2.1 VAUX source pack (VS)

Table 13 shows the mapping of a VAUX source pack.

Table 13 – Mapping of VAUX source pack

MSB					LSB			
PC0	0	1	1	0	0	0	0	0
PC1	Res	Res	Res	Res	Res	Res	Res	Res
PC2	B/W	EN	CLF		Res	Res	Res	Res
PC3	Res	Res	50/60	STYPE				
PC4	VISC							

B/W: Black and white flag

0 = Black and white
1 = Colour

EN : Colour frames enable flag

0 = CLF is valid.
1 = CLF is invalid.

CLF: Colour frames identification code (see ITU-R-BT.470-7)

For 525/60 system

00b = Colour frame A
01b = Colour frame B
Others = Reserved

For 625/50 system

00b = 1st , 2nd field
01b = 3rd , 4th field
10b = 5th , 6th field
11b = 7th , 8th field

50/60:

0 = 60 field system
1 = 50 field system

STYPE: STYPE defines a signal type of video signal.

00000b = 4:1:1 compression
00001b = Reserved
| |
00011b = Reserved
00100b = 4:2:2 compression
00101b = Reserved
| |
11111b = Reserved

VISC:

10001000b = -180
| |
00000000b = 0
| |
01111000b = 180
01111111b = No information
Other = Reserved

Res : Reserved bit for future use
Default value shall be set to 1.

4.5.2.2 VAUX source control pack (VSC)

Table 14 shows the mapping of the VAUX source control pack.

Table 14 – Mapping of VAUX source control pack

	MSB					LSB		
PC0	0	1	1	0	0	0	0	1
PC1	CGMS		Res	Res	Res	Res	Res	Res
PC2	Res	Res	0	0	Res	DISP		
PC3	FF	FS	FC	IL	Res	Res	0	0
PC4	Res	Res	Res	Res	Res	Res	Res	Res

CGMS: Copy generation management system

0 0 b = Copy free

Others = Reserved

DISP: Display select mode

DISP	Aspect ratio and format	Position
0 0 0	4 : 3 full format	Not applicable
0 0 1	Reserved	
0 1 0	16 : 9 full format (squeeze)	Not applicable
0 1 1 1 1 1	Reserved	

FF: Frame/field flag

FF indicates whether two consecutive fields are delivered, or one field is repeated twice during one frame period.

0 = Only one of two fields is delivered twice

1 = Both fields are delivered in order

FS: First/second field flag

FS indicates a field which is delivered during the field one period.

0 = Field 2 is delivered.

1 = Field 1 is delivered.

FF	FS	Output field
1	1	Field 1 and field 2 are output in this order (1,2 sequence).
1	0	Field 2 and field 1 are output in this order (2,1 sequence).
0	1	Field 1 is output twice.
0	0	Field 2 is output twice.

FC: Frame change flag

FC indicates whether the picture of the current frame is repeated based on the immediate previous frame.

0 = Same picture as the previous frame

1 = Different picture from the previous frame

IL: Interlace flag

0 = Noninterlaced
1 = Interlaced

Res : Reserved bit for future use
Default value shall be set to 1.

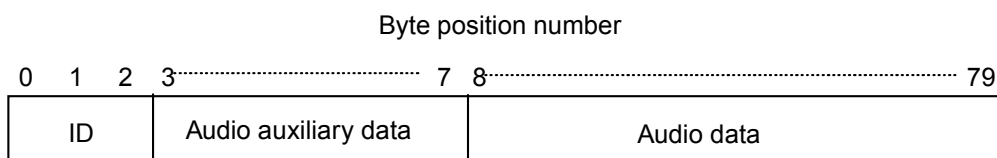
4.6 Audio section

4.6.1 ID

The ID part of each DIF block in the audio section is described in 4.3.1. The section type shall be 011.

4.6.2 Data

The data part (payload) of each DIF block in the audio section is shown in Figure 8. The data of a DIF block in the audio DIF block are composed of 5 bytes of audio auxiliary data (AAUX) and 72 bytes of audio data which are encoded and shuffled by the process shown in Figure 8.



IEC 1912/05

Figure 8 – Data in the audio section

4.6.2.1 Audio encoding

4.6.2.1.1 Source coding

Each audio input signal is sampled at 48kHz, with 16-bit quantization. The system provides two channels of audio for 25 Mb/s structure or four channels of audio for 50 Mb/s structure. Audio data for each audio channel are located in an audio block respectively.

An audio block consists of 45 DIF blocks (9 DIF blocks x 5 DIF sequences) for the 525/60 system and 54 DIF blocks (9 DIF blocks x 6 DIF sequences) for the 625/50 system.

4.6.2.1.2 Emphasis

Audio encoding is carried out with the first order pre-emphasis of 50/15µs. For analogue input recording, emphasis shall be off in the default state.

4.6.2.1.3 Audio error code

In the encoded audio data, 8000h shall be assigned as an audio error code to indicate an invalid audio sample. This code corresponds to negative full-scale value in ordinary twos complement representation. When the encoded data includes 8000h, it shall be converted to 8001h.

4.6.2.1.4 Relative audio-video timing

The audio frame duration equals a video frame period. An audio frame begins with an audio sample acquired within the duration of minus 50 samples relative to zero samples from the first pre-equalizing pulse of the vertical blanking period of the input video signal. The first pre-equalizing pulse means the start of line number 1 for the 525/60 system, and the middle of line number 623 for the 625/50 system.

4.6.2.1.5 Audio frame processing

This standard provides audio frame processing in the locked mode.

The sampling frequency of the audio signal is synchronous with the video frame frequency. Audio data are processed in frames. For an audio channel, each frame contains 1602 or 1600 audio samples for the 525/60 system or 1920 audio samples for the 625/50 system. For the 525/60 system, the number of audio samples per frame shall follow the five-frame sequence as shown below:

1600, 1602, 1602, 1602, 1602 samples.

The sample audio capacity shall be capable of 1620 samples per frame for the 525/60 system or 1944 samples per frame for the 625/50 system. The unused space at the end of each frame is filled with arbitrary values.

4.6.2.2 Audio shuffling

The 16-bit audio data word is divided into two bytes; the upper byte which contains MSB, and the lower byte LSB, as shown in Figure 9. Audio data shall be shuffled over DIF sequences and DIF blocks within a frame. The data bytes are defined as D_n ($n = 0, 1, 2, \dots$) which is sampled at n th order within a frame and shuffled by each D_n unit.

The data shall be shuffled through a process expressed by the following equations:

525/60 system:

DIF sequence number:

$$\begin{aligned} & (\text{INT}(n/3) + 2 \times (n \bmod 3)) \bmod 5 && \text{for CH1, CH3} \\ & (\text{INT}(n/3) + 2 \times (n \bmod 3)) \bmod 5 + 5 && \text{for CH2, CH4} \end{aligned}$$

Audio DIF block number:

$$\begin{aligned} & 3 \times (n \bmod 3) + \text{INT}((n \bmod 45)/15) \\ & \text{where FSC} = 0: \text{CH1, CH2} \\ & \text{FSC} = 1: \text{CH3, CH4} \end{aligned}$$

Byte position number:

$$\begin{aligned} & 8 + 2 \times \text{INT}(n/45) && \text{for the most significant byte} \\ & 9 + 2 \times \text{INT}(n/45) && \text{for the least significant byte} \\ & \text{where } n = 0 \text{ to } 1619 \end{aligned}$$

625/50 system:

DIF sequence number:

$$\begin{aligned} & (\text{INT}(n/3) + 2 \times (n \bmod 3)) \bmod 6 && \text{for CH1, CH3} \\ & (\text{INT}(n/3) + 2 \times (n \bmod 3)) \bmod 6 + 6 && \text{for CH2, CH4} \end{aligned}$$

Audio DIF block number:

$$\begin{aligned} & 3 \times (n \bmod 3) + \text{INT}((n \bmod 54)/18) \\ & \text{where FSC} = 0: \text{CH1, CH2} \\ & \text{FSC} = 1: \text{CH3, CH4} \end{aligned}$$

Byte position number:

$$\begin{aligned} & 8 + 2 \times \text{INT}(n/54) && \text{for the most significant byte} \\ & 9 + 2 \times \text{INT}(n/54) && \text{for the least significant byte} \\ & \text{where } n = 0 \text{ to } 1943 \end{aligned}$$

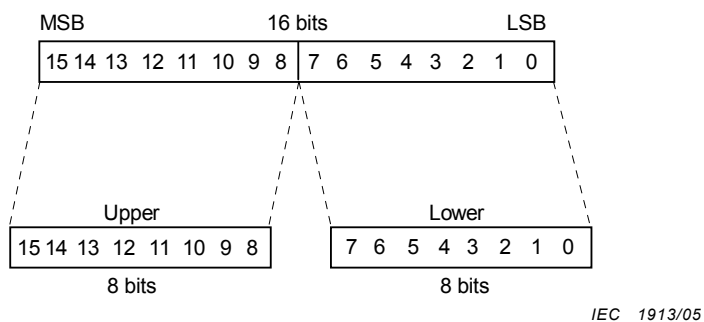


Figure 9 – Conversion of audio sample to audio data bytes

4.6.2.3 Audio auxiliary data (AAUX)

AAUX shall be added to the shuffled audio data as shown in Figures 8 and 10. The AAUX pack shall include an AAUX pack header and data (AAUX payload). The length of the AAUX pack shall be 5 bytes as shown in Figure 10, which depicts the AAUX pack arrangement. Packs are numbered from 0 to 8 as shown in Figure 10. This number is called an audio pack number.

Table 15 shows the mapping of an AAUX pack. An AAUX source pack (AS) and an AAUX source control pack (ASC) shall be included in the compressed stream.

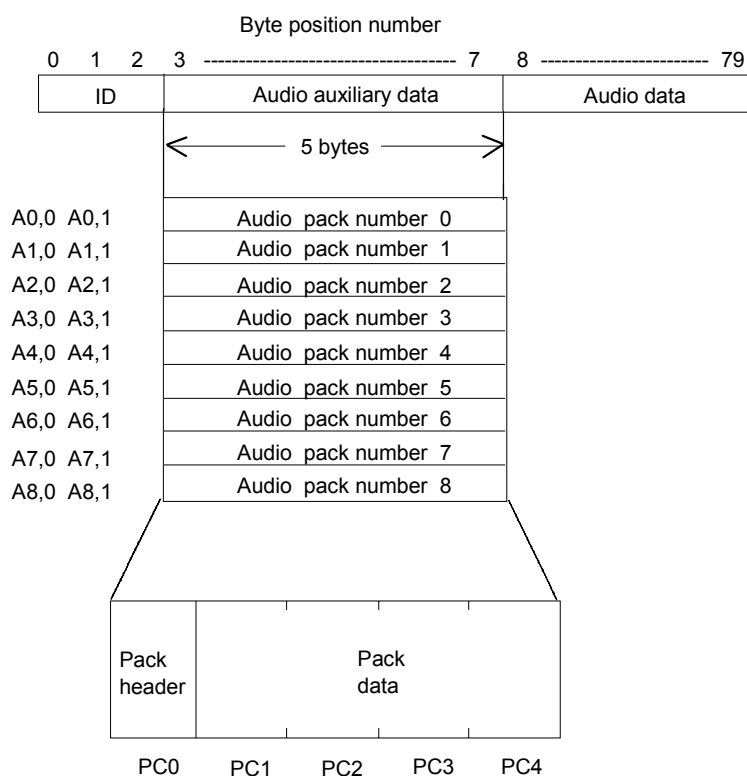


Figure 10 – Arrangement of AAUX packs in audio auxiliary data

Table 15 – Mapping of AAUX pack in a DIF sequence

Audio pack		Pack data
Even DIF sequence	Odd DIF sequence	
3	0	AS
4	1	ASC

Even DIF sequence:

DIF sequence number 0, 2, 4, 6, 8 for 525/60 system
 DIF sequence number 0, 2, 4, 6, 8, 10 for 625/50 system

Odd DIF sequence:

DIF sequence number 1, 3, 5, 7, 9 for 525/60 system
 DIF sequence number 1, 3, 5, 7, 9, 11 for 625/50 system

4.6.2.3.1 AAUX source pack (AS)

The AAUX source pack is configured as shown in Table 16.

Table 16 – Mapping of AAUX source pack

MSB						LSB	
PC0	0	1	0	1	0	0	0
PC1	LF	Res	AF SIZE				
PC2	0	CHN		Res	AUDIO MODE		
PC3	Res	Res	50/60	STYPE			
PC4	Res	Res	SMP			QU	

LF: Locked mode flag

Locking condition of audio sampling frequency with video signal.

0 = Locked mode
 1 = Reserved

AF SIZE: The number of audio samples per frame

010100b = 1600 samples/frame (525/60 system)
 010110b = 1602 samples/frame (525/60 system)
 011000b = 1920 samples/frame (625/50 system)
 Others = Reserved

CHN: The number of audio channels within an audio block

00b = One audio channel per audio block
 Others = Reserved

The audio block is composed of 45 DIF blocks of the audio section in five consecutive DIF sequences for the 525/60 system, and 54 DIF blocks of the audio section in six consecutive DIF sequences for the 625/50 system.

AUDIO MODE: The contents of the audio signal on each audio channel

0000b = CH1(CH3)
 0001b = CH2(CH4)
 1111b = Invalid audio data
 Others = Reserved

50/60:

0 = 60 field system
 1 = 50 field system

STYPE: STYPE defines audio blocks per video frame

00000b = 2 audio blocks
00010b = 4 audio blocks
Others = Reserved

SMP: Sampling frequency

000b = 48 kHz
Others = Reserved

QU: Quantization

000b = 16 bits linear
Others = Reserved

Res : Reserved bit for future use
Default value shall be set to 1.

4.6.2.3.2 AAUX source control pack (ASC)

The AAUX source control pack is configured as shown in Table 17.

Table 17 – Mapping of AAUX source control pack

	MSB						LSB	
PC0	0	1	0	1	0	0	0	1
PC1	CGMS		Res	Res	Res	Res	EFC	
PC2	REC ST	REC END	FADE ST	FADE END	Res	Res	Res	Res
PC3	DRF	SPEED						
PC4	Res	Res	Res	Res	Res	Res	Res	Res

CGMS: Copy generation management system

00b = Copy free
Others = Reserved

EFC: Emphasis audio channel flag

00b = Emphasis off
01b = Emphasis on
Others = Reserved

EFC shall be set for each audio block.

REC ST: Recording start point

0 = Recording start point
1 = Not recording start point

At a recording start frame, REC ST 0 lasts for a duration of one audio block which is equal to 5 or 6 DIF sequences for each audio channel.

REC END: Recording end point

- 0 = Recording end point
- 1 = Not recording end point

At a recording end frame, REC END 0 lasts for a duration of one audio block which is equal to 5 or 6 DIF sequences for each audio channel.

FADE ST: Fading of recording start point

- 0 = Fading off
- 1 = Fading on

The information of FADE ST shall be effective only at the recording start frame (REC ST = 0).

If FADE ST is 1 at the recording start frame, the output audio signal should be faded in from the first sampling signal of the frame. If FADE ST is 0 at the recording start frame, the output audio signal should not be faded.

FADE END: Fading of recording end point

- 0 = Fading off
- 1 = Fading on

The information of FADE END shall be effective only at the recording end frame (REC END = 0).

If FADE END is 1 at the recording end frame, the output audio signal should be faded out to the last sampling signal of the frame. If FADE END is 0 at the recording end frame, the output audio signal should not be faded.

DRF: Direction flag

- 0 = reverse direction
- 1 = forward direction

SPEED: Shuttle speed of VTR

SPEED	Shuttle speed of VTR	
	525/60 system	625/50 system
0000000	0/120 (=0)	0/100 (=0)
0000001	1/120	1/100
:	:	:
1100100	100/120	100/100 (=1)
:	:	Reserved
1111000	120/120 (=1)	Reserved
:	Reserved	Reserved
1111110	Reserved	Reserved
1111111	Data invalid	Data invalid

Res : Reserved bit for future use
Default value shall be set to "1".

4.7 Video section

4.7.1 ID

The ID part of each DIF block in the video section is described in 4.3.1. The section type shall be 100.

4.7.2 Data

The data part (payload) of each DIF block in the video section consists of 77 bytes of video data which shall be sampled, shuffled, and encoded. Video data of every video frame are processed as described in Clause 5.

DIF block and compressed macro block

Correspondence between video DIF blocks and video compressed macro blocks is shown in Tables 18 and 19. Table 18 shows correspondence between video DIF blocks for 50 Mb/s structure and video compressed macro blocks of 4:2:2 compression. Table 19 shows correspondence between the video DIF blocks for 25 Mb/s structure and video compressed macro blocks of 4:1:1 compression.

The rule defining the correspondence between video DIF blocks and compressed macro blocks is shown below:

50 Mb/s structure – 4:2:2 compression

```

if(525/60system) n = 10 else n = 12;
for(i=0; i<n; i++){
    a = i;
    b = (i - 6) mod n;
    c = (i - 2) mod n;
    d = (i - 8) mod n;
    e = (i - 4) mod n;
    p = a;
    q = 3;
    for(j=0; j<5; j++){
        for(k=0; k<27; k++){
            V(5 × k + q),0 of DSNp = CM 2i,j,k;
            V(5 × k + q),1 of DSNp = CM 2i+1,j,k;
        }
        if (q == 3) {p = b; q = 1;}
        else if (q == 1) {p = c; q = 0;}
        else if (q == 0) {p = d; q = 2;}
        else if (q == 2) {p = e; q = 4;}
    }
}

```

25 Mb/s structure – 4:1:1 compression

```

If (525/60 system) n = 10 else n = 12;
for (i = 0; i < n; i++) {
    a = i;
    b = (i - 6) mod n;
    c = (i - 2) mod n;
    d = (i - 8) mod n;
    e = (i - 4) mod n;
    p = a;
    q = 3;
    for (j = 0; j < 5; j++){
        for (k = 0; k < 27; k++){
            V (5 x k + q),0 of DSNp = CM i,j,k;
        }
    }
}

```



```

        if (q == 3) { p = b; q = 1; }
    else if (q == 1) { p = c; q = 0; }
    else if (q == 0) { p = d; q = 2; }
    else if (q == 2) { p = e; q = 4; }
    }
}

```

Table 18 – Video DIF blocks and compressed macro blocks for 50 Mb/s structure – 4:2:2 compression

DIF sequence number	DIF block	Compressed macro block
0	V0,0	CM 4,2,0
	V0,1	CM 5,2,0
	V1,0	CM 12,1,0
	V1,1	CM 13,1,0
	V2,0	CM 16,3,0
	V2,1	CM 17,3,0
	⋮	⋮
	V134,0	CM 8,4,26
	V134,1	CM 9,4,26
1	V0,0	CM 6,2,0
	V0,1	CM 7,2,0
	V1,0	CM 14,1,0
	V1,1	CM 15,1,0
	V2,0	CM 18,3,0
	V2,1	CM 19,3,0
	⋮	⋮
	V134,0	CM 10,4,26
	V134,1	CM 11,4,26
⋮	⋮	⋮
⋮	⋮	⋮
⋮	⋮	⋮
$n - 1$	V0,0	CM 2,2,0
	V0,1	CM 3,2,0
	V1,0	CM 10,1,0
	V1,1	CM 11,1,0
	V2,0	CM 14,3,0
	V2,1	CM 15,3,0
	⋮	⋮
	V134,0	CM 6,4,26
	V134,1	CM 7,4,26
NOTE n = 10 for 525/60 system; n = 12 for 625/50 system		

Table 19 – Video DIF blocks and compressed macro block for 25 Mb/s structure – 4:1:1 compression

DIF sequence number	DIF block	Compressed macro block
0	V0,0	CM 2,2,0
	V1,0	CM 6,1,0
	V2,0	CM 8,3,0
	V3,0	CM 0,0,0
	V4,0	CM 4,4,0
	:	:
	V133,0	CM 0,0,26
	V134,0	CM 4,4,26
1	V0,0	CM 3,2,0
	V1,0	CM 7,1,0
	V2,0	CM 9,3,0
	V3,0	CM 1,0,0
	V4,0	CM 5,4,0
	:	:
	V133,0	CM 1,0,26
	V134,0	CM 5,4,26
:	:	:
:	:	:
:	:	:
:	:	:
$n - 1$	V0,0	CM 1,2,0
	V1,0	CM 5,1,0
	V2,0	CM 7,3,0
	V3,0	CM $n - 1,0,0$
	V4,0	CM 3,4,0
	:	:
	V133,0	CM $n - 1,0,26$
	V134,0	CM 3,4,26
NOTE $n = 10$ for 525/60 system; $n = 12$ for 625/50 system		

5 Video compression

This clause includes video compression processing for 4:2:2 and 4:1:1 compression.

5.1 Video structure

The video signal is sampled with a frequency of 13,5 MHz for luminance (Y) and 6,75 MHz for colour differences (C_R , C_B). The data of the vertical blanking area and the horizontal blanking area are discarded, then the remainder of the video data is shuffled in the video frame. The original quantity of video data shall be reduced by use of bit-rate reduction techniques which adopt DCT and VLC.

The process of the bit rate-reduction is as follows: Video data are assigned to a DCT block (8X8 samples). Two luminance DCT blocks and two colour difference DCT blocks form a macro block for 4:2:2 compression. For 4:1:1 compression, four luminance DCT blocks and two colour difference DCT blocks form a macro block. Five macro blocks constitute a video segment. A video segment is further compressed into five compressed macro blocks by use of the DCT and VLC techniques.

5.1.1 Sampling structure

The sampling structure is identical to the sampling structure of 4:2:2 component television signals described in ITU-R BT.601. Sampling of luminance (Y) and two colour difference signals (C_R , C_B) in the 4:2:2 are described in Table 20.

Line structure in one frame

For the 525/60 system, 240 lines for Y, C_R , and C_B signals from each field shall be transmitted.

For the 625/50 system, 288 lines for Y, C_R , and C_B signals from each field shall be transmitted. The transmitted lines on a TV frame are defined in Table 20.

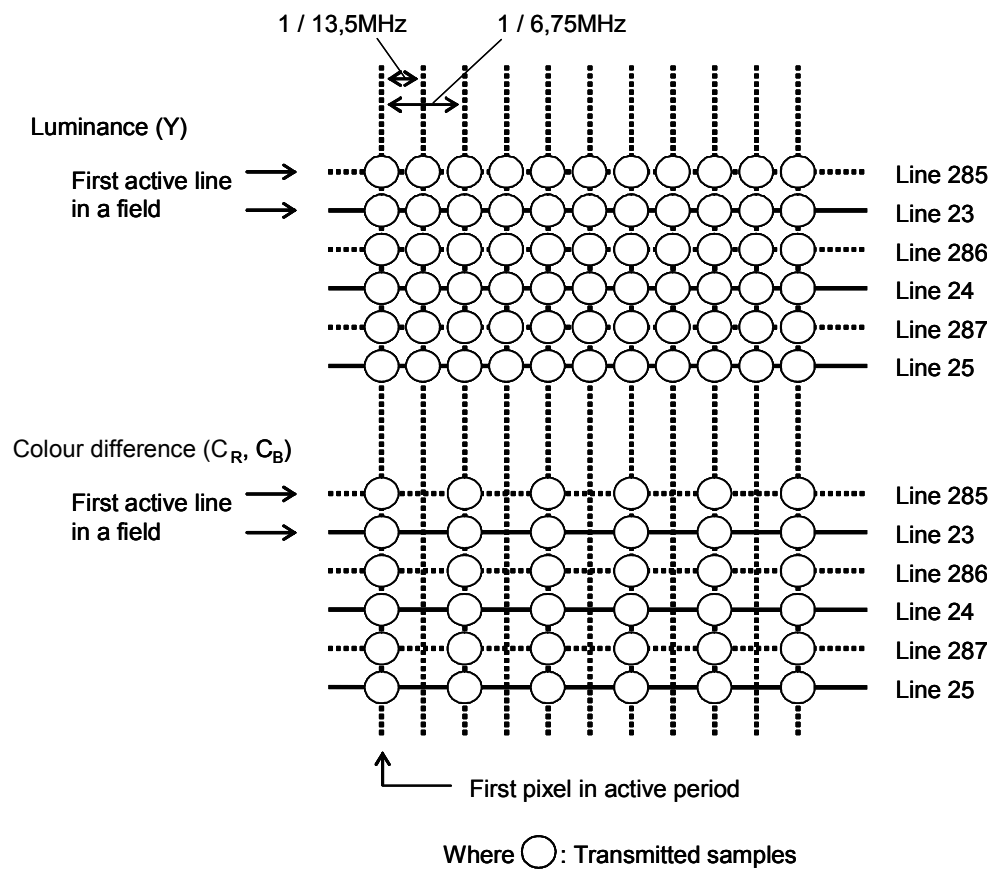
Table 20 – Construction of video signal sampling (4:2:2)

		525/60 system	625/50 system
Sampling frequency	Y	13,5 MHz	
	C_R, C_B	6,75 MHz	
Total number of pixels per line	Y	858	864
	C_R, C_B	429	432
The number of active pixels per line	Y	720	
	C_R, C_B	360	
Total number of lines per frame		525	625
The number of active lines per frame		480	576
The active line numbers	Field 1	23 to 262	23 to 310
	Field 2	285 to 524	335 to 622
Quantization		Each sample is linearly quantized to 8 bits for Y, C_R , C_B .	
The relation between video signal level and quantized level	Scale	1 to 254	
	Y	Video signal level of white: 235 Video signal level of black: 16	Quantized level 220
	C_R, C_B	Video signal level of gray: 128	Quantized level 225

Pixel structure in one frame

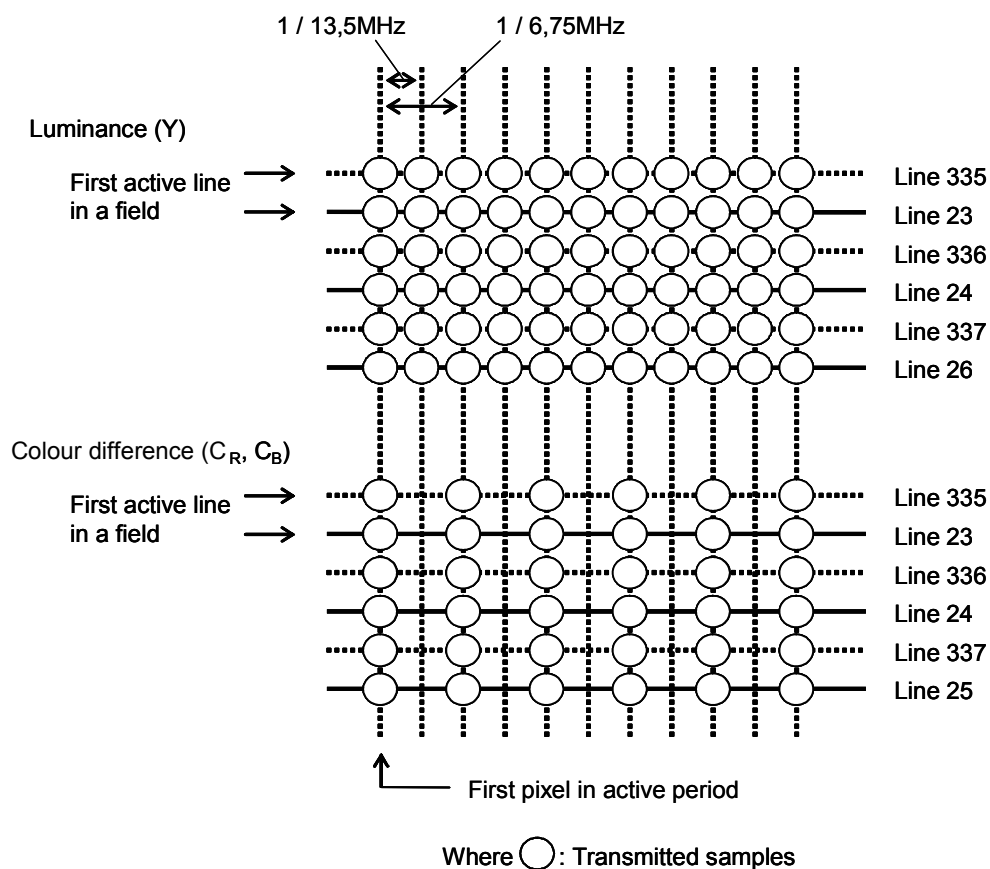
4:2:2 compression

All sampled pixels, 720 luminance pixels per line and 360 colour difference pixels, are retained for processing as shown in Figures 11 and 12. The sampling process starts simultaneously for both luminance and colour difference signals. Each pixel has a value from –127 to +126 which is obtained by the subtraction of 128 from the input video signal level.



IEC 1915/05

Figure 11 – Transmitting samples of 525/60 system for 4:2:2 compression

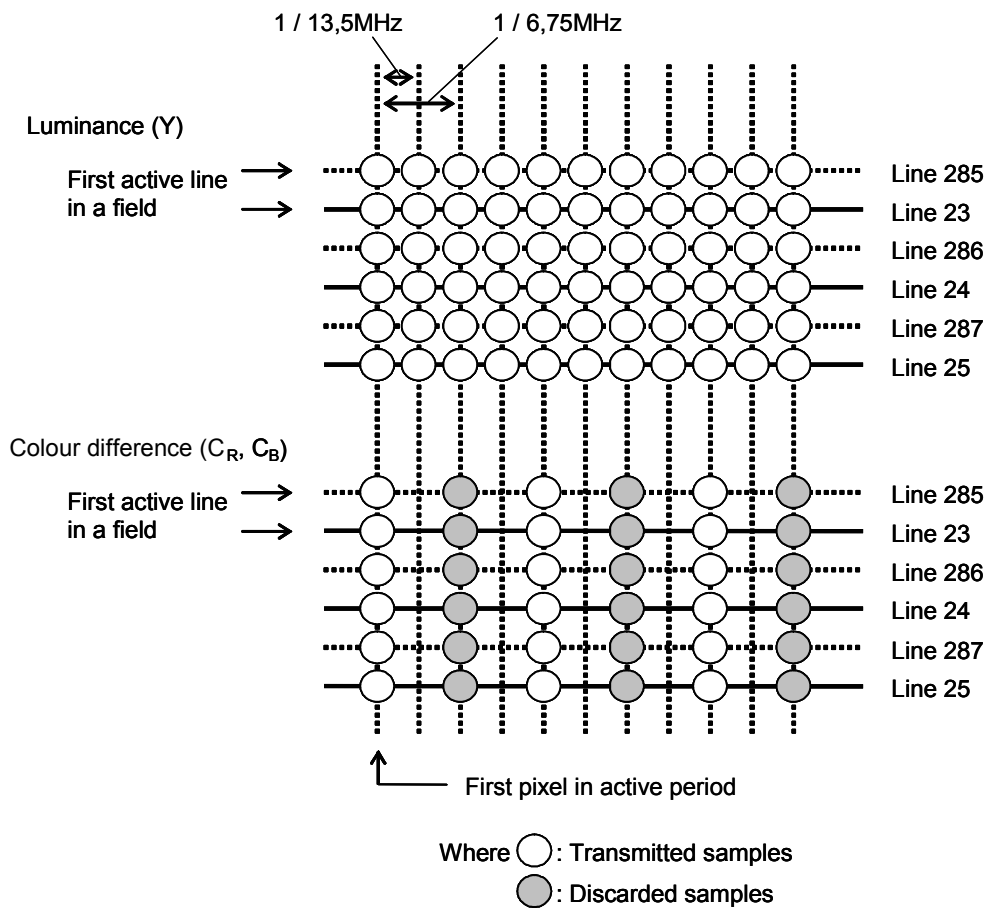


IEC 1916/05

Figure 12 – Transmitting samples of 625/50 system for 4:2:2 compression

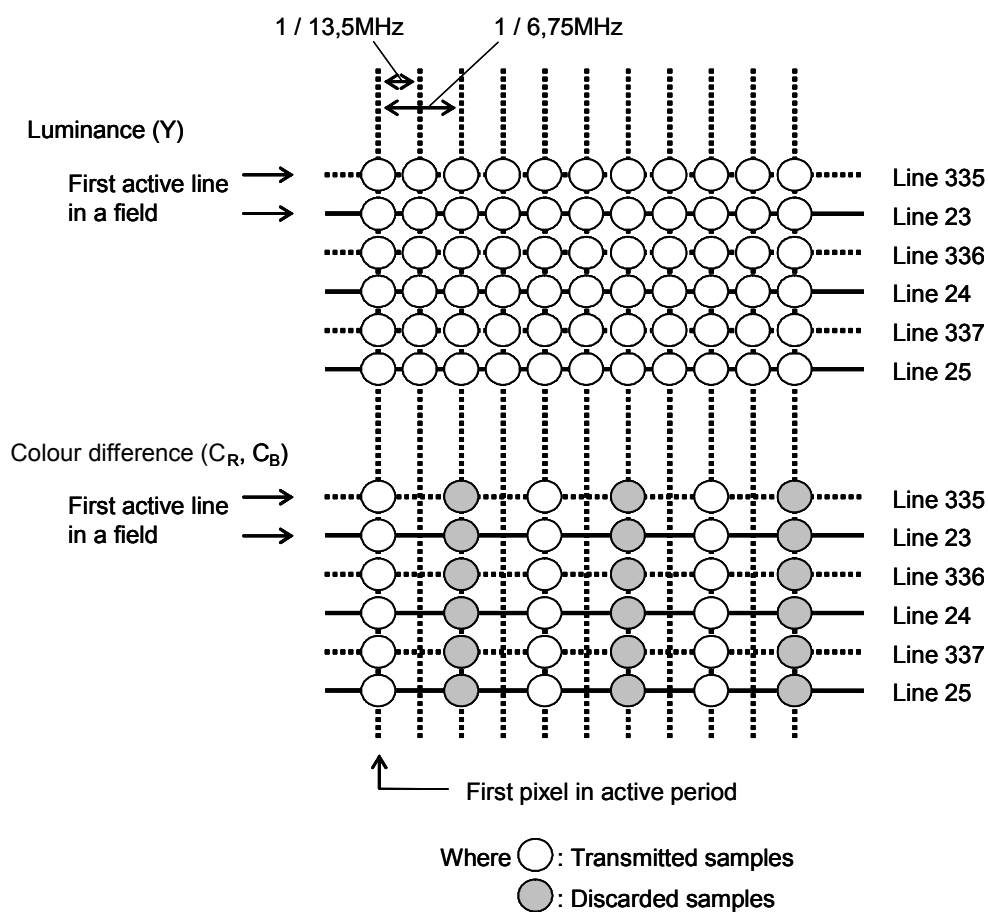
4:1:1 compression

All sampled luminance pixels, 720 pixels per line, are retained for processing. Of 360 colour difference pixels sampled per line, every other pixel is discarded, leaving 180 pixels for processing. The sampling process starts simultaneously for both luminance and colour difference signals. Figures 13 and 14 show sampling process in detail. Each pixel has a value in range from -127 to $+126$ which is obtained by the subtraction of 128 from the input video signal level.



IEC 1917/05

Figure 13 – Transmitting samples of 525/60 system for 4:1:1 compression



IEC 1918/05

Figure 14 – Transmitting samples of 625/50 system for 4:1:1 compression

5.1.2 DCT block

The Y , C_R and C_B pixels in one frame shall be divided into DCT blocks as shown in Figure 15. All DCT blocks for 4:2:2 compression, and DCT blocks for 4:1:1 compression, with the exception of the rightmost DCT blocks in C_R and C_B for 4:1:1 compression, are structured as a rectangular area of eight vertical lines and eight horizontal pixels for each DCT block. The value of x shows the horizontal coordinate from the left and the value of y shows the vertical coordinate from the top. Odd lines of $y = 1, 3, 5, 7$ are the horizontal lines of field one, and even lines of $y = 0, 2, 4, 6$ are those of field two.

In the 4:1:1 compression mode, the rightmost DCT blocks in C_R and C_B are structured with the 16 vertical lines and four horizontal pixels. The rightmost DCT block shall be reconstructed to eight vertical lines and eight horizontal pixels by moving the lower part of eight vertical lines and four horizontal pixels to the higher part of eight vertical lines and four horizontal pixels as shown in Figure 16.

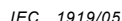


Figure 15 – DCT block and the pixel coordinates

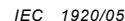


Figure 16 – The rightmost DCT block in colour difference signal for 4:1:1 compression mode

The arrangement of horizontal DCT blocks in one frame in the 4:2:2 compression mode is shown in Figure 17, and in the 4:1:1 compression mode in Figure 18. The same horizontal arrangement is repeated with 60 DCT blocks in the vertical direction. Pixels in one frame are divided into 10 800 DCT blocks for 4:2:2 compression and 8 100 DCT blocks for 4:1:1 compression.

4:2:2 compression

Y: 60 vertical DCT blocks x 90 horizontal DCT blocks = 5 400 DCT blocks
 C_R: 60 vertical DCT blocks x 45 horizontal DCT blocks = 2 700 DCT blocks
 C_B: 60 vertical DCT blocks x 45 horizontal DCT blocks = 2 700 DCT blocks

4:1:1 compression

Y: 60 vertical DCT blocks x 90 horizontal DCT blocks = 5 400 DCT blocks
 C_R: 60 vertical DCT blocks x 22.5 horizontal DCT blocks = 1 350 DCT blocks
 C_B: 60 vertical DCT blocks x 22.5 horizontal DCT blocks = 1 350 DCT blocks

DCT block arrangement in one frame for 625/50 system

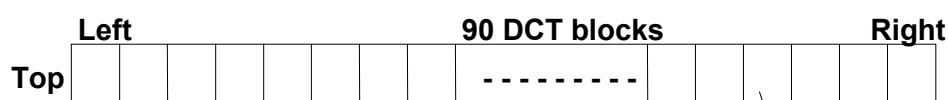
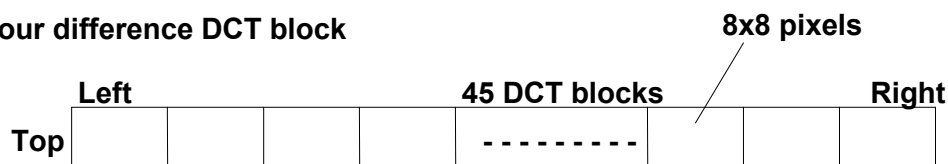
The arrangement of horizontal DCT blocks in one frame for the 4:2:2 compression mode is shown in Figure 17, and for the 4:1:1 compression mode in Figure 18. The same horizontal arrangement is repeated to 72 DCT blocks in the vertical direction. Pixels in one frame are divided into 12 960 DCT blocks for 4:2:2 compression and 9 720 DCT blocks for 4:1:1 compression.

4:2:2 compression

Y: 72 vertical DCT blocks x 90 horizontal DCT blocks = 6 480 DCT blocks
 C_R: 72 vertical DCT blocks x 45 horizontal DCT blocks = 3 240 DCT blocks
 C_B: 72 vertical DCT blocks x 45 horizontal DCT blocks = 3 240 DCT blocks

4:1:1 compression

Y: 72 vertical DCT blocks x 90 horizontal DCT blocks = 6 480 DCT blocks
 C_R: 72 vertical DCT blocks x 22.5 horizontal DCT blocks = 1 620 DCT blocks
 C_B: 72 vertical DCT blocks x 22.5 horizontal DCT blocks = 1 620 DCT blocks

Luminance DCT block**Colour difference DCT block**

IEC 1921/05

Figure 17 – DCT block arrangement for 4:2:2 compression

Macro block arrangement in one frame for 525/60 system

The arrangement of macro blocks in one frame is shown in Figure 21 for 4:2:2 compression and Figure 22 for 4:1:1 compression. Each small rectangle shows a macro block. Pixels in one frame are distributed into 2 700 macro blocks for 4:2:2 compression and 1 350 macro blocks for 4:1:1 compression.

4:2:2 compression

60 vertical macro blocks x 45 horizontal macro blocks = 2 700 macro blocks

4:1:1 compression

60 vertical macro blocks x 22.5 horizontal macro blocks = 1 350 macro blocks

Macro block arrangement in one frame for 625/50 system

The arrangement of macro blocks in one frame is shown in Figure 23 for 4:2:2 compression and Figure 24 for 4:1:1 compression. Each small rectangle shows a macro block. Pixels in one frame are distributed into 3 240 macro blocks for 4:2:2 compression and 1 620 macro blocks for 4:1:1 compression.

4:2:2 compression

72 vertical macro blocks x 45 horizontal macro blocks = 3 240 macro blocks

4:1:1 compression

72 vertical macro blocks x 22,5 horizontal macro blocks = 1 620 macro blocks

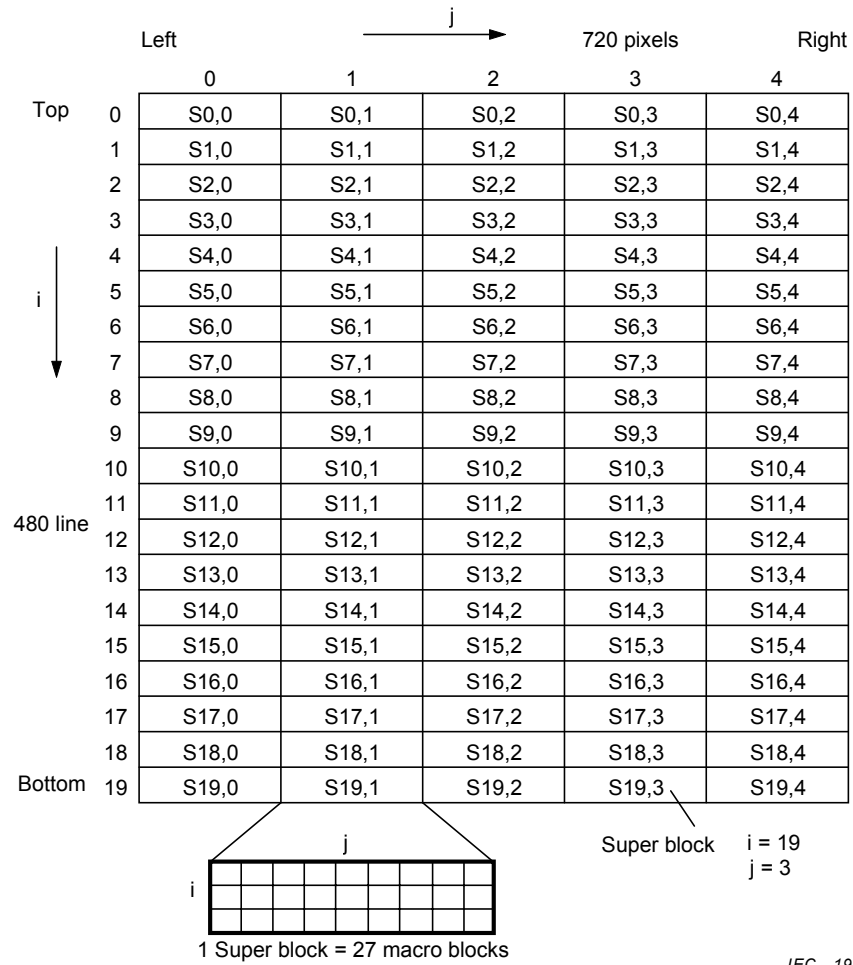
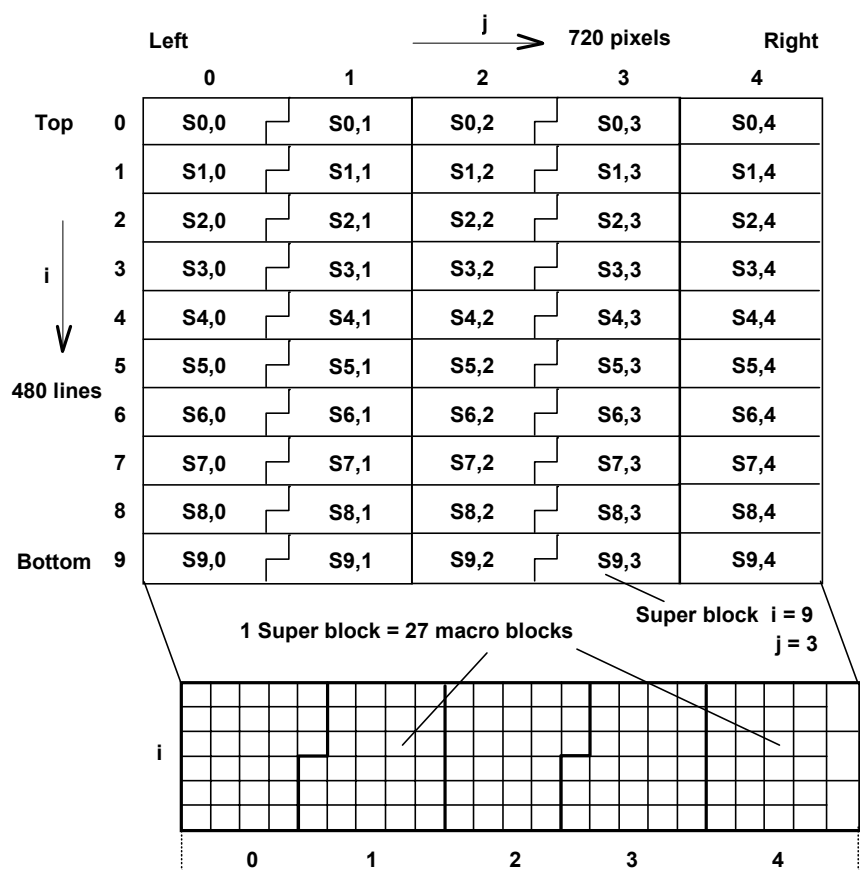
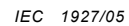


Figure 21 – Super blocks and macro blocks in one TV frame for 525/60 system for 4:2:2 compression

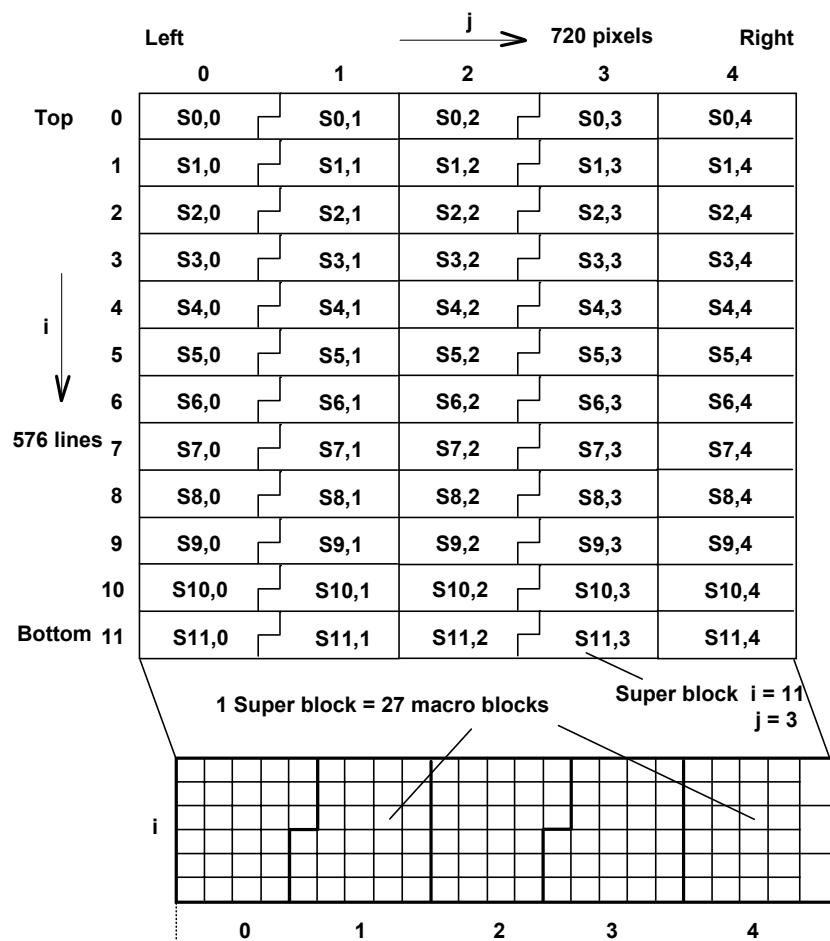


IEC 1926/05

Figure 22 – Super blocks and macro blocks in one TV frame for 525/60 system for 4:1:1 compression



LICENSED TO MECON Limited - RANCHI/BANGALORE
 FOR INTERNAL USE AT THIS LOCATION ONLY, SUPPLIED BY BOOK SUPPLY BUREAU.



IEC 1928/05

Figure 24 – Super blocks and macro blocks in one TV frame for 625/50 system for 4:1:1 compression

5.1.4 Super block

Each super block consists of 27 macro blocks.

Super block arrangement in one frame for 525/60 system

The arrangement of super blocks in one frame is shown in Figure 21 for 4:2:2 compression and Figure 22 for 4:1:1 compression. Each super block consists of 27 adjacent macro blocks, and its boundary is marked by a heavy line. The total number of pixels in a frame is distributed into 100 super blocks for 4:2:2 compression or 50 super blocks for 4:1:1 compression.

4:2:2 compression

20 vertical super blocks x 5 horizontal super blocks = 100 super blocks

4:1:1 compression

10 vertical super blocks x 5 horizontal super blocks = 50 super blocks

Super block arrangement in one frame for 625/50 system

The arrangement of super blocks in one frame is shown in Figure 23 for 4:2:2 compression and Figure 24 for 4:1:1 compression. Each super block consists of 27 adjacent macro blocks, and its boundary is marked by a heavy line. The total number of pixels in a frame are distributed into 120 super blocks for 4:2:2 compression or 60 super blocks for 4:1:1 compression.

4:2:2 compression

24 vertical super blocks x 5 horizontal super blocks = 120 super blocks

4:1:1 compression

12 vertical super blocks x 5 horizontal super blocks = 60 super blocks

5.1.5 Definition of a super block number, a macro block number and value of the pixel

Super block number

The super block number in a frame is expressed as $S_{i,j}$ as shown in Figures 21, 22, 23, and 24.

$S_{i,j}$
where

i : the vertical order of the super block

$i = 0, \dots, n-1$

where

n : the number of vertical super blocks in a video frame

$n = 10 \times m$ for 525/60 system

$n = 12 \times m$ for 625/50 system

m : the compression type

$m = 1$ for 4:1:1 compression

$m = 2$ for 4:2:2 compression

j : the horizontal order of the super block

$j = 0, \dots, 4$

Macro block number

The macro block number is expressed as $M_{i,j,k}$. The symbol k is the macro block order in the super block as shown in Figure 25 for 4:2:2 compression and Figure 26 for 4:1:1 compression. The small rectangle in these figures shows a macro block and a number in the small rectangle indicates k .

$M_{i,j,k}$
where

i, j : the super block order number

k : the macro block order in the super block

$k = 0, \dots, 26$

Pixel location

Pixel location is expressed as $P_{i,j,k,l}(x,y)$. The pixel is indicated as the suffix of $i, j, k, l(x,y)$. The symbol l is the DCT block order in a macro block as shown in Figures 19 and 20. The rectangle in the figure shows a DCT block, and a DCT number in the rectangle expresses l . Symbols x and y are the pixel coordinate in the DCT block as described in 5.1.2.

$P_{i,j,k,l}(x,y)$
where

i, j, k : the macro block number

l : the DCT block order in the macro block

(x,y) : the pixel coordinate in the DCT block

$x = 0, \dots, 7$

$y = 0, \dots, 7$

Super block $S_{i,j}$ ($i = 0, \dots, n-1, j = 0, \dots, 4$)

0	5	6	11	12	17	18	23	24
1	4	7	10	13	16	19	22	25
2	3	8	9	14	15	20	21	26

Where $n = 20$: 525/60 system
 $n = 24$: 625/50 system

IEC 1929/05

Figure 25 – Macro block order in a super block for 4:2:2 compression

Super block $S_{i,0}, S_{i,2}$ ($i = 0, \dots, n-1$)

0	11	12	23	24
1	10	13	22	25
2	9	14	21	26
3	8	15	20	
4	7	16	19	
5	6	17	18	

Super block $S_{i,1}, S_{i,3}$ ($i = 0, \dots, n-1$)

	8	9	20	21
	7	10	19	22
	6	11	18	23
0	5	12	17	24
1	4	13	16	25
2	3	14	15	26

Super block $S_{i,4}$ ($i = 0, \dots, n-1$)

0	11	12	23	24
1	10	13	22	
2	9	14	21	25
3	8	15	20	
4	7	16	19	26
5	6	17	18	

Where $n = 10$: 525/60 system
 $n = 12$: 625/50 system

IEC 1930/05

Figure 26 – Macro block order in a super block for 4:1:1 compression**5.1.6 Definition of video segment and compressed macro block**

A video segment consists of five macro blocks assembled from various areas within the video frame:

$M_{a,2,k}$ where $a = (i+2m) \bmod n$
 $M_{b,1,k}$ where $b = (i+6m) \bmod n$
 $M_{c,3,k}$ where $c = (i+8m) \bmod n$
 $M_{d,0,k}$ where $d = (i+0) \bmod n$
 $M_{e,4,k}$ where $e = (i+4m) \bmod n$
 where

i : the vertical order of the super block

$i = 0, \dots, n-1$

n : the number of vertical super blocks in a video frame

$n = 10 \times m$ for 525/60 system

$n = 12 \times m$ for 625/50 system

m: the compression type
 m = 1 for 4:1:1 compression
 m = 2 for 4:2:2 compression
 k: the macro block order in the super block
 k = 0, ..., 26

Each video segment before the bit-rate reduction is expressed as V i, k which consists of M a, 2, k; M b, 1, k; M c, 3, k; M d, 0, k, and M e, 4, k.

The bit-rate reduction process is operated sequentially from M a, 2, k to M e, 4, k. The data in a video segment are compressed and transformed to a 385-byte data stream. A compressed video data consists of five compressed macro blocks. Each compressed macro block consists of 77 bytes and is expressed as CM. Each video segment after the bit-rate reduction is expressed as CV i, k which consists of CM a, 2, k; CM b, 1, k; CM c, 3, k; CM d, 0, k and CM e, 4, k as shown below.

CM a, 2, k:

This block includes all parts or most parts of the compressed data from macro block M a, 2, k and may include the compressed data of the macro block M b, 1, k; or M c, 3, k; or M d, 0, k; or M e, 4, k.

CM b, 1, k:

This block includes all parts or most parts of the compressed data from macro block M b, 1, k and may include the compressed data of macro block M a, 2, k; or M c, 3, k; or M d, 0, k; or M e, 4, k.

CM c, 3, k:

This block includes all parts or most parts of the compressed data from macro block M c, 3, k and may include the compressed data of macro block M a, 2, k; or M b, 1, k; or M d, 0, k; or M e, 4, k.

CM d, 0, k:

This block includes all parts or most parts of the compressed data from macro block M d, 0, k and may include the compressed data of macro block M a, 2, k; or M b, 1, k; or M c, 3, k; or M e, 4, k.

CM e, 4, k:

This block includes all parts or most parts of the compressed data from macro block M e, 4, k and may include the compressed data of macro block M a, 2, k; or M b, 1, k; or M c, 3, k; or M d, 0, k.

5.2 DCT processing

DCT blocks are comprised of two fields; each field providing pixels from 4 vertical lines and 8 horizontal pixels. In this clause, the DCT transformation from 64 pixels in a DCT block whose numbers are i, j, k, l (x, y) to 64 coefficients whose numbers are i, j, k, l (h, v) is described. P i, j, k, l (x, y) is the value of the pixel and C i, j, k, l (h, v) is the value of the coefficient.

For h = 0 and v = 0, the coefficient is called DC coefficient. Other coefficients are called AC coefficients.

5.2.1 DCT mode

Two modes, 8-8-DCT, and 2-4-8-DCT, are selectively used to optimize the data-reduction process, depending upon the degree of content variations between the two fields of a video frame. The two DCT modes are defined:

8-8-DCT mode

DCT:

$$C, i, j, k, l(h, v) = C(v) C(h) \sum_{y=0}^7 \sum_{x=0}^7 (P i, j, k, l(x, y) \cos(\pi v(2y + 1)/16) \cos(\pi h(2x + 1)/16))$$

Inverse DCT:

$$P, i, j, k, l(x, y) = \sum_{v=0}^7 \sum_{h=0}^7 (C(v) C(h) C i, j, k, l(h, v) \cos(\pi v(2y + 1)/16) \cos(\pi h(2x + 1)/16))$$

where

$$\begin{aligned} C(h) &= 0, 5/\sqrt{2} \text{ for } h = 0 \\ C(h) &= 0, 5 \text{ for } h = 1 \text{ to } 7 \\ C(v) &= 0, 5/\sqrt{2} \text{ for } v = 0 \\ C(v) &= 0, 5 \text{ for } v = 1 \text{ to } 7 \end{aligned}$$

2-4-8-DCT mode

DCT:

$$C i, j, k, l(h, u) = C(u) C(h) \sum_{z=0}^3 \sum_{x=0}^7 (P i, j, k, l(x, 2z) + P i, j, k, l(x, 2z + 1)) KC)$$

$$C i, j, k, l(h, u + 4) = C(u) C(h) \sum_{z=0}^3 \sum_{x=0}^7 ((P i, j, k, l(x, 2z) - P i, j, k, l(x, 2z + 1)) KC)$$

Inverse DCT:

$$P i, j, k, l(x, 2z) = \sum_{u=0}^3 \sum_{h=0}^7 (C(u) C(h) (C i, j, k, l(h, u) + C i, j, k, l(h, u + 4)) KC)$$

$$P i, j, k, l(x, 2z + 1) = \sum_{u=0}^3 \sum_{h=0}^7 (C(u) C(h) (C i, j, k, l(h, u) - C i, j, k, l(h, u + 4)) KC)$$

where

$$\begin{aligned} u &= 0, \dots, 3 \\ z &= \text{INT}(y/2) \\ KC &= \cos(\pi u(2z + 1)/8) \cos(\pi h(2x + 1)/16) \\ C(h) &= 0, 5/\sqrt{2} \text{ for } h = 0 \\ C(h) &= 0, 5 \text{ for } h = 1 \text{ to } 7 \\ C(u) &= 0, 5/\sqrt{2} \text{ for } u = 0 \\ C(u) &= 0, 5 \text{ for } u = 1 \text{ to } 7 \end{aligned}$$

5.2.2 Weighting

DCT coefficients shall be weighted by the process as described below. $W(h, v)$ expresses weight for C i, j, k, l (h, v) of the DCT coefficient.

8-8-DCT mode

$$\begin{aligned} \text{For } h = 0 \text{ and } v = 0 & \quad W(h, v) = 1/4 \\ \text{For others} & \quad W(h, v) = w(h) w(v)/2 \end{aligned}$$

2-4-8-DCT mode

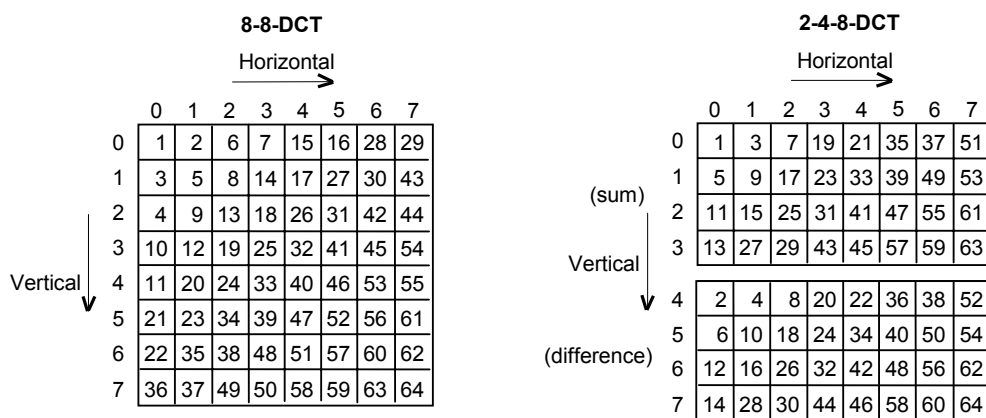
$$\begin{aligned} \text{For } h = 0 \text{ and } v = 0 & \quad W(h, v) = 1/4 \\ \text{For } v < 4 & \quad W(h, v) = w(h) w(2v)/2 \\ \text{For others} & \quad W(h, v) = w(h) w(2(v-4))/2 \end{aligned}$$

where

$$\begin{aligned} w(0) &= 1 \\ w(1) &= CS4/(4 \times CS7 \times CS2) \\ w(2) &= CS4/(2 \times CS6) \\ w(3) &= 1/(2 \times CS5) \\ w(4) &= 7/8 \\ w(5) &= CS4/CS3 \\ w(6) &= CS4/CS2 \\ w(7) &= CS4/CS1 \\ \text{where } CSm &= \cos(m\pi/16) \quad m = 1 \text{ to } 7 \end{aligned}$$

5.2.3 Output order

Figure 27 shows the output order of the weighted coefficients.



IEC 1931/05

Figure 27 – The output order of a weighted DCT block

5.2.4 Tolerance of DCT with weighting

Output error between the reference DCT and the tested DCT should satisfy the tolerances of the following cases:

probability of occurrence of error;

mean square errors for all coefficients;

maximum value of mean square error for each DCT block;

all input pixel values of a DCT block are the same.

5.3 Quantization

5.3.1 General

Weighted DCT coefficients are first quantized to 9-bit words, then divided by quantization step in order to limit the amount of data in one video segment to five compressed macro blocks.

5.3.2 Bit assignment for quantization

Weighted DCT coefficients are represented as follows:

DC coefficient value (9 bits): b8 b7 b6 b5 b4 b3 b2 b1 b0

two's complement (-255 to 255)

AC coefficient value (10 bits): s b8 b7 b6 b5 b4 b3 b2 b1 b0

1 sign bit + 9 bits of absolute value (-511 to 511)

5.3.3 Class number

Each DCT block shall be classified into four classes by the definitions as described in Table 21. For the selecting quantization step, the class number is used. Both c1 and c0 express the class number and are stored in the DC coefficient of compressed DCT blocks as described in 5.5. For reference, Table 22 shows an example of the classification.

Table 21 – Class number and the DCT block

Class number			DCT block	
	c1	c0	Quantization noises	Maximum absolute value of AC coefficient
0	0	0	Visible	Less than or equal to 255
1	0	1	Lower than class 0	
2	1	0	Lower than class 1	
3	1	1	Lower than class 2	
			---	Greater than 255

Table 22 – An example of the classification for reference

	Maximum absolute value of AC coefficient			
	0 to 11	12 to 23	24 to 35	> 35
Y	0	1	2	3
C _R	1	2	3	3
C _B	2	3	3	3

5.3.4 Initial scaling

Initial scaling is an operation for AC coefficients to transform from 10 bits to 9 bits. Initial scaling shall be done as follows:

For class number = 0, 1, 2

input data s b8 b7 b6 b5 b4 b3 b2 b1 b0

```

input data      s b8 b7 b6 b5 b4 b3 b2 b1 b0
output data     s b7 b6 b5 b4 b3 b2 b1 b0

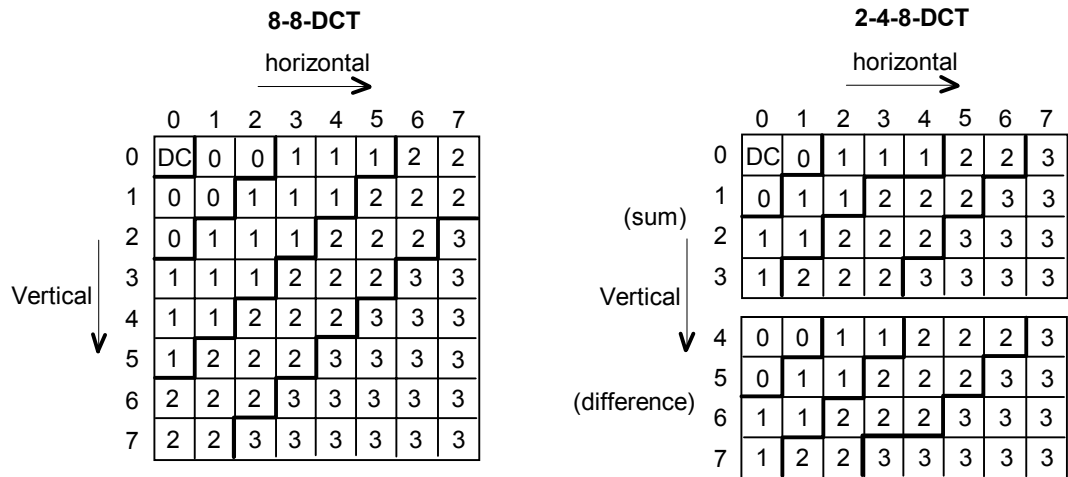
```

For class number = 3

input data s b8 b7 b6 b5 b4 b3 b2 b1 b0
output data s b8 b7 b6 b5 b4 b3 b2 b1

5.3.5 Area number

An area number is used for selection of the quantization step. AC coefficients within a DCT block shall be classified into four areas with area numbers as shown in Figure 28.



IEC 1932/05

Figure 28 – Area numbers

5.3.6 Quantization step

The quantization step shall be decided by the class number, area number, and quantization number (QNO) as specified in Table 23. QNO is selected in order to limit the amount of data in one video segment to five compressed macro blocks.

Table 23 – Quantization step

	Class number				Area number			
	0	1	2	3	0	1	2	3
Quantization number (QNO)	15				1	1	1	1
	14				1	1	1	1
	13				1	1	1	1
	12	15			1	1	1	1
	11	14			1	1	1	1
	10	13		15	1	1	1	1
	9	12	15	14	1	1	1	1
	8	11	14	13	1	1	1	2
	7	10	13	12	1	1	2	2
	6	9	12	11	1	1	2	2
	5	8	11	10	1	2	2	4
	4	7	10	9	1	2	2	4
	3	6	9	8	2	2	4	4
	2	5	8	7	2	2	4	4
	1	4	7	6	2	4	4	8
	0	3	6	5	2	4	4	8
		2	5	4	4	4	8	8
		1	4	3	4	4	8	8
		0	3	2	4	8	8	16
			2	1	4	8	8	16
			1	0	8	8	16	16
			0		8	8	16	16

5.4 Variable length coding (VLC)

Variable length coding is an operation for transforming from quantized AC coefficients to variable length codes. One or more successive AC coefficients within a DCT block are coded into one variable length code according to the order as shown in Figure 27. Run length and amplitude are defined as follows:

Run length: the number of successive AC coefficients quantized to 0

(run = 0, ... 61)

Amplitude: absolute value just after successive AC coefficients quantized to 0

(amp = 0, ... 255)

(run, amp): the pair of run length and amplitude

Table 24 shows the length of codewords corresponding to (run, amp). In the table, sign bit is not included in the length of codewords. When the amplitude is not zero, the code length shall be plus 1 because sign bit is needed. For empty columns, the length of codewords of the (run, amp) equals that of the (run – 1, 0) plus that of the (0, amp).

Variable length code shall be as shown in Table 25. The leftmost bit of code words is MSB and the rightmost bit of codewords is LSB in Table 25. The MSB of a subsequent code word is next to the LSB of the code word just before. Sign bit “s” shall be as follows:

When the quantized AC coefficient is greater than zero, s = 0

When the quantized AC coefficient is less than zero, s = 1

When the values of all of remaining quantized coefficients are zero within a DCT block, the coding process is ended by adding EOB (End of block) codeword of 0110b to just after the last codeword.

Table 24 – Length of codewords

	Amplitude																											
Run length	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	255		
0	11	2	3	4	4	5	5	6	6	7	7	7	8	8	8	8	8	8	9	9	9	9	9	15	15		
1	11	4	5	7	7	8	8	8	9	10	10	10	11	11	11	12	12	12										
2	12	5	7	8	9	9	10	12	12	12	12	12																
3	12	6	8	9	10	10	11	12																				
4	12	6	8	9	11	12																						
5	12	7	9	10																								
6	13	7	9	11																								
7	13	8	12	12																								
8	13	8	12	12																								
9	13	8	12																									
10	13	8	12																									
11	13	9																										
12	13	9																										
13	13	9																										
14	13	9																										
15	13																											
⋮	⋮																											
61	13																											

NOTE 1 Sign bit is not included.

NOTE 2 The length of EOB = 4.

Table 25 – Codewords for variable length coding

(run, amp)	Code	Length	(run, amp)	Code	Length	(run, amp)	Code	Length
0 1	00s	2+1	11 1	111100000s	9+1	7 2	111110110000s	12+1
0 2	010s	3+1	12 1	111100001s		8 2	111110110001s	
EOB	0110	4	13 1	111100010s		9 2	111110110010s	
1 1	0111s	4+1	14 1	111100011s		10 2	111110110011s	
0 3	1000s		5 2	111100100s		7 3	111110110100s	
0 4	1001s		6 2	111100101s		8 3	111110110101s	
2 1	10100s	5+1	3 3	111100110s		4 5	111110110110s	
1 2	10101s		4 3	111100111s		3 7	111110110111s	
0 5	10110s		2 4	111101000s		2 7	111110111000s	
0 6	10111s		2 5	111101001s		2 8	111110111001s	
3 1	110000s	6+1	1 8	111101010s		2 9	111110111010s	
4 1	110001s		0 18	111101011s		2 10	111110111011s	
0 7	110010s		0 19	111101100s		2 11	111110111100s	
0 8	110011s		0 20	111101101s		1 15	111110111101s	
5 1	1101000s	7+1	0 21	111101110s		1 16	111110111110s	
6 1	1101001s		0 22	111101111s		1 17	111110111111s	
2 2	1101010s		5 3	1111100000s	10+1	6 0	1111110000110	13
1 3	1101011s		3 4	1111100001s		7 0	1111110000111	
1 4	1101100s		3 5	1111100010s		R 0	1111110	
0 9	1101101s		2 6	1111100011s		Binary notation of R R = 6 to 61		
0 10	1101110s		1 9	1111100100s		61 0	1111110111101	
0 11	1101111s		1 10	1111100101s		0 23	111111100010111s	15+1
7 1	11100000s	8+1	1 11	1111100110s	11	0 24	111111100011000s	
8 1	11100001s		0 0	11111001110		0	A	
9 1	11100010s		1 0	11111001111		Binary notation of A A = 23 to 255		
10 1	11100011s		6 3	11111010000s	11+1	0	255	1111111111111111s
3 2	11100100s		4 4	11111010001s				
4 2	11100101s		3 6	11111010010s				
2 3	11100110s		1 12	11111010011s				
1 5	11100111s		1 13	11111010100s	12			
1 6	11101000s		1 14	11111010101s				
1 7	11101001s		2 0	111110101100				
0 12	11101010s		3 0	111110101101				
0 13	11101011s		4 0	111110101110				
0 14	11101100s		5 0	111110101111				
0 15	11101101s							
0 16	11101110s							
0 17	11101111s							

NOTE 1 (R, 0) : 1111110r5r4r3r2

where $32r5 + 16r4 + 8r3 + 4r2 + 2r1 + r0 = R$

NOTE 2 (0, A) : 1111111a7a6a5a4a3a2a1a0s

where $128a7 + 64a6 + 32a5 + 16a4 + 8a3 + 4a2 + 2a1 + a0 = A$

NOTE 3 "S" is sign bit. EOB means "End of block".

5.5 The arrangement of a compressed macro block

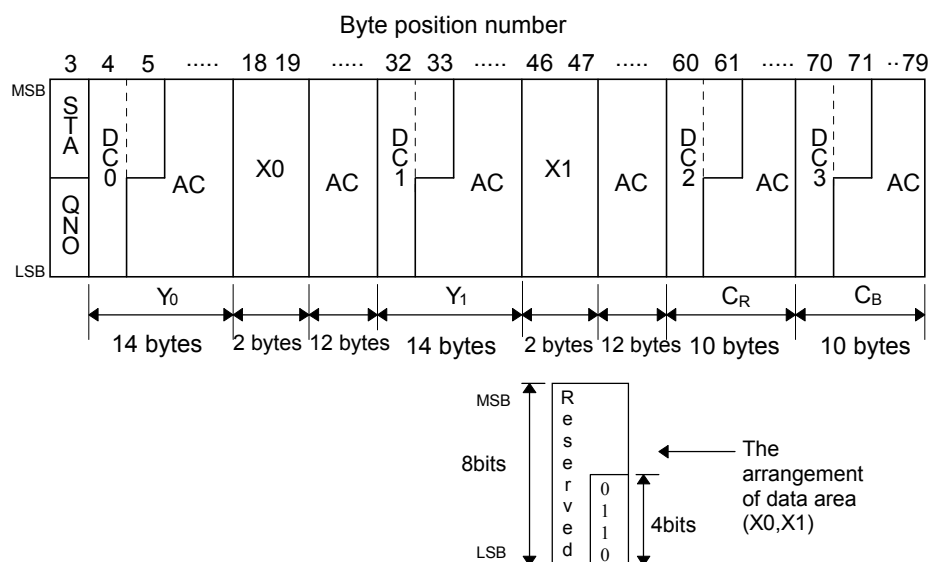
A compressed video segment consists of five compressed macro blocks. Each compressed macro block has 77 bytes of data. The arrangement of the compressed macro block shall be as shown in Figure 29 for 4:2:2 compression and in Figure 30 for 4:1:1 compression. Each compressed macro block of 4:2:2 compression includes a two-byte data area (X0, X1). The data arrangement is shown in Figure 29. The data format of the reserved area is not defined except 100000000000.

STA (status of the compressed macro block)

STA expresses the error and concealment of the compressed macro block and consists of four bits: s3 s2 s1 s0. Table 26 shows the definitions of STA.

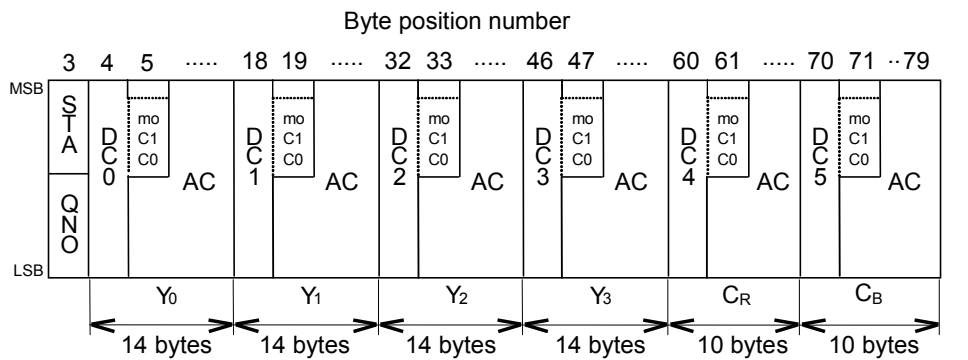
QNO (quantization number)

QNO is the quantization number applied to the macro block. Code words of the QNO shall be as shown in Table 27.



IEC 1933/05

Figure 29 – Arrangement of a compressed macro block for 4:2:2 compression



IEC 1934/05

STA: Error status

QNO: Quantization number

DC: DC component

AC: AC component

EOB: End of block (0110)

mo: DCT mode

c0, c1: class number

Figure 30 – The arrangement of a compressed macro block for 4:1:1 compression

Table 26 – Definition of STA

STA				Information of the compressed macro block		
s3	s2	s1	s0	Error	Error concealment	Continuity
0	0	0	0	No error	Not proceeded	--
0	0	1	0		Type A	Type a
0	1	0	0		Type B	
0	1	1	0		Type C	
0	1	1	1	Error exists	--	--
1	0	1	0	No error	Type A	Type b
1	1	0	0		Type B	
1	1	1	0		Type C	
1	1	1	1	Error exists	--	--
Others				Reserved		
where						
Type A: Replaced with a compressed macro block of the same compressed macro block number in the immediate previous frame.						
Type B: Replaced with a compressed macro block of the same compressed macro block number in the next immediate frame.						
Type C: This compressed macro block is concealed, but the concealment method is not specified.						
Type a: The continuity of the data processing sequence with other compressed macro blocks whose s0 = 0 and s3 = 0 in the same video segment is guaranteed.						
Type b: The continuity of the data processing sequence with other compressed macro blocks is not guaranteed.						
NOTE 1 For STA = 0111b, the error code is inserted in the compressed macro block. This is an option.						
NOTE 2 For STA = 1111b, the error position is unidentified.						

Table 27 – Codewords of the QNO

q3	q2	q1	q0	QNO
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	13
1	1	1	0	14
1	1	1	1	15

DC

DCI (where l is the DCT block order in the macro block, $l = 0, \dots, 3$ for 4:2:2 compression, $l = 0, \dots, 5$ for 4:1:1 compression) consists of a DC coefficient, the DCT mode, and the class number of the DCT block.

MSBLSB

DCI: b8 b7 b6 b5 b4 b3 b2 b1 b0 mo c1 c0

where

b8 to b0: DC coefficient value

mo: DCT mode

mo = 0 for 8-8-DCT mode,

mo = 1 for 2-4-8-DCT mode

c1 c0: class number

AC

AC is a generic term for variable length coded AC coefficients within the video segment V_i , k . For 4:2:2 compression, the areas of Y_0 , Y_1 , C_R , and C_B are defined as compressed-data areas and each of Y_0 and Y_1 consists of 112 bits and each C_R and C_B consists of 80 bits as shown in Figure 29. For 4:1:1 compression, the areas of Y_0 , Y_1 , Y_2 , Y_3 , C_R , and C_B are defined as compressed-data areas and each of Y_0 , Y_1 , Y_2 , and Y_3 consists of 112 bits and each C_R and C_B consists of 80 bits as shown in Figure 30. DCI and variable length code for AC coefficients in the DCT block whose DCT block number is i, j, k, l are assigned from the beginning of the compressed-data area in the compressed macro block CM i, j, k, l . In Figures 29 and 30, the variable length code word is located starting from the MSB which is shown in the upper left side, and the LSB shown in the lower right side. Therefore, AC data are distributed from the upper left corner to the lower right corner.

5.6 The arrangement of a video segment

In this clause, the distribution method of quantized AC coefficients is described. Figures 31 and 32 show the arrangement of a video segment CV i, k after bit-rate reduction. Each row contains a compressed macro block. Columns F i, j, k, l express the compressed data area for DCT blocks whose DCT block numbers are i, j, k, l. Symbol E i, j, k, l expresses an additional AC area for recording remaining data from the fixed AC area. Symbol E i, j, k, l expresses an additional AC area for recording remaining data of fixed AC area.

Bit sequence, defined as B i, j, k, l, shall consist of the following concatenated data: DC coefficient, DCT mode information, class number, and AC coefficient code words for DCT blocks numbered i, j, k, l. Code words for AC coefficients of B i, j, k, l shall be concatenated according to the order as shown in Figure 27 and the last code word shall be EOB. The MSB of the subsequent code word shall be next to the LSB of the code word just before.

The arrangement algorithm of a video segment shall be composed of three passes:

Pass 1: The distribution of B i, j, k, l to the compressed-data area;

Pass 2: The distribution of the overflow B i, j, k, l which are the remainder after the pass 1 operation in the same compressed macro block;

Pass 3: The distribution of the overflow B i, j, k, l which are the remainder after the pass 2 operation in the same video segment.

Arrangement algorithm of a video segment

4:2:2 compression

```

if (525/60 system) n = 20 else n = 24;
for(i = 0; i < n; i++) {
    a = (i + 4) mod n;
    b = (i + 12) mod n;
    c = (i + 16) mod n;
    d = (i + 0) mod n;
    e = (i + 8) mod n;
    for (k = 0; k < 27; k++) {
        q = 2;
        p = a;
        VR = 0;
        /* VR is the bit sequence for the data */
        /* which are not distributed to video segment CV i, k by pass 2. */
        /* pass 1 */
        for(j = 0; j < 5; j++) {
            MRq = 0;
            /* MRq is the bit sequence for the data */
            /* which are not distributed to macro block M i, q, k by pass 1. */
            for(l = 0; l < 4; l++) {
                remain = distribute (B p, q, k, l, F p, q, k, l);
                MRq = connect (MRq, remain);
            }
            if (q == 2) {q = 1; p = b;}
            else if (q == 1) {q = 3; p = c;}
            else if (q == 3) {q = 0; p = d;}
            else if (q == 0) {q = 4; p = e;}
            else if (q == 4) {q = 2; p = a;}
        }
    }
}

```

```

/* pass 2 */
for(j = 0; j < 5; j++) {
    for(l = 0; l < 4; l++) {
        MRq = distribute (MRq, F p, q, k, l);
        if((l == 0) || (l == 1))
            MRq = distribute (MRq, E p, q, k, l);
    }
    VR = connect (VR, MRq);
    if (q == 2) {q = 1; p = b;}
    else if (q == 1) {q = 3; p = c;}
    else if (q == 3) {q = 0; p = d;}
    else if (q == 0) {q = 4; p = e;}
    else if (q == 4) {q = 2; p = a;}
}
/* pass 3 */
for(j = 0; j < 5; j++) {
    for(l = 0; l < 4; l++) {
        VR = distribute (VR, F p, q, k, l);
        if((l == 0) || (l == 1))
            VR = distribute (VR, E p, q, k, l);
    }
    if (q == 2) {q = 1; p = b;}
    else if (q == 1) {q = 3; p = c;}
    else if (q == 3) {q = 0; p = d;}
    else if (q == 0) {q = 4; p = e;}
    else if (q == 4) {q = 2; p = a;}
}
}
}

```

4:1:1 compression

```

if (525/60 system) n = 10 else n = 12;
for(i = 0; i < n; i++) {
    a = (i + 2) mod n;
    b = (i + 6) mod n;
    c = (i + 8) mod n;
    d = (i + 0) mod n;
    e = (i + 4) mod n;
    for (k = 0; k < 27; k++) {
        q = 2;
        p = a;
        VR = 0;
        /* VR is the bit sequence for the data */
        /* which are not distributed to video segment CV i, k by pass 2. */
    }
    /* pass 1 */
    for(j = 0; j < 5; j++) {
        MRq = 0;
        /* MRq is the bit sequence for the data */
        /* which are not distributed to macro block M i, q, k by pass 1. */
        for(l = 0; l < 6; l++) {
            remain = distribute (B p, q, k, l, F p, q, k, l);
            MRq = connect (MRq, remain);
        }
        if (q == 2) {q = 1; p = b;}
        else if (q == 1) {q = 3; p = c;}
        else if (q == 3) {q = 0; p = d;}
        else if (q == 0) {q = 4; p = e;}
        else if (q == 4) {q = 2; p = a;}
    }
}

```

```

/* pass 2 */
for(j = 0; j < 5; j++) {
    for(l = 0; l < 6; l++) {
        MRq = distribute (MRq, F p, q, k, l);
    }
    VR = connect (VR, MRq);
    if (q == 2) {q = 1; p = b;}
    else if (q == 1) {q = 3; p = c;}
    else if (q == 3) {q = 0; p = d;}
    else if (q == 0) {q = 4; p = e;}
    else if (q == 4) {q = 2; p = a;}
}
/* pass 3 */
for(j = 0; j < 5; j++) {
    for(l = 0; l < 6; l++) {
        VR = distribute (VR, F p, q, k, l);
    }
    if (q == 2) {q = 1; p = b;}
    else if (q == 1) {q = 3; p = c;}
    else if (q == 3) {q = 0; p = d;}
    else if (q == 0) {q = 4; p = e;}
    else if (q == 4) {q = 2; p = a;}
}
}
}

```

where

```

distribute (data 0, area 0) {
    /* Distribute data 0 from MSB into empty area of area 0. */
    /* The area 0 is filled starting from the MSB. */
    remain = (remaining_data);
    /* Remaining_data are the data which are not distributed.*/
    return (remain);
}

connect (data 1, data 2) {
    /* Connect the MSB of data 2 with the LSB of data 1. */
    data 3 = (connecting_data);
    /* Connecting_data are the data which are connected. */
    /* data 2 with data 1. */
    return (data3);
}

```

The remaining data which can not be distributed within the unused space of the macro block will be ignored. Therefore, when error concealment is performed for a compressed macro block, some distributed data by pass 3 may not be reproduced.

Video error code processing

If errors are detected in a compressed macro block which is reproduced and processed with error correction, the compressed-data area containing these errors should be replaced with the video error code. This process replaces the first two bytes of data of the compressed-data area with the code as follows:

```

MSB          LSB
1000000000000110b

```

The first 9 bits are the DC error code, the next 3 bits are the information of the DCT mode and class number, and the last 4 bits are the EOB as shown in Figure 33.

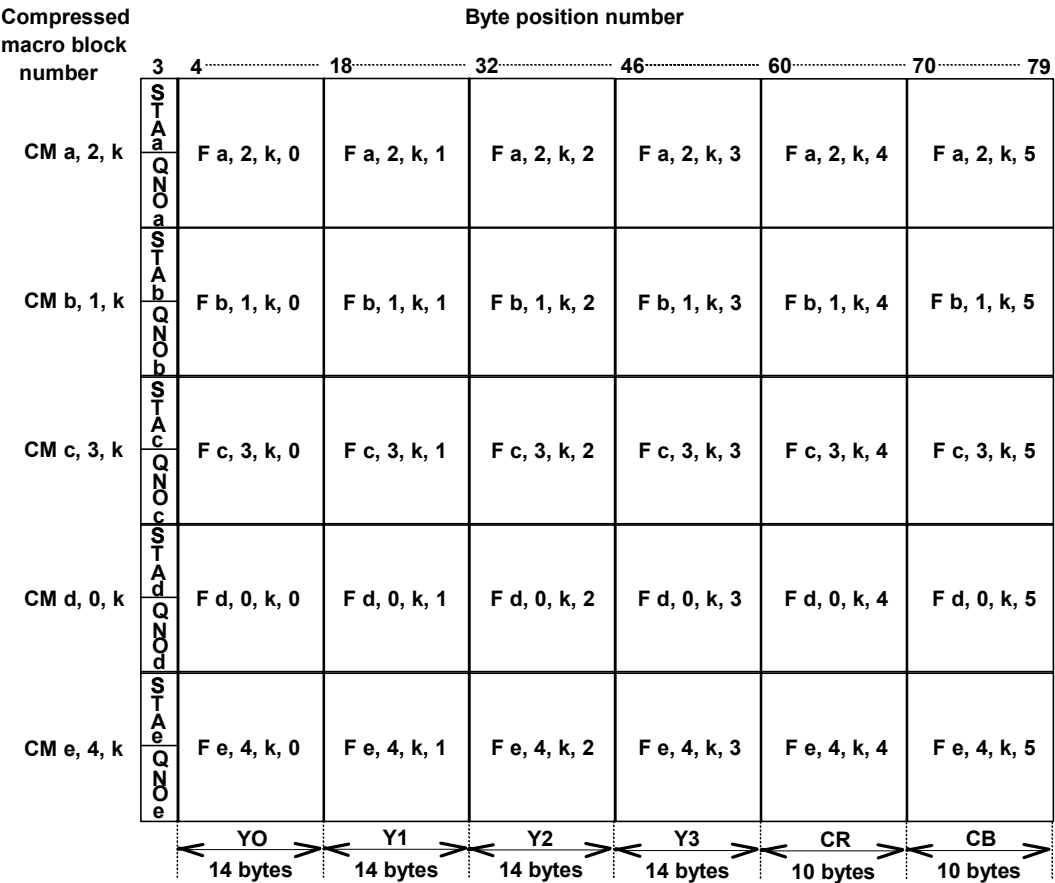
When the compressed macro blocks, after error code processing, are input to the decoder which does not operate with video error code, all data in this compressed macro block should be processed as invalid.

Compressed macro block number		Byte position number					
		3	4	18	32	46	60
CM a, 2, k	STA	F a, 2, k, 0	E a, 2, k, 0	F a, 2, k, 1	E a, 2, k, 1	F a, 2, k, 2	F a, 2, k, 3
	QNO						
CM b, 1, k	STA	F b, 1, k, 0	E b, 1, k, 0	F b, 1, k, 1	E b, 1, k, 1	F b, 1, k, 2	F b, 1, k, 3
	QNO						
CM c, 3, k	STA	F c, 3, k, 0	E c, 3, k, 0	F c, 3, k, 1	E c, 3, k, 1	F c, 3, k, 2	F c, 3, k, 3
	QNO						
CM d, 0, k	STA	F d, 0, k, 0	E d, 0, k, 0	F d, 0, k, 1	E d, 0, k, 1	F d, 0, k, 2	F d, 0, k, 3
	QNO						
CM e, 4, k	STA	F e, 4, k, 0	E e, 4, k, 0	F e, 4, k, 1	E e, 4, k, 1	F e, 4, k, 2	F e, 4, k, 3
	QNO						
		YO		Y1		CR	CB
		14 bytes	14 bytes	14 bytes	14 bytes	10 bytes	10 bytes

IEC 1935/05

where $a = (i + 4) \bmod n$ i : the vertical order of the super block
 $b = (i + 12) \bmod n$ $i = 0, \dots, n-1$
 $c = (i + 16) \bmod n$ n : the number of vertical super block in a video frame
 $d = (i + 0) \bmod n$ $n = 20$ for 525/60 system
 $e = (i + 8) \bmod n$ $n = 24$ for 625/50 system
 k : the macro block order in the super block
 $k = 0, \dots, 26$

Figure 31 – The arrangement of a video segment after the bit rate reduction for 4:2:2 compression

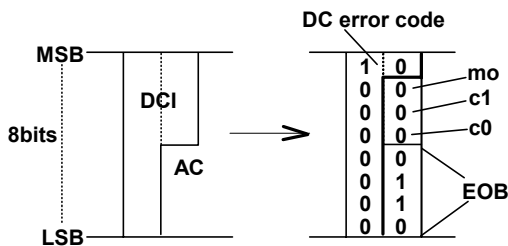


IEC 1936/05

where $a = (i + 2) \bmod n$
 $b = (i + 6) \bmod n$
 $c = (i + 8) \bmod n$
 $d = (i + 0) \bmod n$
 $e = (i + 4) \bmod n$

i: the vertical order of the super block
 $i = 0, \dots, n-1$
n: the number of vertical super block in a video frame
 $n = 10$ for 525/60 system
 $n = 12$ for 625/50 system
k: the macro block order in the super block
 $k = 0, \dots, 26$

Figure 32 – The arrangement of a video segment after the bit rate reduction for 4:1:1 compression



IEC 1937/05

Figure 33 – The video error code

Annex A (informative)

Differences between IEC 61834 and IEC 62071-2 (this standard)

The differences between IEC 61834 and this standard are shown in Table A.1.

Table A.1 – Abstract of differences between IEC 61834 and IEC 62071-2

		DV IEC 61834	DV BASED IEC 62071-2	
			25 Mb/s structure	50 Mb/s structure
Data structure		IEC 61834	Same as IEC 61834	See Figure 2
Header	Bit name			
	APT	000	001	
	AP1	000	001	
	AP2	000	001	
	AP3	000	001	
Video	Sampling structure	525: 4:1:1	525: 4:1:1	525: 4:2:2
		625: 4:2:0	625: 4:1:1	625: 4:2:2
VAUX	VS	IEC 61834	See 4.5.2.1	
	VSC	IEC 61834	See 4.5.2.2	
	Other	IEC 61834	Reserved	
Audio	Sampling	48 kHz (16bits,2ch)	48 kHz (16bits,2ch)	48 kHz (16bits,4ch)
		44.1 kHz (16bits,2ch)		
		32 kHz (16bits,2ch)		
		32 kHz (12bits,4ch)		
	Locked mode	Locked/unlocked	Locked	Locked
AAUX	AS	IEC 61834	See 4.6.2.3.1	
	ASC	IEC 61834	See 4.6.2.3.2	
	Other	IEC 61834	Reserved	
Subcode	SSYB ID	IEC 61834	See 4.4.2.1	
	TC	IEC 61834	See 4.4.2.2.1	
	BG	IEC 61834	Same as IEC 61834	
	Other	IEC 61834	Reserved	

Annex B (normative)

Digital filter for sampling-rate conversion from 4:2:2 to 4:1:1 colour difference signals

A template for insertion loss frequency characteristic is shown in Figure B.1. Figure B.2 shows the passband ripple tolerance.

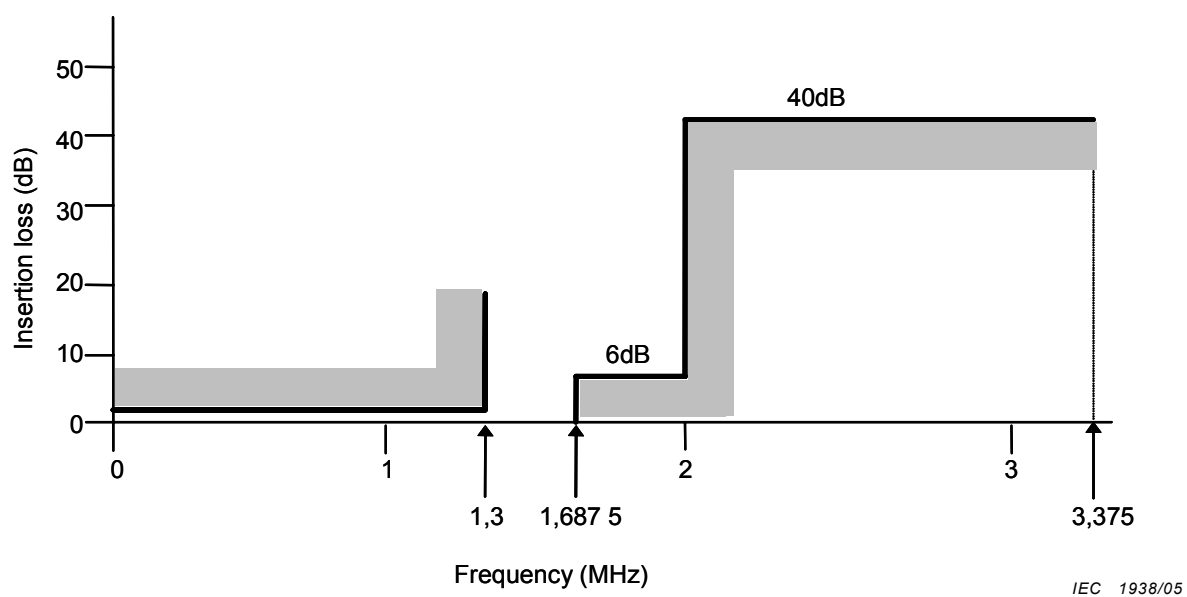


Figure B.1 – Template for insertion loss frequency characteristics

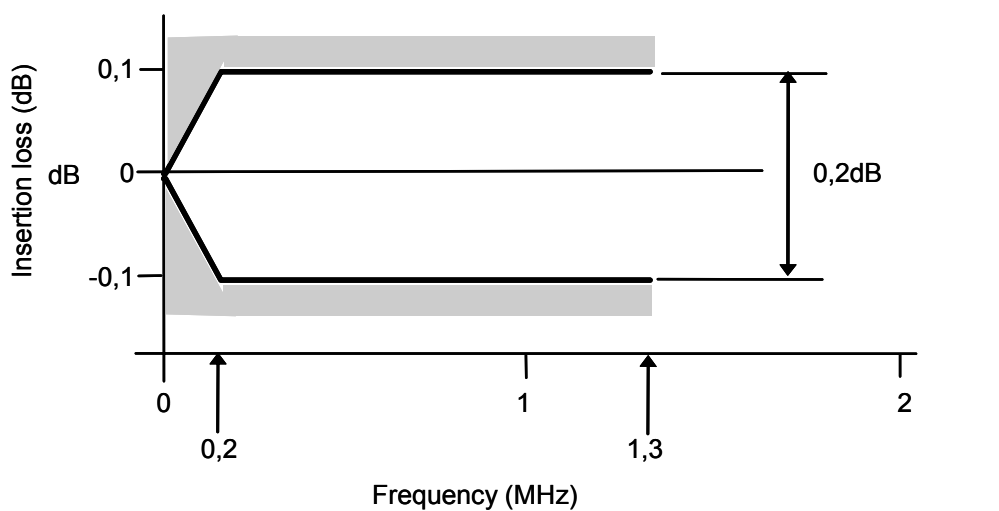
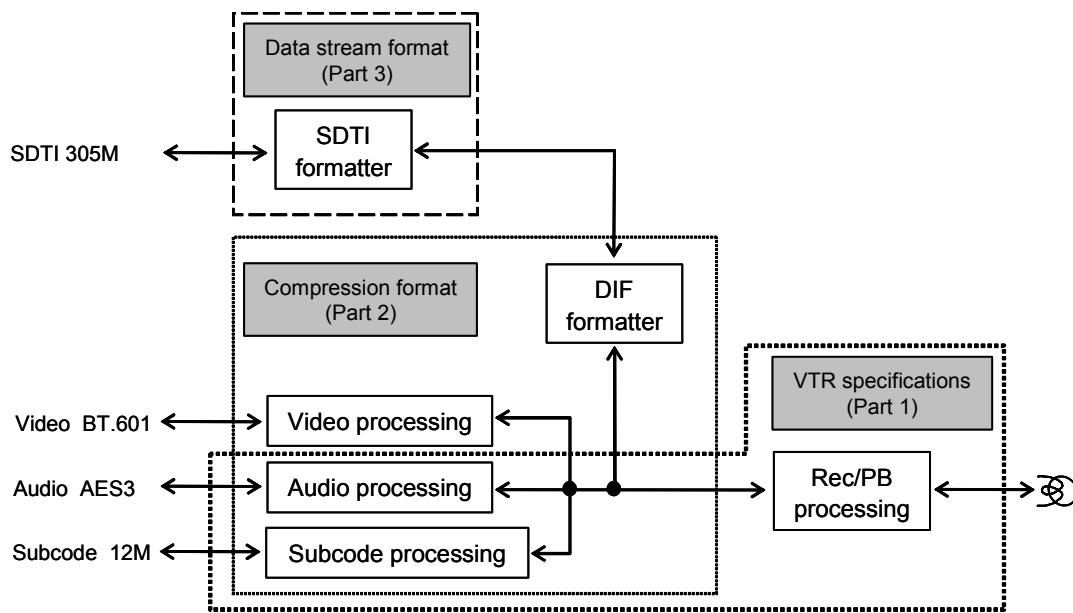


Figure B.2 – Passband ripple tolerance

Annex C (informative)

Block diagram of D-7 recorder

Figure C.1 shows the relationship between the compression format (this part) and other parts defining the D-7 recorder.



IEC 1940/05

Figure C.1 – Block diagram of D-7 recorder

Bibliography

IEC 61834-2: *Recording – Helical scan digital video cassette recording system using 6.35 mm magnetic tape for consumer use (525-60, 625-50, 1125-60 and 1250-50 systems) – Part 2: SD format for 525-60 and 625-50 systems*

IEC 61883-2:2004, *Consumer audio/video equipment – Digital interface – Part 2: SD-DVCR data transmission*

SMPTE 125M:1995, *Television – Component Video Signal 4:2:2 – Bit-Parallel Digital Interface*

ITU-R BT.470-7:2005, *Conventional analogue television systems*



Standards Survey

The IEC would like to offer you the best quality standards possible. To make sure that we continue to meet your needs, your feedback is essential. Would you please take a minute to answer the questions overleaf and fax them to us at +41 22 919 03 00 or mail them to the address below. Thank you!

Customer Service Centre (CSC)

International Electrotechnical Commission

3, rue de Varembé
1211 Genève 20
Switzerland

or

Fax to: **IEC/CSC** at +41 22 919 03 00

Thank you for your contribution to the standards-making process.

A Prioritaire

Nicht frankieren
Ne pas affranchir



Non affrancare
No stamp required

RÉPONSE PAYÉE

SUISSE

Customer Service Centre (CSC)
International Electrotechnical Commission
3, rue de Varembé
1211 GENEVA 20
Switzerland



Q1 Please report on **ONE STANDARD** and **ONE STANDARD ONLY**. Enter the exact number of the standard: (e.g. 60601-1-1)

.....

Q2 Please tell us in what capacity(ies) you bought the standard (tick all that apply). I am the/a:

- purchasing agent ☐
 librarian ☐
 researcher ☐
 design engineer ☐
 safety engineer ☐
 testing engineer ☐
 marketing specialist ☐
 other.....

Q3 I work for/in/as a:
(tick all that apply)

- manufacturing ☐
 consultant ☐
 government ☐
 test/certification facility ☐
 public utility ☐
 education ☐
 military ☐
 other.....

Q4 This standard will be used for:
(tick all that apply)

- general reference ☐
 product research ☐
 product design/development ☐
 specifications ☐
 tenders ☐
 quality assessment ☐
 certification ☐
 technical documentation ☐
 thesis ☐
 manufacturing ☐
 other.....

Q5 This standard meets my needs:
(tick one)

- not at all ☐
 nearly ☐
 fairly well ☐
 exactly ☐

Q6 If you ticked NOT AT ALL in Question 5 the reason is: (tick all that apply)

- standard is out of date ☐
 standard is incomplete ☐
 standard is too academic ☐
 standard is too superficial ☐
 title is misleading ☐
 I made the wrong choice ☐
 other

Q7 Please assess the standard in the following categories, using the numbers:

- (1) unacceptable,
 (2) below average,
 (3) average,
 (4) above average,
 (5) exceptional,
 (6) not applicable

- timeliness.....
 quality of writing.....
 technical contents.....
 logic of arrangement of contents
 tables, charts, graphs, figures.....
 other

Q8 I read/use the: (tick one)

- French text only ☐
 English text only ☐
 both English and French texts ☐

Q9 Please share any comment on any aspect of the IEC that you would like us to know:

.....



ISBN 2-8318-8320-2



ICS 33.160.40
