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Working Party XV/1
Specialists Group on Coding for Visual Telephony

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SOURCE: CHAIRMAN OF THE SPECIALISTS GROUP ON CODING FOR VISUAL TELEPHONY
TITLE : UPDATED SPECIFICATION FOR THE FLEXIBLE PROTOTYPE n x 384 kbit/s VIDEO CODEC

This document is an update of the Hardware Specification incorporating the amendments agreed during the San Jose meeting in March 1987 (see Annex 3 to Doc. #216R) into Doc. #182. This document also provides as Annex the values of programmable items to be used in the initial compatibility checks by editing Doc. #217 and related materials.

The aim is to produce a specification which essentially is the minimum implementation with which all laboratories will comply. The specification will provide considerable scope for optimization and experimentation.

It is expected that the final Recommendation to be produced in 1988 will be significantly different as it would reflect advances made before then and would have the areas of flexibility removed.

An outline block diagram of the codec is given in Figure 1.

CONTENTS

1 SOURCE CODER

1.1 Source format

1.1.1 The format to be coded is 288 lines, 30000/1001 (approximately 29.97) non-interlaced pictures per second - the Common Intermediate Format. The tolerance on the picture frequency is +/-50 ppm.

1.1.2 Pictures are coded in component form, these components being luminance (Y) and two colour difference signals (C_R, C_B). These three components and the codes representing their sampled values are as defined in CCIR Rec.601.

Black = 16
White = 235
Zero colour difference = 128
Peak colour difference = 16 and 240

Codes outside the above ranges will be accepted but may be modified by the coder to avoid emulation of reserved codewords.

1.1.4 The luminance sampling structure is 288 lines per picture, 360 pels per line in an orthogonal sampling arrangement. The colour difference sampling parameters are 144 lines, 180 samples per line, orthogonal. Both C_R and C_B samples are sited such that their block boundaries coincide with luminance block boundaries. (See Table 1 and Figure 2)

1.1.4 Before coding the number of samples per line is reduced to 352 for luminance and 176 for each colour difference signal by discarding 8 pels and 4 pels respectively from the source as shown in Figure 3.

> Note: The center of the coded 352 pels is intended to be the center of the picture.

1.2 Video Coding Algorithm

The video coder algorithm is shown in generalised form in Figure 4. The main elements are prediction, block transformation, quantisation and classification.

1.2.1 The prediction is inter-picture. The predictor may incorporate movement compensation. The predictor requires a picture store with one pel access for each pel being predicted.

> Note: Multi-pel prediction* may be added later, introducing a requirement for a multiple access picture store configuration.

The prediction process may be modified by a two-dimensional spatial filter which operates on pels solely within the predicted block. This filter is separable into 1-D horizontal and vertical functions and full arithmetic precision is retained internally so that the order of these functions is immaterial. The same filter is applicable to luminance and chrominance blocks.

The 1-D horizontal and vertical filter functions are both 3 tap non-recursive with tap weightings of 1/4, 1/2. 1/4. At block edges where either of the two outer taps would fall outside the block, the filter is modified to give the output value obtained by using for input at that tap, the value of the pel at the block periphery. As the latter pel is also the input to the centre tap, this modification is equivalent to, and may be implemented by, changing the filter to 0, 3/4, 1/4 or 1/4, 3/4, 0 as appropriate.

At the output of the 2-D process rounding to 8 bits is performed by incrementing the 2^0 bit if the 2^{-1} bit is a '1'.

The 2-D filter may be switched on or off on a block by block basis depending on, for example, the motion vector or some other criterion. This is for further study.

1.2.2 Motion compensation is optional at the coder. The decoder will accept one motion vector for each luminance block of size 8 pels by 8 lines. The maximum motion vector is +/-15 pels and +/-15 lines. Only integer values of the horizontal and vertical components of the vector are currently considered. Fractional values* may be added later.

A positive value of the horizontal component of the motion vector signifies that the prediction is formed from pels in the previous picture which are spatially to the right of the pels being predicted.

A positive value of the vertical component of the motion vector signifies that the prediction is formed from pels in the previous picture which are spatially below the pels being predicted.

Motion compensation vectors are restricted such that all pels referenced by them are within the coded picture area.

1.2.3 Coder

The prediction error (inter mode) or the original picture (intra mode) is subdivided into 8 pel by 8 line blocks which are segmented as transmitted or non-transmitted. The method of choosing between inter or intra mode is not defined in this specification, nor is the segmentation criterion, both being left open to codec designers and may be varied dynamically as part of the data rate control strategy.

Transmitted blocks are coded by a transform based scheme. Coding block size is 8 lines by 8 pels (64 sample values) for Y, C_R and C_B.

1.2.4 Transformer

The forward and inverse transformers shall be implemented in a flexible manner so that a number of different transforms, or configurations of a particular transform in terms of bits per stage, can be investigated. All hardware should be equivalent in performance to classical matrix multiplication.

The 2-D transform is implemented as the equivalent of two independent 1-D transforms.

For the purposes of compatibility it is necessary to specify the inverse transform in sufficient detail that all implementations produce identical numerical output values when given the same input data.

The 64-point 2-D inverse transform is implemented as two independent 8-point 1-D transforms in series. The first 1-D inverse transform operates on the eight vertical sequency components pertaining to a particular horizontal component. The output of the second 1-D inverse transform is pel domain data for eight pels in a horizontal line of the picture.

Each 1-D output point value is formed by multiplying each of the eight input point values by a coefficient and summing the results. The multiplications and accumulation are performed with full precision two's complement arithmetic. The sixty-four coefficients required for all eight output points shall be programmable independently and with 16 bits representing values in the range -2 to +32767/16384. The value of -2 is not permitted for use.

The first inverse 1-D transform operates on 12 bit numbers (from the inverse quantizer) which represent sequency coefficient amplitudes in the range -2048 to +2047.

The 16 bits representing values in the range -1024 to +32767/32 are carried between the output of the first and the input of the second inverse 1-D transforms, the least significant bits being discarded by truncation. Results outside the range of -1024 to +32767/32 are clipped.

The pel domain output of the second 1-D inverse transform is rounded to the 9 bits corresponding to values in the range -256 to +255. The rounding is performed by incrementing the 2^0 bit of the two's complement value if the 2^{-1} bit is a '1'. Results outside the range of -256 to +255 are clipped.

1.2.5 Classification

The classification method itself, ie the way the choice of the parameters to encode a block is made, is not a matter of recommendation. However, the range of possibilities at the encoder must not exceed those of the decoder. Also the way the parameters are transmitted must be specified. (See Section 2.2.3)

Each class is described by a table (PROM) of dimension 64 x 8 bits. In this table 6 bits (for coefficients 0 up to 63) are used to describe how many of and the order in which the coefficients are transmitted. The other 2 bits are reserved for future use to change the coding characteristics of the various coefficients of the block (eg related to prediction, quantisation, variable length code set). The number of such tables to be implemented is 8.

For chrominance blocks, only one of these eight classes is employed.

The contents of the class tables are for further study.

1.2.6 Quantizer

The number of inverse quantizers in the decoder shall be 32, each of which is programmable and has up to 12 bits input and 12 bits out. One of the 32 characteristics may be assigned as a function of quantizer indicator (QZ of Figure 4), sequency index, luminance/chrominance block and intra/inter mode. See Figure 10. Quantizer characteristics and selection function table are for further study.

1.2.7 Clipping

To prevent the quantisation distortion of transform coefficient amplitudes causing arithmetic overflow in the loops of the encoder and decoder, clipping functions are inserted. Two of these are specified in Section 1.2.4 dealing with the inverse transform. A third clipping function is applied at both encoder and decoder to the reconstructed picture formed by summing the prediction and the prediction error as modified by the coding process. This clipper operates only on pel values less than 0 and greater than 255, changing them to 0 and 255 respectively.

1.3 Data rate control and subsampling modes

The exact method of assessing the encoder data generation rate need not be specified but the specified minimum size of encoder buffer must incorporate an allowance for latency in the assessment and control loop. Hence, any requirement to constrain overall system delay may effectively preclude some schemes.

Control information is carried by side information - not derived recursively from received data.

Horizontal subsampling	- picture, group of blocks or block basis?
Vertical subsampling	- picture, group of blocks or block basis?
Temporal subsampling	- picture basis only. Interpolated pictures are not placed in the picture memory.
Quantizer selection	- see also 1.4.
Block significance criterion	- not part of the specification.

The coding algorithm will automatically permit the full quality of the source format specified in Section 1.1 to be realised on still pictures.

1.4 Forced Updating

There is no separate coding scheme for forced update. This function is achieved merely by forcing the use of the intra mode of the coding algorithm. Since the decoder cannot distinguish between normal and forced update blocks, there are no parameters to specify which are unique to forced update. The bit-rate allotted to forced updating, the sequence in which blocks are updated etc, are not specified.

In order that the quality of forced update blocks can be sufficiently high at all times, quantiser selection must not be dependent solely on buffer fill state.

2 VIDEO MULTIPLEX CODER

2.1 Tasks

The video multiplex coder has the following tasks:

1. Block address coding
2. Video data coding, formatting and serialising
3. Synchronisation - picture/line
4. Motion vector coding
5. Side channels for indicating dynamic coding parameters eg subsampling modes, quantizers, buffer state etc. (Permanent or transient channels? Transient channels require care in switched multipoint.)

2.2 Video Multiplex Arrangement

2.2.1 Picture Header

The structure of the Picture Header is shown in Figure 5. All Picture Headers are transmitted. Two successive Picture Headers indicate that the intervening picture has been dropped.

PSC 21	BS 6	TR 3	TYPE1 7	PEI 3	PGMV 16	PARITY 8	PSPARE mx8

← 40 bits →

Figure 5

Note: For easier hardware implementation, the bit length of the Picture Header is an integer multiple of 8 bits so that circuits which shift the data on a bit by bit basis are not necessary. Except when spare information is inserted, the length of the Picture Header does not change since all the information is fixed length coded.

Picture start code (PSC)

Unique word of 21 bits (value: 0000 0000 0000 0001 xxxx x where xxxxx is an invalid GN value ie 0 or 19 to 31)

Buffer state (BS)

Encoder buffer fullness in 1 Kbit units. The value is sampled at the time of the top of the picture. 6 bits, MSB first. (Truncation of fractional Kbit? Should value be sampled at bottom of previous picture?)

Temporal Reference (TR)

Temporal reference is a 3 bit number, derived using modulo-8 counting, representing the time sequence, in Common Intermediate Format picture periods, of a particular picture. MSB first.

Type information (TYPE1)

TYPE1 is 7 bits for information about the complete picture.

Bit 1. Split-screen indicator. '0' off. '1' on.
Bit 2. Document camera. '0' off. '1' on.
Bits 3 to 7. Spare. For further study. (Intra mode for picture?)

Note: In TYPE information, unless otherwise specified, '0' means inactive and '1' means active.

Extra insertion information (PEI)

The 3 bits indicate insertion of PGMV, PARITY and PSPARE. When one of the PEI bits is set to '1', the corresponding information (eg PGMV, PARITY, PSPARE) is inserted in the correct order before the first GOB Header.

Picture Global Motion Vector (PGMV)

Picture global motion vector consisting of 16 bits is inserted when the first PEI bit is set to '1'. Each component of the motion vector is transmitted as an absolute value using 8 bit two's complement representation, MSB first. The polarity is as defined in 1.2.2. The horizontal component is transmitted first.

Parity information (PARITY)

To facilitate optional demand refreshing, parity information consisting of 8 bits is inserted if the second PEI bit is set to '1'. MSB first. Each bit represents odd parity of the corresponding bit plane of the locally decoded PCM video signal in the previous picture period. In the Picture Header of a dropped picture, the previous parity data are repeated.

Spare information (PSPARE)

For future use, spare bits are reserved and inserted when the third PEI bit is set to '1'. The length is an integer multiple of 8 bits. The definition of the PSPARE information is for further study.

2.2.2 Group of Blocks Header

A group of blocks consists of two lines of 44 luminance blocks each, one line of 22 C_R blocks and one line of 22 C_B blocks. See Figure 6.

Y_U	Y_L	C_R	C_B

Figure 6

The structure of the Group of Blocks Header is shown in Figure 7. All GOB Headers are transmitted except those in dropped pictures.

GBSC 16	GN 5	TYPE2 10	QUANT1 6	GEI 3	GGMV 16	GSPARE1 8	GSPARE2 nx8

◄──── 40 bits ────►

Figure 7

Note: For easier hardware implementation, the bit length of the GOB Header is an integer multiple of 8 bits so that circuits which shift the data on a bit by bit basis are not necessary. Except when spare information is inserted, the length of the GOB Header does not change since all the information is fixed length coded.

Group of Blocks Start Code (GBSC)

Unique sequence of 16 bits (value: 0000 0000 0000 0001)

Group Number (GN)

The group number is a five bit number signifying the vertical spatial position, in units of groups, of the current group of blocks. MSB first. The GN ranges from 1 (00001) for the group of blocks at the top of the picture to 18 (10010) for the group of blocks at the bottom of the picture.

Type information (TYPE2)

TYPE2 is 10 bits which give information about all the blocks in a group of blocks.

Bit 1: When set to '1' all blocks in the GOB are coded in intra mode.

Bit 2: When '0' all blocks in the GOB have zero motion vector. Motion vector information is not present in each block.

When '1' motion vector information is included in each block by a combination of TYPE3 and DMV where the latter is applicable.

Bit 3 is provisionally assigned as follows.

When '0' the filter of 1.2.1 is not applied in the prediction of all the blocks in the GOB.

When '1' information concerning the application of the filter in the block prediction is signalled in TYPE3 on a block by block basis.

Bits 4 to 10: Spare for further study. Set to '0' to indicate inactive.

Quantiser information (QUANT1)

When the first bit is '0', the quantiser type is defined not in the GOB Header, but in each block and the following 5 bits are unspecified and should be ignored by the decoder. When the first bit is set to '1' the following 5 bits indicate the quantiser as a GOB attribute. Coding of these 5 bits is as specified for QUANT2 in section 2.2.3.

Extra insertion information (GEI)

The 3 bits indicate insertion of GGMV, GSPARE1 and GSPARE2. When one of the GEI bits is set to 1, the corresponding information (eg GGMV, GSPARE1, GSPARE2) is inserted in the correct order before the first Block Data.

Group of Blocks Global Motion Vector (GGMV)

GOB global motion vector consisting of 16 bits is inserted when the first GEI bit is set to 1. Each component of the motion vector is transmitted as an absolute value using 8 bit two's complement representation, MSB first. The polarity is as defined in 1.2.2. The horizontal component is transmitted first.

Spare information (GSPARE1, GSPARE2)

For future use, spare bits are reserved and are inserted when the corresponding GEI bit is set to '1'. GSPARE1 is 8 bits. The length of GSPARE2 is an integer multiple of 8 bits. The definition of the GSPARE information is for further study.

2.2.3 Block Data Alignment

The structure of the data for each transmitted block is shown in Figure 8.

BA	TYPE3	QUANT2	CLASS	DMV	TCOEFF	EOB

Figure 8

Note: Data are coded using VLC(s) which require further study. Some of the elements are omitted when not required. Future study may change the order and codes of the elements.

Block Address (BA)

Block Address indicates the position of a transmitted block within a group of blocks. It is a Variable Length Code-word giving the run-length of non-transmitted blocks between this block and the previous transmitted block. In the case of the first transmitted block in a GOB, BA gives the absolute block address.

When all blocks in a GOB are coded in intra mode (TYPE2='1xx'), BA is not transmitted for those blocks.

For the purpose of run-length calculation, the block is regarded as continuous beginning with the upper line of luminance blocks through the lower luminance, through C_R and ending with C_B blocks. The run-length from the last transmitted block in a GOB to the next GOB is not transmitted.

The range of absolute block addresses for the upper line of luminance blocks (Y_U) is 0 to 43.

The range of absolute block addresses for the lower line of luminance blocks (Y_L) is 44 to 87.

The range of absolute block addresses for C_R blocks is 88 to 109.

The range of absolute block addresses for C_B blocks is 110 to 131.

Block Type Information (TYPE3)

A Variable Length Code indicating block attributes such as

Intra or inter
Prediction error coded or not
Filter in predictor applied or not
Motion compensated prediction or not
Differential Motion Vector is zero or not
Future extension

The combination of attributes yields the following types of block:

1. Intra coded
2. Inter coded without filter in predictor
3. Inter, filter in predictor, no coded prediction error
4. Inter, filter in predictor, with coded prediction error
5. Motion compensated, no coded prediction error
   (a) No filter in predictor, DMV is zero
   (b) No filter in predictor, DMV is non-zero

(c) Filter in predictor, DMV is zero
(d) Filter in predictor, DMV is non-zero

6. Motion compensated with coded prediction error
   (a) No filter in predictor, DMV is zero
   (b) No filter in predictor, DMV is non-zero
   (c) Filter in predictor, DMV is zero
   (d) Filter in predictor, DMV is non-zero
7. Extension on

When all blocks in a GOB are coded in intra (TYPE2='1xx'), TYPE3 is not transmitted for those blocks.

Table 2 shows how the block type signalled by TYPE3 controls the insertion of the subsequent elements.

Type of block	Elements present
1, 2, 4, 6a, 6c	CLASS, (QUANT2), TCOEFF, EOB
3, 5a, 5c	None
5b, 5d	DMV
6b, 6d	CLASS, (QUANT2), DMV, TCOEFF, EOB
7	For further study

Note: CLASS is not present in chrominance blocks.
QUANT2 is not present if the first bit of QUANT1 in the GOB Header is '1'.

Table 2

The VLC used to encode TYPE3 is chosen from up to 3 sets, each of maximum length 8 bits, depending on TYPE2 and whether the block is luminance or chrominance. The code set(s) is (are) for further study. Table 3 shows how the coding of TYPE3 in each transmitted block is controlled by TYPE2 in the GOB Header.

TYPE2 bits 1 to 3	Types of Luminance block	Types of Chrominance block
1xx (Intra)	1	1
000 (No MC, no filter)	1, 2	1, 2
001 (No MC, filter)	1, 2, 3, 4	1, 2, 3, 4
010 (MC, no filter)	1, 2, 5a, 5b, 6a, 6b	1, 2
011 (MC, filter)	1, 2, 3, 4, 7, 5a, 5b, 5c, 5d, 6a, 6b, 6c, 6d	1, 2, 3, 4

Table 3

Quantizer Type (QUANT2)

The five bits of the quantizer indicator (QZ) input to the quantizer selection table. QZ4 first, QZ0 last. QUANT2 is not present when the quantizer is previously defined by QUANT1 in the GOB Header.

Classification Index (CLASS)

For luminance blocks, the classification index (8 classes maximum) is variable length coded with a maximum length of 8 bits.

For chrominance blocks, only one classification is used and CLASS is not present.

Motion Vector Information (DMV)

a) Calculation of the differential motion vector

In the first mode, the motion vector to be encoded is predicted from the motion vector of the previous contiguous block. The prediction function is:

$$dv(B_n) = v(B_n) - v(B_{n-1})$$

where $dv(B_n)$ is the resultant difference vector to be transmitted
$v(B_n)$ is the absolute motion vector of the block being transmitted
$v(B_{n-1})$ is the absolute motion vector of the previous contiguous block. For the first blocks in Y_U and Y_L and for previous contiguous blocks which are non-transmitted or intra coded, the value of $v(B_{n-1})$ is set to zero.

Note: Global motion vector is not used in the first mode.

In the second mode the difference vector is obtained from the motion vector of the block being transmitted and the current global vector.

$$dv(B_n) = v(B_n) - v(G)$$

where $dv(B_n)$ and $v(B_n)$ are as defined above,
$V(G)$ = GGMV if present in the Header of this GOB, else PGMV if present in the Header of this Picture, else zero.

In both modes the absolute vectors are as defined in Section 1.2.2 and the difference is also represented in two's complement notation, but only the five LSBs are retained for subsequent encoding.

Note: An indication of which of these two modes is in use at the encoder is not transmitted. For the flexible hardware, the decoder will be manually set to the mode required.

b) Variable Length Coding

When the difference vector is non-zero, it is transmitted by a variable length code-word for the horizontal component followed by a variable length code-word from the same set for the vertical component. The code set is for further study but has a maximum length of 16 bits.

When the difference vector is zero, this is indicated by the block attribute and DMV is not inserted.

Transform coefficient data (TCOEFF)

The transform coefficients are sequentially transmitted according to the scanning sequence defined by the class. The DC component is always the first component transmitted. Coefficients after the last non-zero one are not transmitted.

The VLC used to encode the quantisation index of components shall be programmable within the constraints of 16 bits maximum total length and the number of bits constituting the prefix in a fixed length section of the table being in the range 6 to 9 inclusive.

The last coefficient transmitted in a block is encoded with the same code word set but with a different value assignment.

The code set is for further study.

In the case of a block coded by intra mode, the DC component is fixed length coded with 9 bits. The AC components are transmitted as described above.

The code set is for further study.

The hardware must be designed to be extendable to 4 VLCs controlled as a function of class, quantiser and sequency.

End-of-Block Marker (EOB)

EOB is one of the codewords in the VLC set used for quantised transform coefficients and always immediately follows TCOEFF. EOB is not present in blocks which do not contain TCOEFF.

2.3 Multipoint Considerations

2.3.1 Freeze Picture Request (FPR)

On receipt of a FPR, conveyed in bit .... of timeslot .... the decoder shall freeze its received video until the next picture attribute indicating intra mode is encountered.

2.3.2 Fast Update Request (FUR)

On receipt of a FUR, conveyed in bit .... of timeslot .... the encoder shall empty its transmit buffer and encode its next picture in intra mode with such coding parameters as to avoid buffer overflow.

2.3.2 Data continuity

The protocol adopted for ensuring data continuity in a multipoint connection will be handled by the message channel.

3 TRANSMISSION CODER

3.1 The transmission coder assembles all data and interfaces to the digital line transmission system.

3.1.1 The data rate is n x 384 kbit/s where n is an integer between 1 and 5, both inclusive.

3.1.2 The codec output clock rate source shall be switchable between either a free running internal source or a source synchronised to the received data from the network. The mechanism for this switching is bit .... of the application channel.

3.1.3 When in free running mode the tolerance on output clock rate will be +/-50 ppm of nominal.

3.1.4 When in synchronised mode the synchronism should be maintained when the frequency of the received data clock is within +/-50 ppm of nominal.

3.2 Framing structure (See Figure 9)

As per CCITT Draft Recommendation Y.221 plus the following coding for the application channel:

> List of codec attributes/facilities/parameters needing transmission from transmitter to receiver. No return path is assumed. Currently this list includes only encryption.
>
> Service bits are for further study. Application Channel (bits 17 to 80 of Figure 9) to be set to '0' until agreed otherwise.

Operability with audioconferencing. Timeslot positioning to CCITT Rec. I.431.

3.3 Video data buffering

The size of the transmission buffer at the transmitter is switchable from 8 Kbits to 64 Kbits, both inclusive, in steps of 8 Kbits (K = 1024). Buffer size should be related to the transmission rate (overall - not video) to ensure acceptable system delay.

> Note: The above size is applied only to n = 1 for n x 384 kbit/s. For higher values of n, further study is needed.

3.4 Video clock justification

Not provided.

3.5 Optional full spatial resolution mode data for quasi-stationary pictures.

To be specified later if required.

3.6 Audio

As per CCITT Draft Rec. G.72y Type 2 terminal.

The audio channel is carried by the first timeslot.

Flexible testbed hardware need only incorporate?
(64 kbit/s A-law
64 kbit/s u-law
56 kbit/s sub-band ADPCM according to CCITT Rec. G.722)

Delay of encoded audio relative to encoded video at the channel output provisionally within -35ms to +70ms when the encoder buffer is empty.

3.7 Error handling

Video coding strategy to be error resilient without internal or external error corrector. Note that demand refresh can be implemented using the Fast Update Request of 2.3.2.

3.8 Encryption

3.9 Data transmission

Framing structure to allow 2 data ports of 64 kbit/s each, though picture quality constraints may require only one to be available at 384 kbit/s. In this case timeslot 4 is used.

3.10 Network Interface

Access will be at the primary rate with vacated timeslots as per CCITT Recommendation I.431.

For 1544 kbit/s interfaces the default H0 channel is timeslots 1 to 6. Interface code is B8ZS or AMI.

For 2048 kbit/s interface the default H0 channel is timeslots 1-2-3-17-18-19. Interface code is HDB3.

* Hardware to be capable of these additions later.

END

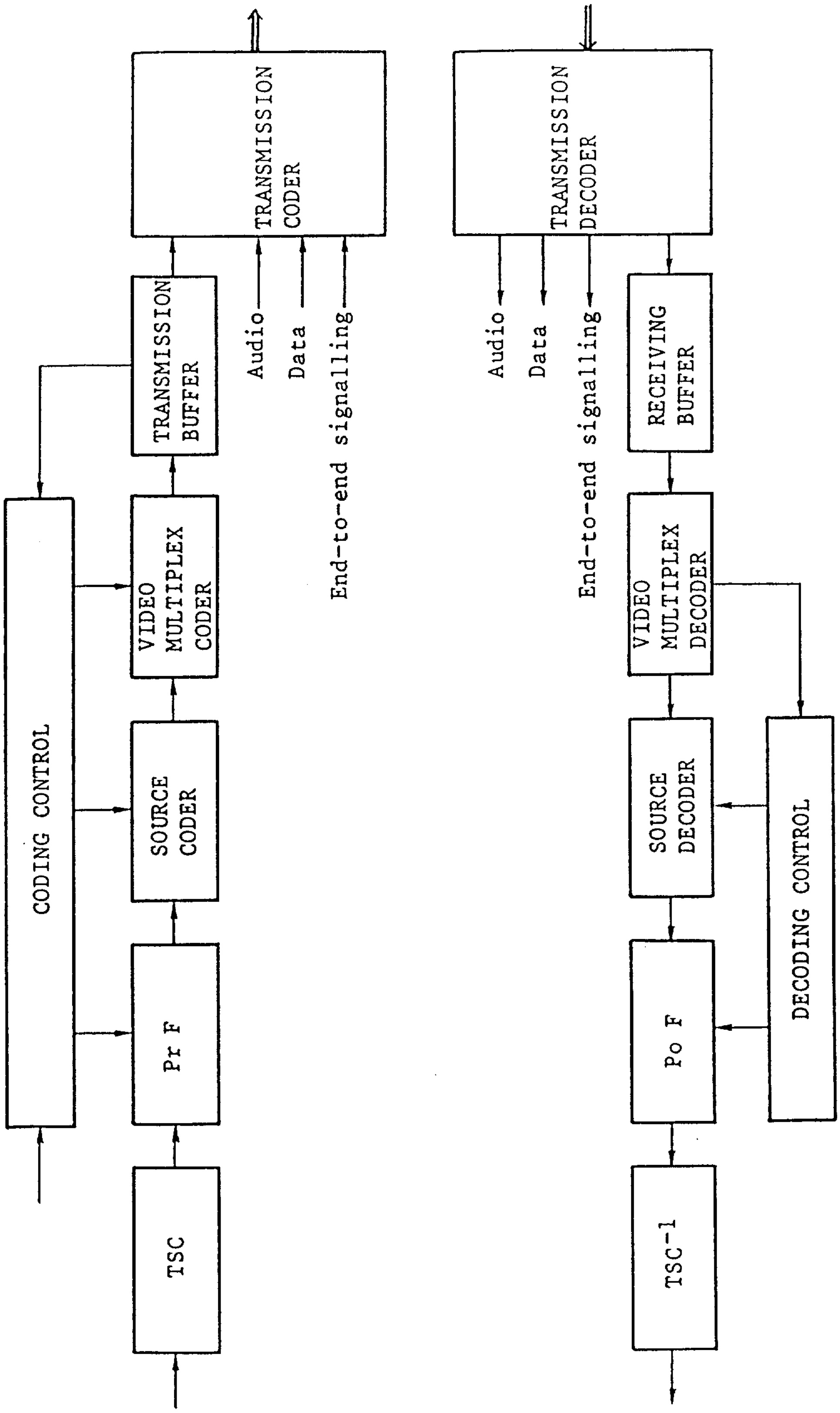

TRANSMISSION CODER
TRANSMISSION BUFFER
CODING CONTROL
VIDEO MULTIPLEX CODER
SOURCE CODER
Pr F
TSC
Audio
Data
End-to-end signalling
TRANSMISSION DECODER
RECEIVING BUFFER
VIDEO MULTIPLEX DECODER
SOURCE DECODER
DECODING CONTROL
Po F
TSC-1
Audio
Data
End-to-end signalling

Fig. 1

Table 1. Basic parameters for the new generation n x 384 kbit/s CODEC

Items	Parameters
1. Reference point	Point B in Fig. 1/Annex 1 to COM XV-R 4
2. Baseband signals and their levels	Y, R-Y, B-Y, as defined in CCIR Rec. 601
3. Number of pels per line	Y: 360 (Note 1) R-Y: 180 B-Y: 180
4. Number of lines per field	Y: 288 (Note 2) R-Y: 144 B-Y: 144
5. Field frequency	Y, R-Y, B-Y: 29.97 Hz
6. Interlace	Y, R-Y, B-Y: 1:1
7. Sampling structure	Y, R-Y, B-Y: orthogonal, positioning of R-Y and B-Y samples share the same block boundaries with Y samples as shown in Fig. 2

Note 1: Active line duration is approximately 53 us.

Note 2: Active field duration is approximately 18.4 ms (for 625/50 systems) and approximately 15.2 ms (for 525/60 systems).

Note 3: The common intermediate format defines the maximum attainable spatial and temporal resolution in the codec. Effective resolution may eventually be reduced by some coding operating modes.

Note 4: The common intermediate format is a logical specification to ensure compatibility among codecs. Hence, it might not appear at the physical interface points in the codec.

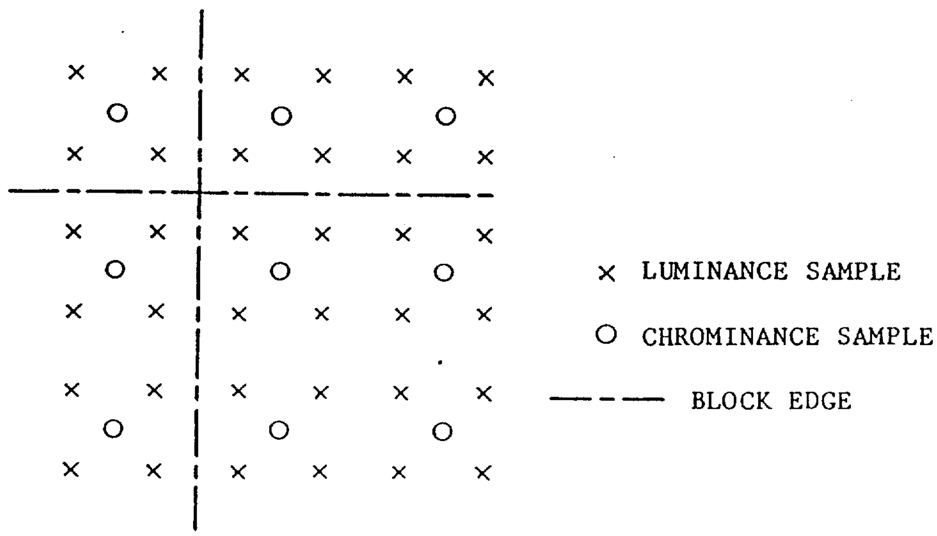


Fig. 2 Positioning of Luminance and Chrominance Samples

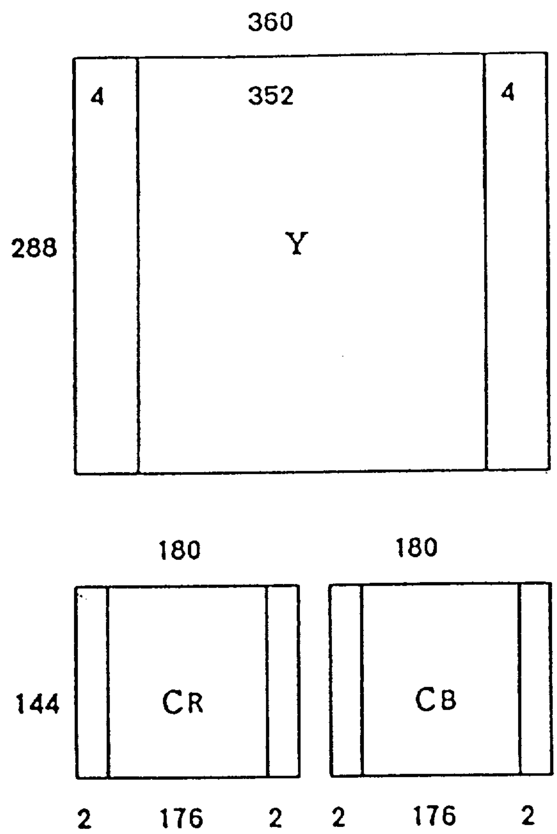
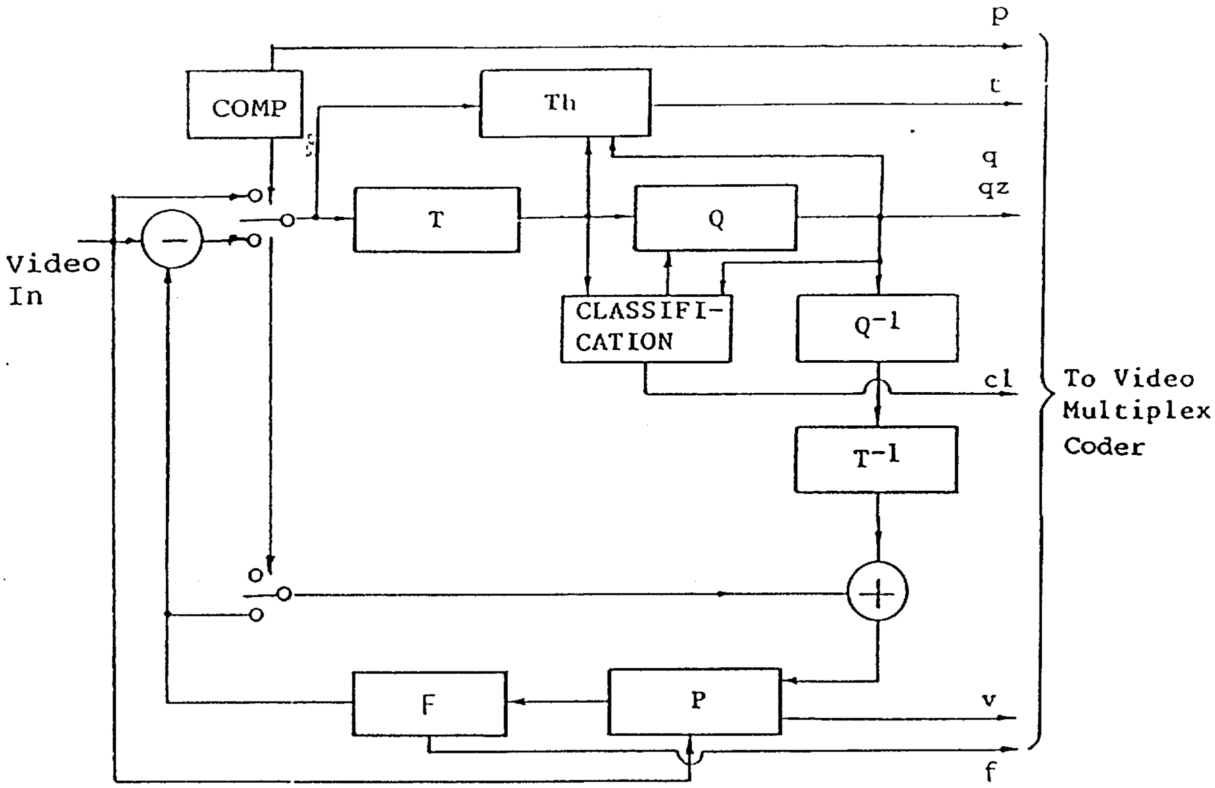


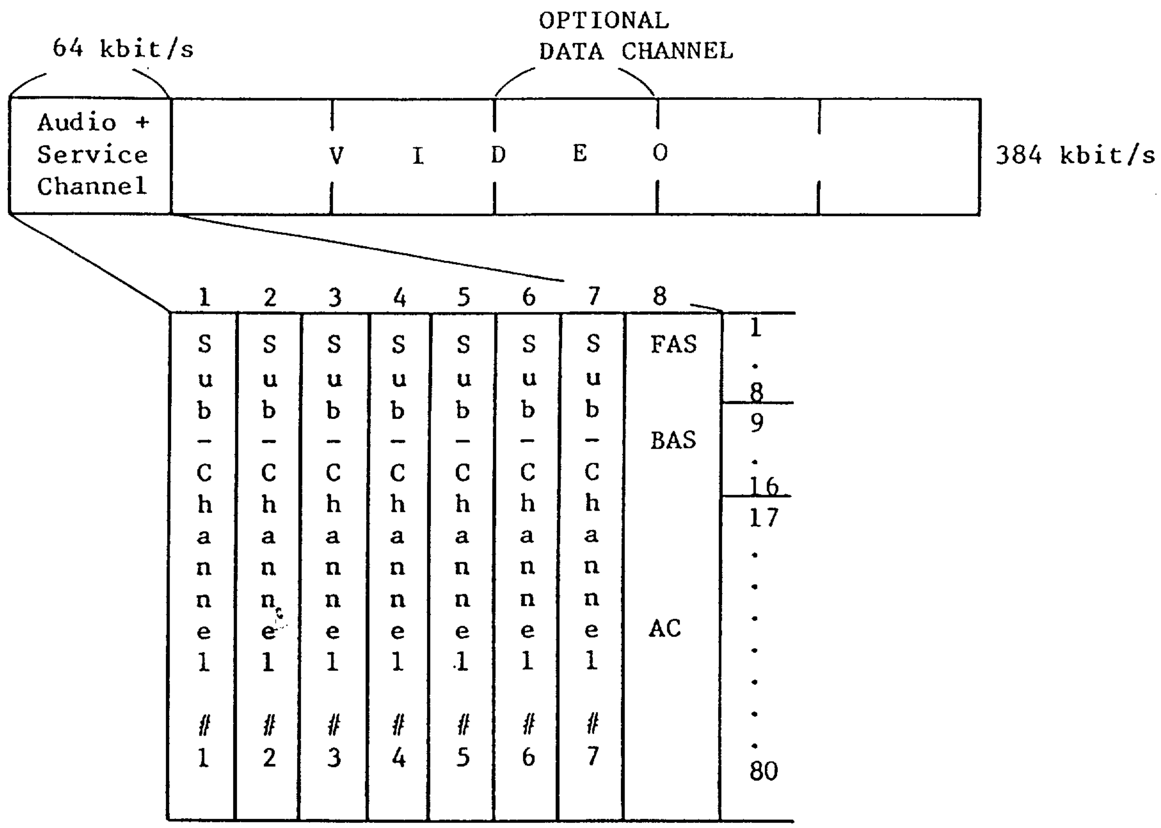
Figure 3 Definition of significant pel area



COMP Comparator for intra/inter
Th Threshold
T Transform
Q Quantizer
P Picture memory with motion compensated variable delay
F Loop filter

p Flag for intra/inter
t Flag for transmitted or not
q Quantizing index for transform coefficietns
qz Quantizer indication
v Motion vector
cl Classification index
f Switching on/off of the loop filter

Fig. 4



FAS: Frame Alignment Signal (note)
BAS: Bitrate Allocation Signal
AC: Applicaion Channel

Note : The block termed as FAS contains also other information than for frame alignment purposes.

Fig. 9 Frame Structure for n x 384 kbit/s codec (in case of n = 1)

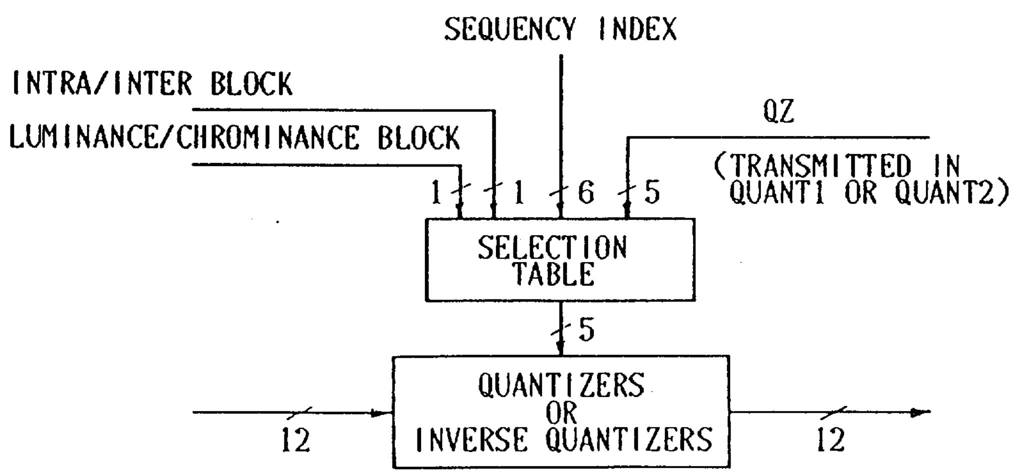


Fig. 10

Annex

VALUES OF PROGRAMMABLE ITEMS TO BE USED IN INITIAL FLEXIBLE HARDWARE

The following programmable items require preliminary values for incorporation in the Test Pattern Generator and for use in initial compatibility checks:

1. Loop filter signalling
2. Inverse Transformer
3. Scanning classes
4. Quantiser selection table
5. Quantisers
6. Picture Start Code
7. PSPARE
8. QUANT1 and QUANT2 codes
9. GSPARE2
10. Block Address codes
11. TYPE3 codes
12. CLASS codes
13. DMV codes
14. TCOEFF codes

1. LOOP FILTER SIGNALLING

Signalling of filter on or off is by TYPE3 coding.

2. INVERSE TRANSFORMER

Table 1 (see Doc. #142, Issue 2) will be used for the first and the second inverse 1-D transforms.

8

3. SCANNING CLASSES

Although the flexible hardware specification allows for eight possible classes, only the four specified for RM3 will be used for initial compatibility checks. These four sequences are listed in Table 2 (see page 22 of Doc. #181R). For chrominance blocks only the "ordinary zig-zag" is used.

4. QUANTISER SELECTION TABLE

Initially programmed as follows:

Y/C	INTER/INTRA	SEQUENCY INDEX (0 to 63)	QSEL (0 to 31)
x	INTRA	0	0
x	INTRA	<>0	QZ
x	INTER	x	QZ

NOTES:
1. x = 'Don't care'.
2. QSEL selects one of 32 quantisers.
3. QZ is the quantiser indication signalled by either QUANT1 or QUANT2. (See Figure 4 of this Doc. #249)
4. QZ is not permitted to be 0.

5. QUANTISERS

The flexible hardware allows up to 32 quantisers selected by QSEL.

Quantiser 0 is used for the dc coefficient in INTRA mode and has stepsize of 4. These coefficients are transmitted as 9 bit fixed length codes. To avoid emulation of PSC and GBSC by these FLCs followed by a VLC with prefix bits of '00000001' the last 8 bits of the FLC must not be all '0's. See Table 3.

All other quantisers are linear, symmetrical about zero and with a threshold of 1.0 times the step-size. Quantiser n (where n is 1 to 31 as determined by QSEL) has step-size of n. See Table 4.

Some quantisers, eg 1 to 3, may not be usable or necessary. They are included for simplicity and completeness.

6. PICTURE START CODE

The invalid Group number used in the PSC is '10101'

7. PSPARE

Value of m is 1, ie PSPARE is 8 bits when present.

8. QUANT1 and QUANT2 CODES

QUANT1 is a fixed length code of 6 bits. When the first bit is '0' then QZ is signalled in each block by QUANT2. When the first bit is '1' then QZ signalled by the following 5 bits is used for all blocks in the GOB. Coding of these 5 bits is as for QUANT2.

QUANT2 is a fixed length code of 5 bits. Code '00000' is not used. Codes '00001' to '11111' are used to signal QZ between 1 and 31.

9. GSPARE

Value of n is 1, ie GSPARE2 is 8 bits when present.

10. BLOCK ADDRESS CODES

As per Table 5. The codes are from Doc. #215. BA is restricterd to the first 132 codes in the table.

11. TYPE3 CODES

As per Table 6.

12. CLASS CODES

As per Table 2.

13. DMV CODES

As per Table 7 (see Table 7 of Doc. #192).

14. TCOEFF CODES

As per Table 5.

Table of Multiplier Values for Inverse DCT

The values listed below are the hexadecimal equivalent of the words, of sixteen bit width, stored in PROMs, each being the two's complement representation of the integer rounded value of 16384 times the matrix element value derived according to:

$$B(i,j) = 1/2\ C(i)\ \cos[(2j+1)\ i\ PI/16]$$

$$i,j = 0,1,\ldots\ldots 7$$

where $C(i) = 1/\mathrm{sqrt}(2)$ for $i = 0$
$= 1$ for $i = 1,2,\ldots.7$

16A1	16A1	16A1	16A1	16A1	16A1	16A1	16A1
1F63	1A9B	11C7	063E	F9C2	EE39	E565	E09D
1D90	0C3F	F3C1	E270	E270	F3C1	0C3F	1D90
1A9B	F9C2	E09D	EE39	11C7	1F63	063E	E565
16A1	E95F	E95F	16A1	16A1	E95F	E95F	16A1
11C7	E09D	063E	1A9B	E565	F9C2	1F63	EE39
0C3F	E270	1D90	F3C1	F3C1	1D90	E270	0C3F
063E	EE39	1A9B	E09D	1F63	E565	11C7	F9C2

Table 1/Annex

SCANNING PATTERNS

Ordinary zig-zag

1,	2,	6,	7,	15,	16,	28,	29
3,	5,	8,	14,	17,	27,	30,	43
4,	9,	13,	18,	26,	31,	42,	44
10,	12,	19,	25,	32,	41,	45,	54
11,	20,	24,	33,	40,	46,	53,	55
21,	23,	34,	39,	47,	52,	56,	61
22,	35,	38,	48,	51,	57,	60,	62
36,	37,	49,	50,	58,	59,	63,	64

Horizontal class

1,	2,	3,	4,	5,	8,	9,	10
6,	7,	11,	12,	13,	14,	15,	16
17,	18,	19,	20,	21,	22,	23,	24
25,	26,	27,	28,	29,	30,	31,	32
33,	34,	35,	36,	37,	38,	39,	40
41,	42,	43,	44,	45,	46,	47,	48
49,	50,	51,	52,	53,	54,	55,	56
57,	58,	59,	60,	61,	62,	63,	64

Vertical class

1,	6,	17,	25,	33,	41,	49,	57
2,	7,	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
8,	14,	22,	30,	38,	46,	54,	62
9,	15,	23,	31,	39,	47,	55,	63
10,	16,	24,	32,	40,	48,	56,	64

Fourth class

1,	3,	8,	12,	22,	23,	39,	40
4,	2,	6,	13,	21,	24,	38,	41
9,	7,	5,	11,	20,	25,	37,	42
14,	15,	10,	19,	26,	36,	43,	54
16,	17,	18,	27,	35,	44,	53,	55
30,	29,	28,	34,	45,	52,	56,	61
31,	32,	33,	46,	51,	57,	60,	62
49,	48,	47,	50,	58,	59,	63,	64

VLC

Zig-zag	1
Horizontal	01
Vertical	001
Fourth	0001

Table 2/Annex

QUANTISER FOR INTRA-MODE DC COMPONENT

INTRA DC level into quantiser	FLC		Reconstruction level into inverse transform
0 - 5	000000001	(1)	4
6 - 9	000000010	(2)	8
10 - 13	000000011	(3)	12
.	.		.
.	.		.
1018 - 1021	011111111	(255)	1020
1022 - 1025	111111111	(511)	1024
1026 - 1029	100000001	(257)	1028
.	.		.
.	.		.
2034 - 2037	111111101	(509)	2036
2038 - 2047	111111110	(510)	2040

Notes.

1. FLC 'n' is used to encode the 4 values 4n-2, 4n-1, 4n, 4n+1.
   except FLC 1 is also used for input values 0 and 1.
   FLC 256 is not used, FLC 511 substitutes.
   FLC 510 is also used for input values 2042 - 2047 though these should not theoretically occur.
   FLC 511 is used for input values 1022 - 1025.

2. The decoded value corresponding to FLC 'n' is 4n except FLC 511 gives 1024

Table 3/Annex

QUANTISERS FOR AC AND INTER MODE DC COMPONENTS

Level into Quantiser	Quantiser Index No. V_I	Reconstruction Level into Inverse Transform
-(QSEL-1) - (QSEL-1)	V_0	0
(QSEL) - (2*QSEL-1)	V_1	1.5*QSEL
(2*QSEL) - (3*QSEL-1)	V_2	2.5*QSEL
(3*QSEL) - (4*QSEL-1)	V_3	3.5*QSEL
.	.	.
.	.	.
(m*QSEL) - ((m+1)*QSEL-1)	Vm	(m+0.5)*QSEL
.	.	.
.	.	.
(101*QSEL) - (102*QSEL-1)	V_{101}	101.5*QSEL

Notes:

1. QSEL selects the quantiser characteristic. QSEL can take integer values between 1 and 31, both inclusive.
2. Where QSEL is an odd number, perform truncation of (I+0.5)*QSEL
3. For m<>0, entries for V_{-m} are obtained by negating the numbers in the first and third columns.
4. Input range is -2048 to 2047. For QSEL less than 20 the input may exceed the highest available level. In such cases V_{101} or V_{-101} is used as appropriate.
5. Quantiser index numbers corresponding to output levels outside the range -2048 to 2047 are not valid.

Table 4/Annex

Code	Length	TCOEFF (a)	TCOEFF (b)	BA
1	1	V0	V1	0
001	3	EOB	not used	1
010	3	V1	V-1	2
011	3	V-1	V2	3
00010	5	V2	V-2	4
00011	5	V-2	V3	5
000010	6	V3	V-3	6
000011	6	V-3	V4	7
0000010	7	V4	V-4	8
0000011	7	V-4	V5	9
00000010	8	V5	V-5	10
00000011	8	V-5	V6	11
0000000100000001	16	V6	V-6	12
0000000100000010	16	V-6	V7	13
0000000100000011	16	V7	V-7	14
0000000100000101	16	V-7	V8	15
0000000100000110	16	V8	V-8	16
0000000100000111	16	V-8	V9	17
0000000100001001	16	V9	V-9	18
0000000100001010	16	V-9	V10	19
0000000100001011	16	V10	V-10	20
....		..	..	..
....		..	..	..
0000000110011110	16	V65	V-65	130
0000000110011111	16	V-65	V66	131
0000000110100001	16	V66	V-66	
0000000110100010	16	V-66	V67	
....		..	..	
....		..	..	
0000000111111101	16	V-100	V101	
0000000111111110	16	V101	V-101	
0000000111111111	16	V-101	V0	

Notes.

1. TCOEFF. Column (a) is used for the quantiser index of all coefficients except for the one immediately preceding the EOB.

Column (b) is used for the quantiser index of the coefficient immediately preceding the EOB.

2. BA is the block address.

3. To find the last 8 bits of the 16 bit codeword in row 'n' where n ranges from 12 (TCOEFF(a)=V6 or BA=12) to 203 (TCOEFF(a)=V-101):

Subtract 11 from n to give p
Divide p by 3 to give integer quotient q and remainder r
Multiply q by 4
If r=0 then subtract 1
r=1 add 1
r=2 add 2
Convert result to 8 bits

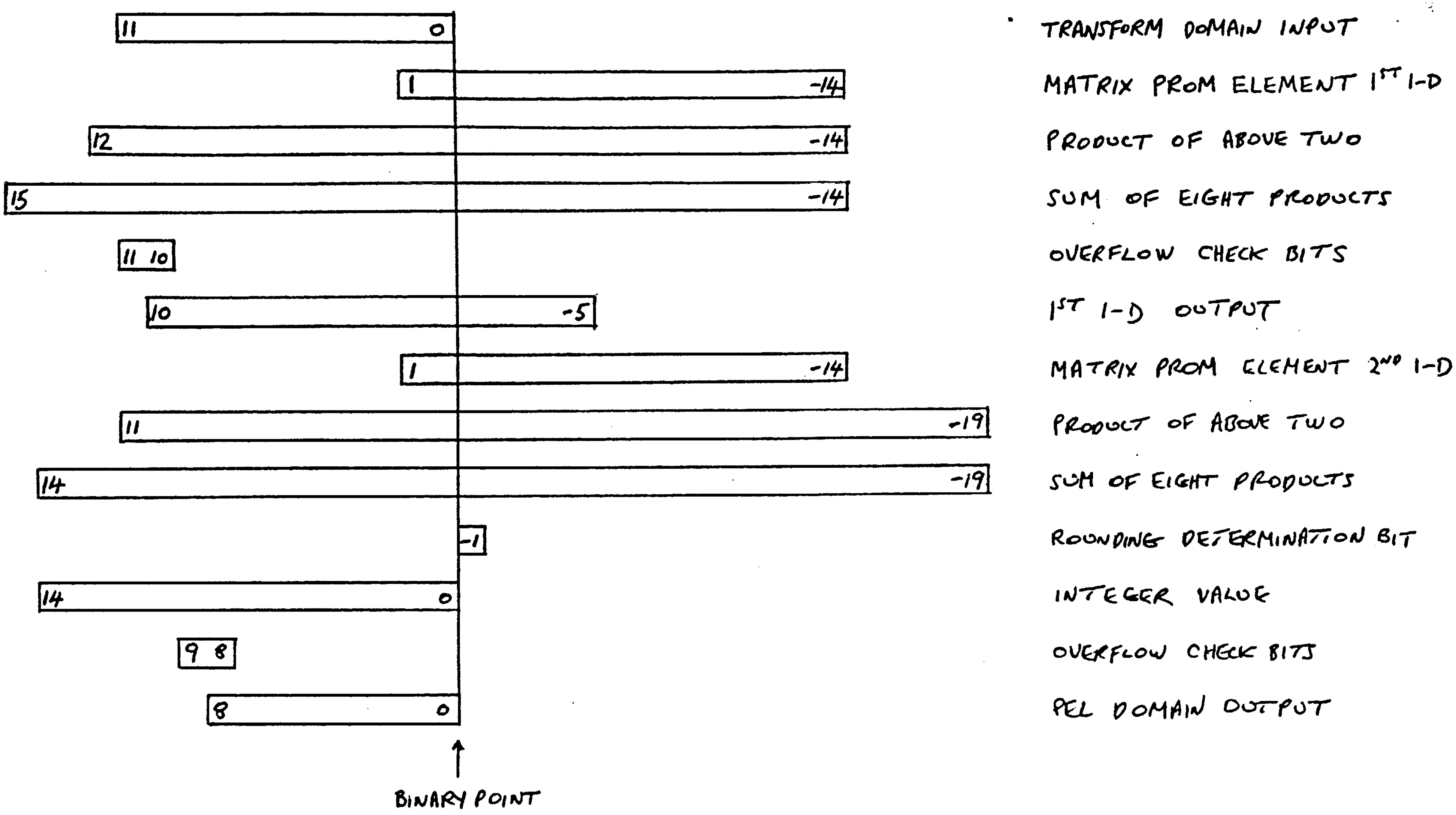
Table 5/Annex

TYPE3	Luminance	Chrominance
1	00010	0001
2	11	1
3	0110	001
4	01010	01
5a	00111	
5b	01011	
5c	00110	
5d	0111	
6a	01000	
6b	101	
6c	01001	
6d	100	
7	001010	

Table 6/Annex

Vx/Vy	Code-length	Code Pattern
-16/+16	8	00000001
-15/+17	8	00000011
-14/+18	8	00000101
-13/+19	8	00000111
-12/+20	7	0000101
-11/+21	7	0000111
-10/+22	7	0001001
- 9/+23	7	0001011
- 8/+24	6	000111
- 7/+25	6	001001
- 6/+26	6	001011
- 5/+27	5	00111
- 4/+28	5	01001
- 3/+29	5	01011
- 2/+30	4	0111
- 1	3	101
0	2	11
+ 1	3	100
+ 2/-30	4	0110
+ 3/-29	5	01010
+ 4/-28	5	01000
+ 5/-27	5	00110
+ 6/-26	6	001010
+ 7/-25	6	001000
+ 8/-24	6	000110
+ 9/-23	7	0001010
+10/-22	7	0001000
+11/-21	7	0000110
+12/-20	7	0000100
+13/-19	8	00000110
+14/-18	8	00000100
+15/-17	8	00000010

Table 7/Annex



2-D INVERSE TRANSFORM BIT SPANS