CCITT SGXV
Working Party XV/4
Specialists Group on Coding for Visual Telephony

Document 446
1988

TITLE: Description of Ref. Model 7 (RM7)

SOURCE: Specialist Group On Coding for Visual Telephony

version : January 21, 1989

revision 1 : May 20 , 1988 doc #339
revision 2 : July 20 , 1988
revision 3 : Sept 5 , 1988 doc #375
revision 4 : Oct 19 , 1988 doc #396
revision 5 : Nov 19 , 1988
revision 6 : Jan 21 , 1989 doc #446

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1 INTRODUCTION

This document gives a comprehensive description of the software in order to simulate REFERENCE MODEL 7 hereafter abbreviated to RM7. This model is used in the course of the research for comparison i.e. to choosing core elements for the flexible hardware specifications.

The given description does NOT intend to substitute the document " Flexible hardware specification for p x 64 kbit/s". This model is a configuration which has the ability to operate at various bitrates p=1,..,30 (see document 445).

The reader should be aware of the fact that:

1. Some adopted techniques described in this document are not a matter of standardization. For the flexible hardware other solutions are therefor allowed. In order to have comparable simulation results the methods described in this document are mandatory.

2. Some implemented techniques in RM7 are debatable but are used for comparison purposes only. One argument is the choice and length of the adopted sequences.

The readers are asked to give comments and corrections to remove ambiguous parts. The reader can send his amendments to:

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2 DESCRIPTION OF REFERENCE MODEL 7

In the proceeding text reference model 7 will be described. Starting with the basic format parameter choice referred to as common source input format. The spatial sizes are specified where these are most critical where the temporal frequency could be variable.

3 COMMON SOURCE INPUT FORMAT (C.S.I.F).

The parameters for the C.S.I.F. are:

	Full CSIF	1/4 CSIF
Number of active lines Luminance (Y) Chrominance (U,V)	 288 144	 144 72
Number of active pixels per line Luminance (Y) Chrominance (U,V)	 360 180	 180 90

Table 1 : Source format (full CSIF and 1/4 CSIF)

The number of coded pels per line is reduced, because 360 divided by 16 does not yield in an integer value. The obtained format is called significant pel area (SPA).

3.1 Definition Of The Significant Pel Area.

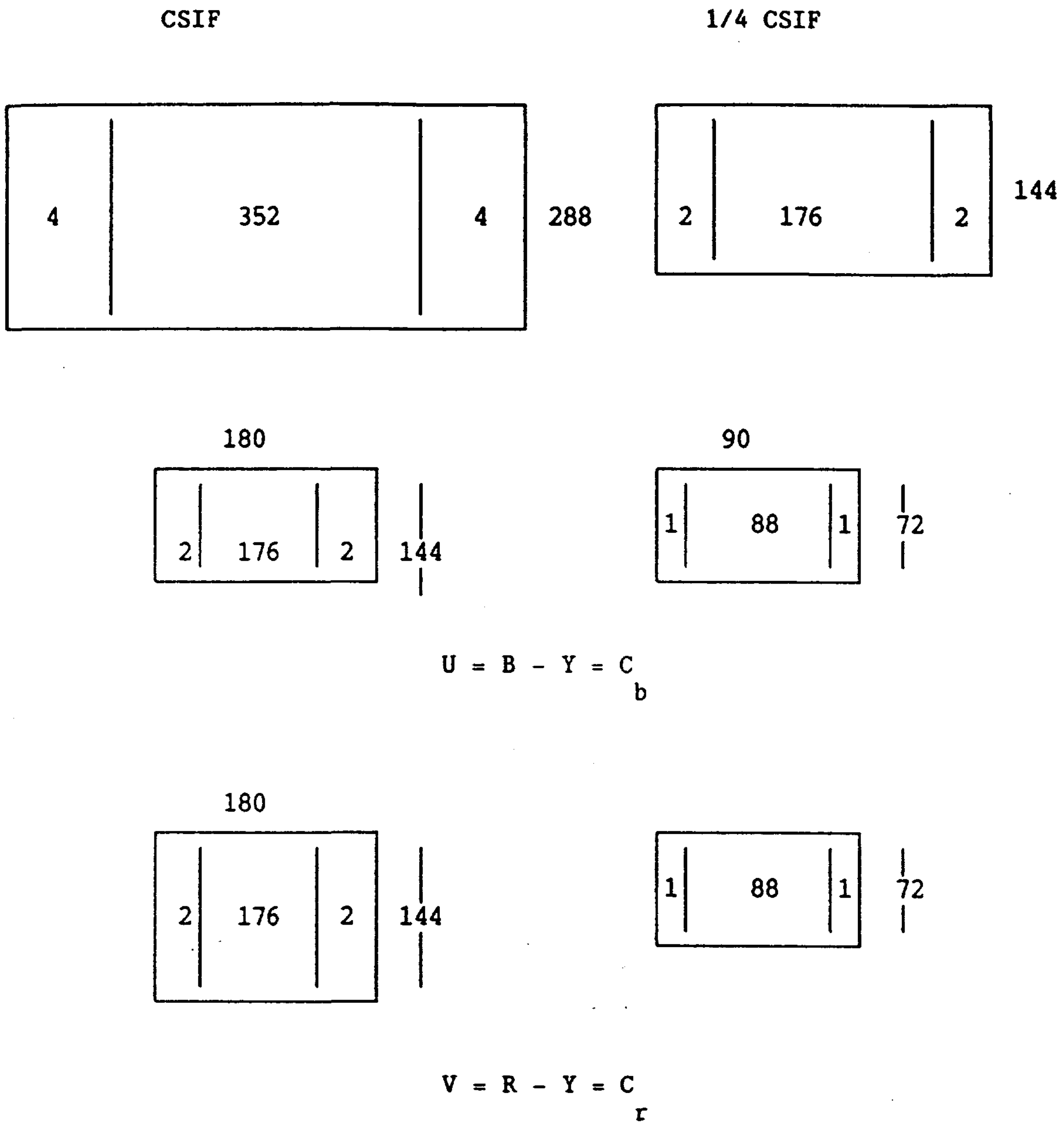

Figure 1 : Definition significant pel area

The number of pixels of the significant pel area (SPA) become:

352 x 288	= 101,376 pixels (Y)	
176 x 144 x 2	= 50,688 pixels (U,V)	
total	= 152,064 pixels/frame	(Y,U,V)

CIF

176 x 144	= 25,344 pixels (Y)	
88 x 72 x 2	= 12,672 pixels (U,V)	
total	= 38,016 pixels/frame	(Y,U,V)

1/4 CIF

In table 2 the influence of the frame rate on the number of pixels per second is given. This figure includes the number of pixels for the chrominance as well.

Frame Rate 30 Hz	Sub-sampling factor	number significant pixels/second	Mbit/s	number active pixels/second 1/4 CSIF	Mbit/s
15 Hz	1 : 2	2,280,960	18.3	570,240	4.6
10Hz	1 : 3	1,520,640	12.2	380,160	3.1
7.5Hz	1 : 4	1,140,480	9.1	285,120	2.3

Table 2 Bitrate versus frame rate

The first column of table 2 gives the frame rate and the third column depicts the number of omitted frames in the coding process for full CSIF and 1/4 CSIF the different values are tabulated. Applying the number of active pixels in one frame the total number of pixels per second are given in the next column with the corresponding bitrates.

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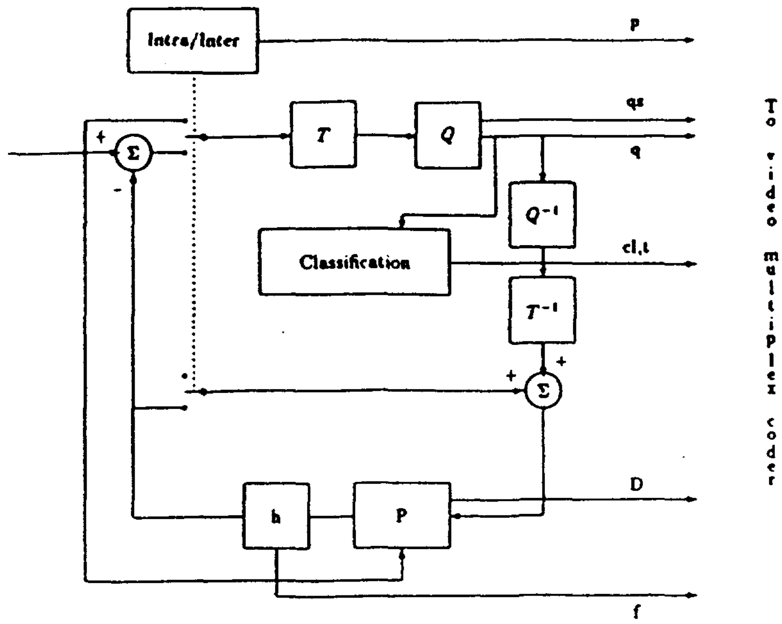

p = Flag for intra/inter
P = Picture memory
qz = Quantization index
q = Quantization index for transform coefficients
cl,t = Classification index, threshold
D = Motion vector
f = Switch loopfilter on/off
T = Transform
Q = Quantization
h = Loop filter
T^{-1} = Inverse transform
Q^{-1} = Reconstruction Quantization

Figure 2 Hybrid transform/DPCM encoder

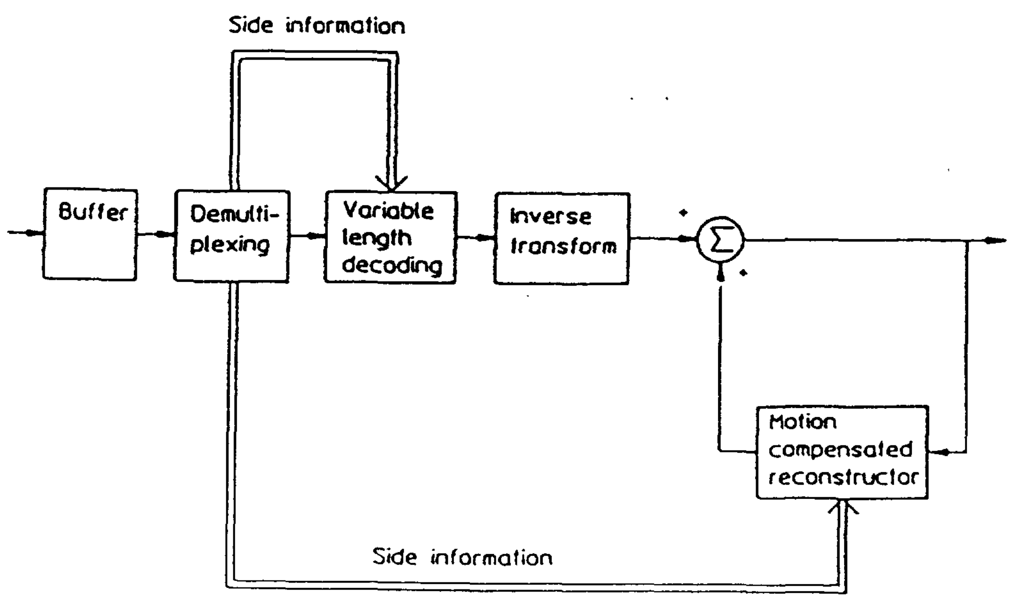

Figure 2 b Hybrid transform/DPCM decoder

4 BASICS OF REFERENCE MODEL 7

4.1 Introduction

The used coding configuration is known as a hybrid DPCM/transform coder. Hybrid denotes a technique which involves more than one redundancy reduction technique, in this case interframe methods where the calculations are performed in pixel and transform domain. This coding procedure requires two transforms, i.e. a forward transform and an inverse transform, which are both located in the coding loop. Due to the usage of a block transform the incoming image is partitioned in non-overlapping blocks of N x N pixels . At the moment the blocksize of the transform is set to N=8.
A simple differential pulse coding modulation loop (DPCM) can be identified as the generic structure of the configuration. This DPCM-loop works in the temporal dimension i.e. interframe. For this purpose a frame memory is included in the loop containing the previously reconstructed image or frame. The generic structure of the reference model depicted in figure 2 is based on:

1. Macro blocks
2. Discrete Cosine Transform (DCT)
3. Variable length coding applying a semi-uniform quantizer
4. A zig-zag scanning of quantized coefficients
5. Displacement estimation
6. Buffer control

Figure 2 Hybrid transform/DPCM encoder.

Let us assume a sequence S of images,

$$S = f(t) \quad \text{with} \quad t = \ldots -3,-2,-1,0,1,2, \ldots$$

where f(t) is a 2-D intensity distribution at time t. Denoting the actual frame by f(t) and the previous frame by $f(t-\tau)$, the frame difference fd(t) becomes :

$$fd(t) = f(t) - f(t-\tau)$$

$\tau = 1$ for skip 1 : 1
$\tau = 2$ for skip 1 : 2

The frames are partitioned in blocks of N x N pixels and are numbered from left to right along a row of blocks. Let b(s,t) denote the intensities of the pixels in a block s at time t and let B(s,t) denote the coefficients of that block after transformation. The block difference bd(s,t) is obtained by subtracting the previous block $b(s,t-\tau)$ from b(s,t) :

$$bd(s,t) = b(s,t) - b(s,t-\tau)$$

Only blocks which have changed significantly are processed. This procedure is known as Conditional Replenishment (CR). With the change detector a distinction is made been between significant and non-significant changed blocks also called block type discrimination (see section 4.6).

The displacement estimation is achieved by a block matching technique with a search of +/- 7 pixels. The blocksize is 16 x 16.

To obtain the displaced block difference the coder applies a displacement vector $\vec{D}$ which might reduce the block difference bd(s,t).

In the case of a translatory motion, the displaced block difference can be expressed as:

$$dbd(s,t) = b(s,t) - b(s_{\vec{D}},t-\tau)$$

where $\vec{D}$ is the obtained displacement vector for the block under consideration.
Let mb(s,t) be a block of size 2N x 2N in the actual frame f(t), and let SW be a M x M search window in a previous frame $f(t-\tau)$, where $M > N$ and $M = 2N+2D_{max}$.
If a brute force method is used and $D_{max} = N-1$, the number of possible integer displacements within this search window becomes $(2N-1)^2$. The prediction error dbd for all these positions is calculated and the displacement vector $\vec{D}$ which produces the minimum error $dbd(s,t-\tau)$ is stored. Zero displacement can be interpretated as the orthogonal projection. After completion of the calculations the minimum error results in the displaced block difference. In a noiseless case, a pure translation by an integer number of pixels will result in an exact match i.e.

$b(s_{\vec{D}},t-\tau) = b(s,t)$. The motion trajectory is used to obtain the displaced block difference dbd(s,t).

Only integer displacement is considered, the brute force algorithm is optimal but for implementation purposes a coarse-fine 3 step algorithm is used (see appendix A). For each macro-block the displacement vector $\vec{D}$ is calculated indicating a block in the previous frame which results in the smallest prediction error. The displacement calculations are performed outside the coding loop and therefore this vector has to be transmitted as side information. For the transmission of the non-zero displacement vectors a differential

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method is adopted using a 1-D prediction of the preceding calculated motion vectors (see section 4.11). The differential values are transmitted applying a VLC.
Next the prediction error (dbd(s,t)) is transformed using a 2-D Discrete Cosine Transform with blocksize N = 8.

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4.2 Macro Block Approach

A macro block (MB) consists of a 16 x 16 luminance block and the two corresponding 8 x 8 U and V chrominance blocks. The luminance block is divided into four 8 x 8 sub blocks, i.e. a MB consists of six 8 x 8 sub blocks.
The construction is depicted in figure 3.

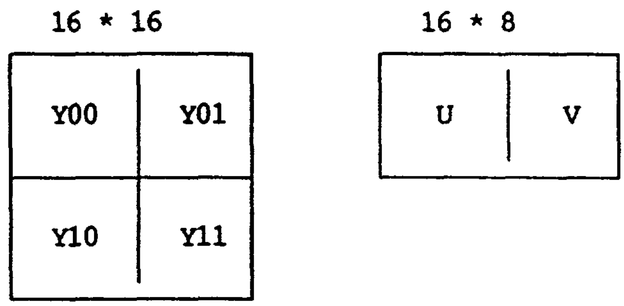


Figure 3 : Construction of a Macro Block (MB)

NOTE : A 16 x 16 Luminance block and the two corresponding 8 x 8 U and V chrominance blocks have the same physical size.

In table 3 the number of macro blocks per frame and the number of group of blocks per frame are shown:

Format	number of GOB in a frame	number of MB in a GOB	total number of MB in a frame
CSIF	12	33	396
1/4 CSIF	3	33	99

Table 3 Relationship between number of Macro blocks and picture format

4.3 Group Of Block Structure

With the introduction of a second picture format the intercommunication of codecs with different formats has to be considered. The smaller format is especially intended for low cost videophones, but realization of a second mode is a burden to all Full CIF codecs. A full CIF codec must be able to receive and transmit Quarter CIF pictures.

To get a good balance between 'wasted' bits for GOB headers and a fast error recovery the number of GOBs for CIF should be about 8 to 18. The block scan in figure 4 respects a high correlation of the motion vectors of succeeding macro blocks.

1	2	3	4	5	6	7	8	9	10	11
12	13	14	15	16	17	18	19	20	21	22
23	24	25	26	27	28	29	30	31	32	33

width : 176 pels
height: 48 lines

Figure 4 GOB with Macro Block Addresses.

CIF

1	2
3	4
5	6
7	8
9	10
11	12

QCIF

1
3
5

Figure 5 Group Number for CIF Picture and QCIF Picture

For the 12 GOBs of a full CIF picture group numbers with four bits are sufficient. The remaining four numbers can be used for other purposes.

4.4 Discrete Cosine Transform

The block-differences bd(s[x,y],t) are transformed with the Discrete Cosine Transform (DCT).
The 2-D DCT is defined as :

$$\underset{1}{BD(s[u,v],t)} = \frac{1}{4} C(u)\, C(v) \sum_{x=0}^{7} \sum_{y=0}^{7} bd(s[x,y],t) \cos\left[\frac{\pi u(2x+1)}{16}\right] \cos\left[\frac{\pi v(2y+1)}{16}\right]$$

with u = 0,1,2, ... 7
v = 0,1,2, ... 7

$$bd(s[x,y],t) = \frac{1}{4} \sum_{u=0}^{7} \sum_{v=0}^{7} C(u)\, C(v)\, BD(s[u,v],t) \cos\left[\frac{\pi u(2x+1)}{16}\right] \cos\left[\frac{\pi v(2y+1)}{16}\right]$$

with x = 0,1,2, ... 7
y = 0,1,2, ... 7

where x,y = spatial coordinates in the pixel domain
u,v = coordinates in the transform domain

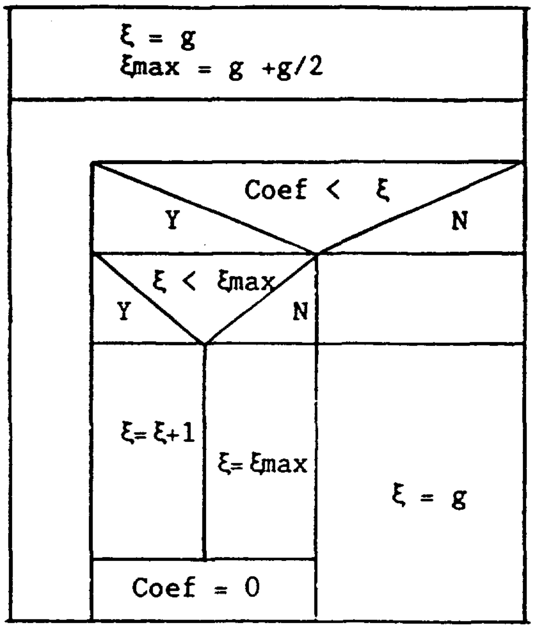
$C(u),C(v) = 1/\sqrt{2}$ for u,v = 0
1 otherwise

The luminance blocks and the chrominance blocks are transformed with a blocksize of 8 x 8 pixels. To assure that the simulation results at the different laboratories are similar it is advisable to exchange the software of the DCT.
The proposed specification for the IDCT Chips can be found in appendix C.

4.5 The Quantization

4.5.1 Variable Threshold -

A variable threshold is applied independantly of the quantization strategy to increase the number of zero coefficients. In the case of the variable threshold the threshold and its value depends on the length of string of zeroes. It is assumed that the transformed components have been zigzag scanned to form a one dimensional set of coefficients, before the quantization process. The accuracy of the coefficients is 12 bits. Referring to this scale the threshold ξ is modified within the block according to the variable thresholding algorithm as described below.



Example for g=32:

Coefficients	50	0	0	0	33	34	0	40	33	34	10	32
Threshold ξ *	32	32	33	34	35	36	37	38	32	32	32	33
New Coeff.	50	0	0	0	0	0	0	40	33	34	0	0
Quantized value	48	0	0	0	0	0	0	48	48	48	0	0

* The threshold is valid for the actual coefficient
New Coeff. denotes new coefficients after thresholding and before quantization.

4.5.2 The Quantization Strategy - The result after the transformation and the variable thresholding technique is quantized with an uniform quantizer. The uniform quantizer is defined by a step g and controlled by the buffer state. For RM7 the quantizer threshold has a value T = g.

$$q_{dec}(n) = T + (n-1) g \quad , n = 1,2,\ldots$$

$$q_{dec}(0) = 0$$

Taking into account the negative values the expression becomes:

$$q_{dec}(n) = \frac{n}{|n|} \{ T + (|n|-1) g \} \quad , |n| = 1, 2, 3,\ldots$$

$$q_{rep}(n) = \frac{q_{dec}(n) + q_{dec}(n+ n/|n|)}{2} \quad \text{for } |n| = 1, 2, \ldots$$

$$q_{rep}(0) = 0$$

with q_{dec} the decision level

q_{rep} the representation level

g the quantizer stepsize

T threshold

Example : A transform coefficient c with :

$$1.0\,g \leq c < 2.0g$$

is quantized to the value of 1.5 g. The characteristic of the quantizer is depicted in figure 6.

Figure 6 . Characteristic of the quantizer

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The dynamic range of the coefficients in the case of a blocksize of 8 x 8 is [-2048,2047]. The same quantizer is used both for luminance and chrominance coding.

The quantization stepsize g is transmitted for each group of block.

4.6 Coding Of Coefficients

4.6.1 Scanning Technique -

In order to increase the efficiency of capturing the non zero components a zig-zag scanning class has been adopted:

ZIG - ZAG SCANNING :

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

The transmission of the coefficients must stop when the last non zero coefficient has been reached.

4.6.2 Coding Of The Scanned Coefficients With A Two Dimensional VLC.

To increase coding efficiency a two dimensional variable length code has been adopted. This means that "events" are coded. "Event" is defined as :

event : a combination of a magnitude (non-zero quantization index) and a RUN (Number of zero indexes preceding the current non-zero index)

Coefficients unequal to zero defining the end of the run-length are considered as composite rather than separate statistical event.

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The run-length and the magnitude of composite events define the entries of the 2-D VLC table which contains the code words for the composite events. Events are coded with Huffman's algorithm. However, events with low probabilities are coded using fixed length codes. These codes consists of the following three parts.

1. Escape (6 bits) for indicating the use of fixed length codes.

2. Run (6 bits)

3. Level (8 bits; See Note 1).

Note 1: Note that clipping must be introduced for the quantized coefficients F : $-128\ g \leq F < 128\ g$. The maximum range for the non-zero coefficients is now +127g and -128g.

Note 2: $0 \leq run < 64$ (for blocksize 8)
After the last non-zero coefficient an End-Of-Block (EOB) marker is sent indicating that all other coefficients are zero. The length of the EOB word is two bits.

An example of the two dimensional VLC is given in figure 7 and the table is annexed.

EVENT = (RUN,LEVEL)

Example: (0,3) (1,2) (7,1) EOB

$$\begin{array}{cccccccc}
3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{array}$$

Figure 7 Example 2-D VLC

That means:

* (0,3) The DC component which has the value +3

* (1,2) is next non-zero component according to the zig-zag scanning the number of zeroes is 1.

* The next component is 1 preceded by 7 zeroes, result (7,1)

* EOB is an End of Block marker which indicates that there are no more non zero components.

4.7 Coding Strategy And Block Type Discrimination

In RM7 five different block types can be distinguished :

- no MC not coded
- no MC coded
- MC not coded (only motion vectors are transmitted)
- MC coded
- Intra

The order in which the block type is determined is depicted in figure 8.

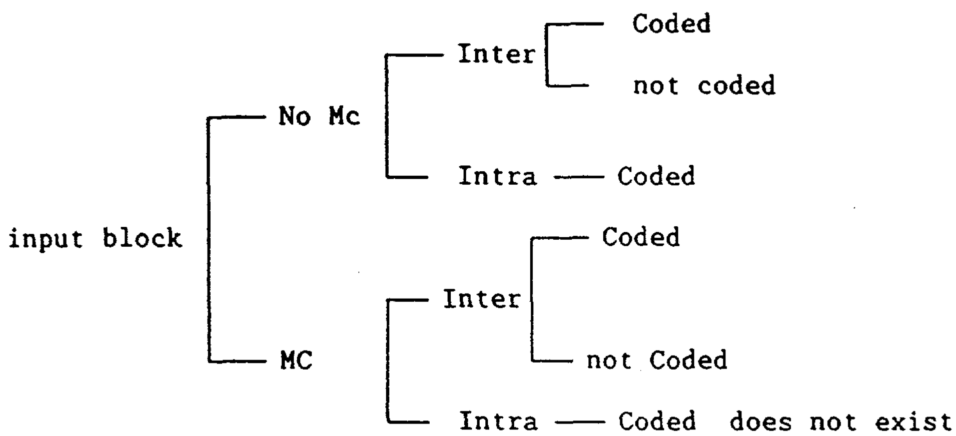

Figure 8 Decision Tree RM7

Macro Block type	code with rel. addr.
1. no MC not coded	-
2. MC coded	1
3. MC not coded	01
4. no MC coded	001
5. Intra	000

Table 4 : Adopted VLC for macro block types

If after quantization, all the quantized components of a sub block are zero, the sub block is declared to be not coded (blocktype 1,3).
If all six sub blocks in a MB are not coded, the MB is declared to be not coded. In all other cases the MB is declared to be coded (blocktype 2,4). When one or more blocks in a coded MB are not coded, only an EOB is sent if the subblock is included in the pattern as in section 4.7 (pattern 7 is assumed) :

Y00	Y01	Y10	Y11	U	V

e.g. Y00, Y10, Y11, U and V are not coded

Y01 is coded

```
Y00        Y01              Y10  Y11   U    V
EOB, EVENT-----EVENT EOB, EOB, EOB, EOB, EOB
```

NOTE : The Data Per Block (DPB) is only transmitted if the macro block is coded (blocktype 2,4).

All modified MB's (blocktype 2,3,4) are addressed with relative addressing, similar to the relative addressing used in RM4 (table 5) . The other block-types are coded according to the VLC in table 4.

N.B. : The last string of fixed blocks in a GOB is not encoded.

number of fixed MB's	codeword length	codeword
0	1	0
1	3	100
2	3	101
3	4	1100
4	4	1101
5	5	11100
6	5	11101
7	6	111100
8	6	111101
9	7	1111100
10	7	1111101
11	8	11111100
12	8	11111101
13	9	111111100
14	9	111111101
15	11	11111111000
16	11	11111111001
17	11	11111111010
18	11	11111111011
19	11	11111111100
20	11	11111111101
21	13	1111111111000
22	13	1111111111001
23	13	1111111111010
24	13	1111111111011
25	13	1111111111100
26	13	1111111111101
27	15	111111111111000
28	15	111111111111001
29	15	111111111111010
30	15	111111111111011
31	15	111111111111100
32	15	111111111111101
33	0	

Table 5 : Adopted VLC for relative addressing of non-fixed MB's

NOTE : More simulations have to be done to ensure that relative addressing causes visible gain.

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4.8 Block Addressing For Macro Block Attribute

By the introduction of the Macro Block scheme in RM7, the side information could be reduced further with the introduction of pattern information. This pattern information consists of a set of seven pattern indicating codec/non-coded blocks within the macro block. The patterns are depicted in figure 9.

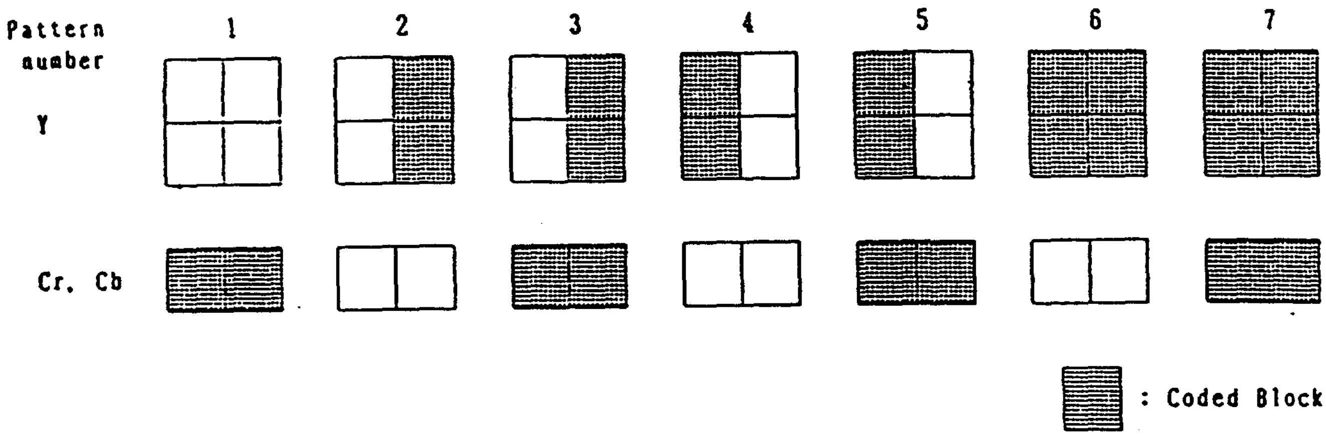

Figure 9 Pattern information Macro block

Pattern number	Code length	Code
6	2	00
2	2	10
4	2	11
7	3	011
1	4	0100
3	5	01010
5	5	01011

Table 6 Code word length Pattern information

NOTE:

If a macro block type is "intra", its pattern information is not transmitted.

Example:
Y00 block is coded, Y01,Y10,Y11,U and V blocks not coded the pattern will be pattern 4.

4.9 Relative Addressing For Blocks Within A Group Of Blocks Structure

The relative addresses is adopted as depicted in figure 10. Run lengths are generated for the number of blocks to the next active blocks.

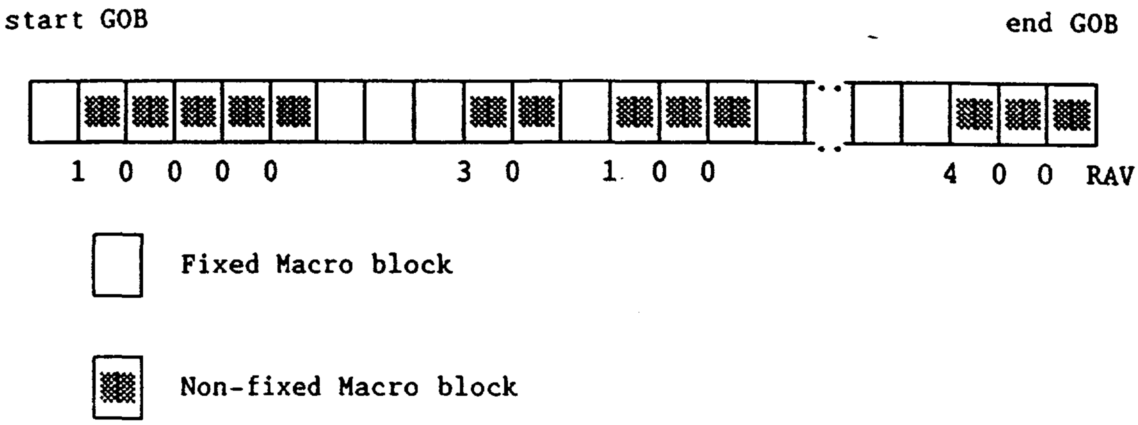

Figure 10 Relative addressing

Where RAV is the relative addressing value (i.e. the number of fixed blocks preceding a non-fixed block).
The last string of fixed blocks in a group of blocks is not encoded.
The GOB start code (see video multiplex) indicate the beginning of the next GOB. The table used for the runs is given in table 5.

4.10 Filter In The Loop

The introduction of a low pass filter after motion compensation (MC) could have the following advantages:

i. A reduction of high frequency artifacts introduced by MC.

ii. A reduction of quantization noise in the feedback loop.

The filter could be controlled with:

1. Displacement vector

2. Prediction error

A filter with impulse response as depicted in (1) is applied on a block of 8 x 8 pixels. The filter is applied both on luminance and the chrominance.

$$h(k,l) = \begin{vmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{vmatrix} \; 1/16 \qquad (1)$$

4.10.1 Filtering Inside The Block Boundaries. -

At the block boundaries the filter coefficients need to be adjusted in the case of adopting filtering inside the block.

i. $\begin{vmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{vmatrix}$ for pixels inside the block edges

ii. $\begin{vmatrix} 3 & 1 \\ 6 & 2 \\ 3 & 1 \end{vmatrix}$ for pixels on the block edges

iii. $\begin{vmatrix} 9 & 3 \\ 3 & 1 \end{vmatrix}$ for pixels on the block corner positions

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In reference model 7 the filter is controlled with the motion vector i.e. if the motion vector is non zero the filter is on.
Luminance blocks as well as chrominance blocks are filtered.

4.11 Buffer

4.11.1 Buffer Control

For RM7 the stepsize varies from 4 to 64 with step 2. The dependence on the buffer fullness is depicted in table 7 (the bitrate is q*64 kbit/s). Each GOB the stepsize is adapted according to table 6. This means that 5 bit/GOB are spent because of the 31 different stepsize values.

buffer content [kbit]	stepsize quantizer
< 400*q	——> 4
< 600*q	——> 6
< 800*q	——> 8
.	.
.	.
.	.
< 6000*q	——>60
< 6200*q	——>62
≥ 6200*q	——>64

or : step = 2 * INT (buf_cont / [200*q]) + 2

Table 7 : Quantizer stepsize as a function of the buffer fullness

Where INT denotes the truncation of the fraction, i.e. 1.5 -> 1 , 1.3 -> 1 and 1.6 -> 1.

The buffer size is only related to the bitrate. In annex F a table is provided giving the number of bits per macro block for each combination of frame and bit rates for full and QCIF. Buffersize= q x 6.4 kbit

4.11.2 Buffer Overflow

A buffer size of q*6.4 kbit is intended. After each MB the buffercontent can be calculated (mean 15 bit/MB for q = 1; 10 Hz).

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When the buffer fullness exceeds q*6.4 kbits, the coefficients and the motion vector are set to zero in the next macro block (however resulting in a small buffer overflow).

N.B. : When the frame rate is not equal 10 Hz or the bitrate is not equal to 64 kbit/s, the mean number of bits per MB are revealed in appendix F.

4.12 Motion Estimation

The prediction error can be minimized with motion compensation.

At the moment the 3-step method is adopted in RM7 with blocksize 16 x 16 i.e. macro block based. The method can be found in appendix A.

The 3-step method is applied on luminance only. The motion vector for the chrominance is derived from the luminance by dividing the luminance vector by two and truncate the result to integer value.

example :

for luminance	-->	for chrominance
(3, 2)		(1, 1)
(-5,-6)		(-2,-3)

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4.12.1 Differential Motion Vector Coding -

The coding of the displacement vector with fixed codeword length (FLC) as used in RM5 wastes a lot of bits when the moving area in the scene is large. Instead of transmitting the value of the calculated vector itself, the differential vector is transmitted applying a variable length code.
The differential technique is employed based on a 1-D prediction: the prediction is the motion vector of the previous macro block.
In case of the first macro block in the GOB, the previous vector is zero. The adopted VLC is depicted in table 8.

Amplitude	Code word	Code word length
-14	11111110000	11
-13	11111101111	11
-12	11111101110	11
-11	1111110110	10
-10	1111110101	10
-9	1111110100	10
-8	111111001	9
-7	111111000	9
-6	11111011	8
-5	11111010	8
-4	1111100	7
-3	11110	5
-2	1110	4
-1	110	3
0	0	1
1	100	3
2	1010	4
3	10110	5
4	1011100	7
5	10111010	8
6	10111011	8
7	101111000	9
8	101111001	9
9	1011110100	10
10	1011110101	10
11	1011110110	10
12	10111101110	11
13	10111101111	11
14	10111110000	11

Table 8 Adopted VLC for Differential motion vector

4.13 MC/No MC Decision

For the moment we use the characteristic as defined in RM4 (adapted to blocksize 16 x 16). The evaluation function for displacement estimation is a sum of absolute differences concerning to all of the pels in a block. The characteristic whether to suppress the displacement vector is depicted in figure11 The characteristic is determined experimentally.

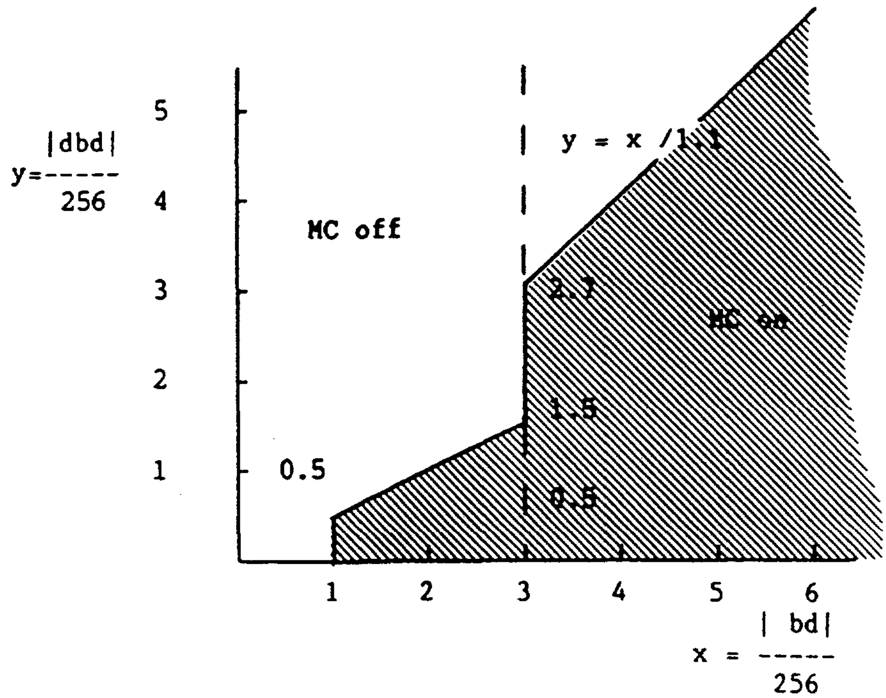

Figure 11. Characteristic MC/ No MC

Where dbd denotes the displaced block difference and bd the block difference, see also page 9.

NOTE: MC off includes the solid line. This characteristic resolves partly the sticking noise in the uncovered background (#107).
The absolute values are teken pel by pel

4.14 Intra Mode Decision

The most important reason for the re-introduction of the inter/intra switch are:

1. much better performance at scene cuts, too fast movement and in areas of decovered background (e.g. when Trevor raises his hands)

2. better error resilience and very simple implementation of (necessary) forced update

The implementation of the decision can be described with:

```
k = 1, 16
  l = 1, 16
    OR = O(k,l)
    Dif   = OR - S(k,l)
    VAR   = VAR+ Dif*Dif
    VAROR=VAROR+OR*OR
    MWOR =MWOR + OR
VAR = VAR/256
VAROR=VAROR/256-MWOR/256*MWOR/256
```

Where: O(k,l) denotes the pixels in the original macro block
S(k,l) denotes the pixels of the <u>motion compensated</u> estimated macro block.

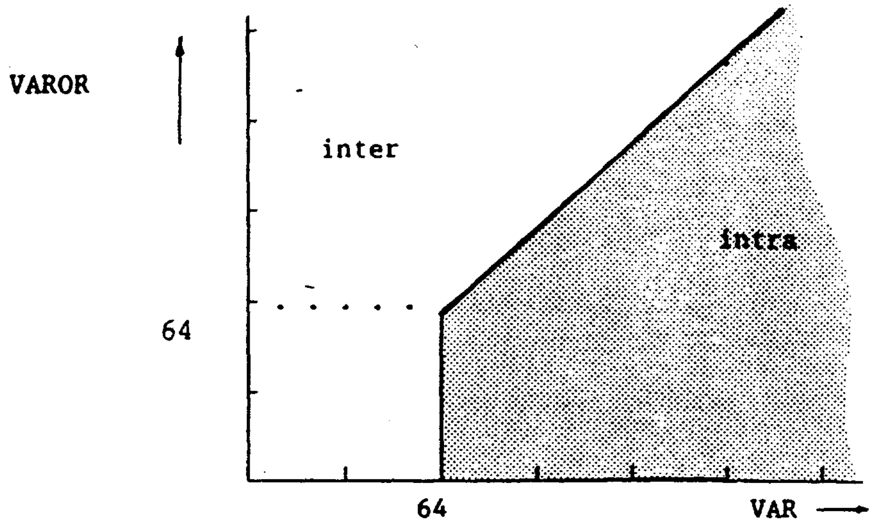

Figure 12. Characteristic intra / inter

NOTE1:
The parameters are calculated as integer values.
The lower threshold of 64 for the decision
is emperically optimized.
The decision is depicted in figure 12.

NOTE2:
Inter mode includes the solid line

After the blocks have been declared intra the coefficients are transmitted as depicted below:

FOR LUMINANCE (Y)

M=rounded mean value of the 16x16 MB	Differential DC Value of LSB1 by comparison with 8 x M	AC	EOB

. . . .

8 bits FLC VLC 2bits

Differential DC Value of LSB4 by comparison with 8 x M	AC	EOB

FOR CHROMINANCE (U,V)

M_U=rounded mean value of the 8 x 8 MB	AC	EOB
8 bits FLC	VLC	2bits

M_V=rounded mean value of the 8 x 8 MB	AC	EOB
8 bits FLC	VLC	2bits

where MB = Macro block
L = Luminance
U,V= Chrominance
LSB= Luminance Sub Block

4.15 First Picture

In order to have a simple method of starting the simulations it was agreed to adopt following method:

- Disregarding the number of bits for the first frame
- Using the stepsize depicted in table 9 for the various bitrates.
- Start the second picture with half full buffer

Video bitrate channels	Bitrate	Stepsize
q = 1	59.4	g = 32
q = 5	297	g = 16
q = 23	1472	g = 12
q = 29	1856	g = 8

Table 9 Bitrate versus stepsize first picture

The temporal reference remains as depicted in table 10.

original sequence	1	2	3	4	5	6	7	8	(10 Hz)
coded sequence	1	2	3	4	5	6	7	8	(10 Hz)

Table 10 : Temporal reference

Note:

For comparison purposes the number of bits for the first picture is counted. For the statistics the first frame is omitted.

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5 QUARTER CIF SIMULATIONS

The QCIF simulations are carried out using the GOB structure outlined in section 4.3. The relation of the number of bits per MB is depicted in annex F.

* for 10 Hz use 60 bits per MB with q = 1
* for 15 Hz use 39 bits per MB with q = 1
* for 30 Hz use 18 bits per MB with q = 1
* for a first approach a prefilter one to one for the down conversion (see figure 13) is used
* for the up conversion a linear interpolation filter is used.
* the result will be displayed by using a full screen
* the SNR will be calculated at the CIF and QCIF level
* the use of other filters must be studied.

Down conversion CIF --> QCIF

```
____X___0___X_______X___0___X____
    x1  p1  x2      x3  p2  x4
```

$$p1 = \frac{x1 + x2}{2} \qquad p2 = \frac{x3 + x4}{2}$$

Up conversion QCIF --> CIF

```
_________0___X_______X___0_________
         p1  x2r     x3r p2
```

$$x2r = 3/4\ p1 + 1/4\ p2$$
$$x3r = 1/4\ p1 + 3/4\ p2$$

Figure 13 Down and up conversion CIF --> QCIF

6 VIDEO MULTIPLEX ARRANGEMENT

The Video multiplex is constructed in a hierarchical structure;

1. Picture layer
2. Group of block layer
3. Macro Block layer
4. Block layer

Picture Layer (PL)

PSC	TR	TYPE1	PEI1	PARITY	PSPARE	GOB Data

Group Of Block Layer (GOBL)

GBSC	GN	TYPE2	QUANT1	GEI	GSPARE	MB Data

Macro Block Layer (MBL)

MBA	TYPE3	QUANT2	MVD	CBP Block Data

Block Layer (BL)

TYPE4	...	CLASS	TCOEFF	EOB

6.1 Picture Layer

PICTURE HEADER :

PSC	TR	TYPE1	PEI1	PARITY	PEI2	PSPARE	
20	5	15	1	0 8	1	0 16	bits

The picture header constist of:

1.	picture start code	(PSC)	20
2.	Temporal reference	(TR)	5
3.	Type information	(TYPE1)	13
4.	Extra insertion information	(PEI1)	1
5.	Parity information	(PARITY)	0 or 8
6.	Extra insertion information	(PEI2)	1
7.	Spare information	(PSPARE)	0 or 16

6.1.1 The Group Of Blocks Layer -

GOB-HEADER :

GBSC	GN	TYPE2	QUANT1	GEI	GSPARE	MBData	
16	4	6	5	1	0 16		bits

The Group of blocks header consists of:

1.	Group of Block Start Code	(GBSC)	16
2.	Group number	(GN)	4

3.	Type information	(TYPE2)	6
4.	Quantizer information	(QUANT1)	5
5.	Extra insertion information	(GEI)	1
6.	Spare information	(GSPARE)	0 or 16

6.1.2 Macro Block Layer -

Macro BLOCK-DATA:

MBA	TYPE3	QUANT2	CLASS	DMV	TCOEFF	EOB

For the Macro block data on can distinguish:

1.	Macro Block address	(MBA)	
2.	Block type information	(TYPE3)	
3.	Quantizer type	(QUANT2)	5 bit
4.	Motion vector data	(MVD)	
5.	Coded Block Pattern	(CBP)	

6.1.3 Block Layer -

BLOCK-DATA :

TYPE4	...	CLASS	TCOEFF	EOB

For the Block Data on can distinguish:

1.	Type 4	(BA)
2.	Classification	(CLASS)
3.	Transform coefficients	(TCOEFF)
4.	End of Block Marker	(EOB)

7 PRESENTATION OF RESULTS

SEQUENCE :
MODIFICATION :
NUMBER OF TRACKS:

INSTITUTE :
DATE :
FRAME RATE:

ITEM			15th Picture	Mean whole seq.
1. RMS for luminance				
2. SNR for luminance				
for chrominance (u)				
for chrominance (v)				
3. Mean value of step size				
4. Mean value of the number of non-zero coefficients				
5. Mean value of the number of zeroes before the last NZ-coefficient				
6. Block type of MACRO	FIXED			
	CODED MC			
	FIXED MC			
	CODED			
	INTRA			
7. Block type of Y	FIXED			
	CODED MC			
	FIXED MC			
	CODED			
	INTRA			
8. Block type of UV	FIXED			
	CODED MC			
	FIXED MC			
	CODED			
	INTRA			
9. Number of bits	Macro attributes			
	mvLMB			
	mvCMB			
	End of block			
	Motion vectors			
	Coefficients	Y		
		U		
		V		
		Total		
	Total			
10.	Number of bits first frame :			
	Number of forced to fixed macro blocks :			

uy

Comments to table : Presentation of results

The statistics exclude the first frame. Because the second picture to code is skipped, the number of tracks for the statistics is equal to the number of coded tracks - 2.

ad 1 :

$$P_{err}(t) = \sum_{i=1}^{352} \sum_{j=1}^{288} [\hat{f}(i,j) - f(i,j)]^2$$

$$P_{norm} = \frac{1}{\text{number pixels in frame}} P_{err}(t)$$

$$RMS = \sqrt{P_{norm}}$$

with:

$P_{err}(t)$ = frame based energy error

$f(i,j)$ = original pixel value

$\hat{f}(i,j)$ = reconstructed pixel value

P_{norm} = normalized error

RMS = root mean square error

ad 2 : The SNR is calculated for luminance as well as chrominance.

$$SNR = 20 \log \frac{255}{RMS}$$

ad 3 : The quantizer is adapted after a group of blocks GOB according to the buffer status. Therefore the mean value of the stepsize becomes :

$$E(g) = \frac{\sum^{pic} \text{step size of each GOB}}{\text{no. of GOBs (18)}}$$

ad 4 and 5 :
For the calculation of the mean value of the number of non-zero coefficients (MVNZC) and zero-coefficients (MVZC) the DC-component is included.

ad 7 : The number of fixed Y-blocks must be at least 4 x the number of fixed MB's, because

- a fixed MB consists of 4 fixed Y blocks
- a coded MB consist of 0 or more (but not all) fixed Y blocks

ad 8 : A similar story as in 7 holds for the number of fixed UV-blocks (at least 2 x the number of fixed MB's)

ad 9 : The number of bits for the MB attributes also includes the bits for relative addressing.

number of bits for 'Motion vectors' must be equal to (excluding rounding errors) :

8 x (#macro coded MC + #macro fixed MC)

mvLMB denotes bits for Mean Value of Luminance Macro Block (see intra mode, section 4.13), mvCMB are bits for Mean Value of Chrominance Macro Block.

ad 10: For comparison the number of bits for the first frame is given.

In order to check buffer overflow in the codec the number of forced to fixed Macro block is counted.

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APPENDIX A

3-STEP-ALGORITHM

Assuming a maximum displacement of 7 pixels the step algorithm iterates in three steps to the resulting minimum absolute error.

Step 1 : The actual block B is matched with 9 blocks in the previous window SW at the following positions :

(-4-4)	(0-4)	(4-4)
(-4 0)	(0 0)	(4 0)
(-4 4)	(0 4)	(4 4)

The position of the non-shifted prediction is (0 0). The order of the search has been defined as:

2	3	4
5	1	6
7	8	9

If the calculated error in position 1 has the same value as on position 3 than position 1 is chosen. The error is calculated by the Boolean less than i.e truncation.

3-STEP-ALGORITHM

Step 2 : For the second step a new search pattern is used. The best match of step 1 is the center of this pattern :

```
(-2-2)   (0-2)   (2-2)

(-2 0)   (0 0)   (2 0)

(-2 2)   (0 2)   (2 2)
```

Step 3 : The position of the best match in step 2 is the central position of the third and final search pattern :

```
(-1-1)(0-1)(1-1)
(-1 0)(0 0)(1 0)
(-1 1)(0 1)(1 1)
```

The best match of step 3 is the resulting minimum match error.

An example of the search process for the 3-step algorithm :

```
1       1       1

            2   2   2

1       1   2   1   2
                  3 3 3
            2   2 3 2 3
                  3 3 3
1       1       1
```


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APPENDIX B

ADOPTED VARIABLE LENGTH CODES

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Word Length of VLC for Two-dimensional Coding

LEVEL (absolute value)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20 . .128
	0	3	5	6	8	9	9	11	13	13	13	13	14	14	14	14	20	20	20	20	20
	1	4	7	9	11	13	14	14	20	20	20	20	20	20	20	20	20	20	20	20	20
	2.	5	8	11	13	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	3	6	9	13	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	4	6	11	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	5	7	11	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	6	7	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	7	7	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
R	8	8	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
U	9	8	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
N	10	9	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	11	9	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	12	9	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	13	9	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	14	11	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	15	11	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	16	11	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	17	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	18	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	19	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	20	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	21	13	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	22	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	23	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	24	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	25	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	26	14	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	27	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	28	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	.																				
	.																				
	63																				

** Word lengths of all other EVENTs (combination of RUN and LEVEL) are 20: ESCAPE CODE(6bits)+RUN(6BITS)+LEVEL(8bits).

** Word length of EOB is 2.

Code Set for Two-dimensional Coding of Coefficient
Quantization Index (RM4)

No	RUN	LEVEL	CODE LENGTH	CODE	CODE STRUCTURE
1	0	-1	3	111	VLC
2	0	1	3	110	
3	1	-1	4	1011	VLC
4	1	1	4	1010	
5	2	-1	5	10011	
6	2	1	5	10010	VLC
7	0	-2	5	10001	
8	0	2	5	10000	
9	3	-1	6	001111	
10	3	1	6	001110	
1	4	-1	6	001101	VLC
2	4	1	6	001100	
3	0	-3	6	001011	
4	0	3	6	001010	
5	5	-1	7	0001111	
6	5	1	7	.	VLC (4bits)
7	1	-2	7	.	
8	1	2	7	.	+
9	6	-1	7	.	
20	6	1	7	.	FLC (3bits)
1	7	-1	7	.	
2	7	1	7	0001000	
3	8	-1	8	00001111	
4	8	1	8	.	VLC (5bits)
5	0	-4	8	.	
6	0	4	8	.	+
7	9	-1	8	.	
8	9	1	8	.	FLC (3bits)
9	2	-2	8	.	
30	2	2	8	00001000	
31	10	-1	9	001001111	VLC (6bits)
2	10	1	9	.	
3	0	-5	9	.	+
4	0	5	9	.	
5	1	-3	9	.	
6	1	3	9	.	FLC (3bits)
7	3	-2	9	.	
8	3	2	9	001001000	
9	11	-1	9	000001111	
40	11	1	9	.	VLC (6bits)
1	12	-1	9	.	
2	12	1	9	.	+
3	0	-6	9	.	
4	0	6	9	.	FLC (3bits)
5	13	-1	9	.	
6	13	1	9	0000010000	

No	RUN	LEVEL	CODE LENGTH	CODE	CODE STRUCTURE
95	22	-1	14	00000000111111	
6	22	1	14	.	
7	23	-1	14	.	
8	23	1	14	.	
9	24	-1	14	.	
100	24	1	14	.	
1	25	-1	14	.	
2	25	1	14	.	
3	26	-1	14	.	
4	26	1	14	.	
5	0	-12	14	.	
6	0	12	14	.	
7	0	-13	14	.	VLC (9bits)
8	0	13	14	.	
9	0	-14	14	.	+
110	0	14	14	.	
1	0	-15	14	.	FLC (5bits)
2	0	15	14	.	
3	1	-6	14	.	
4	1	6	14	.	
5	1	-7	14	.	
6	1	7	14	.	
7	2	-5	14	.	
8	2	5	14	.	
9	3	-4	14	.	
120	3	4	14	.	
1	5	-3	14	.	
2	5	3	14	.	
3	9	-2	14	.	
4	9	2	14	.	
5	10	-2	14	.	
6	10	2	14	00000000100000	
127	EOB WORD		2	01	VLC
128	ESCAPE CODE		6	001000	VLC

** Other EVENTs (combination of RUN and LEVEL) are coded to:
ESCAPE CODE(6bits)+RUN(6bits)+LEVEL(8bits)

No	RUN	LEVEL	CODE LENGTH	CODE	CODE STRUCTURE
47	4	-2	11	00000011111	
8	4	2	11	.	
9	14	-1	11	.	
50	14	1	11	.	
1	15	-1	11	.	
2	15	1	11	.	VLC (7bits)
3	1	-4	11	.	
4	1	4	11	.	+
5	2	-3	11	.	
6	2	3	11	.	FLC (4bits)
7	0	-7	11	.	
8	0	7	11	.	
9	5	-2	11	.	
60	5	2	11	.	
1	16	-1	11	.	
2	16	1	11	00000010000	
3	17	-1	13	0000000111111	
4	17	1	13	.	
5	6	-2	13	.	
6	6	2	13	.	
7	0	-8	13	.	
8	0	8	13	.	
9	3	-3	13	.	
70	3	3	13	.	
1	1	-5	13	.	
2	1	5	13	.	
3	18	-1	13	.	VLC (8bits)
4	18	1	13	.	
5	19	-1	13	.	+
6	19	1	13	.	
7	0	-9	13	.	FLC (5bits)
8	0	9	13	.	
9	20	-1	13	.	
80	20	1	13	.	
1	21	-1	13	.	
2	21	1	13	.	
3	7	-2	13	.	
4	7	2	13	.	
5	2	-4	13	.	
6	2	4	13	.	
7	0	-10	13	.	
8	0	10	13	.	
9	4	-3	13	.	
90	4	3	13	.	
1	8	-2	13	.	
2	8	2	13	.	
3	0	-11	13	.	
4	0	11	13	0000000100000	

APPENDIX C

PROPOSED SPECIFICATION FOR INVERSE DCT CHIPS

Appendix to Specification for p*64 kbit/s Flexible Hardware

Specification for Inverse DCT

1. Generate random integer pixel data values in the range -L to +H according to the attached random number generator (C version). Arrange into 8x8 blocks by allocating each set of consecutive 8 numbers in a row. Data sets of 10000 blocks each should be generated for (L=256, H=255), (L=H=5) and(L=H=300).

2. For each 8x8 block, perform a separable, orthonormal, matrix multiply, Forward Discrete Cosine Transform (FDCT) using at least 64-bit floating point accuracy.

3. For each block, round the 64 resulting transformed coefficients to the nearest integer values. Then clip them to the range -2048 to +2047. This is the 12-bit input data to the inverse transform.

4. For each 8x8 block of 12-bit data produced by step 3, perform a separable, orthonormal, matrix multiply, Inverse Discrete Cosine (IDCT) using at least 64-bit floating point accuracy. Round the resulting pixels to the nearest integer, and clip to the range -256 to +255. These blocks of 8x8 pixels are the "reference" IDCT output data.

5. For each 8x8 block of 12-bit data produced by step 3, use the proposed IDCT chip or an exact-bit simulation thereof to perform an Inverse Discrete Cosine Transform. Clip the output to the range -256 to +255. These blocks of 8x8 pixels are the "test" IDCT output data.

6. For each of the 64 IDCT output pixels, and for each of the 10,000 block data sets generated above, measure the peak, mean and mean square error between the "reference" and "test" data.

7. For any pixel, the peak error should not exceed 1 in magnitude.
   For any pixel, the mean square error should not exceed 0.06.
   Overall, the mean square error should not exceed 0.02.
   For any pixel, the mean error should not exceed 0.015 in magnitude.
   Overall, the mean error should not exceed 0.0015 in magnitude.

8. All-zeros in must produce all-zeros out.

9. Rerun the measurements using exactly the same data values of step 1, but change the sign on each pixel.

```
                    /*L and H must be long, ie, 32 bits*/
long rand(L,H)
long      L,H;
{
   static long    randx = 1;     /*long is 32 bits*/
   static double    z = (double)0x7fffffff;

   long  i,j;
   double x;                       /*double is 64 bits*/

   randx = (randx * 1103515245) + 12345;
   i = randx & 0x7ffffffe;                    /*keep 30 bits*/
   x = ( (double)i ) / z;                     /* range 0 to 0.99999... */
   x *= (L+H+1);                              /* range 0 to  < L+H+1 */
   j = x ;                                    /*truncate to integer*/
   return( j - L );                     /*range  -L  to  H  */
}
```

APPENDIX D

FIGURES

Figure 1 : Definition significant pel area
Figure 2 : Hybrid transform/DPCM encoder
Figure 3 : Construction of a Macro Block (MB)
Figure 4 : GOB with Macro Block Addresses.
Figure 5 : Group Number for CIF Picture and QCIF Picture
Figure 6 : Characteristic of the quantizer
Figure 7 : Example 2-D VLC
Figure 8 : Decision Tree RM7
Figure 9 : Pattern information Macro block
Figure 10: Relative addressing
Figure 11: Characteristic MC/ No MC
Figure 12: Characteristic intra / inter
Figure 13: Down and up conversion CIF --> QCIF

APPENDIX E

TABLES

Table 1 : Source format (full CSIF and 1/4 CSIF)
Table 2 : Bitrate versus frame rate
Table 3 : Relation number of Macro blocks and picture format
Table 4 : Adopted VLC for macro block types
Table 5 : Adopted VLC for relative addressing of non-fixed MB's
Table 6 : Code word length Pattern information
Table 7 : Quantizer stepsize as a function of the buffer fullness
Table 8 : Adopted VLC for Differential motion vector
Table 9 : Bitrate versus stepsize for first picture
Table 10: Temporal reference

APPENDIX F

RELATION BITS PER MACROBLOCK AND CHANNEL RATE

This annex presents a new formula to compute the main number of available bits per MacroBlock (MB).

In order to be more clear and to prevent ambiguous interpretations of the bitrate a parameter q is introduced. The parameter q denotes the bitrate for video only i.e. q = 1 the bitrate is 64 kbit/s. In the case of p=1 this could be interpreted as 64 kbit/s for video and 64 kbit/s for audio.

The formula in section 4.11 of doc. 396 (RM6) was computed starting from the particular case of q= 1 (64 kbit/s) and k = 3 (frame rate 10 Hz), giving 460 overhead bits per frame to be used for the Picture Header (PH) and for the group of MacroBlocks Headers (GMBH).

```
bitrate     : q * 64 kbit/s  ( p = 1..29)
frame rate  : 30 / k Hz      ( k = 1..4)

--> mean number of bits per MB :

    for CSIF     :  5 * k * q  bits/MB
    for 1/4 CSIF : 20 * k * q  bits/MB
```

Assuming the value of 460 bits (as suggested by the formula with q = 1 and k = 3) enough to take into account all the overhead bits which are to be used for PH and GOBs, the formula, when applied with other values of q and k, yields a number of bits for PH and GOBs very far from 460.

Taking into account the outlined considerations, we suggest a new formula to be used in simulations, which allows the computation of the mean number of bits per MB for every value of p and k with a defined number of overhead bits per frame to code the PH and the GOBs:

$$MBIT = \frac{64.000 * k * q - 30 * NOV}{30 * NMBL}$$

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RELATION BITS PER MACROBLOCK AND CHANNEL RATE

with:

bitrate	: q * 64 kbit/s	(q = 1..30)
frame rate	: 30 / k Hz	(k = 1..4)

NMBL = number of macroblocks in a picture= | -> 396 for CSIF
| -> 99 for 1/4 CSIF

NOV = number of overhead bits reserved for each frame

MNBIT = mean number of available bits per Macroblock
For practicle reasons the nearest integer is taken.

Table I. and II. give some values of MBIT (for both the CSIF and 1/4 CSIF resolution) computed by the formula in doc. 396 and the newly given formula for different values of NOV. The values of NOV for 1/4 CSIF resolution was chosen smaller than those for CSIF resolution, as there are less GMBs in 1/4 CSIF. The right values of NOV must be defined in accordance with the number of GOBs in a frame, depending on the resolution (CSIF or 1/4 CSIF) and on the definition of the macroblock structure (12 GOBs for CSIF and 3 GOBs for 1/4 CSIF). Per frame the overhead bits are constant i.e. increasing the frame rate means that more overhead bits need to be transmitted.

	Full CIF	QCIF
PH	42 - 66	42 - 66
GOBH	32 - 48	32 - 48
nGOBs	12	3

Number overhead bits equals PH + nGOBs x GOBH i.e. CIF= 66 + 1248642 and QCIF = 66 + 348 = 210.

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RELATION BITS PER MACROBLOCK AND CHANNEL RATE

	k = 1 (30 Hz)	k = 2 (15 Hz)	k = 3 (10 Hz)	k = 4 (7.5 Hz)	
q = 1	20	40	60	80	doc #396
64kbit/s	19	41	62	84	NOV = 210
q = 2	40	80	120	160	doc #396
128kbit/s	41	84	127	170	NOV = 210
q = 6	120	240	360	480	doc #396
384kbit/s	127	256	386	515	NOV = 210

TABLE I: Mean number of bits per MacroBlock using different formulas (1/4 CSIF resolution)

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RELATION BITS PER MACROBLOCK AND CHANNEL RATE

	k = 1 (30 Hz)	k = 2 (15 Hz)	k = 3 (10 Hz)	k = 4 (7.5 Hz)	
q = 1	5	10	15	20	doc #396
	4	9	15	20	NOV = 642
q = 2	10	20	30	40	doc #396
	9	20	31	42	NOV = 642
q = 6	30	60	90	120	doc #396
	31	63	95	128	NOV = 642
q = 12	60	120	180	240	doc #396
	63	128	192	257	NOV = 642
q = 24	120	240	360	480	doc #396
	128	257	386	516	NOV = 642
q = 30	150	300	450	600	doc #396
	160	322	483	644	NOV = 642

TABLE II: Mean number of bits per MacroBlock using different formulas (CSIF resolution)

APPENDIX G

ACTION POINTS

1. Filtering in loop (Doc #356, #376,#406 and #422). The following topics have to be checked:
   1. The adaptivity of the filter(s) and how to control it
   2. The effectiveness of the filter(s) in the loop v.s. outside the loop
   3. Optimization of the intra mode (#407). Introduction of an intra not coded mode?
2. Use of Motion vectors for sub-blocks (annex to #416)
3. Pattern Issue (#418 #409)
4. VLC optimization
5. Impact of the modification at 384kbit/s and 2 Mbit/s
6. Impact of the GOB configuration regarding the buffer control strategy.
7. RM7 and QCIF
8. Scanning classes