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1. GENERAL DESCRIPTION

1.1 INTRODUCTION

This document gives KDD's proposal of video coding for MPEG2.
Its preregistration number is 17.
The algorithm is based on SM3 M=3 coding of entire picture of 4:2:2 on frame by frame basis, however significant improvement is achieved by employing **adaptive frame / field motion compensation and wavelet transform.**

1.2 PICTURE FORMAT

The picture format in this coding algorithm is 525-line 4:2:2 format of CCIR 601. There is no pre- / postprocessing and the entire picture is coded.

Input format : (Test tape)
- Y : 720 pels * 480 lines * 30 frames / sec
- Cr, Cb : 360 pels * 480 lines * 30 frames / sec

Significant pel area : Significant pel area is truncated as follows, only significant pel area is coded.
- Y : 704 pels * 480 lines * 30 frames / sec
- Cr, Cb : 352 pels * 480 lines * 30 frames / sec

1.3 CODEC OUTLINE

Figure 1.3a and Figure 1.3b show the encoder and decoder block diagram, respectively.

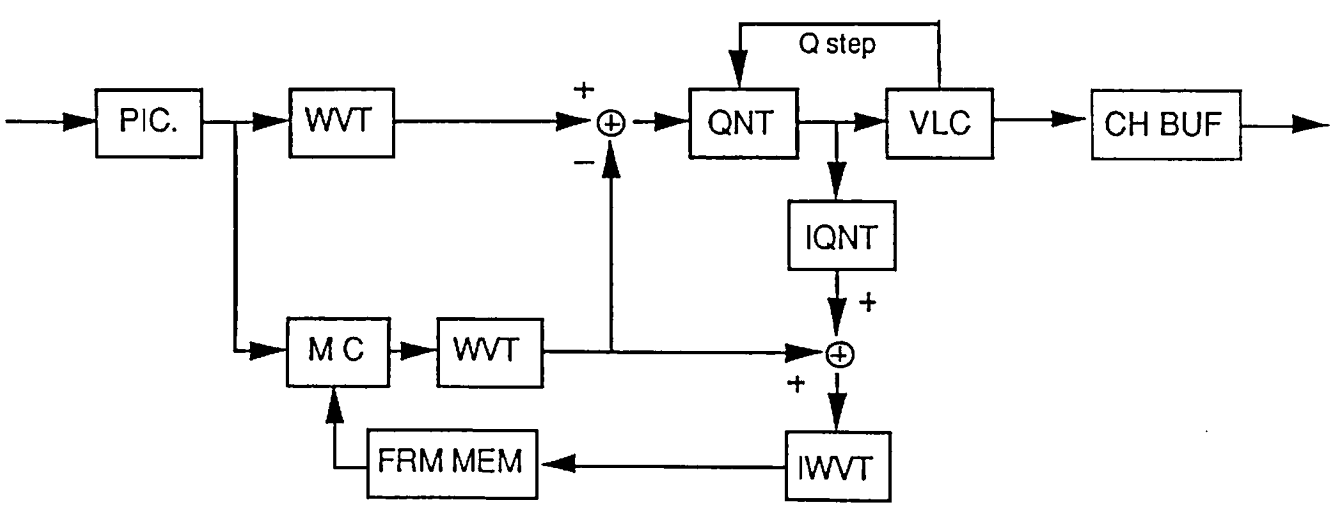


Figure 1.3a Encoder block diagram

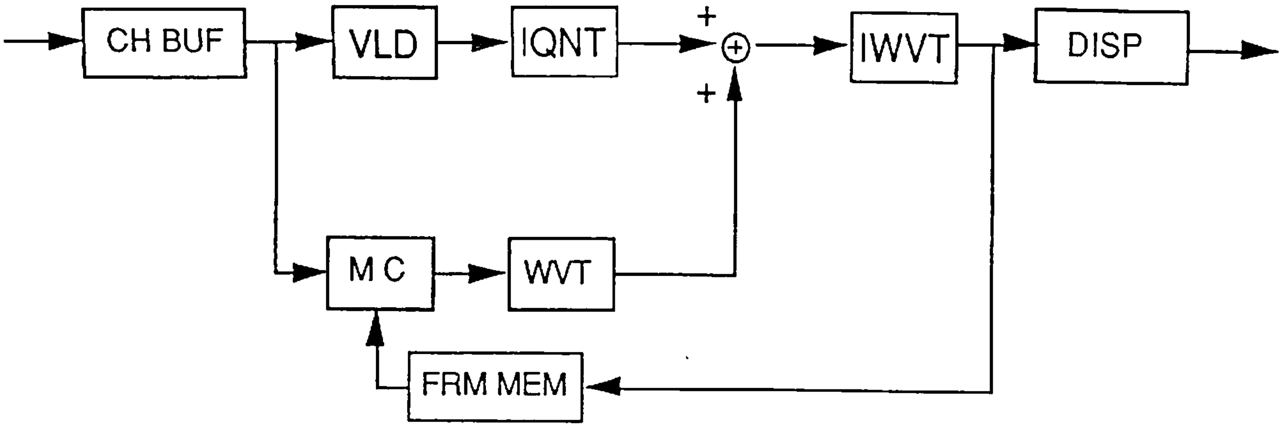


Figure 1.3b Decoder block diagram

1.3.1 Outline

The scheme is based on SM3(M=3, N=12)[1], but the main differences lie in the following points:

- From input to output, entire picture format is 4:2:2 (704 pixels * 480 lines).

- No pre- / postprocessing in terms of temporal and spatial filtering.

- Each picture is **coded on frame by frame basis** (each frame contains even and odd fields).

- In **Intra**-coded picture, odd field is coded by intra field coding, while **even field is coded by inter field coding** which is predicted from the odd field with motion compensation.

- In Predictive- and Bidirectionally predictive-coded pictures, **frame to frame motion compensation as well as field to field motion compensation** are employed.

- In motion estimation, one of the motion vector of the MB at the same position in the reference picture, the left MB, upper MB in the same picture, is used as an **offset vector** with a limit of motion vector of i * 22.5.

- In motion compensation, **an adaptive overlap motion compensation** is used to suppress boundary irregularity between MBs.

- **Wavelet transform** instead of DCT is used.

- Macroblock of 8 subblocks (4 Y + 2 Cb + 2 Cr blocks, subblock = 8 pixels * 8 lines)

- Quantization of every 8*8 block, but different scanning order from conventional zig-zag scanning.

- **Precise quantizer step and data rate control** for target bit.

- For such cases as **scene change and violent motion, P-picture is replaced by I-picture** (called S-picture).

- MPEG1 forward and upward compatibility through syntactic extension.

- Random access, fast forward, and fast reverse play are achieved by using intra picture with a cycle of 12 pictures.

- Coding delay of more than 12 pictures (0.4 sec) because of scene change check and predcise data control, decoding delay of more than 3 pictures (0.1 sec).

1.3.2 Mathematical notations

(1) The operation "/" specifies integer division with truncation towards zero. For example, 3/2 is truncated to 1.

(2) The operation "//" specifies integer division with rounding to the nearest integer. Half-integer values are rounded away from zero unless otherwise specified. For example, 3 // 2 is rounded to 2 and -3 // 2 is rounded to -2.

2. ENCODING ALGORITHM

2.1 LAYERED STRUCTURE OF VIDEO DATA

2.1.1 Sequence layer

A sequence consists of a number of concatenated Group of Pictures.

2.1.2 Group of pictures (GOP) layer

A GOP consists of 12 pictures. M=3 scheme in SM3 is used, i.e., the first picture is Intra-coded(I) picture, following two pictures are Bidirectionally predictive-coded(B) pictures, and then Predictive-coded(P) picture, which is followed by another B picture and so on. There are one I-picture, three P-pictures and eight B-pictures in a GOP. Therefore, first 12 pictures are I,B,B,P,B,B,P,B,B,P,B,B-pictures. However, P-picture is replaced by I-picture when scene change is detected, which is described in section 2.7.1.

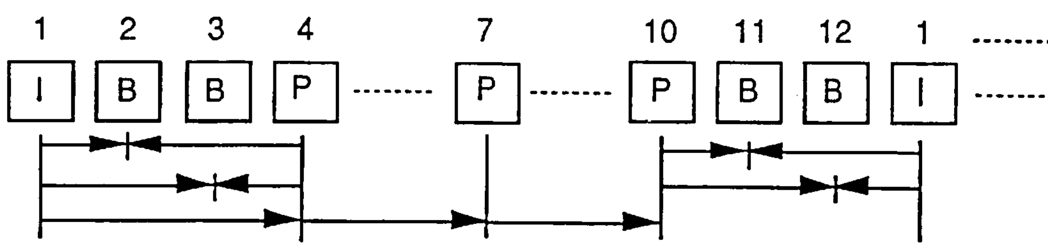


Figure 2.1.2 GOP structure

2.1.3 Picture layer

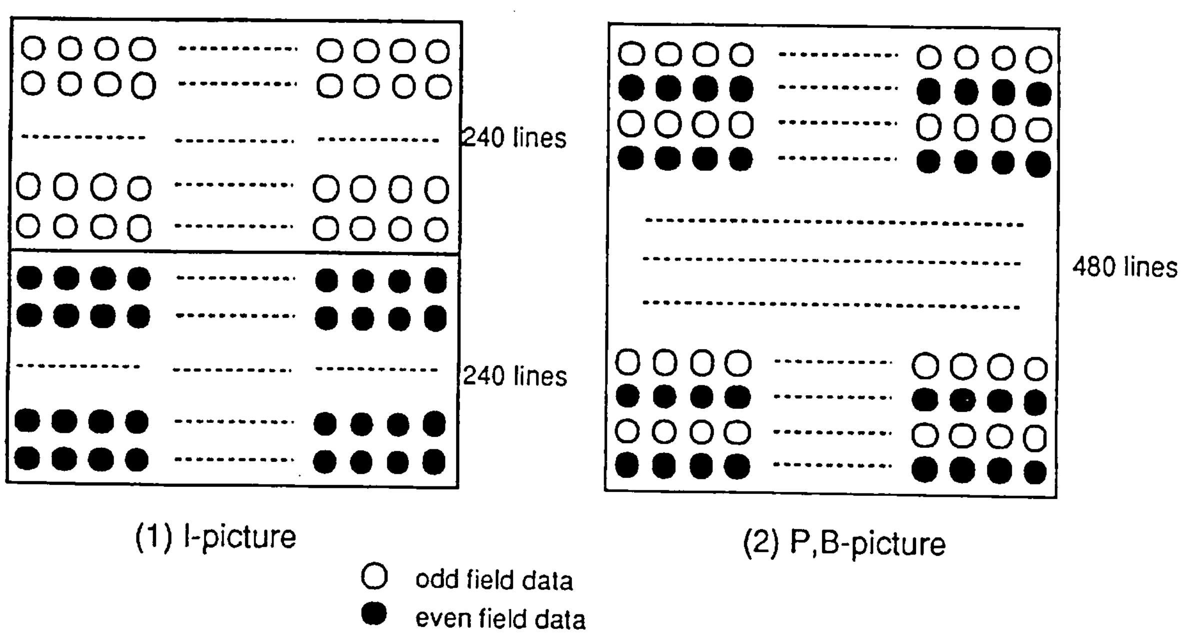


Figure 2.1.3 Picture format

A picture has 30 slices. Each picture is categorized into I-picture, P-picture, and B-picture. In I-picture, upper half slices contain only odd field data and lower half slices have only even field data. In P- and B-pictures, odd field and even field data appear in the alternate lines. These picture formats apply to both luminance and chrominance data.

2.1.4 Slice layer

A slice contains a row of 44 macroblocks (MBs) starting from the left side of the picture which yields 704 pixels (16 * 44) for luminance Y, and 352 pixels (8 * 44) for chrominance Cb, Cr.

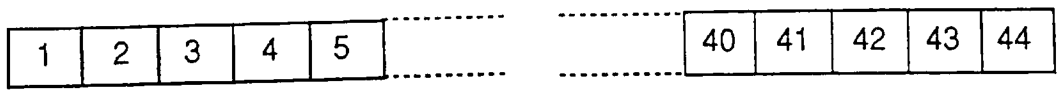


Figure 2.1.4 Slice structure

2.1.5 Macroblock layer

A macroblock(MB) consists of 8 blocks. There are 4 Y blocks, 2 Cr blocks and 2 Cb blocks as shown in Figure 2.1.5.

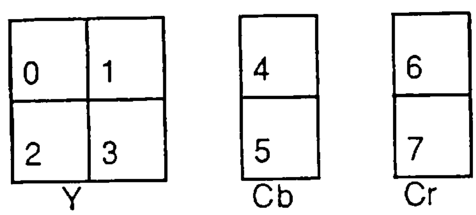


Figure 2.1.5 Macroblock structure

2.1.6 Block

A block consists of an array of 8 pixels * 8 lines of either luminance or chrominance signals. In I-pictures, either odd or even field data exists in a block, whereas, in P- and B-pictures, odd and even field data appears alternately in Y, Cb, and Cr blocks.

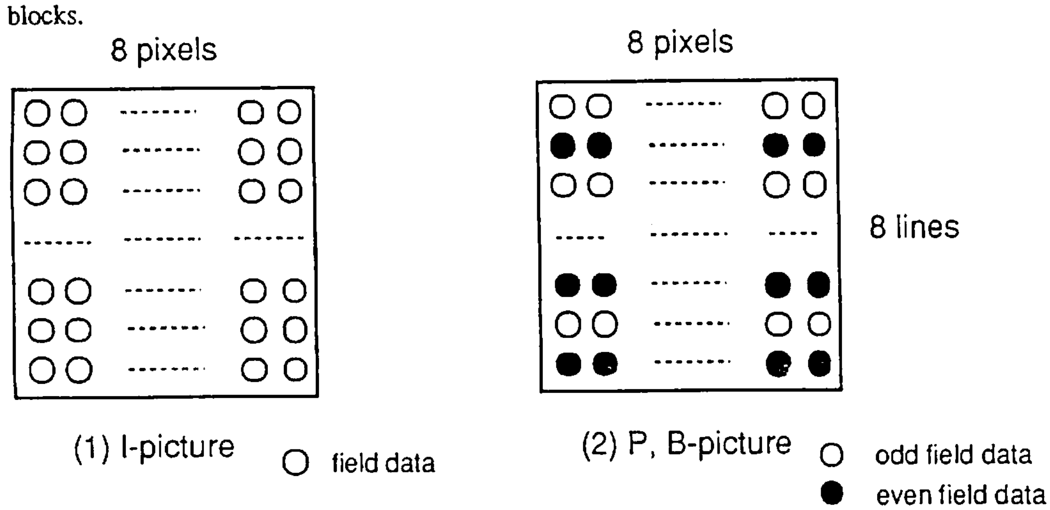


Figure 2.1.6 Block structure

2.2 MOTION ESTIMATION AND COMPENSATION

2.2.1 Overview

Motion estimation and compensation are employed for prediction and interpolation to achieve temporal redundancy.
In I-picture, motion estimation and compensation are made for even field using previous intra-coded odd field as a reference.
In P-picture, forward prediction is performed by using past P- or I-picture.
In B-picture, forward, backward, or interpolative prediction is performed using past and/or future picture.

In all the pictures, motion estimation is performed for every MB for +/- 7.5 search area from the offset vectors with half pel accuracy. Motion estimation is performed in the input pictures. A positive value of the horizontal or vertical component of the motion vector indicates that prediction is formed from pixels in the referenced frame, which are spatially to the right or below the pixels being predicted.

There are two types of motion estimation and compensation. One is done by frame basis and the other is made by field basis. In both cases, motion estimation is performed on the 16 pixels * 16 lines of input luminance data of a MB. In I-picture, only field motion estimation from odd field to even field is used, while in P- and B-pictures, either frame or field motion estimation is selected for each MB.
Figure 2.2.1 shows a motion estimation example starting with I-picture for forward prediction case.

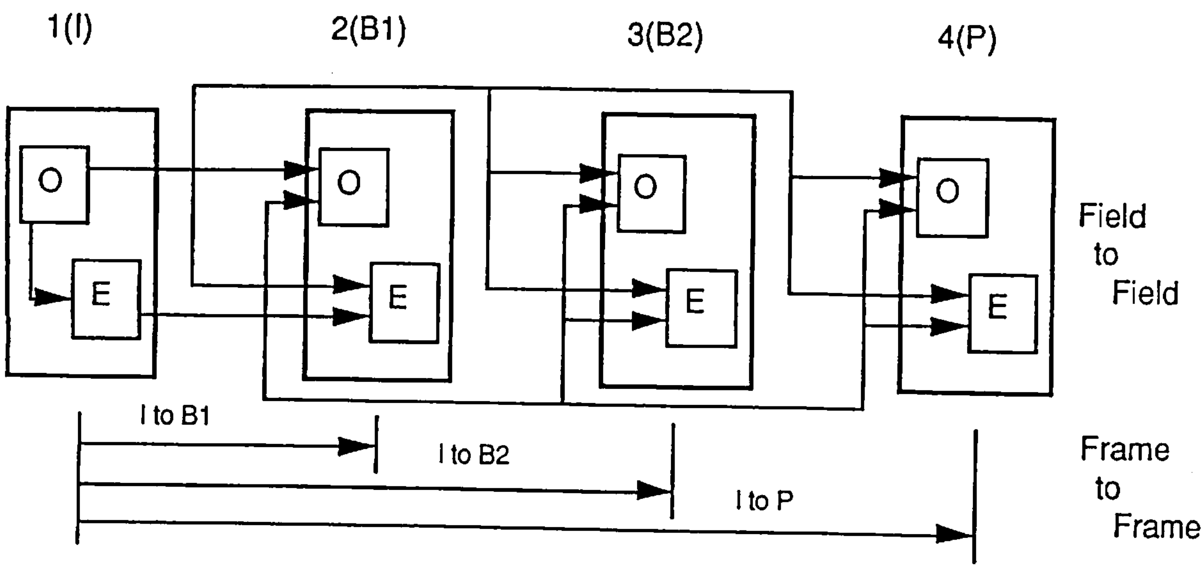


Figure 2.2.1 Motion estimation (forward case)

Followings are descriptions of frame, field motion estimation and its selection.

2.2.2 Frame to frame motion estimation

Motion estimation is performed on the 16 pixels * 16 lines of luminance data of a MB. The matching criteria is the sum of the 16 * 16 absolute difference(AD). The motion vector is chosen after comparing the AD according to the following algorithm.

```
MIN = AD(a, b) ;
V  = (a, b) ;
for (y = -7; y < 8: y++)
 for (x = -7; x < 8; x++)
  {
   if(x != 0 | | y != 0)
   {
    if (AD(a+x, b+y) < MIN)
    { MIN = AD(a+x, b+y) ;
      V  = (a+x, b+y) :
    }
   }
  }
```

where the initial value of V(a, b) is the center of the search area. The search is constrained to take place within the boundaries of the significant pel area.
The searching method is the same as SM3 and described below.

First, an integer pel full search in the range of +/-7 is carried out based on offset vectors which is described later.
Second, the eight neighboring half-pel positions are evaluated in the following order.

1 2 3
4 0 5
6 7 8

where 0 represents the integer-pel position.
The values at half-pel positions are calculated as follows:

S(x+0.5, y) = (S(x, y) + S(x+1, y)) // 2 ;
S(x , y+0.5) = (S(x, y) + S(x, y+2)) // 2 ;
S(x+0.5, y+0.5) = (S(x, y) + S(x+1, y) + S(x, y+2) + S(x+1, y+2)) // 4 ;

where x, y are the integer-pel horizontal and vertical coordinates, and S is the pel value. Unlike SM3, data in the same field are used to make interpolated values at vertically half pel positions as shown in Figure 2.2.2. As for the motion vector for vertical position, displace ment of 3, for example, is the half-pel interpolation position made by even field data as shown in thre figure.

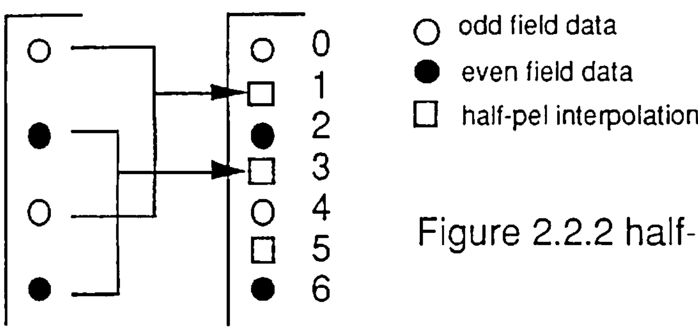


Figure 2.2.2 half-pel interpolation

2.2.3 Field to field motion estimation

In I-picture, motion estimation is performed on the 16 * 16 luminance data of a MB in even field.
In P- and B-picture, 16 * 16 luminance data is split into two sub block named SA and SB.

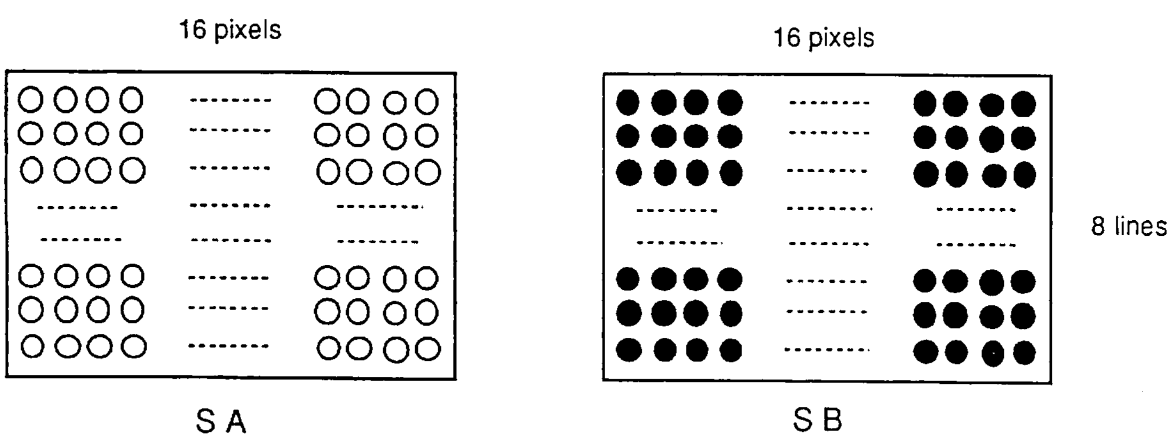


Figure 2.2.3 Field block

Each subblock has a size of 16 pixels * 8 lines. SA only contains odd field data, whereas SB only contains even field data as shown in Figure 2.2.3. The matching criteria is the sum of the 16 * 8 absolute difference(AD). There are two kinds of search area, odd field and even field search areas. The motion estimation for SA is made for both search areas with half pel accuracy, then either the odd or even field search area is selected as a motion estimation of SA. This selection is made by choosing search block which has smaller AD. As for the pixel values at half pel position, the same data as obtained in the frame motion estimation is used since only field data is used to make the interpolated data in the frame motion estimation.

In the same manner as above, the motion estimation for SB is performed.

2.2.4 Frame/Field motion estimation selection

The decision of frame motion estimation or field motion estimation is made by comparing the AD of frame motion estimation (RAD) and the sum of the ADs(LAD) for SA and SB in the field motion estimation. The decision is depicted in Figure 2.2.4. In the figure, frame motion estimation includes the solid line.

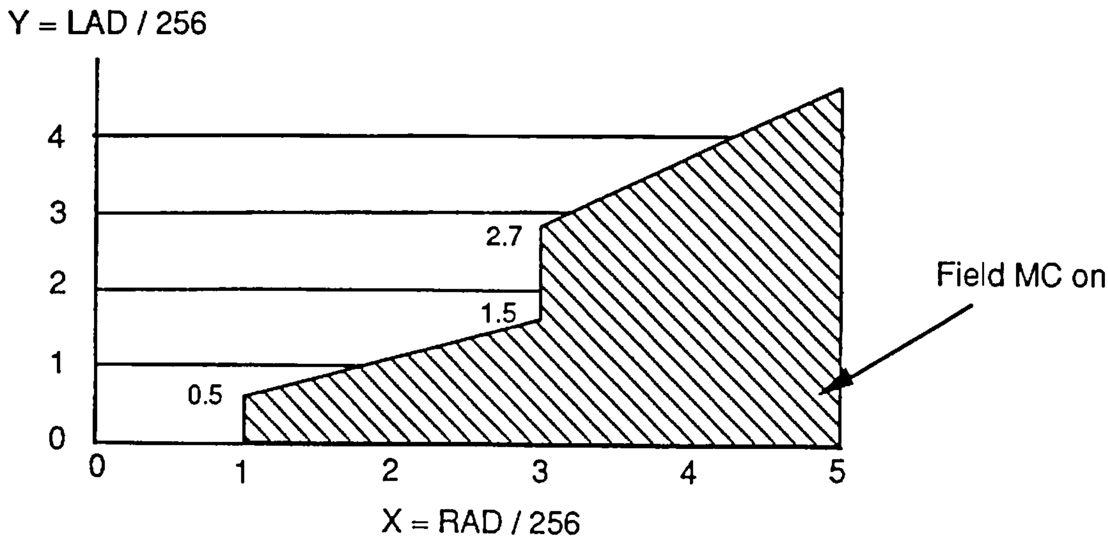


Figure 2.2.4 Frame / Field decision

The offset vectors are given in the following way.

2.2.5 Offset vectors

In I-picture, the offset vector is set to zero.

Let MV(i, j) be the motion vector from the i-th to j-th picture, the following motion vectors are needed for forward, backward, and interpolated compensation in P- and B-pictures.

- for motion-compensated prediction of P-pictures:
  MV(1, 4)
- for forward and interpolative motion compensation of B-pictures:
  MV(1, 2)
  MV(1, 3)
- for backward and interpolative motion compensation of B-pictures:
  MV(4, 3)
  MV(4, 2)

The offset vectors are given in three ways. Suppose (i)th picture is to be predicted
1) Use vectors MV(1, i-1) [MV(4, i+1)] given at the same spatial position in (i-1) [(i+1)]th picture for forward [backward] prediction. The offset vectors are set to zero for estimation of MV(1, 2) and MV(4, 3).
2) Use vectors MV(1, i) [MV(4, i)] obtained at left MB in (i)th picture for forward [backward] prediction. The motion estimation using this offset vector is not carried out when MB is at the start of a slice.
3) Use vectors MV(1, i) [MV(4, i)] obtained at upper MB in (i)th picture for forward [backwar] prediction. The motion estimation using this offset vector is not carried out when MB is in a first slice.

Since the offset vectors may be either frame or field motion estimation, adjustment is necessary to obtain appropriate offset vectors. This adjustment is carried out by considering the temporal relations between motion vectors.

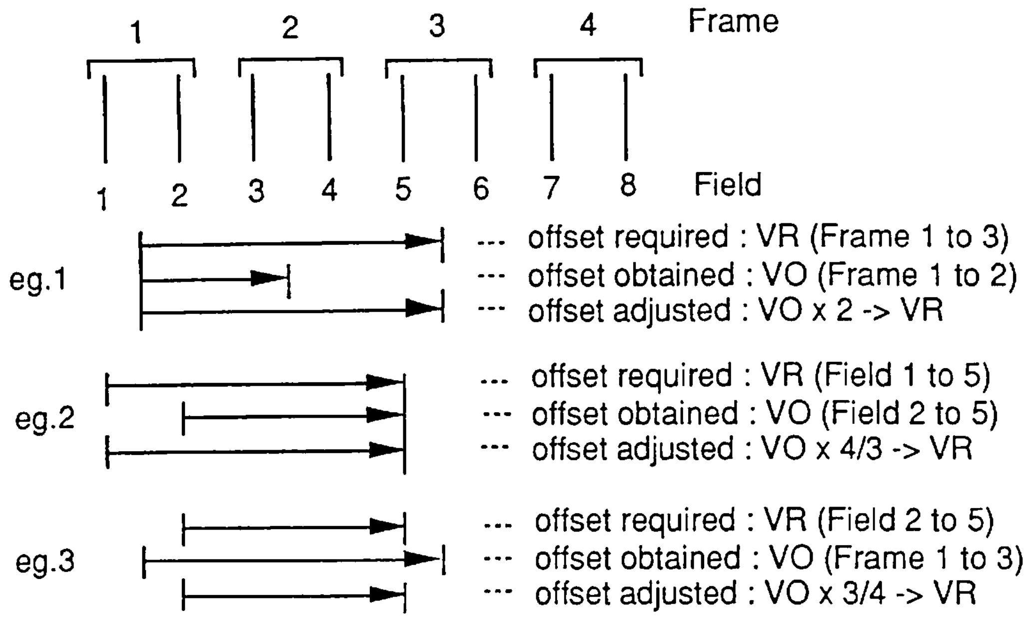


Figure 2.2.5 Offset vector

In each case, the AD's are obtained searching +/-7.5 area with half pel accuracy starting from the offset vectors. The integer part of the absolute values of the horizontal and vertical components of a motion vector must not exceed i * 22.5 for a vector of MV(1, i) or MV(4, i).

2.2.6 Motion decision

Motion decision is carried out for the selected vector. "No motion compensation mode" is selected only if the obtained motion vector is (0, 0).

2.2.7 Forward, backward, and interpolation modes

In B-pictures, either forward, backward, or interpolation mode is decided for the reconstructed image. The mode selection is based on the minimization of a cost function which is the MSE of the luminance difference between the prediction MB and the MB being coded.

2.2.8 Intra mode

Except for odd field data of I-picture, intra mode check is performed for the reconstructed image of each MB.

VAR = (SUM [(OR(i, j) - S(i, j)) * (OR(i, j) - S(i, j))]) / 256 ;
VAROR = (SUM [(OR(i, j) - DC) * (OR(i, j) - DC)]) / 256 ;

where OR(i, j) denotes the pixels in the original MB, S(i, j) denotes the motion compensated pixels of reconstructed MB, and DC = (SUM[OR(i, j)]) // 256. The summation takes place for 16 pixels * 16 lines.

The intra mode decision is carried out as follows:

```
if (VAROR < VAR && VAR > 64)  mode = intra ;
else mode = non intra ;
```

2.2.9 Motion compensation

Forward motion compensation of picture i from picture 1 is performed as follows:
Si(x, y) = S1(x + MVx(1, i)(x, y), y + MVy(1, i)(x, y)) ;

Backward motion compensation of picture i from picture 4 is performed as follows:

Si(x, y) = S4(x + MVx(4, i)(x, y), y + MVy(4, i)(x, y)) ;

Temporal interpolation of picture i from picture 1 and picture 4 is performed as follows:

$Si(x, y) = \{ S1(x + MVx(1, i)(x, y),\ y + MVy(1, i)(x, y)) + S4(x + MVx(4, i)(x, y),\ y + MVy(4, i)(x, y)) \} // 2$;

In case of half pel displacement vectors, spatial interpolation is performed as described in section 2.2.2.

A displacement vector for the chrominance is derived by halving the component values of the corresponding MB vector and rounding the magnitude towards half a pel. For example,

if (MV(lum) >=0 && MV(lum) < 0.5) MV(chr) = 0 ;
if (MV(lum) >=0.5 && MV(lum) < 1) MV(chr) = 0.5 ;

2.2.10 Adaptive overlap motion compensation

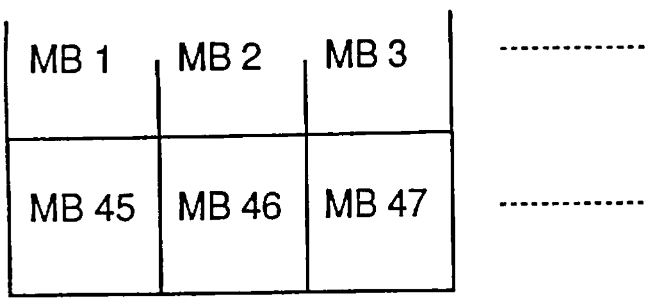
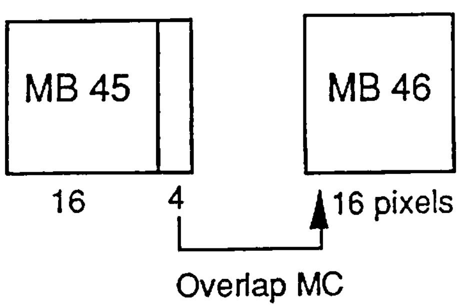


Figure 2.2.9 Overlap motion compensation



After the above process is done for all the MB in the picture, a decision of overlap motion compensation, is made in order to suppress boundary irregularity between MBs.
In each MB, motion compensated image data of neighboring MB extended by 4 pixels and/or 4 lines depending on its position is overlapped to originally motion compensated image. For example, motion compensated image of upper left MB is extended 4 pixels * 4 lines toward the MB in process. In a similar way, the upper MB is extended downward by 4 lines, and the left MB is extended to the right by 4 pixels as is shown in Figure 2.2.9. Therefore, the upper left 4 * 4 block in the current MB has three kinds of overlapped image to the originally motion compensated image. If neighboring MB is intra mode, then that MB is not extended. The overlap motion compensation is obtained by adding all the images and averaging them.

The mode selection of overlap or non-overlap motion compensation is based on the minimization of a cost function which is the MSE of the luminance difference between the prediction MB and the MB being coded.

The overlap motion compensation is not performed for the chrominance data.

2.3 MODES AND MODE SELECTION

2.3.1 Picture modes

For P-picture which is replaced by I-picture in the case of violent motion or scene change, a new picture mode which distinguishes this special I-picture from ordinary I-picture. This mode is called "Scene_change_intra-coded picture" (S-picture). S-picture is treated exactly in the same way as I-picture except for picture_coding_type in picture layer.
[note] Hereafter any description in this proposal regarding to I-picture applies to S-picture unless specified.

- Intra-coded picture

- Predictive-coded picture
- Bidirectionally-coded picture
- DC intra-coded picture
- Scene_change_intra-coded picture

2.3.2 Macroblock types in I-picture

(1) Slice=1 to 15
- Intra

(2) Slice=16 to 30
- No motion compensation not coded
- Motion compensation coded
- No motion compensation coded
- Motion compensation not coded
- Intra

2.3.3 Macroblock types in P-picture

- No motion compensation not coded
- Motion compensation coded
- No motion compensation coded
- Motion compensation not coded
- Intra

In motion compensation mode, there are two steps to specify motion vectors.
- 1 st step : frame / field motion compensation
- 2 nd step : corresponding motion vector

In the field motion compensation, prediction field of odd / even is given for each field to be predicted.

2.3.4 Macroblock types in B-picture

- No motion compensation not coded
- Interpolate, not coded
- Interpolate, coded
- Backwards, not coded
- Backwards, coded
- Forwards, not coded
- Forwards, coded
- Intra

2.3.5 Macroblock types in S-picture

In Scene_change_intra-coded picture(S-picture). the same macroblock types as in I-picture are used.

2.4 TRANSFORMATION AND QUANTIZATION

While mode selection and local motion compensation are based on the MB structure, the quantization is based on blocks of 8 * 8.

2.4.1 Wavelet transform (forward and inverse)

Wavelet transform (forward and inverse) on picture basis is performed. Daubechies wavelet transform at N=2[2] is used and Mallat's scheme[3] is followed for the 3-layered 2-dimensional decomposition and reconstruction of pictures as shown in Annex A. In I-picture, wavelet coefficient plane is obtained by transforming the field (Y:704 * 240, Cb,Cr:352 * 240) of input picture. In P-, B-picture, wavelet coefficient plane is obtained by transforming the entire frame (Y:704 * 480, Cr,Cb:352 * 480).
In any predicted pictures, wavelet transform is performed for both the input and predicted pictures. Otherwise only input picture is wavelet transformed.
Inverse wavelet transform is performed for the wavelet transformed coefficients to obtain reconstructed image.

2.4.2 Quantization overview

Wavelet coefficients are quantized and encoded in a 8 * 8 subblock unit. Each subblock contains layer I to layer III coefficients mapped from wavelet coefficient plane as shown Annex A.

In intra mode block, only transformed coefficients of input block are quantized. In other MBs, the subtracted coefficients of transformed input - predicted data are to be quantized.

However, neighboring MBs to the intra mode MB in P-, B-picture are quantized as intra although motion vectors may also be sent. This happens in order to avoid discontinuity of predicted picture near intra mode MB since wavelet transform has a overlapping nature over the block boundary. Therefore, these MBs may be MC coded with motion vectors but quantization are performed for only transformed coefficients of input block.

1	2	3	4	...
45	46	47	48	...
89	90	91	92	...

if (MB46 == intra)
{ MB1,2,3, are quantized as intra block.
MB45,47, are quantized as intra block.
MB89,90,91 are quantized as intra block. }

[note] Other treatments such as MB type and motion vectors for these MBs (MB1-3, 45, 47, 89-91) are unaffected.

2.4.3 Quantization of I-picture

(1) Slice=1 to 15 (Odd field data)
Wavelet coefficients are quantized in the same way as Intraframe in SM3, in which a uniform quantizer without a dead-zone is used. However, weighting factors are fixed to 16.

a) DC coefficients
The quantized DC value QC(0, 0) is calculated as:

QC(0, 0) = c(0, 0) // 8 ;

where c(0, 0) is the 11-bit unquantized mean value of a block. Reconstruction is obtained by calculating 8 * QC(0, 0).

b) AC coefficients
AC coefficients c(i, j), where i, j != 0, are quantized by using stepsize QP(1, 2, 3..31) given by data rate control which is described in section 2.7.2. The quantized level is then given by

QC(i, j) = c(i, j) // (2 * QP) ;

where QC(i, j) is clamped to +255 and -255. Reconstruction c'(i, j) is obtained by

c'(i, j) = 2 * QP * QC(i, j) ;

(2) Slice=16 to 30
Wavelet coefficients are quantized in the same way as Predicted and Interpolated frames in SM3, in which a flat quantization matrix with a dead-zone is used. However, variable threshold is not used. Intra blocks are quantized as (1) case.
The DC as well as the AC coefficients are quantized equally with a quantizer step QP(1, 2, 3,..,31). Then the quantized value is obtained by

QC(i, j) = c(i, j) / (2 * QP) if QP is odd
QC(i, j) = (c(i, j) + 1) / (2 * QP) if QP is even, c(i, j) > 0
QC(i, j) = (c(i, j) - 1) / (2 * QP) if QP is even, c(i, j) < 0

In neighboring MBs to intra block, AC coefficients are quantized as (1) case. As for DC coefficient, it is quantized as follows:

QC(0, 0) = (c(0, 0) - pdc) / 2 / QP ;
pdc = 128 * 8 if block N= 0, 4, 6 for Y, Cb, Cr, in Figure 2.1.5
pdc = DC of previous block * 8 else previous = N - 1

Reconstruction is obtained by calculating
2 * QP * QC(0, 0) + pdc.

2.4.4 Quantization of P- and B-picture

Wavelet coefficients are quantized in the same way as (2) case of I-picture.

2.4.5 Inverse quantization

The inverse quantization of wavelet coefficients are performed in the same way as SM3. The inverse quantization for reconstruction is defined as follows:

Assume c'(i, j) is reconstructed coefficient

a) DC coefficient in intra block

```
c'(0, 0) = 8 * QC(0, 0) ;
```

b) Other coefficients

```
if (intra block)    k = 0 ;
else
{ if (QC(i, j) > 0)  k = +1 ;
  if (QC(i, j) < 0)  k = -1 ;
}

if (QC(i, j) == 0)  c'(i, j) = 0 ;
else                c'(i, j) = (2 * QC(i, j) + k) * QP ;

if (c'(i, j) is even)
 { if (c'(i, j) > 0)  c'(i, j) = c'(i, j) - 1 ;
   if (c'(i, j) < 0)  c'(i, j) = c'(i, j) + 1 ;
 }
if (c'(i, j) < -2048) c'(i, j) = -2048 ;
if (c'(i, j) >  2047) c'(i, j) =  2047 ;
```

2.4.6 Scanning

Instead of zig-zag scanning in DCT, layer-scanning as shown in Figure 2.4.6 is used.

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

Figure 2.4.6 Wavelet coefficient scanning

2.5 CODING OF MACROBLOCK

The coding of macroblocks are performed in the similar way to MPEG1 Video CD[4].

2.5.1 Macroblock address (MBA)

Macroblock address is defined using variable length codes which are exactly in the same way as CD. Relative addressing is used in coding MBs in all pictures. MBs for which no data is appended are run-length encoded using the MBA; these MBs are called "skipped".
In slice 1 to 15 of I-picture, MBA is sent for each MB.
In P-picture and slice 16 to 30 of I-picture, a MB is skipped MB if motion vector is zero and all its quantized coefficients are zero.
In B-picture, a MB is skipped MB if its quantized coefficients are zero, and MB type and motion vectors are the same as the left MB.

An MBA is a variable length codeword indicating the position of a MB in a slice.The first MB and last MB in a slice shall not be skipped MB. MBA is the difference between the absolute address of the MB and the last transmitted MB. The code table for MBA is given in Table B.1 in ANNEX B.

2.5.2 Overlap motion compensation flag

If there is no skipped MB, the overlap motion compensation flag (omcf) is set as follows.
if (overlap motion compensation) omcf=1 ;
else omcf = 0 ;
If there are skipped MBs, the overlap motion compensation flag for each skipped MB(omcf_skip) is set before setting the omcf of MB being coded. The bit length of omcf_skip is the same as the number of skipped MBs. Therefore, if there are four skipped MBs and overlap motion compensation for each skipped MB is on,off,off,on, then the code "1001" is sent as omcf_skip.
However, if there are more than 21 skipped MBs, an additional flag (omc_on_off) is appended in order to avoid the continuation of more than twenty-three "0"s. If the number of overlap motion compensation "off" is less than or equal to "on" case, omc_on_off is set to "0" and then omcf_skip is sent for the number of skipped MBs. If the number of overlap motion compensation "off" is larger than "on" case, omc_on_off is set to "1" and all the omcf_skip data is reversed so that the number of "1" exceeds that of "0".

2.5.3 Macroblock type

Macroblock type is defined using variable length codes(VLC) based on CD. However, VLC's are slightly modified for additional features such as field/frame motion compensation modes. The MB types are described in section 2.6.9.

2.5.4 Motion vector

Like SM3, motion vectors are coded differentially relative to the last vectors of the same type. The prediction motion vector is set to zero in the MB at the start of a slice, or if the last MB was coded in the intra mode.
Tables in MPEG1 CD are basically used, however +/- 15 table is used for small value of motion vector in order to save bit count and 1-bit is added for this table selection s described in section 2.6.9.

2.5.5 Coded Block Pattern (CBP)

Since there are 4 Y, 2 Cb, and 2 Cr subblocks in a MB, Coded Block Pattern (CBP) codes are extended based on MPEG1 CD.
After quantization, if all the coefficients of a block are zero, the block is declared not coded. If all eight blocks in a MB are not coded, the MB is declared to be not coded. In all other cases, the MB is called coded.
A pattern number defines which blocks within the MB are coded;

Pattern number = 128 * B0 + 64 * B1 + 32 * B2 + 16 * B3 + 8 * B4 + 4 * B5 + 2 * B6 + B7 ;

where Bn is 1 if any coefficient is present for block n, else 0. the numbering is given in Figure 2.1.5.
In intra MB, pattern number is 255.
The code table for CBP is given in Table B.3.

2.5.6 I-picture coding

I-picture is coded in two ways. Slice 1 to 15, which only contain odd field, are coded intra, while slice 16 to 30, which only contain even field, are coded Inter MC which is predicted from slice 1 to 15.
Slice 1 to 15 are coded in a similar way to I-picture of MPEG1 CD, although the weighting factor is fixed to 16. Slice 16 to 30 are coded in the same way as P-picture of MPEG1 CD, although there is no variable threshold in the encoder.

(1) Slice 1 to 15

a) DC prediction

After the DC coefficient of a block has been quantized to a 8 bits, it is coded losslessly by a DPCM technique. Coding of the blocks within a MB follows the normal scan of Figure 2.1.5. Thus the DC value

of block 3,5,7 becomes the DC predictor for block 0,4,6 of the following MB, respectively. At the left edge of a slice, the DC predictors for block 0,4,6 are set to 128.
The difference DC values DDC are first categorized to their SIZE;
SIZE = log2 (abs(DDC)) + 1, if DDC != 0 ;
SIZE = 0, if DDC = 0 ;

For each category, additional bits are appended to the SIZE code to uniquely identify which difference in that category. If SIZE =3, 3 bits are used as additional bits in which DDC = -3 to 3 are coded as 000 to 111. The VLC code tables for SIZE are shown in Table B.5a-b.

b) AC coefficients

The combinations of successive zeros(RUN) and the following value(LEVEL) are encoded with variable length codes shown in Table B.5c-g. Other combinations of (RUN,LEVEL) are encoded with a 20 or 28 bit word consisting of ESCAPE,RUN and LEVEL as shown in Table B.5c-g. In every coded block EOB is appended to distinguish block boundary. The scanning is shown in Figure 2.4.6.

(2) Slice 16 to 30

a) Intra blocks

Intra blocks are coded as in slice 1-15 as described above. The DC predictor for B0,B4,B6 are reset to 128, unless the previous block was also intra; in this case, the predictors are obtained from the previous block.

b) Non intra blocks
The combinations of successive zeros(RUN) and the following value(LEVEL) are encoded in the same way as (1)-b) case including the (0,0) coefficient. The neighboring MBs to intra MB are also coded in this way.

2.5.7 P- and B-picture coding

P- and B-picture coding are performed in the same way as slice 16 to 30 of I-picture.

2.5.8 Coding of transform coefficients

The same run-level table of MPEG1 CD is used for the coding of transform coefficients as shown in Table B.5. The scanning order is shown in Figure 2.4.6.

2.6 VIDEO MULTIPLEX

Bit stream is constructed and reconstructed according to MPEG1 CD.
Beginning with video sequence layer, bit stream consists of group of picture (GOP) layer, picture layer, slice layer, macroblock layer, and block layer.
In video sequence layer, from GOP layer to slice layer, bit stream is constructed in the same way as MPEG1 CD.

2.6.1 Bit stream syntax

The mnemonics for bit stream are:

bslbf : Bit string, left bit first, where "left" is the order in which bit strings are written in the standard. Bit strings are written as a string of 1s and 0s within single quote marks, e.g. '1000 0001'. Blanks within a bit string are for ease of reading and have no significance.
uimsbf : Unsigned integer, most significant bit first.
vlclbf : Variable length code, left bit first.

2.6.2 Start codes

Exactly the same start codes as MPEG 1 CD are used. The codes are shown below.

name	hexadecimal value
picture_start_code	00000100
slice_start_codes (including slice_vertical_positions)	00000101 through 000001AF
reserved	000001B0
reserved	000001B1
user_data_start_code	000001B2
sequence_header_code	000001B3
sequence_error_code	000001B4
extension_start_code	000001B5
reserved	000001B6
sequence_end_code	000001B7
group_start_code	000001B8
system start codes	000001B9 through 000001FF

2.6.3 Next_start_code

Next_start_code is used as byte alignment and byte stuffing in the same way as MPEG1.

```
next_start_code() {
  while ( !bytealigned() )
    zero_bit                                        1        "0"
  while ( nextbits() != '0000 0000 0000 0000 0000 0001' )
    zero_byte                                       8        "00000000"
}
```

2.6.4 Video sequence layer

A video sequence starts with a sequence header and is followed by one or more GOPs and is ended by a sequence_end_code.

```
video_sequence() {
 next_start_code()
 do {
   sequence_header()
   do {
      group_of_pictures()
   }  while ( nextbits() == group_start_code )
 } while ( nextbits() == sequence_header_code )
 sequence_end_code                                  32       bslbf
}
```

2.6.5 Video sequence header

In this data stream, basic structure is the same as MPEG1, but several points described below are modified..

```
sequence_header() {
 sequence_header_code                               32       bslbf
 horizontal_size                                    12       uimsbf
 vertical_size                                      12       uimsbf
 pel_aspect_ratio                                   4        uimsbf
 picture_rate                                       4        uimsbf
 bit_rate                                           18       uimsbf
 marker_bit                                         1        "1"
 vbv_buffer_size                                    10       uimsbf
 constrained_parameter_flag                         1
 load_intra_quantizer_matrix                        1
```

```
if ( load_intra_quantizer_matrix )
   intra_quantizer_matrix[64]                      8*64        uimsbf
load_non_intra_quantizer_matrix                    1
if ( load_non_intra_quantizer_matrix )
   non_intra_quantizer_matrix[64]                  8*64        uimsbf
next_start_code()
if (nextbits() == extension_start_code ) {
   extension_start_code                            32          bslbf
   while ( nextbits () != '0000 0000 0000 0000 0000 0001' ) {
      sequence_extension_data                      8
   }
   next_start_code()
}
if (nextbits() == user_data_start_code ) {
   user_data_start_code                            32          bslbf
   while ( nextbits() != '0000 0000 0000 0000 0000 0001' ) {
      user_data                                    8
   }
   next_start_code()
}
}
```

In this structure, following points are modified from MPEG1.
a)**horizontal_size** : set to 704
b)**vertical_size** : set to 480
c)**pel_aspect_ratio** : set to "1100"
d)**contrained_parameters_flag** : set to "0"
e)**load_intra_quantizer_matrix** : set to "0"
f)**load_non_intra_quantizer_matrix** : set to "0"
The distinction of between MPEG1 and MPEG2 is made by a) to c).

2.6.6 GOP layer

A GOP is a series of one or more pictures intended to assist random access to the sequence. The orders of encoder input, encoder output, and the decoder output are as follows.

At the encoder input
```
X  1I   2B   3B   4P   5B   6B   7P   8B   9B   10P X 11B  12B
   13I  14B  15B  16P  17B  18B  19P  20B  21B  22P X 23B  24B
   25I  ...
```

At the encoder output
```
X 1I   4P   2B   3B   7P   5B   6B   10P  8B   9B X
  13I  11B  12B  16P  14B  15B  19P  17B  18B  22P
  20B  21B X 25I 23B  24B  ...
```
where "X"s mark the GOP boundaries.

At the decoder output
```
        1    2    3    4    5    6    7    8    9
   10   11   12   13   14   15   16   .....
```

```
group_of_pictures() {

    group_start_code                               32 bits     bslbf
    time_code                                      25
    closed_gop                                     1
    broken_ link                                   1
    next_start_code()
    if ( nextbits() == extension_start_code ) {
       extension_start_code                        32          bslbf
       while ( nextbits() != '0000 0000 0000 0000 0000 0001' ) {
          group_extension_data                     8
       }
       next_start_code()
    }
    if ( nextbits() == user_data_start_code ) {
```

```
        user_data_start_code                                    32          bslbf
        while ( nextbits() != '0000 0000 0000 0000 0000 0001' ) {
           user_data                                            8
           }
        next_start_code()
        }
    do {
       picture()
       } while ( nextbits() == picture_start_code )
    }
```

The structure of time code is shown below.

time_code	range of value	bits	
drop_frame_flag		1	
time_code_hours	0 - 23	5	uimsbf
time_code_minutes	0 - 59	6	uimsbf
marker_bit	1	1	"1"
time_code_seconds	0 - 59	6	uimsbf
time_code_pictures	0 - 59	6	uimsbf

2.6.7 Picture layer

The structure of picture layer is almost the same as MPEG 1 CD except that thre is not "if clause" for forward vector since all the picture including I-picture has motion vectors.

```
picture() {

   picture_start_code                                           32 bits    bslbf
   temporal_reference                                           10         uimsbf
   picture_coding_type                                          3          uimsbf
   vbv_delay                                                    16         uimsbf
        full_pel_forward_vector                                 1
        forward_f_code                                          3          uimsbf
    if ( picture_coding_type == 3 ) {
        full_pel_backward_vector                                1
        backward_f_code                                         3
        }
    while ( nextbits() == '1' ) {
        extra_bit_picture                                       1          "1"
        extra_information_picture                               8
    }
     extra_bit_picture                                          1          "0"
    next_start_code()

    if (nextbits() == extension_start_code ) {
        extension_start_code                                    32         bslbf
        while ( nextbits() != '0000 0000 0000 0000 0000 0001' ) {
          picture_extension_data                                8
          }
       next_start_code()
       }
    if ( nextbits() == user_data_start_code ) {
       user_data_start_code                                     32         bslbf
       while ( nextbits() != '0000 0000 0000 0000 0000 0001' ) {
          user_data                                             8
          }
        next_start_code()
        }
    do {
       slice()
    } while ( nextbits() == slice_start_code )

  }
```

the temporal_reference is an unsigned integer starting 0 to 11 which associate with each input picture.

The codes for picture_coding_type is shown below.

picture_coding_type	coding method
000	forbidden
001	intra-coded (I)
010	predictive-coded (P)
011	bidirectionally-predictive (B)
100	dc intra-coded (D)
101	scene_change_intra-coded(S)
110	reserved
111	reserved

There are five types of pictures that use different coding methods.
An I-picture is coded using information only from itself. A P-picture is a picture which is coded using motion compensated prediction from a past I-picture or P-picture. A B-picture is a picture which is coded using motion compensation from a past and/or future I-picture or P-picture. A DC intra-coded picture is intra-coded picture with only dc coefficients (D) according to the following table. D-pictures shall never be included in the same video sequence as the other picture coding types. In P-picture, if scene_change_flag is set to "1", Scene_change_intra_coded (S) is selected as describe in section 2.7. A Scene_change_intra-coded picture is coded exactly in the same way as I-picture.

The vbv_delay is used to set the initial occupancy of the decoder's buffer at the start of play and is calculated as

vbv_delay = 90000 * B / R ;
where B = VBV occupancy before removing picture from the buffer
R = bit rate

The full_pel_forward_vector and full_pel_backward_vector are set to "0" so that half pel operation is performed.
The forward_f_code is an unsigned integer taking values from 1 through 7. The forward_r_size and forward_f are derived from forward_f_code as follows:

forward_r_size = forward_f_code - 1
forward_f = 1 << forward_r_size

In this proposal, forward_f_code is set to 3,4,5 for first B-picture, second B-picture, and P-picture, respectively.
The backward_f_code is an unsigned integer taking values from 1 through 7. The backward_r_size and forward_f are derived from forward_f_code as follows:

backward_r_size = backward_f_code - 1
backward_f = 1 << backward_r_siz

In this proposal, backward_f_code is set to 4,3 for first B-picture, and second B-picture, respectively.
The extra_bit_picture is set to "0".

2.6.8 Slice layer

A slice consists of 44 macroblocks from left to right in a picture. The structure of slice layer is exactly the same as MPEG1 CD.

```
slice() {


    slice_start_code                          32 bit     bslbf
    quantizer_scale                           5          uimsbf
    while ( nextbits() == '1' ) {
        extra_bit_slice                       1          "1"
        extra_information_slice               8
    }
    extra_bit_slice                           1          "0"
   do {
```

```
    macroblock()
    } while ( nextbits() != '000 0000 0000 0000 0000 0000' )
    next_start_code()
}
```

slice_vertical_position is the last eight bits of the slice_start_code. It is an unsigned integer starting with 1 at first row.
quantizer_scale is an unsigned integer in the range 1 to 31 which is describe as QP in section 2.4.

2.6.9 MB layer

A MB contains a 16 pel * 16 line section of luminance component Y and the spatially corresponding 8 pel * 16 line section of each chrominance component Cb,Cr. A MB consists of 8 blocks as shown in Figure 2.1.5.

In macroblock layer, contents and bit amount of macroblock type, motion vector codes, and coded block pattern are modified and overlap motion compensation flag is added as below.

```
macroblock() {

    while ( nextbits() == '0000 0001 111' )
        macroblock_stuffing                              11 bits      vlclbf
    while ( nextbits() == '0000 0001 000' )
        macroblock_escape                                11           vlclbf
    macroblock_address_increment                         1-11         vlclbf
    if (fix macroblock exist)
    { if (macroblock_address_increment < 22)
          omcf_skip                                      1-21         uimsb
      else
      { omc_on_off                                       1            uimsb
        omc_skip                                         1-42         uimsb
      }
    }
    omcf                                                 1            uimsb
    macroblock_type                                      1-6          vlclbf
    if ( field_escape )
        macroblock_sub_type                              1-5          vlclbf
    if ( macroblock_motion_forward_odd ||
        macroblock_motion_forward_frame )
      { motion_horizontal_forward_code                   1-11         vlclbf
      if ( motion_horizontal_forward_code != 0 )
        { mvd_length_flag                                1            uimsb
          if ( mvd_length_flag )
          motion_horizontal_forward_r                    1-6          uismbf
        }

      motion vector vertical in the same way as horizontal case
       }

    if ( macroblock_motion_forward_even )
      {
     motion vector even in the same way as odd case
      }

    if ( macroblock_motion_backward )
      {
     motion vector backward in the same way as forward case
      }

    if ( macroblock_pattern)
       coded_block_pattern                               3-12         vlclbf
     for ( i=0; i<6; i++ )
        block( i )
    if ( picture_coding_type == 4 )
        end_of_macroblock                                1            "1"
}
```

macroblock_stuffing is a fixed bit string "0000 0001 111" which is used to increase bitrate to the required bit amount. However in the proposed algorithm, this code is not used.

macroblock_escape is a fixed bit_string "0000 0001 000" which is used when macroblock_increment exceeds 33. If macroblock_increment - 33 is more than 0, the difference is sent by the macroblock_increment.

macroblock_address_increment is a variable length coded integer code which indicates the difference between macroblock_address and previous_macroblock_address.
The codes are shown in Table B.1.

omcf_skip is used when there are skipped MBs. It indicates the status of overlap motion compensation for skipped MBs as described in section 2.5.2.
omc_on_off indicates if the overlap motion compensation flag is normal or reverse as described in section 2.5.2.
omcf indicates the status of overlap motion compensation for MB being coded as described in section 2.5.2.

The codes for macroblock_type are shown in Table B.2.

macroblock_sub_type is used to indicate that field motion compensation is used. The codes for macroblock_sub_type are shown in Table B.2d,f.

In the following, motion vector coding is described for horizontal vector of frame motion compensation as a example.

The coding of motion vector is almost the same as MPEG 1 CD, however there are some additional features such as field motion compensation and mvd_length_flag.

Assume mvs = motion vector - previous motion vector.
If mvs = 0, only motion_horizontal_forward_code is sent using Table B.4.
If mvs is within +/- 16, mvd_length_flag is set to "0" and mvs is coded using only Table B.4 as motion_horizontal_forward_code.

In other cases,

```
max = (16 * forward_f) -1 ;
min = (-16 * forward_f) ;
if (mvs <= max && mvs >= min) mvn = mvs ;
else
{ if (mvs >0) mvn = mvs - 32 * forward_f ;
  else       mvn = mvs + 32 * forward_f ;
}
if (mvn>0)
{ mvf = (mvn -1)/ forward_f + 1 ;
  mvc = forward_f - 1 - (mvf * forward_f - mvn)   ;
}
else
{ mvf = (mvn +1)/ forward_f - 1 ;
  mvc = forward_f - 1 - (mvn - mvf * forward_f)   ;
}
```

The values of mvf is coded as motion_horizontal_forward_code using Table B.4. The values of mvc is coded as motion_horizontal_forward_r using bit length of forward_r_size.

In the case of field motion compensation, the above coding is performed for both odd and even fields. In this case different treatment is taken for vertical motion vector in order to specify which field is used as motion vector. The field motion vector obtained in motion estimation stage is converted to the motion vectors which includes both fields. For example, if the obtained motion vector is 1 in the even field, the converted vector is 3 as shown in Figure 2.6.9. Then the same process starting with mvs is carried out as above. As for forward_f and backward_f, these values are multiplied by 2 for vertical motion vector since maximum of +/- 22.5 with half pel for each field yields +/- 45 for converted motion vector range. In other words, forward_f for horizontal vector of first B-picture is 3, for example, as mentioned in section 2.6.7, but 4 is used for vertical vector.

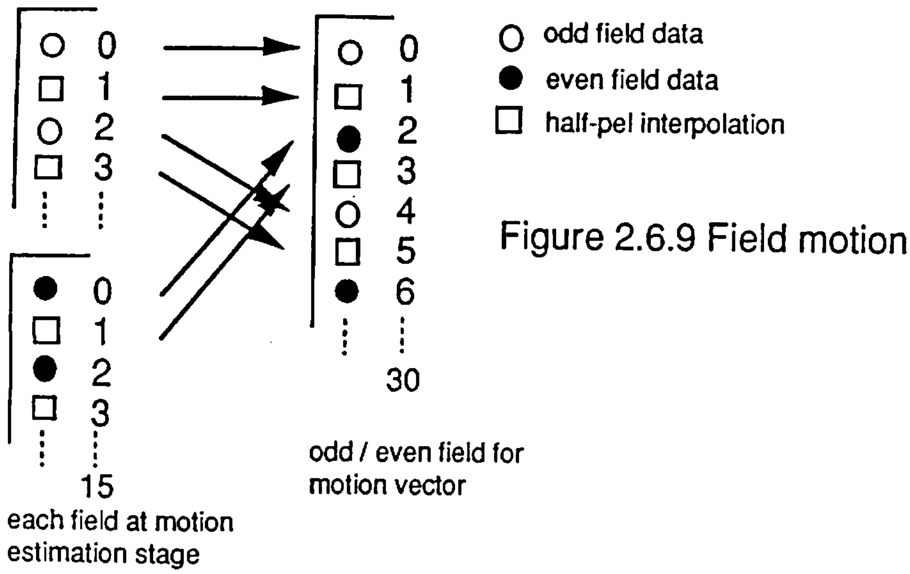


Figure 2.6.9 Field motion vector

The code table for CBP is given in Table B.3.

2.6.10 Block

A block is an orthogonal 8 pel * 8 line section of a luminance or chrominance component. The structure of block is the same as MPEG1 CD.

```
block( i ) {

    if ( pattern_code[i] ) {
      if ( macroblock_intra ) {
        if ( i<4 ) {
          wvt_dc_size_luminance                    2-7     vlclbf
         if(wvt_dc_size_luminance != 0)
            wvt_dc_differential                    1-8     uimsbf
          }
        else {
          wvt_dc_size_chrominance                  2-8     vlclbf
          if(wvt_dc_size_chrominance !=0)
            wvt_dc_differential                    1-8     uimsbf
          }
        }
      else {
        coeff_first                                2-28    vlclbf
        }
     if ( picture_coding_type != 4 ) {
        while ( nextbits() != '10')
          coeff_next                               3-28    vlclbf
        end_of_block                               2       "10"
        }
      }
 }
```

2.7 SCENE CHANGE CHECK AND DATA RATE CONTROL

2.7.1 Scene change check

Scene change check is performed before encoding a picture. For a picture with violent motion or after scene change, P-picture is replaced by I-picture in order to improve coding efficiency.

If the absolute difference of each frame(ADF) of P-picture exceeds half of that of I-picture, scene_change_flag is set to "1" and scene_change_intra_picture is selected as a picture type. The ADF is obtained from motion estimation stage by gathering absolute difference of each MB in P- and B-picture. In first 15 slices of I-picture, absolute difference of MB is obtained by using the average of MB as a prediction.

This check is performed for all the P-pictures in a GOP. Therefore, a picture can not be encoded until motion estimation of all the pictures in a GOP is carried out.

2.7.2 Data rate control

Data rate control is performed in a similar way to SM3, in which target bit and quantizer step are calculated for each slice. However, in order to control bit amount more precisely, a different measure is taken for this rate control.
The data rate control is performed by the following two steps.

At first, target bit amount for each picture of GOP is defined. This decision is done by comparing absolute difference of each frame(ADF). This difference is obtained in the same way as section 2.7.1. More bits are allocated for frames which have larger ADF. Therefore, like section 2.7.1, a picture can not be encoded until motion estimation of all the pictures in a GOP is carried out.

Next, target bit amount for each slice is calculated according to absolute difference of each slice(ADS). This difference is obtained in the same way as above and bit allocation is decided by the value of ADS in a frame. At the same time, quantizer step for the slice is calculated according to ADS. After the slice is encoded, the bit amount is inspected and the encoding of that slice is repeated if the bit amount is out of the allowable target bit amount range.
In the following, the detail of the above control is described:

1) Data rate control for each picture

```
/* P : picture number in Figure 2.1.2 */
/* TBF : target bit for the picture */
/* BRT : bit rate, bit / sec */

 ADG = 0 ;                      /* total dif in a GOP */
 TBG = BRT / 30 * 12 ;          /* target bit for a GOP */

/* After motion estimation of all the pictures in a GOP */

 for (P=1; P<13; P++)
 {
  if (P==1) ADF = ADF * W1 ;           /* I-picture */
  else if ((P-1) % 4 == 3)             /* P-picture */
     { if (scene_change_flag == 1)
      { if (P == 4) ADF = ADF * W2 ;
        else if (P == 7) ADF = ADF * W3 ;
        else if (P == 10) ADF = ADF * W4 ;
     }
      else  ADF = ADF * W5 ;
   }
  else ADF = ADF * W6 ;                /* B-picture */
  ADG += ADF ;
 }
 TBF = TBG * ADF / ADG ;

  encode_each_picture() ;
```

a) 4 Mbit/sec case
BRT = 4,000,000, W1=0.75, W2=2, W3=1.5, W4=1, W5=1.5, W6=1,
b) 9 Mbit/sec case
BRT = 9,000,000, W1=0.6, W2=2, W3=1.5, W4=1, W5=1.7, W6=1.4,

(2) Data rate control for each slice

```
/*  QP : quantizer step as in section 2.4  */
/*  BUF : amount of virtual buffer  */
/*  BUFS : start BUF  */
/*  BUFD : buffer difference  */


/* Before encoding the first slice of each picture */

  if (!B-picture)
   { ADST = 0 ;
     for (S=1; S<31; S++) ADST += sqrt(ADS) ;
   }
  for (S=1; S<31; S++)
  { if (B-picture) TBS = TBF / 30 ;  /* TBS : target bit for the slice */
    else TBS = TBF * sqrt(ADS) /  ADST ;
  }

  if (first I-picture in a sequence) QP = 8 ;
  else QP = QP at first slice of last I-picture
  if (first P-picture in a sequence) QP = 10 ;
  else QP = QP at first slice of last P-picture
  if (first B-picture in a sequence) QP = 12 ;
  else QP = QP at first slice of last B-picture

  BUFS = QP * 4000 + 2000, BUF = BUFS ;
  BUFD = TBS / B ; ( B=4 if 4Mbit/s, B=8 if 9 Mbit/s)

/* After encoding a slice S of each picture */

  BUF += BITS ; /* BITS : bit amount in the slice */
  BUF -= TBS :
  if (BUF > BUFS && QP != 31)
    { QP ++ ; /* increment QP */
        slice (S) ; /* REPEAT encoding the past slice */
    }
  else if (BUFS - BUF > BUFD && QP != 1)
    { QP -- ; /* decrement QP */
        slice (S) ; /* REPEAT encoding the past slice */
    }
  else
   {
     QP = QP ; /* same QP */
     slice (S+1) ; /* encode the next slice */
   }
```

3 DECODING ALGORITHM

3.1 VARIABLE LENGTH DECODING (VLD)

In the VLD, coded information is decoded from the sequence layer to block layer by following the syntax described in section 2.6.

3.2 INVERSE QUANTIZAYION

In inverse quantizer, every 8 * 8 block data is inverse quantized in the same way as section 2.4.5.

3.3 WAVELET TRANSFORM (forward and inverse)

The wavelet transform (forward and inverse) is performed for the entire picture as described in section 2.4.1.

3.4 MOTION COMPENSATION

The motion compensation is performed for the even field of I-picture, P-picture, and B-picture. Almost the same process as MPEG 1 CD is applied to obtain motion vectors except that +/- 16 table is used if mvd_length_flag is set to "0" and that field motion compensation is employed if the field motion compensation is specified in MB type. The adaptive overlap motion compensation is applied as described in section 2.2.9 and 2.5.2.
The general descriptions of motion compensation and motion vector are described in section 2.2 and section 2.6.9.

3.5 I-PICTURE DECODING

In the bit stream, the order of the coded picture follows
1I 4P 2B 3B 7P 5B 6B 10P 8B 9B ...
as explained in section 2.6.6.
In the I-picture, the data obtained in first 15 slices construct odd field of I-picture by using inverse quantization and inverse wavelet transformation.
The data in next 15 slices contain transformed coefficients and motion vectors which are used to predict the even field from the odd field. The predicted field is wavelet transformed and the transformed coefficients are added to the inverse quantized values. Then the even field is reconstructed by inverse wavelet transformation. The neighboring MBs to intra mode block are decoded as intra as shown in section 2.4.

3.6 P-PICTURE DECODING

In this case, each MB contains frame data in which odd and even line appears alternately. The adaptive frame / field motion compensation as well as overlap motion compensation are employed as described in section 2.2. The reconstructed P-picture is obtained by inverse wavelet transform of
(wavelet transformed coefficients of predicted picture) + (inverse quantized data).

3.7 B-PICTURE DECODING

B-picture decoding is performed in the same way as P-picture except that motion compensation can be carried out through forward, backward or interpolated prediction from the past I/P-picture and future I/P-picture.

4. COMPATIBILITY

Compared with MPEG1, the proposed algorithm differs in DCT, motion compensation, picture size, and data coding mainly of MB layer. However, by preparing DCT coefficients and several tables of MPEG1, forward compatibility to MPEG1 can be achieved. Recognition of MPEG2 is made through horizontal size, vertical size, and constrained_parameter_flag in the sequence layer.

5. ADDITIONAL PERFORMANCE

5.1 FAST PLAY (forward and reverse)

Fast play in forward and reverse can be achieved by decoding I-picture and displaying each picture for a given length of time. Since a GOP consists of 12 pictures, 12 * fast play is possible by displaying each I-picture for 1/30 sec and 2 * fast play by displaying each I-picture for 6/30 sec.

For a simpler hardware implementation of fast play, only the information of slice 1 to 15 of I-picture can be decoded and fast play pictures are displayed using only odd fields since odd and even field data in I-picture are stored separately.

5.2 RANDOM ACCESS

Random access to any image in the coded sequence is either one or two stage process depending on whether the target is an I-picture or not. If the target picture is I-picture, then only the first picture is decoded in the GOP. In other pictures, the target picture is decoded after decoding I-picture and associating P-picture if necessary which are in the same GOP as the target picture.

6. CODING / DECODING DELAY

Since the encoder requires 12 pictures to investigate scene change and to determine bit amount for each picture in order to perform precise data rate control, more than 12 pictures (0.4 sec) delay is necessary. In the decoder, more than 3 pictures delay is necessary since there are two B-pictures in between I/P pictures.

7. STATISTICS

The statistics of 7 sequences at 4,9 Mbit/s are shown in ANNEX C.
Due to the strict data rate control, none of the bit amount for each GOP exceeds the target bit and the difference from the target bit is very small $< 0.1\%$.

8. BIT STREAM LIST

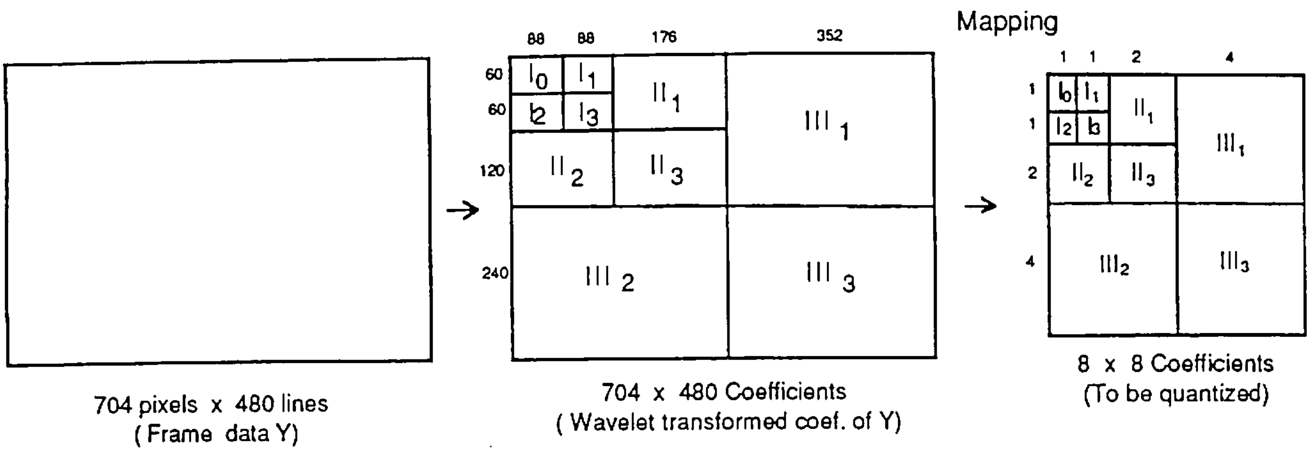
ANNEX D shows the bit stream list of test sequences.

REFERENCES

[1] ISO/IEC/JTC1/SC2/WG11 MPEG90/041, "MPEG Video Simulation Model Three (SM3)," Jul.1990.
[2] Daubechies, I, "Orthonormal bases of compactly supported wavelets," Communications in Pure and Applied Mathematics, vol.41, pp.909-996, Nov.1988.
[3] Mallat, S, "A theory for multiresolution signal decomposition: the wavelet representation," IEEE Trans. Pattern Anal. Machine Intell., vol.PAMI-11, pp.674-693,Jul.1989.
[4] ISO/IEC/JTC1/SC2/WG11 CD 11172-2, "Coding of Moving Pictures and Associated Audio -- For Digital Storage Media at up to about 1.5Mbit/s -- Part 2 Video," Aug.1991.

ANNEX A

1. Forward wavelet transform (Frame data Y case)



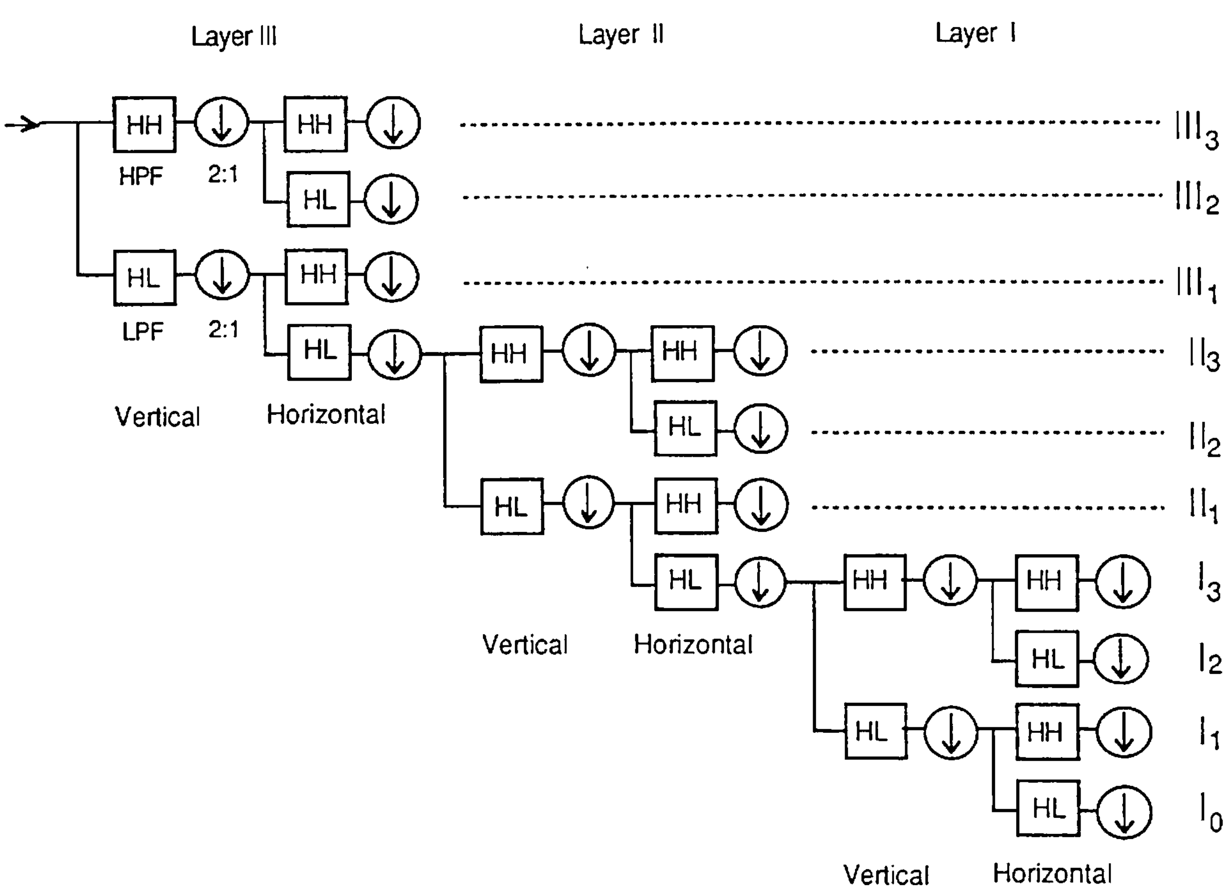
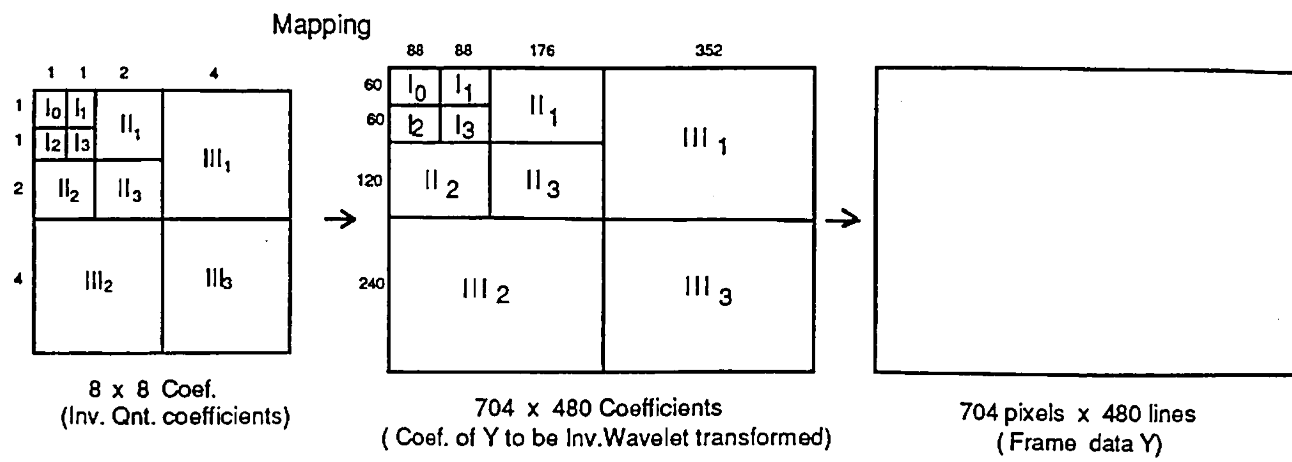


Figure A.1 Schematic diagram of 2-D 3-layer forward wavelet transform

2. Inverse wavelet transform (Frame data Y case)



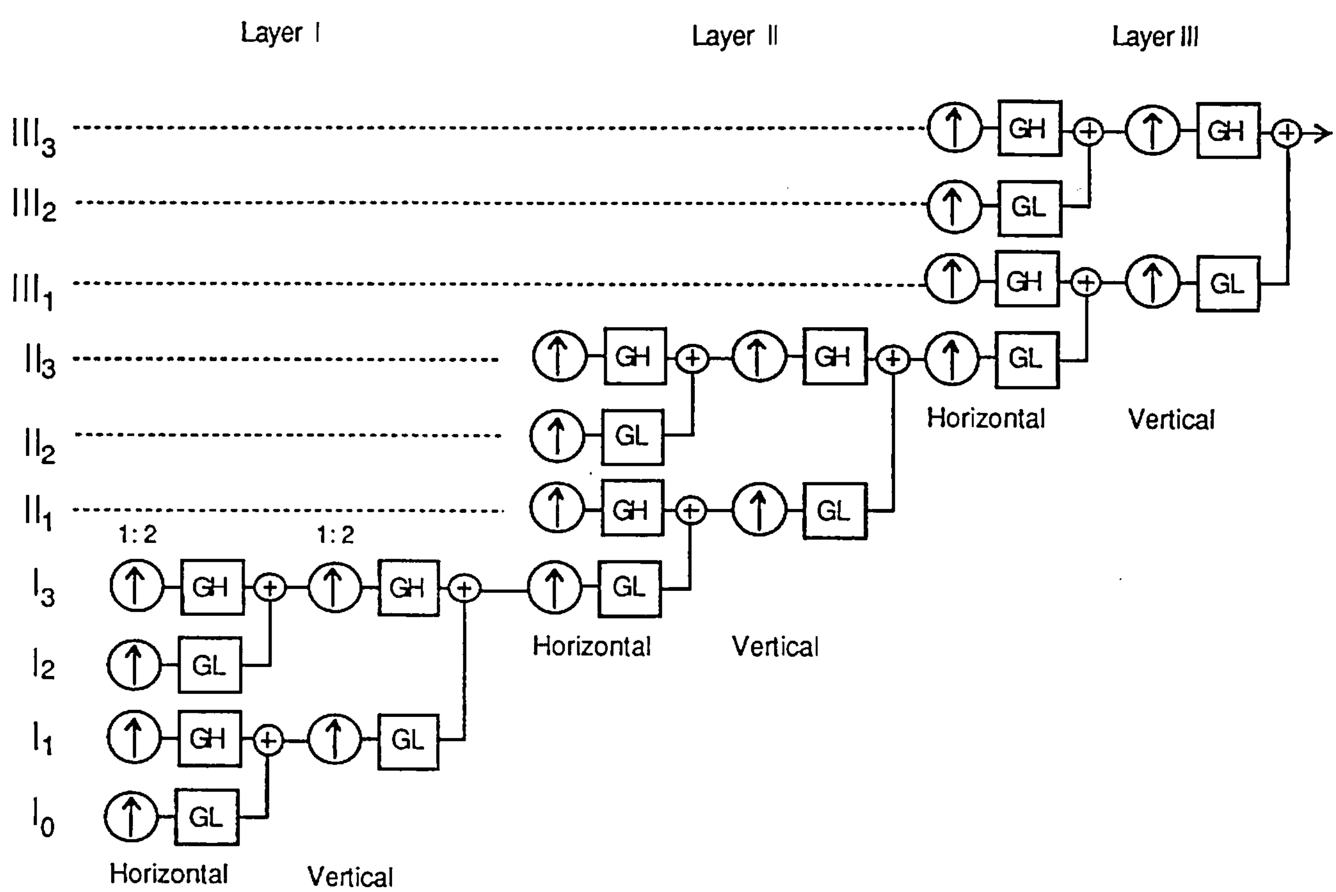


Figure A.2 Schematic diagram of 2-D 3-layer inverse wavelet transform

ANNEX B

VARIABLE LENGTH CODE TABLES

Introduction

This annex contains the variable length code tables for macroblock addressing, macroblock type, macroblock pattern, motion vectors, and wavelet transform coefficients.

B1. Macroblock Addressing

Table.B.1 Variable length codes for macroblock_address_increment.

macroblock_address_ increment VLC code	increment value	macroblock_address_ increment VLC code	increment value
1	1	0000 0101 10	17
011	2	0000 0101 01	18
010	3	0000 0101 00	19
0011	4	0000 0100 11	20
0010	5	0000 0100 10	21
0001 1	6	0000 0100 011	22
0001 0	7	0000 0100 010	23
0000 111	8	0000 0100 001	24
0000 110	9	0000 0100 000	25
0000 1011	10	0000 0011 111	26
0000 1010	11	0000 0011 110	27
0000 1001	12	0000 0011 101	28
0000 1000	13	0000 0011 100	29
0000 0111	14	0000 0011 011	30
0000 0110	15	0000 0011 010	31
0000 0101 11	16	0000 0011 001	32
		0000 0011 000	33
		0000 0001 111	macroblock_stuffing
		0000 0001 000	macroblock_escape

B2. Macroblock Type

Table B.2a Variable length codes for macroblock_type in intra-coded even field (I-pictures).

VLC code	macroblock_ intra
1	1

Table B.2b Variable length codes for macroblock_type in predictive-coded odd field (I-pictures).

VLC code	macroblock_ motion_forward	macroblock_ pattern	macroblock_ intra
1	1	1	0
01	1	0	0
001	0	1	0
0001	0	0	1

Table B.2c Variable length codes for macroblock_type in predictive-coded pictures (P-pictures).

VLC code	macroblock_field_esc	macroblock_motion_forward	macroblock_pattern	macroblock_intra
1	1	0	0	0
01	0	1	1	0
001	0	1	1	0
0001	0	0	0	0
00001	0	0	0	1

Table B.2d Fixed length codes for macroblock_sub_type in predictive-coded pictures (P-pictures).

VLC code	macroblock_motion_forward_even	macroblock_motion_forward_odd	macroblock_pattern
1	1	1	1
0	1	1	0

Table B.2e Variable length codes for macroblock_type in bidirectional-coded pictures (B-pictures).

VLC code	macroblock_field_esc	macroblock_motion_forward	macroblock_motion_backward	macroblock_pattern	macroblock_intra
1	1	0	0	0	0
011	0	1	1	1	0
010	0	1	1	0	0
0011	0	1	0	1	0
0010	0	0	1	1	0
00011	0	1	0	0	0
00010	0	0	1	0	0
00001	0	0	0	0	1

Table B.2f Variable length codes for macrobock_sub_type in bidirectional-coded pictures (B-pictures).

VLC code	macroblock_motion_forward_even	macroblock_motion_forward_odd	macroblock_motion_backward_even	macroblock_motion_backward_odd	macroblock_pattern
110	1	0	1	1	1
111	1	1	1	0	1
011	1	1	1	1	1
101	1	0	1	1	0
100	1	1	1	0	0
010	1	1	1	1	0
0011	1	1	0	0	1
0010	0	0	1	1	1
00011	1	1	0	0	0
00010	0	0	1	1	0

B3. Macroblock Pattern

Table B.3 Variable length codes for coded_block_pattern.

coded_block_pattern VLC code	cbp	coded_block_pattern VLC code	cbp
111	240	0000 1011 01	113
1101	16	0000 1011 00	114
1100	32	0000 0111 01	116
1011	64	0000 0111 00	120
1010	128	0000 1011 11	115
1001 1	48	0000 0111 11	124
1000 1	80	0000 1010 01	177
1000 0	160	0000 1010 00	178
1001 0	192	0000 0110 01	180
0111 1	112	0000 0110 00	184
0111 0	176	0000 1010 11	179
0110 1	208	0000 0110 11	188
0110 0	224	0000 1001 01	209
0011 11	96	0000 1001 00	210
0011 10	144	0000 0101 01	212
0101 101	1	0000 0101 00	216
0101 100	2	0000 1001 11	211
0100 101	4	0000 0101 11	220
0100 100	8	0000 1000 01	225
0101 111	3	0000 1000 00	226
0100 111	12	0000 0100 01	228
0101 001	241	0000 0100 00	232
0101 000	242	0000 1000 11	227
0100 001	244	0000 0100 11	236
0100 000	248	0000 0011 11	127
0101 011	243	0000 0011 01	191
0100 011	252	0000 0010 11	223
0011 011	15	0000 0010 01	239
0011 001	255	0000 0001 11	111
0101 1101	5	0000 0001 01	159
0100 1101	6	0001 1111 011	23
0100 1100	9	0001 1111 010	27
0101 1100	10	0001 1111 001	29
0101 0101	245	0001 1111 000	30
0100 0101	246	0001 1110 011	39
0100 0100	249	0001 1110 010	43
0101 0100	250	0001 1110 001	45
0011 0101 1	7	0001 1110 000	46
0011 0101 0	11	0001 1101 011	71
0011 0100 1	13	0001 1101 010	75
0011 0100 0	14	0001 1101 001	77
0011 0001 1	247	0001 1101 000	78
0011 0001 0	251	0001 1100 011	135
0011 0000 1	253	0001 1100 010	139
0011 0000 0	254	0001 1100 001	141
0010 1110 1	17	0001 1100 000	142
0010 1110 0	18	0001 1011 101	53
0010 0110 1	20	0001 1011 100	54
0010 0110 0	24	0001 0111 101	57
0010 1111 1	19	0001 0111 100	58
0010 0111 1	28	0001 1010 101	197
0010 1100 1	33	0001 1010 100	198
0010 1100 0	34	0001 0110 101	201
0010 0100 1	36	0001 0110 100	202
0010 0100 0	40	0001 1001 101	85
0010 1101 1	35	0001 1001 100	86
0010 0101 1	44	0001 0101 101	89
		0001 0101 100	90

0010 1010 1	65
0010 1010 0	66
0010 0010 1	68
0010 0010 0	72
0010 1011 1	67
0010 0011 1	76
0010 1000 1	129
0010 1000 0	130
0010 0000 1	132
0010 0000 0	136
0010 1001 1	131
0010 0001 1	140
0001 1111 1	31
0001 1110 1	47
0001 1101 1	79
0001 1100 1	143
0001 0011 1	63
0001 0010 1	207
0001 0001 1	95
0001 0000 1	175
0010 1111 01	21
0010 1111 00	22
0010 0111 01	25
0010 0111 00	26
0010 1101 01	37
0010 1101 00	38
0010 0101 01	41
0010 0101 00	42
0010 1011 01	69
0010 1011 00	70
0010 0011 01	73
0010 0011 00	74
0010 1001 01	133
0010 1001 00	134
0010 0001 01	137
0010 0001 00	138
0001 1011 01	49
0001 1011 00	50
0001 0111 01	52
0001 0111 00	56
0001 1011 11	51
0001 0111 11	60
0001 1010 01	193
0001 1010 00	194
0001 0110 01	196
0001 0110 00	200
0001 1010 11	195
0001 0110 11	204
0001 1001 01	81
0001 1001 00	82
0001 0101 01	84
0001 0101 00	88
0001 1001 11	83
0001 0101 11	92
0001 1000 01	161
0001 1000 00	162

0001 1000 101	165
0001 1000 100	166
0001 0100 101	169
0001 0100 100	170
0001 0011 011	55
0001 0011 010	59
0001 0011 001	61
0001 0011 000	62
0001 0010 011	199
0001 0010 010	203
0001 0010 001	205
0001 0010 000	206
0001 0001 011	87
0001 0001 010	91
0001 0001 001	93
0001 0001 000	94
0001 0000 011	167
0001 0000 010	171
0001 0000 001	173
0001 0000 000	174
0000 1111 101	101
0000 1111 100	102
0000 1101 101	105
0000 1101 100	106
0000 1110 101	149
0000 1110 100	150
0000 1100 101	153
0000 1100 100	154
0000 1011 101	117
0000 1011 100	118
0000 0111 101	121
0000 0111 100	122
0000 1010 101	181
0000 1010 100	182
0000 0110 101	185
0000 0110 100	186
0000 1001 101	213
0000 1001 100	214
0000 0101 101	217
0000 0101 100	218
0000 1000 101	229
0000 1000 100	230
0000 0100 101	233
0000 0100 100	234
0000 0011 1011	119
0000 0011 1010	123
0000 0011 1001	125
0000 0011 1000	126
0000 0011 0011	183
0000 0011 0010	187
0000 0011 0001	189
0000 0011 0000	190
0000 0010 1011	215
0000 0010 1010	219

0001 0100 01	164
0001 0100 00	168
0001 1000 11	163
0001 0100 11	172
0000 1111 01	97
0000 1111 00	98
0000 1101 01	100
0000 1101 00	104
0000 1111 11	99
0000 1101 11	108
0000 1110 01	145
0000 1110 00	146
0000 1100 01	148
0000 1100 00	152
0000 1110 11	147
0000 1100 11	156

0000 0010 1001	221
0000 0010 1000	222
0000 0010 0011	231
0000 0010 0010	235
0000 0010 0001	237
0000 0010 0000	238
0000 0001 1011	103
0000 0001 1010	107
0000 0001 1001	109
0000 0001 1000	110
0000 0001 0011	151
0000 0001 0010	155
0000 0001 0001	157
0000 0001 0000	158

B4. Motion Vectors

Table B.4 Variable length codes for motion_horizontal_forward_code, motion_vertical_forward_code, motion_horizontal_backward_code, and motion_vertical_backward_code.

motion VLC code	code
0000 0011 001	-16
0000 0011 011	-15
0000 0011 101	-14
0000 0011 111	-13
0000 0100 001	-12
0000 0100 011	-11
0000 0100 11	-10
0000 0101 01	-9
0000 0101 11	-8
0000 0111	-7
0000 1001	-6
0000 1011	-5
0000 111	-4
0001 1	-3
0011	-2
011	-1
1	0
010	1
0010	2
0001 0	3
0000 110	4
0000 1010	5
0000 1000	6
0000 0110	7
0000 0101 10	8
0000 0101 00	9
0000 0100 10	10
0000 0100 010	11
0000 0100 000	12
0000 0011 110	13
0000 0011 100	14
0000 0011 010	15
0000 0011 000	16

B5. WVT Coefficients

Table B.5a Variable length codes for wvt_dc_size_luminance.

VLC code	wvt_dc_size_luminance
100	0
00	1
01	2
101	3
110	4
1110	5
11110	6
111110	7
1111110	8

Table B.5b Variable length codes for wvt_dc_size_chrominance.

VLC code	wvt_dc_size_chrominance
00	0
01	1
10	2
110	3
1110	4
11110	5
111110	6
1111110	7
11111110	8

Table B.5c Variable length codes for wvt_coeff_first and wvt_coeff_next.

wvt_coeff_first and wvt_coeff_next variable length code (NOTE1)	run	level
10	end_of_block	
1 s (NOTE2)	0	1
11 s (NOTE3)	0	1
011 s	1	1
0100 s	0	2
0101 s	2	1
0010 1 s	0	3
0011 1 s	3	1
0011 0 s	4	1
0001 10 s	1	2
0001 11 s	5	1
0001 01 s	6	1
0001 00 s	7	1
0000 110 s	0	4
0000 100 s	2	2
0000 111 s	8	1
0000 101 s	9	1
0000 01	escape	
0010 0110 s	0	5
0010 0001 s	0	6
0010 0101 s	1	3
0010 0100 s	3	2
0010 0111 s	10	1
0010 0011 s	11	1
0010 0010 s	12	1
0010 0000 s	13	1
0000 0010 10 s	0	7
0000 0011 00 s	1	4
0000 0010 11 s	2	3
0000 0011 11 s	4	2
0000 0010 01 s	5	2
0000 0011 10 s	14	1
0000 0011 01 s	15	1
0000 0010 00 s	16	1

NOTE1 - The last bit 's' denotes the sign of the level, '0' for positive, '1' for negative.
NOTE2 - This code shall be used for wvt_coeff_first.
NOTE3 - This code shall be used for wvt_coeff_next.

Table B.5d Variable length codes for wvt_coeff_first and wvt_coeff_next (continued).

wvt_coeff_first and wvt_coeff_next variable length code (NOTE)	run	level
0000 0001 1101 s	0	8
0000 0001 1000 s	0	9
0000 0001 0011 s	0	10
0000 0001 0000 s	0	11
0000 0001 1011 s	1	5
0000 0001 0100 s	2	4
0000 0001 1100 s	3	3
0000 0001 0010 s	4	3
0000 0001 1110 s	6	2
0000 0001 0101 s	7	2
0000 0001 0001 s	8	2
0000 0001 1111 s	17	1
0000 0001 1010 s	18	1
0000 0001 1001 s	19	1
0000 0001 0111 s	20	1
0000 0001 0110 s	21	1
0000 0000 1101 0 s	0	12
0000 0000 1100 1 s	0	13
0000 0000 1100 0 s	0	14
0000 0000 1011 1 s	0	15
0000 0000 1011 0 s	1	6
0000 0000 1010 1 s	1	7
0000 0000 1010 0 s	2	5
0000 0000 1001 1 s	3	4
0000 0000 1001 0 s	5	3
0000 0000 1000 1 s	9	2
0000 0000 1000 0 s	10	2
0000 0000 1111 1 s	22	1
0000 0000 1111 0 s	23	1
0000 0000 1110 1 s	24	1
0000 0000 1110 0 s	25	1
0000 0000 1101 1 s	26	1

NOTE - The last bit 's' denotes the sign of the level, '0' for positive, '1' for negative.

Table B.5e Variable length codes for wvt_coeff_first and wvt_coeff_next (continued).

wvt_coeff_first and wvt_coeff_next variable length code (NOTE)	run	level
0000 0000 0111 11 s	0	16
0000 0000 0111 10 s	0	17
0000 0000 0111 01 s	0	18
0000 0000 0111 00 s	0	19

0000 0000 0110 11 s	0	20
0000 0000 0110 10 s	0	21
0000 0000 0110 01 s	0	22
0000 0000 0110 00 s	0	23
0000 0000 0101 11 s	0	24
0000 0000 0101 10 s	0	25
0000 0000 0101 01 s	0	26
0000 0000 0101 00 s	0	27
0000 0000 0100 11 s	0	28
0000 0000 0100 10 s	0	29
0000 0000 0100 01 s	0	30
0000 0000 0100 00 s	0	31
0000 0000 0011 000 s	0	32
0000 0000 0010 111 s	0	33
0000 0000 0010 110 s	0	34
0000 0000 0010 101 s	0	35
0000 0000 0010 100 s	0	36
0000 0000 0010 011 s	0	37
0000 0000 0010 010 s	0	38
0000 0000 0010 001 s	0	39
0000 0000 0010 000 s	0	40
0000 0000 0011 111 s	1	8
0000 0000 0011 110 s	1	9
0000 0000 0011 101 s	1	10
0000 0000 0011 100 s	1	11
0000 0000 0011 011 s	1	12
0000 0000 0011 010 s	1	13
0000 0000 0011 001 s	1	14

NOTE - The last bit 's' denotes the sign of the level, '0' for positive, '1' for negative.

Table B.5f Variable length codes for wvt_coeff_first and wvt_coeff_next (continued).

wvt_coeff_first and wvt_coeff_next variable length code (NOTE)	run	level
0000 0000 0001 0011 s	1	15
0000 0000 0001 0010 s	1	16
0000 0000 0001 0001 s	1	17
0000 0000 0001 0000 s	1	18
0000 0000 0001 0100 s	6	3
0000 0000 0001 1010 s	11	2
0000 0000 0001 1001 s	12	2
0000 0000 0001 1000 s	13	2
0000 0000 0001 0111 s	14	2
0000 0000 0001 0110 s	15	2
0000 0000 0001 0101 s	16	2
0000 0000 0001 1111 s	27	1
0000 0000 0001 1110 s	28	1
0000 0000 0001 1101 s	29	1
0000 0000 0001 1100 s	30	1
0000 0000 0001 1011 s	31	1

NOTE - The last bit 's' denotes the sign of the level, '0' for positive, '1' for negative.

Table B.5g Encoding of run and level following escape code as a 20-bit fixed length code (-127 <= level <= 127) or as a 28-bit fixed length code (-255 <= level <= -128, 128 <= level <= 255).

fixed length code	run
0000 00	0
0000 01	1
0000 10	2
...	...
...	...
...	...
...	...
...	...
...	...
1111 11	63

fixed length code	level
forbidden	-256
1000 0000 0000 0001	-255
1000 0000 0000 0010	-254
...	
1000 0000 0111 1111	-129
1000 0000 1000 0000	-128
1000 0001	-127
1000 0010	-126
...	...
1111 1110	-2
1111 1111	-1
forbidden	0
0000 0001	1
...	...
0111 1111	127
0000 0000 1000 0000	128
0000 0000 1000 0001	129
...	
0000 0000 1111 1111	255

ANNEX C

THE STATISTICS OF 7 SEQUENCES at 4 and 9 Mbit/s

Sequence : Flower Garden
No. of Frame : 148
Bit Rate : 4.0 Mbit/s
Group of Picture : 12 Frame/GOP
M : 3

		All	Intra	Predicted	Interpo.
RMS for Luminace		7.82	7.01	7.71	7.97
SNR for Luminace		30.30	31.24	30.40	30.14
SNR for Chrominance(Cb)		33.08	33.06	32.80	33.19
SNR for Chrominance(Cr)		33.51	33.39	33.32	33.60
Mean value of Stepsize		22.57	22.94	18.42	24.09
Mean value of non_zero_coef.		7.08	13.94	10.39	4.93
Mean value of zero_run		10.07	3.83	5.65	12.57
Macroblock Type					
(I,P-Picture)	(B-Picture)				
Fixed	Fixed		0.00	0.00	94.03
MC Coded	Int. Coded		593.00	1135.54	538.31
MC not Coded	Int. not Coded		65.54	173.24	283.41
No MC Coded	For. Coded		1.46	1.78	81.92
INTRA	For. not Coded		660.00	9.43	87.62
	Back. Coded				128.69
	Back. not Coded				106.00
	INTRA				0.02
Coded Macroblocks		892.78	1254.46	1146.76	748.92
Coded Blocks		3119.64	8217.54	5200.00	1657.95
Number of bits	Macro attributes	6503.68	2708.46	5475.57	7395.30
	Motion vectors	14970.97	2928.38	12970.30	17323.81
	CBP	4962.01	3860.31	7707.38	4071.63
	EOB	6239.28	16435.08	10400.00	3315.90
	Differential DC	3151.84	34287.31	557.30	1.19
	Coefficients (Y)	84880.41	380917.53	145820.00	22602.38
	Coefficients (Cb)	7825.17	42131.85	13726.65	1046.17
	Coefficients (Cr)	5495.43	31248.62	9100.49	718.10
	Extra data	1322.56	1379.69	1314.54	1318.01
Total Bits / frame		135351.34	515897.22	207072.22	57792.49

Sequence Header (include sequence_end_code)		128 Bits
Group of Picture Total Bits	1th - 12th	1599552 Bits
	13th - 24th	1599880 Bits
	25th - 36th	1599600 Bits
	37th - 48th	1599920 Bits
	49th - 60th	1599672 Bits
	61th - 72th	1599800 Bits
	73th - 84th	1599808 Bits
	85th - 96th	1599944 Bits
	97th - 108th	1599480 Bits
	109th - 120th	1599784 Bits
	121th - 132th	1599696 Bits
	133th - 144th	1599752 Bits
	145th - 148th	835112 Bits
Sequence Total Bits		20032128 Bits

KDD R&D Labs.

Sequence : Table Tennis
No. of Frame : 148
Bit Rate : 4.0 Mbit/s
Group of Picture : 12 Frame/GOP
M : 3

		All	Intra	Predicted	Interpo.
RMS for Luminace		6.55	6.18	6.25	6.72
SNR for Luminace		32.39	33.03	32.78	32.16
SNR for Chrominance(Cb)		39.58	39.47	39.50	39.62
SNR for Chrominance(Cr)		39.86	39.77	39.73	39.92
Mean value of Stepsize		16.42	18.44	13.53	17.24
Mean value of non_zero_coef.		7.52	12.29	11.49	5.39
Mean value of zero_run		9.53	4.65	5.28	11.78
Macroblock Type					
(I,P-Picture)	(B-Picture)				
Fixed	Fixed		0.15	16.41	133.68
MC Coded	Int. Coded		594.38	916.41	438.31
MC not Coded	Int. not Coded		60.38	139.76	291.27
No MC Coded	For. Coded		5.08	202.49	75.26
INTRA	For. not Coded		660.00	44.95	102.27
	Back. Coded				165.92
	Back. not Coded				112.09
	INTRA				0.21
Coded Macroblocks		852.18	1259.46	1163.84	680.48
Coded Blocks		2782.18	7690.08	4554.00	1462.18
Number of bits	Macro attributes	6429.89	2710.54	5678.16	7207.08
	Motion vectors	12923.51	3464.77	10126.57	15234.23
	CBP	4275.30	3340.15	6547.41	3541.52
	EOB	5564.36	15380.15	9108.00	2924.37
	Differential DC	2653.25	24896.00	1836.49	11.05
	Coefficients (Y)	93752.38	367697.06	168121.97	29334.47
	Coefficients (Cb)	3290.27	16035.69	6445.62	408.24
	Coefficients (Cr)	5104.22	21064.08	10245.03	1046.17
	Extra data	1321.35	1372.15	1317.14	1316.20
Total Bits / frame		135314.55	455960.62	219426.38	61023.35

Sequence Header (include sequence_end_code)		128 Bits
Group of Picture Total Bits	1th - 12th	1599648 Bits
	13th - 24th	1599424 Bits
	25th - 36th	1599096 Bits
	37th - 48th	1599576 Bits
	49th - 60th	1599064 Bits
	61th - 72th	1599968 Bits
	73th - 84th	1599152 Bits
	85th - 96th	1598768 Bits
	97th - 108th	1599624 Bits
	109th - 120th	1599176 Bits
	121th - 132th	1599600 Bits
	133th - 144th	1598920 Bits
	145th - 148th	834536 Bits
Sequence Total Bits		20026680 Bits

KDD R&D Labs.

Sequence : Mobile & Calendar
No. of Frame : 148
Bit Rate : 4.0 Mbit/s
Group of Picture : 12 Frame/GOP
M : 3

	All	Intra	Predicted	Interpo.
RMS for Luminace	8.95	7.40	8.81	9.21
SNR for Luminace	29.15	30.76	29.26	28.89
SNR for Chrominance(Cb)	33.24	33.11	33.00	33.35
SNR for Chrominance(Cr)	33.54	33.52	33.29	33.64
Mean value of Stepsize	26.17	24.34	22.35	27.86
Mean value of non_zero_coef.	7.13	16.08	9.03	5.23
Mean value of zero_run	9.77	3.20	6.56	11.85

Macroblock Type

(I,P-Picture)	(B-Picture)	All	Intra	Predicted	Interpo.
Fixed	Fixed		0.00	0.11	186.68
MC Coded	Int. Coded		638.54	1172.73	485.71
MC not Coded	Int. not Coded		19.00	131.08	218.29
No MC Coded	For. Coded		2.46	2.57	85.18
INTRA	For. not Coded		660.00	13.51	76.95
	Back. Coded				160.29
	Back. not Coded				106.80
	INTRA				0.10
Coded Macroblocks		895.64	1301.00	1188.81	731.18
Coded Blocks		2863.97	8236.23	4651.51	1476.43
Number of bits	Macro attributes	6211.63	2663.92	5449.57	6969.96
	Motion vectors	9479.88	2273.69	7647.16	11127.75
	CBP	5215.01	4338.92	8665.81	4028.37
	EOB	5727.93	16472.46	9303.03	2952.86
	Differential DC	3791.64	40610.31	881.27	6.34
	Coefficients (Y)	88984.29	460563.53	125221.87	26011.63
	Coefficients (Cb)	7479.89	50402.69	10305.05	719.40
	Coefficients (Cr)	7818.37	48466.77	12046.38	829.95
	Extra data	1323.70	1383.08	1319.86	1317.27
Total Bits / frame		136032.33	627175.38	180840.00	53963.51

Sequence Header (include sequence_end_code)		128 Bits
Group of Picture Total Bits	1th - 12th	1599440 Bits
	13th - 24th	1598768 Bits
	25th - 36th	1598552 Bits
	37th - 48th	1598944 Bits
	49th - 60th	1599680 Bits
	61th - 72th	1598536 Bits
	73th - 84th	1599520 Bits
	85th - 96th	1599808 Bits
	97th - 108th	1599840 Bits
	109th - 120th	1599232 Bits
	121th - 132th	1599440 Bits
	133th - 144th	1599912 Bits
	145th - 148th	941112 Bits
Sequence Total Bits		20132912 Bits

KDD R&D Labs.

Sequence : Flower Garden
No. of Frame : 148
Bit Rate : 9.0 Mbit/s
Group of Picture : 12 Frame/GOP
M : 3

	All	Intra	Predicted	Interpo.
RMS for Luminace	5.01	4.64	4.62	5.20
SNR for Luminace	34.17	34.81	34.85	33.83
SNR for Chrominance(Cb)	35.87	35.92	35.96	35.84
SNR for Chrominance(Cr)	35.71	35.72	35.69	35.71
Mean value of Stepsize	11.20	13.59	9.55	11.51
Mean value of non_zero_coef.	12.38	20.21	18.46	9.04
Mean value of zero_run	5.35	2.40	2.95	6.65

Macroblock Type

(I,P-Picture)	(B-Picture)	All	Intra	Predicted	Interpo.
Fixed	Fixed		0.00	0.00	17.64
MC Coded	Int. Coded		607.08	1208.57	767.07
MC not Coded	Int. not Coded		51.46	100.46	90.28
No MC Coded	For. Coded		1.46	1.78	150.35
INTRA	For. not Coded		660.00	9.19	49.93
	Back. Coded				187.35
	Back. not Coded				57.36
	INTRA				0.03
Coded Macroblocks		1147.84	1268.54	1219.54	1104.77
Coded Blocks		5378.67	8701.77	7195.51	4251.90
Number of bits	Macro attributes	6571.90	2694.38	5408.97	7525.33
	Motion vectors	14876.16	2928.38	12974.22	17179.15
	CBP	7408.64	4273.15	8908.68	7258.23
	EOB	10757.34	17403.54	14391.03	8503.80
	Differential DC	3149.09	34287.31	544.59	1.85
	Coefficients (Y)	213109.66	599181.88	353970.59	108713.80
	Coefficients (Cb)	24404.62	86170.46	46280.08	7952.09
	Coefficients (Cr)	21223.88	78074.23	38249.38	7254.52
	Extra data	1325.41	1380.54	1322.19	1319.32
Total Bits / frame		302826.69	826393.88	482049.72	165708.08

Sequence Header (include sequence_end_code)		128 Bits
Group of Picture Total Bits	1th - 12th	3598832 Bits
	13th - 24th	3599368 Bits
	25th - 36th	3598912 Bits
	37th - 48th	3599744 Bits
	49th - 60th	3599616 Bits
	61th - 72th	3599032 Bits
	73th - 84th	3598144 Bits
	85th - 96th	3599488 Bits
	97th - 108th	3599880 Bits
	109th - 120th	3599960 Bits
	121th - 132th	3598136 Bits
	133th - 144th	3597160 Bits
	145th - 148th	1630080 Bits
Sequence Total Bits		44818480 Bits

KDD R&D Labs.

Sequence : Popple
No. of Frame : 148
Bit Rate : 9.0 Mbit/s
Group of Picture : 12 Frame/GOP
M : 3

		All	Intra	Predicted	Interpo.
RMS for Luminace		4.84	3.89	4.07	5.26
SNR for Luminace		34.69	36.43	36.12	33.92
SNR for Chrominance(Cb)		36.92	39.62	38.67	35.90
SNR for Chrominance(Cr)		36.92	39.48	38.41	36.02
Mean value of Stepsize		13.13	12.49	8.81	14.84
Mean value of non_zero_coef.		13.26	12.72	19.40	11.01
Mean value of zero_run		4.90	4.44	2.90	5.72
Macroblock Type					
(I,P-Picture)	(B-Picture)				
Fixed	Fixed		0.00	0.00	1.56
MC Coded	Int. Coded		586.69	1182.92	586.24
MC not Coded	Int. not Coded		66.31	108.95	203.44
No MC Coded	For. Coded		7.00	20.86	142.08
INTRA	For. not Coded		660.00	7.27	117.56
	Back. Coded				140.41
	Back. not Coded				127.51
	INTRA				1.19
Coded Macroblocks		988.13	1253.69	1211.05	868.73
Coded Blocks		5073.71	8396.00	6628.38	4046.03
Number of bits	Macro attributes	6814.19	2720.31	5452.27	7871.45
	Motion vectors	33431.50	7354.69	24088.81	40418.01
	CBP	7003.28	4287.38	8920.76	6639.60
	EOB	10147.42	16792.00	13256.76	8092.06
	Differential DC	2764.72	29715.77	442.30	66.41
	Coefficients (Y)	147458.73	318245.62	271711.94	77891.40
	Coefficients (Cb)	50139.91	83699.46	88391.95	31246.04
	Coefficients (Cr)	42294.40	71780.16	77392.62	25131.65
	Extra data	1323.21	1383.08	1317.08	1317.58
Total Bits / frame		301377.34	535978.44	490974.50	198674.20

Sequence Header (include sequence_end_code)		128 Bits
Group of Picture Total Bits	1th - 12th	3597832 Bits
	13th - 24th	3599752 Bits
	25th - 36th	3599552 Bits
	37th - 48th	3599088 Bits
	49th - 60th	3599968 Bits
	61th - 72th	3598688 Bits
	73th - 84th	3598136 Bits
	85th - 96th	3599344 Bits
	97th - 108th	3599304 Bits
	109th - 120th	3599432 Bits
	121th - 132th	3599352 Bits
	133th - 144th	3599480 Bits
	145th - 148th	1413920 Bits
Sequence Total Bits		44603976 Bits

KDD R&D Labs.

Sequence : Table Tennis
No. of Frame : 148
Bit Rate : 9.0 Mbit/s
Group of Picture : 12 Frame/GOP
M : 3

		All	Intra	Predicted	Interpo.
RMS for Luminace		4.53	4.30	3.95	4.78
SNR for Luminace		35.46	36.07	36.53	34.98
SNR for Chrominance(Cb)		41.12	40.86	41.23	41.11
SNR for Chrominance(Cr)		41.99	41.75	42.11	41.98
Mean value of Stepsize		9.09	11.54	7.38	9.41
Mean value of non_zero_coef.		12.81	18.51	19.61	9.49
Mean value of zero_run		5.29	2.82	2.90	6.51
Macroblock Type					
(I,P-Picture)	(B-Picture)				
Fixed	Fixed		0.08	0.24	38.56
MC Coded	Int. Coded		637.77	1040.97	808.02
MC not Coded	Int. not Coded		17.00	15.78	80.53
No MC Coded	For. Coded		5.15	218.73	130.30
INTRA	For. not Coded		660.00	44.27	27.35
	Back. Coded				207.93
	Back. not Coded				27.14
	INTRA				0.17
Coded Macroblocks		1199.44	1302.92	1303.97	1146.24
Coded Blocks		4837.05	8243.85	6477.84	3765.65
Number of bits	Macro attributes	6431.16	2667.31	5615.68	7238.33
	Motion vectors	13137.44	3464.77	10138.08	15552.96
	CBP	6264.64	3644.15	7613.70	6102.91
	EOB	9674.11	16487.69	12955.68	7531.31
	Differential DC	2643.61	24896.00	1803.97	8.78
	Coefficients (Y)	241541.27	588302.38	410131.09	131891.11
	Coefficients (Cb)	9412.96	36994.23	19111.27	2092.61
	Coefficients (Cr)	12124.34	40163.85	24628.16	3683.98
	Extra data	1322.15	1379.00	1315.68	1317.05
Total Bits / frame		302551.69	717999.38	493313.31	175419.02

Sequence Header (include sequence_end_code)		128 Bits
Group of Picture Total Bits	1th - 12th	3597056 Bits
	13th - 24th	3599864 Bits
	25th - 36th	3598664 Bits
	37th - 48th	3599728 Bits
	49th - 60th	3597472 Bits
	61th - 72th	3597512 Bits
	73th - 84th	3596064 Bits
	85th - 96th	3596840 Bits
	97th - 108th	3597320 Bits
	109th - 120th	3597376 Bits
	121th - 132th	3595416 Bits
	133th - 144th	3590920 Bits
	145th - 148th	1613416 Bits
Sequence Total Bits		44777776 Bits

KDD R&D Labs.

Sequence	: Mobile & Calendar
No. of Frame	: 148
Bit Rate	: 9.0 Mbit/s
Group of Picture	: 12 Frame/GOP
M	: 3

	All	Intra	Predicted	Interpo.
RMS for Luminace	5.65	4.63	5.12	5.99
SNR for Luminace	33.15	34.84	33.97	32.61
SNR for Chrominance(Cb)	35.84	36.12	35.89	35.78
SNR for Chrominance(Cr)	36.29	36.65	36.39	36.21
Mean value of Stepsize	13.26	13.63	11.11	14.03
Mean value of non_zero_coef.	12.59	23.46	16.42	9.71
Mean value of zero_run	5.10	1.95	3.38	6.17

Macroblock Type (I,P-Picture)	(B-Picture)	Intra	Predicted	Interpo.
Fixed	Fixed	0.00	0.05	55.89
MC Coded	Int. Coded	644.62	1264.22	758.39
MC not Coded	Int. not Coded	12.92	40.65	86.77
No MC Coded	For. Coded	2.46	2.62	135.91
INTRA	For. not Coded	660.00	12.46	34.03
	Back. Coded			206.29
	Back. not Coded			42.66
	INTRA			0.07

		All	Intra	Predicted	Interpo.
Coded Macroblocks		1163.40	1307.08	1279.30	1100.58
Coded Blocks		4886.13	8878.85	6917.95	3589.37
Number of bits	Macro attributes	6340.59	2657.85	5362.54	7198.39
	Motion vectors	9714.94	2273.69	7666.92	11475.28
	CBP	7790.08	4913.69	10178.43	7269.92
	EOB	9772.26	17757.69	13835.89	7178.73
	Differential DC	3774.14	40610.31	816.73	4.29
	Coefficients (Y)	221629.67	742673.75	323487.22	114055.16
	Coefficients (Cb)	22262.41	113676.30	35219.43	5244.13
	Coefficients (Cr)	21423.41	105431.46	35940.14	4798.68
	Extra data	1323.47	1378.77	1315.84	1319.02
Total Bits / frame		304030.97	1031373.56	433823.12	158543.59

Sequence Header (include sequence_end_code)		128 Bits
Group of Picture Total Bits	1th - 12th	3595608 Bits
	13th - 24th	3594344 Bits
	25th - 36th	3595224 Bits
	37th - 48th	3599616 Bits
	49th - 60th	3596944 Bits
	61th - 72th	3599808 Bits
	73th - 84th	3595904 Bits
	85th - 96th	3597568 Bits
	97th - 108th	3598760 Bits
	109th - 120th	3595848 Bits
	121th - 132th	3599136 Bits
	133th - 144th	3595464 Bits
	145th - 148th	1832360 Bits
Sequence Total Bits		44996712 Bits

KDD R&D Labs.

Flower Garden 4.0 Mbit/sec SN & Bits Result

Frame	Ptype	SN-Y	SN-Cb	SN-Cr	Total-bit
1th	0	32.40	34.11	34.60	475024
2th	2	30.97	34.01	34.52	54592
3th	2	30.67	33.83	34.49	54856
4th	1	31.41	33.93	34.48	207600
5th	2	30.83	33.81	34.45	58992
6th	2	30.71	33.83	34.39	61720
7th	1	31.03	33.42	34.05	237136
8th	2	30.69	33.51	34.14	52520
9th	2	30.44	33.41	34.09	54112
10th	1	30.82	33.29	33.96	214744
11th	2	30.18	33.65	34.34	58928
12th	2	29.73	33.69	34.37	69328
13th	0	31.72	33.60	34.08	477728
14th	2	30.43	33.61	34.23	57864
15th	2	30.24	33.51	34.05	55872
16th	1	30.79	33.28	33.88	222200
17th	2	29.88	33.23	33.98	55880
18th	2	28.64	32.96	33.84	66328
19th	1	30.35	33.02	33.82	201496
20th	2	30.17	33.35	33.91	61184
21th	2	29.76	33.08	33.73	60040
22th	1	30.25	32.83	33.55	228752
23th	2	30.74	33.87	34.25	54096
24th	2	30.54	33.80	34.35	58440
25th	0	31.76	33.70	34.00	504624
26th	2	29.66	33.29	33.86	62120
27th	2	30.59	33.67	34.13	54776
28th	1	31.14	33.65	34.18	207376
29th	2	30.60	33.62	34.25	55824
30th	2	30.22	33.41	34.05	56616
31th	1	30.85	33.28	33.91	214520
32th	2	30.36	33.18	33.95	55960
33th	2	30.02	33.02	33.85	58528
34th	1	30.47	32.92	33.76	211768
35th	2	30.53	33.98	34.44	62072
36th	2	31.42	33.90	34.30	55416
37th	0	31.86	33.80	34.01	508712
38th	2	31.22	33.95	34.23	51424
39th	2	30.64	33.72	34.05	56040
40th	1	30.95	33.52	33.92	203608
41th	2	30.96	33.92	34.21	61392
42th	2	30.26	33.45	33.90	58040
43th	1	30.70	33.11	33.65	219160
44th	2	29.91	33.29	33.84	63128
45th	2	29.16	32.84	33.59	61448
46th	1	30.53	32.85	33.44	199776
47th	2	30.77	33.65	33.89	58288
48th	2	31.37	34.02	34.18	58904
49th	0	31.24	33.03	33.48	509928
50th	2	30.21	33.15	33.70	57536
51th	2	30.13	33.15	33.54	54520
52th	1	30.35	32.80	33.30	218632
53th	2	30.10	33.23	33.64	58688
54th	2	30.09	33.10	33.67	56984
55th	1	30.28	32.74	33.46	211208
56th	2	29.92	32.75	33.43	56000
57th	2	29.79	32.98	33.57	61536
58th	1	30.19	32.55	33.35	200648
59th	2	31.12	33.85	34.07	56656
60th	2	31.56	33.95	34.27	57336
61th	0	31.59	33.34	33.68	528520
62th	2	30.01	33.46	33.83	62504
63th	2	29.61	33.23	33.71	57520
64th	1	30.91	33.20	33.58	186848
65th	2	30.87	33.61	33.84	59832
66th	2	30.31	33.21	33.62	56728
67th	1	30.54	32.88	33.36	219936
68th	2	30.30	32.97	33.45	51792
69th	2	30.35	33.01	33.51	53080
70th	1	30.70	32.88	33.44	206424
71th	2	31.47	33.98	34.08	57400
72th	2	30.93	33.40	33.64	59216
73th	0	30.98	32.82	33.13	524920
74th	2	30.27	33.04	33.38	59288
75th	2	30.30	33.27	33.63	63272
76th	1	30.36	32.76	33.35	217168
77th	2	30.30	32.99	33.43	54296
78th	2	30.56	33.02	33.54	54200
79th	1	30.33	32.57	33.18	219736
80th	2	30.05	32.72	33.24	48928
81th	2	29.79	32.64	33.29	51360
82th	1	30.34	32.49	33.08	192888
83th	2	30.36	33.19	33.57	56280
84th	2	30.83	33.62	33.80	57472
85th	0	31.26	33.04	33.30	527080
86th	2	31.30	33.64	33.69	52904
87th	2	30.83	33.34	33.53	53416
88th	1	30.66	32.90	33.19	223848
89th	2	30.70	33.12	33.40	48384
90th	2	30.45	32.96	33.35	48528
91th	1	30.31	32.61	33.08	193960
92th	2	30.27	32.76	33.22	55584
93th	2	29.75	32.47	32.97	55648
94th	1	29.81	32.08	32.72	228960
95th	2	30.87	33.41	33.67	53608
96th	2	30.57	33.23	33.56	58024
97th	0	31.03	32.78	33.16	511840
98th	2	29.17	32.93	33.44	62600
99th	2	29.23	32.87	33.33	58328
100th	1	30.35	32.73	33.12	185128
101th	2	28.92	32.61	33.15	61240
102th	2	29.00	32.67	33.21	64640
103th	1	30.06	32.54	33.06	188080
104th	2	28.59	32.30	32.89	62392
105th	2	28.10	32.34	32.82	69632
106th	1	29.59	32.20	32.76	203824
107th	2	28.91	32.98	33.25	69152
108th	2	29.15	33.04	33.28	62624
109th	0	30.91	32.68	32.94	548416
110th	2	29.37	32.87	33.16	66496
111th	2	29.09	32.89	33.15	62536
112th	1	30.38	32.77	33.06	189768
113th	2	29.06	32.77	33.05	65392
114th	2	29.32	32.76	33.03	55528
115th	1	30.23	32.70	33.03	182888
116th	2	28.87	32.72	33.03	69256
117th	2	28.49	32.46	33.01	64720
118th	1	29.97	32.48	32.96	189416
119th	2	30.86	33.64	33.60	53240
120th	2	31.01	33.67	33.70	52128
121th	0	30.91	32.70	33.00	542216
122th	2	30.09	32.82	33.21	59304
123th	2	29.68	32.98	33.38	65032
124th	1	30.32	32.74	33.13	201816
125th	2	30.42	33.10	33.30	51944
126th	2	30.10	32.85	33.10	51000
127th	1	30.19	32.50	32.89	204376
128th	2	28.96	32.58	32.96	69424
129th	2	28.78	32.34	32.88	58320
130th	1	29.83	32.36	32.77	188944
131th	2	30.50	33.33	33.33	54024
132th	2	30.77	33.32	33.35	53296
133th	0	30.39	32.31	32.47	532528
134th	2	30.38	32.84	32.91	59632
135th	2	30.23	32.83	33.00	59024
136th	1	30.16	32.42	32.68	244528
137th	2	30.16	32.82	33.06	50864
138th	2	30.19	32.73	33.02	49688
139th	1	30.24	32.48	32.81	189848
140th	2	29.74	32.49	32.90	54624
141th	2	29.37	32.44	32.85	57800
142th	1	30.07	32.26	32.71	203072
143th	2	31.18	33.30	33.40	48296
144th	2	30.87	33.10	33.22	49848
145th	0	30.05	31.88	32.27	515128
146th	2	29.43	32.15	32.48	58616
147th	2	29.28	32.23	32.53	59776
148th	1	29.33	31.87	32.29	201592

Ptype
0 : I-picture
1 : P-picture
2 : B-picture
3 : S-picture

KDD R&D Labs.

Table Tennis 4.0 Mbit/sec SN & Bits Result

Frame	Ptype	SN-Y	SN-Cb	SN-Cr	Total-bit
1th	0	26.74	37.78	38.17	407536
2th	2	26.70	37.90	38.47	56816
3th	2	26.71	37.97	38.50	56768
4th	1	26.69	38.01	38.36	201568
5th	2	26.94	38.12	38.65	56600
6th	2	26.37	38.02	38.55	59960
7th	1	26.44	37.83	38.22	232112
8th	2	26.22	37.92	38.48	67720
9th	2	25.93	38.09	38.57	72504
10th	1	26.98	38.01	38.38	250000
11th	2	26.23	38.04	38.71	69088
12th	2	26.53	38.02	38.77	68976
13th	0	26.32	37.71	38.13	381432
14th	2	25.83	37.80	38.37	67464
15th	2	26.26	37.92	38.41	63968
16th	1	26.51	37.88	38.21	246368
17th	2	26.18	37.99	38.43	61144
18th	2	26.18	37.92	38.37	64120
19th	1	26.87	37.81	38.08	238408
20th	2	26.32	37.97	38.48	60144
21th	2	26.27	37.89	38.35	59720
22th	1	26.76	37.69	38.05	212376
23th	2	25.91	37.93	38.67	71160
24th	2	25.87	37.98	38.83	73120
25th	0	28.74	38.03	38.63	439136
26th	2	27.46	38.42	39.35	82320
27th	2	28.43	38.65	39.32	75120
28th	1	30.08	38.73	39.26	231080
29th	2	29.11	39.14	39.67	67544
30th	2	29.23	39.09	39.68	66320
31th	1	30.72	39.23	39.59	214120
32th	2	29.90	39.59	40.11	60784
33th	2	30.23	39.71	40.14	59072
34th	1	31.64	39.68	39.79	193560
35th	2	31.23	40.12	40.88	56192
36th	2	32.09	40.47	41.16	53848
37th	0	34.29	40.48	40.99	367144
38th	2	32.86	40.75	41.43	68192
39th	2	33.07	40.79	41.49	65960
40th	1	34.21	40.65	41.13	218880
41th	2	33.33	40.92	41.20	64096
42th	2	33.53	40.80	41.10	64368
43th	1	34.58	40.87	40.89	236064
44th	2	33.68	40.78	40.73	67408
45th	2	33.68	40.74	40.46	67784
46th	1	34.63	40.85	40.53	247112
47th	2	34.17	41.05	40.39	65968
48th	2	34.49	41.21	40.82	66600
49th	0	36.33	41.57	42.11	353240
50th	2	34.49	40.89	40.61	64184
51th	2	34.34	40.67	40.36	64968
52th	1	35.36	40.80	40.61	251920
53th	2	34.14	40.38	40.29	65056
54th	2	34.31	40.31	40.21	65392
55th	1	35.16	40.38	40.25	245760
56th	2	34.17	40.24	40.39	63192
57th	2	34.30	40.23	40.33	62376
58th	1	35.15	40.24	40.25	234016
59th	2	34.46	40.33	40.57	64416
60th	2	34.48	40.39	40.79	64544
61th	0	35.50	40.58	40.83	332656
62th	2	34.07	40.09	40.44	47976
63th	2	34.00	40.01	40.25	47744
64th	1	34.56	39.97	39.92	180336
65th	2	33.71	39.74	39.82	47176
66th	2	33.56	39.64	39.57	48976
67th	1	34.21	39.54	39.32	182136
68th	2	33.39	39.10	38.77	105288
69th	2	33.66	39.22	38.93	105992
70th	3	33.59	38.93	38.69	409728
71th	2	34.20	39.97	39.57	44856
72th	2	34.16	39.93	39.65	47104
73th	0	35.42	39.93	40.14	574712
74th	2	34.31	40.04	39.86	57664
75th	2	34.34	40.04	40.14	58096
76th	1	34.95	40.13	40.36	194576
77th	2	34.55	40.25	40.49	56944
78th	2	34.65	40.20	40.39	57216
79th	1	35.25	40.27	40.53	192768
80th	2	34.84	40.25	40.54	54888
81th	2	34.81	40.26	40.62	56280
82th	1	35.37	40.33	40.72	180400
83th	2	35.28	40.49	40.90	58456
84th	2	35.23	40.60	41.03	57152
85th	0	35.63	40.08	40.35	592064
86th	2	34.71	40.29	40.70	57688
87th	2	34.64	40.26	40.57	57904
88th	1	35.23	40.35	40.75	188392
89th	2	34.93	40.43	40.78	56288
90th	2	35.00	40.41	40.79	57304
91th	1	35.58	40.46	40.93	183008
92th	2	35.11	40.54	41.00	55464
93th	2	35.13	40.54	40.94	56640
94th	1	35.71	40.60	41.08	177504
95th	2	35.08	40.43	40.69	57640
96th	2	35.07	40.43	40.81	58872
97th	0	32.82	38.27	37.89	363248
98th	2	32.23	39.17	38.95	100920
99th	2	32.91	39.25	39.15	93376
100th	3	33.80	39.42	39.63	500168
101th	2	33.11	39.45	39.60	41896
102th	2	32.89	39.37	39.52	41664
103th	1	32.78	39.22	39.35	156792
104th	2	32.77	39.26	39.33	39128
105th	2	32.38	39.18	39.26	39952
106th	1	32.30	39.03	39.09	143672
107th	2	33.70	39.96	40.26	38904
108th	2	33.81	39.95	40.22	39904
109th	0	34.62	39.83	40.21	571080
110th	2	34.18	39.94	40.42	53568
111th	2	34.08	39.89	40.36	54496
112th	1	34.11	39.84	40.32	195560
113th	2	34.12	39.91	40.43	54336
114th	2	33.91	39.87	40.37	54480
115th	1	34.08	39.84	40.38	191528
116th	2	33.99	39.81	40.30	55136
117th	2	33.80	39.76	40.22	56016
118th	1	34.16	39.79	40.26	190128
119th	2	34.36	40.06	40.54	60384
120th	2	34.24	40.04	40.55	62464
121th	0	33.90	39.45	39.66	508776
122th	2	32.92	39.50	39.64	57536
123th	2	33.28	39.52	39.72	60384
124th	1	33.59	39.30	39.54	204192
125th	2	31.24	38.97	39.38	61272
126th	2	32.97	39.34	39.67	58320
127th	1	33.46	39.25	39.50	199896
128th	2	31.08	39.25	39.52	64824
129th	2	32.50	39.27	39.68	60528
130th	1	33.50	39.26	39.46	204160
131th	2	33.67	40.05	40.39	59528
132th	2	33.68	39.97	40.19	60184
133th	0	34.63	39.80	40.07	517488
134th	2	33.70	39.89	40.15	56408
135th	2	32.07	39.88	40.15	60632
136th	1	34.08	39.61	39.92	201368
137th	2	31.99	39.36	39.79	60456
138th	2	33.20	39.35	39.80	58176
139th	1	33.87	39.33	39.72	194936
140th	2	33.26	39.35	39.86	58472
141th	2	31.95	39.29	39.78	61208
142th	1	33.41	39.06	39.35	199680
143th	2	31.83	39.71	39.87	65352
144th	2	32.49	39.69	40.12	64744
145th	0	34.41	39.59	39.81	518976
146th	2	32.20	39.67	39.88	60432
147th	2	31.37	39.39	39.58	60624
148th	1	33.66	39.39	39.75	194504

Mobile & Calendar 4.0 Mbit/sec SN & Bits Result

Frame	Ptype	SN-Y	SN-Cb	SN-Cr	Total-bit
1th	0	30.12	33.06	33.58	573288
2th	2	28.06	33.26	33.68	55248
3th	2	27.95	33.20	33.50	57816
4th	1	28.59	32.84	33.26	193584
5th	2	27.55	33.03	33.38	57024
6th	2	27.49	32.91	33.19	57944
7th	1	28.16	32.63	33.04	190800
8th	2	27.23	32.81	33.23	58784
9th	2	27.28	32.71	33.09	57208
10th	1	28.16	32.57	32.95	188424
11th	2	28.42	33.67	34.07	53688
12th	2	28.68	33.73	34.20	55632
13th	0	30.75	33.46	34.01	623136
14th	2	29.24	33.72	34.19	55224
15th	2	28.99	33.53	34.01	56536
16th	1	29.47	33.68	34.10	185672
17th	2	28.82	33.53	33.97	51536
18th	2	28.74	33.55	33.97	50472
19th	1	29.24	33.47	33.84	177264
20th	2	28.37	33.27	33.67	54512
21th	2	28.35	33.36	33.79	53728
22th	1	29.09	33.11	33.49	179872
23th	2	29.80	34.00	34.40	54928
24th	2	29.60	34.06	34.56	55888
25th	0	31.00	33.51	34.00	643328
26th	2	29.68	33.82	34.15	50760
27th	2	29.60	33.83	34.10	51352
28th	1	29.72	33.43	33.78	188008
29th	2	28.80	33.42	33.73	50144
30th	2	29.13	33.75	34.06	48768
31th	1	29.11	33.10	33.42	179992
32th	2	27.83	33.56	33.79	56728
33th	2	28.05	33.37	33.75	57728
34th	1	29.06	33.09	33.43	151528
35th	2	28.89	33.68	34.08	59968
36th	2	29.08	33.81	34.19	60248
37th	0	30.64	33.07	33.50	620032
38th	2	28.65	33.36	33.65	55872
39th	2	28.54	33.49	33.82	57352
40th	1	29.64	33.22	33.53	153696
41th	2	28.79	33.34	33.51	54224
42th	2	28.95	33.48	33.74	52312
43th	1	29.39	33.04	33.28	181184
44th	2	28.46	33.13	33.31	54336
45th	2	28.47	33.35	33.50	56120
46th	1	28.87	32.74	32.95	197176
47th	2	28.93	33.65	33.85	57904
48th	2	28.97	33.71	33.95	58736
49th	0	30.54	33.00	33.39	615504
50th	2	29.21	33.41	33.75	49184
51th	2	29.24	33.49	33.82	50360
52th	1	29.36	32.99	33.24	182408
53th	2	28.25	33.11	33.41	52920
54th	2	28.31	33.30	33.53	52648
55th	1	28.89	32.65	32.96	169032
56th	2	28.13	32.89	33.19	55984
57th	2	28.16	32.89	33.18	56496
58th	1	28.53	32.37	32.71	196056
59th	2	28.75	33.40	33.74	59944
60th	2	28.72	33.31	33.69	59144
61th	0	30.06	32.62	32.95	581768
62th	2	28.54	33.01	33.28	54320
63th	2	28.56	33.01	33.22	53896
64th	1	28.75	32.54	32.85	192560
65th	2	28.12	32.78	33.03	54352
66th	2	28.01	32.69	32.92	55168
67th	1	28.23	32.25	32.53	190688
68th	2	27.80	32.54	32.85	56544
69th	2	27.66	32.42	32.75	55928
70th	1	28.05	32.09	32.41	189824
71th	2	28.50	33.19	33.49	57008
72th	2	28.60	33.25	33.57	56480
73th	0	30.10	32.62	32.96	592496
74th	2	28.17	32.90	33.18	59296
75th	2	28.16	32.75	33.04	59288
76th	1	28.83	32.52	32.79	200848
77th	2	27.60	32.74	32.87	56224
78th	2	27.85	32.62	32.81	56504
79th	1	28.54	32.43	32.71	195144
80th	2	27.89	32.71	32.91	52728
81th	2	27.95	32.66	32.88	50800
82th	1	28.56	32.56	32.70	175056
83th	2	28.90	33.80	34.01	48560
84th	2	29.02	33.75	34.09	52576
85th	0	30.54	32.84	33.16	619944
86th	2	28.87	33.19	33.50	52136
87th	2	28.78	32.96	33.23	52184
88th	1	29.55	33.02	33.21	164744
89th	2	28.53	33.31	33.47	54384
90th	2	28.20	33.15	33.29	54528
91th	1	29.15	33.00	33.15	186480
92th	2	27.94	32.80	33.00	55544
93th	2	27.94	32.78	33.00	56424
94th	1	28.71	32.61	32.80	193024
95th	2	29.32	33.72	33.92	54096
96th	2	29.41	33.61	33.84	56320
97th	0	30.77	32.93	33.26	644736
98th	2	29.63	33.53	33.70	47272
99th	2	29.60	33.45	33.62	47080
100th	1	29.68	33.28	33.49	181160
101th	2	29.34	33.33	33.49	47736
102th	2	29.16	33.25	33.42	47056
103th	1	29.15	33.10	33.37	185776
104th	2	29.10	33.09	33.24	49208
105th	2	28.82	33.01	33.17	49376
106th	1	28.90	32.85	33.11	187240
107th	2	28.96	33.72	33.82	54312
108th	2	29.63	33.70	33.92	58888
109th	0	30.76	32.86	33.17	627920
110th	2	28.86	33.32	33.51	53224
111th	2	28.83	33.09	33.24	53504
112th	1	29.63	32.98	33.15	191624
113th	2	28.56	33.12	33.24	55472
114th	2	28.23	32.81	32.98	54616
115th	1	29.44	32.96	33.17	186664
116th	2	28.70	32.81	32.92	52152
117th	2	28.41	33.09	33.25	55184
118th	1	29.37	32.83	33.01	167536
119th	2	30.07	33.65	33.86	50184
120th	2	30.10	33.83	34.10	51152
121th	0	31.34	33.41	33.83	660256
122th	2	29.36	33.49	33.69	56856
123th	2	29.87	33.49	33.68	55672
124th	1	30.32	33.56	33.80	171616
125th	2	29.08	33.24	33.49	57728
126th	2	29.58	33.34	33.51	53296
127th	1	30.28	33.48	33.70	187288
128th	2	29.47	33.53	33.72	47224
129th	2	29.66	33.57	33.77	47160
130th	1	30.19	33.52	33.81	157064
131th	2	30.77	34.44	34.73	50880
132th	2	30.22	34.54	34.80	54400
133th	0	32.05	33.91	34.36	682328
134th	2	30.72	33.98	34.37	51000
135th	2	30.44	33.97	34.35	51872
136th	1	31.10	34.04	34.39	165696
137th	2	30.20	33.78	34.16	51736
138th	2	30.32	33.80	34.13	52912
139th	1	30.81	33.82	34.20	164408
140th	2	29.86	33.66	34.01	50544
141th	2	29.59	33.56	33.91	50224
142th	1	29.95	33.50	33.91	168160
143th	2	30.83	33.81	34.27	54736
144th	2	30.21	33.76	34.20	56296
145th	0	31.26	33.10	33.55	668544
146th	2	30.09	33.36	33.81	50208
147th	2	30.14	33.43	33.83	48576
148th	1	30.21	33.04	33.36	173784

Flower Garden 9.0 Mbit/sec SN & Bits Result

Frame	Ptype	SN-Y	SN-Cb	SN-Cr	Total-bit
1th	0	35.90	37.01	37.02	750600
2th	2	34.53	36.59	36.73	155280
3th	2	34.55	36.50	36.73	157000
4th	1	35.81	37.08	37.07	478896
5th	2	34.84	36.53	36.70	167136
6th	2	34.77	36.74	36.75	176992
7th	1	35.80	36.84	36.72	548544
8th	2	34.91	36.63	36.59	149712
9th	2	34.75	36.50	36.52	153816
10th	1	35.54	36.78	36.66	495824
11th	2	33.94	36.07	36.33	168208
12th	2	33.53	35.98	36.26	196824
13th	0	35.21	36.45	36.43	755960
14th	2	34.24	36.21	36.39	164640
15th	2	34.10	36.13	36.20	158720
16th	1	35.29	36.45	36.33	514880
17th	2	33.91	35.99	36.09	159272
18th	2	32.74	35.41	35.79	189080
19th	1	34.93	36.22	36.31	466704
20th	2	34.17	36.23	36.10	173768
21th	2	33.87	35.90	35.88	170208
22th	1	35.02	36.19	35.98	526976
23th	2	34.23	36.38	36.28	153632
24th	2	34.01	36.16	36.33	165528
25th	0	35.32	36.59	36.35	804656
26th	2	33.20	35.70	35.87	178240
27th	2	34.22	36.37	36.31	157312
28th	1	35.49	36.77	36.65	482032
29th	2	34.46	36.43	36.40	161272
30th	2	34.17	36.24	36.17	162232
31th	1	35.50	36.59	36.32	495904
32th	2	34.29	36.05	36.03	160696
33th	2	33.99	35.85	35.93	167408
34th	1	35.29	36.43	36.18	493560
35th	2	34.06	36.30	36.43	178232
36th	2	34.64	36.39	36.44	157368
37th	0	35.35	36.55	36.34	806608
38th	2	34.54	36.48	36.38	147872
39th	2	34.16	36.25	36.22	160416
40th	1	35.15	36.49	36.29	474288
41th	2	34.74	36.66	36.41	174856
42th	2	34.35	36.19	36.05	166544
43th	1	35.25	36.29	36.04	510496
44th	2	33.69	35.93	35.91	180512
45th	2	33.21	35.51	35.55	175736
46th	1	35.00	36.17	35.86	465248
47th	2	34.29	36.20	35.91	167680
48th	2	34.82	36.65	36.33	169488
49th	0	34.78	35.84	35.74	812568
50th	2	33.98	35.85	35.87	166080
51th	2	33.81	35.67	35.70	156768
52th	1	34.82	35.85	35.55	509664
53th	2	34.12	36.07	35.86	168128
54th	2	33.82	35.85	35.82	162944
55th	1	34.97	35.97	35.74	494000
56th	2	33.80	35.52	35.47	160352
57th	2	33.87	35.79	35.64	177440
58th	1	34.86	35.83	35.69	464448
59th	2	34.65	36.36	36.13	160944
60th	2	34.93	36.63	36.41	166280
61th	0	35.15	36.23	36.04	843368
62th	2	33.42	35.87	35.92	180648
63th	2	33.23	35.61	35.70	165344
64th	1	34.97	36.16	35.86	438328
65th	2	34.70	36.39	36.00	172200
66th	2	34.22	35.89	35.68	163816
67th	1	35.03	36.02	35.64	513760
68th	2	34.22	35.79	35.59	148480
69th	2	34.32	35.94	35.73	152112
70th	1	35.23	36.16	35.83	483000
71th	2	34.95	36.63	36.25	166176
72th	2	34.27	36.15	35.77	171800
73th	0	34.59	35.65	35.38	841640
74th	2	33.57	35.62	35.42	169584
75th	2	33.70	35.89	35.71	181584
76th	1	34.73	35.79	35.59	508448
77th	2	33.96	35.77	35.59	156896
78th	2	34.45	35.94	35.76	155296
79th	1	34.89	35.76	35.51	514200
80th	2	34.17	35.77	35.53	141232
81th	2	34.06	35.69	35.49	147624
82th	1	35.01	35.90	35.50	453496
83th	2	33.96	35.51	35.43	162520
84th	2	34.30	36.37	35.98	165624
85th	0	34.94	35.98	35.69	851576
86th	2	34.82	36.43	36.04	152984
87th	2	34.57	36.23	35.84	154968
88th	1	35.16	36.08	35.66	524192
89th	2	34.57	36.06	35.67	139600
90th	2	34.52	36.02	35.63	140040
91th	1	34.90	35.90	35.46	456608
92th	2	34.50	35.99	35.57	158760
93th	2	34.03	35.61	35.26	159752
94th	1	34.78	35.57	35.19	538984
95th	2	34.51	36.01	35.76	153640
96th	2	34.09	35.84	35.59	168384
97th	0	34.43	35.52	35.37	809560
98th	2	32.80	35.30	35.39	179640
99th	2	32.82	35.28	35.29	166664
100th	1	34.35	35.52	35.34	429208
101th	2	32.79	35.00	35.04	174968
102th	2	32.69	35.05	35.08	184432
103th	1	34.26	35.42	35.27	434696
104th	2	32.38	34.78	34.76	177848
105th	2	31.87	34.68	34.64	198752
106th	1	33.95	35.14	34.98	467200
107th	2	32.33	35.06	35.03	197720
108th	2	32.42	35.15	35.13	179192
109th	0	34.47	35.49	35.26	874176
110th	2	32.93	35.24	35.18	191800
111th	2	32.80	35.26	35.12	179456
112th	1	34.41	35.63	35.35	444032
113th	2	32.64	35.10	35.02	188336
114th	2	32.86	35.28	35.05	159896
115th	1	34.33	35.66	35.31	427808
116th	2	32.59	35.13	34.98	198200
117th	2	32.29	34.89	34.88	186624
118th	1	34.35	35.59	35.29	443872
119th	2	34.07	36.21	35.66	151728
120th	2	34.29	36.29	35.82	154032
121th	0	34.54	35.62	35.33	870912
122th	2	33.45	35.36	35.32	169448
123th	2	33.43	35.54	35.46	186720
124th	1	34.59	35.72	35.43	468728
125th	2	34.06	35.89	35.46	150688
126th	2	33.70	35.60	35.21	147704
127th	1	34.49	35.60	35.14	479168
128th	2	32.71	35.01	34.88	201520
129th	2	32.59	34.96	34.84	169664
130th	1	34.17	35.46	35.09	443712
131th	2	33.88	35.88	35.54	156072
132th	2	34.15	35.99	35.65	153800
133th	0	34.35	35.34	35.00	902568
134th	2	33.61	35.50	35.23	169752
135th	2	33.78	35.64	35.41	168912
136th	1	34.65	35.60	35.17	562880
137th	2	33.67	35.64	35.34	143992
138th	2	33.79	35.60	35.32	140928
139th	1	34.45	35.63	35.20	439416
140th	2	33.40	35.30	35.05	155688
141th	2	33.11	35.26	34.97	161352
142th	1	34.42	35.50	35.04	472056
143th	2	34.36	35.98	35.56	136472
144th	2	34.07	35.77	35.38	143144
145th	0	33.55	34.65	34.39	818928
146th	2	32.63	34.64	34.53	168864
147th	2	32.72	34.77	34.58	171704
148th	1	33.46	34.71	34.42	470584

Popple 9.0 Mbit/sec SN & Bits Result

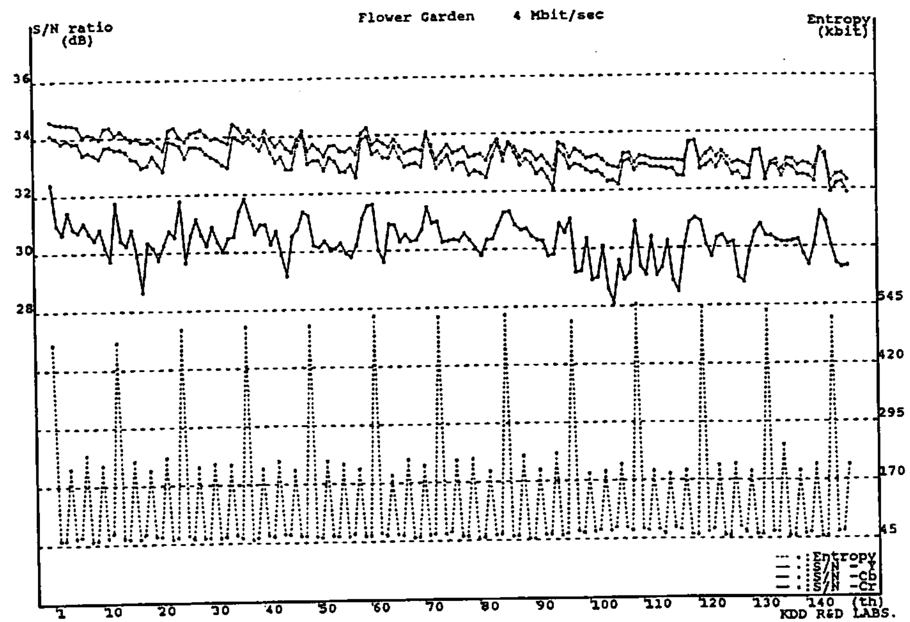
Frame	Ptype	SN-Y	SN-Cb	SN-Cr	Total-bit
1th	0	37.32	41.02	40.57	599648
2th	2	35.22	38.32	38.46	186824
3th	2	35.22	38.34	38.42	188944
4th	1	37.48	41.09	40.59	509792
5th	2	35.27	38.23	38.25	187768
6th	2	35.30	38.33	38.45	186736
7th	1	37.50	41.03	40.49	501568
8th	2	35.36	38.47	38.45	182688
9th	2	35.32	38.55	38.53	184832
10th	1	37.46	40.76	40.32	495072
11th	2	35.22	38.48	38.45	184928
12th	2	35.26	38.44	38.57	189032
13th	0	37.23	40.78	40.41	620200
14th	2	35.28	38.34	38.30	186744
15th	2	35.21	38.46	38.54	183920
16th	1	37.33	40.73	40.35	499928
17th	2	35.32	38.41	38.43	184280
18th	2	35.34	38.51	38.56	183312
19th	1	37.43	40.78	40.49	489560
20th	2	35.36	38.50	38.58	186632
21th	2	35.45	38.61	38.72	185944
22th	1	37.51	40.86	40.49	501376
23th	2	35.41	38.70	38.66	188608
24th	2	35.45	38.65	38.78	189248
25th	0	37.28	40.90	40.53	594608
26th	2	35.34	38.55	38.63	182200
27th	2	35.28	38.16	38.23	184928
28th	1	37.42	40.97	40.59	486376
29th	2	35.37	38.34	38.42	186480
30th	2	35.43	38.25	38.23	188552
31th	1	37.54	41.09	40.60	500328
32th	2	35.39	38.54	38.63	188648
33th	2	35.48	38.50	38.51	187320
34th	1	37.67	41.23	40.63	520776
35th	2	35.45	38.75	38.82	188120
36th	2	35.47	38.76	38.79	191216
37th	0	37.36	41.02	40.68	601552
38th	2	35.30	38.58	38.60	185072
39th	2	35.41	38.65	38.62	185968
40th	1	37.48	41.11	40.68	508968
41th	2	35.49	38.62	38.70	185104
42th	2	35.47	38.63	38.73	183680
43th	1	37.59	41.04	40.62	504072
44th	2	35.47	38.72	38.82	184648
45th	2	35.43	38.54	38.72	187392
46th	1	37.59	41.10	40.69	499832
47th	2	35.51	38.79	38.89	185704
48th	2	35.56	38.95	39.03	187096
49th	0	37.25	40.80	40.47	594936
50th	2	35.32	38.44	38.57	177888
51th	2	35.35	38.55	38.65	176640
52th	1	37.38	40.91	40.59	480456
53th	2	35.15	38.59	38.64	186536
54th	2	35.06	38.64	38.72	189240
55th	1	37.51	40.88	40.57	510320
56th	2	35.04	38.52	38.55	193256
57th	2	35.15	38.67	38.64	192752
58th	1	37.41	40.84	40.46	518088
59th	2	35.03	38.64	38.65	189528
60th	2	35.30	38.72	38.72	190328
61th	0	37.10	40.83	40.57	554488
62th	2	34.78	38.16	38.20	190312
63th	2	34.43	38.32	38.44	198000
64th	1	37.32	40.61	40.33	496192
65th	2	34.60	38.40	38.43	196024
66th	2	34.78	38.57	38.58	196704
67th	1	37.51	40.77	40.44	511728
68th	2	34.93	38.51	38.47	194544
69th	2	34.92	38.54	38.64	193744
70th	1	37.47	40.94	40.50	491040
71th	2	35.17	38.76	38.79	188280
72th	2	35.13	38.76	38.81	187632
73th,	0	37.83	42.03	41.66	533560
74th	2	35.69	39.06	38.98	192976
75th	2	35.64	38.58	38.52	192576
76th	1	37.75	41.46	40.97	495040
77th	2	35.87	38.45	38.36	190616
78th	2	35.83	38.19	38.23	186680
79th	1	37.63	40.96	40.41	492488
80th	2	35.90	38.41	38.29	200200
81th	2	35.76	38.06	37.94	197768
82th	1	37.54	40.98	40.33	499688
83th	2	35.79	37.90	37.94	208800
84th	2	35.79	37.74	37.76	207744
85th	0	37.35	41.35	40.95	408352
86th	2	35.32	36.71	36.74	174416
87th	2	35.17	36.14	36.20	181864
88th	1	36.79	39.48	39.02	466424
89th	2	34.97	35.88	36.04	188952
90th	2	34.87	35.78	35.83	199080
91th	1	36.45	38.62	38.38	516600
92th	2	34.58	35.29	35.59	211352
93th	2	34.46	35.14	35.30	222256
94th	1	36.15	38.05	37.90	535952
95th	2	34.04	34.93	35.10	241168
96th	2	33.99	34.73	34.89	252928
97th	0	36.04	38.97	39.01	434384
98th	2	32.93	33.47	33.59	190096
99th	2	32.75	32.93	33.20	193016
100th	1	35.14	36.56	36.58	465144
101th	2	32.29	32.66	32.90	207968
102th	2	32.35	32.46	32.73	207648
103th	1	34.52	35.61	35.64	491224
104th	2	32.06	32.41	32.55	221208
105th	2	32.21	32.23	32.41	222728
106th	1	34.46	35.39	35.39	513864
107th	2	31.83	31.97	32.25	224048
108th	2	32.30	32.33	32.69	227976
109th	0	35.31	37.52	37.73	490992
110th	2	31.65	31.85	32.20	212536
111th	2	31.93	31.84	31.99	204760
112th	1	34.18	35.53	35.44	459936
113th	2	31.63	31.68	32.03	214176
114th	2	31.87	31.58	31.86	207648
115th	1	33.94	34.99	34.98	468904
116th	2	31.72	31.69	31.96	218288
117th	2	31.89	31.68	31.95	213688
118th	1	33.90	34.85	34.85	464912
119th	2	31.64	31.68	32.01	221832
120th	2	31.69	31.65	31.94	221760
121th	0	34.83	36.85	37.20	494728
122th	2	31.06	31.56	31.73	217200
123th	2	31.21	31.35	31.59	212352
124th	1	33.69	34.91	34.96	466816
125th	2	30.72	31.17	31.48	212896
126th	2	30.99	31.01	31.31	216728
127th	1	33.45	34.50	34.47	470248
128th	2	30.92	31.49	31.66	211952
129th	2	31.00	31.00	31.32	209792
130th	1	33.33	34.27	34.17	458736
131th	2	31.04	31.41	31.64	210288
132th	2	31.20	31.33	31.59	217616
133th	0	34.34	36.51	36.71	506576
134th	2	30.95	31.32	31.60	206656
135th	2	30.96	31.38	31.49	209920
136th	1	33.27	34.69	34.79	464976
137th	2	30.57	31.19	31.47	211600
138th	2	30.92	31.35	31.40	213768
139th	1	33.01	34.22	34.27	471288
140th	2	30.56	31.15	31.41	214544
141th	2	31.02	31.27	31.53	206360
142th	1	33.11	34.16	34.13	473032
143th	2	30.44	31.13	31.34	210736
144th	2	30.91	31.51	31.74	210024
145th	0	34.35	36.43	36.71	533696
146th	2	30.36	31.19	31.46	210464
147th	2	30.89	31.60	31.88	204448
148th	1	33.48	34.90	34.93	465312

Table Tennis 9.0 Mbit/sec SN & Bits Result

Frame	Ptype	SN-Y	SN-Cb	SN-Cr	Total-bit
1th	0	30.29	38.31	39.39	629712
2th	2	30.11	38.54	39.63	158648
3th	2	30.22	38.63	39.70	158896
4th	1	31.48	38.74	39.66	455008
5th	2	31.33	38.92	39.94	157464
6th	2	30.64	38.78	39.75	165952
7th	1	31.82	38.58	39.56	527552
8th	2	30.27	38.64	39.72	190168
9th	2	29.64	38.82	39.82	201256
10th	1	32.31	38.79	39.82	563912
11th	2	30.04	38.73	39.90	193952
12th	2	29.86	38.72	39.99	194536
13th	0	29.68	38.24	39.27	588872
14th	2	28.59	38.44	39.48	188400
15th	2	29.37	38.62	39.60	174872
16th	1	31.43	38.62	39.54	555728
17th	2	29.97	38.69	39.62	167376
18th	2	29.74	38.67	39.62	176968
19th	1	31.86	38.59	39.52	536112
20th	2	29.95	38.73	39.70	166856
21th	2	29.97	38.71	39.71	165072
22th	1	31.74	38.58	39.55	477416
23th	2	28.95	38.65	39.90	195376
24th	2	28.76	38.65	39.97	206816
25th	0	32.48	38.75	40.06	680800
26th	2	30.30	39.20	40.64	229880
27th	2	31.31	39.55	40.79	207720
28th	1	34.39	39.82	40.89	529376
29th	2	31.96	40.10	41.14	187656
30th	2	32.16	40.15	41.19	183072
31th	1	34.75	40.40	41.34	483848
32th	2	32.71	40.58	41.56	170592
33th	2	32.97	40.75	41.71	165456
34th	1	35.25	40.91	41.64	440800
35th	2	33.69	41.12	42.24	157488
36th	2	34.43	41.46	42.52	161976
37th	0	37.02	41.55	42.54	573400
38th	2	35.17	41.71	42.76	186592
39th	2	35.44	41.77	42.86	182432
40th	1	37.61	41.89	42.89	488624
41th	2	35.77	41.98	42.69	174640
42th	2	35.94	42.01	42.82	178944
43th	1	37.89	42.30	43.00	517024
44th	2	36.20	41.99	42.55	186616
45th	2	36.31	41.99	42.47	190720
46th	1	38.04	42.44	43.06	543968
47th	2	36.45	42.15	42.49	184136
48th	2	36.68	42.30	42.72	192632
49th	0	38.58	42.76	43.73	538000
50th	2	36.60	42.18	42.62	174008
51th	2	36.58	42.07	42.53	177552
52th	1	38.32	42.57	43.06	558000
53th	2	36.55	42.04	42.42	176424
54th	2	36.67	42.01	42.39	178808
55th	1	38.35	42.50	43.05	554696
56th	2	36.65	41.91	42.48	177520
57th	2	36.75	41.99	42.56	175104
58th	1	38.26	42.36	42.88	523832
59th	2	36.70	41.95	42.47	181056
60th	2	36.72	41.96	42.58	182472
61th	0	37.73	42.07	42.71	517080
62th	2	36.19	41.66	42.16	136568
63th	2	36.21	41.73	42.13	135704
64th	1	37.29	41.93	42.22	417968
65th	2	36.06	41.50	41.90	136872
66th	2	35.97	41.43	41.71	140816
67th	1	37.23	41.68	41.91	420920
68th	2	37.02	41.67	42.50	302184
69th	2	37.26	41.78	42.64	301784
70th	3	37.96	41.72	42.49	826400
71th	2	36.51	41.95	42.52	129808
72th	2	36.51	41.94	42.48	131408
73th	0	38.74	42.07	42.94	917024
74th	2	36.69	41.84	42.62	169264
75th	2	36.71	41.87	42.68	170320
76th	1	38.18	42.14	43.12	438584
77th	2	36.90	42.09	42.88	170464
78th	2	37.03	42.13	42.96	173360
79th	1	38.47	42.34	43.29	446264
80th	2	37.17	42.12	42.96	170200
81th	2	37.10	42.13	42.98	178088
82th	1	38.38	42.31	43.20	405480
83th	2	37.42	42.43	43.30	181024
84th	2	37.35	42.51	43.34	175992
85th	0	38.99	42.27	43.09	947024
86th	2	36.98	42.11	42.99	171304
87th	2	36.96	42.07	42.92	174880
88th	1	38.20	42.32	43.28	404560
89th	2	37.19	42.23	43.08	178328
90th	2	37.25	42.23	43.15	179032
91th	1	38.31	42.40	43.35	385920
92th	2	37.35	42.31	43.19	190256
93th	2	37.39	42.29	43.07	192496
94th	1	38.37	42.45	43.31	380800
95th	2	37.31	42.03	42.82	194992
96th	2	37.30	42.03	42.89	197248
97th	0	35.52	39.99	40.20	586816
98th	2	36.28	41.55	42.67	298048
99th	2	36.68	41.75	42.93	268656
100th	3	38.89	42.10	43.39	1040176
101th	2	36.09	41.67	42.79	121368
102th	2	35.92	41.60	42.65	118312
103th	1	36.61	41.47	42.67	371232
104th	2	35.82	41.38	42.41	113832
105th	2	-35.63	41.27	42.20	114856
106th	1	36.19	41.16	42.17	333936
107th	2	36.20	41.73	42.78	115136
108th	2	36.26	41.73	42.76	114952
109th	0	37.88	41.52	42.58	912512
110th	2	36.74	41.63	42.83	159944
111th	2	36.72	41.59	42.79	160512
112th	1	37.69	41.66	42.97	463888
113th	2	36.85	41.72	42.89	157984
114th	2	36.75	41.67	42.87	159528
115th	1	37.83	41.77	42.99	458576
116th	2	36.82	41.61	42.77	165104
117th	2	36.70	41.59	42.68	166488
118th	1	37.79	41.73	42.96	436448
119th	2	36.97	41.71	42.89	176008
120th	2	36.88	41.74	42.90	180384
121th	0	36.92	40.97	41.85	799840
122th	2	35.67	40.98	41.86	162856
123th	2	35.99	41.16	42.12	172712
124th	1	37.12	41.13	42.14	472648
125th	2	34.86	40.68	41.55	177312
126th	2	35.93	41.00	41.95	166144
127th	1	37.08	41.31	42.24	466280
128th	2	34.81	40.84	41.56	185728
129th	2	35.68	40.96	41.90	179008
130th	1	37.19	41.35	42.19	474952
131th	2	36.25	41.65	42.60	172608
132th	2	36.16	41.53	42.32	165328
133th	0	37.65	41.49	42.32	824168
134th	2	36.17	41.44	42.28	159144
135th	2	35.33	41.48	42.33	171000
136th	1	37.56	41.47	42.39	472432
137th	2	35.42	41.02	41.81	175944
138th	2	36.13	41.12	41.89	162200
139th	1	37.44	41.49	42.24	456352
140th	2	36.19	41.18	41.98	158840
141th	2	35.35	41.13	42.03	177912
142th	1	37.18	41.21	41.96	470816
143th	2	35.08	41.25	41.81	176168
144th	2	35.60	41.23	42.11	185944
145th	0	37.38	41.19	42.01	818744
146th	2	35.15	41.15	41.91	170512
147th	2	34.67	40.87	41.52	172096
148th	1	37.14	41.26	42.08	452064

Mobile & Calendar 9.0 Mbit/sec SN & Bits Result

Frame	Ptype	SN-Y	SN-Cb	SN-Cr	Total-bit
1th	0	34.03	35.77	36.43	924344
2th	2	31.58	35.55	36.16	161448
3th	2	31.43	35.42	35.97	166576
4th	1	33.10	35.41	36.10	454264
5th	2	31.45	35.29	35.78	164904
6th	2	31.31	35.11	35.64	168784
7th	1	33.05	35.27	35.88	453184
8th	2	31.30	35.05	35.65	173008
9th	2	31.29	35.01	35.57	168448
10th	1	33.08	35.18	35.76	442488
11th	2	31.74	35.76	36.29	156440
12th	2	32.04	35.90	36.46	161720
13th	0	34.92	36.39	36.96	1028352
14th	2	32.68	36.12	36.66	161776
15th	2	32.30	35.78	36.38	163728
16th	1	34.11	36.40	36.96	442448
17th	2	32.81	35.82	36.35	153312
18th	2	32.69	35.83	36.37	151208
19th	1	34.06	36.18	36.75	427664
20th	2	32.41	35.56	36.08	160472
21th	2	32.44	35.69	36.19	155176
22th	1	33.94	35.87	36.45	425888
23th	2	33.31	36.17	36.72	163272
24th	2	33.12	36.20	36.78	161048
25th	0	35.16	36.47	37.12	1062832
26th	2	33.30	36.26	36.76	147664
27th	2	33.14	36.29	36.78	150808
28th	1	34.30	36.40	36.95	455952
29th	2	32.81	35.92	36.39	145288
30th	2	33.16	36.36	36.77	142936
31th	1	34.02	36.01	36.50	431104
32th	2	31.82	36.13	36.37	168864
33th	2	32.08	35.75	36.29	172984
34th	1	34.16	36.24	36.62	363160
35th	2	32.37	36.07	36.57	175952
36th	2	32.51	36.07	36.61	177680
37th	0	34.66	36.01	36.53	1018016
38th	2	31.92	35.66	36.09	159944
39th	2	31.90	35.82	36.32	167792
40th	1	33.99	36.25	36.67	368296
41th	2	32.58	35.68	36.06	157352
42th	2	32.90	35.96	36.37	152432
43th	1	34.01	36.02	36.44	433808
44th	2	32.54	35.64	35.97	158992
45th	2	32.46	35.84	36.17	166360
46th	1	33.89	35.73	36.18	471048
47th	2	32.43	35.87	36.26	171184
48th	2	32.45	35.99	36.38	174392
49th	0	34.59	35.94	36.51	1013904
50th	2	32.79	35.86	36.31	141608
51th	2	32.68	35.95	36.44	145200
52th	1	33.78	35.82	36.30	434472
53th	2	32.05	35.47	35.91	152656
54th	2	32.29	35.71	36.07	151960
55th	1	33.60	35.62	36.05	405000
56th	2	32.22	35.45	35.84	162224
57th	2	32.31	35.44	35.87	168088
58th	1	33.62	35.41	35.84	471504
59th	2	32.51	35.78	36.23	176656
60th	2	32.28	35.65	36.14	173672
61th	0	33.98	35.44	35.96	946832
62th	2	31.96	35.36	35.76	158496
63th	2	32.06	35.38	35.77	157600
64th	1	33.30	35.33	35.81	452032
65th	2	31.96	35.20	35.67	157496
66th	2	31.90	35.12	35.55	159272
67th	1	33.16	35.07	35.60	454392
68th	2	31.84	34.99	35.49	164648
69th	2	31.75	34.91	35.39	163984
70th	1	33.10	34.97	35.43	452264
71th	2	32.07	35.46	35.88	163136
72th	2	32.27	35.55	35.94	169656
73th	0	34.11	35.58	36.04	968360
74th	2	31.79	35.29	35.74	174616
75th	2	31.81	35.17	35.59	174312
76th	1	33.42	35.36	35.81	474992
77th	2	31.58	35.19	35.50	165208
78th	2	31.86	35.08	35.39	166160
79th	1	33.33	35.19	35.69	469472
80th	2	32.01	35.30	35.58	152088
81th	2	32.03	35.12	35.45	147672
82th	1	33.36	35.32	35.71	410656
83th	2	32.38	35.99	36.31	139872
84th	2	32.37	36.04	36.43	152496
85th	0	34.60	35.85	36.30	1020424
86th	2	32.12	35.69	36.09	150312
87th	2	32.17	35.59	35.94	152976
88th	1	33.92	36.04	36.49	396368
89th	2	32.09	35.82	36.15	156584
90th	2	32.01	35.59	35.98	157944
91th	1	33.85	35.94	36.30	445488
92th	2	31.81	35.34	35.73	163144
93th	2	31.97	35.30	35.68	163968
94th	1	33.66	35.54	36.02	465848
95th	2	33.12	36.18	36.44	159256
96th	2	32.95	35.98	36.30	165256
97th	0	34.94	36.06	36.51	1065544
98th	2	33.40	36.24	36.46	141488
99th	2	33.50	36.19	36.40	139976
100th	1	34.20	36.28	36.66	436064
101th	2	33.48	36.01	36.26	145184
102th	2	33.30	35.92	36.24	143344
103th	1	34.03	36.05	36.46	446176
104th	2	33.43	35.83	36.04	144896
105th	2	33.33	35.78	36.05	150160
106th	1	33.97	35.85	36.34	448704
107th	2	32.62	36.06	36.32	164592
108th	2	33.02	36.09	36.39	172632
109th	0	34.83	35.96	36.45	1033160
110th	2	32.44	35.88	36.27	155672
111th	2	32.43	35.62	35.95	156544
112th	1	34.12	35.99	36.43	460072
113th	2	32.50	35.63	35.98	165024
114th	2	31.98	35.28	35.72	160872
115th	1	34.20	35.93	36.47	447784
116th	2	32.85	35.36	35.69	156400
117th	2	32.37	35.54	35.88	164864
118th	1	34.24	35.88	36.36	398528
119th	2	33.46	35.98	36.32	148224
120th	2	33.69	36.13	36.60	148704
121th	0	35.48	36.57	37.14	1086560
122th	2	32.56	35.77	36.14	163312
123th	2	33.34	35.99	36.41	170248
124th	1	34.80	36.63	37.09	420104
125th	2	32.73	35.61	36.14	171008
126th	2	33.28	35.83	36.26	157072
127th	1	34.90	36.39	37.01	459352
128th	2	33.52	36.22	36.62	139936
129th	2	33.75	36.24	36.69	136512
130th	1	34.85	36.44	37.02	381368
131th	2	34.05	36.97	37.34	152168
132th	2	33.39	37.03	37.36	161496
133th	0	36.13	37.12	37.64	1129816
134th	2	34.00	36.45	37.00	150120
135th	2	33.76	36.38	36.96	153288
136th	1	35.24	36.80	37.44	405832
137th	2	33.54	36.08	36.66	157464
138th	2	33.91	36.21	36.68	155816
139th	1	35.26	36.64	37.18	404200
140th	2	33.73	36.28	36.72	153504
141th	2	33.57	36.20	36.63	149264
142th	1	34.63	36.40	36.99	410008
143th	2	34.29	36.29	36.84	159872
144th	2	33.74	36.09	36.65	166280
145th	0	35.48	36.35	36.86	1109712
146th	2	33.81	36.01	36.57	147856
147th	2	33.83	36.14	36.65	143320
148th	1	34.59	36.18	36.66	431472


Flower Garden 4 Mbit/sec
S/N ratio (dB)
Entropy (kbit)
36
34
32
30
28
545
420
295
170
45
Entropy
S/N -Y
S/N -Cb
S/N -Cr
1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 (th)
KDD R&D LABS.

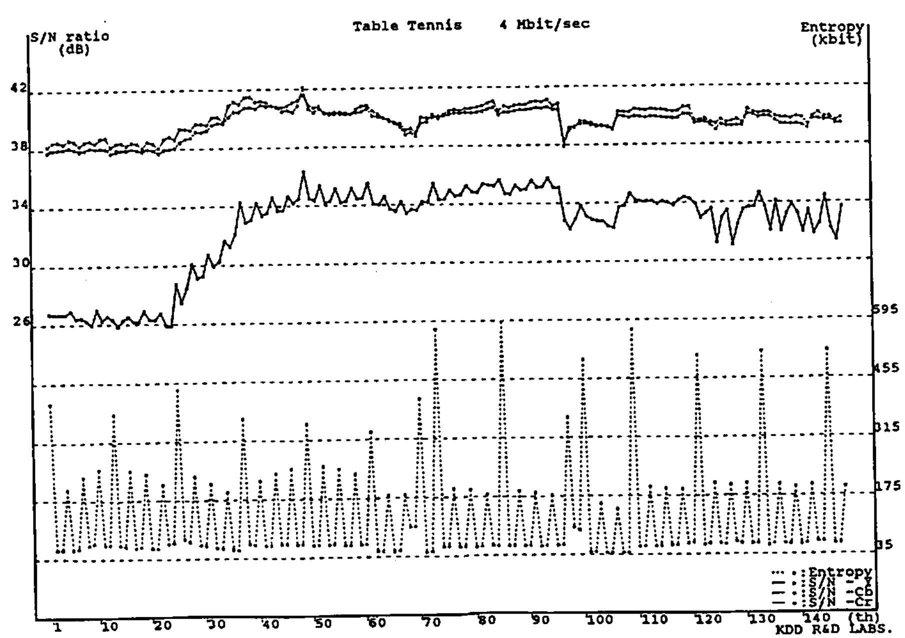
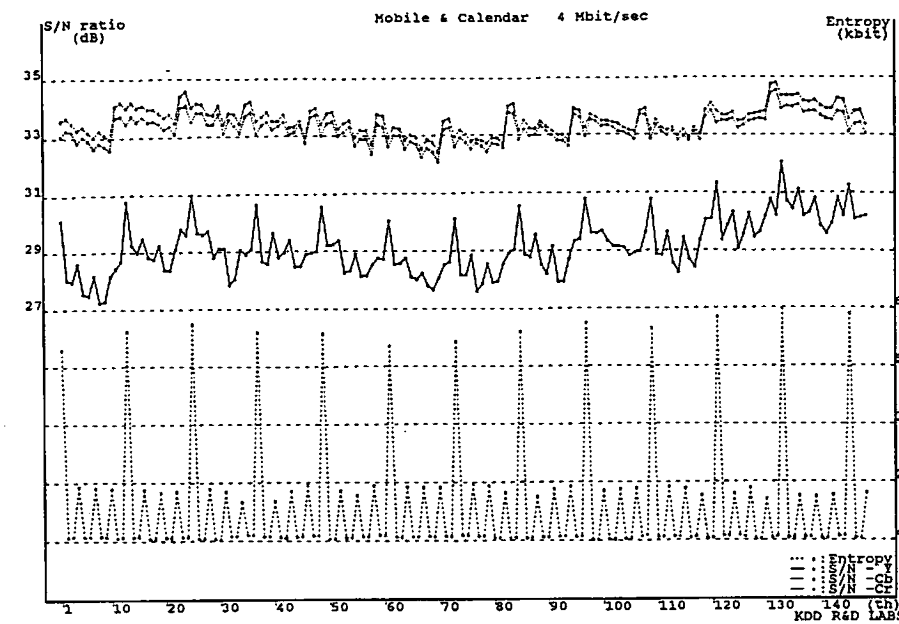


Table Tennis 4 Mbit/sec
S/N ratio (dB)
Entropy (kbit)
42
38
34
30
26
595
455
315
175
35
Entropy
S/N -Y
S/N -Cb
S/N -Cr
1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 (th)
KDD R&D LABS.


Mobile & Calendar 4 Mbit/sec
S/N ratio (dB)
Entropy (kbit)
35
33
31
29
27
685
525
365
205
45
Entropy
S/N -Y
S/N -Cb
S/N -Cr
1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 (th)
KDD R&D LABS.

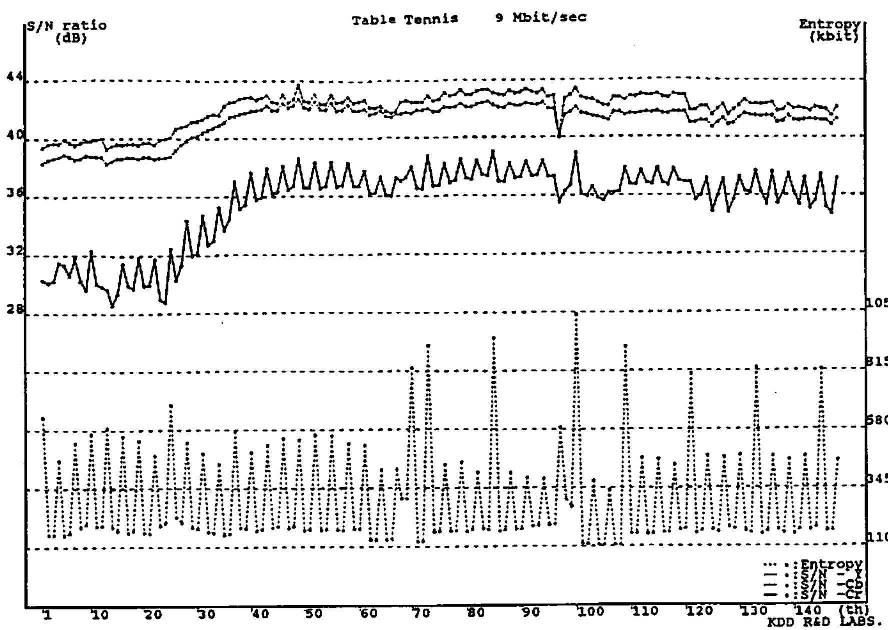
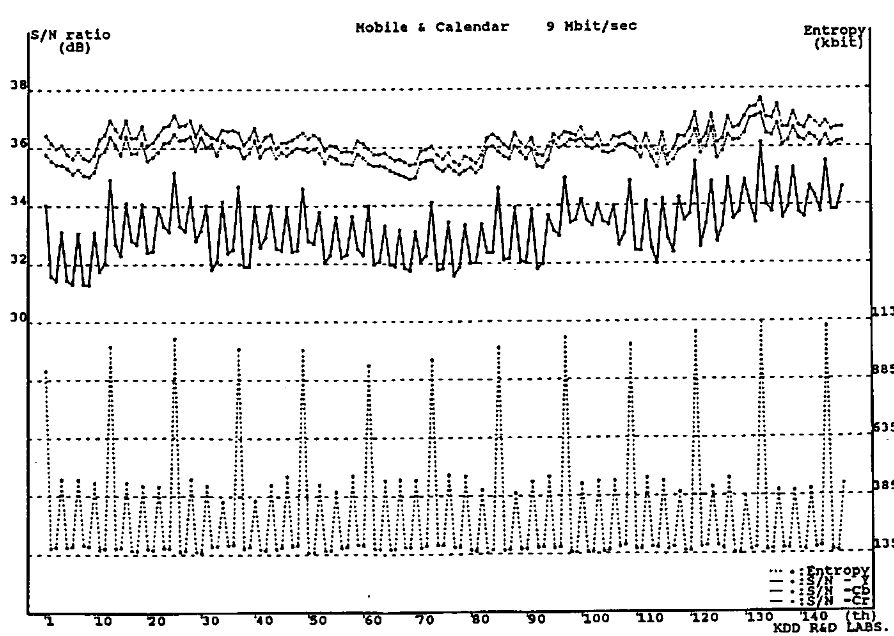
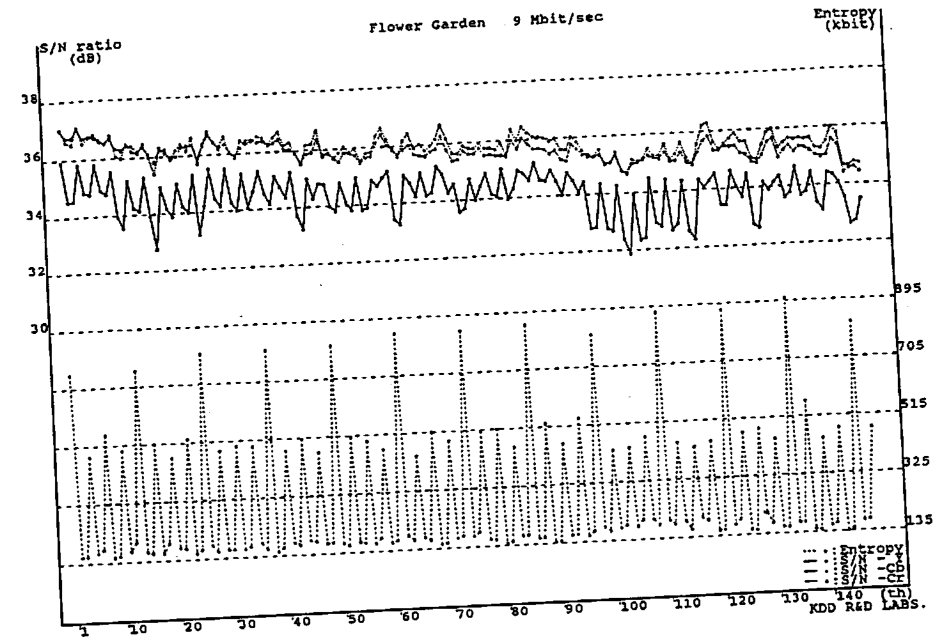
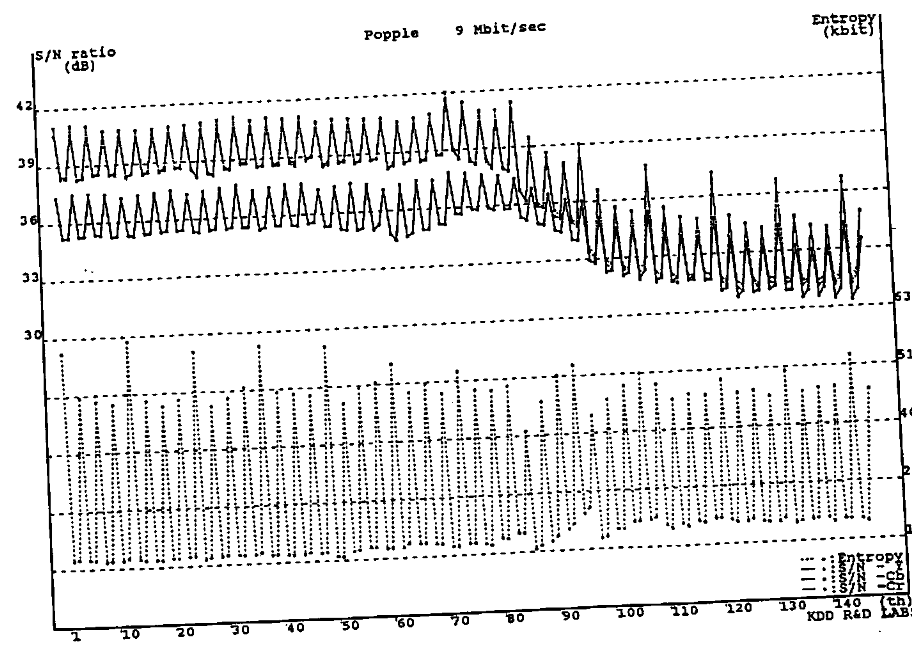


Table Tennis 9 Mbit/sec
S/N ratio (dB)
Entropy (kbit)
44
40
36
32
28
1050
815
580
345
110
1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 (th)
: Entropy
: S/N -Y
: S/N -Cb
: S/N -Cr
KDD R&D LABS.


Mobile & Calendar 9 Mbit/sec
S/N ratio (dB)
Entropy (kbit)
38
36
34
32
30
1135
885
635
385
135
1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 (th)
: Entropy
: S/N -Y
: S/N -Cb
: S/N -Cr
KDD R&D LABS.


Flower Garden 9 Mbit/sec
S/N ratio (dB)
Entropy (kbit)
38
36
34
32
30
895
705
515
325
135
1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 (th)
: Entropy
: S/N -Y
: S/N -Cb
: S/N -Cr
KDD R&D LABS.


Popple 9 Mbit/sec
S/N ratio (dB)
Entropy (kbit)
42
39
36
33
30
630
515
400
285
170
1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 (th)
: Entropy
: S/N -Y
: S/N -Cb
: S/N -Cr
KDD R&D LABS.

ANNEX D

THE BIT STREAM LIST OF 7 SEQUENCES at 4 and 9 Mbit/s

```
-rw-rw-rw-   1 nakajima   invite    2504016 Oct 15 15:57 flower4.bst
-rw-rw-rw-   1 nakajima   invite    5602310 Oct 13 12:26 flower9.bst
-rw-rw-rw-   1 nakajima   invite    2516614 Oct 12 11:35 mobile4.bst
-rw-rw-rw-   1 nakajima   invite    5624589 Oct 14 02:14 mobile9.bst
-rw-rw-rw-   1 nakajima   invite    5575497 Oct 15 05:53 popple9.bst
-rw-rw-rw-   1 nakajima   invite    2503335 Oct 13 00:16 tennis4.bst
-rw-rw-rw-   1 nakajima   invite    5597222 Oct 14 16:38 tennis9.bst
```