AVC-156

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ORGANISATION INTERNATIONALE DE NORMALISATION
ISO / IEC JTC1 / SC2 / WG11
CODING OF MOVING PICTURES AND ASSOCIATED AUDIO

ISO / IEC JTC1 / SC2 / WG11 N
MPEG 91 / 219
Nov. 1991

Source : Tokumichi Murakami, Kohtaro Asai,
Masami Nishida, Hirofumi Nishikawa
(Mitsubishi Electric Corporation)

Title : Description of the coding algorithm for the proposal package (#24)
Purpose : proposal
Group : Video

GENERAL DESCRIPTION

This document gives a full description of the algorithm we propose for the Kurihama tests. The algorithm is submitted to the second phase work of ISO-IEC JTC1 / SC2 / WG11 (MPEG).

This document contains the materials which are requested in MPEG 91 / 100 Rev. (WG11 N0098).

Our registration number is 24 as given in WG11 N0064.

The contents of this document are divided into four parts. Part-1 provides an explanation of the coding algorithm accompanied with the syntax and VLC & FLC tables in annex. Part-2 provides an explanation of the features of this algorithm. Part-3 provides a statistics of coded data. And part-4 provides a result of an implementation study.

REFERENCES

[1] CD11172-2 draft copy 22/08/91 (MPEG1-video)
[2] MPEG video simulation model three (SM3) WG11 N0010
[3] CCITT recommendation H.261

CONTENTS

PART - 1 CODING ALGORITHM

PART - 2 FEATURES

PART - 3 STATISTICS

PART - 4 IMPLEMENTATION STUDY

PART - 1 CODING ALGORITHM

1. PICTURE FORMAT

The picture format for this coding method is basically 525-line version of the "4:2:0" level of CCIR Rec 601. It is possible to encode 625-line version using this scheme and a subtle modification enables the scheme to encode whole 4:2:2 level of CCIR Rec.601.

The siginificant pixels which were coded are as follows.

Number of siginificant lines per fields

Luminance	240
Chrominance	120

Number of significant pixels per line

Luminance	704
Chrominance	352

Field rate (per second) 60

Please note that this format is the double of the source input format which appeared in SM3 WG11 N0010.

The chrominance pixels are decimated in vertical (240 to 120) from the whole format using a decimation filter. The coefficients are as below.

-29, 0, 88, 138, 88, 0, -29 // 256

After decoding of chrominance pixels, they are interpolated (120 to 240) using an interpolation filter. The coefficients are as below.

-12, 0, 140, 256, 140, 0, -12 // 256

2. OUTLINE OF ALGORITHM

This scheme is based on hybrid DCT coding with motion compensation such as the MPEG1 algorithm. Simultaneously, this scheme is an enhancement of the MPEG1 algorithm and is intended to utilize the characteristics of interlaced video signals. DCT is performed at the block (8 pixels x 8 lines) level.

Bidirectional motion compensation between frames is performed as introduced in MPEG1. Further, interfield prediction is also performed. The interfield prediction is one of main features of this scheme.

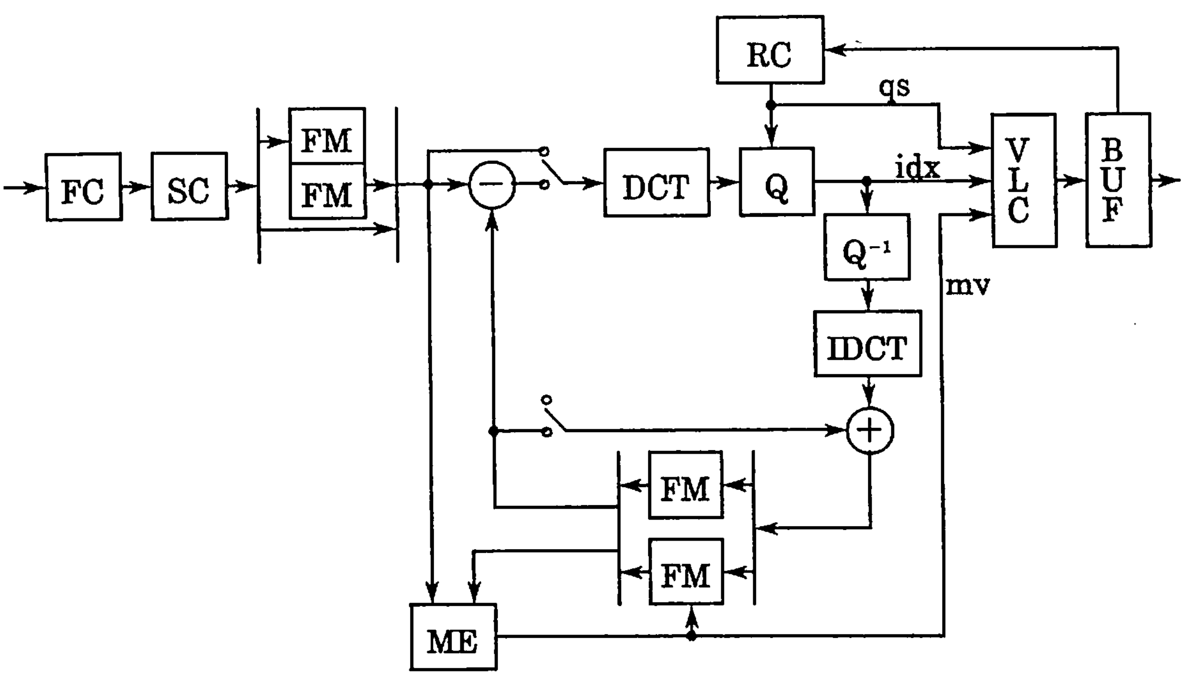
Each picture (a pair of fields) is divided into 30 slices which consists of 16 field lines; 8 lines from the first field and 8 lines from the second field.

Each slice is divided into 44 macroblocks (collecting four luminance blocks and two chrominance blocks). Motion estimation is performed at the half of macroblock level.

In a macroblock, each block is adaptively formed ; some blocks are formed using pixels on either field (field-block) and other blocks are formed using pixels on both fields (frame-block). We defined one type of field-block and multiple types of frame-block. This adaptive blocking technique is also one of main features of this scheme.

Each block (inter or intra) is transformed using DCT, quantized and coded using a variable length coder.

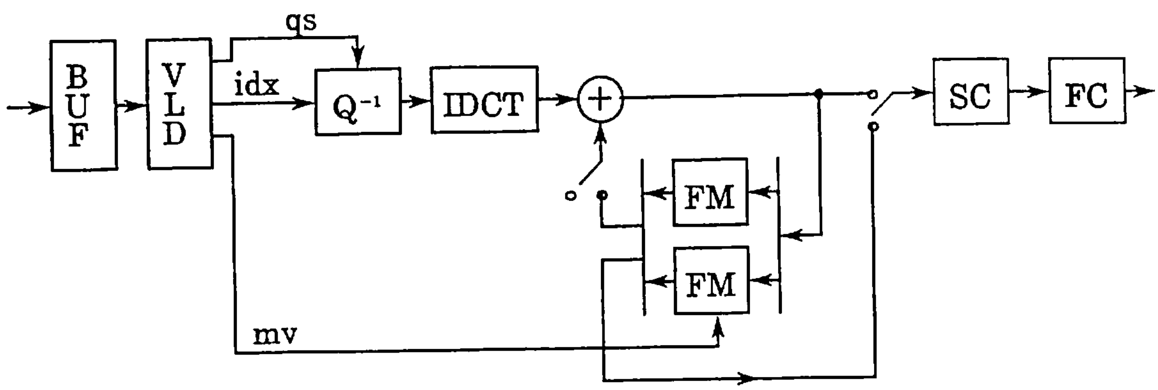
Block diagrams of an encoder and a decoder are shown respectively in Fig. 1 and Fig. 2.



FC : Format Conversion (4:2:2 to 4:2:0)
SC : Scan Conversion
FM : Frame Memory
DCT : Discrete Cosine Transform
Q : Quantization
RC : Rate Control
ME : Motion Estimation
VLC : Variable Length Coding
BUF : BUFfer

qs : quantization step
idx : index (coefficients)
mv : motion vectors

Fig.1 A Block Diagram of an Encoder



BUF : BUFfer
VLD : Variable Length Decoding
Q : Quantization
DCT : Discrete Cosine Transform
FM : Frame Memory
SC : Scan Conversion
FC : Format Conversion (4:2:0 to 4:2:2)

qs : quantization step
idx : index (coefficients)
mv : motion vectors

Fig.2 A Block Diagram of a decoder

3. LAYERED STRUCTURE OF VIDEO DATA

3-1 Block Layer

A block consists of 8 pixels x 8 lines of either luminance or one of the color difference signals. A block is a unit for DCT. Each luminance block is defined by collecting pixels from both fields adaptively, so that power of transformed coefficients are intensive at smaller number of coefficients. All of chrominance blocks are frame based. Procedure of the adaptation will be explained in chapter 6.

3-2 Macroblock Layer

A macroblock consists of four luminance blocks (16 pixels x 16 lines) and a block of Cb and a block of Cr.

3-3 Slice Layer

A slice is a consecutive array of macroblocks. In our simulation, we defined a fixed-length slice which consists of a row of 44 macroblocks across the complete width of the picture (704 pixels x 8 lines x 2 fields).

3-4 Picture Layer

A picture consists of 30 slices (704 pixels x 240 lines X 2 fields). Each picture can be intra-coded, predictive-coded or bidirectionally-predictive-coded. They are introduced in the next chapter.

3-5 Group Of Picture (GOP) Layer

A GOP is a series of pictures containing at least one picture which is intra coded. In our simulation, a GOP consists of twelve pictures. Single picture of each GOP is intra coded. Three pictures of each GOP are predicted from the past pictures only. Eight pictures of each GOP may be coded using bidirectional prediction. A GOP is considered to be helpful for random access.

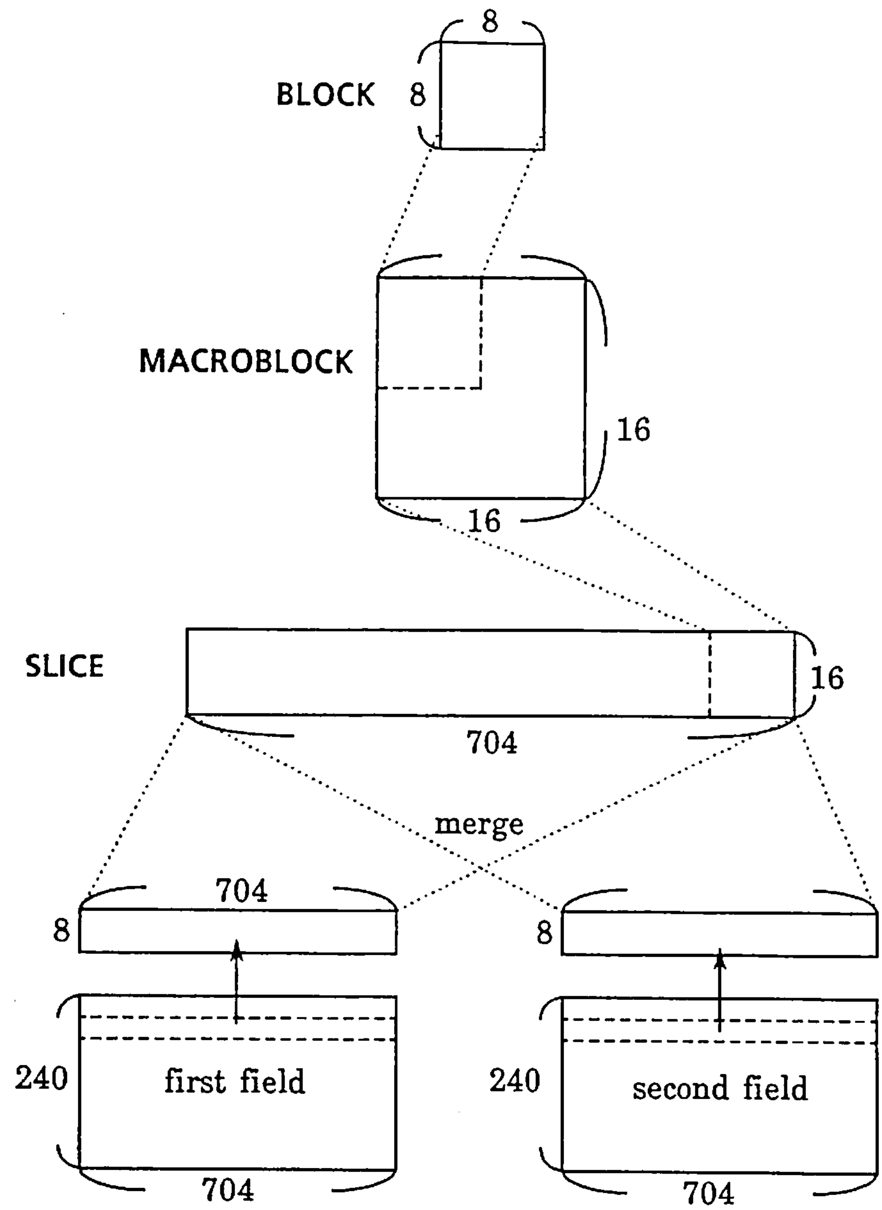


Fig.3 Layered Structure (Only luminance pixels are shown here)

4. PICTURE TYPE

There are three types of pictures :

(A) Intra-coded picture (I-picture):
all the macroblocks are intra coded.

(B) Predictive-coded picture (P-picture):
macroblocks may be intra coded or inter coded by using the motion compensated unidirectional prediction from the coded pictures in past.

(C) Bidirectionally predictive-coded picture (B-picture):
macroblocks may be intra coded or inter coded by using the motion compensated bidirectional prediction from the coded pictures in both past and future.

In our simulation, the size of GOP was set to 12 and the intervals between P-pictures were set to 3. A GOP contains one I-picture, three P-pictures and eight B-pictures. The beginning two pictures are B-pictures.

B→B→I→B→B→P→B→B→P→B→B→P

5. MOTION ESTIMATION AND COMPENSATION

5-1 Procedure

Motion estimation and compensation are used to exploit temporal redundancy. Motion compensation is used for prediction and inter-polation.

Motion estimation is based on the 16 pixels x 8 lines of luminance samples on respective field. We call this unit a pairblock. A pairblock consists of two luminance blocks (16 pixels x 8 field lines) and a half block (8 pixels x 4 field lines) of Cb and a half block (8 pixels x 4 field lines) of Cr on either field. Motion estimation and compensation are performed at the pairblock level. After motion compensation, two co-sited pairblocks on respective fields are merged to form a macroblock. The outline of motion estimation is described below.

· size of matching block :	16 × 8 (luminance)
· accuracy of estimation :	half pixel
· search range (integer) :	+/− 7 pixels × +/− 7 lines (for one picture interval)
· search range (half) :	+/− 0.5 pixels × +/− 0.5 lines

A linear interpolation filter is applied in both directions in order to provide half-pixel accuracy. This procedure is same as in SM3.

Motion compensated prediction is carried out on both the luminance and chrominance samples within each pairblock. The vectors which were searched for luminance samples are used for chrominance samples after halving the vectors (fragrance smaller than +/-0.5 is rounded toward zero).

The vector chosen is the one which gives the minimum value to the total of the 16 x 8 absolute differences. The reference pictures are shown in Fig.4 and Fig.5.

The additional interfield prediction which was newly adopted provides a great improvement in the picture quality.

5-2 MC on / off Decision

The basis of the decision for motion estimation is the sum of absolute differences of all the luminance pixels in a pairblock. The decision of whether to use the vector depends on the relation between the minimum sum and the sum in the case of no-MC, so like in SM3.

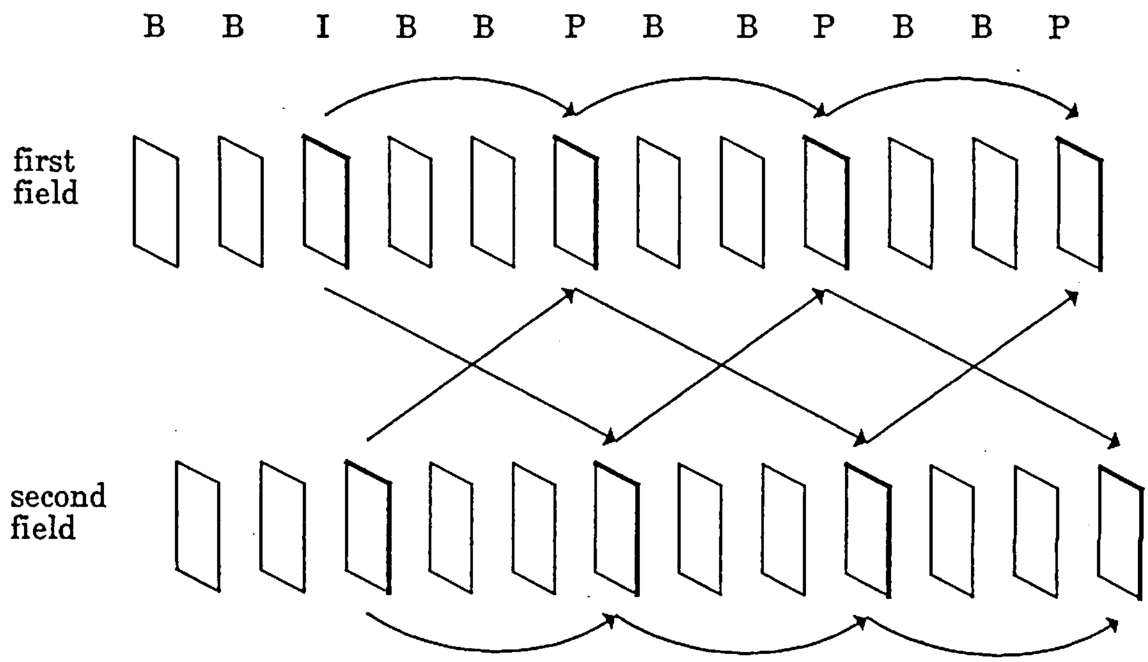


Fig.4 Structure of prediction (P-pictures)

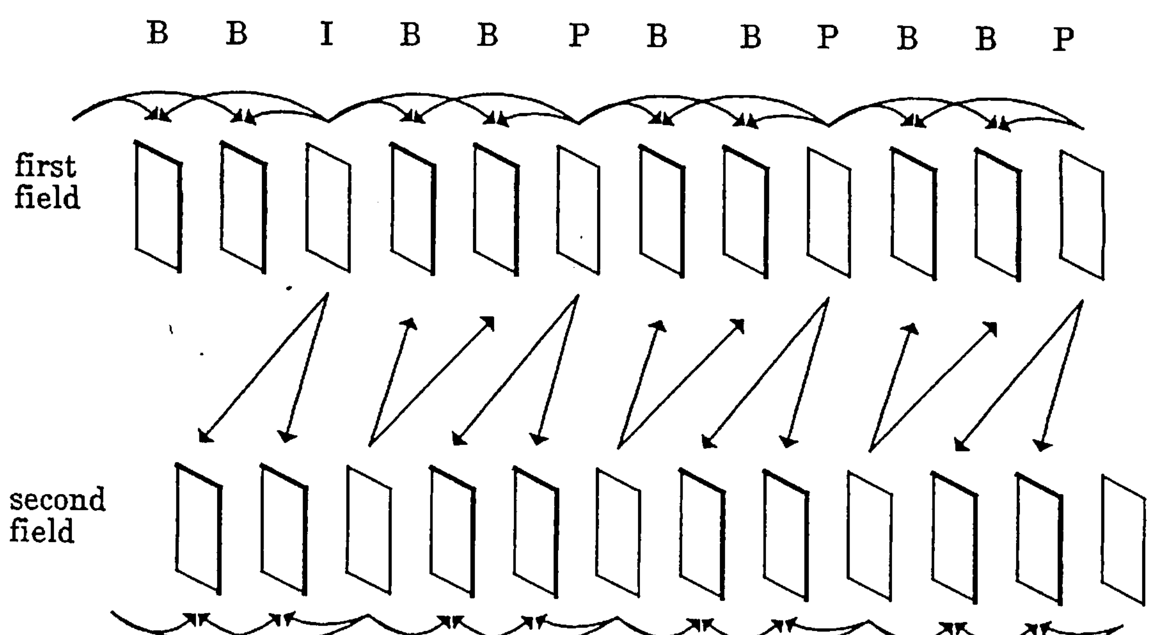


Fig.5 Structure of prediction (B-pictures)

6. TRANSFORMATION

6-1 Adaptive Blocking

For each component (Y, Cb or Cr), the Discrete Cosine Transform (DCT) is applied to each block. The optimal formation of blocks cannot be defined uniquely. We have defined some classes of adaptive blocking. Each block is adaptively formed when a couple of pairblocks are merged to form a macroblock. Basically the types of blocking are classified into field-block and frame-block. A frame-based DCT provides a good performance since the correlation within a block is high. However a frame-block may contain bumpy patterns due to the motion of the objects. In order to avoid such cases, we arranged a blocking patterns of frame-block. Three types of blocking are defined.

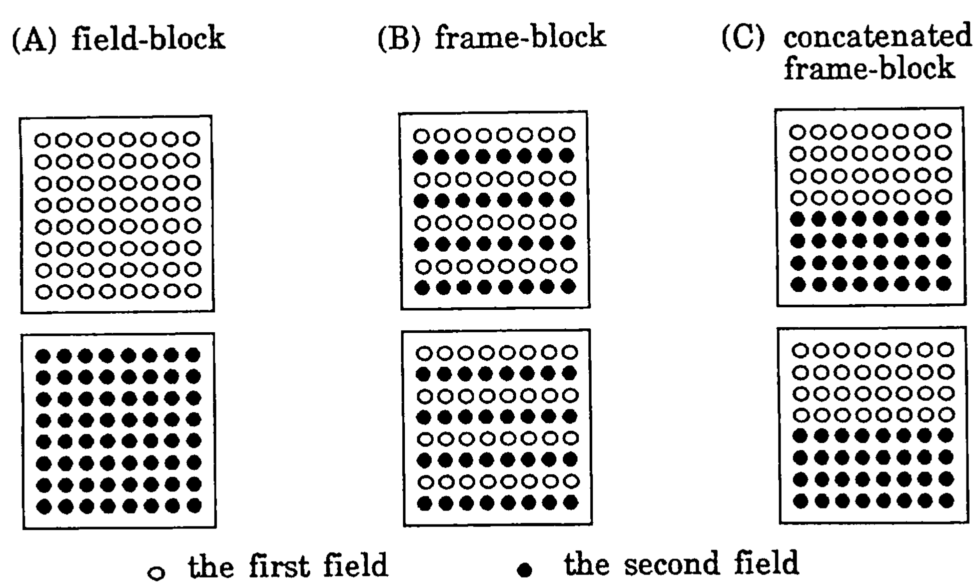


Fig.4 Three types of adaptive blocking

(A) field-block

In this type, each block consists of 64 pixels from either the first field or the second field. Therefore one block is a block defined on the first field and another block is defined on the second field.

(B) frame-block

In this type, each block consists of 32 pixels (8 pixels x 4 field lines) from the first field and another 32 pixels from the second field. Every line of respective fields are interlaced within a block. The block is considered to be defined on a pseudo-progressive frame.

(C) concatenated frame-block

In this type, each block consists of 32 pixels (8 pixels x 4 field lines) from the first field and another 32 pixels from the second field, too. A block is defined so that the pixels of the first field correspond to upper half of the block and the pixels of the second field correspond to lower half of the block.

Since each pairblock contains only four lines of Cb and Cr, all chrominance blocks within a macroblock are fixed to be progressive frame based in any type of macroblock.

Type-B and C are basically frame based while type-A is field based. In case of frame-block, spatial distances between pixels in vertical are shorter than in field-block. Further, degradation which occurs near a moving edge is suppressed within a smaller area on the picture. Power of coefficients becomes intensive at lower sequency as the result of this adaptive blocking method.

6-2 Blocking Class Decision

In our simulation, the decision of the optimum blocking was performed as follows. DCT operation is performed three times corresponding to three classes for each block. After each DCT, the number of coefficients whose magnitude is beyond the quantization step is counted. The blocking formation which gives the minimum number is chosen.

7. QUANTIZATION

7-1 Procedure

The quantization algorithm is close to the quantizer of the MPEG1. Quantization matricies can be utilized. However we did not use any special quantization matricies but used flat quantization matrix for our simulation.

Every quantization is basically a linear quantization. A step size is determined according to the occupancy of the buffer excepting the fixed step size for DC component of intra coded blocks.

The number of quantization levels is 256 for DC component of intra-coded blocks and is 512 for other components.

Variable thresholding is not a necessity condition. However we used variable thresholding in our simulation. This technique was explained in

SM3 document WG11 N0010. Variable thresholding is performed after scanning of coefficients. We used vertical scanning instead of zigzag one.

7-2 Quantization Step Control (Rate Control)

The amount of coded data is controlled by adjusting a quantization step. The quantization step was updated slice by slice. We did not use "Quant" at the macroblock level. The quantization step can be 2, 4, 6, 8, ..., 62. The step is determined according to the buffer occupancy and the picture type.

The rate control method attempts to allocate appropriate number of bits to each picture like the manner in SM3.

In this scheme, flexible and effective control of quantization step can be realized based on a picture type (each picture) and a blocking class (each block).

8. VARIABLE LENGTH CODING

8-1 Coding of transform coefficients

Tansform coefficients are variable-length-coded using the same method as MPEG1. Similarity in VLC is the most significant factor especially for compatibility. Therefore we used the same codetables as in MPEG1 as far as possible.

Every DC component of intra-coded blocks is, after quantization, coded losslessly by a DPCM technique. At the left edge of a slice, the DC predictor is set to 128. The differential DC values are expressed with "size" and "differential" like in MPEG1. Both codes are encoded with variable length codes.

Transform coefficients are not always present for all six blocks in an inter-coded macroblock. In such cases, CBP (Coded Block Pattern) indicates which blocks have significant (non-zero) coefficients.

The most commonly occurring combinations of zero-run and the following non-zero value are encoded wit h variable length codes. And other combinations are encoded with ESCAPE code and fixed length codes. Encoding is performed along the scanning order. Vertical scanning was adopted in our simulation. EOB (End Of Block) code is included in the above variable length code table.

8-2 Coding of motion vectors

We used the same codetables as in MPEG1 also for motion vectors. Motion vectors are coded differentially within a slice. A macro-block is composed of two pairblocks and may have two sets of motion vectors. Each vector is predicted by previously coded vector which belongs to the same presence and the kind of motion v ors are indicated by macroblock type code.

Forward, interframe
Backward, interframe
Forward, interfield
Backward, interfield

Dynamic range of motion vectors can be changed by some codes in picture layer as same as in MPEG1.

8-3 Coding of other information

A macroblock type, which is an extended version of MPEG1, contains the following information.

Intra / Inter
Forward frame / Backward frame / Field
Coded / not Coded
Quantization step included / not included

A blocking information code indicates the decision of adaptive blocking. This code is encoded with variable length codes.

ANNEX-1 CODED VIDEO DATA BITSTREAM SYNTAX

1 Video Sequence Layer

```
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 Sequence Header

```
sequence_headr( ) {
    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_marix[64]                              8*64 uimsbf
    load_non_intra_quantizer_matrix                            1
        if( load_non_intra_quantizer_matrix )
    non_intra_quantizer_marix[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_start_code ) {
        user_data_start_code                                   32 bslbf
        while( nextbits( ) != '0000 0000 0000 0000 0000 0001' ) {
            user_data                                          8
        }
        next_start_code( )
    }
}
```

3 Group of Picture Layer

```
group_of_pictures( ) {
    group_start_code                                        32 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 )
}
```

4 Picture Layer

```
picture( ) {
    picture_start_code                                      32 bslbf
    temporal_reference                                      10 uimsbf
    picture_coding_type                                     3 uimsbf
    vbv_delay                                               16 uimsbf
    if( picture_coding_type==2 || picture_coding_type==3 ) {
        full_pel_forward_vector                             1
        forward_f_code                                      3 uimsbf
    }
    if( picture_coding_type==3 ) {
        full_pel_backward_vector                            1
        backward_f_code                                     3 uimsbf
    }
    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 )
}
```

5 Slice Layer

```
slice( ) {
    slice_start_code                                             32 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( )
}
```

6 Macroblock Layer

```
macroblock( ) {
    while( nextbits( ) == '0000 0001 111' )
        macroblock_stuffing                                      11 vlclbf
    while( nextbits( ) == '0000 0001 000' )
        macroblock_escape                                        11 vlclbf
    macroblock_address_increment                                 1-11 vlclbf
    macroblock_type                                              1-12 vlclbf
    if( macroblock_quant )
        quantizer_scale                                          5 uimsb
    if( macroblock_motion_forward ) {
        macroblock_motion_forward_odd                            1
        macroblock_motion_forward_even                           1
    }
    if( macroblock_motion_backward ) {
        macroblock_motion_backward_odd                           1
```

```
        macroblock_motion_backward_even             1
}
if( macroblock_motion_field ) {
        macroblock_motion_field_odd                 1
        macroblock_motion_field_even                1
}
if( macroblock_motion_forward ) {
        if( macroblock_motion_forward_odd ) {
                motion_horizontal_forward_odd_code     1-11 vlclbf
                if(( forward_f != 1 ) &&
                        ( motion_horizontal_forward_odd_code != 0 ))
                        motion_horizontal_forward_odd_r    1-6 uismbf
                motion_vertical_forward_odd_code       1-11 vlclbf
                if(( forward_f != 1 ) &&
                        ( motion_vertical_forward_odd_code != 0 ))
                        motion_vertical_forward_odd_r      1-6 uismbf
        }
        if( macroblock_motion_forward_even ) {
                motion_horizontal_forward_even_code    1-11 vlclbf
                if(( forward_f != 1 ) &&
                        ( motion_horizontal_forward_even_code != 0 ))
                        motion_horizontal_forward_even_r   1-6 uismbf
                motion_vertical_forward_even_code      1-11 vlclbf
                if(( forward_f != 1 ) &&
                        ( motion_vertical_forward_even_code != 0 ))
                        motion_vertical_forward_even_r     1-6 uismbf
        }
}
if( macroblock_motion_backward ) {
        if( macroblock_motion_backward_odd ) {
                motion_horizontal_backward_odd_code    1-11 vlclbf
                if(( backward_f != 1 ) &&
                        ( motion_horizontal_backward_odd_code != 0 ))
                        motion_horizontal_backward_odd_r   1-6 uismbf
                motion_vertical_backward_odd_code      1-11 vlclbf
                if(( backward_f != 1 ) &&
                        ( motion_vertical_backward_odd_code != 0 ))
                        motion_vertical_backward_odd_r     1-6 uismbf
        }

        if( macroblock_motion_backward_even ) {
                motion_horizontal_backward_even_code1-11 vlclbf
                if(( backward_f != 1 ) &&
                        ( motion_horizontal_backward_even_code != 0 ))
                        motion_horizontal_backward_even_r1-6 uismbf
                motion_vertical_backward_even_code     1-11 vlclbf
                if(( backward_f != 1 ) &&
                        ( motion_vertical_backward_even_code != 0 ))
                        motion_vertical_backward_even_r    1-6 uismbf
```

```
        }
    }
    if( macroblock_motion_field ) {
        if( macroblock_motion_field_odd ) {
            motion_horizontal_field_odd_code          1-11 vlclbf
            if(( field_f != 1 ) &&
                ( motion_horizontal_field_odd_code != 0 ))
                motion_horizontal_field_odd_r         1-6 uismbf
            motion_vertical_field_odd_code            1-11 vlclbf
            if(( field_f != 1 ) &&
                ( motion_vertical_field_odd_code != 0 ))
                motion_vertical_field_odd_r           1-6 uismbf
        }
        if( macroblock_motion_field_even ) {
            motion_horizontal_field_even_code         1-11 vlclbf
            if(( field_f != 1 ) &&
                ( motion_horizontal_field_even_code != 0 ))
                motion_horizontal_field_even_r        1-6 uismbf
            motion_vertical_field_even_code           1-11 vlclbf
            if(( field_f != 1 ) &&
                ( motion_vertical_field_even_code != 0 ))
                motion_vertical_field_even_r          1-6 uismbf
        }
    }
    if( macroblock_pattern )
        coded_block_pattern                           3-9 vlclbf
    blocking_information_left                         1-2 vlclbf
    blocking_information_right                        1-2 vlclbf
    for( i=0; i<6; i++ )
        block( i )
    if( picture_coding_type == 4 )
        end_of_macroblock                             1 "1"
}
```

7 Block Layer

```
block( i ) {
    if( pattern_code[i] ) {
        if( macroblock_intra ) {
            if( i<4 ) {
                dct_dc_size_luminance                 2-7 vlclbf
                if( dct_dc_size_luminance != 0 )
                    dct_dc_differential               1-8 uimsbf
            }
            else {
                dct_dc_size_chrominance               2-8 vlclbf
                if( dct_dc_size_chrominance != 0 )
                    dct_dc_differential               1-8 uimsbf
            }
        else {
```

```
        dct_coeff_first                                  2-28 vlclbf
    }
    if( picture_coding_type != 4 ) {
        while( nextbits( ) != '10' )
            dct_coeff_next                               3-28 vlclbf
        end_of_block                                     2 "10"
    }
}
```

ANNEX - 2 VARIABLE & FIXED LENGTH CODE TABLES

A2-1 Macroblock Type

* I-picture
* number of levels 2

*type	bit	vlc-code			
1	1	1	!! Intra		
-1	2	01	!! Intra		Quant

* P-picture
* number of levels 11

*type	bit	vlc-code			
1	4	0011	!! Intra		
2	3	011	!! forward	Coded	
3	2	11	!! forward + field	Coded	
4	4	0010	!! field	Coded	
12	3	010	!! forward	not Coded	
13	2	10	!! forward + field	not Coded	
14	5	00011	!! field	not Coded	
-1	6	000010	!! intra		Quant
-2	6	000011	!! forward	Coded	Quant
-3	5	00010	!! forward + field	Coded	Quant
-4	6	000001	!! field	Coded	Quant

* B-picture
* number of levels 23

*type	bit	vlc-code			
1	8	00000011	!! Intra		
2	2	11	!! forward + backward	Coded	
3	4	0011	!! forward + field	Coded	
4	5	00011	!! backward + field	Coded	
5	6	000011	!! forward	Coded	
6	7	0000011	!! backward	Coded	
7	3	011	!! for + back + field	Coded	
8	8	00000010	!! field	Coded	
12	2	10	!! forward + backward	not Coded	
13	4	0010	!! forward + field	not Coded	
14	5	00010	!! backward + field	not Coded	
15	6	000010	!! forward	not Coded	
16	7	0000010	!! backward	not Coded	
17	3	010	!! for + back + field	not Coded	
18	9	000000011	!! field	not Coded	
-1	12	000000000010	!! Intra		Quant
-2	9	000000010	!! forward + backward	Coded	Quant
-3	10	0000000010	!! forward + field	Coded	Quant
-4	11	00000000011	!! backward + field	Coded	Quant

-5	11	00000000010	!! forward	Coded	Quant
-6	12	000000000011	!! backward	Coded	Quant
-7	10	0000000011	!! for + back + field	Coded	Quant
-8	12	000000000001	!! field	Coded	Quant

A2-2 Blocking type information

*type	bit	vlc-code	
1	1	0	!! frame-block
2	2	10	!! field-block
3	2	11	!! concatenated frame-block

A2-3 Others

Other tables for respective information such as Macroblock Addressing, Macroblock Pattern (CBP), Motion Vectors and DCT coefficients are same as those which appeared in CD11172-2 8/22/91 Draft Copy (MPEG1-video). Therefore they are omitted here.

PART - 2 FEATURES

1. RANDOM ACCESS FEATURE

The random access is facilitated by decoding only I-pictures. Necessary time depends on a size of GOP, which is currently 12 (in 30Hz).

2. CODING / DECODING DELAY

The coding / decoding delay depends on how long each data is stored in picture buffers and coded data buffers. A delay which occurs in coded data buffer is estimated from the maximum amount of data per one picture.

Item	Delay
scan conversion (field delay)	1 / 60
re-ordering (frame delay)	3 / 30
coded data buffer delay	600,000 / 4,000,000 (4Mbit/s) 1,100,000 / 9,000,000 (9Mbit/s)
scan conversion (field delay)	1 / 60
TOTAL	283 msec. (4Mbit/s) 256 msec. (9Mbit/s)

NOTE : If a shorter delay is required (likely conversational services), the following modification will be effective to shorten the coding / decoding delay.
(1) Bidirectional prediction may not be used. (remove re-ordering delay)
(2) Bit-assignment for each type of picture may be flattened. (reduce coded data buffer delay)

3. COMPATIBILITY FEATURE

"Compatibility" is considered to mean that a codec has the same configuration of functional modules. That is, the connection between the modules are similar and the dataflow pass through the similar path. Similarity in VLC is the most significant since VLC codewords are the interfacial media between different equipments.

Our algorithm is basically an enhanced MPEG1 algorithm and has much similarity to MPEG1. The transcoding in both directions will be easily realized. The differences between this scheme and MPEG1, and transcodability are summarized below. (Please refer to Fig.1 and Fig.2) Indication whether MPEG1 or this algorithm is assumed to be given. This scheme is expressed as "Ours" in the table.

MC	MPEG1	Ours	MPEG1 → Ours	Ours → MPEG1
unit	16×16	16×8	OK	OK (same vectors for both fields)
reference	frame	frame/field	OK	OK (no interfield)
DCT	**MPEG1**	**Ours**	**MPEG1 → Ours**	**Ours → MPEG1**
unit	8×8	8×8	OK	OK
quantize	linear	linear	OK	OK
scan	Zig-Zag	vertical	OK (need scan conversion)	
blocking	one type	three types	OK	OK (fixed blocking)
VLC	**MPEG1**	**Ours**	**MPEG1 → Ours**	**Ours → MPEG1**
MBA	relative addressing	relative addressing	OK	OK
MB type	(original)	(extended)	OK (need codeword mapping)	
CBP	(original)	(same)	OK	OK
MVD	(original)	(same)	OK	OK (no interfield)
blocking	none	used	OK	OK (fixed blocking)
coeff.	2-d VLC	2-d VLC	OK	OK

PART - 3 STATISTICS

1. NUMBER OF BITS AND SNR

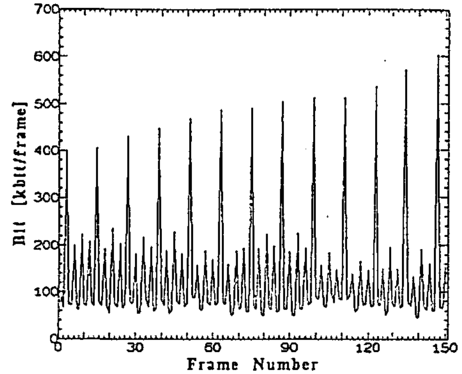
The number of bits and SNR for each frame of each coded sequence are shown in the following figures. The outputs of "ls -l" are also shown.

FGM4M	Flower Garden 4Mbit/s
FGM9M	Flower Garden 9Mbit/s
MAC4M	Mobile and Calendar 4Mbit/s
MAC9M	Mobile and Calendar 9Mbit/s
TBT4M	Table Tennis 4Mbit/s
TBT9M	Table Tennis 9Mbit/s
POP9M	Popple 9Mbit/s

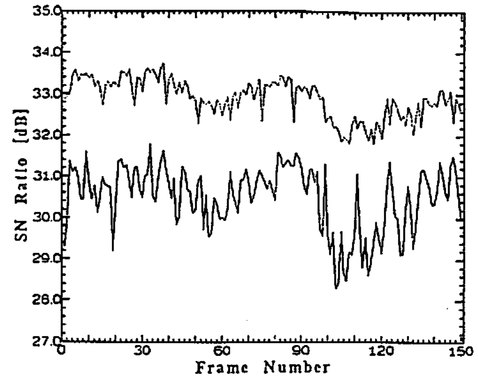
2. DATA TABLES

The tables of coded data are presented.

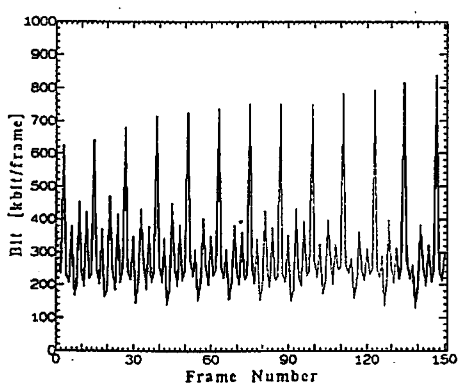
FGM4M



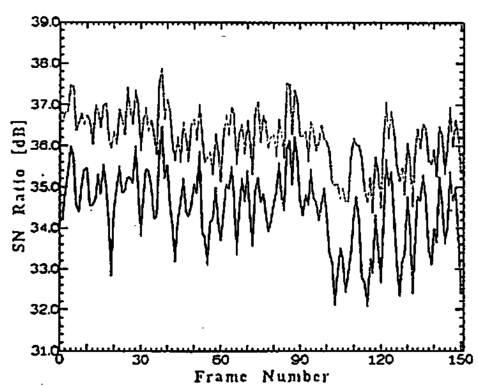
FGM4M



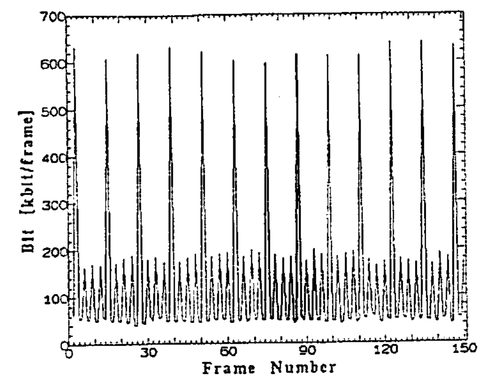
FGM9M



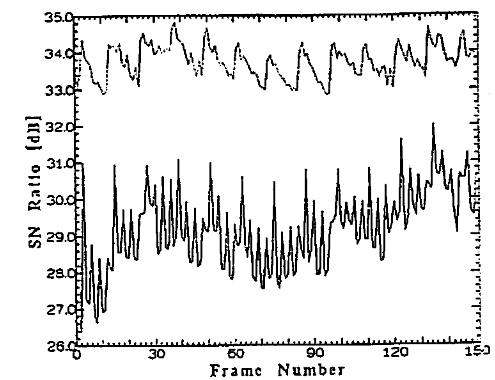
FGM9M



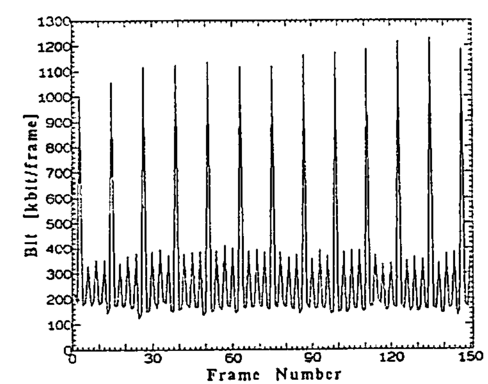
MAC4M



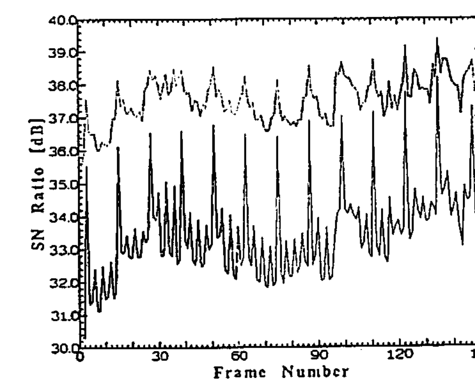
MAC4M



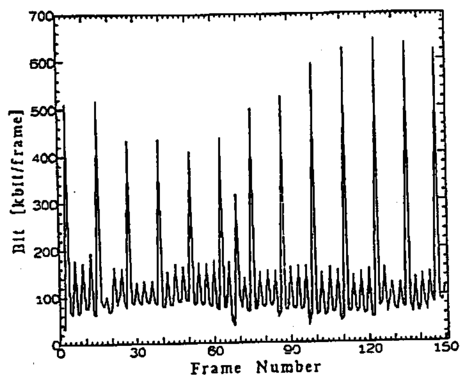
MAC9M



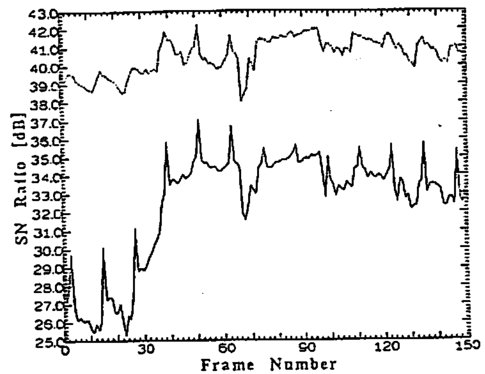
MAC9M



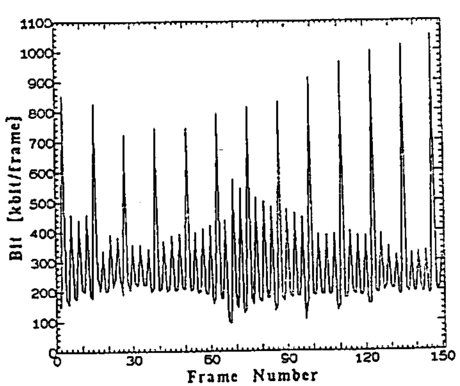
TBT4M



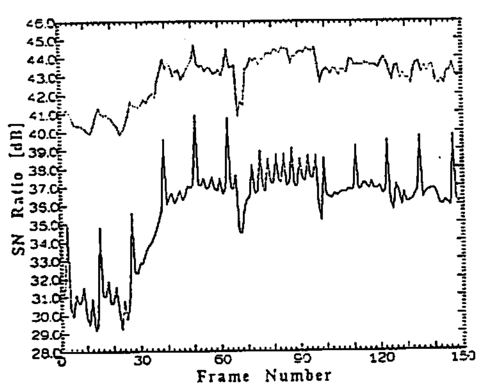
TBT4M



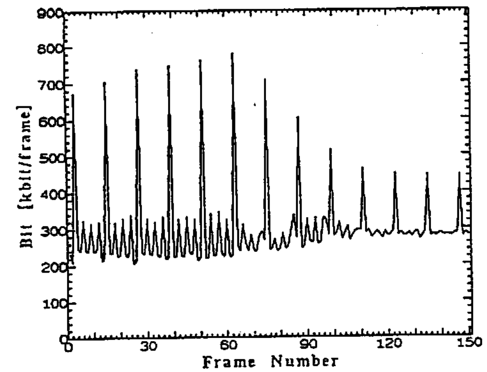
TBT9M



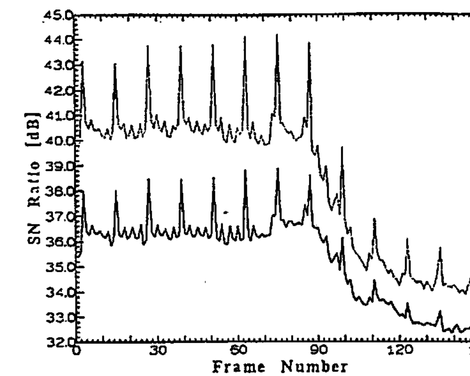
TBT9M



POP9M



POP9M



```
guest(100)ls -l
total 58576
-rw-rw-rw-  1 guest    guest    2496691 Nov  8 13:32 fgm4m_bs
-rw-rw-rw-  1 guest    guest    5610584 Nov  8 13:33 fgm9m_bs
-rw-rw-rw-  1 guest    guest    2461287 Nov  8 13:33 mac4m_bs
-rw-rw-rw-  1 guest    guest    5622866 Nov  8 13:34 mac9m_bs
-rw-rw-rw-  1 guest    guest    5601101 Nov  8-13:38 pop9m_bs
-rw-rw-rw-  1 guest    guest    2492936 Nov  8 13:35 tbt4m_bs
-rw-rw-rw-  1 guest    guest    5620313 Nov  8 13:35 tbt9m_bs
```


Presentation of Results Page(1/4)

Sequence : FGM_4M Institute : Mitsubishi
Frames : 1 - 150 Date : Fri Nov 1 00:00:00 1991
I pictures Number of frames : 13

1. SNR	luminance	Y		31.2
	chrominance	Cb		31.7
	chrominance	Cr		33.3
2. RMS	luminance	Y		7.04
	chrominance	Cb		6.60
	chrominance	Cr		5.53
3. Mean of QP				22.0
4. MB type				
	1.Intra			1320
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
5. DCT blocking				
	1.field-block			466
	2.concatenated frame-block			644
	3.frame-block			1528
6. Number of bit				
	1.Sequence header			7.4
	2.GOP header			64.0
	3.Picture header			64.0
	4.GOB header			1251.4
	5.MBA			1320.0
	6.MB type			1320.0
	7.MB quant			0.0
	8.MV on/of			0.0
	9.MC vec(Forward)			0.0
	10.MC vec(Backward)			0.0
	11.MC vec(Field)			0.0
	12.DCT block			3751.2
	13.CBP			0.0
	14.Coefficient			
	DC (Y)			37932.3
	DC (Cb)			7035.6
	DC (Cr)			6292.5
	AC (Y)			390381.7
	AC (Cb)			24913.5
	AC (Cr)			16328.5
	15.TOTAL			490662.2

Presentation of Results Page(2/4)

Sequence : FGM_4M Institute : Mitsubishi
Frames : 1 - 150 Date : Fri Nov 1 00:00:00 1991
P pictures Number of frames : 37

1. SNR	luminance	Y		30.5
	chrominance	Cb		32.1
	chrominance	Cr		33.5
2. RMS	luminance	Y		7.61
	chrominance	Cb		6.32
	chrominance	Cr		5.40
3. Mean of QP				22.4
4. MB type				
	1.Intra			38
	2.Forward	MC	Coded	178
	3.Forward + Field	MC	Coded	789
	4.Field	MC	Coded	38
	0.			0
	0.			0
	0.			0
	0.			0
	12.Forward	MC Not	Coded	112
	13.Forward + Field	MC Not	Coded	154
	14.Field	MC Not	Coded	8
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	20.Skipped			0
	0.			0
5. DCT blocking				
	1.field-block			665
	2.concatenated frame-block			596
	3.frame-block			1378
6. Number of bit				
	1.Sequence header			0.0
	2.GOP header			0.0
	3.Picture header			72.0
	4.GOB header			1244.3
	5.MBA			1320.0
	6.MB type			3109.7
	7.MB quant			0.0
	8.MV on/of			4451.2
	9.MC vec(Forward)			16862.2
	10.MC vec(Backward)			0.0
	11.MC vec(Field)			10349.2
	12.DCT block			3901.5
	13.CBP			5055.8
	14.Coefficient			
	DC (Y)			4974.5
	DC (Cb)			641.8
	DC (Cr)			436.8
	AC (Y)			121313.0
	AC (Cb)			7144.7
	AC (Cr)			3709.7
	15.TOTAL			184586.4

Presentation of Results

Page(3/4)

Sequence : FGM_4M
Frames : 1 - 150
B pictures

Institute : Mitsubishi
Date : Fri Nov 1 00:00:00 1991
Number of frames : 100

1. SNR	luminance	Y		30.3
	chrominance	Cb		32.4
	chrominance	Cr		33.6
2. RMS	luminance	Y		7.81
	chrominance	Cb		6.12
	chrominance	Cr		5.31
3. Mean of QP				30.7
4. MB type				
	1.Intra			7
	2.Forward + Backward	MC	Coded	254
	3.Forward + Field	MC	Coded	58
	4.Backward + Field	MC	Coded	65
	5.Forward	MC	Coded	25
	6.Backward	MC	Coded	38
	7.For + Back + Field	MC	Coded	109
	8.Field	MC	Coded	6
	12.Forward + Backward	MC Not	Coded	326
	13.Forward + Field	MC Not	Coded	74
	14.Backward + Field	MC Not	Coded	93
	15.Forward	MC Not	Coded	27
	16.Backward	MC Not	Coded	45
	17.For + Back + Field	MC Not	Coded	172
	18.Field	MC Not	Coded	14
	0.			0
	20.Skipped			0
	0.			0
5. DCT blocking				
	1.field-block			384
	2.concatenated frame-block			388
	3.frame-block			1866
6. Number of bit				
	1.Sequence header			0.0
	2.GOP header			0.0
	3.Picture header			72.0
	4.GOB header			1246.0
	5.MBA			1320.0
	6.MB type			4478.5
	7.MB quant			0.0
	8.MV on/of			5499.5
	9.MC vec(Forward)			9519.6
	10.MC vec(Backward)			10360.4
	11.MC vec(Field)			6400.4
	12.DCT block			3413.1
	13.CBP			2725.9
	14.Coefficient			
	DC (Y)			726.6
	DC (Cb)			101.3
	DC (Cr)			73.4
	AC (Y)			20276.1
	AC (Cb)			1050.4
	AC (Cr)			388.9
	15.TOTAL			67651.9

Presentation of Results

Page(4/4)

Sequence : FGM_4M
Frames : 1 - 150
All pictures

Institute : Mitsubishi
Date : Fri Nov 1 00:00:00 1991
Number of frames : 150

1. SNR	luminance	Y	30.4
	chrominance	Cb	32.3
	chrominance	Cr	33.6
2. RMS	luminance	Y	7.69
	chrominance	Cb	6.21
	chrominance	Cr	5.35
3. Mean of QP			27.9
5. DCT blocking			
	1.field-block		461
	2.concatenated frame-block		461
	3.frame-block		1717
6. Number of bit			
	1.Sequence header		0.6
	2.GOP header		5.5
	3.Picture header		71.3
	4.GOB header		1246.0
	5.MBA		1320.0
	6.MB type		3867.1
	7.MB quant		0.0
	8.MV on/of		4764.3
	9.MC vec(Forward)		10505.7
	10.MC vec(Backward)		6906.9
	11.MC vec(Field)		6819.7
	12.DCT block		3562.8
	13.CBP		3064.4
	14.Coefficient		
	DC (Y)		4998.9
	DC (Cb)		835.6
	DC (Cr)		702.0
	AC (Y)		77274.3
	AC (Cb)		4621.8
	AC (Cr)		2589.5
	15.TOTAL		133156.6
7.Bit Rate			3994699.2

From	To	sum-bits	I-bits	P-bits	B-bits
1	12	1603936	90480	209088	1304368
13	24	1590744	74592	218888	1297264
25	36	1576080	63336	215128	1297616
37	48	1587096	58080	215200	1313816
49	60	1572272	66656	224080	1281536
61	72	1557488	70584	188448	1298456
73	84	1578280	56584	181800	1339896
85	96	1579472	56456	175512	1347504
97	108	1630040	70600	256192	1303248
109	120	1569544	83864	210208	1275472
121	132	1563408	68056	192640	1302712
133	144	1558304	66240	188672	1303392

Presentation of Results

Page(1/4)

Sequence : FGM_9M
Frames : 1 - 150
I pictures

Institute : Mitsubishi
Date : Fri Nov 1 00:00:00 1991
Number of frames : 13

1. SNR	luminance	Y	34.9
	chrominance	Cb	36.1
	chrominance	Cr	36.4
2. RMS	luminance	Y	4.58
	chrominance	Cb	4.00
	chrominance	Cr	3.84
3. Mean of QP			19.9
4. MB type			
	1.Intra		1320
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
5. DCT blocking			
	1.field-block		492
	2.concatenated frame-block		681
	3.frame-block		1465
6. Number of bit			
	1.Sequence header		7.4
	2.GOP header		64.0
	3.Picture header		64.0
	4.GOB header		1247.4
	5.MBA		1320.0
	6.MB type		1320.0
	7.MB quant		0.0
	8.MV on/of		0.0
	9.MC vec(Forward)		0.0
	10.MC vec(Backward)		0.0
	11.MC vec(Field)		0.0
	12.DCT block		3814.7
	13.CBP		0.0
	14.Coefficient		
	DC (Y)		37947.4
	DC (Cb)		7035.6
	DC (Cr)		6292.5
	AC (Y)		575762.4
	AC (Cb)		57627.7
	AC (Cr)		47378.8
	15.TOTAL		739881.9

Presentation of Results

Page(2/4)

Sequence : FGM_9M
Frames : 1 - 150
P pictures

Institute : Mitsubishi
Date : Fri Nov 1 00:00:00 1991
Number of frames : 37

1. SNR	luminance	Y		33.8
	chrominance	Cb		35.3
	chrominance	Cr		35.7
2. RMS	luminance	Y		5.18
	chrominance	Cb		4.39
	chrominance	Cr		4.16
3. Mean of QP				13.0
4. MB type				
	1.Intra			40
	2.Forward	MC	Coded	211
	3.Forward + Field	MC	Coded	863
	4.Field	MC	Coded	45
	0.			0
	0.			0
	0.			0
	0.			0
	12.Forward	MC Not	Coded	53
	13.Forward + Field	MC Not	Coded	85
	14.Field	MC Not	Coded	2
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	20.Skipped			17
	0.			0
5. DCT blocking				
	1.field-block			750
	2.concatenated frame-block			652
	3.frame-block			1237
6. Number of bit				
	1.Sequence header			0.0
	2.GOP header			0.0
	3.Picture header			72.0
	4.GOB header			1246.1
	5.MBA			1323.3
	6.MB type			3049.5
	7.MB quant			0.0
	8.MV on/of			4424.5
	9.MC vec(Forward)			16401.9
	10.MC vec(Backward)			0.0
	11.MC vec(Field)			10305.0
	12.DCT block			4005.8
	13.CBP			5713.2
	14.Coefficient			
	DC (Y)			9014.6
	DC (Cb)			1046.4
	DC (Cr)			740.2
	AC (Y)			279376.4
	AC (Cb)			18397.0
	AC (Cr)			12639.2
	15.TOTAL			367755.3

33

Presentation of Results — Page(3/4)

Sequence : PGM_9M   Institute : Mitsubishi
Frames : 1 - 150   Date : Fri Nov 1 00:00:00 1991
B pictures   Number of frames : 100

1. SNR	luminance	Y	34.5
	chrominance	Cb	36.3
	chrominance	Cr	36.5
2. RMS	luminance	Y	4.82
	chrominance	Cb	3.93
	chrominance	Cr	3.82
3. Mean of QP			12.3

4. MB type

1.Intra			7
2.Forward + Backward	MC	Coded	531
3.Forward + Field	MC	Coded	99
4.Backward + Field	MC	Coded	111
5.Forward	MC	Coded	61
6.Backward	MC	Coded	68
7.For + Back + Field	MC	Coded	185
8.Field	MC	Coded	23
12.Forward + Backward	MC Not	Coded	63
13.Forward + Field	MC Not	Coded	30
14.Backward + Field	MC Not	Coded	37
15.Forward	MC Not	Coded	6
16.Backward	MC Not	Coded	10
17.For + Back + Field	MC Not	Coded	77
18.Field	MC Not	Coded	3
0.			0
20.Skipped			0
0.			0

5. DCT blocking

1.field-block	671
2.concatenated frame-block	640
3.frame-block	1327

6. Number of bit

1.Sequence header	0.0
2.GOP header	0.0
3.Picture header	72.0
4.GOB header	1243.1
5.MBA	1320.7
6.MB type	4489.3
7.MB quant	0.0
8.MV on/of	5423.4
9.MC vec(Forward)	9163.3
10.MC vec(Backward)	9662.7
11.MC vec(Field)	6056.3
12.DCT block	3949.8
13.CBP	5427.8
14.Coefficient	
DC (Y)	3325.3
DC (Cb)	332.5
DC (Cr)	250.4
AC (Y)	150046.6
AC (Cb)	9163.6
AC (Cr)	6665.7
15.TOTAL	216592.3

Presentation of Results — Page(4/4)

Sequence : PGM_9M   Institute : Mitsubishi
Frames : 1 - 150   Date : Fri Nov 1 00:00:00 1991
All pictures   Number of frames : 150

1. SNR	luminance	Y	34.3
	chrominance	Cb	36.0
	chrominance	Cr	36.3
2. RMS	luminance	Y	4.89
	chrominance	Cb	4.05
	chrominance	Cr	3.91
3. Mean of QP			13.1

5. DCT blocking

1.field-block	675
2.concatenated frame-block	647
3.frame-block	1317

6. Number of bit

1.Sequence header	0.6
2.GOP header	5.5
3.Picture header	71.3
4.GOB header	1244.2
5.MBA	1321.3
6.MB type	3859.4
7.MB quant	0.0
8.MV on/of	4707.0
9.MC vec(Forward)	10154.7
10.MC vec(Backward)	6441.8
11.MC vec(Field)	6579.5
12.DCT block	3951.9
13.CBP	5027.8
14.Coefficient	
DC (Y)	7729.3
DC (Cb)	1089.5
DC (Cr)	894.8
AC (Y)	218843.4
AC (Cb)	15641.4
AC (Cr)	11667.7
15.TOTAL	299230.9

7.Bit Rate 8976928.0

From	To	sum-bits	I-bits	P-bits	B-bits
1	12	3608440	265120	631448	2711872
13	24	3582320	217936	657952	2706432
25	36	3552328	205056	652000	2695272
37	48	3571200	205408	646384	2719408
49	60	3561608	212920	682304	2666384
61	72	3542064	226456	639768	2675840
73	84	3563544	214720	632920	2715904
85	96	3571288	213024	606928	2751336
97	108	3648448	225752	741360	2681336
109	120	3567968	245616	666976	2655376
121	132	3554216	231208	638480	2684528
133	144	3519136	215752	653504	2649880

34

Presentation of Results — Page(1/4)

Sequence : MAC_4M   Institute : Mitsubishi
Frames : 1 - 150   Date : Fri Nov 1 00:00:00 1991
I pictures   Number of frames : 13

1. SNR	luminance	Y	31.0
	chrominance	Cb	33.9
	chrominance	Cr	34.1
2. RMS	luminance	Y	7.19
	chrominance	Cb	5.14
	chrominance	Cr	5.02
3. Mean of QP			31.9

4. MB type

1.Intra	1320
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0

5. DCT blocking

1.field-block	260
2.concatenated frame-block	463
3.frame-block	1916

6. Number of bit

1.Sequence header	7.4
2.GOP header	64.0
3.Picture header	64.0
4.GOB header	1244.8
5.MBA	1320.0
6.MB type	1320.0
7.MB quant	0.0
8.MV on/of	0.0
9.MC vec(Forward)	0.0
10.MC vec(Backward)	0.0
11.MC vec(Field)	0.0
12.DCT block	3363.9
13.CBP	0.0
14.Coefficient	
DC (Y)	39316.2
DC (Cb)	7982.2
DC (Cr)	8420.1
AC (Y)	474468.8
AC (Cb)	40645.1
AC (Cr)	43374.9
15.TOTAL	621591.4

Presentation of Results — Page(2/4)

Sequence : MAC_4M   Institute : Mitsubishi
Frames : 1 - 150   Date : Fri Nov 1 00:00:00 1991
P pictures   Number of frames : 37

1. SNR	luminance	Y	29.8
	chrominance	Cb	33.5
	chrominance	Cr	33.5
2. RMS	luminance	Y	8.27
	chrominance	Cb	5.40
	chrominance	Cr	5.37
3. Mean of QP			22.3

4. MB type

1.Intra			71
2.Forward	MC	Coded	426
3.Forward + Field	MC	Coded	473
4.Field	MC	Coded	37
0.			0
0.			0
0.			0
0.			0
12.Forward	MC Not	Coded	125
13.Forward + Field	MC Not	Coded	144
14.Field	MC Not	Coded	6
0.			0
0.			0
0.			0
0.			0
0.			0
20.Skipped			33
0.			0

5. DCT blocking

1.field-block	671
2.concatenated frame-block	567
3.frame-block	1401

6. Number of bit

1.Sequence header	0.0
2.GOP header	0.0
3.Picture header	72.0
4.GOB header	1247.3
5.MBA	1331.5
6.MB type	3362.0
7.MB quant	0.0
8.MV on/of	3667.0
9.MC vec(Forward)	10857.0
10.MC vec(Backward)	0.0
11.MC vec(Field)	7020.2
12.DCT block	3792.6
13.CBP	4843.6
14.Coefficient	
DC (Y)	4303.9
DC (Cb)	758.8
DC (Cr)	905.0
AC (Y)	128463.8
AC (Cb)	4849.3
AC (Cr)	6829.1
15.TOTAL	182303.1

35

Presentation of Results — Page(3/4)

Sequence : MAC_4M — Institute : Mitsubishi
Frames : 1 - 150 — Date : Fri Nov 1 00:00:00 1991
B pictures — Number of frames : 100

1. SNR	luminance	Y		28.6
	chrominance	Cb		33.8
	chrominance	Cr		33.7
2. RMS	luminance	Y		9.53
	chrominance	Cb		5.22
	chrominance	Cr		5.26
3. Mean of QP				41.0
4. MB type				
	1.Intra			16
	2.Forward + Backward	MC	Coded	76
	3.Forward + Field	MC	Coded	44
	4.Backward + Field	MC	Coded	49
	5.Forward	MC	Coded	9
	6.Backward	MC	Coded	15
	7.For + Back + Field	MC	Coded	67
	8.Field	MC	Coded	1
	12.Forward + Backward	MC Not	Coded	545
	13.Forward + Field	MC Not	Coded	52
	14.Backward + Field	MC Not	Coded	66
	15.Forward	MC Not	Coded	35
	16.Backward	MC Not	Coded	67
	17.For + Back + Field	MC Not	Coded	139
	18.Field	MC Not	Coded	2
	0.			0
	20.Skipped			131
	0.			0
5. DCT blocking				
	1.field-block			236
	2.concatenated frame-block			172
	3.frame-block			2230
6. Number of bit				
	1.Sequence header			0.0
	2.GOP header			0.0
	3.Picture header			72.0
	4.GOB header			1246.7
	5.MBA			1360.0
	6.MB type			3840.1
	7.MB quant			0.0
	8.MV on/of			4839.4
	9.MC vec(Forward)			6156.6
	10.MC vec(Backward)			6741.8
	11.MC vec(Field)			3045.7
	12.DCT block			2766.1
	13.CBP			1190.2
	14.Coefficient			
		DC (Y)		658.9
		DC (Cb)		135.6
		DC (Cr)		152.4
		AC (Y)		15998.6
		AC (Cb)		136.6
		AC (Cr)		303.0
	15.TOTAL			48643.6

Presentation of Results — Page(4/4)

Sequence : MAC_4M — Institute : Mitsubishi
Frames : 1 - 150 — Date : Fri Nov 1 00:00:00 1991
All pictures — Number of frames : 150

1. SNR	luminance	Y	29.0
	chrominance	Cb	33.7
	chrominance	Cr	33.7
2. RMS	luminance	Y	9.05
	chrominance	Cb	5.26
	chrominance	Cr	5.26
3. Mean of QP			35.6
5. DCT blocking			
	1.field-block		345
	2.concatenated frame-block		295
	3.frame-block		1998
6. Number of bit			
	1.Sequence header		0.6
	2.GOP header		5.5
	3.Picture header		71.3
	4.GOB header		1246.7
	5.MBA		1349.5
	6.MB type		3503.8
	7.MB quant		0.0
	8.MV on/of		4130.8
	9.MC vec(Forward)		6782.5
	10.MC vec(Backward)		4494.6
	11.MC vec(Field)		3762.1
	12.DCT block		3071.1
	13.CBP		1988.2
	14.Coefficient		
		DC (Y)	4908.3
		DC (Cb)	969.4
		DC (Cr)	1054.6
		AC (Y)	83474.1
		AC (Cb)	4809.8
		AC (Cr)	5645.7
	15.TOTAL		131268.4
7.Bit Rate			3938052.8

From	To	sum-bits	I-bits	P-bits	B-bits
1	12	1589504	79776	154264	1355464
13	24	1554200	57600	143840	1352760
25	36	1540248	40120	154632	1345496
37	48	1557432	46288	140584	1370560
49	60	1579472	45048	147800	1386624
61	72	1565616	44312	144832	1376472
73	84	1544048	50048	149216	1344784
85	96	1563136	42064	154216	1366856
97	108	1547544	45056	135928	1366560
109	120	1532360	42656	157728	1331976
121	132	1558880	49944	146744	1362192
133	144	1566216	48592	141472	1376152

36

Presentation of Results — Page(1/4)

Sequence : MAC_9M — Institute : Mitsubishi
Frames : 1 - 150 — Date : Fri Nov 1 00:00:00 1991
I pictures — Number of frames : 13

1. SNR	luminance	Y	36.8
	chrominance	Cb	38.3
	chrominance	Cr	38.7
2. RMS	luminance	Y	3.69
	chrominance	Cb	3.09
	chrominance	Cr	2.97
3. Mean of QP			14.5
4. MB type			
	1.Intra		1320
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
5. DCT blocking			
	1.field-block		347
	2.concatenated frame-block		652
	3.frame-block		1639
6. Number of bit			
	1.Sequence header		7.4
	2.GOP header		64.0
	3.Picture header		64.0
	4.GOB header		1244.3
	5.MBA		1320.0
	6.MB type		1320.0
	7.MB quant		0.0
	8.MV on/of		0.0
	9.MC vec(Forward)		0.0
	10.MC vec(Backward)		0.0
	11.MC vec(Field)		0.0
	12.DCT block		3640.3
	13.CBP		0.0
	14.Coefficient		
		DC (Y)	39282.2
		DC (Cb)	7982.2
		DC (Cr)	8420.1
		AC (Y)	888735.1
		AC (Cb)	95604.9
		AC (Cr)	95428.2
	15.TOTAL		1143112.6

Presentation of Results — Page(2/4)

Sequence : MAC_9M — Institute : Mitsubishi
Frames : 1 - 150 — Date : Fri Nov 1 00:00:00 1991
P pictures — Number of frames : 37

1. SNR	luminance	Y		33.9
	chrominance	Cb		37.3
	chrominance	Cr		37.6
2. RMS	luminance	Y		5.14
	chrominance	Cb		3.48
	chrominance	Cr		3.37
3. Mean of QP				11.9
4. MB type				
	1.Intra			54
	2.Forward	MC	Coded	600
	3.Forward + Field	MC	Coded	505
	4.Field	MC	Coded	46
	0.			0
	0.			0
	0.			0
	0.			0
	12.Forward	MC Not	Coded	43
	13.Forward + Field	MC Not	Coded	57
	14.Field	MC Not	Coded	2
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	20.Skipped			10
	0.			0
5. DCT blocking				
	1.field-block			658
	2.concatenated frame-block			714
	3.frame-block			1267
6. Number of bit				
	1.Sequence header			0.0
	2.GOP header			0.0
	3.Picture header			72.0
	4.GOB header			1247.2
	5.MBA			1323.8
	6.MB type			3472.2
	7.MB quant			0.0
	8.MV on/of			3635.4
	9.MC vec(Forward)			10465.4
	10.MC vec(Backward)			0.0
	11.MC vec(Field)			6558.0
	12.DCT block			3984.5
	13.CBP			7111.2
	14.Coefficient			
		DC (Y)		6729.5
		DC (Cb)		982.8
		DC (Cr)		1231.1
		AC (Y)		282085.9
		AC (Cb)		21915.7
		AC (Cr)		23805.1
	15.TOTAL			374619.9

37

Presentation of Results Page(3/4)

Sequence : MAC_9M Institute : Mitsubishi
Frames : 1 - 150 Date : Fri Nov 1 00:00:00 1991
B pictures Number of frames : 100

1. SNR	luminance	Y	32.7
	chrominance	Cb	37.3
	chrominance	Cr	37.5
2. RMS	luminance	Y	5.88
	chrominance	Cb	3.48
	chrominance	Cr	3.39
3. Mean of QP			14.9

4. MB type			
1.Intra			10
2.Forward + Backward	MC	Coded	464
3.Forward + Field	MC	Coded	72
4.Backward + Field	MC	Coded	83
5.Forward	MC	Coded	48
6.Backward	MC	Coded	85
7.For + Back + Field	MC	Coded	116
8.Field	MC	Coded	1
12.Forward + Backward	MC Not	Coded	254
13.Forward + Field	MC Not	Coded	19
14.Backward + Field	MC Not	Coded	22
15.Forward	MC Not	Coded	16
16.Backward	MC Not	Coded	27
17.For + Back + Field	MC Not	Coded	56
18.Field	MC Not	Coded	0
0.			0
20.Skipped			39
0.			0

5. DCT blocking	
1.field-block	664
2.concatenated frame-block	571
3.frame-block	1403

6. Number of bit	
1.Sequence header	0.0
2.GOP header	0.0
3.Picture header	72.0
4.GOB header	1244.4
5.MBA	1337.1
6.MB type	4138.0
7.MB quant	0.0
8.MV on/of	5069.5
9.MC vec(Forward)	6210.3
10.MC vec(Backward)	6731.8
11.MC vec(Field)	2775.2
12.DCT block	3768.3
13.CBP	4618.7
14.Coefficient	
DC (Y)	1917.2
DC (Cb)	184.8
DC (Cr)	250.9
AC (Y)	114113.9
AC (Cb)	4609.0
AC (Cr)	5573.9
15.TOTAL	162615.0

Presentation of Results Page(4/4)

Sequence : MAC_9M Institute : Mitsubishi
Frames : 1 - 150 Date : Fri Nov 1 00:00:00 1991
All pictures Number of frames : 150

1. SNR	luminance	Y	33.2
	chrominance	Cb	37.4
	chrominance	Cr	37.6
2. RMS	luminance	Y	5.55
	chrominance	Cb	3.45
	chrominance	Cr	3.35
3. Mean of QP			14.1

5. DCT blocking	
1.field-block	635
2.concatenated frame-block	614
3.frame-block	1390

6. Number of bit	
1.Sequence header	0.6
2.GOP header	5.5
3.Picture header	71.3
4.GOB header	1245.0
5.MBA	1332.3
6.MB type	3729.5
7.MB quant	0.0
8.MV on/of	4276.4
9.MC vec(Forward)	6721.7
10.MC vec(Backward)	4487.8
11.MC vec(Field)	3467.8
12.DCT block	3810.5
13.CBP	4833.3
14.Coefficient	
DC (Y)	6342.5
DC (Cb)	1057.4
DC (Cr)	1200.7
AC (Y)	222680.8
AC (Cb)	16764.3
AC (Cr)	17858.3
15.TOTAL	299886.0
7.Bit Rate	8996579.2

From	To	sum-bits	I-bits	P-bits	B-bits
1	12	3531504	217656	527448	2786400
13	24	3468824	139624	500656	2828544
25	36	3560144	121408	525464	2913272
37	48	3572448	151176	500784	2920488
49	60	3589648	133296	489368	2966984
61	72	3593456	143784	499248	2950424
73	84	3573104	162288	510744	2900072
85	96	3581848	139608	507224	2935016
97	108	3559736	141640	454312	2963784
109	120	3578512	153096	519088	2906328
121	132	3578592	171600	471784	2935208
133	144	3603728	160504	467600	2975624

38

Presentation of Results Page(1/4)

Sequence : TBT_4M Institute : Mitsubishi
Frames : 1 - 150 Date : Fri Nov 1 00:00:00 1991
I pictures Number of frames : 13

1. SNR	luminance	Y	33.8
	chrominance	Cb	41.3
	chrominance	Cr	40.8
2. RMS	luminance	Y	5.22
	chrominance	Cb	2.20
	chrominance	Cr	2.32
3. Mean of QP			21.0

4. MB type	
1.Intra	1320
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0
0.	0

5. DCT blocking	
1.field-block	456
2.concatenated frame-block	708
3.frame-block	1474

6. Number of bit	
1.Sequence header	7.4
2.GOP header	64.0
3.Picture header	64.0
4.GOB header	1243.2
5.MBA	1320.0
6.MB type	1320.0
7.MB quant	0.0
8.MV on/of	0.0
9.MC vec(Forward)	0.0
10.MC vec(Backward)	0.0
11.MC vec(Field)	0.0
12.DCT block	3805.2
13.CBP	0.0
14.Coefficient	
DC (Y)	28389.0
DC (Cb)	4412.8
DC (Cr)	4893.4
AC (Y)	452967.2
AC (Cb)	13162.0
AC (Cr)	18280.6
15.TOTAL	529928.6

Presentation of Results Page(2/4)

Sequence : TBT_4M Institute : Mitsubishi
Frames : 1 - 150 Date : Fri Nov 1 00:00:00 1991
P pictures Number of frames : 37

1. SNR	luminance	Y	31.1
	chrominance	Cb	40.6
	chrominance	Cr	39.9
2. RMS	luminance	Y	7.08
	chrominance	Cb	2.37
	chrominance	Cr	2.59
3. Mean of QP			18.2

4. MB type			
1.Intra			150
2.Forward	MC	Coded	252
3.Forward + Field	MC	Coded	434
4.Field	MC	Coded	8
0.			0
0.			0
0.			0
0.			0
12.Forward	MC Not	Coded	132
13.Forward + Field	MC Not	Coded	278
14.Field	MC Not	Coded	1
0.			0
0.			0
0.			0
0.			0
0.			0
20.Skipped			61
0.			0

5. DCT blocking	
1.field-block	593
2.concatenated frame-block	556
3.frame-block	1490

6. Number of bit	
1.Sequence header	0.0
2.GOP header	0.0
3.Picture header	72.0
4.GOB header	1246.7
5.MBA	1337.9
6.MB type	3225.5
7.MB quant	0.0
8.MV on/of	3641.6
9.MC vec(Forward)	15878.9
10.MC vec(Backward)	0.0
11.MC vec(Field)	10557.3
12.DCT block	3628.5
13.CBP	3365.6
14.Coefficient	
DC (Y)	5185.2
DC (Cb)	839.2
DC (Cr)	987.7
AC (Y)	100660.1
AC (Cb)	2642.3
AC (Cr)	4532.1
15.TOTAL	157800.7

40

Presentation of Results

Sequence : TBT_9M — Frames : 1 - 150 — I pictures
Institute : Mitsubishi — Date : Fri Nov 1 00:00:00 1991 — Number of frames : 13

1. SNR	luminance	Y	38.1
	chrominance	Cb	43.1
	chrominance	Cr	43.2
2. RMS	luminance	Y	3.18
	chrominance	Cb	1.78
	chrominance	Cr	1.77
3. Mean of QP			11.9
4. MB type			
	1.Intra		1320
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
	0.		0
5. DCT blocking			
	1.field-block		467
	2.concatenated frame-block		646
	3.frame-block		1526
6. Number of bit			
	1.Sequence header		7.4
	2.GOP header		64.0
	3.Picture header		64.0
	4.GOB header		1242.2
	5.MBA		1320.0
	6.MB type		1320.0
	7.MB quant		0.0
	8.MV on/of		0.0
	9.MC vec(Forward)		0.0
	10.MC vec(Backward)		0.0
	11.MC vec(Field)		0.0
	12.DCT block		3753.8
	13.CBP		0.0
	14.Coefficient		
	DC (Y)		28384.5
	DC (Cb)		4412.8
	DC (Cr)		4893.4
	AC (Y)		756382.9
	AC (Cb)		29608.8
	AC (Cr)		37677.9
	15.TOTAL		869131.7

Presentation of Results

Page(2/4)

Sequence : TBT_9M — Frames : 1 - 150 — P pictures
Institute : Mitsubishi — Date : Fri Nov 1 00:00:00 1991 — Number of frames : 37

1. SNR	luminance	Y		35.3
	chrominance	Cb		42.6
	chrominance	Cr		42.5
2. RMS	luminance	Y		4.40
	chrominance	Cb		1.88
	chrominance	Cr		1.90
3. Mean of QP				9.0
4. MB type				
	1.Intra			153
	2.Forward	MC	Coded	420
	3.Forward + Field	MC	Coded	684
	4.Field	MC	Coded	11
	0.			0
	0.			0
	0.			0
	0.			0
	12.Forward	MC Not Coded		15
	13.Forward + Field	MC Not Coded		32
	14.Field	MC Not Coded		0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	20.Skipped			1
	0.			0
5. DCT blocking				
	1.field-block			760
	2.concatenated frame-block			750
	3.frame-block			1129
6. Number of bit				
	1.Sequence header			0.0
	2.GOP header			0.0
	3.Picture header			72.0
	4.GOB header			1242.9
	5.MBA			1321.5
	6.MB type			3403.1
	7.MB quant			0.0
	8.MV on/of			3761.9
	9.MC vec(Forward)			14970.6
	10.MC vec(Backward)			0.0
	11.MC vec(Field)			9707.1
	12.DCT block			4144.8
	13.CBP			5495.4
	14.Coefficient			
	DC (Y)			8999.2
	DC (Cb)			1162.6
	DC (Cr)			1427.1
	AC (Y)			326325.4
	AC (Cb)			11435.9
	AC (Cr)			15102.1
	15.TOTAL			408571.7

39

Presentation of Results

Page(3/4)

Sequence : TBT_4M — Frames : 1 - 150 — B pictures
Institute : Mitsubishi — Date : Fri Nov 1 00:00:00 1991 — Number of frames : 100

1. SNR	luminance	Y		30.9
	chrominance	Cb		40.8
	chrominance	Cr		40.1
2. RMS	luminance	Y		7.25
	chrominance	Cb		2.33
	chrominance	Cr		2.53
3. Mean of QP				21.2
4. MB type				
	1.Intra			11
	2.Forward + Backward	MC	Coded	139
	3.Forward + Field	MC	Coded	48
	4.Backward + Field	MC	Coded	66
	5.Forward	MC	Coded	13
	6.Backward	MC	Coded	19
	7.For + Back + Field	MC	Coded	118
	8.Field	MC	Coded	1
	12.Forward + Backward	MC Not Coded		252
	13.Forward + Field	MC Not Coded		108
	14.Backward + Field	MC Not Coded		100
	15.Forward	MC Not Coded		33
	16.Backward	MC Not Coded		42
	17.For + Back + Field	MC Not Coded		309
	18.Field	MC Not Coded		1
	0.			0
	20.Skipped			51
	0.			0
5. DCT blocking				
	1.field-block			455
	2.concatenated frame-block			390
	3.frame-block			1794
6. Number of bit				
	1.Sequence header			0.0
	2.GOP header			0.0
	3.Picture header			72.0
	4.GOB header			1245.7
	5.MBA			1324.8
	6.MB type			4366.6
	7.MB quant			0.0
	8.MV on/of			5659.8
	9.MC vec(Forward)			9405.0
	10.MC vec(Backward)			9902.4
	11.MC vec(Field)			7885.8
	12.DCT block			3357.4
	13.CBP			1963.8
	14.Coefficient			
	DC (Y)			797.9
	DC (Cb)			92.7
	DC (Cr)			129.4
	AC (Y)			24229.8
	AC (Cb)			549.3
	AC (Cr)			1175.1
	15.TOTAL			72157.6

Presentation of Results

Page(4/4)

Sequence : TBT_4M — Frames : 1 - 150 — All pictures
Institute : Mitsubishi — Date : Fri Nov 1 00:00:00 1991 — Number of frames : 150

1. SNR	luminance	Y	31.2
	chrominance	Cb	40.8
	chrominance	Cr	40.1
2. RMS	luminance	Y	7.05
	chrominance	Cb	2.33
	chrominance	Cr	2.53
3. Mean of QP			20.5
5. DCT blocking			
	1.field-block		489
	2.concatenated frame-block		459
	3.frame-block		1691
6. Number of bit			
	1.Sequence header		0.6
	2.GOP header		5.5
	3.Picture header		71.3
	4.GOB header		1245.7
	5.MBA		1327.6
	6.MB type		3821.1
	7.MB quant		0.0
	8.MV on/of		4671.5
	9.MC vec(Forward)		10186.8
	10.MC vec(Backward)		6601.6
	11.MC vec(Field)		7861.3
	12.DCT block		3463.1
	13.CBP		2139.4
	14.Coefficient		
	DC (Y)		4271.3
	DC (Cb)		651.2
	DC (Cr)		754.0
	AC (Y)		80239.8
	AC (Cb)		2158.7
	AC (Cr)		3485.6
	15.TOTAL		132956.4
7.Bit Rate			3988691.2

From	To	sum-bits	I-bits	P-bits	B-bits
1	12	1532520	35608	205272	1291640
13	24	1559160	62512	239032	1257616
25	36	1525872	92976	268992	1163904
37	48	1593592	88328	249880	1255384
49	60	1605472	92664	247520	1265288
61	72	1615648	74768	217608	1323272
73	84	1547240	68320	225784	1253136
85	96	1554912	53448	212272	1289192
97	108	1519848	35432	176328	1308088
109	120	1551728	44912	185424	1321392
121	132	1613704	52480	207120	1354104
133	144	1636632	76000	232808	1327824

Presentation of Results

Sequence : TBT_9M
Frames : 1 - 150
B pictures

Institute : Mitsubishi
Date : Fri Nov 1 00:00:00 1991
Number of frames : 100

1. SNR	luminance	Y		34.3
	chrominance	Cb		42.7
	chrominance	Cr		42.6
2. RMS	luminance	Y		4.91
	chrominance	Cb		1.87
	chrominance	Cr		1.89
3. Mean of QP				10.2
4. MB type				
	1.Intra			15
	2.Forward + Backward	MC	Coded	412
	3.Forward + Field	MC	Coded	108
	4.Backward + Field	MC	Coded	130
	5.Forward	MC	Coded	44
	6.Backward	MC	Coded	59
	7.For + Back + Field	MC	Coded	313
	8.Field	MC	Coded	2
	12.Forward + Backward	MC Not	Coded	60
	13.Forward + Field	MC Not	Coded	23
	14.Backward + Field	MC Not	Coded	28
	15.Forward	MC Not	Coded	13
	16.Backward	MC Not	Coded	13
	17.For + Back + Field	MC Not	Coded	86
	18.Field	MC Not	Coded	0
	0.			0
	20.Skipped			7
	0.			0
5. DCT blocking				
	1.field-block			746
	2.concatenated frame-block			724
	3.frame-block			1168
6. Number of bit				
	1.Sequence header			0.0
	2.GOP header			0.0
	3.Picture header			72.0
	4.GOB header			1247.5
	5.MBA			1322.8
	6.MB type			4468.9
	7.MB quant			0.0
	8.MV on/of			5723.9
	9.MC vec(Forward)			8580.3
	10.MC vec(Backward)			9074.6
	11.MC vec(Field)			6594.5
	12.DCT block			4089.5
	13.CBP			5302.4
	14.Coefficient			
	DC (Y)			2656.2
	DC (Cb)			282.0
	DC (Cr)			379.0
	AC (Y)			127381.2
	AC (Cb)			3224.5
	AC (Cr)			5066.8
	15.TOTAL			185466.1

Presentation of Results

Sequence : TBT_9M
Frames : 1 - 150
All pictures

Institute : Mitsubishi
Date : Fri Nov 1 00:00:00 1991
Number of frames : 150

1. SNR	luminance	Y	34.8
	chrominance	Cb	42.7
	chrominance	Cr	42.6
2. RMS	luminance	Y	4.66
	chrominance	Cb	1.87
	chrominance	Cr	1.89
3. Mean of QP			10.1
5. DCT blocking			
	1.field-block		725
	2.concatenated frame-block		724
	3.frame-block		1190
6. Number of bit			
	1.Sequence header		0.6
	2.GOP header		5.5
	3.Picture header		71.3
	4.GOB header		1245.9
	5.MBA		1322.2
	6.MB type		3933.1
	7.MB quant		0.0
	8.MV on/of		4743.9
	9.MC vec(Forward)		9413.0
	10.MC vec(Backward)		6049.7
	11.MC vec(Field)		6790.7
	12.DCT block		4074.0
	13.CBP		4890.5
	14.Coefficient		
	DC (Y)		6450.6
	DC (Cb)		857.2
	DC (Cr)		1028.8
	AC (Y)		230967.7
	AC (Cb)		7536.6
	AC (Cr)		10368.5
	15.TOTAL		299749.8
7.Bit Rate			8992494.4

From	To	sum-bits	I-bits	P-bits	B-bits
1	12	3609120	153920	557672	2897528
13	24	3622168	186544	664800	2770824
25	36	3552936	246896	687176	2618864
37	48	3538344	197120	604456	2736768
49	60	3580824	210216	588736	2781872
61	72	3530920	157632	433288	2940000
73	84	3594504	126288	520552	2947664
85	96	3582864	131656	551152	2900056
97	108	3485816	104632	565200	2815984
109	120	3536120	133136	556576	2846408
121	132	3592048	156832	601952	2833264
133	144	3575512	182400	606600	2786512

Presentation of Results

Sequence : POP_9M
Frames : 1 - 150
I pictures

Institute : Mitsubishi
Date : Fri Nov 1 00:00:00 1991
Number of frames : 13

1. SNR	luminance	Y		36.2
	chrominance	Cb		41.8
	chrominance	Cr		38.1
2. RMS	luminance	Y		3.95
	chrominance	Cb		2.06
	chrominance	Cr		3.16
3. Mean of QP				10.0
4. MB type				
	1.Intra			1320
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
5. DCT blocking				
	1.field-block			1068
	2.concatenated frame-block			608
	3.frame-block			962
6. Number of bit				
	1.Sequence header			7.4
	2.GOP header			64.0
	3.Picture header			64.0
	4.GOB header			1241.3
	5.MBA			1320.0
	6.MB type			1320.0
	7.MB quant			0.0
	8.MV on/of			0.0
	9.MC vec(Forward)			0.0
	10.MC vec(Backward)			0.0
	11.MC vec(Field)			0.0
	12.DCT block			4317.1
	13.CBP			0.0
	14.Coefficient			
	DC (Y)			28563.8
	DC (Cb)			7641.5
	DC (Cr)			7281.3
	AC (Y)			407201.1
	AC (Cb)			94701.7
	AC (Cr)			64935.3
	15.TOTAL			618658.4

Presentation of Results

Sequence : POP_9M
Frames : 1 - 150
P pictures

Institute : Mitsubishi
Date : Fri Nov 1 00:00:00 1991
Number of frames : 37

1. SNR	luminance	Y		35.0
	chrominance	Cb		38.0
	chrominance	Cr		36.8
2. RMS	luminance	Y		4.55
	chrominance	Cb		3.22
	chrominance	Cr		3.69
3. Mean of QP				12.1
4. MB type				
	1.Intra			31
	2.Forward		MC Coded	285
	3.Forward + Field		MC Coded	646
	4.Field		MC Coded	4
	0.			0
	0.			0
	0.			0
	0.			0
	12.Forward		MC Not Coded	134
	13.Forward + Field		MC Not Coded	133
	14.Field		MC Not Coded	0
	0.			0
	0.			0
	0.			0
	0.			0
	0.			0
	20.Skipped			83
	0.			0
5. DCT blocking				
	1.field-block			728
	2.concatenated frame-block			560
	3.frame-block			1351
6. Number of bit				
	1.Sequence header			0.0
	2.GOP header			0.0
	3.Picture header			72.0
	4.GOB header			1246.8
	5.MBA			1328.7
	6.MB type			2968.2
	7.MB quant			0.0
	8.MV on/of			3970.1
	9.MC vec(Forward)			27332.7
	10.MC vec(Backward)			0.0
	11.MC vec(Field)			14702.6
	12.DCT block			3710.4
	13.CBP			5777.7
	14.Coefficient			
	DC (Y)			7615.1
	DC (Cb)			2526.8
	DC (Cr)			2393.8
	AC (Y)			167813.9
	AC (Cb)			37638.0
	AC (Cr)			28010.4
	15.TOTAL			307107.0

```
Presentation of Results                                  Page(3/4)

        Sequence : POP_9M          Institute : Mitsubishi
        Frames   : 1 - 150         Date : Fri Nov  1 00:00:00 1991
        B pictures                 Number of frames : 100

-------------------------------------------------------------------
1. SNR    luminance     Y                                      34.8
          chrominance   Cb                                     38.0
          chrominance   Cr                                     36.9
2. RMS    luminance     Y                                      4.62
          chrominance   Cb                                     3.20
          chrominance   Cr                                     3.65
-------------------------------------------------------------------
3. Mean of QP                                                  12.7
-------------------------------------------------------------------
4. MB type
          1.Intra                                                52
          2.Forward + Backward    MC     Coded                  112
          3.Forward + Field       MC     Coded                  167
          4.Backward + Field      MC     Coded                  170
          5.Forward               MC     Coded                    7
          6.Backward              MC     Coded                   10
          7.For + Back + Field    MC     Coded                  270
          8.Field                 MC     Coded                   17
         12.Forward + Backward    MC Not Coded                   86
         13.Forward + Field       MC Not Coded                   89
         14.Backward + Field      MC Not Coded                   90
         15.Forward               MC Not Coded                    5
         16.Backward              MC Not Coded                   10
         17.For + Back + Field    MC Not Coded                  224
         18.Field                 MC Not Coded                    4
          0.                                                      0
         20.Skipped                                               0
          0.                                                      0
-------------------------------------------------------------------
5. DCT blocking
          1.field-block                                         705
          2.concatenated frame-block                            504
          3.frame-block                                        1429
-------------------------------------------------------------------
6. Number of bit
          1.Sequence header                                     0.0
          2.GOP      header                                     0.0
          3.Picture  header                                    72.0
          4.GOB      header                                  1245.8
          5.MBA                                              1320.2
          6.MB type                                          5037.1
          7.MB quant                                            0.0
          8.MV on/of                                         5946.3
          9.MC vec(Forward)                                 18928.9
         10.MC vec(Backward)                                19101.4
         11.MC vec(Field)                                   20735.9
         12.DCT block                                        3848.6
         13.CBP                                              4764.8
         14.Coefficient
                 DC (Y)                                      5889.8
                 DC (Cb)                                     2543.6
                 DC (Cr)                                     2196.2
                 AC (Y)                                    108362.6
                 AC (Cb)                                    31152.3
                 AC (Cr)                                    22887.0
         15.TOTAL                                          254032.6
-------------------------------------------------------------------
```

```
Presentation of Results                                  Page(4/4)

        Sequence : POP_9M          Institute : Mitsubishi
        Frames   : 1 - 150         Date : Fri Nov  1 00:00:00 1991
        All pictures               Number of frames : 150

-------------------------------------------------------------------
1. SNR    luminance     Y                                      35.0
          chrominance   Cb                                     38.2
          chrominance   Cr                                     36.9
2. RMS    luminance     Y                                      4.55
          chrominance   Cb                                     3.12
          chrominance   Cr                                     3.62
-------------------------------------------------------------------
3. Mean of QP                                                  12.3
-------------------------------------------------------------------
5. DCT blocking
          1.field-block                                         742
          2.concatenated frame-block                            527
          3.frame-block                                        1370
-------------------------------------------------------------------
6. Number of bit
          1.Sequence header                                     0.6
          2.GOP      header                                     5.5
          3.Picture  header                                    71.3
          4.GOB      header                                  1245.7
          5.MBA                                              1322.3
          6.MB type                                          4204.6
          7.MB quant                                            0.0
          8.MV on/of                                         4943.5
          9.MC vec(Forward)                                 19361.3
         10.MC vec(Backward)                                12734.2
         11.MC vec(Field)                                   17450.6
         12.DCT block                                        3855.1
         13.CBP                                              4601.7
         14.Coefficient
                 DC (Y)                                      8280.4
                 DC (Cb)                                     2981.2
                 DC (Cr)                                     2685.7
                 AC (Y)                                    148926.7
                 AC (Cb)                                    38259.7
                 AC (Cr)                                    27795.0
         15.TOTAL                                          298725.2
-------------------------------------------------------------------
7.Bit Rate                                                8961755.2
-------------------------------------------------------------------
```

From	To	sum-bits	I-bits	P-bits	B-bits
1	12	3527328	234912	726472	2565944
13	24	3502520	211752	685496	2605272
25	36	3519712	204112	693896	2621704
37	48	3535704	215072	684016	2636616
49	60	3553720	212592	676000	2665128
61	72	3576216	223960	756472	2595784
73	84	3588656	293712	721400	2573544
85	96	3739520	339472	763584	2636464
97	108	3698128	321904	809600	2566624
109	120	3600448	294264	838512	2467672
121	132	3557568	282792	842728	2432048
133	144	3547032	280216	844216	2422600

PART - 4 IMPLEMENTATION STUDY

1. OVERVIEWS OF ESTIMATION

An estimate of implementation will be described in the following chapters. Please refer to Fig.1 and Fig.2 in Part-1. The estimate is based on the procedures which are performed in our simulation. Further investigation of the simplification is required for practical implementation.

2. PICTURE BUFFERS

2-1 Encoder

scan conversion	1
re-ordering of pictures	2
interframe (field) prediction	2

number of picture buffers in encoder : 1 + 2 + 2 = 5

2-2 Decoder

interframe(field) prediction	2
scan conversion	1

number of picture buffers in decoder : 2 +1 = 3

The sizes of all picture buffers are 704 x 480 (luminancre) and 352 x 240 x 2 (chrominance) while each pixel is expressed in 8 bits.

No display buffers are required. Each picture is decoded synchronously with a period of display. B-pictures are displayed immediately after decoding while I-pictures and P-pictures are decoded, temporary stored in the picture buffers for inter frame(field) prediction and then displayed.

3. CODED DATA BUFFER

The sizes of coded data buffers were estimated from the maximum amount of coded data per one picture in the simulation.

in case of 4Mbit/s :	700kbit
in case of 9Mbit/s :	1400kbit

4. ENCODER MODULES

Addition, multiplications and table lookups are expressed in "number of ... per second" in the following description.

4-1 decimation filter for chrominance pixels

The chrominance pixels are decimated in vertical (240 to 120) using a decimation filter below.

-29, 0, 88, 138, 88, 0, -29 // 256

memory:	352 x 6 x 2	= 4,224 (x 8bits)
additions:	(4 x 352 x 120 x 2) x 60	= 20,275,200
multiplications:	(3 x 352 x 120 x 2) x 60	= 15,206,400

(Symmetry in filter coefficients was utilized.)

4-2 motion estimation and compensation

In the part of motion estimation, the followings are assumed:

An integer pel full search in the range of +/− 7 (per picture interval) is carried out for every pairblock. Afte r the integer pel search, the eight neighbouring half-pel positions are evaluated. All of prediction modes are evaluated (interframe and interfield).

Motion vectors which refer to pixels outside the significant pel area do not make sense. Howeve r such vectors are not excluded in this estimate.

memory: 4 x 7 x (16 x 8) x 3 + 16 x 8 x 4 + (16 x 8 + 8 x 4 x 2)
+(16 x 8) x 3 + 16 + 8 + 1 = 11865 (x 8bits)

additions:

(P-picture); 2,512,268,880 (per picture)

(B-picture); 1,101,114,960 (per picture)

(3 x 2,512,268,880 + 8 x 1,101,114,960) x 30/12 = 40.86e9

NOTE: Simplification such as hierarchical search, reduction of pixels for matching or reduction of reference frames(fields) (adaptively maybe) will provide reduction of operation by 1/30 ~ 1/40 and slight degradation.

4-3 interframe(field) subtraction

additions: (704 x 480 + 352 x 240 x 2) x 11/12 x 30 = 13,939,200

4-4 DCT

In the part of DCT, the followings are assumed:

A buffer, whose size corresponds to a macroblock, is required.

In order to decide an optimal class of adaptive blocking, we used quite primitive but quite efficient method. DCT operation is performed three times corresponding to three classes for each block. After each DCT, the number of coefficients whose magnitude is beyond the quantization step is counted. The blocking formation which gives the minimum number is chosen. Not any fast calculation algorithm was used.

memory :	(8 x 8 x 4) + (8 x 8 x 2)	= 384 (x 8bits)
additions :	(88 x 60 x 3 + 44 x 30 x 2) x 896 x 30	= 496,742,400
multiplications :	(88 x 60 x 3 + 44 x 30 x 2) x 1024 x 30	= 567,705,600

NOTE : Simplification of the decision procedure may be adopted. DCT operation can be simplified by using fast calculation algorithm. The number of operation wil be reduced to about 1 / 6.

4-5 quantization

We used the quantizer which is similar to one in MPEG1. The quantization step can be 2, 4, 6, 8, ..., 62. The step is determined according to the buffer occupancy and the picture type. A buffer whose size corresponds to a block is required.

memory :	8 x 8	= 64 (x 12bits)
table size :	(12 + 5) (bits) x 8bits	= 131,072 (x 8bits)
table lookups :	(704 x 480 + 352 x 240 x2) x 30	= 15,206,400

(Symmetry in tables was utilized.)

4-6 quantization (reproduction)

We assumed that 50 % of coefficients are non-zero coefficients.

memory :	8 x 8	= 64 (x 12bits)
table size :	(9 + 5) (bits) x 12bits	= 16,384 (x 12bits)
table lookups :	(704 x 480 + 352 x 240 x 2) x 30 / 2	= 7,603,200

4-7 IDCT

memory :	(8 x 8 x 4) + (8 x 8 x 2)	= 384 (x 8bits)
additions :	(88 x 60 + 44 x 30 x 2) x 896 x 30	= 212,889,600
multiplications :	(88 x 60 + 44 x 30 x 2) x 1024 x 30	= 243,302,400

4-8 interframe(field) reproduction

additions : (704 x 480 + 352 x 240 x 2) x 11/12 x 30 = 13,939,200

4-9 variable length coding

We assumed that 50 % of coefficients are non-zero and that 50 % of interframe(field) prediction need interpolation operation. A codeword and its codelength are necessary as the outputs of the tables.

table size :

(coefficients) ;	(8 + 6) (bits) x (16 + 4)(bits)	= 16,384 (x 20bits)
(vectors) ;	5 (bits) x (11 + 4) (bits)	= 512 (x 15bits)

table lookups :

(coefficients) ;	(704 x 480 + 352 x 240 x 2) x 30 / 2	= 7,603,200
(vectors) ;	(3 x 2640 x 2 x 1.5) + (8 x 2640 x 2 x 1.5) x 30/12	= 217,800

(Symmetry in tables was utilized.)

5. DECODER MODULES

Addition, multiplications and table lookups are expressed in "number of ... per second" in the follwing description.

5-1 variable length decoding

We assumed that 50 % of coefficients are non-zero and that 50 % of interframe(field) prediction need interpolation operation. A codeword and its codelength are necessary as the outputs of the tables.

table size :

(coefficients);	16 (bits) x (8 + 4)(bits)	= 65,536 (x 12 bits)
(vectors) ;	11 (bits) x (5 + 4)(bits)	= 2,048 (x 9bits)

table lookups :

(coefficients) ; (704 x 480 + 352 x 240 x 2) x 30 / 2 = 7,603,200

(vectors) ; (3 x 2640 x 2 x 1.5) + (8 x 2640 x 2 x 1.5) x 30/12 = 217,800

(Symmetry in tables was utilized.)

5-2 quantization (reproduction) / IDCT / interframe (field) reproduction

as same as in encoder

5-3 motion compensated prediction

The operations of interpolation for half-pel prediction and interpolative prediction are required also in a decoder. We assumed that 50 % of motion vectors need half-pel operation in either direction and that 50 % of interframe (field) prediction need interpolative prediction.

addition : (16 x 8 + 8 x 4 x 2) x (2640/2 + 2640/2 x 3/2)x 11/12 x 30
= 17,424,000

5-4 interpolation filter for chrominance pixels

The chrominance pixels are interpolated in vertical (120 to 240) using an interpolation filter below.

-12, 0, 140, 256, 140, 0, -12 // 256

memory :	352 x 6 x 2	= 4,224	(x 8bits)
additions :	(3 x 352 x 120 x 2) x 60	= 15,206,400	
multiplications :	(2 x 352 x 120 x 2) x 60	= 10,137,600	

(Symmetry in filter coefficients was utilized.)