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AWARE MPEG-2 VIDEO CODING PROPOSAL II

ntroduction

This document represents the second proposal from Aware, Inc. for the PEG-2 video coding standard. Its registration number is 04. This proposal escribes the architecture of a motion-compensated three-dimensional ubband-wavelet coder. The encoder/decoder architecture is very flexible and an be adapted to the application and the complexity required. This rchitecture was designed for CCIR-601 digital video. However, it could be pplied to other formats. The coder treats luminance and chrominance into eperate channels but uses the same basic architecture for both. The main eature of the algorithm is the representation of the input video into several ideo layers at various resolution scales and frame rates. This architecture s a multi-resolution three-dimensional coder and is therefore easily scalable.

. Algorithm description

1.1. Image format

The input video is CCIR-601 digital video. The frames are cropped to btain the following format:

luminance (Y): 704 x 240 x 2 x 30
chrominance (U, V): 352 x 240 x 2 x 30

The three components Y, U, V go through the same coding architecture. However, some of the coding parameters are adjusted differently for luminance and chrominance. The general encoder block diagram is given in Figure 1.

1.2. Temporal transform

1.1.1. Decomposition

The temporal transform is a motion-compensated subband decomposition. Figure 2 illustrates the architecture of the transform. The wavelet filters used for the temporal transform are very simple 2-tap FIR filters. When transforming the output of the low-pass filter recursively, you obtain a multi-level Haar transform. Consider two successive frames F1 and F2, the Haar transform of these two frames without motion compensation generates a low-pass frame F1+F2 and a high-pass frame F1-F2. You can also use block motion compensation as an option. In that case, the second frame F2 is divided into 16x16 blocks. Each block of F2 is matched to a block in F1 through classical motion estimation. We use a full search algorithm for the motion estimation with a search area of 16 full pixel horizontally and 10 full pixels vertically. The motion compensated Haar transform of the two frames F1 and F2 is done by computing the Haar transform of matched pairs of blocks for each block in F2. If a pixel (x,y) in F2 belongs to a block whose motion vector is (dx,dy), the low-pass pixel is F1(x+dx,y+dy)+F2(x,y) and the high-pass pixel is F1(x+dx,y+dy)-F2(x,y). The high-pass pixel goes into the temporal high band Ht at location (x,y). The low-pass pixel goes into the temporal low band Lt at location (x+dx,y+dy). If a pixel in F1 at (x,y) is matched more than once to a pixel in F2 or not matched at all, then this F1 pixel is intra-coded in the low band Lt by setting Lt(x,y) to 2*F1(x,y).

If you apply the Haar transform to each pair of frames you get two temporal bands Lt and Ht. You can repeat this process on the Lt band to create another high band and a new low band and so on. If Nt is the number of levels of the temporal decomposition, the number of temporal subbands is Nt+1: one low band and Nt high bands. A Group of Frames (GOF) is defined as the frames needed to generate one frame from the Lt band. A GOF contains 2**Nt frames inter-coded together into Nt+1 temporal bands. This decomposition is a pyramid of multi-level bands at different rates. At a given level, a band is half the rate of the previous band.

1.1.2. Recomposition

From the motion vectors alone, the decoder can identify which pixels of an Lt frame were matched only once to a pixel in the corresponding Ht frame. The inverse Haar transform is computed for each such pixel. The remaining pixels in Lt which were matched more than once or not at all, are intra-coded and decoded by simply scaling them by 2. The pixels in the Ht frame which were matched to a pixel in the corresponding Lt frame matched more than once, are DPCM-coded and are decoded by simply adding the residual from Ht to the previous frame pixel in Lt after proper scaling. In the temporal pyramid decomposition, the last level temporal bands are recomposed first. Namely each frame of the last level Lt and Ht bands corresponding to a group of frames are recomposed first to form the two frames corresponding to the Lt band of the previous level. The process is repeated down the hierarchy until the complete GOF is reconstructed.

1.3. Odd field shift

The input video is interlaced. To reduce the energy in the high vertical spatial band caused by interlacing due to the horizontal camera pan, the odd field is shifted so that the two fields are maximally aligned. This is done by circularly shifting the odd lines of each frame of the low temporal band Lt. The amount of shift is estimated by doing a full pixel search of +- 8 pixels horizontally only. At the decoder, the odd field is shifted in the opposite direction to restore proper interlacing.

1.4. Spatial transform

Each frame after temporal decomposition goes through an identical subband decomposition. Figure 3 illustrates the structure of the spatial subband decomposition. This is done using a wavelet filter bank (6-tap Daubechies FIR filters). Each frame row goes through two filters to generate a low horizontal band Lh and a high horizontal band Hh after down-sampling by 2. Then each resulting columns go through the same process resulting into four bands: LhLv, HhLv, HhHv, LhHv. After one level of spatial decomposition, this process is repeated on the quarter frame size bands LhLv and LhHv (only on the LhLv band for U and V). If the number of decomposition levels is Ns, the total number of spatial bands is 6Ns-2. You get a multi-level pyramid of bands corresponding to multiple resolution scales (octave band-splitting).

The spatial subband recomposition is the reverse of the decomposition. Since the decomposition is hierarchical, you start at the top of pyramid. The last level is recomposed first. Each column of each band is up-sampled. A column from the low band goes through the reversed low-pass FIR filter and its corresponding column from the high band goes through the reversed high-pass FIR filter. The output of the two filter are then added together. You repeat the same process for each rows. This completes the reconstruction of one level which becomes the LhLv band of the previous level. The process is repeated until the full size frame is recomposed for each temporal bands.

1.5. Adaptive block quantizer

Once the spatial-temporal decomposition is completed, you get a hierarchical collection of spatial-temporal bands or a spatial-temporal pyramid. Each one of those bands is divided into 3D spatial-temporal blocks for adaptive quantization. The GOF is divided into Nt+1 temporal bands. The Lt and Ht bands corresponding to the last level contain only one frame. The Ht band of the first level contains 2**(Nt-1) frames, the next band contains half as many frames and so on. The statistics for each temporal band are gathered over the number of frames in that band corresponding to the GOF. For example, for Nt=4:

band:	level:	# frames:
Ht	1	8
Ht	2	4
Ht	3	2
Ht	4	1
Lt	4	1

Several GOF's can be grouped together to compute the statistics over a number of frames multiple of 2**Nt. This will increase the encoding delay but decrease the overhead bit rate.

In addition, each spatial band is divided into blocks of Bv x Bh pixels. The variance of each block of each spatial band is computed for each temporal band over its corresponding number of frames. Once the variances are computed for a GOF (or group of GOF's), for a given target rate, the bin-widths for each spatial-temporal block are computed to minimize the overall distortion. The bin-widths are included into the bit stream as overhead. The quantizers are standard uniform quantizers. Alternatively to the adaptive quantization scheme, fixed static quantization tables can be used for a simpler encoder with slightly worse performance. For the luminance, we used Bv = 15 pels and Bh = 22 pels, over one GOF of 16 frames. This corresponds to Ns=5 and Nt=4. For the chrominance signals U and V, adaptive quantization was applied to each spatial-temporal band without sub-blocking. The bin-widths are computed for U and V assuming they are coded together (statistically multiplexed). At the decoder, de-quantization is performed using bin-widths loaded from RAM in the static case or decoded from the bit stream in the adaptive case.

1.6. Coder

Two types of coding are used: FLC and VLC (entropy coder). The different types of data are coded as follows:

Coefficients from Lt(Nt-1)Lh(Ns-1)Lv(Ns-1) bands:	FLC 16 bits
Coefficients from all other bands:	VLC
Motion vectors:	VLC
Quantizer bin-widths:	FLC 16 bits
Block standard deviations:	FLC 16 bits

The VLC used is an entropy coder which is performed in two steps. First, the quantized values of each band go through a modeler wich creates symbols from them. Typically, the modeler identifies the zero run-lengths. Different models are used depending on the bands being coded. Annex 1 gives examples of models used in the VLC.

The histogram of the symbols is computed to generate dynamic Huffman tables which are included in the bit stream. The number of tables is flexible. Typically, you can use one table for each level of the spatial-temporal decomposition. You can use fewer tables by grouping levels together for a given table. The system will have worse performance but less overhead bit rate. Alternatively, you can use static Huffman tables which do not need to be transmitted. Examples of Huffman tables for models 1 and 2 are given in annex 2.

2. Functionalities

2.1. Compatibility

The only compatible mode we can claim is the switchable scheme. (cf. PPD)

2.2. Random access

To access a given frame randomly, the decoder needs to identify the GOF number where the frame belongs. The frames of the Lt temporal band are the entry points in the bit stream. From the top of the temporal pyramid (Lt frame), the decoder identifies the path in the tree that yields to the pair of decoded frames containing the desired frame. Two frames at the top need to be decoded and one frame at each level below. The decoding delay for random access is therefore Nt+1 frame delays added to the search time for the decoder to identify the beginning of each decoded frame (marker identification). For Nt=4, the delay is about 0.17 s. For channel switch, the delay is the same added to the delay to identify the first available GOF.

2.3. Coding/decoding delay

In our implementation, we have tried to minimize the number of frame buffers needed for the decoder (minimize decoder complexity). The decoding delay is Nt+1 frame delays (0.17 s for Nt=4). However, to achieve the low decoding delay, the sequence of the frames in a GOF is such that the number of frame buffers needed at the encoder increases rapidly with Nt. We need 2**(Nt+1) - 1 frame delays at the encoder, or 1.03 s for Nt=4.

2.4. Fast forward/reverse

Fast forward and fast reverse modes are possible. The decoder decodes only the top of the temporal pyramid (Lt band). For Nt=4, this will yield about 16 times the original speed. The decoder can also reconstructs the next temporal level yielding half the speed.

2.5. Scalability

Scalability is built in this architecture because of the multi-resolution structure of the representation of the video signal. The decoder can do a partial reconstruction of the input video by skipping the appropriate spatial-temporal bands. In that manner, the decoder can decode from the bit stream various fractions (powers of 2) of the original spatial resolution or frame rate. The decoding of the spatial-temporal pyramid is done from the top down, so the decoder can stop at whatever level is appropriate for the application.

2.6. Architecture flexibility

The architecture described above presents various degrees of flexibility. Various levels of complexity can be introduced into the coder/decoder depending on the application, the cost and the performance of the system.

. Flexibility in the spatial-temporal transform: If the motion compensation is turned off, the system becomes a 3D wavelet-subband coder. The number of levels Nt defines the depth of the temporal pipeline. With no motion compensation, only one level of Haar transform can be used. You can also switch to intra-coding mode only. In that case, the system is a 2D wavelet transform coder. The flexibility in the transform impacts mostly the amount of frame buffers needed at the encoder/decoder.

. Flexibility in the quantization: If adaptive block quantization is used, the level of adaptivity can be adjusted by the 3D block sizes. Also static quantization can be used for simpler encoder/decoder.

. Flexibility in the Huffman coding: If adaptive Huffman coding is used, the number of dynamic tables used can be adjusted. Also static Huffman tables can be used for simpler encoder/decoder.

. The architecture has flexibility in bit rate and can be used with statistical multiplexing.

3. Implementation

3.1. Block motion estimation module

Same complexity as the MPEG-1 motion estimation, except this algorithm uses only forward prediction, and only full pixel accuracy.

3.2. Field shift estimation module

memory: 2 x line buffer x 8 bits
bandwidth: Fs (Fs = video sampling rate)
additions: 31/pel

multiplications: 16/pel
tables: none

3.3. Spatial-temporal transform module

picture buffers (including delays):

ENC: 8 bit buffers
* 1 FB per level of temporal transform: Nt FB's
* delay buffers: 2**(Nt+1) - 1

DEC: 8 bit buffers
* 1 FB per level of temporal transform: Nt FB's
* delay buffers: none

Haar transform:
additions: 2/pel x Nt
multiplications: none

Other memory:
* motion vectors buffer: FB/256 x 8 bits
  bandwidth: no requirement
* flag bits: FB x 2 bits
  bandwidth: Fs

Wavelet Transform (WT) stage (same as IWT):
* memory:
  6 x line buffer on chip - bandwidth: 5.2 Fs
  1 FB x 16 bits off chip - bandwidth: 1.58 Fs
* additions:
  width: 16 bits
  number: 199.0 millions
* multiplications:
  width: 16 x 16 = 32 bits
  number: 265.4 millions
* WT coefficients: 4 fixed
* table LUT: none
* two on chip address generators needed, could be implemented
  by registers, counters and 2 adders.

3.4. Adaptive quantizer module

Symmetric part (ENC and DEC):
* memory on/off chip: none
* additions:
  width: 32 bits
  number: 21.0 millions
* multiplications:
  width: 16 x 16 = 32 bits
  number: 21.0 millions
* table: 40 x 32 bits down-loaded
* LUT speed: Fs
* others:
  - very simple address generation on chip.

Non-symmetric part (ENC only)

* memory:
  on chip: (Nt+1) x 1024 x 56 bits static RAM
  off chip: none
  bandwidth: 2 Fs
* additions:
  width: 16 bits
  number: 21.0 millions
  width: 40 bits
  number: 21.0 millions
* multiplications:
  width: 16 x 16 = 32 bits
  number: 21.0 millions
* table: none
* others:
  - adaptive Qn matrix generation based on statistics collected must be performed by off chip controller.
  - for adaptive Qn to work, there must be a minimum of Nt delay frames, this is satisfied by temporal decomposition part (2**(Nt+1) - 1 frames).

3.5. Entropy coder module

Coded data buffer: estimated 0.5 frame of low speed FIFO RAM

Modeler and Huffman coder:

* memory:
  on/off chip: none
* additions:
  width: 16 bits
  number: 84.0 millions
* multiplications: none
* table: 6 x 256 x 28 bits
  bandwidth: Fs
* note:
  the LUT's for modeling (6 x 256 x 8 bits) are ROMable and thus could be fixed.

Histogram collector (ENC only):

* memory:
  on chip: none
  off chip: 6 x 256 x 16 bits
  bandwidth: 2 Fs
* additions:
  width: 16 bits
  number: 42.0 millions
* multiplications: none
* table: none
* note:
  this module is required for only the following two cases:
  - adaptive Huffman code tables are required.
  - accurate rate control (the exact rate can be computed before encoding)

4. Test sequences statistics

The statistics for the test sequences are given in Tables 1 through 7.

The output of the "ls -l" for the corresponding coded bit stream files follows:

```
-rw-r-----  1 philippe  2483597 Nov  8 14:32 flower_4Mbps
-rw-r-----  1 philippe  5621195 Nov  8 14:31 flower_9Mbps
-rw-r-----  1 philippe  2465349 Nov  8 14:29 mobile_4Mbps
-rw-r-----  1 philippe  5626559 Nov  8 14:32 mobile_9Mbps
-rw-r-----  1 philippe  5640059 Nov  8 14:33 popple_9Mbps
-rw-r-----  1 philippe  2498909 Nov  8 14:30 tennis_4Mbps
-rw-r-----  1 philippe  5599450 Nov  8 14:33 tennis_9Mbps
```

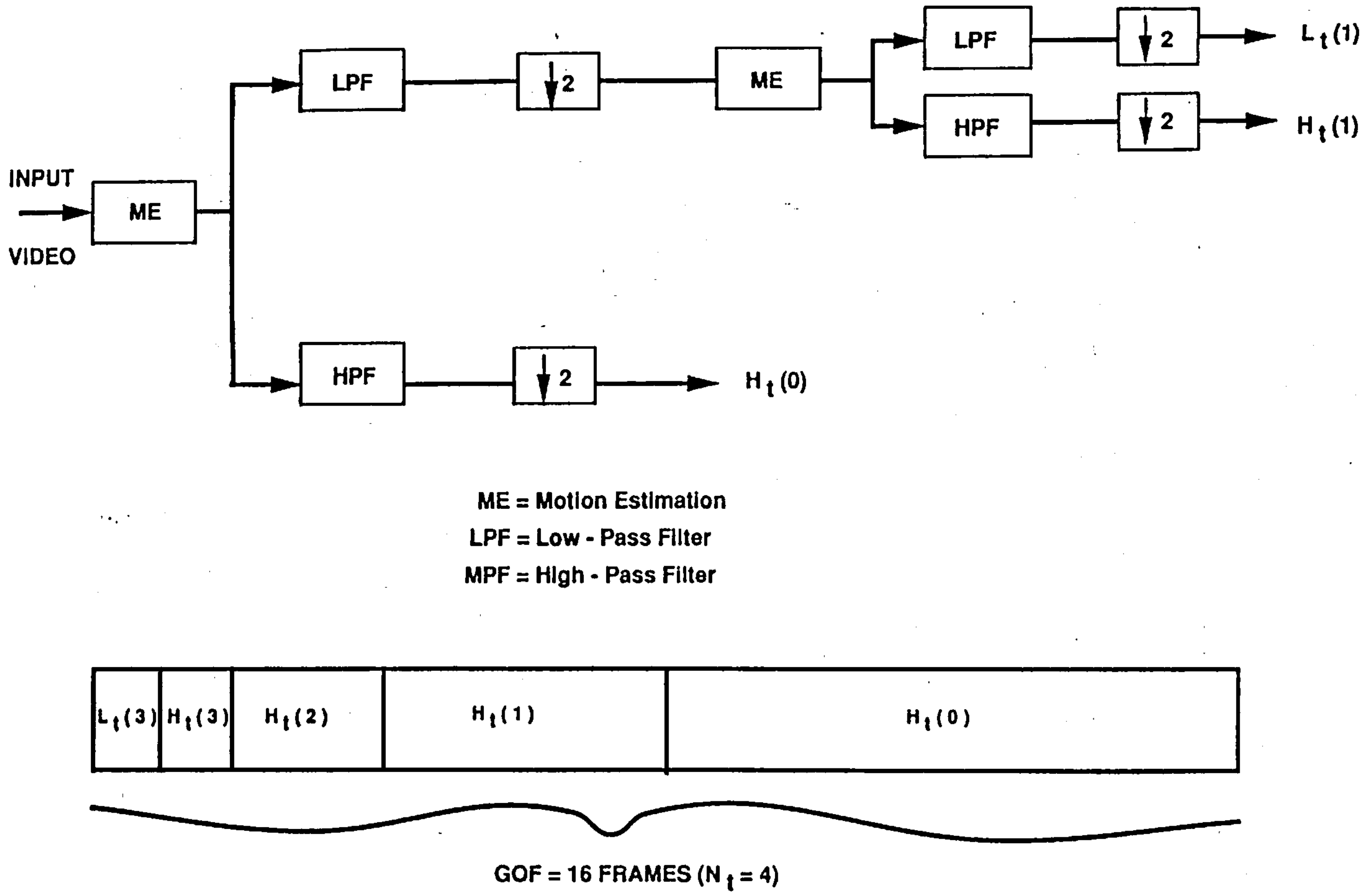

FIGURE 2: MOTION COMPENSATED TEMPORAL SUBBAND DECOMPOSITION

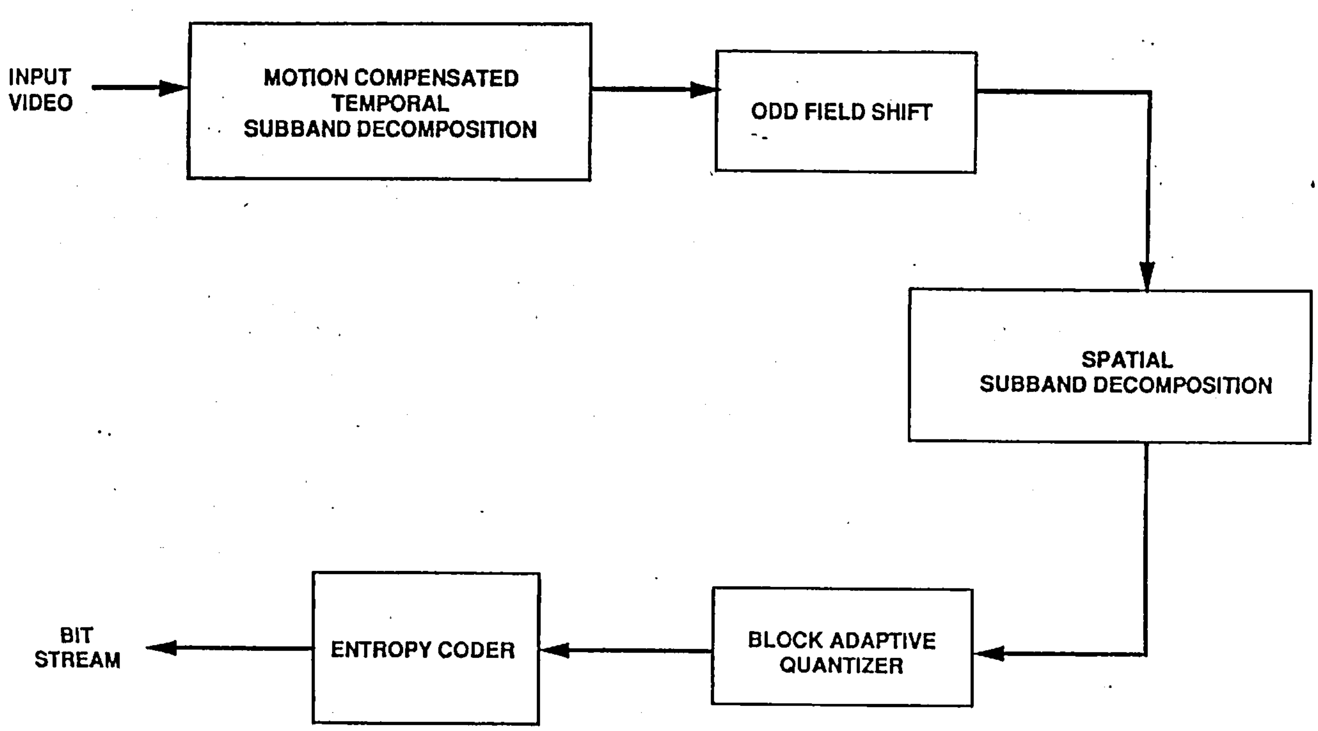

FIGURE 1: ENCODER BLOCK DIAGRAM

ANNEX 1

Simple description of models used as preprocessing of entropy coding. Model 1 is developed for higher level blocks of the pyramid where larger non-zero coefficients and very small zero-runs are most likely. Model 2 is suitable for the lower level blocks of the wavelet pyramid, where smaller non-zero coefficients are scattered with long runs of zeros. Model 3 is more efficient with blocks of dominant zero runs and only few very small magnitude non-zero coefficients. Harr frames of "high band channel", if the scene is not changing too much are good examples of blocks which should use Model 3.

MODEL 1:

Symbol (hex)	Meaning
00	Next byte is raw 8-bit binary outside [-123,123]
01	Next 12 bits are raw binary beyond [-251, 251]
02	Run of 5 to 20 zeroes, next 4 bits says how many more than 5
03	Run of 21 to 276 zeroes, next 8 bits says how many more than 21
04	Run of more than 276 zeroes, next 12 bits says how many more than 276
05	code for -123
06	code for -122
.	.
.	.
.	.
7F	code for -1
80	Next 16 bits are raw binary beyond [-2299, 2299]
81	code for 1
.	.
.	.
.	.
FA	code for 122
FB	code for 123
FC	Single zero
FD	Run of 2 zeroes
FE	Run of 3 zeroes
FF	Run of 4 zeroes

MODEL 2:

Symbol (hex)	Meaning
00	code for -32
01	code for -31
.	.
.	.
.	.
1F	code for -1
20	UNUSED
21	code for 1
.	.

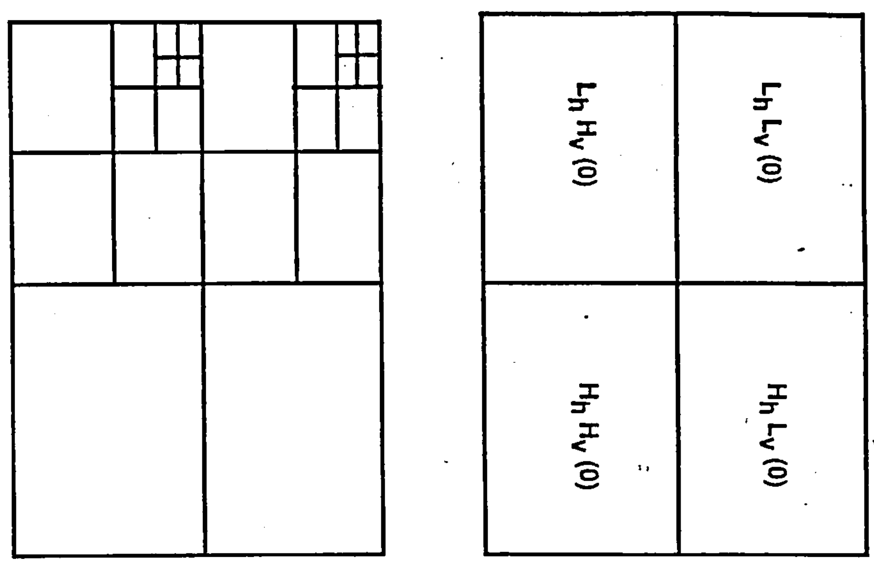

FIGURE 3: SPATIAL SUBBAND DECOMPOSITION

```
 .        .
 .        .
 3F       code for 31
 40       code for 32
 41       Single zero
 42       Run of 2 zeroes
 43       Run of 3 zeroes
 .        .
 .        .
 .        .
 7A       Run of 58 zeroes
 7B       Run of 59 zeroes
 7C         UNUSED
 7D         UNUSED
 .          .
 .          .
 .          .
 ED         UNUSED
 EE         UNUSED
 EF       Run of >18490 zeroes, next 16 bit is the # of Z [18490, ~]
 F0       Run of >2106 zeroes, next 14 bit is the # of Z [2106, 18489]
 F1       Run of >1082 zeroes, next 10 bit is the # of Z [1082, 2105]
 F2       Run of >570 zeroes, next 9 bit is the # of Z [570, 1081]
 F3       Run of >314 zeroes, next 8 bit is the # of Z [314, 569]
 F4       Run of >186 zeroes, next 7 bit is the # of Z [186, 313]
 F5       Run of >122 zeroes, next 6 bit is the # of Z [122, 185]
 F6       Run of >90 zeroes, next 5 bit is the # of Z [90, 121]
 F7       Run of >74 zeroes, next 4 bit is the # of Z [74, 89]
 F8       Run of >66 zeroes, next 3 bit is the # of Z [66, 73]
 F9       Run of >62 zeroes, next 2 bit is the # of Z [62, 65]
 FA       Run of >60 zeroes, next 1 bit is the # of Z [60, 61]
 FB         UNUSED
 FC         UNUSED
 FD       End-of-Block marker
 FE       Next 14 bits raw binary outside of [-544, 544]
 FF       Next 10 bits raw binary outside of [-32,32]
```

MODEL 3: For this model, each symbol represents one zero-run-length and the non-zero coefficient follows it. The Non-Z is expressed in two parts. The BIN number is put in the lower 4 bits of symbol. The raw binary follows the symbol deliveres the actual length.

```
Symbol(hex)     Meaning
  00       Non-Z = -8, Z-Run BIN # = 0
  01       Non-Z = -8, Z-Run BIN # = 1
  02       Non-Z = -8, Z-Run BIN # = 2
  .              .
  0f       Non-Z = -8, Z-Run BIN # = 15
  10       Non-Z = -7, Z-Run BIN # = 0
  11       Non-Z = -7, Z-Run BIN # = 1
  .              .
  1F       Non-Z = -7, Z-Run BIN # = 15
  .              .
  .              .
  .              .
  7F       Non-Z = -1, Z-Run BIN # = 15
```



```
 80       Next byte is Non-Z Extended outside [-7, 8], Z-Run BIN # = 0
 81       Non-Z Extended, next 1 bit is Z-Run
 81       Non-Z Extended, next 2 bit is Z-Run
 81       Non-Z Extended, next 3 bit is Z-Run
 .        .
 8D       Non-Z Extended, next 13 bit is Z-Run
 8E       Z-Run LENGTH = 65535
 8F       End-of-Block marker
 90       Non-Z = 1, Z-Run BIN # = 0
 91       Non-Z = 1, Z-Run BIN # = 1
 .        .
 9F       Non-Z = 1, Z-Run BIN # = 15
 A0       Non-Z = 2, Z-Run BIN # = 0
 .              .
 .              .
 .              .
 F0       Non-Z = 7, Z-Run BIN # = 0
 .              .
 FF       Non-Z = 7, Z-Run BIN # = 15
```

ANNEX 2

```
// Lum. BUFCO TABLE #1
@00  ff6b       //16
@01  ff76       //16
@02  a000       // 5
@03  f000       // 8
@04  ff77       //16
@05  ff78       //16
@06  ff79       //16
@07  ff7a       //16
@08  ff7b       //16
@09  ff7c       //16
@0a  ff7d       //16
@0b  ff7e       //16
@0c  ff7f       //16
@0d  ff80       //16
@0e  ff81       //16
@0f  ff82       //16
@10  ff83       //16
@11  ff84       //16
@12  ff85       //16
@13  ff86       //16
@14  ff87       //16
@15  ff88       //16
@16  ff89       //16
@17  ff8a       //16
@18  ff8b       //16
@19  ff8c       //16
@1a  ff8d       //16
@1b  ff8e       //16
@1c  ff8f       //16
@1d  ff90       //16
@1e  ff91       //16
@1f  ff92       //16
@20  ff93       //16
@21  ff94       //16
@22  ff95       //16
@23  ff96       //16
@24  ff97       //16
@25  ff98       //16
@26  ff99       //16
@27  ff9a       //16
@28  ff9b       //16
@29  ff9c       //16
@2a  ff9d       //16
@2b  ff9e       //16
@2c  ff9f       //16
@2d  ffa0       //16
@2e  ffa1       //16
@2f  ffa2       //16
@30  ffa3       //16
@31  ffa4       //16
```



```
@32  ffa5       //16
@33  ffa6       //16
@34  ffa7       //16
@35  ffa8       //16
@36  ffa9       //16
@37  ffaa       //16
@38  ffab       //16
@39  ffac       //16
@3a  ffad       //16
@3b  ffae       //16
@3c  ffaf       //16
@3d  ffb0       //16
@3e  ffb1       //16
@3f  ffb2       //16
@40  ffb3       //16
@41  ffb4       //16
@42  ff6c       //16
@43  ffb5       //16
@44  ffb6       //16
@45  ff6d       //16
@46  ffb7       //16
@47  ff6e       //16
@48  ffb8       //16
@49  ffb9       //16
@4a  ffba       //16
@4b  ffbb       //16
@4c  ff6f       //16
@4d  ff5b       //16
@4e  ffbc       //16
@4f  ff4f       //16
@50  ffbd       //16
@51  ff5c       //16
@52  ffbe       //16
@53  ffbf       //16
@54  ff5d       //16
@55  ff50       //16
@56  ff5e       //16
@57  ff70       //16
@58  ff5f       //16
@59  ff60       //16
@5a  ff61       //16
@5b  fee0       //13
@5c  ff51       //16
@5d  fee8       //13
@5e  fef0       //13
@5f  fef8       //13
@60  ff00       //13
@61  ff08       //13
@62  ff10       //13
@63  ff18       //13
@64  fe40       //12
@65  fe50       //12
@66  fd00       //11
@67  fe60       //12
@68  fe70       //12
@69  fd20       //11
```

```
6a  fd40   //11
6b  fd60   //11
6c  fd80   //11
6d  fda0   //11
6e  fdc0   //11
6f  fa80   //10
70  fac0   //10
71  fb00   //10
72  f800   // 9
73  f880   // 9
74  f900   // 9
75  f100   // 8
76  f200   // 8
77  f300   // 8
78  e800   // 7
79  ea00   // 7
7a  d000   // 6
7b  d400   // 6
7c  a800   // 5
7d  b000   // 5
7e  8000   // 4
7f  0000   // 2
80  ffc0   //16
81  4000   // 3
82  9000   // 4
83  b800   // 5
84  c000   // 5
85  d800   // 6
86  dc00   // 6
87  ec00   // 7
88  ee00   // 7
89  f400   // 8
8a  f500   // 8
8b  f600   // 8
8c  f700   // 8
8d  f980   // 9
8e  fa00   // 9
8f  fb40   //10
90  fb80   //10
91  fbc0   //10
92  fc00   //10
93  fc40   //10
94  fc80   //10
95  fde0   //11
96  fe00   //11
97  fe20   //11
98  fcc0   //10
99  fe80   //12
a   fe90   //12
b   fea0   //12
c   feb0   //12
d   fec0   //12
e   fed0   //12
f   ff20   //13
0   ff28   //13
1   ff30   //13
```



```
@a2  ff38   //13
@a3  ff52   //16
@a4  ff40   //13
@a5  ff48   //14
@a6  ff53   //16
@a7  ff4c   //15
@a8  ff62   //16
@a9  ff63   //16
@aa  ff54   //16
@ab  ff55   //16
@ac  ff64   //16
@ad  ff65   //16
@ae  ff71   //16
@af  ff72   //16
@b0  ff56   //16
@b1  ff57   //16
@b2  ff58   //16
@b3  ff66   //16
@b4  ff67   //16
@b5  ff68   //16
@b6  ff69   //16
@b7  ff73   //16
@b8  ffc1   //16
@b9  ff74   //16
@ba  ffc2   //16
@bb  ff6a   //16
@bc  ff75   //16
@bd  ff59   //16
@be  ff4e   //16
@bf  ff5a   //16
@c0  ffc3   //16
@c1  ffc4   //16
@c2  ffc5   //16
@c3  ffc6   //16
@c4  ffc7   //16
@c5  ffc8   //16
@c6  ffc9   //16
@c7  ffca   //16
@c8  ffcb   //16
@c9  ffcc   //16
@ca  ffcd   //16
@cb  ffce   //16
@cc  ffcf   //16
@cd  ffd0   //16
@ce  ffd1   //16
@cf  ffd2   //16
@d0  ffd3   //16
@d1  ffd4   //16
@d2  ffd5   //16
@d3  ffd6   //16
@d4  ffd7   //16
@d5  ffd8   //16
@d6  ffd9   //16
@d7  ffda   //16
@d8  ffdb   //16
@d9  ffdc   //16
```

```
@da  ffdd      //16
@db  ffde      //16
@dc  ffdf      //16
@dd  ffe0      //16
@de  ffe1      //16
@df  ffe2      //16
@e0  ffe3      //16
@e1  ffe4      //16
@e2  ffe5      //16
@e3  ffe6      //16
@e4  ffe7      //16
@e5  ffe8      //16
@e6  ffe9      //16
@e7  ffea      //16
@e8  ffeb      //16
@e9  ffec      //16
@ea  ffed      //16
@eb  ffee      //16
@ec  ffef      //16
@ed  fff0      //16
@ee  fff1      //16
@ef  fff2      //16
@f0  fff3      //16
@f1  fff4      //16
@f2  fff5      //16
@f3  fff6      //16
@f4  fff7      //16
@f5  fff8      //16
@f6  fff9      //16
@f7  fffa      //16
@f8  fffb      //16
@f9  fffc      //16
@fa  fffd      //16
@fb  fffe      //16
@fc  6000      // 3
@fd  c800      // 5
@fe  e000      // 6
@ff  e400      // 6
// Lum. HUFCO TABLE #2
@00  ffe4      //16
@01  ffe5      //16
@02  ffe6      //16
@03  ffe7      //16
@04  ffe8      //16
@05  ffe9      //16
@06  ffea      //16
@07  ffeb      //16
@08  ffec      //16
@09  ffed      //16
@0a  ffee      //16
@0b  ffef      //16
@0c  fff0      //16
@0d  ffe0      //16
@0e  ffdb      //16
@0f  ffdc      //16
@10  ffda      //16
```



```
@11  ffd5      //16
@12  ffd6      //16
@13  ffb0      //13
@14  ffb8      //13
@15  fee0      //12
@16  fef0      //12
@17  fc00      //11
@18  fc20      //11
@19  f900      //10
@1a  f200      // 9
@1b  e800      // 8
@1c  dc00      // 7
@1d  c800      // 6
@1e  b000      // 5
@1f  0000      // 2
@20  0000      // 0
@21  4000      // 2
@22  b800      // 5
@23  cc00      // 6
@24  de00      // 7
@25  e900      // 8
@26  f280      // 9
@27  f940      //10
@28  fc40      //11
@29  fc60      //11
@2a  fc80      //11
@2b  ff00      //12
@2c  ffc0      //13
@2d  ffd7      //16
@2e  ffd8      //16
@2f  ffd9      //16
@30  ffdd      //16
@31  ffde      //16
@32  ffe1      //16
@33  ffe2      //16
@34  fff1      //16
@35  fff2      //16
@36  ffe3      //16
@37  fff3      //16
@38  fff4      //16
@39  fff5      //16
@3a  fff6      //16
@3b  fff7      //16
@3c  fff8      //16
@3d  fff9      //16
@3e  fffa      //16
@3f  fffb      //16
@40  fffc      //16
@41  8000      // 3
@42  a000      // 4
@43  c000      // 5
@44  d000      // 6
@45  d400      // 6
@46  d800      // 6
@47  e000      // 7
@48  e200      // 7
```

```
@49  e400      // 7
@4a  e600      // 7
@4b  ea00      // 8
@4c  eb00      // 8
@4d  ec00      // 8
@4e  ed00      // 8
@4f  ee00      // 8
@50  ef00      // 8
@51  f300      // 9
@52  f380      // 9
@53  f400      // 9
@54  f480      // 9
@55  f500      // 9
@56  f580      // 9
@57  f600      // 9
@58  f680      // 9
@59  f700      // 9
@5a  f980      //10
@5b  f9c0      //10
@5c  fa00      //10
@5d  fa40      //10
@5e  fa80      //10
@5f  fac0      //10
@60  fb00      //10
@61  fb40      //10
@62  fb80      //10
@63  fca0      //11
@64  fcc0      //11
@65  fce0      //11
@66  fd00      //11
@67  fd20      //11
@68  fd40      //11
@69  fd60      //11
@6a  fd80      //11
@6b  fda0      //11
@6c  fdc0      //11
@6d  fde0      //11
@6e  fe00      //11
@6f  fe20      //11
@70  fe40      //11
@71  fe60      //11
@72  fe80      //11
@73  ff10      //12
@74  ff20      //12
@75  ff30      //12
@76  ff40      //12
@77  ff50      //12
@78  ff60      //12
@79  ff70      //12
@7a  ff80      //12
@7b  ff90      //12
@7c  0000      // 0
@7d  0000      // 0
@7e  0000      // 0
@7f  0000      // 0
@80  0000      // 0
```



```
@81  0000      // 0
@82  0000      // 0
@83  0000      // 0
@84  0000      // 0
@85  0000      // 0
@86  0000      // 0
@87  0000      // 0
@88  0000      // 0
@89  0000      // 0
@8a  0000      // 0
@8b  0000      // 0
@8c  0000      // 0
@8d  0000      // 0
@8e  0000      // 0
@8f  0000      // 0
@90  0000      // 0
@91  0000      // 0
@92  0000      // 0
@93  0000      // 0
@94  0000      // 0
@95  0000      // 0
@96  0000      // 0
@97  0000      // 0
@98  0000      // 0
@99  0000      // 0
@9a  0000      // 0
@9b  0000      // 0
@9c  0000      // 0
@9d  0000      // 0
@9e  0000      // 0
@9f  0000      // 0
@a0  0000      // 0
@a1  0000      // 0
@a2  0000      // 0
@a3  0000      // 0
@a4  0000      // 0
@a5  0000      // 0
@a6  0000      // 0
@a7  0000      // 0
@a8  0000      // 0
@a9  0000      // 0
@aa  0000      // 0
@ab  0000      // 0
@ac  0000      // 0
@ad  0000      // 0
@ae  0000      // 0
@af  0000      // 0
@b0  0000      // 0
@b1  0000      // 0
@b2  0000      // 0
@b3  0000      // 0
@b4  0000      // 0
@b5  0000      // 0
@b6  0000      // 0
@b7  0000      // 0
@b8  0000      // 0
```

```
@b9  0000       // 0
@ba  0000       // 0
@bb  0000       // 0
@bc  0000       // 0
@bd  0000       // 0
@be  0000       // 0
@bf  0000       // 0
@c0  0000       // 0
@c1  0000       // 0
@c2  0000       // 0
@c3  0000       // 0
@c4  0000       // 0
@c5  0000       // 0
@c6  0000       // 0
@c7  0000       // 0
@c3  0000       // 0
@c9  0000       // 0
@ca  0000       // 0
@cb  0000       // 0
@cc  0000       // 0
@cd  0000       // 0
@ce  0000       // 0
@cf  0000       // 0
@d0  0000       // 0
@d1  0000       // 0
@d2  0000       // 0
@d3  0000       // 0
@d4  0000       // 0
@d5  0000       // 0
@d6  0000       // 0
@d7  0000       // 0
@d8  0000       // 0
@d9  0000       // 0
@da  0000       // 0
@db  0000       // 0
@dc  0000       // 0
@dd  0000       // 0
@de  0000       // 0
@df  0000       // 0
@e0  0000       // 0
@e1  0000       // 0
@e2  0000       // 0
@e3  0000       // 0
@e4  0000       // 0
@e5  0000       // 0
@e6  0000       // 0
@e7  0000       // 0
@e8  0000       // 0
@e9  0000       // 0
@ea  0000       // 0
@eb  0000       // 0
@ec  0000       // 0
@ed  0000       // 0
@ee  0000       // 0
@ef  ffdf       //16
@f0  ffc8       //13
```



```
@f1  ffd0       //14
@f2  ffa0       //12
@f3  fea0       //11
@f4  f000       // 8
@f5  f100       // 8
@f6  f780       // 9
@f7  f800       // 9
@f8  f880       // 9
@f9  fbc0       //10
@fa  fec0       //11
@fb  0000       // 0
@fc  0000       // 0
@fd  ffd4       //16
@fe  fffd       //16
@ff  fffe       //16
```

Table No. 1 Flower Garden sequence at 4 Mb/sec

Frame Num	Lumina Peak SNR	Chroma Peak SNR	Lumina Data BitCount	Chroma Data BitCount	Motion Vector BitCount	Data Overhead BitCount	Total BitCount
001	30.86	31.97					
002	30.00	32.22					
003	30.12	32.33					
004	29.10	32.17					
005	29.51	32.14					
006	28.92	32.33					
007	28.91	32.21					
008	27.79	31.77					
009	29.73	31.72					
010	29.11	32.21					
011	28.95	32.30					
012	27.36	31.78					
013	28.29	31.87					
014	28.31	32.22					
015	28.35	32.23					
016	27.49	31.59	1656384	248533	84616	98528	2088061
017	29.17	31.35					
018	29.12	31.95					
019	28.65	32.14					
020	27.65	31.72					
021	29.27	31.88					
022	29.08	32.21					
023	28.93	32.21					
024	27.96	31.68					
025	29.38	31.70					
026	28.82	32.09					
027	29.41	32.23					
028	28.26	31.86					
029	29.28	31.98					
030	28.52	32.10					
031	28.64	32.00					
032	27.89	31.58	1653624	260373	79928	98528	4180514
033	28.88	31.35					
034	29.11	31.88					
035	29.51	32.05					
036	28.41	31.68					
037	29.85	31.77					
038	29.60	32.01					
039	29.32	31.98					
040	28.00	31.53					
041	29.27	31.45					
042	29.45	31.88					
043	29.17	31.98					
044	27.91	31.68					
045	28.50	31.47					
046	28.50	31.88					
047	28.53	31.76					
048	27.62	31.21	1687576	258773	74440	98528	6299832
049	28.57	31.17					
050	29.02	31.60					
051	29.18	31.62					
052	28.86	31.42					
053	27.09	30.88					
054	27.39	31.66					
055	28.00	31.71					
056	27.37	31.24					
057	28.27	31.17					
058	28.62	31.73					
059	28.98	31.71					
060	27.85	31.44					
061	27.80	31.37					
062	27.95	31.59					
063	27.84	31.50					
064	26.89	30.96	1691144	254133	71864	98528	8415501
065	29.43	30.99					
066	30.34	31.41					
067	30.63	31.54					
068	29.66	31.32					
069	29.41	31.23					
070	29.61	31.57					
071	29.50	31.48					
072	28.01	30.98					
073	29.18	30.99					
074	29.53	31.56					
075	29.12	31.72					

Table No. 1 (Continued) Flower Garden sequence at 4 Mb/sec

Frame Num	Lumina Peak SNR	Chroma Peak SNR	Lumina Data BitCount	Chroma Data BitCount	Motion Vector BitCount	Data Overhead BitCount	Total BitCount
076	27.85	31.32					
077	29.42	31.27					
078	29.36	31.54					
079	29.16	31.36					
080	27.93	30.89	1699744	248480	65920	98528	10528173
081	30.66	30.91					
082	30.09	31.31					
083	30.47	31.44					
084	29.10	31.20					
085	29.92	31.11					
086	29.88	31.50					
087	29.68	31.33					
088	28.45	30.87					
089	29.91	30.86					
090	29.70	31.29					
091	29.95	31.38					
092	28.47	31.04					
093	29.63	31.00					
094	29.38	31.25					
095	29.29	31.16					
096	28.21	30.71	1707160	248160	64880	98528	12646901
097	28.21	30.52					
098	28.34	31.14					
099	28.22	31.12					
100	26.92	30.66					
101	27.46	30.49					
102	27.63	31.05					
103	27.54	31.09					
104	26.51	30.63					
105	27.04	30.46					
106	26.77	31.02					
107	26.90	31.06					
108	26.17	30.45					
109	27.15	30.64					
110	27.51	31.04					
111	27.39	31.03					
112	26.35	30.59	1715376	255733	72792	98528	14789330
113	27.16	30.15					
114	27.74	30.92					
115	28.07	31.06					
116	26.97	30.68					
117	28.01	30.77					
118	28.28	31.19					
119	28.29	31.08					
120	27.65	30.56					
121	28.30	30.53					
122	28.79	31.06					
123	28.65	31.28					
124	27.31	30.87					
125	28.61	30.96					
126	28.42	31.13					
127	28.01	31.02					
128	26.43	30.40	1703376	245653	65168	98528	16902055
129	29.73	30.40					
130	29.95	30.97					
131	30.49	31.11					
132	29.36	30.79					
133	29.86	30.73					
134	29.71	31.07					
135	29.88	31.04					
136	28.56	30.44					
137	29.97	30.47					
138	30.03	30.97					
139	30.13	31.05					
140	29.06	30.65					
141	29.98	30.68					
142	29.51	30.96					
143	29.40	30.86					
144	28.75	30.27	1707304	232000	51664	98528	18991551
145	28.57	29.09					
146	30.07	30.00					
147	30.11	30.47					
148	28.61	30.57					
149	29.46	31.42					
150	32.16	32.17					
Ave	28.74	31.31	1691298	250204	70141	98528	126610

Total Bits: 19868776

Table No. 2 Mobile and Calendar sequence at 4 Mb/sec

Frame Num	Lumina Peak SNR	Chroma Peak SNR	Lumina Data BitCount	Chroma Data BitCount	Motion Vector BitCount	Data Overhead BitCount	Total BitCount
001	26.48	30.81					
002	26.74	31.71					
003	26.63	32.09					
004	25.65	31.91					
005	26.48	31.92					
006	26.19	32.38					
007	26.11	32.22					
008	25.47	31.27					
009	26.69	31.95					
010	26.60	32.58					
011	26.20	32.51					
012	26.59	32.00					
013	27.20	32.03					
014	25.94	32.43					
015	25.86	32.48					
016	26.16	32.02	1728560	264533	49896	98528	2141517
017	27.83	32.56					
018	28.87	32.51					
019	28.75	33.06					
020	27.92	33.19					
021	28.77	33.02					
022	27.78	32.96					
023	29.19	32.91					
024	26.88	33.06					
025	29.81	32.95					
026	26.29	33.01					
027	29.71	32.68					
028	27.28	33.14					
029	29.81	33.08					
030	27.65	32.92					
031	28.50	32.87					
032	28.85	32.93	1699496	259840	29472	98528	4228853
033	29.97	32.51					
034	28.33	33.09					
035	26.87	32.04					
036	29.85	32.80					
037	29.19	32.92					
038	26.07	32.76					
039	28.47	32.84					
040	27.69	32.87					
041	29.19	32.75					
042	27.17	32.51					
043	28.20	32.68					
044	28.58	32.92					
045	28.27	32.60					
046	27.94	32.06					
047	26.31	32.77					
048	27.85	32.42	1698232	253067	26456	98528	6305136
049	28.38	32.06					
050	27.23	32.32					
051	28.30	31.96					
052	27.15	32.35					
053	28.49	32.44					
054	27.43	32.42					
055	26.63	32.23					
056	27.59	32.45					
057	27.42	32.18					
058	27.97	32.32					
059	27.50	32.30					
060	26.89	32.46					
061	28.01	32.12					
062	26.97	31.61					
063	26.71	32.06					
064	26.54	31.42	1712976	255147	34104	98528	8405890
065	27.71	31.20					
066	27.01	31.67					
067	27.50	31.65					
068	26.99	32.01					
069	27.10	32.01					
070	27.49	31.87					
071	27.18	32.07					
072	26.27	31.72					
073	26.65	31.11					
074	27.13	32.17					
075	27.10	31.90					

Table No. 2 (Continued) Mobile and Calendar sequence at 4 Mb/sec

Frame Num	Lumina Peak SNR	Chroma Peak SNR	Lumina Data BitCount	Chroma Data BitCount	Motion Vector BitCount	Data Overhead BitCount	Total BitCount
076	26.19	32.00					
077	26.76	31.97					
078	27.18	31.40					
079	27.10	31.91					
080	25.96	31.08	1731568	270827	42600	98528	10549413
081	29.68	32.09					
082	30.19	32.77					
083	29.37	32.88					
084	27.23	32.46					
085	27.48	32.79					
086	29.44	32.28					
087	28.53	32.69					
088	27.42	32.38					
089	28.86	31.70					
090	29.23	32.87					
091	29.12	32.49					
092	27.14	32.33					
093	26.62	32.49					
094	28.18	32.09					
095	28.68	32.72					
096	28.38	31.23	1704032	252053	28816	98528	12632842
097	29.08	31.63					
098	29.80	32.84					
099	30.26	32.18					
100	29.83	32.82					
101	30.24	32.35					
102	30.61	32.85					
103	30.39	32.55					
104	29.25	32.34					
105	29.95	32.08					
106	29.95	32.76					
107	28.89	32.69					
108	26.61	32.27					
109	27.65	32.62					
110	29.28	31.95					
111	29.62	32.59					
112	27.84	30.81	1684816	257280	27752	98528	14701218
113	28.67	31.88					
114	27.17	32.51					
115	27.79	31.67					
116	29.28	32.41					
117	27.37	32.37					
118	29.03	32.12					
119	26.99	32.31					
120	28.49	32.45					
121	29.35	32.26					
122	27.86	32.52					
123	27.24	32.15					
124	28.87	31.42					
125	27.98	32.21					
126	29.41	32.57					
127	29.02	32.45					
128	28.03	32.06	1693544	259147	30112	98528	16782549
129	30.73	31.81					
130	31.02	32.37					
131	30.60	32.66					
132	27.96	32.68					
133	30.52	32.72					
134	29.46	32.92					
135	27.93	32.50					
136	30.23	31.49					
137	28.23	32.64					
138	30.37	33.02					
139	30.62	32.98					
140	29.67	32.66					
141	30.08	32.70					
142	30.65	32.93					
143	27.18	32.73					
144	28.80	31.77	1654000	253440	26400	98528	18814917
145	31.73	31.95					
146	29.46	31.25					
147	32.10	33.17					
148	29.84	33.35					
149	29.58	32.55					
150	35.73	34.03					
Ave	28.24	32.35	1700802	258370	32845	98528	125432

Total Bits: 19722792

Table No. 3

Table Tennis sequence at 4 Mb/sec

Frame Num	Lumina Peak SNR	Chroma Peak SNR	Lumina Data BitCount	Chroma Data BitCount	Motion Vector BitCount	Data Overhead BitCount	Total BitCount
001	29.33	39.51					
002	28.80	39.39					
003	28.98	39.41					
004	28.21	39.35					
005	29.68	39.26					
006	29.08	39.32					
007	29.28	39.42					
008	27.86	39.24					
009	27.04	39.36					
010	29.15	39.38					
011	28.03	39.18					
012	26.88	38.95					
013	26.19	38.94					
014	27.32	39.59					
015	27.99	39.81					
016	27.47	39.33	1789928	256000	35808	98528	2180264
017	27.08	38.55					
018	27.95	38.67					
019	28.14	38.81					
020	27.41	38.96					
021	27.33	39.26					
022	27.56	39.27					
023	26.50	39.04					
024	24.55	38.60					
025	26.48	37.89					
026	25.42	37.93					
027	26.25	37.89					
028	25.49	37.87					
029	26.79	38.19					
030	26.16	38.14					
031	26.37	37.85					
032	25.84	37.62	1839184	281387	83008	98528	4482370
033	32.19	37.98					
034	31.04	38.05					
035	31.24	38.08					
036	30.28	38.15					
037	31.89	38.11					
038	31.07	38.14					
039	31.19	37.99					
040	30.57	37.95					
041	32.87	37.78					
042	32.04	37.45					
043	32.04	37.38					
044	31.33	37.25					
045	32.37	37.02					
046	31.38	36.85					
047	31.48	36.73					
048	30.73	36.80	1814272	417067	128648	98528	6940885
049	35.23	36.10					
050	33.59	35.98					
051	33.54	35.91					
052	32.38	35.84					
053	33.81	35.67					
054	32.62	35.60					
055	32.72	35.44					
056	31.84	35.24					
057	33.96	34.98					
058	32.84	35.20					
059	32.84	35.27					
060	31.88	35.13					
061	32.98	35.11					
062	32.13	35.14					
063	32.08	35.28					
064	31.22	35.25	1668008	358773	134848	98528	9201042
065	31.56	34.13					
066	30.35	34.18					
067	29.41	34.08					
068	26.69	36.29					
069	31.30	37.62					
070	31.18	37.65					
071	31.21	37.52					
072	30.91	37.35					
073	32.76	37.26					
074	32.43	37.55					
075	32.45	38.09					

Table No. 3 (Continued)

Table Tennis sequence at 4 Mb/sec

Frame Num	Lumina Peak SNR	Chroma Peak SNR	Lumina Data BitCount	Chroma Data BitCount	Motion Vector BitCount	Data Overhead BitCount	Total BitCount
076	32.18	38.09					
077	32.46	38.09					
078	32.35	38.16					
079	32.37	38.02					
080	32.08	37.87	1451840	244587	58760	98528	11054757
081	37.72	37.95					
082	37.52	38.24					
083	37.63	38.20					
084	37.27	38.29					
085	37.59	38.34					
086	37.54	38.51					
087	37.42	38.50					
088	37.12	38.26					
089	37.79	38.39					
090	37.72	38.52					
091	37.79	38.54					
092	37.53	38.53					
093	37.66	38.45					
094	37.54	38.59					
095	37.51	38.55					
096	37.33	38.25	1708432	178880	20392	98528	13060989
097	28.31	34.10					
098	28.32	37.66					
099	30.10	38.14					
100	30.04	38.15					
101	31.20	38.32					
102	31.41	38.46					
103	31.42	38.49					
104	30.79	38.45					
105	31.97	38.51					
106	32.48	38.68					
107	32.58	38.68					
108	32.13	38.60					
109	32.28	38.62					
110	32.39	38.71					
111	32.14	38.70					
112	31.34	38.55	1565736	227307	43400	98528	14995959
113	34.69	38.76					
114	35.32	38.87					
115	35.37	38.91					
116	34.84	38.81					
117	35.06	38.59					
118	34.81	38.60					
119	34.69	38.51					
120	33.53	38.28					
121	32.95	38.19					
122	33.44	38.40					
123	33.52	38.43					
124	32.50	38.31					
125	33.04	38.25					
126	32.60	37.91					
127	32.60	38.32					
128	31.01	37.88	1725952	194773	26408	98528	17041621
129	31.61	37.60					
130	32.67	38.17					
131	33.18	38.38					
132	32.24	38.16					
133	33.06	38.07					
134	32.90	38.38					
135	32.44	38.43					
136	30.97	38.01					
137	32.11	37.97					
138	32.92	38.24					
139	33.31	38.15					
140	32.43	38.21					
141	32.60	37.85					
142	30.60	38.31					
143	32.09	38.39					
144	30.96	38.02	1763392	183467	35120	98528	19122127
145	32.75	37.63					
146	33.69	38.02					
147	33.50	37.94					
148	32.38	37.45					
149	32.12	37.69					
150	35.14	38.56					
Ave	31.76	37.88	1702971	260248	62932	98528	127480

Total Bits: 19991272

018	31.12	39.80					
019	31.34	39.77					
020	30.79	39.98					
021	31.04	40.27					
022	31.19	40.32					
023	30.37	40.05					
024	28.98	39.45					
025	30.51	38.86					
026	29.23	38.80					
027	29.88	38.72					
028	28.79	38.75					
029	30.43	39.12					
030	29.43	39.06					
031	29.81	38.73					
032	28.92	38.52	4408352	585600	83008	98528	10024520
033	35.95	38.80					
034	34.54	38.89					
035	34.94	38.94					
036	33.74	39.00					
037	35.42	38.88					
038	34.41	38.95					
039	34.65	38.70					
040	33.89	38.71					
041	36.20	38.47					
042	35.12	38.13					
043	35.26	38.00					
044	34.37	37.90					
045	35.57	37.78					
046	34.52	37.52					
047	34.59	37.27					
048	33.77	37.44	4336784	812267	128648	98528	15400746
049	38.18	36.90					
050	36.42	36.81					
051	36.55	36.69					
052	35.36	36.71					
053	36.92	36.48					
054	35.65	36.43					
055	35.81	36.23					
056	34.93	36.06					
057	37.19	35.78					
058	35.86	36.01					
059	35.93	36.08					
060	34.95	35.97					
061	36.17	35.89					
062	35.11	35.92					
063	35.15	36.07					
064	34.26	36.21	3971328	696000	134848	98528	20301450
065	35.96	35.53					
066	34.56	35.59					
067	33.72	35.53					
068	31.60	37.49					
069	35.42	38.45					
070	35.10	38.43					
071	35.14	38.30					
072	34.84	38.12					
073	36.35	38.03					
074	36.03	38.26					
075	36.06	38.85					

092	40.39	39.18					
093	40.41	39.14					
094	40.37	39.25					
095	40.35	39.25					
096	40.25	39.10	4226184	363520	20392	98528	28839485
097	33.84	36.19					
098	32.93	38.75					
099	34.36	39.06					
100	34.24	39.10					
101	35.53	39.27					
102	35.57	39.37					
103	35.55	39.41					
104	35.08	39.44					
105	36.17	39.48					
106	36.45	39.56					
107	36.50	39.54					
108	36.23	39.52					
109	36.37	39.51					
110	36.33	39.56					
111	36.18	39.54					
112	35.64	39.48	3622256	467040	43400	98528	33070709
113	38.06	39.57					
114	38.31	39.66					
115	38.39	39.67					
116	38.21	39.56					
117	38.33	39.40					
118	38.14	39.35					
119	38.07	39.26					
120	37.35	39.19					
121	37.12	39.15					
122	37.30	39.20					
123	37.42	39.20					
124	36.59	39.18					
125	37.17	39.13					
126	36.79	38.83					
127	36.81	39.28					
128	35.72	38.96	3883816	392373	26409	98528	37471834
129	35.95	38.73					
130	36.84	39.23					
131	37.18	39.13					
132	36.60	39.05					
133	36.96	38.99					
134	36.83	39.19					
135	36.84	39.11					
136	35.78	38.89					
137	36.53	38.81					
138	36.91	38.94					
139	37.10	38.90					
140	36.58	38.95					
141	36.82	38.69					
142	35.49	39.10					
143	36.51	39.11					
144	35.92	38.93	4080584	380160	35120	98528	42066226
145	37.06	38.78					
146	37.57	38.99					
147	37.66	38.83					
148	36.71	38.47					
149	36.69	38.45					
150	40.00	39.07					
Ave	35.43	38.73	3994757	517807	62932	98528	280441

Total Bits: 44795600

068	33.91	32.30
069	33.86	32.20
070	33.80	32.47
071	33.78	32.45
072	32.69	32.11
073	33.64	32.11
074	33.73	32.52
075	33.24	32.62

140	[illegible]	[illegible]					
141	34.04	31.65					
142	33.52	31.90					
143	33.51	31.82					
144	33.15	31.43	3992096	503200	51664	98528	42106434
145	34.43	30.74					
146	35.33	31.49					
147	35.11	31.75					
148	33.85	31.59					
149	33.72	31.97					
150	37.63	32.79					
Ave	33.14	32.33	3978842	530980	70141	98528	280709

Total Bits: 44969560

Table No. 7

Popple sequence at 9 Mb/sec

Frame Num	Lumina Peak SNR	Chroma Peak SNR	Lumina Data BitCount	Chroma Data BitCount	Motion Vector BitCount	Data Overhead BitCount	Total BitCount
001	37.21	34.44					
002	36.85	34.71					
003	36.97	34.45					
004	36.44	34.70					
005	37.09	34.61					
006	36.58	34.51					
007	36.72	34.79					
008	36.17	34.48					
009	37.05	34.60					
010	36.76	34.81					
011	36.74	34.68					
012	36.31	34.66					
013	36.83	34.72					
014	36.50	34.58					
015	36.55	34.79					
016	36.09	34.39	3617200	400907	36976	98528	4153610
017	37.21	34.45					
018	36.98	34.84					
019	37.02	34.65					
020	36.65	34.62					
021	37.07	34.73					
022	36.74	34.57					
023	36.78	34.80					
024	36.34	34.55					
025	37.15	34.37					
026	36.87	34.72					
027	36.86	34.62					
028	36.41	34.61					
029	36.94	34.65					
030	36.60	34.66					
031	36.48	34.86					
032	36.24	34.36	3672208	395360	37304	98528	8357010
033	37.22	34.46					
034	37.01	34.82					
035	37.07	34.57					
036	36.71	34.70					
037	37.12	34.65					
038	36.84	34.64					
039	36.84	34.77					
040	36.43	34.52					
041	37.10	34.55					
042	36.96	34.85					
043	36.98	34.87					
044	36.60	34.81					
045	36.94	34.75					
046	36.72	34.90					
047	36.72	34.74					
048	36.43	34.62	3623824	398453	33960	98528	12511776
049	36.88	34.51					
050	36.70	34.71					
051	36.73	34.73					
052	36.38	34.67					
053	36.70	34.61					
054	36.38	34.72					
055	36.38	34.54					
056	35.97	34.55					
057	36.67	34.67					
058	36.36	34.65					
059	36.40	34.71					
060	35.88	34.39					
061	36.47	33.93					
062	36.07	34.67					
063	36.01	34.64					
064	35.39	34.31	3553520	418987	42192	98528	16625002
065	36.90	34.25					
066	36.33	34.31					
067	36.37	34.31					
068	35.66	34.29					
069	36.50	34.03					
070	35.91	34.34					
071	35.91	34.27					
072	35.14	33.66					
073	36.87	33.65					
074	35.91	33.38					
075	36.03	33.26					

Table No. 7 (Continued)

Popple sequence at 9 Mb/sec

Frame Num	Lumina Peak SNR	Chroma Peak SNR	Lumina Data BitCount	Chroma Data BitCount	Motion Vector BitCount	Data Overhead BitCount	Total BitCount
076	35.06	32.91					
077	36.23	32.71					
078	35.24	32.77					
079	35.38	32.45					
080	34.52	32.06	3535024	609600	87360	98528	20955514
081	38.17	32.14					
082	36.43	31.94					
083	36.61	32.06					
084	35.58	32.15					
085	37.12	31.70					
086	35.85	31.91					
087	35.98	31.66					
088	34.98	31.18					
089	37.67	31.29					
090	35.73	30.78					
091	35.81	30.54					
092	34.57	30.96					
093	36.08	30.36					
094	34.69	30.46					
095	34.70	30.50					
096	33.44	30.34	3769624	771733	118712	98528	25714111
097	36.65	30.56					
098	34.13	29.91					
099	34.12	29.97					
100	32.83	30.10					
101	34.56	29.86					
102	32.77	29.95					
103	32.74	30.36					
104	31.64	29.80					
105	34.98	29.51					
106	33.27	30.33					
107	32.94	29.46					
108	31.76	29.27					
109	33.45	30.22					
110	32.10	29.22					
111	32.15	29.15					
112	31.31	29.92	4050848	880533	154952	98528	30898973
113	35.57	28.95					
114	33.42	28.87					
115	33.39	29.57					
116	32.17	28.87					
117	33.88	28.76					
118	32.60	29.73					
119	32.55	29.02					
120	31.50	29.01					
121	34.29	29.81					
122	32.60	29.36					
123	32.58	29.29					
124	31.44	29.98					
125	32.95	29.60					
126	31.48	29.23					
127	31.67	29.87					
128	30.75	29.55	4178000	873067	146144	98528	36194711
129	34.96	29.06					
130	32.78	29.75					
131	32.69	29.52					
132	31.31	28.99					
133	32.98	29.63					
134	31.61	29.60					
135	31.50	29.27					
136	30.34	29.61					
137	33.90	29.73					
138	31.87	29.38					
139	31.84	29.59					
140	30.65	29.75					
141	32.38	29.39					
142	30.97	29.27					
143	31.09	29.72					
144	30.08	29.42	4251128	853867	146800	98528	41545034
145	36.05	29.12					
146	33.76	29.66					
147	33.86	29.48					
148	32.13	29.30					
149	33.99	29.66					
150	33.45	29.29					
Ave	35.08	32.32	3805708	622500	89377	98528	276966

Total Bits: 45120472