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

Document #459
March 7, 1989

SOURCE: Japan

TITLE: Loop Filter Proposal for px64Kb/s FH

1. Introduction

This document describes a proposal on loop filter specification for px64 Flexible Hardware. The proposal has been produced considering the experimental results in the past and results of newly performed simulations. The main points of the proposal are:

1) 2-D filter, which is separable into two 1-D filters (coefficients = 1/4, 1/2, 1/4) controlled in principle by motion vector on a MB by MB basis.

2) Loop filter on or off is indicated by TYPE3 in the MB layer. When a TYPE3 code indicates the existence of DMV (Differential Motion Vector) field, the blocks in the MB are filtered. By this specification, encoders without MC function can control the loop filter on or off by sending zero DMV.

3) "DMV=0" is transmitted as data, not by TYPE3.

2. Proposal

Proposed text in the px64 FH specification (Annex 3 to Doc. #445R) is as follows:

1.2.3 Loop Filter (Annex 3 to Doc. #445R, p. 24)

The prediction process may be modified by a two-dimensional spatial filter which operates on pels within a predicted block (8x8 block).

The filter is separable into one dimensional horizontal and vertical functions. Both are non-recursive with coefficients of 1/4, 1/2, 1/4. At block edges, where one of the taps would fall outside the block, the peripheral pel is used for two taps. Full arithmetic precision is retained with rounding to 8 bit integer values at the 2-D filter output. Values whose fractional part is one half are rounded up.

The filter is switched on or off depending on TYPE3 information on a macro-block by

macro-block basis. The filter is switched on when the DMV field in the macro block layer exists. When it does not exist, the filter is switched off. The existence of DMV field is indicated by TYPE3.

NOTE: An encoder without motion estimation can control the loop filter by sending DMV value of zero.

---

3. Considerations

3.1 Simulations

Coding simulations have been carried out changing filter coefficients, control mechanism, picture format and value of q. Annex 1 shows results concerning coefficients of filter and control method (control by MCV or side information). Annex 2 describes a result of a try on utilizing coded/not-coded block information in the previous frame. Loop filter characteristics in QICF is investigated in Annex 3. According to the results in the annexes, no significant difference has been found in performances with tested coefficients sets and the loop filter control method by MCV is superior or equal to other methods. In addition, loop filter importance has been proven in QCIF as well as in CIF.

3.2 Filter coefficients

In Document #406, it was reported through the experiments using nx384 FH that the RM7 type loop filter (1/4, 1/2, 1/4) gives no worse picture quality than filters with other coefficients in high bit-rate operations. In newly performed simulations using RM7, processed picture with coefficients set (1/6, 4/6, 1/6) has been found very similar to the one with coefficients set (1/4, 1/2, 1/4). These hardware experiment and simulation results (see Annex 1, 2 and 3) suggest that the coefficients set (1/4, 1/2, 1/4) can be generally used in low-bit rate, high-bit rate and low-bit rate with QCIF operations. In addition, the coefficients set (1/4, 1/2, 1/4) does not need dividing operation, hence hardware may be simplified.

3.3 Filter control

In nx384 algorithm investigations, no significant difference was found between MCV control and side information control (see Doc. #286). In order to confirm this fact in 60Kbit/s and 1.5Mbits/s operations, a set of coding simulations was carried out using RM7 (see Annex 1). In a comparison of the two methods in picture quality, any significant difference was observed. Here, the side information control method was based on RM4 but the filter was controlled on a macro-block by macro-block basis.

In Annex 2, several methods to use coded/not-coded information in the previous frame

are evaluated. The conclusion is, however, no method is superior to the MCV control method.

Comparing the tested methods in the annexes from hardware point of view, obviously side information control method need more hardware or processing steps because it requires filtering of all blocks in principle and evaluation function for determining whether to switch on or off. On the other hand, two other methods do not need any additional evaluation function since filtered blocks are determined directry by MCV value and/or coded/not-coded information in the previous frame.

The MCV control method has a slight problem because Motion Compensation is an optional function at the encoder. Some ideas have been considered for controlling loop filter in encoders without MC function. One is that when an encoder indicates 'having no MC function' to a decoder by using Bit 2/TYPE2 or other means, the decoder interprets "Motion Vector = 0" attribute in TYPE3 as loop filter on or off switching information (Method 1). The other is that use of loop filter is only indicated by existence of DMV field (Method 2). Encoders without MC can control loop filter in decoders by sending zero DMV value. This method works owing to the current differential motion vector coding. Decoders need not distinguish whether coders have MC or not. For encoders without MC, there is a slight loss of coding efficiency compared to Method 1. If zero DMV is coded at 1 bit as in RM7 and if 10-20% of total macroblocks are to be filtered, 20-40 bits may be wasted for QCIF coded picture. Furthermore, this method provides a way to filter the blocks with zero motion vector if it is desirable. Considering specification and hardware simplicity, Method 2 is preferred and proposed.

3.4 Possibility of noise reduction filter

Possibility of introducing noise reduction filter in front of the frame memory is considered to be very small because the IDCT mismatch inhibits use of decoded pel values and currently the inside the block boundary processing is mandatory. We have no ongoing activities on this technique.

3.5 Coding of DMV=0

See Doc. # 462

Attribute of differential motion vector being zero was transmitted as part of TYPE3 in the nx384 Flexible Hardware. An alternative method is to transmit DMV=0 as motion vector data (RM7). Since coding efficiency does not differ so much, the latter method is preferred because TYPE3 is simplified.

4. Conclusion

A proposal on loop filter specification for px64 FH has been described. Our position is to define loop filter as in RM5-7.

END

TITLE: Simulation Results of LoopFfiler Coefficients and Control Method

SOURCE: Japan

1. Introduction

This document describes coding simulation results carried out for determining the loop filter specification for px64Kb/s FH. Two items are mainly investigated: One is characteristics of filter coefficients and the other is filter on or off control method. According to the simulation results, no significant differences were found among tested schemes in comparisons of SNR and processed image observations.

2. Simulation

Coefficients:

Scince the 2-D filter must be separable, candidates of 1-D filter coefficnets are considered to be as follows:

A) 1/4, 2/4, 1/4 B) 1/5, 3/5, 1/5 C) 1/6, 4/6, 1/6

Control Method:

In this document, following two mehods are compared:

X) MCV control, same as in RM7.

Y) Side information control, MB basis, 1bit/MB of side information is sent.

Other methods using coded/not-coded infomation of the previous frame are investigated in Annex 2.

Combinations of the coefficients and the control methods have been tested changing input sequence and value of q.

Simulation results are shown in Tables 1-3. In the tables, upper values represent average SNY for the whole sequence and lower values represent the average number of filtered MBs per frame. No significant difference has been found among the tested combinations of a coefficient and a control method in the tables. In addition, it was very hard to find any difference in the observation of processed images.

3. Conclusion

The simulation results show that coding performances of the tested schemes are very similar. Accordingly, the specification of the loop filter should be defined considering other aspects as far as one of the schemes discussed in this document is adopted.

END.

		Coefficients		
		A	B	C
Cont.	X	38.2553	38.3253	38.3353
	Y	38.2554		38.2864

(a) Claire

		Coefficients		
		A	B	C
Cont.	X	37.9597	37.9597	37.9798
	Y	37.94119		37.93130

(b) Miss America

		Coefficients		
		A	B	C
Cont.	X	31.5744	31.6244	31.5944
	Y	31.5855		31.5568

(c) Salesman

		Coefficients		
		A	B	C
Cont.	X	34.597	34.487	34.107
	Y	34.6520		34.5821

(d) Swing

		Coefficients		
		A	B	C
Cont.	X	33.0427	33.0327	33.1727
	Y	33.2343		33.1452

(e) Blue Jacket

Upper: SNY

Lower: number of filtered MB

A: 1/4, 2/4, 1/4

B: 1/5, 3/5, 1/5

C: 1/6, 4/6, 1/6

X: MCV control

Y: side infomation control

Table 1. Simulation Result (1), q=1, frame rate=10Hz

		Coefficients		
		A	B	C
Cont.	X	40.3172		40.3173
	Y	40.40164		40.40171

(a) Miss America

		Coefficients		
		A	B	C
Cont.	X	37.7832		37.8232
	Y	37.7631		37.7442

(b) Salesman

		Coefficients		
		A	B	C
Cont.	X	38.5818		38.6318
	Y	38.6534		38.7146

(c) Blue Jacket

Table 2. Simulation Result (2), q=5, frame rate=15Hz

		Coefficients		
		A	B	C
Cont.	X	38.3046		38.3346
	Y	38.5439		38.5565

Salesman

Table 3. Simulation Result (3), q=23, frame rate=30Hz

117

Annex 2 to Doc.#459
March 7, 1989

CCITT SGXV
Working Party XV/1
Specialist Group on Coding for Visual Telephony

Source : JAPAN
Title : Simulation Results of Loop Filter Control Method

1 Introduction

It is described in the document #445R,pp4-5 that the loop filter may be controlled by coded/not-coded information in the previous frame. In this document the simulation results about several modifications on filter control method are presented.

2 Simulation

Following five modifications were tested on each sequence and compared with RM7. The simulation results are shown in Table 1 to 5. The loop filter is controlled on macro basis by MC information, and controlled on block basis by coded/not-coded information in the previous frame.

mod 1: If 'type 3' of the current MB is MC *or* 'block type' of the same address in the previous frame is coded, the loop filter is on.

mod 2: If 'type 3' of the current MB is MC *or* 'block type' of the same address in the previous frame is coded but not INTRA, the loop filter is on.

mod 3: The modofication is the same as **mod 2**. But the filter coeficients are modified as

$$\begin{vmatrix} 1 & 4 & 1 \\ 4 & 16 & 4 \\ 1 & 4 & 1 \end{vmatrix}$$

mod 4: If 'type 3' of the current MB is MC *and* the predicting block for the current block includes the region of coded block in the previous frame, the loop filter is on.

mod 5: If the predicting block for the current block includes the region of coded block in the previous frame, the loop filter is on.

3 Concludion

For the simulation results, any modification is not superior to the MC based control method.

Table:1 Statistics for loop filter test "CLAIRE"

Statistics : RM7
Sequence : CLAIRE
Modification : LOOP FILTER TEST

Institute : G.C.T.
Date : March 7, 1989
Bit-rate : 59.4 kbps
Frame-rate : 10 Hz

ITEM		RM7	mod1	mod2	mod3	mod4	mod5
SNR for luminance	Y	38.31	35.64	36.87	37.32	38.19	36.90
SNR for chrominance	U	39.00	37.10	37.95	38.37	38.83	37.90
	V	42.14	39.77	41.22	41.53	41.89	40.99
RMS for luminance	Y	3.10	4.21	3.66	3.47	3.14	3.65
RMS for chrominance	U	2.86	3.56	3.23	3.07	2.91	3.25
	V	1.99	2.62	2.22	2.14	2.05	2.27
Mean value of step size		19.03	32.08	25.53	22.76	18.93	24.65
Mean value of number of	Y	3.21	2.61	2.85	2.76	3.22	2.89
non-zero coefficients	C	1.67	1.17	1.29	1.35	1.66	1.30
	Y and C	2.99	2.53	2.71	2.62	3.00	2.74
Mean value of number of	Y	5.97	12.80	8.94	8.61	5.96	8.60
zeroes before the last NZ	C	2.75	2.17	1.86	1.90	2.76	1.75
	Y and C	5.52	12.25	8.31	7.97	5.51	8.00
Block type of MACRO	Intra	0	0	0	0	0	0
	Fixed	278	278	275	270	278	274
	Fixed MC	7	11	10	9	8	10
	Coded	65	76	69	73	65	70
	Coded MC	46	31	42	43	46	42
Block type of Y	Fixed	1270	1274	1259	1251	1268	1260
	Fixed MC	88	106	113	108	90	112
	Coded	104	141	116	122	103	116
	Coded MC	122	63	96	102	122	96
Block type of C	Fixed	755	781	771	767	756	771
	Coded	36	12	21	24	37	21
Number of bits	Macro attr.	810	856	849	883	807	852
	EOB	743	568	659	701	742	663
	MV	332	281	344	342	329	337
	Coeff. DC	2	0	1	2	2	3
	Coeff. Y	3767	4165	3964	3862	3778	3963
	Coeff. U	187	36	81	97	184	78
	Coeff. V	86	22	36	43	85	36
	TOTAL	5929	5929	5936	5933	5930	5935
Number of filtered blocks	NoMC	0	–	123	–	0	122
	MC	316	–	312	–	186	156

Table:2 Statistics for loop filter test "SWING"

Statistics : RM7
Sequence : SWING
Modification : LOOP FILTER TEST

Institute : G.C.T.
Date : March 7, 1989
Bit-rate : 59.4 kbps
Frame-rate : 10 Hz

ITEM		RM7	mod1	mod2	mod3	mod4	mod5
SNR for luminance	Y	34.72	25.78	29.40	29.67	34.70	29.46
SNR for chrominance	U	36.68	30.13	31.21	31.58	36.65	31.24
	V	37.49	31.66	32.45	32.73	37.37	32.44
RMS for luminance	Y	4.69	13.69	8.64	8.37	4.69	8.58
RMS for chrominance	U	3.74	7.95	7.02	6.72	3.75	6.99
	V	3.40	6.66	6.08	5.89	3.08	6.09
Mean value of step size		23.10	57.75	40.68	36.14	22.78	40.30
Mean value of number of	Y	3.28	3.69	5.28	4.93	3.13	5.47
non-zero coefficients	C	2.88	0.81	2.71	1.73	2.78	2.99
	Y and C	3.21	3.66	5.18	4.84	3.08	5.37
Mean value of number of	Y	21.93	23.64	23.14	23.45	21.86	23.05
zeroes before the last NZ	C	14.60	2.74	9.67	9.21	12.85	12.05
	Y and C	21.03	23.39	22.57	22.92	20.89	22.51
Block type of MACRO	Intra	1	1	1	1	1	1
	Fixed	308	303	299	298	303	299
	Fixed MC	2	3	3	3	2	3
	Coded	80	82	84	85	85	88
	Coded MC	5	6	9	8	4	5
Block type of Y	Fixed	1402	1394	1423	1418	1398	1433
	Fixed MC	14	27	32	31	14	24
	Coded	157	152	114	121	162	116
	Coded MC	12	11	15	14	11	10
Block type of C	Fixed	756	788	784	783	755	784
	Coded	36	5	8	14	37	8
Number of bits	Macro attr.	624	700	722	732	660	738
	EOB	606	517	487	494	629	481
	MV	56	88	108	101	57	77
	Coeff. DC	24	20	23	24	24	25
	Coeff. Y	3837	4590	4489	4457	3777	4506
	Coeff. U	494	36	97	110	488	100
	Coeff. V	298	11	30	33	302	30
	TOTAL	5942	5965	5959	5953	5936	5959
Number of filtered blocks	NoMC	0	–	122	–	0	116
	MC	38	–	71	–	21	23

120

Table:3 Statistics for loop filter test "MISS AMERICA"

Statistics : RM7
Sequence : MISS AMERICA
Modification : LOOP FILTER TEST

Institute : G.C.T.
Date : March 7, 1989
Bit-rate : 59.4 kbps
Frame-rate : 10 Hz

ITEM		RM7	mod1	mod2	mod3	mod4	mod5
SNR for luminance	Y	37.94	36.84	37.00	37.36	37.78	36.99
SNR for chrominance	U	37.89	37.24	37.35	37.43	37.73	37.29
	V	38.75	37.93	38.04	38.24	38.61	37.96
RMS for luminance	Y	3.23	3.67	3.60	3.45	3.29	3.60
RMS for chrominance	U	3.25	3.50	3.46	3.43	3.31	3.48
	V	2.94	3.23	3.19	3.12	2.99	3.22
Mean value of step size		19.13	25.93	24.82	22.19	19.03	24.31
Mean value of number of	Y	2.43	1.98	2.02	2.09	2.42	2.04
non-zero coefficients	C	1.39	2.83	2.66	2.28	1.38	2.58
	Y and C	2.07	3.23	2.28	2.17	2.05	2.27
Mean value of number of	Y	4.01	3.89	3.93	3.50	3.89	3.65
zeroes before the last NZ	C	2.48	9.14	8.49	7.37	2.44	8.14
	Y and C	3.48	6.03	5.74	5.09	3.37	5.46
Block type of MACRO	Intra	0	0	0	0	0	0
	Fixed	217	230	228	222	213	226
	Fixed MC	23	33	32	28	24	31
	Coded	84	70	72	78	85	73
	Coded MC	72	63	63	68	74	66
Block type of Y	Fixed	1126	1144	1140	1136	1117	1134
	Fixed MC	254	289	284	278	264	291
	Coded	75	58	63	63	75	60
	Coded MC	129	93	98	106	127	98
Block type of C	Fixed	686	687	689	677	682	689
	Coded	106	105	102	115	109	103
Number of bits	Macro attr.	1211	1082	1097	1158	1232	1113
	EOB	978	789	814	876	988	822
	MV	595	618	615	610	609	628
	Coeff. DC	0	1	1	0	1	0
	Coeff. Y	2451	1462	1591	1713	2402	1577
	Coeff. U	318	853	771	666	332	695
	Coeff. V	348	1102	1017	880	338	1069
	TOTAL	5904	5910	5908	5907	5904	5908
Number of filtered blocks	NoMC	0	–	132	–	0	121
	MC	574	–	576	–	312	265

121

Table:4 Statistics for loop filter test "SALESMAN"

Statistics : RM7
Sequence : SALESMAN
Modification : LOOP FILTER TEST

Institute : G.C.T.
Date : March 7, 1989
Bit-rate : 59.4 kbps
Frame-rate : 10 Hz

ITEM		RM7	mod1	mod2	mod3	mod4	mod5
SNR for luminance	Y	31.56	29.02	29.37	30.23	31.53	29.73
SNR for chrominance	U	38.74	36.40	36.76	37.41	38.31	36.76
	V	39.60	37.17	37.50	38.02	39.15	37.50
RMS for luminance	Y	6.74	9.03	8.31	7.86	6.76	8.31
RMS for chrominance	U	2.95	3.86	3.79	3.44	3.10	3.70
	V	2.67	3.53	3.40	3.20	2.81	3.40
Mean value of step size		26.02	41.24	35.54	31.20	25.91	35.54
Mean value of number of	Y	2.91	2.12	2.35	2.43	2.96	2.35
non-zero coefficients	C	1.39	4.09	4.01	3.62	1.26	4.01
	Y and C	2.83	2.50	2.54	3.20	2.87	2.54
Mean value of number of	Y	9.29	10.54	9.95	9.18	9.29	9.95
zeroes before the last NZ	C	2.46	16.81	15.76	16.43	1.50	15.76
	Y and C	8.92	11.73	10.61	10.07	8.85	10.61
Block type of MACRO	Intra	2	2	2	2	2	2
	Fixed	271	253	257	258	271	257
	Fixed MC	7	12	11	8	7	11
	Coded	82	104	99	96	81	99
	Coded MC	35	26	28	31	35	28
Block type of Y	Fixed	1275	1287	1273	1276	1275	1273
	Fixed MC	78	100	96	88	79	96
	Coded	142	145	155	150	142	155
	Coded MC	90	51	60	71	88	60
Block type of C	Fixed	779	746	765	762	777	765
	Coded	13	46	27	30	13	27
Number of bits	Macro attr.	825	973	936	927	823	936
	EOB	730	718	743	753	729	743
	MV	267	263	263	261	266	263
	Coeff. DC	41	38	41	41	43	41
	Coeff. Y	3973	2713	3156	3186	3994	3156
	Coeff. U	54	602	346	347	46	346
	Coeff. V	39	631	451	418	29	451
	TOTAL	5933	5940	5936	5935	5933	5939
Number of filtered blocks	NoMC	0	–	171	–	0	173
	MC	251	–	245	–	126	97

Table:5 Statistics for loop filter test "BLUE JACKET"

		Institute	: G.C.T.
Statistics	RM7	Date	: March 7, 1989
Sequence	: BLUE JACKET	Bit-rate	: 59.4 kbps
Modification	: LOOP FILTER TEST	Frame-rate	: 10 Hz

ITEM		RM7	mod1	mod2	mod3	mod4	mod5
SNR for luminance	Y	33.23	32.38	32.57	32.74	33.14	32.51
SNR for chrominance	U	38.76	38.29	38.41	38.49	38.53	38.11
	V	37.55	37.05	37.15	37.26	37.35	36.99
RMS for luminance	Y	5.56	6.13	6.00	5.88	5.62	6.04
RMS for chrominance	U	2.94	3.10	3.06	3.03	3.02	3.17
	V	3.38	3.58	3.54	3.50	3.46	3.61
Mean value of step size		30.14	30.47	30.89	30.08	30.82	30.96
Mean value of number of	Y	5.49	4.84	5.17	5.42	5.67	5.22
non-zero coefficients	C	1.94	1.59	1.69	1.80	2.05	1.70
	Y and C	4.64	4.41	4.60	4.58	4.83	4.63
Mean value of number of	Y	10.49	11.85	11.49	10.98	10.66	11.59
zeroes before the last NZ	C	4.57	3.06	3.39	4.27	4.96	3.36
	Y and C	9.36	10.78	10.40	9.68	9.60	10.43
Block type of MACRO	Intra	0	0	0	0	0	0
	Fixed	311	306	309	310	315	310
	Fixed MC	6	5	5	6	7	5
	Coded	59	65	62	61	55	61
	Coded MC	19	19	19	19	19	19
Block type of Y	Fixed	1384	1371	1377	1382	1387	1377
	Fixed MC	52	47	48	52	54	50
	Coded	99	118	111	102	94	110
	Coded MC	49	48	48	48	48	48
Block type of C	Fixed	755	770	767	757	757	767
	Coded	37	23	25	35	35	26
Number of bits	Macro attr.	589	611	589	593	556	587
	EOB	518	540	524	521	493	521
	MV	156	150	149	153	157	152
	Coeff. DC	12	12	11	12	13	11
	Coeff. Y	4215	4435	4425	4268	4254	4418
	Coeff. U	199	80	104	175	207	107
	Coeff. V	247	106	132	213	261	137
	TOTAL	5940	5936	5936	5940	5944	5936
Number of filtered blocks	NoMC	0	–	127	–	0	126
	MC	152	–	152	–	79	80

123

Annex 3 to Document #459

Title: Simulation Results of Loop Filter Coefficients and Loop Filter Effectiveness in QCIF

Annex 3 to Doc.#459
March 7, 1989

Source: Japan

1. Introduction

This document describes simulation results carried out to study loop filter characteristics in QCIF. Two items are investigated. One is characteristics of filter coefficients and the other is coding performamce of QCIF encoder with / without MC(Motion Compensation) and LF(Loop Filter).

2. Simulation

Coefficients:

The loop filter should be separable 2-D filter. The following two candidates of filter coefficients are compared.

(a) 1/4, 2/4, 1/4 (RM7)

(b) 1/6, 4/6, 1/6

The simulation results are shown at Fig.1-3 and Table1,2. The SNR of coefficients (b) is slightly better than that of coefficients (a).

Loop Filter Effectiveness:

QCIF encoder without MC will be advent for saving cost. The control method(Method2 at 3.3 Filter Control in Doc.#459) is used in QCIF encoder without MC. The following three QCIF encoders are compared.

(a) Encoder with MC, with MCV control of LF
(RM7)

(b) Encoder without MC, with Method2 control of LF
(LF on/off decision rule is the same rule for MC on/off)

(c) Encoder without MC, with no control of LF
(LF is off)

The simulation results are shown at Fig.4-6 and Table3,4. The SNR of Encoder (b) is between (a) and (c). And the decoded images of Encoder(b) look like those of Encoder(a). According to the results, the loop filter is very effective in QCIF as well as in FCIF.

3. Conclusion

Coefficients:

The simulation results show that coding performances of the two loop filter coefficients are very similar. Accordingly the loop filter coefficients should be determined by the other aspects.

Loop Filter Effectiveness:

The simulation results show that coding performances of Encoder with Method2 are superior than Encoder without the loop filter. Accordingly it has been cleared that the loop filter is necessary for QCIF encoder with / without MC.

Fig.1 : 121 vs 141 (RM7_9step loop filter)

(Claire,QCIF,SNR_Y in QCIF,p=1,10Hz,165frames)

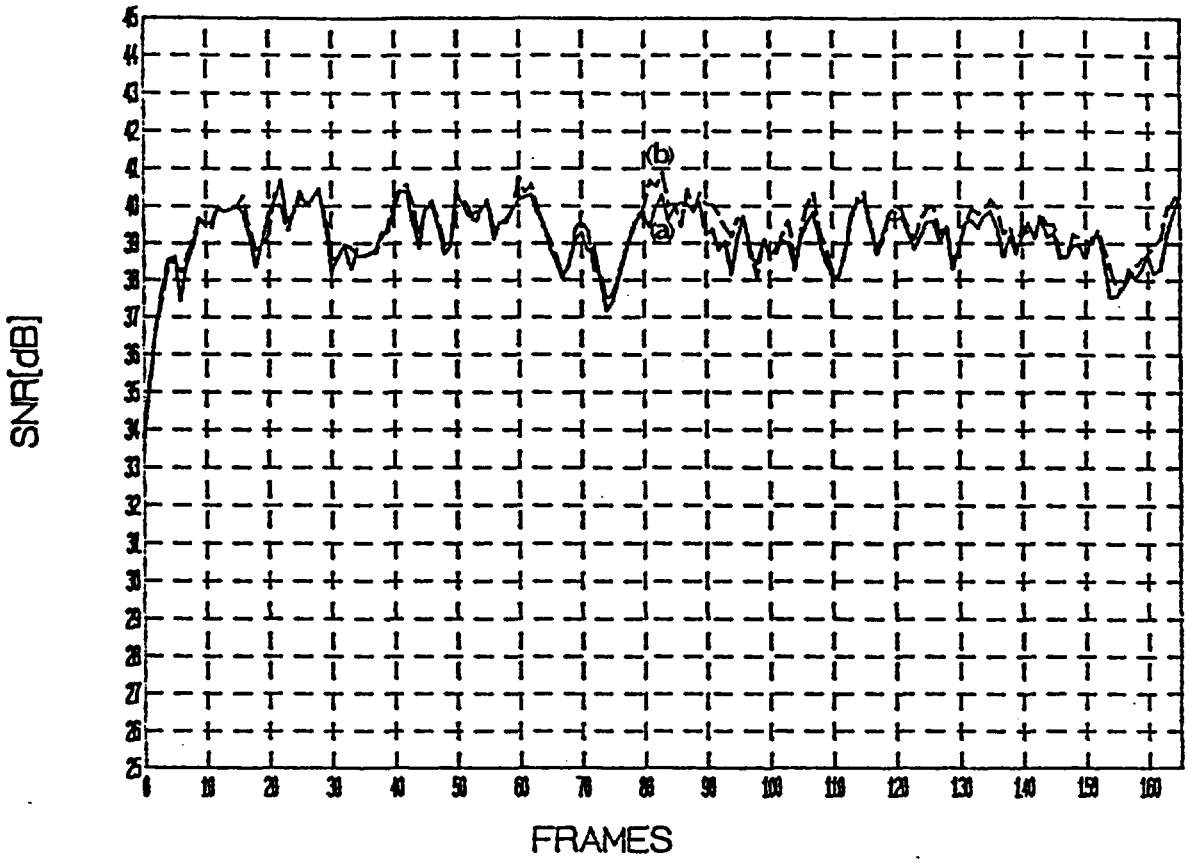

Fig.2 : 121 vs 141 (RM7_9step loop filter)

(salesman,QCIF,SNR-Y in QCIF,p=1,10Hz,150frames)

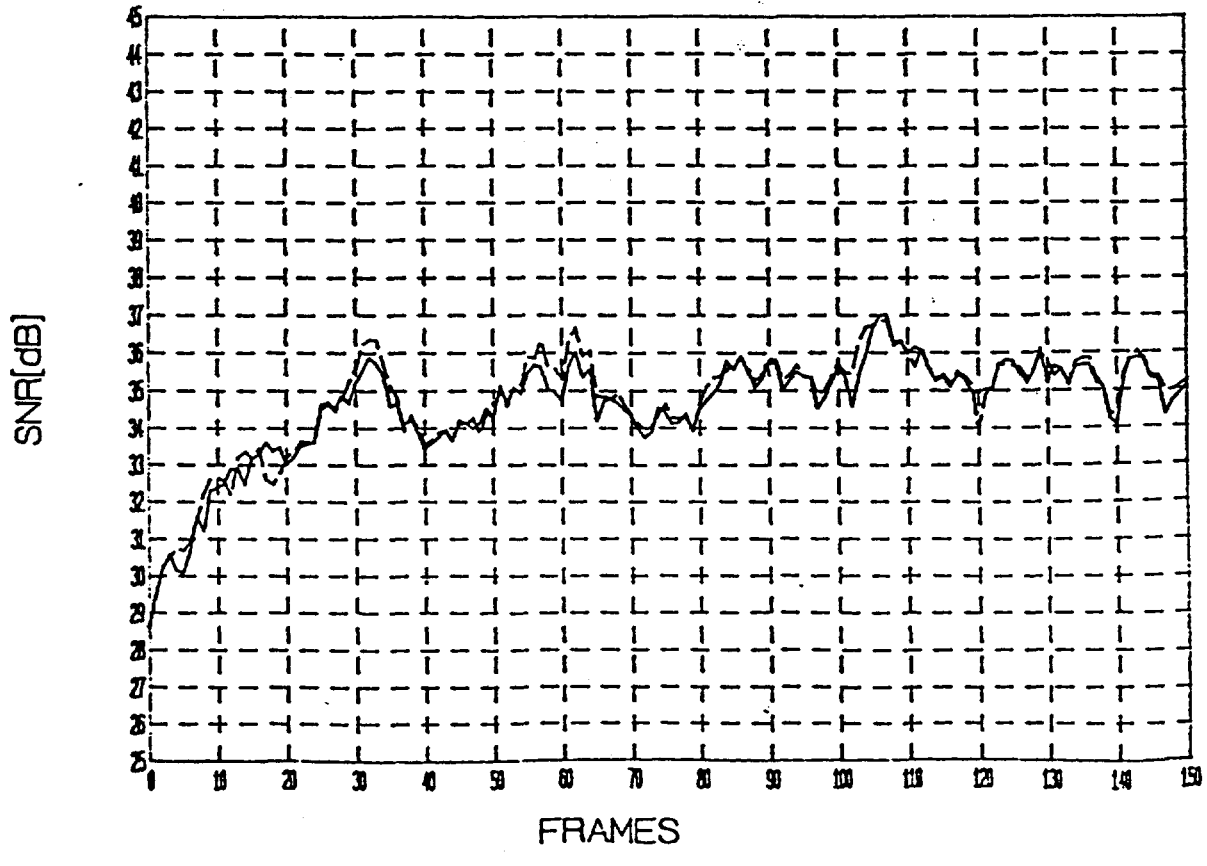

Fig.3 : 121 vs 141 (RM7_9step loop filter)

(Miss.america,QCIF,SNR_Y in QCIF,p=1,10Hz,50frames)

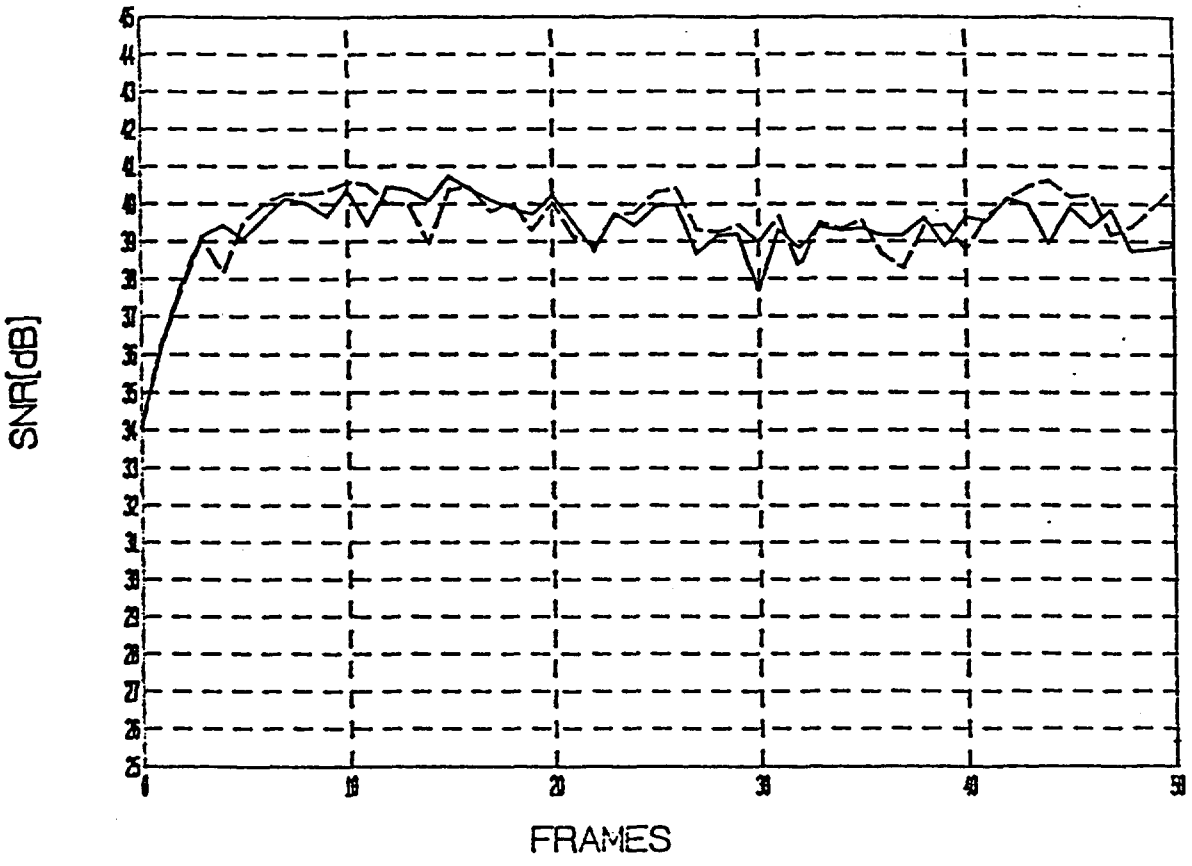

TABLE 1 Loop_filter(121), RM7, QCIF, 9_step

STATISTICS RM7 DATE : 1989. 2. 15
SEQUENCE : FRAME RATE : 10Hz
MODIFICATION :Loop_filter(121), 9_step, QCIF

SEQUENCE		CLAIRE	SALES	Miss. A
RMS for Y (in QCIF)		2. 83	4. 87	2. 74
SNR for Y (in QCIF)		39. 10	34. 37	39. 38
SNR for U		39. 88	40. 04	39. 21
SNR for V		42. 89	40. 98	39. 21
SNR for C		41. 13	40. 48	39. 21
RMS for Y (in FCIF)		5. 23	9. 63	4. 32
SNR for Y (in FCIF)		33. 75	28. 46	35. 41
SNR for U		38. 07	30. 90	31. 74
SNR for V		41. 42	30. 40	30. 63
SNR for C		39. 43	30. 64	31. 15
MEAN STEP SIZE		10. 11	12. 86	10. 87
MEAN Numb. of NONZERO Coeff.	Y	5. 88	6. 17	5. 32
	C	3. 05	1. 78	2. 81
MEAN Numb. of ZERO Coeff.	Y	13. 32	16. 23	9. 68
	C	8. 76	4. 87	7. 59
Block Type of MACRO	INTRA	0	0	0
	FIXED	48	44	36
	CODED MC	9	5	19
	FIXED MC	0	0	1
	CODED	42	49	43
Block Type of Y	FIXED	279	265	240
	CODED MC	29	18	51
	FIXED MC	8	3	29
	CODED	81	110	77
Block Type of UV	FIXED	172	180	134
	CODED	26	18	64
MACRO ATTRIB.		357	370	450
End of Block		368	398	522
Motion Vector		44	29	91
INTRA DC		0	4	0
Coeff. Y		4353	4819	3828
Coeff. UV		440	165	1004
Coeff. TOTAL		5562	5784	5896

TABLE 2 Loop_filter(141), RM7, QCIF, 9_step

STATISTICS RM7 DATE : 1989. 2. 21
SEQUENCE : FRAME RATE : 10Hz
MODIFICATION :Loop_Filter(141), 9_step, QCIF

SEQUENCE		CLAIRE	SALES	Miss. A
RMS for Y (in QCIF)		2. 78	4. 80	2. 71
SNR for Y (in QCIF)		39. 26	34. 51	39. 48
SNR for U		40. 05	40. 24	39. 22
SNR for V		42. 94	41. 00	39. 25
SNR for C		41. 26	40. 60	39. 23
RMS for Y (in FCIF)		5. 21	9. 63	4. 31
SNR for Y (in FCIF)		33. 79	28. 49	35. 45
SNR for U		38. 20	30. 92	31. 74
SNR for V		41. 51	30. 42	30. 64
SNR for C		39. 54	30. 66	31. 16
MEAN STEP SIZE		9. 76	12. 96	10. 75
MEAN Numb. of NONZERO Coeff.	Y	6. 69	6. 31	5. 20
	C	2. 88	1. 85	2. 85
MEAN Numb. of ZERO Coeff.	Y	13. 36	16. 40	9. 47
	C	8. 45	4. 88	7. 83
Block Type of MACRO	INTRA	0	0	0
	FIXED	46	46	34
	CODED MC	9	5	19
	FIXED MC	0	0	1
	CODED	44	48	45
Block Type of Y	FIXED	277	268	237
	CODED MC	28	17	50
	FIXED MC	8	3	31
	CODED	83	108	79
Block Type of UV	FIXED	171	180	131
	CODED	27	18	67
MACRO ATTRIB.		366	364	463
End of Block		378	389	532
Motion Vector		44	29	92
INTRA DC		0	4	0
Coeff. Y		4316	4795	3781
Coeff. UV		428	172	1040
Coeff. TOTAL		5531	5754	5908

Fig.4 : MC vs noMC+LP vs noMC+noLP (RM7_9step)
(Claire,QCIF,SNR_Y in QCIF,p=1,10Hz,165frames)

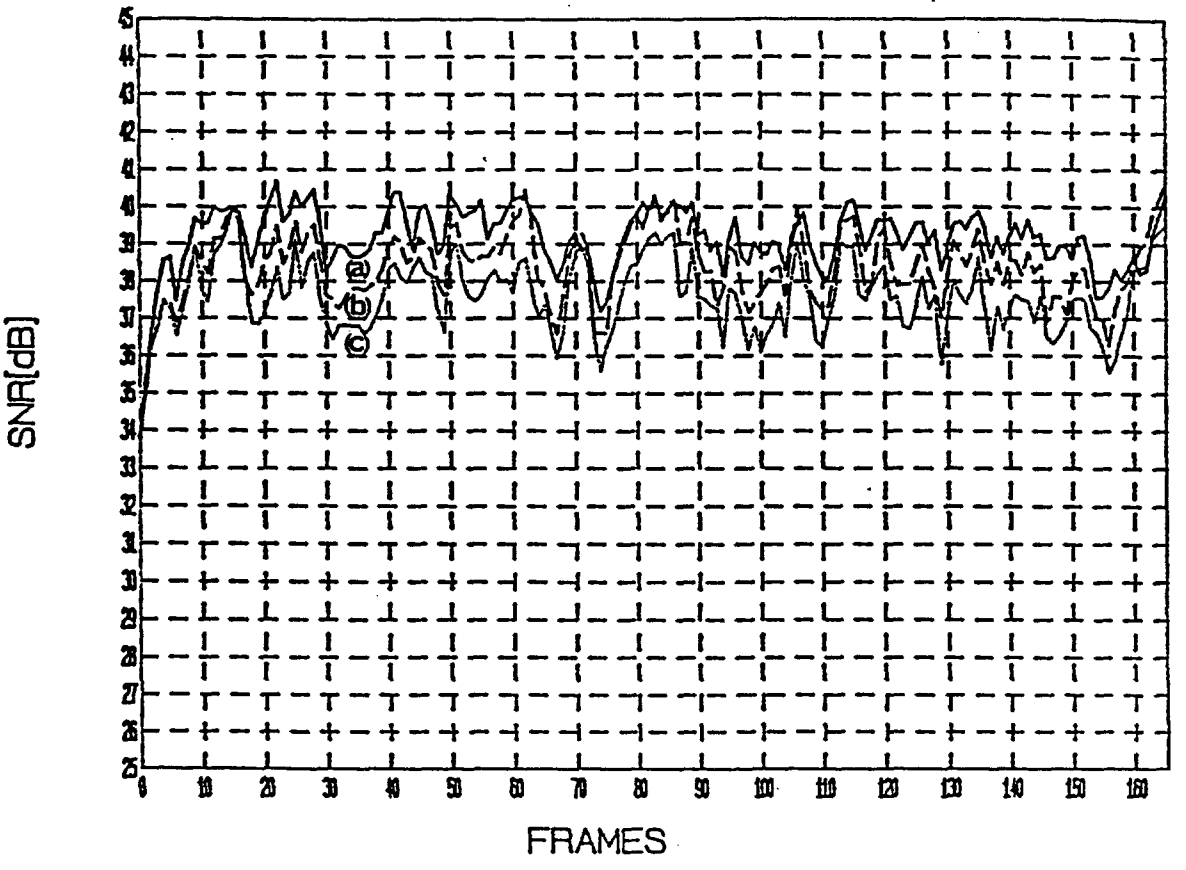

Fig.5 : MC vs noMC+LP vs noMC+noLP (RM7_9step)
(salesman,QCIF,SNR-Y in QCIF,p=1,10Hz,150frames)

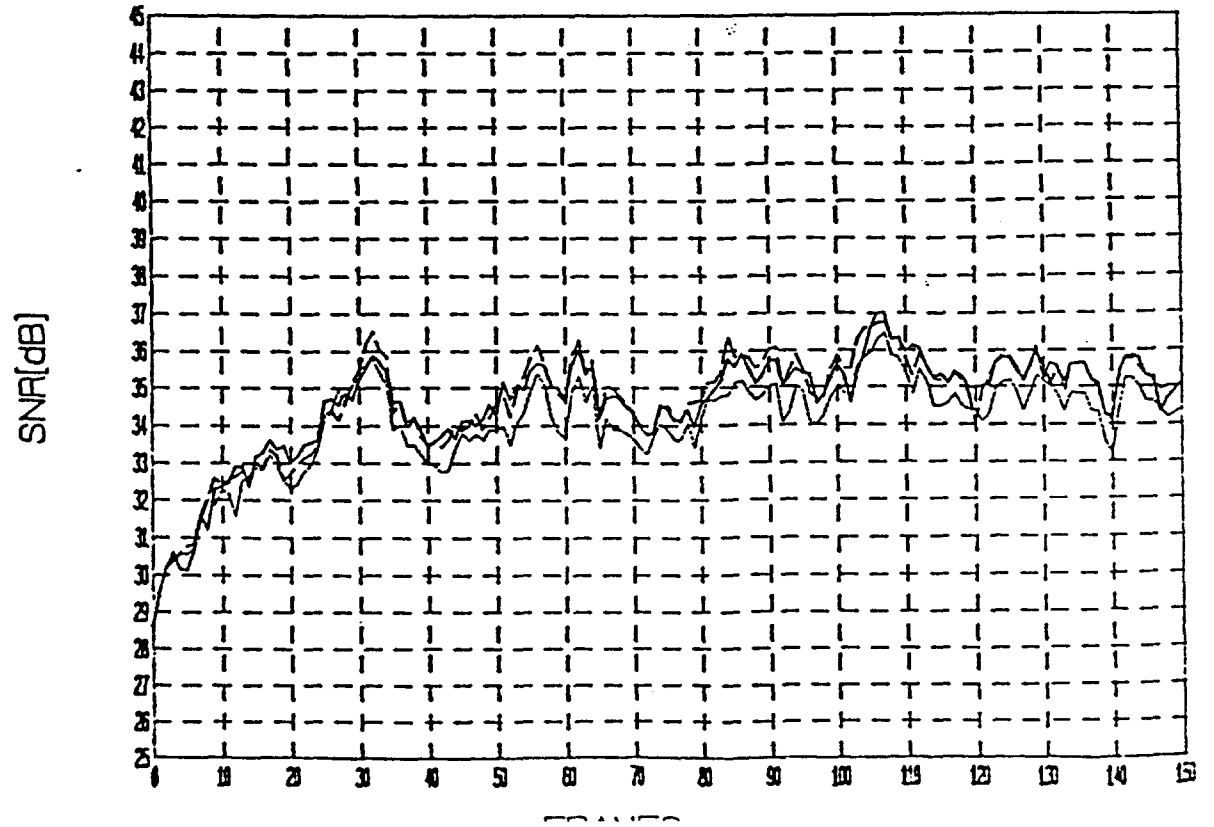

Fig.6 : MC vs noMC+LP vs noMC+noLP (RM7_9step)

(Miss.america,QCIF,SNR_Y in QCIF,p=1,10Hz,50frames)

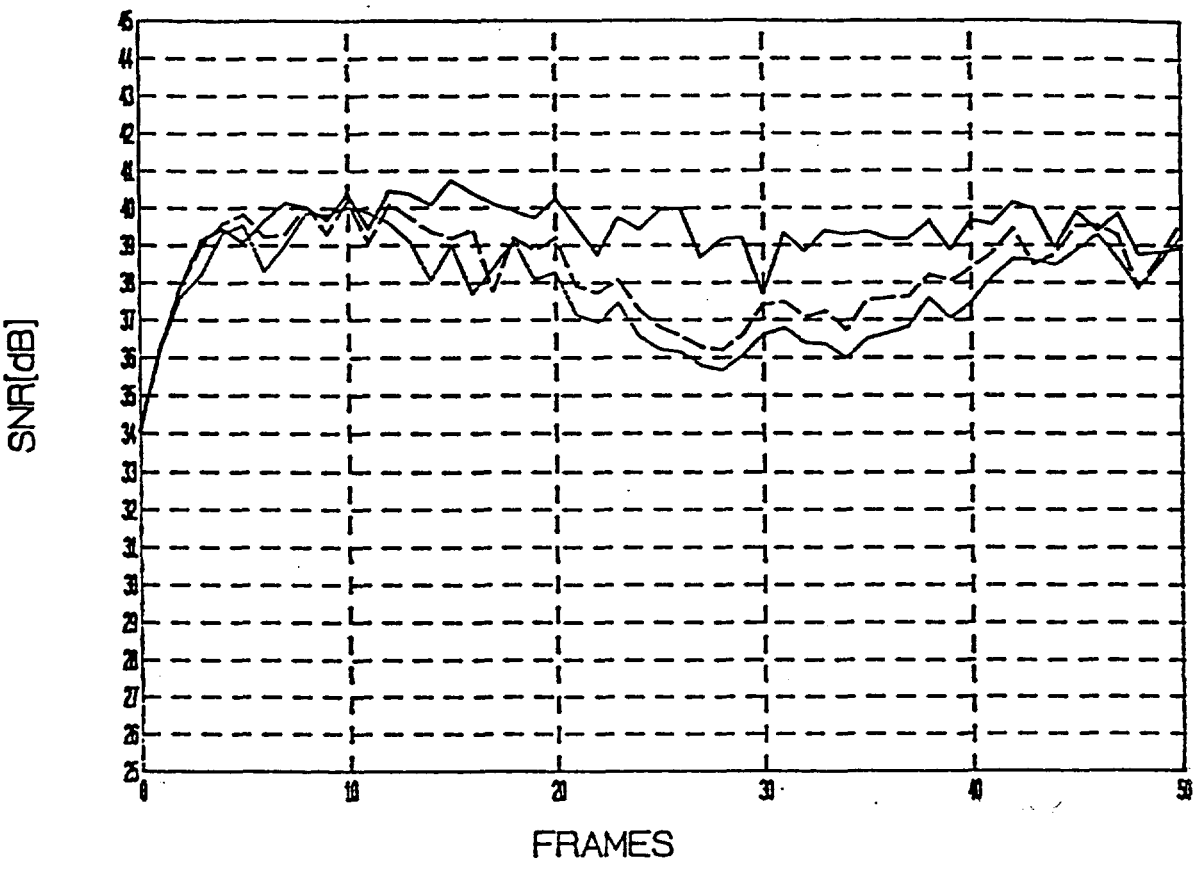

TABLE 3 No MC + LF, RM7, QCIF, 9_step

STATISTICS RM7 DATE : 1989. 2. 21
SEQUENCE : FRAME RATE : 10Hz
MODIFICATION :No MC + LF, 9_step, QCIF

SEQUENCE		CLAIRE	SALES	Miss. A
RMS for Y (in QCIF)		3. 10	4. 86	3. 13
SNR for Y (in QCIF)		38. 30	34. 40	38. 22
SNR for U		39. 40	40. 08	38. 60
SNR for V		42. 37	40. 97	38. 02
SNR for C		40. 63	40. 50	38. 30
MEAN STEP SIZE		11. 46	13. 22	13. 56
MEAN Numb. of NONZERO Coeff.	Y	7. 00	6. 28	5. 59
	C	3. 06	1. 78	2. 45
MEAN Numb. of ZERO Coeff.	Y	12. 29	16. 03	8. 12
	C	7. 84	4. 67	6. 01
Block Type of MACRO	INTRA	0	1	1
	FIXED	49	46	40
	CODED MC	7	5	14
	FIXED MC	0	0	1
	CODED	42	48	44
Block Type of Y	FIXED	282	267	248
	CODED MC	23	17	41
	FIXED MC	6	3	17
	CODED	84	110	90
Block Type of UV	FIXED	173	181	143
	CODED	25	17	55
MACRO ATTRIB.		349	358	423
End of Block		356	387	499
Motion Vector		15	10	29
INTRA DC		5	15	15
Coeff. Y		4449	4860	4200
Coeff. UV		406	156	709
Coeff. TOTAL		5581	5786	5874

TABLE 4 No MC + No LF, RM7, QCIF, 9_step

STATISTICS RM7 DATE : 1989. 2. 21
SEQUENCE : FRAME RATE : 10Hz
MODIFICATION :No MC + No LF, 9_step, QCIF

SEQUENCE		CLAIRE	SALES	Miss. A
RMS for Y (in QCIF)		3. 41	5. 16	3. 33
SNR for Y (in QCIF)		37. 48	33. 88	37. 67
SNR for U		38. 94	39. 82	38. 24
SNR for V		41. 68	40. 72	37. 52
SNR for C		40. 10	40. 24	37. 86
MEAN STEP SIZE		12. 65	14. 10	14. 31
MEAN Numb. of NONZERO Coeff.	Y	7. 44	6. 68	5. 70
	C	3. 16	1. 77	2. 32
MEAN Numb. of ZERO Coeff.	Y	13. 06	16. 49	8. 88
	C	9. 51	4. 80	5. 85
Block Type of MACRO	INTRA	0	1	1
	FIXED	51	48	40
	CODED MC	0	0	0
	FIXED MC	0	0	0
	CODED	47	50	58
Block Type of Y	FIXED	293	275	266
	CODED MC	0	0	0
	FIXED MC	0	0	0
	CODED	103	121	130
Block Type of UV	FIXED	174	182	144
	CODED	24	16	54
MACRO ATTRIB.		351	357	450
End of Block		341	373	495
Motion Vector		0	0	0
INTRA DC		9	19	24
Coeff. Y		4524	4895	4250
Coeff. UV		408	152	655
Coeff. TOTAL		5633	5796	5875