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

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SOURCE: CHAIRMAN
TITLE : REPORT OF THE SIXTEENTH MEETING IN STUTTGART (June 13 - 16, 1989)

CONTENTS

1. GENERAL

The Specialists Group met in Stuttgart, FRG, from June 13 to 16, 1989 at the kind invitation of Standard Elektrik Lorenz AG. Welcoming address was delivered by Dr. Bostelmann on behalf of the hosting organization.

The list of participants appears at the end of this report.

At the closing session, Chairman thanked the hosting organization for the meeting facilities provided and the excellent operation of the meeting.

2. DOCUMENTS FOR THE MEETING (TD 2)

For this meeting, 41 normal documents and 14 temporary documents have been available. Annex 1 shows the outline of each document.

3. TAPE DEMONSTRATIONS (TD 3)

A number of tape demonstrations as listed in Annex 2 were presented during the meeting.

4. REPORT OF WORKING PARTY XV/I MEETING (TD 4)

Chairman reported the major outcome of the first WP XV/I meeting held in March focusing on the following points;

- Organization of Study Group XV,
- Acceptance of the proposals which the Specialists Group made,
- Study items of priority for WP XV/I,

- Outline of revised H.221, AV242, AV320,
- Items to which the Specialists Group should react.

5. **REFERENCE MODEL 8**

5.1 RM8 Description (#500, #525)

Mr. Schuurink presented full description of RM8, which is the update of Doc. #446 (RM7 description) incorporating Annex 3 to Doc. #499R and Doc. #500.

5.2 RM8 Implementation (#504, #524, #527, #531, #534)

Several laboratories presented numerical data and processed pictures for RM8, which show good comparable results. For small discrepancies found in different implementations, Mr. Guichard undertook to give some suggestions.

In the SWING sequence at q=1, QCIF, 10Hz (Doc. #534), a considerable number of bits are used for stuffing. Mr. Brusewitz raised these may be used for lowering the step size, thus improving the picture quality.

5.3 Operation at Higher Bit Rates (#528, #504)

Mr. Guichard presented his work on RM8 and its modification at 1.1 Mbit/s for sequences "Table Tennis" and "Voiture". In the panning portion of "Table Tennis", use of "motion compensated but not filtered" macroblock type is shown to improve noticeably the coding performance. The actions needed to respond to this finding are discussed in § 7.4.

5.4 RM8 Updated Version

In order to make RM8 in line with the Flexible Hardware specification, necessary modifications were clarified by Mr. Guichard's small group. The outcome is in Annex 3.

6. **SOURCE CODING**

6.1 Scene Change (#505)

Mr. Yukitake presented experimental results on the scene change detection and subsequent particular processing to get faster build up, suggesting no additional mechanism to treat scene change is required.

Mr. Brusewitz stated that his previous experiments using only INTER showed noisy mixture of the two pictures. Mr. May suggested that the performance may be different with different combinations of scenes, flat background as in Claire makes scene change easier.

6.2 Quantization

6.2.1 INTRA DC component (#500)

Relation between respective FLC and its reconstruction level into IDCT (§ 1.1/Doc. #500) will be included in the Recommendation.

6.2.2 INTRA overload (#509, #522)

Mr. Mochizuki and Mr. Morrison presented their works on the INTRA overload for step size g=4 or 6. After reviewing the contents of these two documents as well as the tape demonstrations on cyclic refresh and forced update at g=8, the meeting decided to adopt the approach of "temporary but signalled change of step size". The meeting also decided to include a note in the Recommendation to warn readers of possible quantizer overloads (a wording is found in § 3/Doc. #509).

6.2.3 Adaptive Quantization (#506, #508)

Mr. Murakami presented an adaptive quantization experiment where smaller step sizes are applied to the moving macroblocks and to the macroblocks which were frequently quantized with large step sizes.

Mr. Ohzeki presented another adaptive quantization experiment where a facial region is detected and quantized with smaller step sizes compared to other regions. Mr. Shuurink made a comment that this technique may be applied to videophone but may cause disasters in other type of pictures.

Mr. Brusewitz informed about his previous trial where finer quantization was used in the background and coarser quantization in moving areas. This technique showed improved subjective quality after scene change.

It was clarified that both of the above experiments were carried out in the framework of the current video multiplex specification. Mr. Haskell suggested a study to reduce the amount of overhead bits for adaptively changing quantizer step sizes with such a method as "tag bit".

6.3 Pre- and Post-filtering (#511)

Mr. Kato demonstrated his work on one type of pre-filter as well as two types of post-filters, indicating some possibilities to improve performance of the standard codec without losing compatibility. In response to a question, he clarified that the "error" in Fig. 1 and 2/Doc. #511 is "mean squared error for replenished blocks".

6.4 Video Capability (#514, #535)

Mr. Matsuda and Mr. Hein raised the necessity to include in the Recommendation some DSP oriented architecture requirements. The meeting discussed extensively on whether to adopt this idea. The summary of discussion is as follows;

1) Background

a. We have already the minimum coded picture interval restriction in the current Flexible Hardware specification.

b. There are two types of implementation methods for the H.261 codec;

   - hardware oriented architecture,
   - DSP oriented architecture.

   which should be compatible with shared burden.

c. There are concerns about low cost implementation with DSP oriented architecture, for which the current minimum coded picture interval specification is not convenient due to the limited processing power.

2) Problem for the DSP architecture codec

It can decode almost all ordinary pictures coded at e.g. 15 Hz frame rate, but can not accept a few worst case pictures coded at that frame rate. Consequently it is forced to declare its decoding capability as e.g. 7.5 Hz to the remote coder. If the remote coder can eliminate those worst case coded pictures according to the indication of the decoder, then the decoder can provide better performance with lower cost implementation.

3) Proposed method of restricting the encoded picture content

The decoder indicates its processing power in terms of "Number of Processing Units per Unit Time", and the coder controls its information generation rate according to this restriction by dropping pictures etc.

Processing Unit: transmitted macroblock, transmitted block, transmitted non-zero coefficient, transmitted bit, etc.
Time Unit : picture, sum-multiple of picture, second, etc.

4) Opinions against the proposal

a. There are DSP oriented decoders which do not need additional restrictions to the current minimum coded picture interval.

b. Selection of "Processing Unit" and "Time Unit" depends upon the bottleneck of each implementation. The proposed solution in Doc. #514 and #535 only solves one specific bottleneck in one implementation.

c. Short term requirements may not be appropriate for the Recommendation.

   - A rebuttal to this opinion is that low cost implementation will help early penetration of the standard.

d. It may further complicate definition of the decoding capability which is currently envisaged as a combination of format, picture rate and transfer rate.

5) Possible decisions at this meeting

a. Adopt the proposal, but the details are for further study. Video decoding capability will be defined taking into account both of minimum coded picture interval and "Number of Processing Units per Unit Time".

b. Not adopt the proposal. Leave the specification as it is.

c. Keep it open until the next meeting as part of the problem concerning how to define the video capability in the final Recommendation.

As to the decision of this meeting, opinions diverged. Chairman proposed to take the third alternative (keep it open until the next meeting) and the meeting accepted this proposal. It was further decided that unless the study would be carried out and consensus would be made before November, we revert back to the second alternative (not adopt the proposal).

7. VIDEO MULTIPLEX CODING

7.1 Picture and GOB Headers

7.1.1 Emulation of start codes (#501, #510)

Mr. Brusewitz and Mr. Mochizuki presented their results of search for possible emulation of the start code in the current initial compatibility VLC sets contained in Annex 4 to Doc. #499R. The following three particular cases have been identified to cause emulation of the start code;

1) QUANT2=16, CBP=60, TCOEFF=those codes having 8 zeroes in the head
2) MVDy=12, CBP=60, TCOEFF=those codes having 8 zeroes in the head
3) MVDy=12, CBP=60, TCOEFF=those codes having 7 zeroes in the head

It was also recognized that the solution to cope with these three cases is to modify CBP, particularly CBP=60. After having discussed on when to modify the code set with future possibility of making optimization taken into account, the meeting agreed on the following actions;

- We will seek to avoid emulation of the start code as far as possible.
- It does not mean that we should never allow emulation since more beneficial factors may arise.
- "VLC Table for CBP" in Appendix 6/Annex 4 to Doc. #499R is replaced with that of Appendix 2 to Doc. #510. Flexible Hardware tests are carried out with this code set, including the DIS test signal generator.

7.1.2 TYPE1 bits (#518)

The meeting accepted the proposal to use Bit 3 of TYPE1 in the picture start code to indicate "Freeze Picture Release" with "0" for normal operation and "1" for that purpose. It was confirmed that this indication is independent of the way to encode the picture following this release signal, thus macroblock types should be indicated with TYPE3 as in normal pictures.

In response to a question of timing when this release signal is issued, Mr. Carr clarified that the MCU takes care of the timing.

7.1.3 Reduction of header bits

Mr. Brusewitz reminded the members of the subject item of further study and particularly raised a point whether we should maintain the guideline that the header length be multiples of 8 bits. There were no immediate reactions, which fact will be reflected in the study toward the final Recommendation. The meeting recognized that it was needed to make consensus on the picture/GOB header contents as soon as possible.

7.2 Macroblock Addressing

7.2.1 Stuffing code (#500, #533)

The meeting agreed on the allowable positions of stuffing code, which Mr. Speidel depicted in the syntax diagram of Doc. #533. It is noted that insertion of stuffing between a picture header and the first GOB header is prohibited.

7.2.2 End of Picture Marker (#512)

Mr. Wada proposed to include a new code for indicating the end of picture in the MBA code set, primarily to provide a mechanism to insert optional data between two ordinarily coded pictures.

Though there were some support to this proposal on the ground that this code could provide a mechanism for future extension, for special applications or for introduction of special signals to improve codec performance, the following skeptical opinions were expressed;

- If the optional data is intended to improve the coding performance, it may have to be in the block layer.
- Effectiveness of the optional data is not shown. Optional facility should first be identified.
- Some advantages listed are dependent on hardware design.
- If the option is not defined in the standard, the standard decoder performs simply worse due to the loss of transmission efficiency. If the optional data is proprietary, there is unlimited freedom to transmit any signals once shifted into a proprietary mode.

The meeting concluded to take note of this proposal without any actions.

7.3 TYPE3 Code (#503)

Mr. Mochizuki provided information on the TYPE3 optimization trials, concluding that the current VLC need not be modified for smaller values of p.

7.4 General (#532, #528)

Mr. Speidel presented syntax diagrams for each of the picture, GOB and macroblock according to the video multiplex specification. The meeting recognized these diagrams are clear and easy to understand and decided to include them in the H.261 Recommendation.

As to the point raised in Doc. #528 concerning provisions for future improvements in higher bit rates, the meeting confirmed that we would continued to do our best for obtaining better performance of the standard and that the higher bit rate oriented improvements should not lay burden to the lower bit rate operation. Specific modifications were discussed in a small group coordinated by Mr. Brusewitz. The outcome is as follows;

1) An extended TYPE3 was agreed to be used for all bit rates (see Table 1).

2) The chosen VLC guarantees that there is no loss in performance. It is also acceptable for all Flexible Hardwares (although some decoders will not accept the new codewords).

3) Flexible Hardware tests will be performed where the filter is switched on/off manually on encoder side.

4) Simulations will be made to identify gains with the new possibility to switch off the filters.

5) If it can be shown that a different VLC gives significant improvements, it may be agreed at the Tokyo meeting to make a change.

Table 1 TYPE3 Definition and VLC Codewords

TYPE3	MC	Fil	Coded	Intra	Q	VLC	Length
1. no MC coded			X			1	1
2. MC coded	X	X	X			01	2
3. MC not_coded	X	X				001	3
4. Intra				X		0001	4
5. no_MC coded Q			X		X	0 0001	5
6. MC coded Q	X	X	X		X	00 0001	6
7. Intra Q				X	X	000 0001	7
8. MC coded NF	X		X			0000 0001	8
9. MC not_coded NF	X					0 0000 0001	9
10. MC coded Q NF	X		X		X	00 0000 0001	10

8. TRANSMISSION CODING

8.1 Buffer Specification (#513, #523)

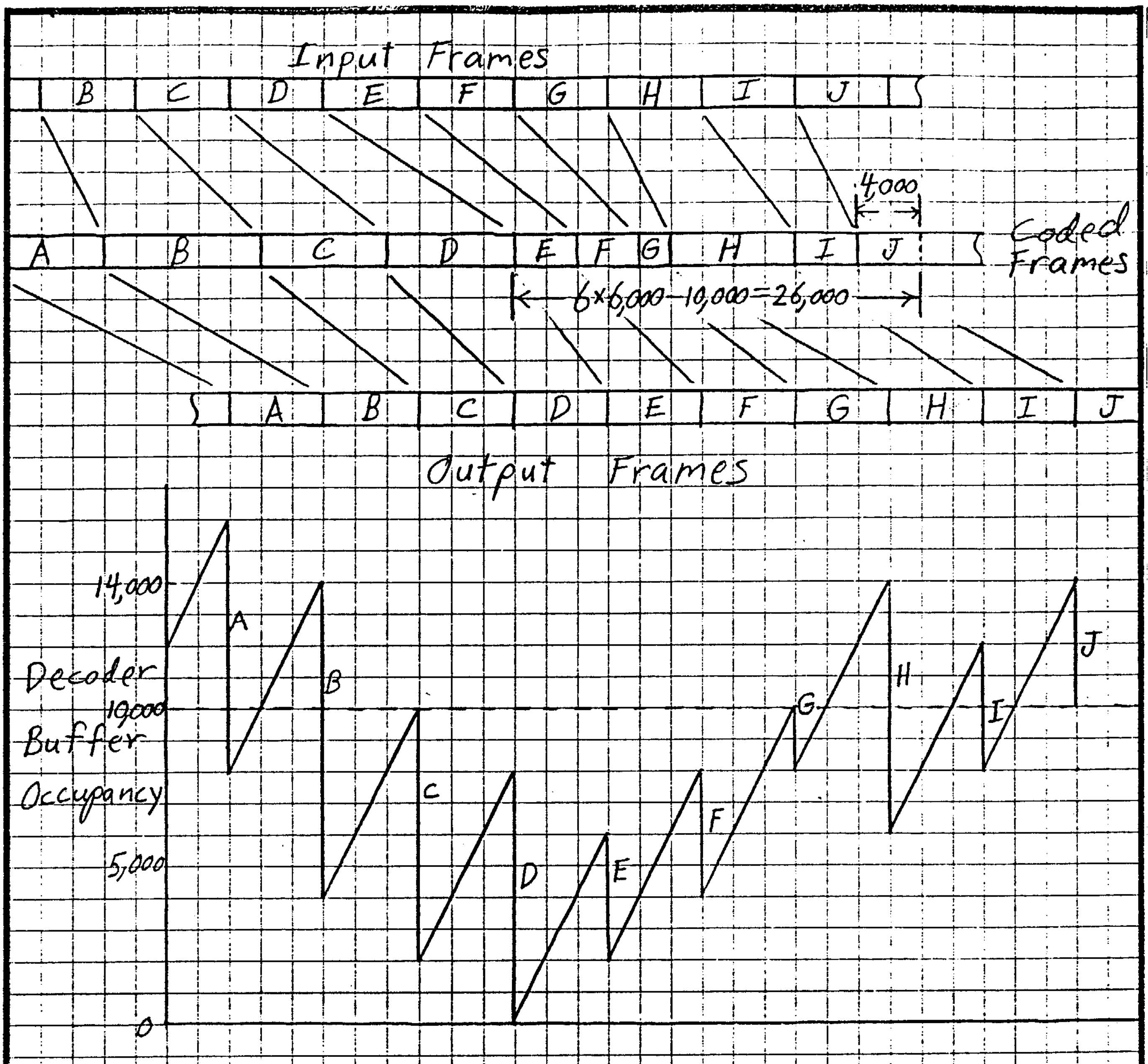
Mr. Matsuda and Mr. Morrison introduced their works in Japan and Europe on how to specify the data generation rate at the coder so that different architecture codecs can intercommunicate. After some questions for clarification, detailed discussion was held under Mr. Haskell's chairmanship. The summary of discussion is as follows;

Several discussions were held on the problem of constructing a specification that would ensure that a decoder buffer would never overflow under normal, error free transmission. Behavior in the presence of bit-errors would be implementation dependent.

It was decided that a tentative specification could be written based on a hypothetical reference decoder having a buffer of size B bits. Operation of such a decoder is described in Figure 1. Original frames are encoded at a variable number of bits per frame, then sent over a constant rate channel where they enter the decoder buffer. The decoder then extracts a corresponding variable number of bits per frame in order to display the original frame rate. As long as the buffer occupancy is below B, overflow does not occur.

In practice, such a decoder might need a buffer larger than B to accommodate transmission errors. It might also need to operate at a frame rate slightly higher than the encoder. Both these aspects are implementation dependent.

Decoder buffer overflow occurs if the buffer fills. This is caused by the variable rate of data extraction for decoding being less than the constant fill rate from the transmission channel for too long. This



$B = 10{,}000$ bits, $R/P = 6{,}000$ bits

N	$N \times R/P - B$	$b_{(N-1)}$	$\sum_{i=1}^{N} b_{(i-1)}$	$N \times R/P - B - \sum_{i=1}^{N} b_{(i-1)}$	
1	−4000	—	0	−4000	
2	2000	4000	4000	−2000	
3	8000	8000	12000	−4000	
4	14000	2000	14000	0	
5	20000	4000	18000	2000	
6	26000	4000	22000	4000	← Max. Value
7	32000	8000	30000	2000	
8	38000	8000	38000	0	
9	44000	10000	48000	−4000	
10	50000	8000	56000	−6000	

Figure 1 Hypothetical reference decoder

happens only if the number of coded bits per picture is too low over a sufficiently long period. This is equivalent to the pictures being encoded "early" in a relative sense.

If the channel rate is R bit/s then the maximum advance which can be allowed is B/R seconds. Hence the minimum time T_N between N+1 Picture Start Codes on the channel is N/P - B/R where P is the picture rate. (P is the nominal rate plus the 50 ppm tolerance.)

If D_N is the number of bits used to code N successive frames, then the number of bits d used to code the next frame must satisfy:

$$D_N + d > \frac{(N+1)R}{P} - B \text{ for all } N$$

$$\text{or} \quad d > \frac{(N+1)R}{P} - B - D_N \text{ for all } N$$

This is a requirement on the coder output bit-stream, which is illustrated in Figure 1.

The meeting decided to further elaborate the above "tentative solution", particularly by checking it against coder operation of each implementation.

8.2 Error Correction

8.2.1 Performance of the BCH code (#507)

Mr. Murakami provided information on the performance of a random/burst parallel decoder to respond to "the question whether the performance of double error corrector is decreased by about 17%" recorded in § 7.4/Doc. #499R. The calculated value was found to be 5.3% in this implementation.

It was clarified that the channel error was modeled as ideal in the answer to the question of Mr. Speidel.

8.2.2 Lock-up time of the error correction framing (#519)

Mr. Carr proposed to specify a nominal maximum frame structure lock-up time in the final specification from the switched multipoint consideration. The meeting accepted this proposal. The "lock-up time" may be expressed in terms of "number of bits".

To a question of whether H.221 lock-up time should also be considered, Mr. Carr clarified that H.221 framing is terminated to each codec at MCU, thus only video signal switching is concerned.

8.3 Interface between CODEC and Terminal Adaptor (#516)

Mr. Kato proposed a definition of polarity for the reference points of R and S/T to be that inversion of logical binary code is not allowed between these two points. This was thought as a useful guideline to make different design videophone terminals compatible. Mr. Schaphorst confirmed that his Test Signal Generator is in line with this proposal.

8.4 Interconnection Between 64 and 56 kbit/s and One's Density Restriction (TD9, TD5)

Mr. Tabatabai presented an idea on how to accommodate a H.221 framed signal in 56 kbit/s channel according to the relevant projected ANSI standard. In case of 56 vs 64 kbit/s interworking, the framing is septet timed, and the FAS and BAS should be located at the 7th sub-channel of the 64 kbit/s coder while the 64 kbit/s decoder should carry out bit searching for framing. Extension of this scheme to multiple connections of 56 kbit/s channel is also suggested. Mr. Tabatabai stated that the US would not seek any more the zero byte replacement previously proposed in Doc. #470.

The meeting confirmed that the responsibility for these system related matter is not in the Specialists Group but in the Working Party XV/1 and that we may have different approaches to cope with 56 vs 64 kbit/s interworking and one's density restriction in higher bit rates such as 384 kbit/s.

Since this material (TD9) is new to the meeting, the members are requested to make thorough review, distribute their comments among them and get in touch with SGXV representatives so that practical agreements would be obtained in the November WPXV/1 meeting.

9. **FLEXIBLE HARDWARE**

9.1 Test Signal Generator (#539)

Mr. Schaphorst reported on the current status of the test signal generator development, highlighting that a tester had been delivered to PKI for test and verification during this meeting. Mr. Hein demonstrated decode pictures (QCIF test pattern and Claire) which were produced from the encoded picture bit streams in PROM of the tester.

9.2 Flexible Hardware Specification

An update of the specification in Annex 4 to Doc. #499R is in Annex 4 of this report, incorporating the following items agreed during this meeting (inside parentheses indicate corresponding parts in Annex 4 to Doc. #499R);

- Description of loop filter control (§ 1.2.3)
- Syntax diagrams (§ 2.2)
- Bit 3 in TYPE1 in (§ 2.2.1)
- Clarification of stuffing code insertion in MBA (§ 2.2.3)
- VLC for TYPE3 (Table 1)
- CBP code set (Appendix 6)

10. **SYSTEM ASPECTS** (#515, #520, #536, #537)

Mr. Wada and Mr. Carr presented Doc. #515 and #520 respectively, introducing their comments to improve Recommendations H.221 and AV242. Mr. Tabatabai addressed the same topic with Doc. #536 and #537. Members are requested to investigate these materials and communicate with SGXV representatives for early consensus.

The meeting confirmed that the Specialists Group is charged to provide information through experiments how to define the video capability so that appropriate BAS codes could be included in Rec. H.221.

The meeting discussed to some extent on what channels be used for negotiation,invocation and indication of the video capability. It is a general feeling that the negotiation and invocation should be carried out in H.221 and that bits in the picture header be used merely for picture synchronized indication.

11. STUDY PLAN

11.1 Hardware Trials (#526, #538, #539; TD10)

In order to materialize the trial plan, Flexible Hardware developers had a small group meeting coordinated by Mr. Wada. The outcome is as follows;

> Small Group for flexible hardware field trial met in the Tuesday evening. First, a view was introduced that basically negotiation for Flexible Hardware field trial should be made in a bilateral way, but since it was a good chance to share information on a plan of each organization, it seemed better to have brief introductions of plans here, go to bilateral negotiations, and collect reports of negotiations. This view was accepted, but it was stressed that these reports of negotiations are just information on each plan and never put burden on any organizations.
>
> Then U.K., Japan, U.S., FRG, IMAGIN project and France introduced their field trial plans, some of which are summarized in documents #526 and #538. In the introduction it was mentioned that in Europe there are some 2Mbit/s occasional satellite links available for the field trials on a booking basis. France suggested their plan to use 1B switching network, TRANSOM, which is connected to U.K. and U.S.
>
> Discussion was raised concerning H.221 verification and it was agreed upon that, in the field trials we should concentrate on the verification of H.261 that has a complicated algorithm, while H.221 has a simple straightforward structure. In the field trial, therefore, BAS is undefined and the decoder may just discard BAS bits. It was recognized, however, that H.221 has to be completed at the same time as H.261 and other videophone-related recommendations.
>
> Lastly, it was reconfirmed that in the Flexible Hardware experiment, BCH framing structure is maintained but it is not mandatory for the encoder to put error correcting bits and the decoder may discard these bits. Dummy error correcting bits will be all one's in that case.
>
> The summary of 'negotiation' reports is in Annex 5.

The meeting recognized that establishments of end-to-end clear channels should first be confirmed before September in advance of the video codec connection tests.

11.2 Editorial Group Meeting (TD6)

Chairman proposed the purpose and terms of reference of this editorial group as follows;

1) Date: October 24(Tue) - 26(Thu), 1989

2) Venue: BTRL, Ipswich, UK

3) Purpose

Prepare a complete draft for Recommendation H.261 "CODEC FOR AUDIOVISUAL SERVICES AT px64 KBIT/S" so that it can be discussed and finalized at the November Specialists Group meeting. The finalized draft will subsequently be forwarded to Working Party XV/1 for approval.

4) Terms of Reference of the Editorial Group

a. Review study results available by that time, Flexible Hardware trial results in particular.

b. Draft every detail of H.261 including the preamble and annexes if necessary.

c. List up alternative solutions if there could not be a unified view. Preference of the editorial group may be expressed for the consideration of the Specialists Group.

d. List up all items for further study, if they unfortunately could remain unsolved.

5) Participants

Coordinator (Mr. Morrison) and volunteers. Members are requested to advise Chairman (S. Okubo) of their intent of participation by July 14 for task assignments.

It was stressed that the main task of this group should be to prepare a full text of Rec. H.261 so that the November meeting of the Specialists Group could approve it. The meeting accepted this plan.

Since there still remains some items requiring detailed study (see § 10.3), members are requested to contribute to this drafting work through correspondence and submitting documents for the November meeting as early as possible so that this editorial group can sort out the problems if any.

11.3 Items to Be Solved before the Final Recommendation (TD7)

Chairman presented such items as in Annex 4 to facilitate the work in coming five months.

Since this list may not be complete, members are requested to review this list and return their comments to Chairman in two weeks. An updated version will be distributed subsequently.

Mr. Carr raised a question of H.261 coverage, more specifically whether H.261 is a recommendation only for video coding or for terminal. Since we have now several related audiovisual recommendations such as H.221, AV242, AV320, etc, H.261 may be concentrated on video coding. In that case, interface items currently included in the Flexible Hardware specification may be moved to other recommendations.

Chairman will get contact with Mr. Yamashita (Chairman of WPXV/1) and Mr. Kenyon (Special Rapporteur for Q.4/XV) to get their advice on this point.

11.4 ATM-Codec Study (#517)

Mr. Kato presented Doc. #517, proposing to initiate standardization activities in a specialists group level.

Mr. Speidel made a comment that the lower bit rate coding (64 kbit/s to 2 Mbit/s) covered by H.261 should not be targeted, though it might eventually be covered by ATM-coding, for the life of H.261.

Mr. Carr stated that since this study has been initiated in ETSI, COST211bis, etc, Europe can contribute to the CCITT work.

The next opportunity to organize the CCITT study on this topic is the November WPXV/1 meting. It is expected to get consensus by that time.

12. INTELLECTUAL PROPERTY

12.1 Patent Applications (#502, #521)

Mr. Helkio and Mr. Morrison advised the meeting of their patent/patent applications.

12.2 Patent Policy Statements (#529, #530)

Statements on patent information disclosure policy were submitted by 6 organizations. The meeting confirmed that this information disclosure will continue till this Specialists Group work ends.

In response to the action requested at the previous meeting (§ 9.3), statements on patent licensing policy were submitted by 15 organizations at this meeting.

Those organizations which have not yet submitted statements are requested to do so by the end of September to avoid difficulties at the time of higher body approval of the draft Recommendation.

13. FUTURE MEETINGS

- Editorial group meeting for Rec. H.261: October 24(Tue) - 26(Thu), 1989, at BTRL
- 17th meeting of the Specialists Group: Nov. 7(Tue) - 10(Fri) in Tokyo
- Working Party XV/1 meeting: Nov. 27(Mon) - Dec. 1(Fri), 1989 in Geneva
- Study Group XV meeting: July 1990 in Geneva

END

Annexes

Annex 1 Documents for the Stuttgart meeting
Annex 2 List of tape demonstrations
Annex 3 Update of RM8
Annex 4 Update of Flexible Hardware Specification
Annex 5 Summary of field trial plans
Annex 6 Items to be solved before the final Recommendation

LIST OF PARTICIPANTS
(Stuttgart; June 13 - 16, 1989)

Chairman	S. Okubo	- NTT, Japan

Core Members

F. R. of Germany	J. Speidel	- PKI
	G. Zedler	- FTZ
USA	A. Tabatabai	- BELLCORE
	B.G. Haskell	- AT&T Bell Laboratories
	R.A. Schaphorst	- DIS
Finland	R. Helkio	- VISTACOM
France	G. Eude	- CNET
	J. Guichard	- CNET
Italy	B. Riolfo	- CSELT (acting for L. Chariglione)
Japan	Y. Kato	- NTT
	M. Wada	- KDD
Korea	J-S Lee	- ETRI
Norway	G. Bjϕntegaard	- Norwegian Telecom
The Netherlands	B. Shuurink	- PTT-RNL (acting for R. Plompen)
United Kingdom	D. G. Morrison	- BTRL
	N.L. Shilston	- GPT Video Systems
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Assisting Experts

F. R. of Germany	W. Geuen	- SEL
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USA	J. Bruder	- PictureTel
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	B. Kruger	- PictureTel
	G. Rekstadt	- NCS
	J. Zingman	- CLI
France	D. David	- ALCATEL CIT
Japan	K. Matsuda	- FUJITSU
	T. Mochizuki	- NEC
	T. Murakami	- Mitsubishi Electric
	K. Ohzeki	- Toshiba
	T. Yukitake	- Matsushita Communication Ind.
Korea	J-H. Jeong	- ETRI
United Kingdom	M.D. Carr	- BTRL

DOCUMENTS FOR THE STUTTGART MEETING

Normal Documents

#499R REPORT OF THE FIFTEENTH MEETING IN OSLO (CHAIRMAN)

Points agreed upon and/or left for further study in the previous meeting are recorded to provide backgrounds for discussion in this meeting.

#500 CLARIFICATION OF FLEXIBLE HARDWARE SPECIFICATION AND RM8 (CHAIRMAN)

Coding of INTRA DC component and possible positions of "stuffing code" are clarified for the Flexible Hardware specification. Buffer regulation in RM8 is also clarified.

#501 GBSC EMULATION IN FLEXIBLE HARDWARE
(SWEDEN, UK, FRANCE, FRG, ITALY, NETHERLANDS, NORWAY)

It is pointed out that GBSC can be emulated in some cases by selecting the most critical code words, i.e. those with many zeroes in the beginning or end of the code words and checking possible combinations of them. The followings are three particular cases;

1) QUANT2=16, CBP=60, 2D-VLC=(0,12)
2) MVD=12, CBP=60, 2D-VLC=(0,12)
3) MVD=12, CBP=60, 2D-VLC=(0,8)

#502 PATENTS/PATENT APPLICATIONS OF VISTACOM INDUSTRIES ON LOW BIT RATE VIDEO CODING (FINLAND)

Information is provided on the two patents concerning low bit rate video coding.

#503 TYPE3 VLC OPTIMIZATION (JAPAN)

According to the statistics of Macroblock Types in RM8 simulations for q=1/CIF/10Hz, q=1/QCIF/10Hz and q=5/CIF/10Hz, coding efficiency of TYPE3 is discussed. It is concluded that the optimized VLC code set for q=1/CIF/10Hz gives no significant improvement of coding performance compared to the current VLC code set, because the number of no MC coded macroblock is rulingly large and the percentage of TYPE3 bits is low in the total coded bits.

#504 SIMULATION RESULTS OF REFERENCE MODEL 8 (JAPAN)

Coding performance of RM8 is given at various video bit rates (44-108 kbit/s, q=1-23). It is observed that RM8 has stabler control of the step size than RM7.

#505 SCENE CHANGE DETECTION (JAPAN)

This document discusses a problem of whether scene change detection can improve the coding performance, using a sequence with "Claire" and "Salesman" connected. It is concluded that RM8 without any specific scene change processing works well, and that if faster build-up is required, inter/intra switch may be used for scene change detection and fixing the step size for the first frame after scene change is effective.

#506 CODING RESULTS USING ADAPTIVE QUANTIZER (JAPAN)

An adaptive quantization scheme is experimented where lower step sizes are assigned to macroblocks which were quantized frequently with large step size as well as motion compensated macroblocks. It is reported that "Salesman" was improved with this scheme.

#507 PERFORMANCE OF BCH CODE FOR RANDOM AND BURST ERROR (JAPAN)

Performance of a (511,493)BCH decoder is analyzed, where a random error decoder and a burst error decoder are operated in parallel and one of the two decoded outputs is selected to a certain rule. If the selection is predetermined according to the results of "uncorrectable error detection", 5.3% of all the correctable patters are miscorrected. It is pointed out that if the selection is adapted to the channel characteristics, the percentage of miscorrection can be reduced.

#508 IMPROVEMENT OF PICTURE IN THE FACIAL REGION (JAPAN)

A scheme assigning more bits to the facial region is experimented in a frame based coding control where a constant step size is applied throughout the coded frame. Rectangular regions surrounding the face are detected automatically using frame difference. It is reported that 1dB SNR improvement at the facial region for "Claire " is obtained at the expense of 2dB SNR loss at other regions.

#509 INTRA OVERLOAD (JAPAN)

According to the open loop simulation with g=4, 30Hz and cyclic refresh of 3 macroblocks per picture, a suggestion is made that forced update should be carried out with $g \geqq 8$ to avoid block-shaped distortion due to quantizer overload. This restriction theoretically ensures that quantizer overload never happens for INTRA coded blocks. As a conclusion, it is proposed that some note should be included in the final Recommendation to warn possible overload.

#510 PSC/GBSC EMULATION PROBLEM (JAPAN)

Emulation of the picture and GOB start code is analyzed taking into account all possible combinations. The following two cases take place in the macroblock layer;

1) MVDy=16, CBP=60, TCOEFF=those codes having 8 zeroes in the head
2) QUANT2=16, CBP=60, TCOEFF=those codes having 8 zeroes in the head

It is proposed that CBP should be modified to cope with the emulation of PSC/GBSC codes.

#511 IMAGE QUALITY IMPROVEMENT WITH PRE- AND POST-FILTERINGS (JAPAN)

A pre-filter and two post-filters are experimented with RM8. The non-linear temporal pre-filter reduces noise contained in the source coder input, thus improving coding efficiency. It was found that coding error is larger at the block boundaries than inside. Post-filter 1 operates only at block boundaries, thus reducing block-shaped noise and improves SNR by 0.2-0.3 dB. Post-filter 2 reduces mosquito noise around sharp edges, giving sharper pictures.

#512 INTRODUCTION OF END OF PICTURE -EOP- MARKER (JAPAN)

It is proposed to include an EOP code in the VLC table for MBA in the final Recommendation to facilitate inserting optional data, such as conditional motion compensated interpolation data, between the two normally coded pictures and reducing the display delay time when stuffing codes are added after the end of a picture.

#513 VIDEO DATA BUFFERING (JAPAN)

In order to evaluate several possible specifications on data buffering (or data generation rate at the coder), the following criteria are presented;

1) assurance of communication among different decoder architectures
2) easiness of implementation
3) simplicity of definition
4) coding efficiency in terms of delay, bit loss, full usage of decoding capability
5) freedom in coding control

A new alternative method is also presented, where minimum number of bits per coded frame is specified according to the transmission bit rate and the remote decoder processing capability.

#514 MAXIMUM FRAME RATE SPECIFICATION ACCORDING WITH THE NUMBER OF SIGNIFICANT BLOCKS IN EACH FRAME (JAPAN)

Processing amount for controlling the maximum frame rate according with the number of significant blocks in one coded frame is shown comparable to that for controlling the maximum number of bits per coded frame. It is emphasized that adoption of the former frame rate control should be considered toward the final Recommendation.

#515 COMMENTS ON RECOMMENDATIONS H.221 AND H.200/AV242 (JAPAN)

As a result of "system aspects" study in Japan, some comments on the latest texts for Rec. H.221 (frame structure for a 64-1920 kbit/s channel) and H.200/AV242 (AV communication procedure).

#516 INTERFACE BETWEEN CODEC AND TERMINAL ADAPTOR (JAPAN)

Definition of polarity is proposed for the reference points R and S/T that inversion of logical binary (1 or 0) is not allowed between them. Correspondence between logical binary code 1/0 and physical signals are noted for RS422 and I.430 interfaces.

#517 STUDY ON ATM-CODEC (NTT, KDD)

A proposal is made to initiate standardization activities in a specialists group level on video coding for Asynchronous Transfer Mode. Possible study categories, study items, work plan, etc. are presented.

#518 MULTIPOINT FOR THE H.261 CODEC
(UK, FRANCE, FRG, ITALY, NETHERLANDS, NORWAY, SWEDEN)

Appropriate channels for the three multipoint signals are proposed based on timing requirement of respective signal;

- Freeze Picture Release: Bit 3 of TYPE1, "0" being for normal operation, "1" preceding the INTRA coded frame.
- Advance Warning of Interruption and Fast Update Request: BAS codes.

#519 ERROR CORRECTION FRAMING LOCK-UP TIME - MULTIPOINT CONSIDERATIONS
(UK, FRANCE, FRG, ITALY, NETHERLANDS, NORWAY, SWEDEN)

Inclusion of a nominal maximum lock-up time for error correction frame structure is proposed toward the final Recommendation since the framing for the error corrector is in-band as far as the video signal is concerned and the framing pattern is interrupted during multipoint switching as the MCU switches from one source to another source.

#520 FAS AND BAS IN DATA TIME SLOTS
(UK, FRANCE, FRG, ITALY, NETHERLANDS, NORWAY, SWEDEN)

In order to accommodate CCITT X.21 data ports operating at 64 kbit/s, it is
required not to include FAS and BAS in time slots which are used for data. A proposal is made to ask the WPXV/1 meeting to consider this problem.

#521 BT PATENT APPLICATION (BRITISH TELECOM)

A patent application on bias cancelling DCT codec is informed of the Specialists Group.

#522 SOLUTIONS TO THE QUANTISER OVERLOAD PROBLEM
(UK, FRANCE, FRG, ITALY, NETHERLANDS, NORWAY, SWEDEN)

The following four solutions to cope with possible overload in INTRA coded macroblocks with a step size of 4 or 6 are catalogued;

1) Non-linear quantiser
2) Increase the code table size
3) Temporary and signalled change of step size
4) Temporary but unsignalled change of step size

It is suggested that 3) or 4) may be promising as they are permitted within the current Flexible Hardware specification, encouraging confirmation with Flexible Hardware and/or simulation experiments.

#523 BUFFER SPECIFICATION
(UK, FRANCE, FRG, ITALY, NETHERLANDS, NORWAY, SWEDEN)

How to specify the data generation rate at the coder is addressed. After reviewing the problem and previously presented two solutions, the concept of a Reference Decoder is introduced. This Reference Decoder has not a fixed size but holds one coded picture plus X bits, removes the coded picture instantaneously at the picture rate. Any coded data stream is required not to cause data loss by buffer overflow in this Reference Decoder.

#524 REFERENCE MODEL 8 SIMULATION RESULTS (ETRI)

Statistical data of RM8 are presented for q=1, 10Hz.

#525 DESCRIPTION OF REF. MODEL 8 - RM8
(SPECIALISTS GROUP ON CODING FOR VISUAL TELEPHONY)

Full specification of Reference Model 8 is described.

#526 HARDWARE STATUS AND PLANS (AEG, BT, FRANCE, IMAGIN PROJECT, PKI)

This is a status report of the European work by the source organizations aimed at providing hardware to verify the CCITT Recommendation on px64 kbit/s video codecs.

#527 COMPUTER EVALUATION OF REFERENCE MODEL 8 (BELLCORE)

Experimental results on RM8 are provided for q=1, 10Hz.

#528 RM8 IMPROVEMENTS FOR BIT RATES AROUND 1 MBIT/S (FRANCE)

Based on the simulation experiments at 1.1 Mbit/s using "Table Tennis" and "Voiture", it is pointed out that a 4dB or 3dB gain can be obtained for zooming and panning scenes by introducing "MC coded but not filtered" macroblock type. Considering that the px64 kbit/s algorithm is a candidate for the ISO standard for CD-ROM applications, a suggestion is made to leave the door open at higher bit rates for certain elements such as;

- on/off filtering control,
- quantization table,
- VLC for MB types.

#529 PATENT INFORMATION DISCLOSURE POLICIES (CHAIRMAN)

A collection of statements on the patent information disclosure policy from 6 organizations.

#530 PATENT LICENSING POLICIES FOR REC. H.261 (CHAIRMAN)

A collection of statements on the patent licensing policy from 17 organizations.

#531 SYNTAX DIAGRAM FOR THE VIDEO MULTIPLEX CODER OF THE px64 KBIT/S FLEXIBLE HARDWARE (FRG)

Clarification of the current video multiplex specification is presented in the form of syntax diagram for "picture", "picture header", "GOB header", "macroblocks" and "macroblock data".

#533 NO STUFFING CODEWORDS AFTER THE PICTURE HEADER (FRG)

Positions where the stuffing code can be inserted are clarified in the form of syntax diagram. Particularly it is noted that insertion between a picture header and the first GOB header is not allowed.

#534 RM8 SIMULATION RESULTS (VIDEOTELECOM)

Experimental results on RM8 are provided for q=1, 10Hz in CIF as well as QCIF.

#535 SPECIFICATION OF SIGNIFICANT BLOCKS PER FRAME (VIDEOTELECOM)

It is proposed that a set of BAS codes be defined to allow the decoder to inform an encoder about its capabilities for processing significant blocks in terms of SBL (Significant Block Limit), because it allows for greater freedom in the implementation of compatible codecs. The SBL is defined as the maximum number of significant blocks that the decoder can process during each of the 33ms CIF frame intervals.

#536 IMPROVEMENTS TO H.221 FOR AUDIO/VISUAL SERVICES (BELLCORE)

The following proposals are made;

1) Elimination of the Application Channel as part of H.221. Simpler terminals such as videophones may use BAS for C&I signalling currently envisioned for AC. Remaining signals envisioned for AC can be transmitted through the data channel with a protocol of rate adaptation, sub-multiplexing and communication of interface status.

2) Extension of the BAS hierarchical structure to "attribute class" / "attribute family" / "attribute" / "attribute value". It is further proposed that escape code tables be defined for each combination of attribute class, attribute family. A BAS message approach is illustrated to communicate non-standard algorithms information.

Some comments are also made on video decoder capabilities, C&I signalling, 64/56 kbps interworking.

#537 STATUS OF 56 KBPS TRANSMISSION OF 7 KHZ AUDIO (BELLCORE)

Audio coding, frame structure and signalling procedures for 56 kbit/s channels specified in a projected ANSI standard are presented for information. A parallel approach is suggested for visual telephony.

#538 USA FLEXIBLE HARDWARE STATUS
(VIDEOTELECOM, BELLCORE, AT&T, PICTURETEL, CLI)

This document reports current status of the US joint project with reports of individual companies.

#539 STATUS OF THE SIGNAL GENERATOR TO TEST PX64 KBIT/S VIDEO DECODERS (DIS)

Current status of the test signal generator development is reported.

Temporary Documents

No. 1 Agenda for the Stuttgart meeting (Chairman)
No. 2 Available documents (Chairman)
No. 3 List of tape demonstrations (Chairman)
No. 4 Report of the first SGXV meeting (Chairman)
No. 5 Chronicle on one's density problem - Excerpt of meeting reports (Chairman)
No. 6 Meeting of editorial group for Recommendation H.261 (Chairman)
No. 7 Items to be studied further toward the final REcommendation (Chairman)
No. 8 Summary of the Tuesday afternoon discussion on the video decoding capability definition (Chairman)
No. 9 North American network considerations (Bellcore, CLI, PictureTel, VideoTelecom, AT&T)
No.10 Reports of small group meeting (Small Group on FH Field Trial)
No.11 Discussion on buffer specification (Small Group)
No.12 Small group conclusions on conditional loop filtering (Small Group)
No.13 Draft report of the sixteenth meeting in Stuttgart (Chairman)
No.14 RM8 up-dated version and action points (Sub-group)

END

Annex 2 to Doc. #540R

LIST OF TAPE DEMONSTRATIONS (June 13, 1989)

	Topics	Source	Doc.
a	RM8 results	Bellcore	#527
b	RM8 results	NL	#531
c	Adaptive quantization	Japan	#506
d	Improvement of picture in the facial region	Japan	#508
e	INTRA overload	Japan	#509
f	1.1 Mbit/s CD-ROM application	France	#528
g	Pre- and post-filterings	Japan	#511
h	DIS Test Signal Generator	VideoTelecom	#539

Annex 3 to Doc. #540R

RM8 updated version and action points

For people producing the exact bit stream by simulation, it is necessary to update RM8. In particular, the VLC tables for relative addressing, differential motion vector coding and coefficients are given in Appendix 1. The VLC for coded Block Patterns is defined in Doc. #510 (see Appendix 2).

Action points

1. Conditional filtering.
2. Buffer regulation.
3. Study of the modifications at other bit rates.
4. Set of quantization tables for high bit rates.

END

VLC Table for Macroblock Addressing

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

VLC Table for MVD

MVD	CODE
-16 & 16	0000 0011 001
-15 & 17	0000 0011 011
-14 & 18	0000 0011 101
-13 & 19	0000 0011 111
-12 & 20	0000 0100 001
-11 & 21	0000 0100 011
-10 & 22	0000 0100 11
-9 & 23	0000 0101 01
-8 & 24	0000 0101 11
-7 & 25	0000 0111
-6 & 26	0000 1001
-5 & 27	0000 1011
-4 & 28	0000 111
-3 & 29	0001 1
-2 & 30	0011
-1	011
0	1
1	010
2 & -30	0010
3 & -29	0001 0
4 & -28	0000 110
5 & -27	0000 1010
6 & -26	0000 1000
7 & -25	0000 0110
8 & -24	0000 0101 10
9 & -23	0000 0101 00
10 & -22	0000 0100 10
11 & -21	0000 0100 010
12 & -20	0000 0100 000
13 & -19	0000 0011 110
14 & -18	0000 0011 100
15 & -17	0000 0011 010

VLC Table for TCOEFF

The most commonly occurring combinations of zero-run and the following value are encoded with variable length codes as listed in the table below. End of Block (EOB) is in this set. Because CBP indicates those blocks with no coefficient data, EOB cannot occur as the first coefficient. Hence EOB can be removed from the VLC table for the first coefficient.

The last bit 's' denotes the sign of the level, '0' for +ve and '1' for -ve.

RUN	¦ LEVEL ¦	CODE
EOB		10
0	1	1s IF FIRST COEFFICIENT
0	1	11s NOT FIRST COEFFICIENT
0	2	0100 s
0	3	0010 1s
0	4	0000 110s
0	5	0010 0110 s
0	6	0010 0001 s
0	7	0000 0010 10s
0	8	0000 0001 1101 s
0	9	0000 0001 1000 s
0	10	0000 0001 0011 s
0	11	0000 0001 0000 s
0	12	0000 0000 1101 0s
0	13	0000 0000 1100 1s
0	14	0000 0000 1100 0s
0	15	0000 0000 1011 1s
1	1	011s
1	2	0001 10s
1	3	0010 0101 s
1	4	0000 0011 00s
1	5	0000 0001 1011 s
1	6	0000 0000 1011 0s
1	7	0000 0000 1010 1s
2	1	0101 s
2	2	0000 100s
2	3	0000 0010 11s
2	4	0000 0001 0100 s
2	5	0000 0000 1010 0s
3	1	0011 1s
3	2	0010 0100 s
3	3	0000 0001 1100 s
3	4	0000 0000 1001 1s
4	1	0011 0s
4	2	0000 0011 11s
4	3	0000 0001 0010 s
5	1	0001 11s
5	2	0000 0010 01s
5	3	0000 0000 1001 0s

6	1	0001 01s
6	2	0000 0001 1110 s
7	1	0001 00s
7	2	0000 0001 0101 s
8	1	0000 111s
8	2	0000 0001 0001 s
9	1	0000 101s
9	2	0000 0000 1000 1s
10	1	0010 0111 s
10	2	0000 0000 1000 0s
11	1	0010 0011 s
12	1	0010 0010 s
13	1	0010 0000 s
14	1	0000 0011 10s
15	1	0000 0011 01s
16	1	0000 0010 00s
17	1	0000 0001 1111 s
18	1	0000 0001 1010 s
19	1	0000 0001 1001 s
20	1	0000 0001 0111 s
21	1	0000 0001 0110 s
22	1	0000 0000 1111 1s
23	1	0000 0000 1111 0s
24	1	0000 0000 1110 1s
25	1	0000 0000 1110 0s
26	1	0000 0000 1101 1s
ESCAPE		0000 01

The remaining combinations of (RUN, LEVEL) are encoded with a 20 bit word consisting of 6 bits ESCAPE, 6 bits RUN and 8 bits LEVEL.

RUN is a 6 bit fixed length code

0	0000 00
1	0000 01
2	0000 10
.	.
.	.
63	1111 11

LEVEL is an 8 bit fixed length code

-127	1000 0001	
.	.	
.	.	
-2	1111 1110	
-1	1111 1111	
0	0000 0000	FORBIDDEN
1	0000 0001	
2	0000 0010	
.	.	
127	0111 1111	

VLC Table for CBP

CBP	CODE	CBP	CODE
60	111	35	0001 1100
4	1101	13	0001 1011
8	1100	49	0001 1010
16	1011	21	0001 1001
32	1010	41	0001 1000
12	1001 1	14	0001 0111
48	1001 0	50	0001 0110
20	1000 1	22	0001 0101
40	1000 0	42	0001 0100
28	0111 1	15	0001 0011
44	0111 0	51	0001 0010
52	0110 1	23	0001 0001
56	0110 0	43	0001 0000
1	0101 1	25	0000 1111
61	0101 0	37	0000 1110
2	0100 1	26	0000 1101
62	0100 0	38	0000 1100
24	0011 11	29	0000 1011
36	0011 10	45	0000 1010
3	0011 01	53	0000 1001
63	0011 00	57	0000 1000
5	0010 111	30	0000 0111
9	0010 110	46	0000 0110
17	0010 101	54	0000 0101
33	0010 100	58	0000 0100
6	0010 011	31	0000 0011 1
10	0010 010	47	0000 0011 0
18	0010 001	55	0000 0010 1
34	0010 000	59	0000 0010 0
7	0001 1111	27	0000 0001 1
11	0001 1110	39	0000 0001 0
19	0001 1101		

63 Patters codeword length

■ : coded block

Pattern		CB CR	■	■	■ ■
Y1 Y2 Y3 Y4	(0)	–	5	5	6
     ■	(4)	4	7	7	8
 ■	(8)	4	7	7	8
■ 	(16)	4	7	7	8
■ 	(32)	4	7	7	8
 ■ ■	(12)	5	8	8	8
■ ■ 	(48)	5	8	8	8
■ ■	(20)	5	8	8	8
■ ■	(40)	5	8	8	8
■ ■	(24)	6	8	8	9
■ ■	(36)	6	8	8	9
■ ■ ■	(28)	5	8	8	9
■ ■ ■	(44)	5	8	8	9
■ ■ ■	(52)	5	8	8	9
■ ■ ■	(56)	5	8	8	9
■ ■ ■ ■	(60)	3	5	5	6

Specification for p*64 kbit/s Flexible Hardware

Updated June 16, 1989
Original March 10, 1989

CONTENTS

An outline block diagram of the codec is given in Figure 1.

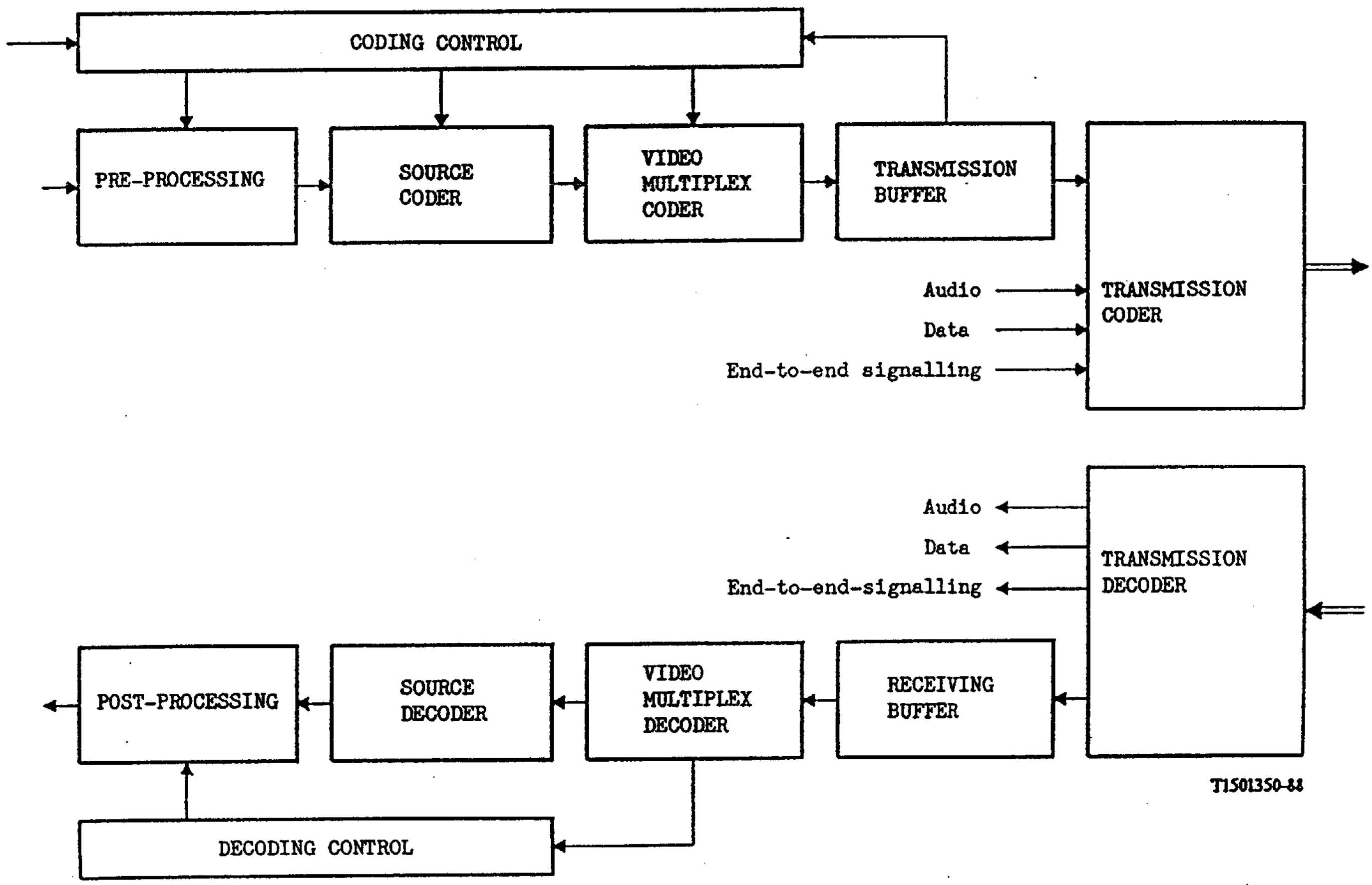


Figure 1 Outline blockdiagram of the codec

1. Source Coder

1.1 Source format

The source coder operates on non-interlaced pictures occurring 30000/1001 (approximately 29.97) times per second. The tolerance on picture frequency is +/-50 ppm.

Pictures are coded as luminance and two colour difference components (Y, C_B and C_R). These components and the codes representing their sampled values are as defined in CCIR Recommendation 601.

Black = 16
White = 235
Zero colour difference = 128
Peak colour difference = 16 and 240

These values are nominal ones and the coding algorithm functions with input values of 1 through to 254. Values of 0 and 255 are not allowed.

Two picture scanning formats are specified.

In the first format (CIF), the luminance sampling structure is 288 lines per picture, 352 pels per line in an orthogonal arrangement. Sampling of each of the two colour difference components is at 144 lines, 176 pels per line, orthogonal. Colour difference samples are sited such that their block boundaries coincide with luminance block boundaries as shown in Figure 2. The picture area covered by these numbers of pels and lines has an aspect ratio of 4:3 and corresponds to the active portion of the local standard video input.

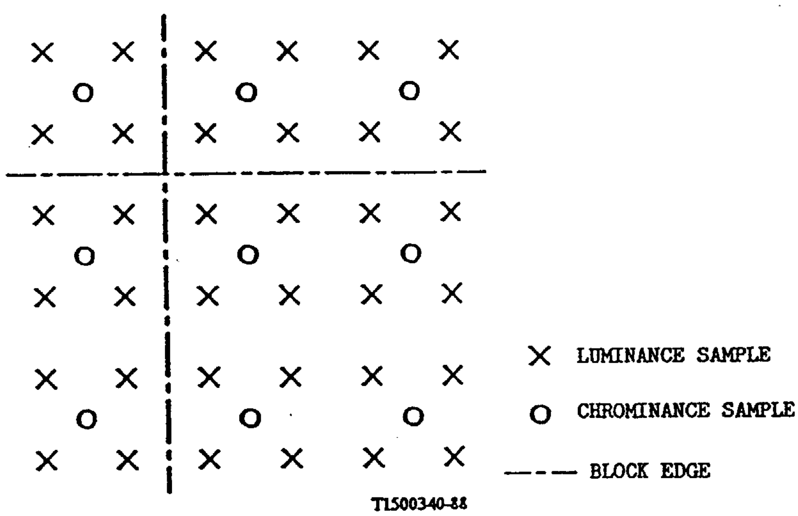


Figure 2 Positioning of luminance and chrominance samples

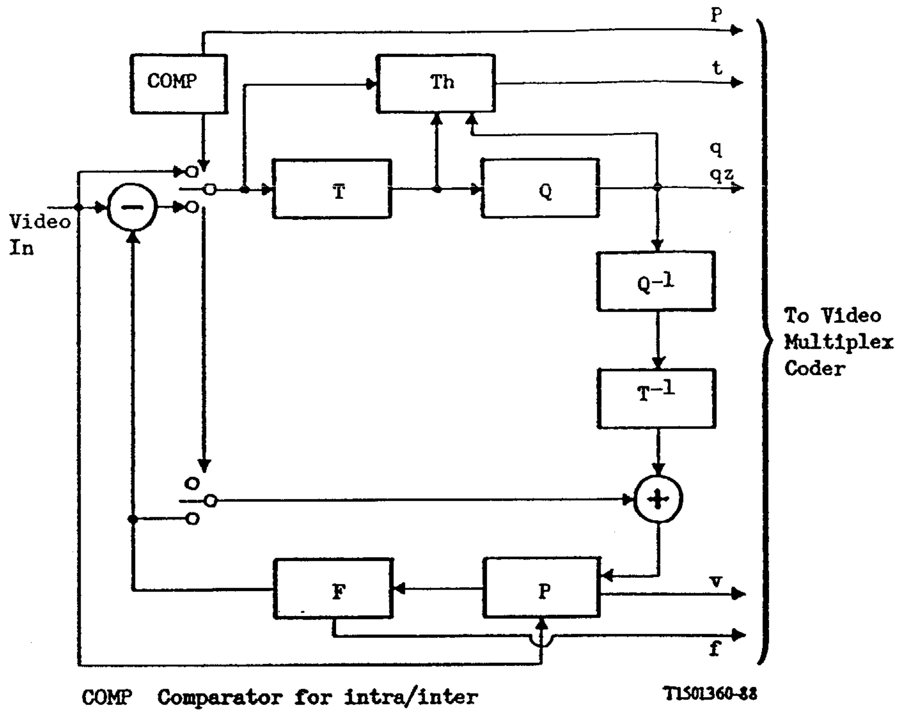
The second video format (QCIF) has half the number of pels and half the number of lines stated above.

The maximum picture rate (CIF and QCIF) is under study. Means shall be provided to restrict the maximum picture rate of encoders by having at least 0, 1, 2 or 3 non-transmitted pictures between transmitted ones. Selection of this minimum number will be performed manually.

All codecs must be able to operate using QCIF. Some codecs can also operate with CIF.

1.2 Video source coding algorithm

The video coding algorithm is shown in generalised form in Figure 3. The main elements are prediction, block transformation, and quantisation.



COMP	Comparator for intra/inter
Th	Threshold
T	Transform
Q	Quantizer
P	Picture memory with motion compensated variable delay
F	Loop filter
p	Flag for intra/inter
t	Flag for transmitted or not
q	Quantizing index for transform coefficients
qz	Quantizer indication
v	Motion vector
f	Switching on/off of the loop filter

Figure 3 Video coding algorithm

The prediction error (INTER mode) or the input picture (INTRA mode) is subdivided into 8 pel by 8 line blocks which are segmented as transmitted or non-transmitted. The criteria for choice of mode and transmitting a block are not subject to recommendation and may be varied dynamically as part of the data rate control strategy. Transmitted blocks are transformed and resulting coefficients are quantised and variable length coded.

1.2.1 Prediction

The prediction is inter-picture and may be augmented by motion compensation (§ 1.2.2) and a spatial filter (§ 1.2.3).

1.2.2 Motion compensation

Motion compensation is optional in the encoder. The decoder will accept one vector per macroblock. Both horizontal and vertical components of these motion vectors have integer values not exceeding +/- 15. The vector is used for all four luminance blocks in the macroblock. The motion vector for both colour difference blocks is derived by halving the component values of the macroblock vector and truncating towards zero.

A positive value of the horizontal or vertical component of the motion vector signifies that the prediction is formed from pels in the previous picture which are spatially to the right or below the pels being predicted.

Motion vectors are restricted such that all pels referenced by them are within the coded picture area.

1.2.3 Loop filter

The prediction process may be modified by a two-dimensional spatial filter which operates on pels within a predicted 8 by 8 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 except at block edges where one of the taps would fall outside the block. In such cases the 1-D filter is changed to have coefficients of 0, 1, 0. 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/off for all 6 blocks in a macroblock according to the macroblock type. (See TYPE3).

1.2.4 Transformer

Transmitted blocks are coded with a separable 2-dimensional Discrete Cosine Transform of size 8 by 8. The input to the forward transform and output from the inverse transform have 9 bits. The transfer function of the inverse transform is given by

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

with $u,v,x,y = 0, 1, 2, \ldots, 7$

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

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

The arithmetic procedures for computing the transforms are not defined, but the inverse one should meet the error tolerance specified in Appendix 1.

1.2.5 Quantisation

The number of quantisers is 32. Their characteristics are given in Appendix 2. Assignment of quantisers is as in Figure 4.

1.2.6 Clipping

To prevent quantisation distortion of transform coefficient amplitudes causing arithmetic overflow in the encoder and decoder loops, clipping functions are inserted. In addition to those in the inverse transform, a

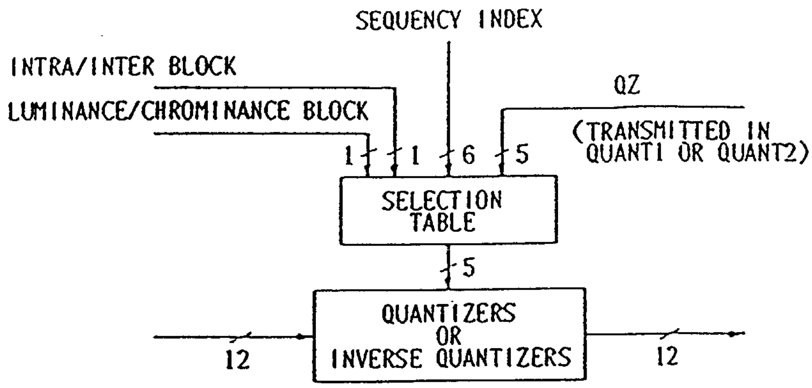


Figure 4 Quantiser assignment

clipping function is applied at both encoder and decoder to the reconstructed picture which is formed by summing the prediction and the prediction error as modified by the coding process. This clipper operates on resulting pel values less than 0 or greater than 255, changing them to 0 and 255 respectively.

1.3 Data rate control

Sections where parameters which may be varied to control the rate of generation of coded video data include processing prior to the source coder, the quantiser, block significance criterion and temporal subsampling. The proportions of such measures in the overall control strategy are not subject to recommendation.

When invoked, temporal subsampling is performed by discarding complete pictures. Interpolated pictures are not placed in the picture memory.

1.4 Forced updating

This function is achieved by forcing the use of the INTRA mode of the coding algorithm. The update pattern is not defined. For control of accumulation of inverse transform mismatch error a block should be forcibly updated at least once per every 132 times it is transmitted.

2. Video Multiplex Coder

2.1 Data Structure

Note 1: Unless specified otherwise the most significant bit is transmitted first.
Note 2: Unless specified otherwise Bit 1 is transmitted first.
Note 3: Unless specified otherwise all unused or spare bits are set to '1'.

2.2 Video Multiplex arrangement

The video multiplex is arranged in a hierarchical structure with four layers. From top to bottom the layers are:

Picture
Group of Blocks (GOB)
Macroblock (MB)
Block

A syntax diagram of the video multiplex coder is shown in Figure 5.

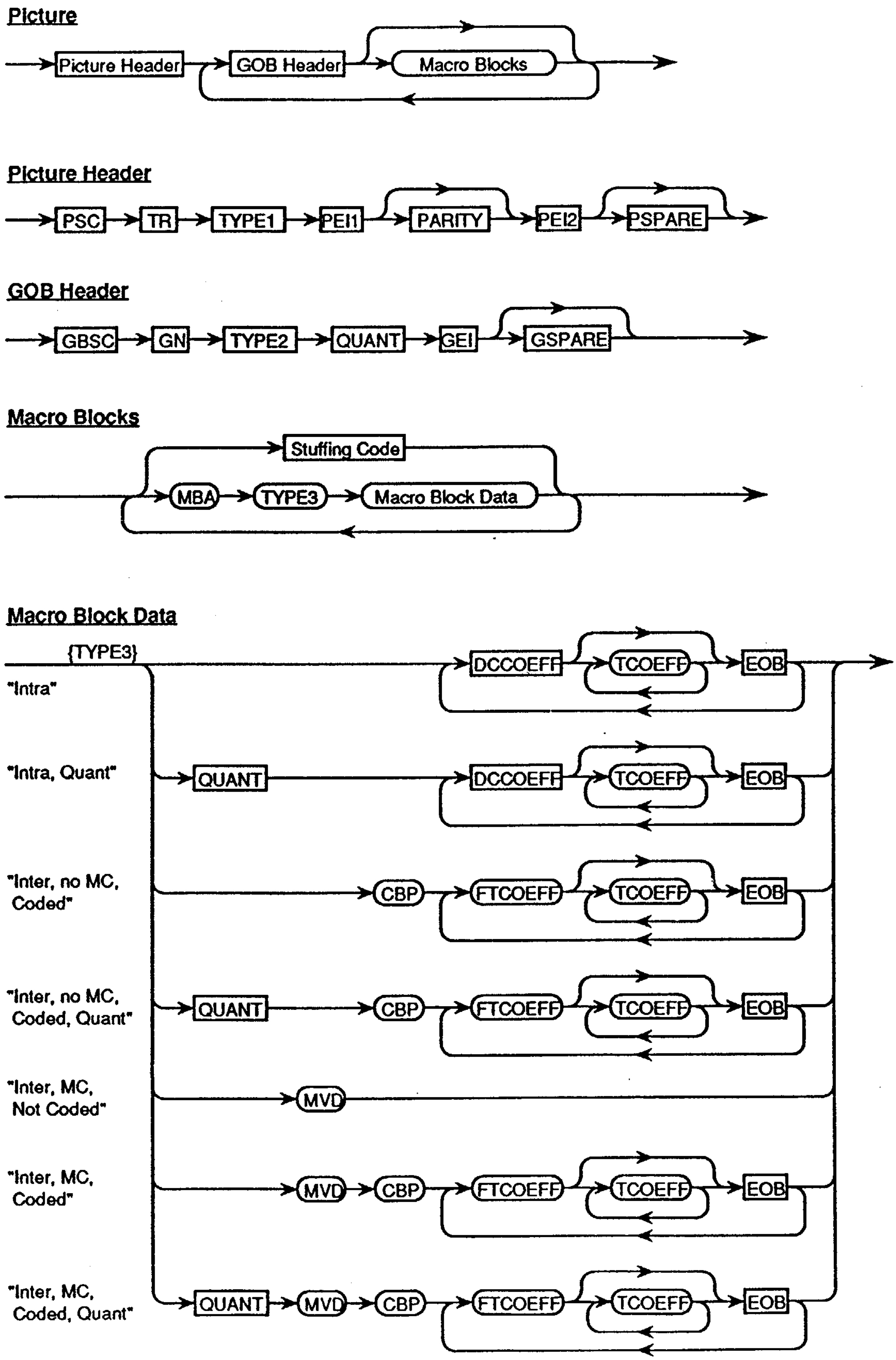


Figure 5 Syntax diagram for the px64 kbit/s Flexible Hardware

2.2.1 Picture Layer

Data for each Picture consists of a Picture Header followed by data for GOBs. The structure is shown in Figure 6. Picture Headers for dropped pictures are not transmitted.

PSC	TR	TYPE1	PEI1	PARITY	PEI2	PSPARE	GOB Data

Figure 6 Structure of the Picture Layer

Picture Start Code (PSC) 20 bits

A word of 20 bits. Its value is 0000 0000 0000 0001 0000

Temporal Reference (TR) 5 bits

A five bit number which can have 32 possible values. It is formed by incrementing its value in the previously transmitted Picture header by 1 plus the number of non-transmitted pictures (at 29.97 Hz) since that last transmitted one. The arithmetic is performed with only the 5 LSBs.

Type Information (TYPE1) 13 bits

Information about the complete picture;

Bit 1 Split screen indicator. '0' off, '1' on.
Bit 2 Document camera. '0' off, '1' on.
Bit 3 Freeze Picture Release. '0' off, '1' on.
Bit 4 Format indicator. '0' QCIF, '1' CIF.
Bits 5 to 13 Under study.

Extra Insertion Information (PEI1) 1 bit

A bit which signals the presence of the following optional data field.

Parity Information (PARITY) 0 or 8 bits

For optional use and present only if the PEI1 bit is set to '1'. Eight parity bits each representing odd parity of the aggregate of the corresponding bit planes of the locally decoded PCM values of Y, C_B and C_R in the previous picture period.

Extra Insertion Information (PEI2) 1 bit

A bit which signals the presence of the following optional data field.

Spare Information (PSPARE) 0 or 16 bits

Sixteen bits are present when the PEI2 bit is set to '1'. The use of these bits is under study.

2.2.2 Group of Blocks Layer

Each picture is divided into Groups of Blocks (GOBs). A group of blocks (GOB) comprises one twelfth of the CIF or one third of the QCIF picture areas (see Figure 7). A GOB relates to 176 pels by 48 lines of Y and the spatially corresponding 88 pels by 24 lines of each of C_R and C_B.

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

CIF

1
3
5

QCIF

Figure 7 Arrangement of GOBs in a Picture

Data for each Group of Blocks consists of a GOB Header followed by data for macroblocks. The structure is shown in Figure 8. Each GOB Header is transmitted once between Picture Start Codes in the CIF or QCIF sequence numbered above, even if no macroblock data is present in that GOB.

GBSC	GN	TYPE2	QUANT1	GEI	GSPARE	MB Data

Figure 8 Structure of Group of Blocks Layer

Group of Blocks Start Code (GBSC) 16 bits

A word of 16 bits, 0000 0000 0000 0001.

Group Number (GN) 4 bits

Four bits indicating the position of the group of blocks. The bits are the binary representation of the numbers in Figure 7. Group numbers 13, 14 and 15 are reserved for future use. Group number 0 is used in the PSC.

Type Information (TYPE2) 6 bits

TYPE2 is 6 bits which give information about all the transmitted blocks in a group of blocks.

Bits 1 to 6 Spare, under study.

Quantiser Information (QUANT1) 5 bits

A fixed length codeword of 5 bits which indicates the quantiser table(s) to be used in the group of blocks until overridden by any subsequent QUANT2. The codewords are given in Appendix 3.

Extra Insertion Information (GEI) 1 bit

A bit which signals the presence of the following optional data field.

Spare Information (GSPARE) 0 or 16 bits

Sixteen bits are present if the GEI bit is set to '1'. The use of these bits is under study.

2.2.3 Macroblock Layer

Each GOB is divided into 33 macroblocks as shown in Figure 9. A macroblock relates to 16 lines by 16 pels of Y and the spatially corresponding 8 lines by 8 pels of each of C_B and C_R.

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

Figure 9 Arrangement of macroblocks in a GOB

Data for a macroblock consists of a MB Header followed by data for blocks (Figure 10). Elements are omitted when not required.

MBA	TYPE3	QUANT2	MVD	CBP	Block Data

Figure 10 Structure of macroblock layer

Macroblock Address (MBA) Variable Length

A variable length codeword indicating the position of a macroblock within a group of blocks. The transmission order is as shown in Figure 9. For the first transmitted block in a GOB, MBA is the absolute address in Figure 9. For subsequent macroblocks, MBA is the difference between the absolute addresses of the macroblock and the last transmitted macroblock. The code table for MBA is given in Appendix 4.

An extra codeword is available in the table for bit stuffing between macroblocks, between a GOB header and a coded macroblock or between a macroblock and a Picture header (see Figure 11). This codeword should be discarded by decoders.

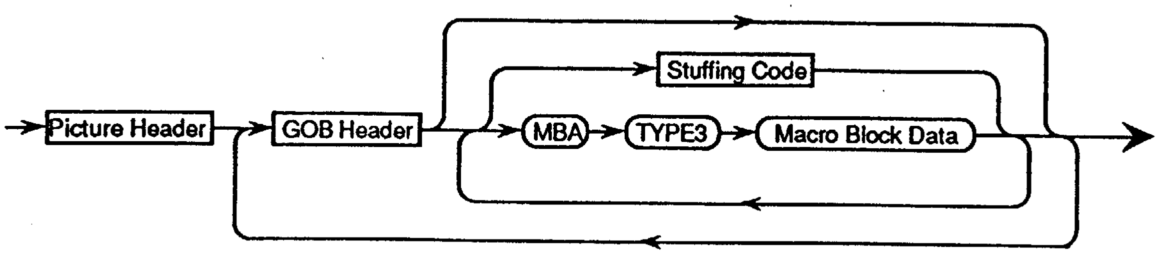


Figure 11 Insertion of the stuffing code

MBA is always included in transmitted macroblocks.

Macroblocks are not transmitted when they contain no information for that part of the picture.

Type Information (TYPE3)   Variable Length

Variable length codewords giving information about the macroblock and which data elements are present. Macroblock types, included elements and VLC words are listed in Table 1.

TYPE3 is always included in transmitted macroblocks.

Table 1 TYPE3

Intra/Inter/MC/MC+FIL	QUANT2	MVD	CBP	TCOEFF	VLC
Intra				x	0001
Intra	x			x	0000 001
Inter			x	x	1
Inter	x		x	x	0000 1
*MC		x			0000 0000 1
*MC		x	x	x	0000 0001
*MC	x	x	x	x	0000 0000 01
MC+FIL		x			001
MC+FIL		x	x	x	01
MC+FIL	x	x	x	x	0000 01

Note: - 'x' means that the item is present in the macroblock
- *) These three macroblock types may not be implemented in some Flexible Hardware Decoders. When connected to such decoders, Flexible Hardware Encoders must not use these three macroblock types. Control of this restriction on encoders should be by local manual means.

Quantiser (QUANT2)   5 bits

QUANT2 is present only if so indicated by TYPE3.

A codeword of 5 bits signifying the quantiser table(s) to be used for this and any following blocks in the group of blocks until overridden by any subsequent QUANT2.

Codewords for QUANT2 are the same as for QUANT1.

Motion Vector Data (MVD)   Variable length

Motion Vector Data is included for all MC macroblocks. MVD is obtained from the macroblock vector by subtracting the vector of the preceding macroblock. For this calculation the vector of the preceding macroblock is regarded as zero in the following three situations:

1) Evaluating MVD for macroblocks 1, 12 and 23.
2) Evaluating MVD for macroblocks in which MBA does not represent a difference of 1.
3) TYPE3 of the previous macroblock was not MC.

MVD consists of a variable length codeword for the horizontal component followed by a variable length codeword for the vertical component. Variable length codes are given in Appendix 5.

Advantage is taken of the fact that the range of motion vector values is constrained. Each VLC word represents a pair of difference values. Only one of the pair will yield a macroblock vector falling within the permitted range.

Coded Block Pattern (CBP)   Variable length

CBP is present if indicated by TYPE3. The codeword gives a pattern number signifying those blocks in the macroblock for which transform coefficients are transmitted. The pattern number is given by

$$32*P_1 + 16*P_2 + 8*P_3 + 4*P_4 + 2*P_5 + P_6$$

where P_n is 1 if coefficients are present for block n, else 0. Block numbering is given in Figure 12.

The code table for CBP is given in Appendix 6.

2.2.4 Block Layer

A macroblock comprises four luminance blocks and one of each of the two colour difference blocks.

```
 -------        -------        -------
| 1 | 2 |      |       |      |       |
|-------|      |   5   |      |   6   |
| 3 | 4 |      |       |      |       |
 -------        -------        -------
    Y             CB             CR
```

Figure 12 Arrangement of blocks in a macroblock

Data for a block consists of codewords for transform coefficients followed by an end of block marker (Figure 13). The order of block transmission is as in Figure 12.

```
 --------------
| TCOEFF | EOB |
 --------------
```

Figure 13 Structure of Block Layer

Transform Coefficients (TCOEFF)

Transform coefficient data is always present for all 6 blocks in a macroblock when TYPE3 indicates INTRA. In other cases TYPE3 and CBP signal which blocks have coefficient data transmitted for them. The quantised transform coefficients are sequentially transmitted according to the sequence given in Appendix 7.

The most commonly occurring combinations of zero-run and the following value are encoded with variable length codes. Other combinations of (RUN, LEVEL) are encoded with a 20 bit word consisting of 6 bits ESCAPE, 6 bits RUN and 8 bits level. For the variable length encoding there are two code tables, one being used for the first transmitted coefficient in INTER and MC blocks, the other for all other coefficients except the first one in INTRA blocks.

Codes are given in Appendix 8.

For INTRA blocks the first coefficient is the transform dc value linearly quantised with a stepsize of 8 and no dead-zone. The resulting values are represented with 8 bits. A nominally black block will give 0001 0000 and a nominally white one 1110 1011. The code 1000 0000 is replaced by 1111 1111. (See Table 2)

Table 2 Quantiser for INTRA-mode DC component

FLC	Reconstruction level into inverse transform
0000 0001 (1)	8
0000 0010 (2)	16
0000 0011 (3)	24
.	.
.	.
0111 1111 (127)	1016
1111 1111 (255)	1024
1000 0001 (129)	1032
.	.
.	.
1111 1101 (253)	2024
1111 1110 (254)	2032

Note: The decoded value corresponding to FLC 'n' is 8n except FLC 255 gives 1024.

Coefficients after the last non-zero one are not transmitted. EOB (End of Block code) is always the last item in blocks for which coefficients are transmitted.

2.3 Multipoint considerations

Both switched and continuous presence multipoint are under study. The feasibility of the latter is increased by the two formats of CIF and QCIF together with the configuration of GOBs, which permit four QCIF sources to be combined into one CIF stream.

2.3.1 Freeze Picture Request

Causes the decoder to freeze its received picture until a picture freeze release signal is received or a timeout period has expired. The transmission method for this control signal and the timeout period are under study.

2.3.2 Fast Update Request

Causes the encoder to encode its next picture in INTRA mode with coding parameters such as to avoid buffer overflow. The transmission method for this control signal is under study.

2.3.3 Picture Freeze Release

A signal from an encoder which has responded to a Fast Update Request and causes a decoder to exit from its picture freeze mode and display decoded pictures in the normal manner. The transmission method for this signal is under study. (See § 2.2.1, TYPE1, Bit 3)

2.3.4 Data continuity

The protocol adopted for ensuring continuity of data channels in a switched multipoint connection is handled by the message channel. Under study.

3. **Transmission Coder**

3.1 Bit rate

The bit rate including audio and optional data channels is p*64 kbit/s where p is an integer between 1 and 30 both inclusive. Some codecs may have restrictions on the available values of p. Desirable values of p are 1, 2, 6, 24 and 30. The corresponding video rates are:

46.4 kbit/s	(64-16-FAS-BAS)
62.4 kbit/s	(64-FAS-BAS)
312.0 kbit/s	5*(64-FAS-BAS)
1435.2 kbit/s	23*(64-FAS-BAS)
1809.6 kbit/s	29*(64-FAS-BAS)

The codec output clock rate source shall be switchable between either a free running internal source or a source synchronised to the received data from the network. When in free running mode the tolerance on output clock rate will be +/- 50 ppm of nominal. When in synchronised mode the synchronism should be maintained when the frequency of the received data clock is within +/- 50 ppm of nominal.

Selection of free-running or synchronised mode will be performed manually at the encoder.

3.2 Video Data Buffering

Under study. The specification will cover both post-coding and pre-coding buffers. The effect on overall system delay will be considered.

When operating with CIF the number of bits created by coding any single picture must not exceed 256 Kbits.

When operating with QCIF the number of bits created by coding any single picture must not exceed 64 Kbits. This requirement is consistent with combining four QCIF sources into one CIF stream at a continuous presence type of multipoint unit.

In both the above cases the bit count includes the Picture Start Code and all other data related to that picture. K = 1024.

Encoder buffer overflow and underflow are not permitted. Underflow can be prevented by use of dummy block in the error corrector block framing. See Figure 14.

3.3 Video clock justification

Video clock justification is not provided.

3.4 Frame structure

3.4.1 Frame structure

The frame structure is defined in Recommendations H.221 and H.222.

3.4.2 Bit assignment in Application Channel

When the Application Channel is present, bits 17 to 80 are set to '0' until agreed otherwise.

3.4.3 Timeslot positioning

According to Recommendation I.431.

3.5 Audio coding

For p > 1, Recommendation G.722 56/48 kbit/s audio, 0/8 kbit/s data and 8 kbit/s service channel is used in the first timeslot (primary rate interface) or channel (ISDN basic access).

For p = 1 the decoder may disregard the 16 kbit/s assigned for audio in the first two bits of each octet.

The delay of the encoded audio relative to the encoded video at the channel output is under study.

3.6 Data transmission

For p>2 one or more timeslots may be allocated as data channels of 64 kbit/s each. The first channel uses the fourth timeslot of a primary rate interface.

Positioning of the other channels, and possible restrictions on availability at lower overall bit rates are under study. The BAS codes used to signal that these data channels are in use are specified in Recommendation H.221.

3.7 Forward Error Correction for Coded Video Signal

3.7.1 Error correcting code

Double error correcting BCH(511,493).

3.7.2 Generator polynomial

$g(x)=(x^9+x^4+1)(x^9+x^6+x^4+x^3+1)$

3.7.3 ECC bits transmission

Independent framing is used with multiframe of 8 frames, where a 512-bit frame consists of 1-bit framing, 493-bit data and 18-bit ECC (Error Correcting Code). The frame alignment pattern is

$(S_0S_1S_2S_3S_4S_5S_6S_7)=(0001101X)$, where X is a reserved bit for future multiframe use and set to 1. See Figure 14 for the frame arrangement. Note that the ECC is calculated against the 493-bit including Fill Indicator.

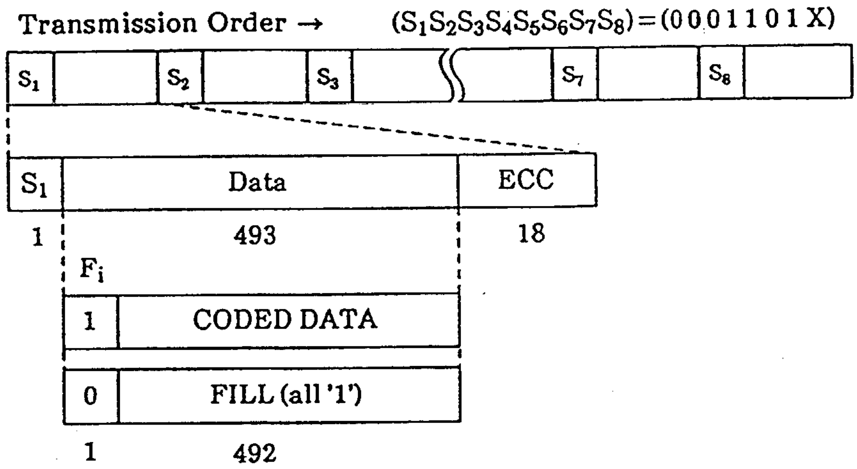


Figure 14 Error correcting frame

3.8 Encryption

3.9 Bit Sequence Independence Restrictions

3.10 Network interface

Access at the primary rate is with vacated timeslots as per Recommendation I.431.

For 1544 kbit/s interfaces the default H0 channel is timeslots 1 to 6.

For 2048 kbit/s interfaces the default H0 channel is timeslots 1-2-3-17-18-19.

Interfaces using ISDN basic access - Recommendation I.420.

END

Specification for Inverse DCT

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

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

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

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

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

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

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

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

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

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

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

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

Quantizers

The uniform quantizer is defined by a step g and the threshold T. In this specification, T=g.

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

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

Taking into account the negative values the expression becomes:

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

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

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

with q_{dec} the decision level

q_{rep} the representation level

g the quantizer stepsize

T threshold

The quantiser assignment table of Figure 4 is programmed so that the selected quantiser is used for all coefficients except the dc coefficient in INTRA coded blocks.

Appendix 3/Annex 4 to Doc. #540R

Codeword for QUANT1/QUANT2

Codeword for QUANT1/QUANT2 is natural binary representation of its value.

g = 2x(1+QUANT)
g: quantizer step size
QUANT: 1 to 31, as transmitted in QUANT1 or QUANT2

Note that '0000 0' is never used for QUANT1 or QUANT2.

Appendix 4/Annex 4 to Doc. #540R **VLC Table for Macroblock Addressing**

MBA	CODE
1	1
2	011
3	010
4	0011
5	0010
6	0001 1
7	0001 0
8	0000 111
9	0000 110
10	0000 1011
11	0000 1010
12	0000 1001
13	0000 1000
14	0000 0111
15	0000 0110
16	0000 0101 11

MBA	CODE
17	0000 0101 10
18	0000 0101 01
19	0000 0101 00
20	0000 0100 11
21	0000 0100 10
22	0000 0100 011
23	0000 0100 010
24	0000 0100 001
25	0000 0100 000
26	0000 0011 111
27	0000 0011 110
28	0000 0011 101
29	0000 0011 100
30	0000 0011 011
31	0000 0011 010
32	0000 0011 001
33	0000 0011 000
Stuffing	0000 0001 111
Start code	0000 0000 0000 0001

Appendix 5/Annex 4 to Doc. #540R **VLC Table for MVD**

MVD	CODE
-16 & 16	0000 0011 001
-15 & 17	0000 0011 011
-14 & 18	0000 0011 101
-13 & 19	0000 0011 111
-12 & 20	0000 0100 001
-11 & 21	0000 0100 011
-10 & 22	0000 0100 11
-9 & 23	0000 0101 01
-8 & 24	0000 0101 11
-7 & 25	0000 0111
-6 & 26	0000 1001
-5 & 27	0000 1011
-4 & 28	0000 111
-3 & 29	0001 1
-2 & 30	0011
-1	011
0	1
1	010
2 & -30	0010
3 & -29	0001 0
4 & -28	0000 110
5 & -27	0000 1010
6 & -26	0000 1000
7 & -25	0000 0110
8 & -24	0000 0101 10
9 & -23	0000 0101 00
10 & -22	0000 0100 10
11 & -21	0000 0100 010
12 & -20	0000 0100 000
13 & -19	0000 0011 110
14 & -18	0000 0011 100
15 & -17	0000 0011 010

Appendix 6/Annex 4 to Doc. #540R **VLC Table for CBP**

CBP	CODE	CBP	CODE
60	111	35	0001 1100
4	1101	13	0001 1011
8	1100	49	0001 1010
16	1011	21	0001 1001
32	1010	41	0001 1000
12	1001 1	14	0001 0111
48	1001 0	50	0001 0110
20	1000 1	22	0001 0101
40	1000 0	42	0001 0100
28	0111 1	15	0001 0011
44	0111 0	51	0001 0010
52	0110 1	23	0001 0001
56	0110 0	43	0001 0000
1	0101 1	25	0000 1111
61	0101 0	37	0000 1110
2	0100 1	26	0000 1101
62	0100 0	38	0000 1100
24	0011 11	29	0000 1011
36	0011 10	45	0000 1010
3	0011 01	53	0000 1001
63	0011 00	57	0000 1000
5	0010 111	30	0000 0111
9	0010 110	46	0000 0110
17	0010 101	54	0000 0101
33	0010 100	58	0000 0100
6	0010 011	31	0000 0011 1
10	0010 010	47	0000 0011 0
18	0010 001	55	0000 0010 1
34	0010 000	59	0000 0010 0
7	0001 1111	27	0000 0001 1
11	0001 1110	39	0000 0001 0
19	0001 1101		

Appendix 7/Annex 4 to Doc. #540R

Transmission Order for Transform Coefficients

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

 VLC Table for TCOEFF

The most commonly occurring combinations of zero-run and the following value are encoded with variable length codes as listed in the table below. End of Block (EOB) is in this set. Because CBP indicates those blocks with no coefficient data, EOB cannot occur as the first coefficient. Hence EOB can be removed from the VLC table for the first coefficient.

The last bit 's' denotes the sign of the level, '0' for +ve and '1' for -ve.

RUN	|LEVEL|	CODE
EOB		10
0	1	1s IF FIRST COEFFICIENT
0	1	11s NOT FIRST COEFFICIENT
0	2	0100 s
0	3	0010 1s
0	4	0000 110s
0	5	0010 0110 s
0	6	0010 0001 s
0	7	0000 0010 10s
0	8	0000 0001 1101 s
0	9	0000 0001 1000 s
0	10	0000 0001 0011 s
0	11	0000 0001 0000 s
0	12	0000 0000 1101 0s
0	13	0000 0000 1100 1s
0	14	0000 0000 1100 0s
0	15	0000 0000 1011 1s
1	1	011s
1	2	0001 10s
1	3	0010 0101 s
1	4	0000 0011 00s
1	5	0000 0001 1011 s
1	6	0000 0000 1011 0s
1	7	0000 0000 1010 1s
2	1	0101 s
2	2	0000 100s
2	3	0000 0010 11s
2	4	0000 0001 0100 s
2	5	0000 0000 1010 0s
3	1	0011 1s
3	2	0010 0100 s
3	3	0000 0001 1100 s
3	4	0000 0000 1001 1s
4	1	0011 0s
4	2	0000 0011 11s
4	3	0000 0001 0010 s
5	1	0001 11s
5	2	0000 0010 01s
5	3	0000 0000 1001 0s

6	1	0001 01s
6	2	0000 0001 1110 s
7	1	0001 00s
7	2	0000 0001 0101 s
8	1	0000 111s
8	2	0000 0001 0001 s
9	1	0000 101s
9	2	0000 0000 1000 1s
10	1	0010 0111 s
10	2	0000 0000 1000 0s
11	1	0010 0011 s
12	1	0010 0010 s
13	1	0010 0000 s
14	1	0000 0011 10s
15	1	0000 0011 01s
16	1	0000 0010 00s
17	1	0000 0001 1111 s
18	1	0000 0001 1010 s
19	1	0000 0001 1001 s
20	1	0000 0001 0111 s
21	1	0000 0001 0110 s
22	1	0000 0000 1111 1s
23	1	0000 0000 1111 0s
24	1	0000 0000 1110 1s
25	1	0000 0000 1110 0s
26	1	0000 0000 1101 1s
ESCAPE		0000 01

The remaining combinations of (RUN, LEVEL) are encoded with a 20 bit word consisting of 6 bits ESCAPE, 6 bits RUN and 8 bits LEVEL.

RUN is a 6 bit fixed length code

0	0000 00
1	0000 01
2	0000 10
.	.
.	.
63	1111 11

LEVEL is an 8 bit fixed length code

-127	1000 0001	
.	.	
.	.	
-2	1111 1110	
-1	1111 1111	
0	0000 0000	FORBIDDEN
1	0000 0001	
2	0000 0010	
.	.	
127	0111 1111	

Flexible Hardware Connection Experiment Plans

	Name	Organization	Place	Date	Connection	Bit rate, Format, etc	Remarks
1	F.May J.Speidel	AEG PKI	Ulm - Nurnberg	September	First back-to-back,if successful : ISDN	64kbit/s speech + 64kbit/s video CIF and QCIF	
2	M.Carr J.Speidel	BTRL PKI	Martlesham - Nurnberg	September	2Mbit/s point-to-point satellite	px64kbit/s CIF and QCIF	
3	G.Eude J.Guichard	CNET	Paris or Greno-ble	October	1B switched Network (TRANSCOM*) X.21 interface	2x64kbit/s,QCIF around 10frames/sec	No FEC Simplified H.221 on audio channel
4	W.Hubers B.Schuurink	PTT-RNL, (IMAGIN Project)	RNL - Leid-schendam	(End of) September	H.120, HDB3 inter-face	64kbit/s CIF	IMAGIN CODEC: CNET,CSELT,FI/DBP, PTT-RNL and STA, DOC.#526
5	B.Haskell	AT&T,Bellcore PictureTel VideoTelecom CLI,BT,KDD	Lincroft,NJ - BTRL - KDD	September - October	Basic ISDN 2B+D	around 48kbit/s ? around 64kbit/s ? around 112kbit/s QCIF	DOC.#538
6	B.Haskell Y.Hatori	AT&T,Bellcore PictureTel VideoTelecom CLI,KDD,NTT	Lincroft,NJ - Kamifukuoka	from mid-September	International ISDN	64-128kbit/s QCIF	
7	M.Carr Y.Hatori	BT KDD NTT	Ipswich - Kam-ifukuoka	from mid-September	International leased-line, international ISDN (if possible)	64kbit/s-1.5Mbit/s CIF,QCIF	
8	Y.Hatori	Japanese Organiza-tions**	KDD Kami-fukuoka Labs., each Lab.	Aug.25-end of September	back-to-back ISDN basic access (2B+D)	All rates All formats	

*TRANSCOM is available for connections with UK at 64kbit/s and with the US at 56kbit/s (ACCUNET)

**Japanese Organizations:NTT,KDD,NEC,FUJITSU,MATSUSHITA Comm., HITACHI,TOSHIBA,MITSUBISHI,SONY,OKI,GCT and SHARP

ITEMS TO BE STUDIED FURTHER TOWARD THE FINAL RECOMMENDATION

Note: § l.m.n corresponds to the section number of the px64 kbit/s Flexible Hardware specification (Annex 4 to Doc. #540R).

1. Source Coding

   1.1 Definition of video decoding capability (§ 1.1)
      - combination of format/temporal resolution/transfer rate
      - maximum picture rate with DSP oriented architecture taken into account

   1.2 Through what channels negotiation, invocation and indication should be carried out?

   1.3 Quantizer assignment (Fig. 4/§ 1.2.5)

2. Video Multiplex Coding

   2.1 Some description is necessary in § 2.1.
   2.2 Start code emulation (§ 2.2.1)
   2.3 Bit 5 to 13 in TYPE1 (§ 2.2.1)
   2.4 Bit 1 to 6 in TYPE2 (§ 2.2.2)
   2.5 Reduction of Picture/GOB Header bits (§ 2.2.1, § 2.2.2)
   2.6 Freeze Picture Request: transmission method and time out period (§ 2.3.1)
   2.7 Fast Update Request: transmission method (§ 2.3.2)
   2.8 Data continuity (§ 2.3.4)
   2.9 Provision for future improvements at higher bit rates

3. Transmission Coding

   3.1 Bit rates - values of p (§ 3.1, corresponding to H.221, AV242)
   3.2 Indication of synchronous/asynchronous network (§ 3.1)
   3.3 Video data buffering - data generation rate at the coder (§ 3.2)
   3.4 Bit assignment in Application Channel (§ 3.4.2)
   3.5 Delay compensation between video and audio (§ 3.5)
   3.6 Restriction of data channel availability at lower bit rates (§ 3.6)
   3.7 Lock-up time of the error correction frame (§ 3.7.3)
   3.8 Encryption (§ 3.8)
   3.9 BSI restrictions (§ 3.9)
      - 56 kbit/s vs 64 kbit/s
      - One's density at 384 kbit/s etc.

4. Performance of the codec

   4.1 Picture quality against motion pictures and still pictures
   4.2 Transmission error sensitivity
   4.3 Processing delay
   4.4 Delay difference between video and audio
   4.5 Picture build-up following a source change

END