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

Document #255
Oct. 1987

Source: NTT,KDD, NEC and FUJITSU
Title : ACCURACY OF DCT CALCULATION

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1. Introduction

Document #222 describes that accuracy of DCT calculation in the current Flexible Hardware is redundant from picture quality view point. First, this document shows the minimum accuracy of forward and inverse DCT which does not degrade image quality. This document also describes about the effect of 'mismatch' between accuracy of encoder's inverse DCT calculation and decoder's one. Finally, discussion points are suggested on the specification of transform circuits.

2. Approximation of DCT calculation

An example of DCT calculation accuracy in the first Flexible Hardware is shown in Fig.1.

The first figure in each bracket represents bit length above the binary point, and the second one represents fractional bit length below the point. According to Doc.#222, this specification is more than enough, that is, the accuracy with (2.10)bit for transform matrix elements and the (11.1)bit accuracy for data transfer from vertical to horizontal transform calculation are sufficient for the purpose of encoding video conference sequences. Moreover, it is shown that the 16 bit accuracy i.e.(10.6) is enough for Multiplication results. In

Fig.2, these are summarized.

Multiplication results are approximated to 16 bit data accuracy by round-off. In hardware implementation, it is easy to carry out rounding by connecting the 17th(LSB/2) bit to Adder's carry-in.

3. Mismatch Experiments

Simulation result of mismatch experiment is given in Fig.3. The encoder calculates DCT with minimum specification shown in Section 2, and multiplication results in the decoder are approximated to 14-, 15- or 17-bit accuracy in the decoder. SNR values are shown as a function of the number of coded pictures. This simulation was using RM4 with quantization characteristics fixed at (4,4). The first frame is not coded (start with the original picture). 'Checked Jacket' was used repeatedly.

When mismatch exists, the SNR value of decoded pictures degrades as the number of decoded frame increases. Even if the accuracy in inverse DCT calculation at the decoder is higher than that at the encoder, more or less mismatch causes visible distortion. Therefore, cyclic refresh is needed basically, and the refresh speed should be faster than the rate of picture quality degradation.

4. Discussion points for the specification of Transform circuits

Following points should be discussed on the inverse DCT

calculation for the specification of transform circuits.

*Should two-dimensional transform be separated to vertical and horizontal transform and cascaded?

*Standard matrix approach or fast algorithms?

*If different algorithms are used, what will be the minimum specification for accuracy in transform calculation?

Judging from the mismatch experiment above, it seems at the moment that different accuracy between the two inverse-transform operations at the encoder and decoder, if it even exist, will produce visible distortion.

5. Conclusion

Minimum specification when mismatch does not exist is shown in Fig.2. A combination of 12-, 12- and 16-bit accuracy is sufficient for transform matrix elements, transfer data and Multiplication result, respectively. Approximation should be carried out by round-off.

If mismatch exists, for example different algorithms and/or different accuracy are employed between encoders and decoders, even high accuracy will not help because degradation becomes visible within several seconds. Further study is needed about the mismatch problem.

(VTR demonstration follows.)

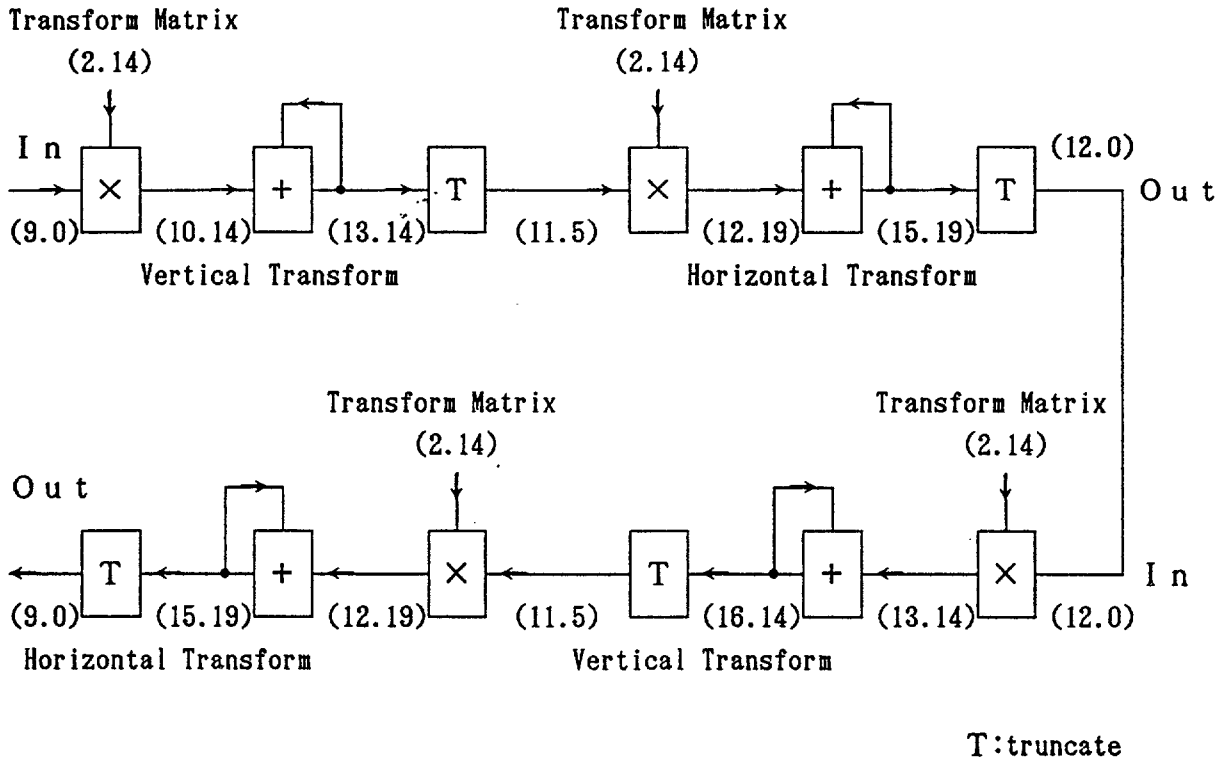

FIG.1 Flexible Hardware:

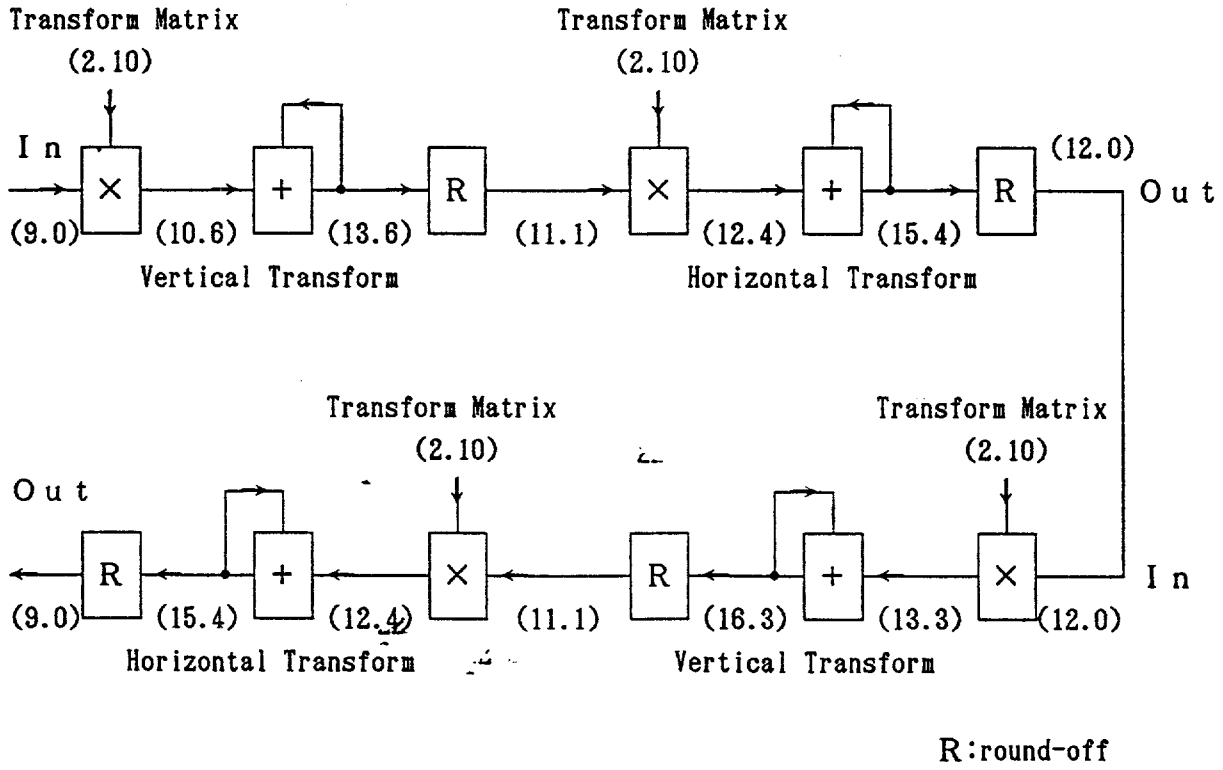

FIG.2 Minimum Specification:

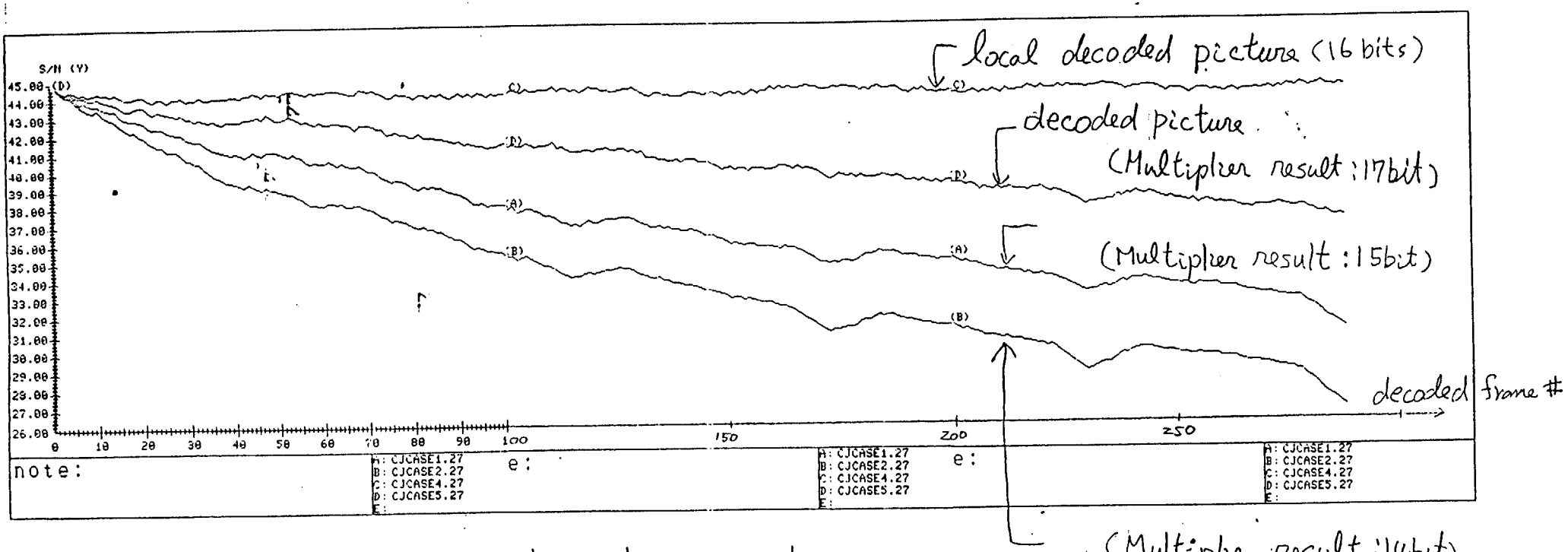

FIG3 : SNR degradation when mismatch occures