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.INTRODUCTION

In previous documents, methods to ensure compatibility between codecs implemented with different inverse discrete cosine transform (IDCT) algorithms were investigated. Document number 281 proposed defining a maximum allowable amount of mismatch between encoder and decoder, as well as minimum amount of refresh in order to control the accumulation of error. Document number 284 proposed determining the refresh cycle using an analytical analysis of mismatch error. The purpose of this paper is to report on test results which extend the analysis of previous documents by

1. Examining mismatch error using not only matrix IDCT algorithm, but also a fast IDCT algorithm.
2. Verifying that mismatch error accumulation varies greatly with parameters such as quantizer step size.

2.FAST INVERSE COSINE TRANSFORM [1]

Previous documents conducted studies using a matrix IDCT and varying the bit precision. Here simulation is conducted to determine how well the results hold for an actual Fast IDCT algorithm. A flowgraph of the one-dimensional fast IDCT algorithm used is shown in Figure 1. The bit precision at every location is indicated in the figure using the following notation:

([bits above the binary point].[bits below the binary point])

The results of every calculation are rounded to the nearest LSB. All coefficients, including those described in Figure 2, are re presented with 16 bits. The two-dimensional version is realized as shown in Figure 3. The mismatch error (MME) of this algorithm computed according to method of Document number 281 is 0.02.

3.SIMULATION

Simulation was conducted using RM4 with the baseline IDCT of Document 281 in the encoder. The following three algorithms were used as the decoder's IDCT algorithm:

1. The above fast IDCT (FAST)
2. The baseline IDCT of Document 281 with precision reduced to 12 bits (12.0) between one-dimensional transforms (MATRIX,N=12)
3. The baseline IDCT of Document 281 (MATRIX,N=16)

The third algorithm corresponds to the case of no mismatch between encoder and decoder.

The three second scene "Trevor" was repeated (forward, backward, forward, backward, forward) a total of five times to generate a fifteen second sequence and coded at 10 frames per second. A frame from the original sequence was placed in the frame memories of encoder and decoder before coding.

Figure 4 shows the results of coding the above sequence at a bit rate of 768 Kbps. Because of their similiarity, the results of the fast IDCT and the bit reduced baseline IDCT are plotted separately against the no mismatch case for clarity. For both cases the SNR loss due to using the mismatched IDCT grows to about 1 dB in 15 seconds (fast-IDCT : 1.15 dB loss, 12-bit baseline : 1.05 dB loss).

Coding the same sequence at a rate of 384 Kbps produces the results shown in Figure 5. Here the SNR loss is a mere 0.09 dB for the fast-IDCT case and 0.03 dB for the 12-bit baseline case.

3.1 Fast-Algorithm vs. 12-bit Baseline Algorithm

The above results are at first glance somewhat counter-intuitive. Namely, an examination of mismatch error (MME) calculations for each algorithm (based on the method described in Document number 281) shown in Figure 6 reveal that the MME of the fast-IDCT algorithm is three times less. Inspite of this the SNR loss in Figures 4 and 5 is roughly the same for both algorithms.

Figure 7 which plots the distortion between the locally decoded signal and the decoded signal indicates that initially distortion is less for the fast-IDCT decoder, but that error tends to accumulate at a faster rate.

The fact that initially distortion is less for the fast-IDCT case reconciles the apparent disparity between MME and SNR loss figures; however it is not fully understood why the error due to the fast algorithm accumulates faster. It is thought that perhaps the uneven pixel-by-pixel MME characteristics of the fast-algorithm (see Figure 7) may cause error to accumulate at a faster rate.

3.2 Quantizer Dependent Performance

One other observation based on these simulation results supports statements from previous documents that the mismatch effect slowly appears if a coarse quantizer is used. At a bit rate of 768 Kbps (average quantizer step = 7.7) the SNR loss for both algorithms grows to about 1 dB, while at a bit rate of 384 Kbps (average quantizer step = 15.2) the SNR loss is negligible.

4. SUMMARY

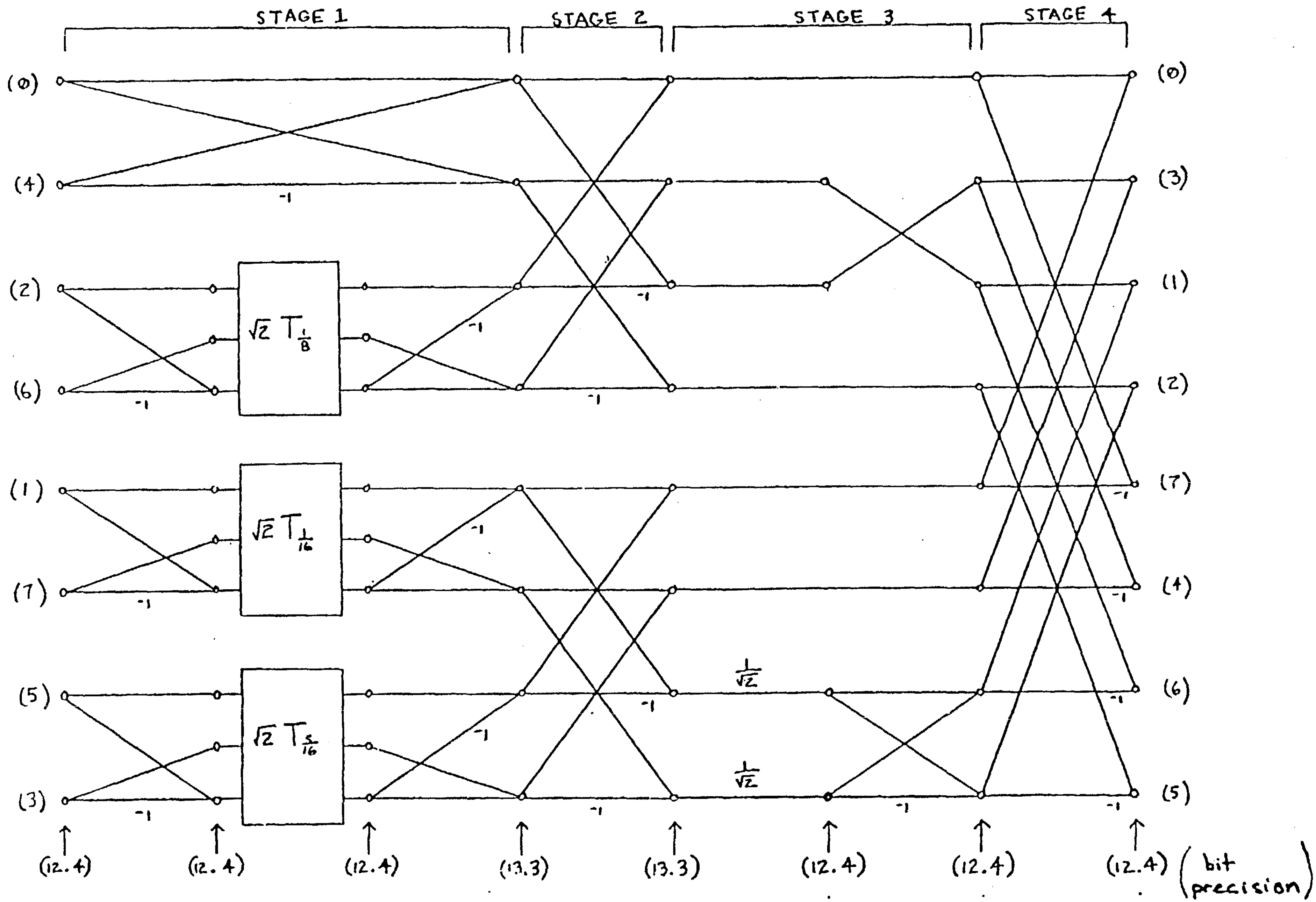
Although further study is needed two conclusions are suggested from the above discussion.

1. The way in which mismatch error is accumulated may vary significantly from algorithm to algorithm (particulary when comparing matrix- and fast-IDCT algorithms), thus MME alone may not completely specify how error accumulates

in the decoder.
2. Quantizer step size can have a great effect on the appearance and accumulation of MME.

(1) N.Suehiro, M.Hatori, "Fast Algorithm for the DFT and DCT", Tech Rep of IECE, IE85-4, 1985

FIGURE 1: FAST INVERSE COSINE TRANSFORM (1-DIM)



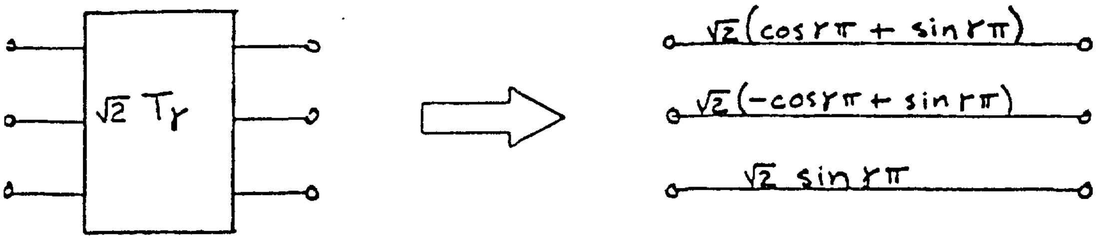


FIGURE 2: REPRESENTATION OF TRIGONOMETRIC COEFFICIENTS IN FIGURE 1

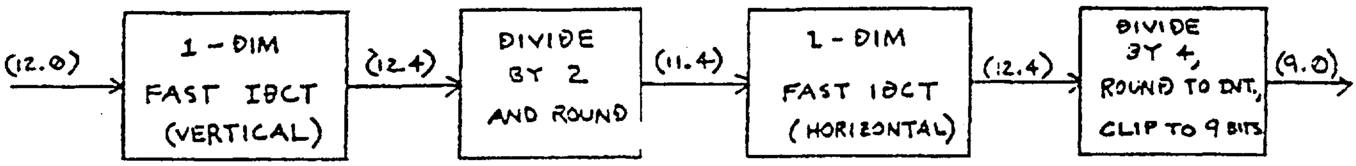
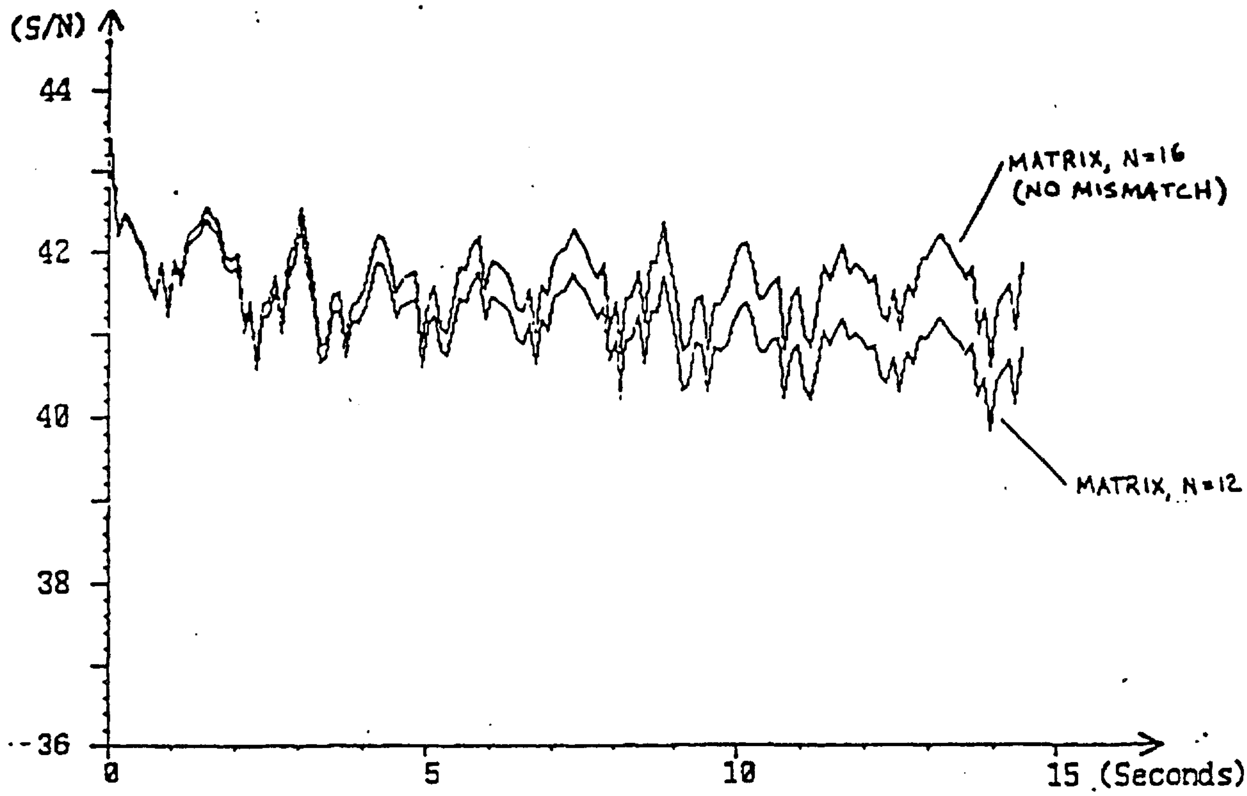


FIGURE 3: IMPLEMENTATION OF 2-DIMENSIONAL INVERSE TRANSFORM AND BIT PRECISION BETWEEN STAGES



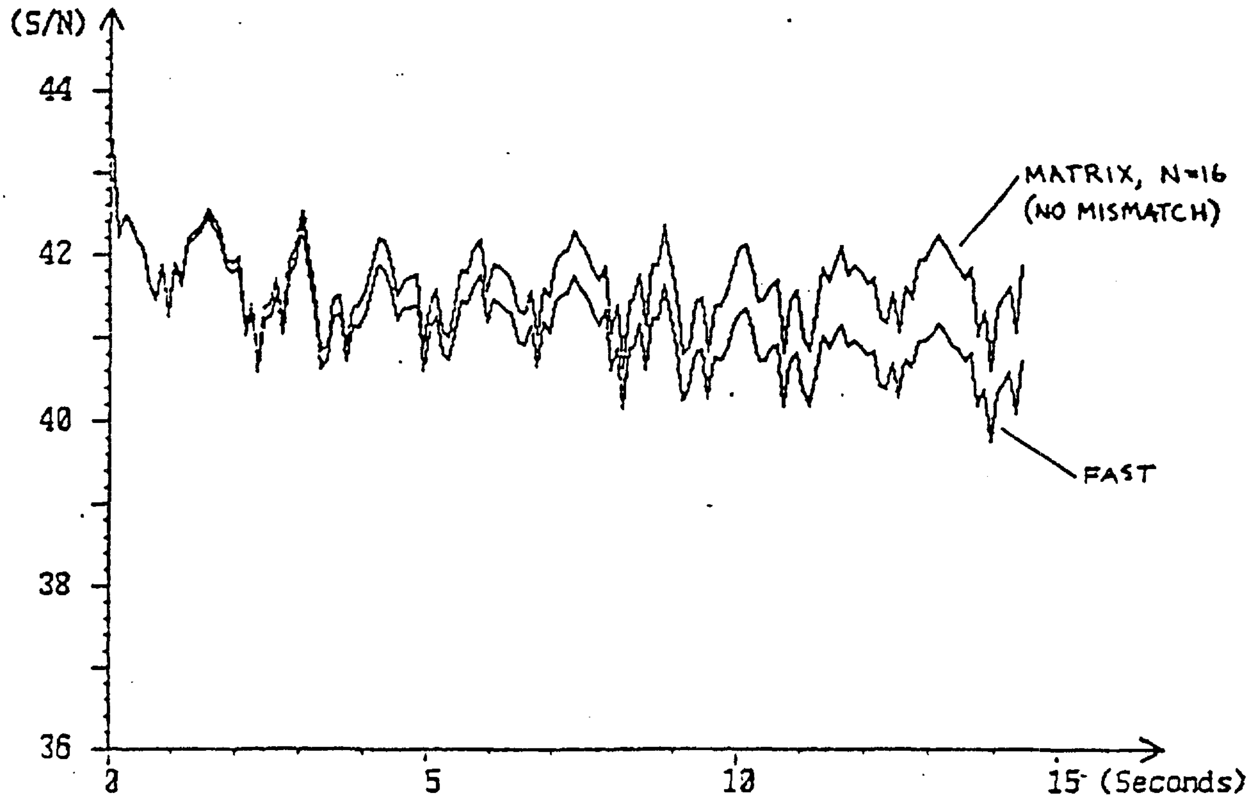
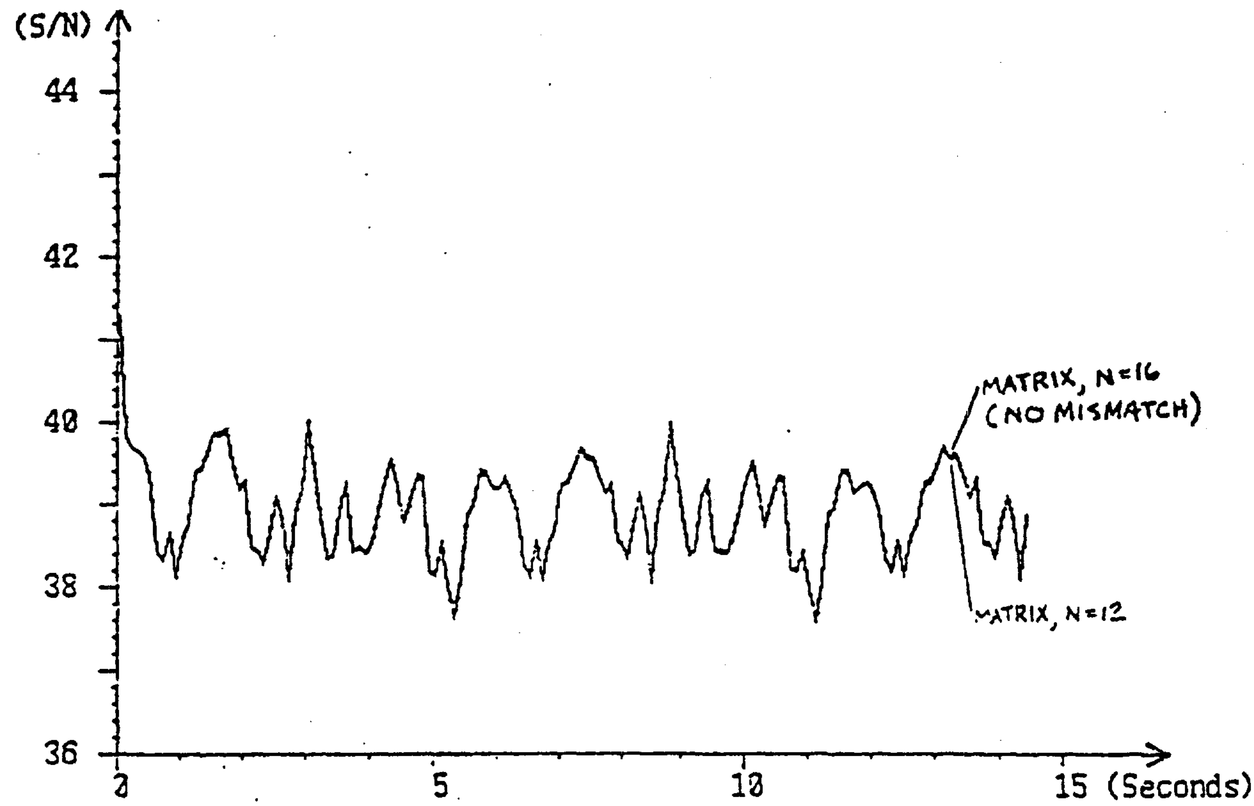


FIGURE 4: DISTORTION (BETWEEN DECODED AND ORIGINAL SIGNALS) VS. TIME (BIT RATE = 768 Kbps)



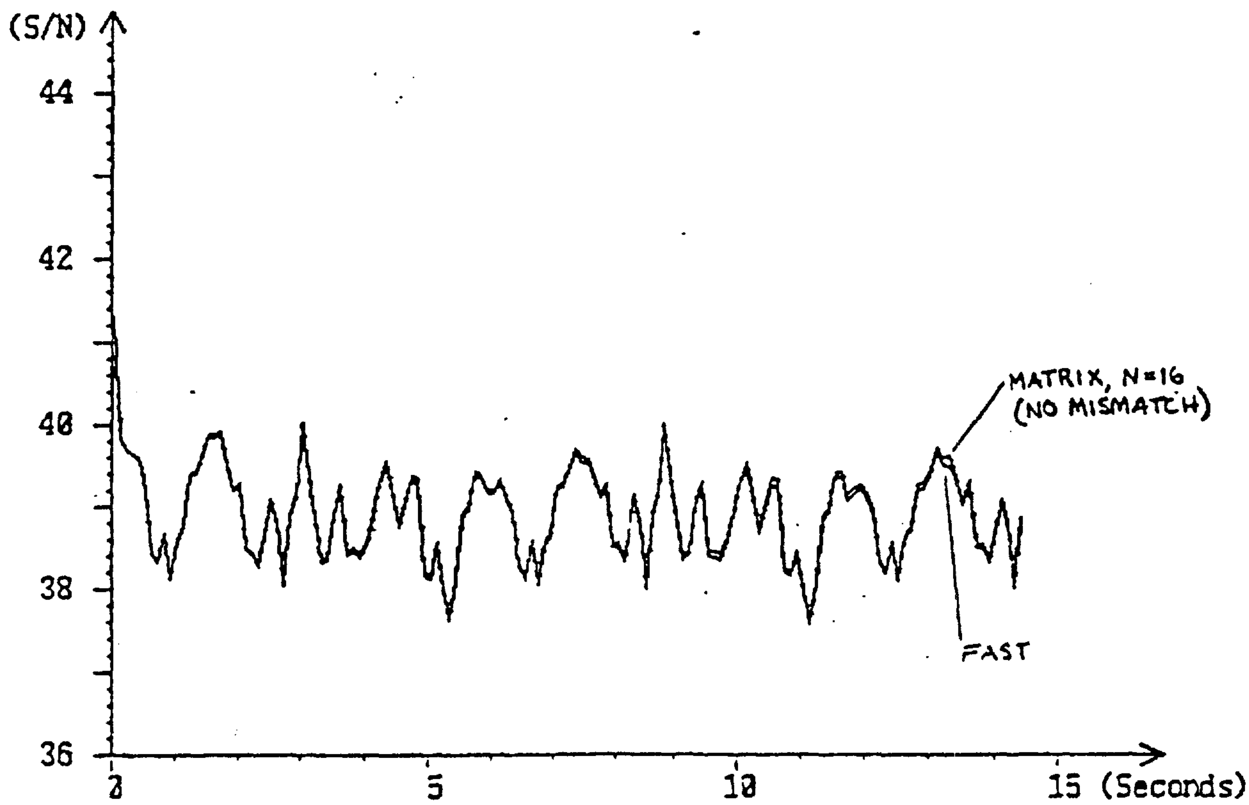


FIGURE 5: DISTORTION (BETWEEN DECODED AND ORIGINAL SIGNALS)
VS. TIME (BIT RATE = 384 Kbps)

MME (PIXEL-BY-PIXEL BASIS)							
0.06	0.05	0.06	0.05	0.06	0.05	0.06	0.05
0.06	0.05	0.06	0.03	0.05	0.06	0.06	0.06
0.05	0.05	0.05	0.06	0.06	0.05	0.05	0.06
0.06	0.06	0.05	0.05	0.05	0.06	0.05	0.06
0.06	0.05	0.06	0.05	0.05	0.05	0.06	0.06
0.06	0.06	0.05	0.06	0.06	0.06	0.05	0.05
0.06	0.06	0.05	0.03	0.06	0.06	0.06	0.05
0.05	0.05	0.06	0.05	0.06	0.05	0.06	0.05

OVERALL MME = 0.06 (MATRIX, N=12)

MME (PIXEL-BY-PIXEL BASIS)							
0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.06	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02

OVERALL MME = 0.02 (FAST IDCT)

FIGURE 6: MISMATCH ERROR (MME)

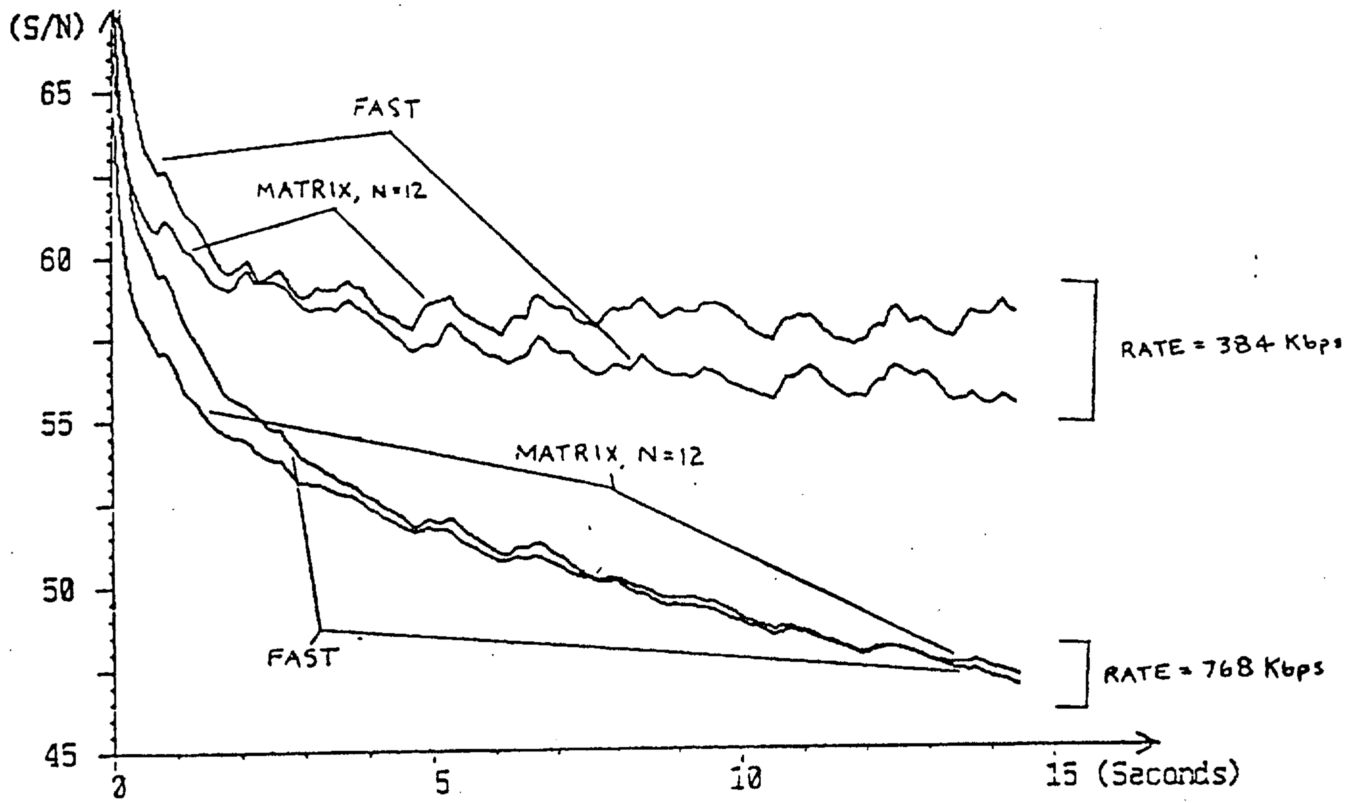


FIGURE 7: ACCUMULATION OF ERROR BETWEEN DECODED SIGNAL AND LOCAL DECODED SIGNAL