COMMITTEE T1
CONTRIBUTION

Document Number: T1A1.5/94-103

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STANDARDS PROJECT: Analog Interface Performance Specifications for Digital Video Teleconferencing/Video Telephony Service

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TITLE: VTC Hypothetical Reference Circuit Signal to Noise Ratio Measurements

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ISSUE ADDRESSED: Analog Objective Measures

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DATE: 17 Jan 1994

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DISTRIBUTION TO: T1A1.5

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KEYWORDS: Video Quality, Video Performance Specifications, Objective Quality, Subjective Quality

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DISCLAIMER: This contribution references specific vendors' video test equipment. This is not intended to be an endorsement of any particular vendor's products.

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1. Introduction

The signal to noise ratio (SNR) (as measured using traditional analog test waveforms) was mentioned in a recent meeting of the T1A1.5 Objective Test Ad Hoc Group as a candidate objective video quality measurement. Inclusion of this traditional measurement in the data analysis will provide a useful baseline against which the other proposed objective measurements can be compared. Therefore, the Institute for Telecommunication Sciences has measured the SNR of the twenty-five hypothetical reference circuits (HRCs). This contribution discusses the method of measurement used to obtain the SNR values and reports the SNR found for each of the twenty-five HRCs.

2. Method of Measurement

2.1 Data Collection

The SNR was measured using a flat field (55 IRE gray). The section of gray used was before the colorbar signal near the beginning of the tape (Betacam SP), and was processed by all twenty-five HRCs. A video line through the center of the screen was used. The video line can be selected using a video line selector as seen in Figure 1.
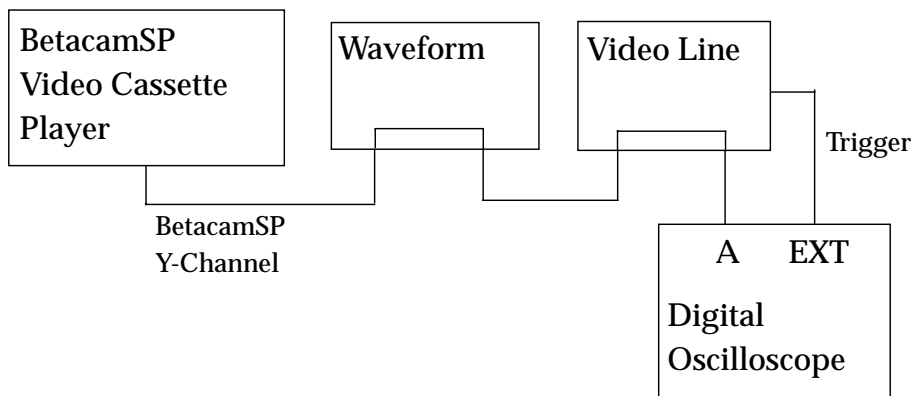
Figure 1   Laboratory test configuration.

The oscilloscope accumulated data in four 512-sample registers (R0-R3). It was set to accumulate a sample from the selected line (Tektronix 1730 waveform monitor field 1: line 141) in four consecutive frames while the player was in play mode.

The oscilloscope was set as follows:

2 μs/div ~ 25 MHz (512 samples over 10 divisions)

200 mV/div

DC coupling

Ext Trigger

Trigger Delay: 20 μs

The trigger delay was adjusted such that the center third of the video line was accumulated.

The data accumulated in the four registers (R0-R3) was then transferred to an ascii data file on a PC. Thus, there were a total of 100 data files for the 25 HRCs. An additional four data files were obtained by sampling the output of a 10-bit signal generator. The sampled data was used to calculate the signal to noise ratio of the 26 video systems as discussed in the next section.

2.2 Calculation of Unweighted SNR

Each data file was filtered in the frequency domain by the NTC7 unweighted filter response shown in Figure 2. The average variance ($\sigma^2_{(s+n)}$) over the four data files for each HRC was calculated and its square root was used to calculate the unweighted SNR as indicated in Ref. [1]. [Note: The difference between the weighted and unweighted SNR calculation is simply the application of a weighting function on the data in the weighted case. This will be given in Section 2.3.] The equation for the SNR calculation is given in Ref. [1] as

$$\text{Signal-to-weighted noise (dB)} \quad = \quad 20 \ \log_{10} \frac{\text{P-P signal amplitude}}{\text{RMS weighted noise}} \tag{1}$$

The nominal peak-to-peak amplitude of the *luminance* signal is given in Ref. [1] as 100 IRE (100 IRE = 714 mV). The method of measurement given in Ref. [1] includes a 10 kHz highpass filter which ensures the noise to be measured is zero mean. Thus, the variance, $\sigma^2_{(s+n)}$, of the signal + noise taken from a quiet video line of constant signal value is equivalent to the square of the RMS of the noise. Because the data was processed in the digital domain the mean was removed during the variance operation [see equation (5)] and the 10 kHz filter was not implemented. For this case,

$$\sigma_{(s+n)} = \sigma_n = \text{RMS}_n \tag{2}$$

Hence the equation for the SNR becomes

$$SNR \ = \ 20 LOG_{10} \left(\frac{714 \ \text{mV}}{\sigma_{(s+n)} \ \text{mV}} \right), \tag{3}$$

where

$$\sigma_{(s+n)} = \left(\frac{1}{4} \sum_{j=1}^{4} \sigma_j^2 \right)^{1/2} , \tag{4}$$

and

$$\sigma_j^2 = \frac{1}{512} \sum_{i=1}^{512} \hat{x}_{ij}^2 - \left(\frac{1}{512} \sum_{i=1}^{512} \hat{x}_{ij} \right)^2 . \tag{5}$$

$\hat{x}_{ij}$ are the filtered data samples from each measured line of video. That is

$$\hat{x}(t) = \Im^{-1} \{ \Im \{ x(t) \} \cdot |H(f)| \} , \tag{6}$$

where $\Im \{ \bullet \}$ indicates the Fourier transform operation and x_{ij} denotes the ith pixel of the video line measured from the jth frame. $|H(f)|$ is shown in Figure 2.

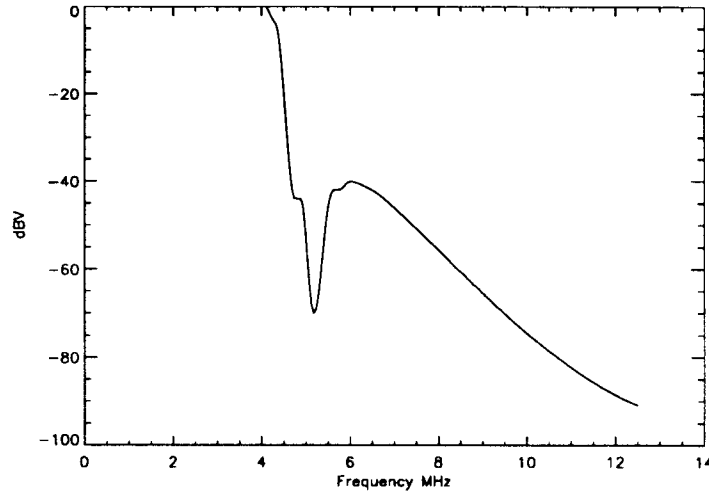

Figure 2 |H(f)| - NTC7 Unweighted Filter Response Ref. [2].

2.3 Calculation of Weighted SNR

The calculation of the weighted SNR is identical to that for the unweighted SNR except that the data is weighted (filtered) in the frequency domain using both the NTC7 filter shown in Figure 2 and the weighting function given in Ref. [1] and shown in Figure 3.
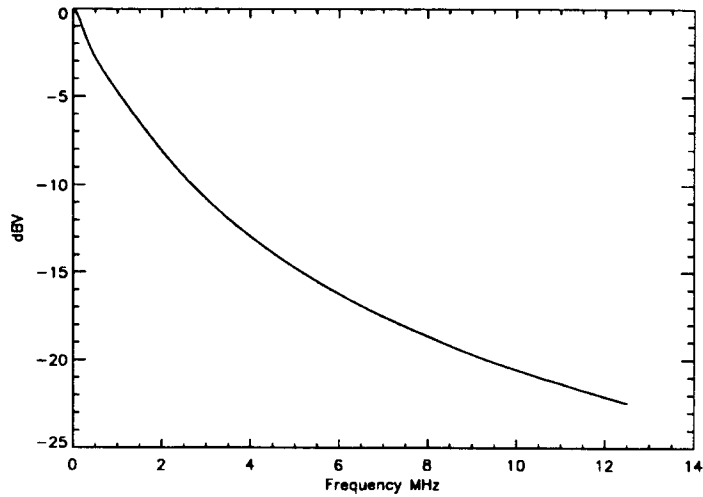
Figure 3   Random Noise Weighting Network Response

3. Results

The data shown in Table 1 are the SNRs calculated for each HRC. Included here is the SNR for the signal from a 10-bit signal generator for comparison. The advertised specification for Betacam SP is "More than 51 dB" for luminance (component IN/OUT) and "More than 53 dB" for Chrominance. The data shown are taken from the luminance signal.

Table 1: HRC Signal to Noise Ratio

HRC	SNR Unweighted	SNR Weighted
1	44.77	53.12
2	44.51	53.82
3	44.81	54.57
4	45.80	54.55
5	44.54	52.04
6	44.13	53.43
7	44.85	53.86
8	45.39	54.88

Table 1: HRC Signal to Noise Ratio (Continued)

HRC	SNR Unweighted	SNR Weighted
9	45.45	54.32
10	44.46	52.99
11	45.20	53.64
12	44.96	54.63
13	45.33	54.24
14	45.38	54.93
15	45.35	53.43
16	45.05	54.09
17	45.29	54.37
18	45.41	55.05
19	44.56	52.59
20	44.34	51.24
21	45.00	54.00
22	44.60	53.98
23	44.80	53.22
24	45.49	54.49
25	44.66	53.25
Signal Generator Pedestal (10 bits)	50.49	59.61

4. References

[1]   E.B. Crutchfield, Ed., National Association of Broadcasters Engineering Handbook, Seventh Edition, Washington, DC: National Association of Broadcasters,1985, pp. 4.1-38 to 4.1-40.

[2]   Tektronix Television Products 1990-1991, Beaverton, Oregon: Tektronix, Inc., 1990, page 11.