MEASURING THE PERFORMANCE OF TELEMETRY VIDEO CODECS

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The Range Commanders Council has recently approved standard RCC 209-88 which defines the compression algorithms and communications frame structure for telemetry video coders. The compression algorithm is very flexible permitting the TV image to be encoded using either 2 bit or 3 bit DPCM, sub-sampled or not, coarse of fine quantizations.

Any combination of these modes of operation can be selected and changed on a line-to-line basis. Each manufacturer of the video encoder will develop his own algorithms for selecting various modes of operations as the complexity of the picture changes. Clearly the picture quality produced by the encoder/decoder system will depend strongly on the mode control algorithm in the encoder.

The purpose of this paper is to describe new test procedures which are required to measure the performance of encoders designed to meet RCC 209-88.

INTRODUCTION

There are three basic modes of operation of the video code that can be selected in order to achieve the best configuration to suit the needs of the user.

Mode 1:

1) Fixed frequency - comm rate of 20, 10, 5 M.H.Z. on internal clock, or any frequency between 5 MHZ and 20 MHZ on external (user specify) clock.

Mode 2:

Field or frame skip at a fixed skip rate.

Mode 3:

Field or frame skip at a variable skip rate.

The test procedure that will be explained involves the sensitivity of each mode of operation to large changes in picture content (complexity). the amount of data compression that is required for any mode of operation is determined by: 1) number of pixels per field, 2) comm rate of the system, 3) the number of fields per second. For real-time video transmission, 60 fields per second is the standard.

Chart #1 shows the number of bits per pixel that must be achieved for three of the typical comm rates, for real time transmission of 60 fields/sec.

COMM RATE	PIXE / LINE	LINES / FIELD	AVERAGE BITS/PIXEL	FIELD RATE
20 MHZ	640	240	2.17	60/SEC
10 MHZ	512	240	1.32	60/SEC
5 MHZ	256	240	1.32	60/SEC

CHART #1

For a continuous transmission of data, the average bits/ pixel compression rate must be maintained at all times by the computer that controls the encoder. The variable parameters available to the computer include the choice of Kernel, the use of horizontal sub-sampling on a per line basis, and the number of lines sub-sampled. If the picture is very simple the computer can also add fill bits.

Fig. 1 shows a typical picture of a tank that contains a great number of transitions, and without sub-sampling compresses to a value of 2.32 bits/pixel.

Fig. 2 shows a picture which has many areas (sky) with nominal change to adjacent pixels, and compresses to a value of 1.93 bit/pixel. Both of these pictures would require the use of pixel sub-sampling as indicated in Chart #2.

PICTURE	BITS/PIXEL	PIXELS/LINE	COMM RATE	# OF HSS LINES	# OF FILL BITS/LINE
TANK	2.32	512	10 MHZ	207	0
PLANE	1.93	512	10 MHZ	152	0
TANK	2.32	640	20 MHZ	32	0
PLANE	1.93	640	20 MHZ	0	128

CHART #2

The system must be capable of switching from a complicated picture to a simple picture and vise versa without overloading its buffers at either the encoder or the decoder. This means that the computer must respond a sudden change in picture complexity by changing the compression algorithm rapidly enough to prevent buffer overflow or underflow. Subjective pictures like the tank or airplane are poor tools to make objective evaluation, because the subject matter influences the effects of the compression parameters.

To achieve a reliable measure of performance, test patterns which have identical patterns on each line are used. Figure 3 shows two patterns that are used, with the number of bits per line that each pattern produces without pixel sub-sampling. By switching back and forth between these two patterns, or combinations of these two patterns, the sensitivity of the codec to buffer limitations can be evaluated with an objective and repeatable figure of performance.

The test consists of the following sequences:

6A, 6B, 6A, 6B, Etc.
1C, 1D, 1C, 1D, Etc.

where 6A refers to 6 fields of pattern A, followed by (6B) six fields of pattern, etc.

We can assume that the encoder is encoding pattern #1 and has stabilized to the condition that the buffer level remains constant. At a 10 MHZ comm rate, the buffer will be depleting at an effective rate of 1.32 bits per pel or 16 kilobits/field. The computer will have adjusted the compression parameters to insure the data entering the buffer is doing so at the same rate of 1.32 bits per pel. Since this is a simple, highly compressible pattern, the average data rate is only 1.20 bits per pel. The computer must therefore be adding 41 bits per line or 9800 bits per field.

If we now switch instantaneously to pattern #2, we will enter data into the buffer at a new rate of 23 Kbits per field. Since the compression algorithm was still operating at the rate needed for the simple pattern, the 9.8 Kbits of fill would still be added. This means that the buffer would be filling at a 33 Kbit rate while depleting at a 16 Kbit rate. A typical buffer size of 3 fields would then overflow within the 1½ fields, unless the computer can respond rapidly enough to prevent the overflow from occurring.

The same scenario applies to a rapid change in the opposite direction, where the buffer would deplete in 1½ fields. Since there is a two field lag in response time before the computer can adjust the algorithm to correct for the change, overflow or underflow would be certain.

The tolerance to rapid changes could be improved by using a larger buffer. However, this has the negative effect of delaying the real time data.

The magnitude of the change between the two test patterns can be decreased to any level by simply combining the two pattern in one field. This can be done by generating a group of lines from pattern 1 followed by a group of lines of pattern 2. These groups can be alternated several times in one field. Typically, we use alternate groups of 20 lines of each pattern, as a basic starting point. The ratio of the number of lines of pattern 1 to pattern 2 controls the equivalent complexity of the field. The basic compression rate (before kernal changes or sub-sampling) can be adjusted to any value of bits/pixel from 1.2 to 3.1. The performance of any particular codec can then be evaluated objectively, and a repeatable level of performance can be measured.

Since the computer calculates the compression algorithm on a field basis, there is the possibility of encountering periods within the field where maximum or minimum data rates can not be accommodated. These conditions will be encountered when short bursts of complex data lines generate data faster than the data can be transferred into the buffer. An example of this problem will occur if the multiburst pattern were encoded without any addition compression. The data would be clocked out of the buffer at a 10 MHZ rate while the buffer input would be clocked at 24 MHZ rate. If the buffer, or any other portion of the codec can not handle this higher frequency, the point at which the failure occurs can be accurately determined.

A similar failure could occur if the circuitry can not add a sufficient number of fill bits to keep the buffer from depleting. This test consists of coding a blank field which generates 1.04 bits per pel. The computer should add sufficient fill to prevent buffer depletion. The frequency of the comm clock is then increased until depletion occurs. That is the point at which the maximum available fill is not sufficient to prevent buffer depletion.

Initially, I mentioned three different modes of operation. The above test is used for measuring the dynamic performance in the non skip mode, and the fixed skip mode. It is of no importance in the variable, skip mode. The variable skip mode must be tested to perform satisfactorily on the most complex pattern available. This number can be either measured or calculated, since it is based only on the number of bits per line that result after compression. In the variable skip mode, no pixel sub-sampling or kernel changes are used. The dynamic performance of the variable skip mode is measured by the capability of the codec to handle a multiburst pattern that generates at least 1500 bits per horizontal line. The amplitude of the multiburst can be adjusted to reduce the number of bits per line until the point is reached where the codec transmits the complete picture with no loss in picture content. This test primarily evaluates buffer size and buffer clock.

STATIC TEST

The static test are used to evaluate the systems frequency response, impulse response (slew rate) and linearity. The static tests are easily performed by comparing the input signal to the codec against the video output at the decoder.

The multiburst pattern is ideally suited for measuring the frequency response at both high and low amplitudes (ie. 100 IRE amplitude down to 10 IRE amplitude).

The stair case pattern is used to measure linearity and slew rate. The ramp pattern is used to measure linearity and z axis resolution.

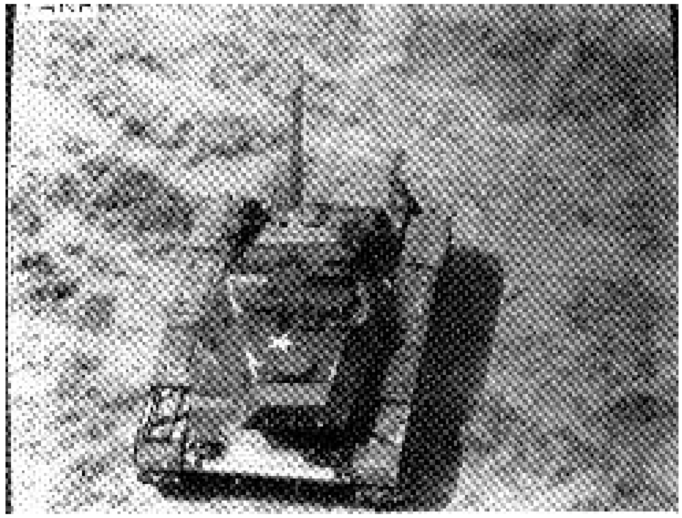

FIGURE 1

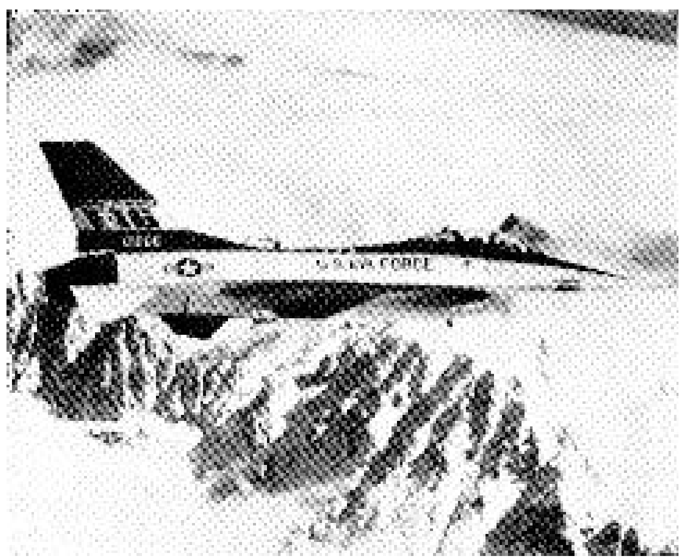

FIGURE 2

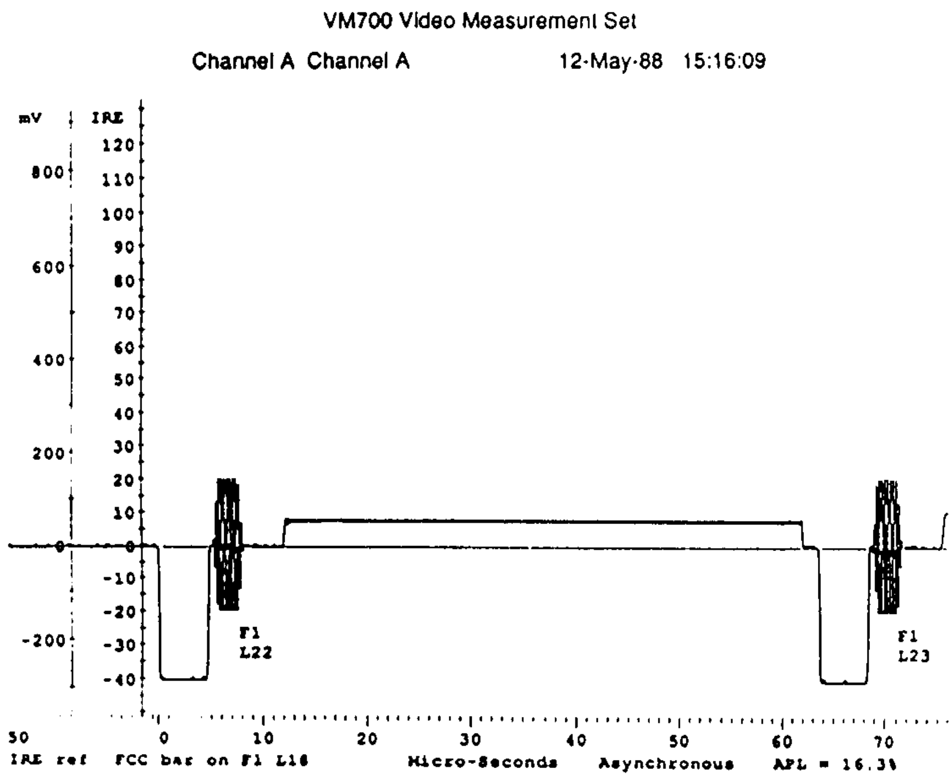

FIGURE 3 A

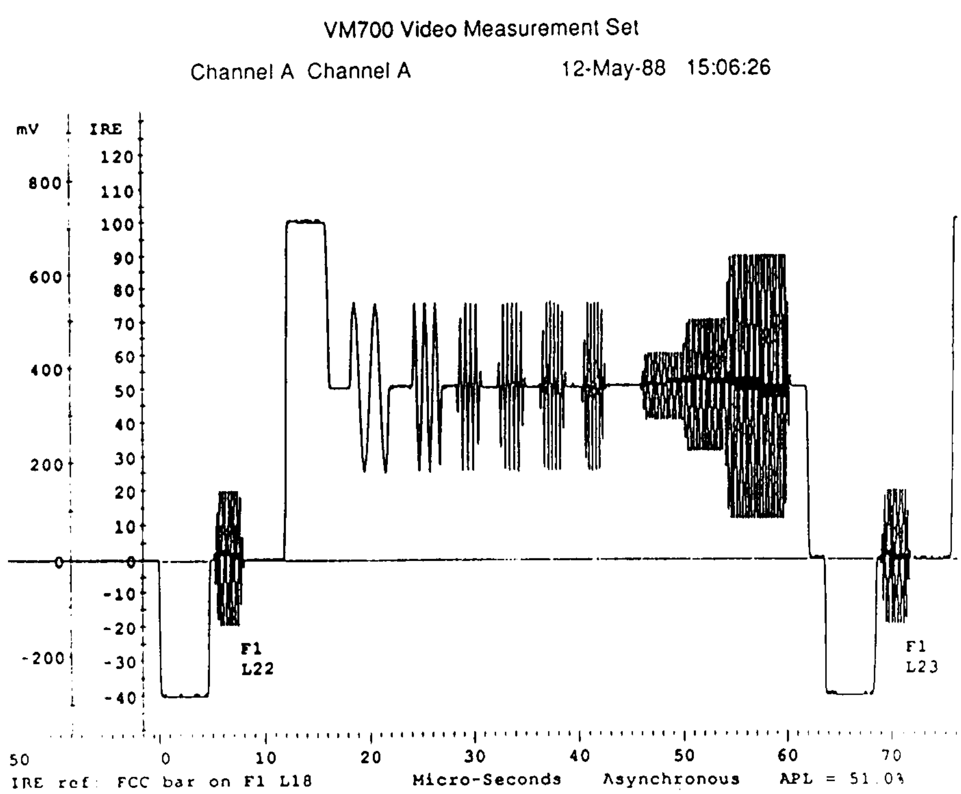

FIGURE 3 B