TECHNIQUES FOR SYNCHRONIZING THERMAL ARRAY CHART RECORDERS TO VIDEO

David M. Gaskill
Vice President, Research and Development
Astro-Med, Inc.
West Warwick, R.I. USA

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ABSTRACT

Video tape is becoming more and more popular for storing and analyzing missions. Video tape is inexpensive, it can hold a two hour test, and it can be edited and manipulated by easily available consumer electronics equipment. Standard technology allows each frame to be time stamped with SMPTE code, so that any point in the mission can be displayed on a CRT. To further correlate data from multiple acquisition systems, the SMPTE code can be derived from IRIG using commercially available code converters.

Unfortunately, acquiring and storing analog data has not been so easy. Typically, analog signals from various sensors are coded, transmitted, decoded and sent to a chart recorder. Since chart recorders cannot normally store an entire mission internally, or time stamp each data value, it is very difficult for an analyst to accurately correlate analog data to an individual video frame. Normally the only method is to note the time stamp on the video frame and unroll the chart to the appropriate second or minute, depending on the code used, noted in the margin, and estimate the frame location as a percentage of the time code period. This is very inconvenient if the telemetrist is trying to establish an on-line data retreival system. To make matters worse, the methods of presentation are very different, chart paper as opposed to a CRT, and require the analyst to shift focus constantly. For these reasons, many telemetry stations do not currently have a workable plan to integrate analog and video subsystems even though it is now generally agreed that such integration is ultimately desirable.

INTRODUCTION

The objective of this paper is to examine the relationship between analog and video data with regard to bandwidth and storage capacity for mission length records and to describe some practical methods using IRIG and commercial DAT (digital audio tape) technology to achieve frame to frame correlation between analog and video data including video display of analog data for paperless analysis.

There are several ways to synchronize NTSC/RS-170A video to IRIG which are well known in the telemetry community as well as different methods of time stamping on video tape. For further information on IRIG synchronization, refer to "Guide to Synchronization of Video to IRIG Timing", published by, Optical Systems Group, Range Commanders Council. The techniques and solutions described below assume that a video frame synch pulse is available for full resolution analysis although for real-time video display only, it is not necessary. The system described here consists of two major sections; a real-time video output compatible with commercial video recording equipment, and a data acquisition sub-system which can store mission length records at high resolution for expanded time base playback and analysis.

REAL-TIME VIDEO OUTPUT

The video output can be formatted in three ways; 1024 x 768 high resolution, 640 x 480 VGA, or NTSC/ RS-170A color video. the high resolution mode is best for stand-alone monitoring or review of captured data while the NTSC/RS-170A is needed for its compatibility with video recording equipment despite the fact that the resolution is much lower. The VGA mode is included because it is needed as an intermediate conversion step from high resolution to NTSC video. In addition, VGA can be useful where inexpensive VGA monitors are already available on-site.

In any display mode, the waveform data is taken from the main data bus and processed locally without intervention by the chart recorder controller. This allows complete freedom of the video system so that the waveforms can be presented in different time-bases and in diferent orientation from the chart recorder. For example, the waveforms can "waterfall" top to bottom like the chart paper or scroll right to left; the chart recorder can be operated at trending speed and the display can scroll at 50 mm/sec. It also allows the display to continue in real-time while the chart recorder is capturing test information in the background. For simplicity of set-up, the display can also be slaved to echo the chart.

The display output is updated at 60 Hz but the bandwidth of the system is actually about 20 kHz because the waveforms are processed as MIN/MAX pairs. The incoming signals are sampled at 200 kHz and each time a new video frame is to be displayed, a line is sent representing the highest and lowest values occuring since the last frame. In other words, each frame represents over 3000 sample points for each new update line. The full field of view for a 525 line NTSC display represents 1.75 million samples. It should be noted that each new frame has only one new line of data. The newest line is added and the oldest line is dropped.

The real-time output in NTSC/RS-170A mode can provide the basis for simultaneous and seamless display of analog and video information from the same video tape to a single monitor using standard commercial mixing and editing equipment. The output can be considered as an additional video camera source and, like a video camera output, can be frame synched and time stamped by conventional means.

DATA STORAGE

As noted above, the thermal array chart recorder is capable of handling much more data than the video interface. In normal data capture modes, the recorder can store waveform information at rates from 10 Hz to 200 kHz while the video update is fixed at 60 Hz. Historically, the problem with recorders has been that only small amounts of data could be saved and, even then, the data was not time stamped with enough frequency or accuracy to allow video frame synchronization. Recent developments in DAT (digital audio tape) technology provide an economical and easily available answer.

The basic DAT recorder holds 1.2 Gigabyte tape cartridges and is small enough to fit within the chassis of a thermal array recorder. The storage capacity and bandwidth of the DAT stroage system are a perfect match for two hour capacity video tape recorders. Take a typical example: an eight channel recorder storing waveform data at 10 kHz per channel for two hours requires 1.15 Gigabytes. This gives a permenant record with a 1 kHz bandwidth that can be re-played in numerous ways and can be removed for archiving. Note that the transient bandwidth of the real-time chart recording remains at a full 20 kHz because, like the video sub-system, the data capture section is completely independent and can take data from the main data bus at its own rate without interrupting any real-time processes.
Video synchronization is achieved in two different ways. First, IRIG code, either modulated or demodulated, is fed into the recorder controller. The controller decodes the signal and sends the start pulse and the decoded time to the data capture board every time code period. Second, the user feeds a frame sync pulse into the data capture board from the video recording system - defining blocks of data that correspond to one frame length. At a 10 kHz sample rate, one frame block contains about 167 samples per channel. This represents a single line update, not the full frame as displayed on video. The full NTSC525 line display actually represents 87.5 kSamples per channel updated 167 samples at a time.

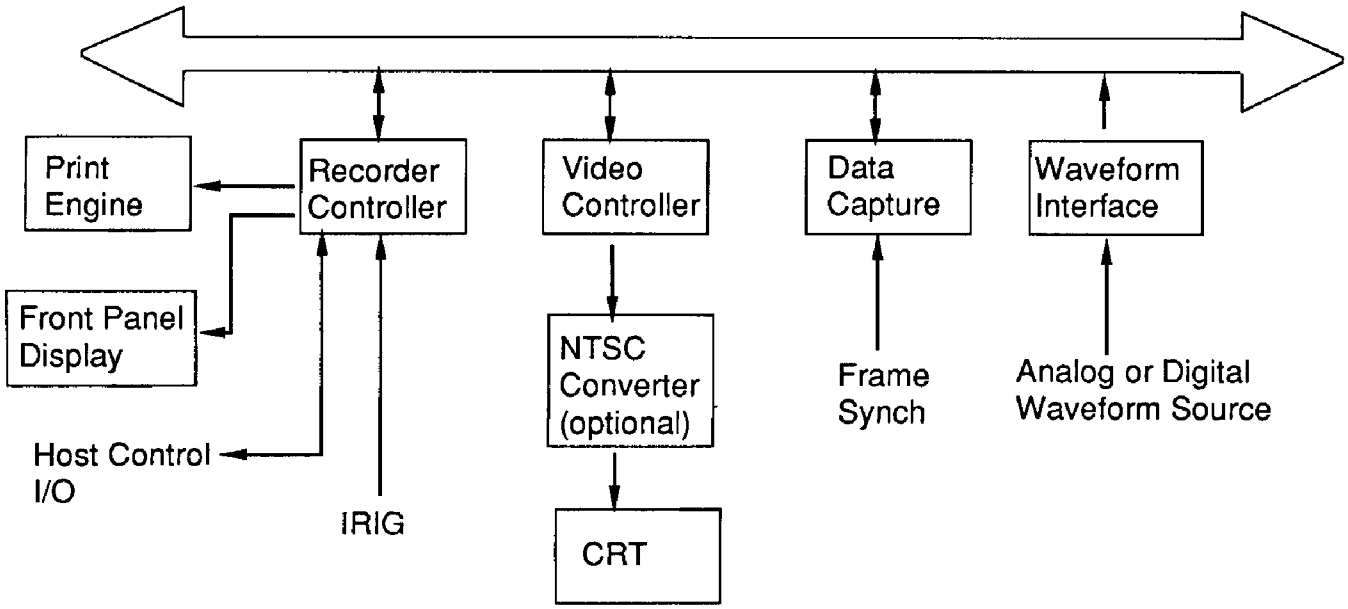

Figure 1
Basic Archtecture

The number of samples per frame depends on the sample rate. It can be calculated by dividing the sample rate in hertz by 60 (the video frame rate).

Time synchronization is then possible by finding the desired time stamp and locating the nearest start pulse. This gives the frame block that contains the exact IRIG time reference. The exact location desired can then be easily found by counting frame blocks which now equal each video frame.

DATA PLAYBACK

Once the desired frame is located, it can be played back in several ways. Data before and after the target frame can be played back on a CRT in simulation of real-time to see general activity or it can be played back point by point on the CRT for an expanded time base look at the waveforms. Again using the example of an eight channel, 10 kHz acquisition, each frame block of data, (a single update line in the real-time display), is expanded to about a third of the screen.

The best method for review is to transfer a block of data, say 64 KSamples, that contains the target frame to the recorder CPU memory. In our example, this would be about fifty, eight-channel frames. It would then be possible to scroll back and forth through the fifty frames for detailed analysis. For furthur review or documentation, the same data could be played back on the chart. If played back point for point, each frame block would take about 8 mm and the entire buffer about 400 mm at the standard 20 dot per mm playback rate. For a little more resolution, the recorder also allows time base expansion by 2, 4, or 8. The chart format includes a human readable IRIG time stamp, the IRIG start pulse mark, and a frame synchronization mark for complete data identification.

CONCLUSION

By using proven commercial video tape equipment, recently available Digital audio tape recorders and the latest generation of thermal array chart recorder, it is now possible to link video images with analog recordings to sub-frame accuracy for tests of up to two hours duration. The images and waveforms can be mixed graphically for single screen presentation or can be synchronized on different media for maximum resoltuion and archivability.

REFERENCES

"Guide to Synchronization of Video to IRIG Timing", Optical Systems Group, Range Commanders Council. 1991