EXPLOITING TELEMETRY DATA IN THE VERTICAL BLANKING INTERVAL

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ABSTRACT

This paper describes how ongoing developments in digital and video technology have been merged to exploit the telemetry data inserted into the vertical blanking interval of the composite-video signal. The insertion of 96 bits of digital data into two lines of the vertical blanking interval is reviewed. The automatic retrieval and reformatting of the digital data for use by a Main-Frame Computer is explored. A unique video editing and data merging facility coupled to the computer is described. To emphasize the versatility of this systems approach, specific industrial applications will be outlined. Finally, future considerations and applications involving control systems will be discussed.

INTRODUCTION

Background - A respectable 8% of TV time is used during the vertical blanking interval, some 21 TV scan lines out of every 262.5 lines, 60 fields per second. The intended function of synchronizing the vertical sweep and stabilizing the horizontal sweep interlace is fully accomplished with the first 9 lines. The remaining 12 lines have historically been used to assure blanking of the vertical retrace lines for those TV receivers with slower vertical retrace (deflection) circuits and without internal retrace blanking circuits. At an accelerated pace, the merging of digital and video technology has exploited this valuable piece of spectrum by inserting digital data into one or more of the last 7 blanking lines in each TV field.

A video data system consists of; the data sources and their digitizing means; the insertion of the digital data onto the CCTV video; its transmission (or recording) from the source; the retrieval of the data from the video; its reformatting for further computer processing; and its final application to respond to the system needs. A unique part of the system is a video editing facility which interfaces to a Host-Computer to merge the video and digital information.

VERTICAL INTERVAL DATA INSERTION

Commercial Standards - One of the first commercial applications of vertical interval data insertion was the 48 bit Source Identification (SID) signal applied to line 20. This application was soon followed by the use of a Vertical Interval Reference (VIR) signal using precise analog standard TV chrominance and luminance signals. Commercial TV networks have provided a captioning service with 32 bits on line 21 which, when decoded, can produce visual text for the hearing-impaired. These FCC Broadcast Standard allocations are specifically related to the video program material, augment it in one way or another, and all represent a slow-speed data transmission.

Although not a subject of this paper, a natural extension of the data insertion technique is applied to Teletext, a high-speed data transmission system where up to 288 digital bits of data are inserted into one or more vertical blanking lines. The higher bit error rate and complexity of high-speed encoder/decoder logic are traded-off for a much higher data throughput rate for these applications.

Example Application - An example can be drawn from a slow-speed data transmission system where telemetering data at 5760 bits per second was needed. TV lines 17 and 18 were selected for digital data insertion. The source of data to be telemetered can be asynchronous dynamic serial, parallel, or a combination of each. The data is first formatted into two 56 bit words, each having 48 bits of data and eight data sync pulses (4 “zeros” plus 4 “ones”) to aid retrieval.

Figure 1 illustrates the Timing Format Waveform for the example system. This format was chosen to minimize problems in the retrieval of the digital data. The first 56 bit word is used to serially pulse-amplitude modulate the composite-video signal with a 0.9 usec pulse period after recognition of the 17th TV sync pulse. These 56 pulses fit into the blank line interval between the 17th and 18th sync pulse. The second word is inserted into line 18 in the same manner. Every bit modulates the video signal between the black reference level and the white reference level. Bit intelligence (zero or one) is carried by pulse-width modulation, where the 0.9 usec period will have a half-power width between the leading and trailing edge of 0.3 usec for a logic “zero” and 0.6 usec width for a logic “one”. During the 1/60 second period following insertion of data, any or all of the data bits can be changed by the source. This system provides a 5760 bit per second maximum throughput rate.

Figure 2 shows two TV monitor views of the digital data appearing on lines 17 and 18. To make the vertical-blanking interval visable for these pictures adjustments were made to the vertical sweep circuit. The second view expanded the vertical sweep to separate the two lines. Note how the effect of double interlace separates line 17 field 1 and field 2 (also for line 18) during the 1/30 second full frame shown.

VERTICAL INTERVAL DATA RETRIEVAL

Functional Description - In order to exploit the digital telemetry data inserted into one or more vertical blanking lines, it must be retrieved and reformatted. The retrieval can be accomplished in either real-time or during tape recording replay. The three major functional blocks for the retrieval, reformatting and interfacing the digital data to a Host-Computer are illustrated in Figure 3. The input consists of RS-170 composite-video that has been annotated with digital data on line 17 and 18 as described in the previous section. The first functional block consists of a sync separator circuit that recognizes and locks onto the 17th horizontal sync pulse (in the vertical blanking interval). The digital pulses residing between the 17th and 18th sync pulse are first applied to a pulse-width-to-digital decoder (as well as those from line 18). The pulse-width modulation technique assures that the pulses can be used as their own clocks for decoding. If the pulse-width is about 0.3 usec it is outputted as a logic “zero” with much narrower pulses being rejected as noise. If the pulse-width is about 0.6 usec it is outputted as a logic “one”, with wider pulses being rejected. The resultant burst of 56 bits of digital data (for each line) is latched into a serial-in, parallel-out register shown in the second block. The first 8 bits are next examined for the data sync code of four “ones” followed by four “zeros”. If the sync is found valid for each line of each field the data can be accessed by the third block. Depending on the system error rate needs, parity and error checking/correcting codes and techniques can be applied at this point. About 1/60 second remains to transfer the data prior to receipt of the next burst of data.

Functions which are auxiliary to data retrieval, such as local bit status indicators and flags would be used to meet specific applicatons. Considering the power of the Host-Computer to massage data and store numbers it appears judicious to dump the data directly into the computer so that software routines can provide the desired final output effects. Implementation of the data retrieval functions have been accomplished using a microprocessor. This enables the unit to make smart decisions on how to accept inputs and format outputs to make optimum use of the Host-Computer. Parity checking and code recognition are the minimum capability expected. Depending upon the required I/O throughput requirements, redundancy checking can be used both to reduce error rate and moderate input traffic to the Host-Computer.

COMPUTER PROTOCOL

The Communications Handshake - Amongst the various computer I/O ports the most convenient to use is the terminal port with signal characteristics that are EIA RS232C comparable. In this application the digital retrieval unit output emulates a terminal I/O with a 2400 baud output using even parity. The computer must supply control lines for “Data Request” so that the current 96 bits of retrieved data can be frozen in the output register until the data transfer is complete. The entire 96 bit message extracted from line 17 and 18 is formatted into only 34 ASCII characters (using 8 bit serial format) which include a source character selected by the operator and a carriage return character at the end of each message.

Figure 4 illustrates a portion of an example communications handshake protocol which makes use of a data code conversion to 7 bit Hexidecimal with 1 parity bit. This simple program is not the most efficient in that only the numerical ASCII code was used for ease of terminal monitor presentation. A more efficient code would just transfer 7 bits at a time using most ASCII characters, reducing the message length from 34 down to 16 characters. This would require the Host-Computers applications program to reformat the data for use.

The Applications Program - Since the digital data flowing to the computer from the CCTV system is in packets, formatted by the communications program, it is up to the applications programmer to design a program that will reformat the data into a useful output. Almost all applications will wish to store the data in defined bins or tables. The 96 bits of data may be from many different sources, as infered in Figure 4, IRIG-B time, serial data, and parallel data sources will need to be separated, massaged, and analyzed by the applications program to produce a useful output. One area of interest is the ability to compare the input data to an assigned limit and output a warning or flag if it is exceeded. The applications programs are responsive to the systems need.

VIDEO EDITING & DATA MERGE FACILITY

Description - Just as the CCTV cameras and data sources for telemetering represent the system input, the system output is the video editing and data merge facility. It represents the man-machine interface (or machine-machine interface for some functions) where output reports, monitoring, and control actions are produced. The facility is used by the analysts and operators based on an operations plan and applications program designed for the particular job. The example facility consists of a pair of consoles, configured as shown in Figure 5, containing typically the following subsystem units:

Editing Console

- One 14" and four 9" TV monitors
- Vertical Interval Data Retrieval Unit & Computer Interface
- Vertical Interval Switcher and Audio/Video Patch units
- Videomedia Z6M computerized editing system
- CRT computer terminal and auxiliary units

Dubbing Console (in background)

- Three Sony editing U-Matic tape players and one recorder
- Remote monitor

A simplified block diagram of the facility is shown in Figure 6. Of special interest here is the use of the Z6M editing system which allows either the operator or the Host-Computer to control the activity of the four tape machines. It provides for random access to any video frame for any of the three tape players as well as bidirectional control of the tape in the editing mode. Based on the use of a Z80 microprocessor it will store up to 99 edit events. The timing means (micro-loc) encodes the frame locations by altering control track pulses without occupying any audio channel with SMPTE time code. The system includes the editing keyboard and microprocessor editing controller (with I/O interfaces to the four tape machines). An 8-bit parallel ASCII multiplexer between the keyboard and controller permits automatic functions to be controlled by either the operator or the retrieved digital data. In this case, the retrieved data may represent specific points of time or a measured function that would elicit an operator edit action, but can be accomplished faster automatically.

The monitors, switchers and patch units are standard but some of the auxiliaries are worth mentioning. The video effects generator can supply split-screen and inserts for some applications needing them. The character display generator module, under computer control can annotate the video raster with alpha-numeric characters as a means of converting the retrieved digital data and merging it into the video pictorial scene. Time and date numerics, event flags and warnings, can all be applied to the picture. Addition of an electronic reticule or other computer generated graphic symbols enhance the utility of the system.

INDUSTRIAL (& MILITARY) APPLICATIONS

In some industrial applications such as nuclear fuel operations it is mandatory that handling, measuring, and control functions be performed remotely. Where periscopes and shielding glass windows have been used for viewing, CCTV is finding more applications for remote control in high radiation environments. A CCTV system represents a wideband data highway over which digital data can also travel. Since the facility must be responsive to the system needs, the raw digital data can represent such varied functions as time, temperature, pressure, position, volume, flow, radiation level, or anything measurable. The retrieved data, when computer processed, can represent such varied things as inputs to process control systems, feedback for data logging and recording, or even camera control functions such as pan and tilt positions.

An example military application is the CCTV facility at the U.S. Army Combat Developments Experimentation Command at Fort Hunter Liggett, Ca. There, instrumented combat troops, tactical vehicles, armor and aircraft are engaged in the field in simulated battle scenarios which are designed to provide a realistic environment for the evaluation of forces, tactics, and weapons in simulated combat. The CCTV system collects a varied range of digital data which includes the IRIG-B time, the weapon trigger pulls and hits (coded laser firings and detections) and player line-of-sight intervisibility data. The retrieved digital data is both stored in the computer complex and also serves as an input to the video editing and data merge facility.

FUTURE CONSIDERATIONS AND APPLICATIONS

A natural extension of the subject system techniques will be to couple them to automated overhead cranes and electromechanical manipulators. Remote handling is inseparable from remote viewing and is either limited or enhanced by the facility of the viewing. The manipulators and associated articulated CCTV systems will generate many position and control signals which can occupy bits in the vertical interval. A future application enhancement of this system is a marriage of the “bar-code” and scanner decoder to yield automatic item recognition. Televising an item’s bar-code will generate a psuedo-digital signal on one or more active TV line(s). If selected for decoding using the grocery check-out scanner technique the signal can be recognized, compared in a look-up table and have the item identification entered into the data base.

CONCLUSION

Close attention to the needs and requirements of a process or system can permit the CCTV systems engineer to be an applied technologist with the merging of the best in digital and video techniques to augment the electromechanical equipment to be controlled.

ACKNOWLEDGEMENT

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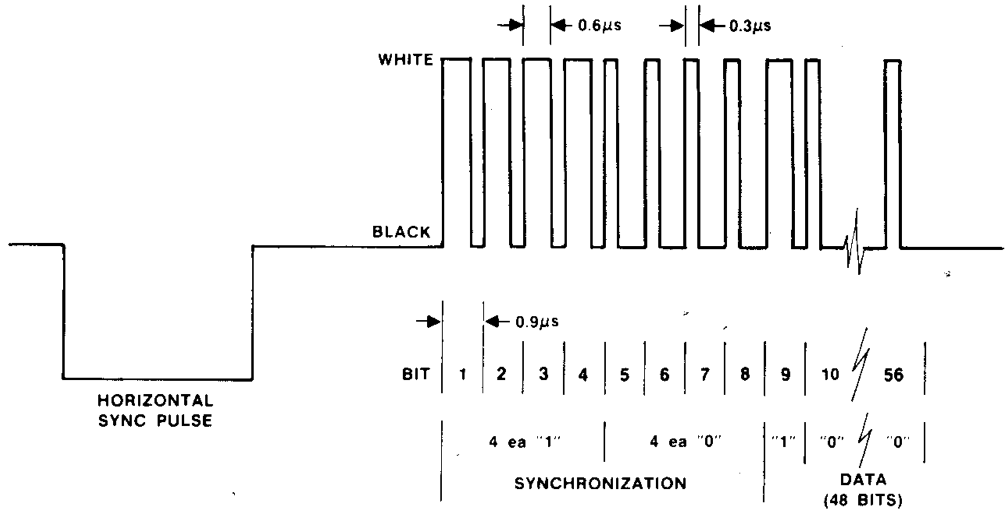

FIGURE 1 TIMING FORMAT WAVEFORM

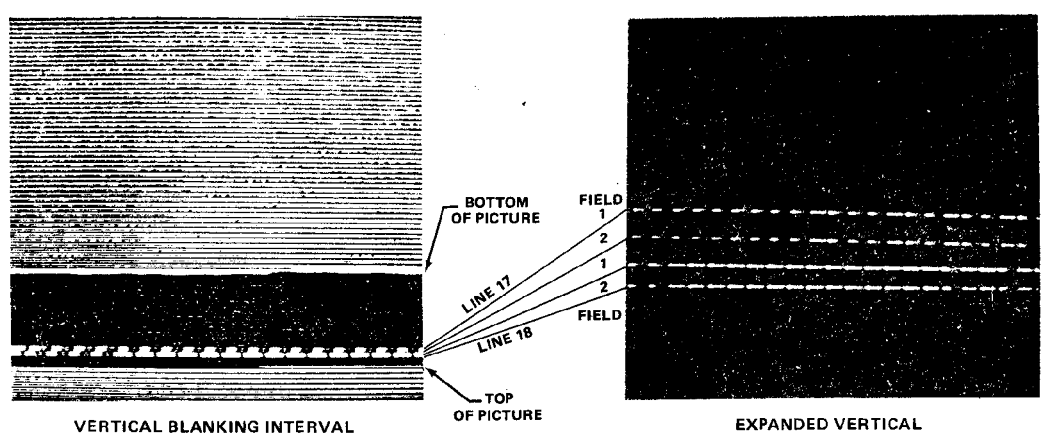

FIGURE 2 MONITOR VIEWS OF DIGITAL DATA IN VERTICAL BLANKING INTERVAL

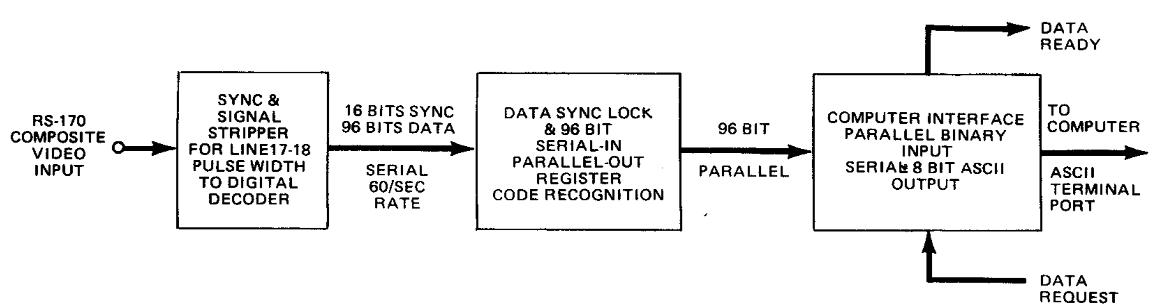

FIGURE 3. DATA RETRIEVAL & REFORMATTER BLOCK DIAGRAM

NOTE: 96 BITS OF PARALLEL DATA SHIFTED TO "PARALLEL BINARY INPUT/SERIAL ASCII OUTPUT" MEANS AND FREEZE UNTIL OUTPUT MESSAGE COMPLETE.

1. OUTPUT MESSAGE PROTOCOL; 8 BIT SERIAL ASCII, 2400 BAUD, EVEN PARITY.

ASCII CHARACTER	HEX (7 BITS)	SUBJECT/NOTES	OBTAINED FROM
#1. EITHER 1, 2, OR 3	EITHER 31, 32, OR 33	SOURCE VTP DECK # (1, 2, OR 3)	FRONT PANEL SELECTION BY OPERATOR
2. 0, 1, OR 2	30, 31, OR 32	BCD HOURS (2 BITS) MSB	LINE 17: BITS 9 & 10
3. 0 THRU 9	30 THRU 39	BCD HOURS (4 BITS) LSB	BITS 11 THRU 14
4. 0 THRU 5	30 THRU 35	BCD MINUTES (3 BITS) MSB	BITS 15 THRU 17
5. 0 THRU 9	30 THRU 39	BCD MINUTES (4 BITS) LSB	BITS 18 THRU 21
30. 0 THRU 7	30 THRU 37	SERIAL BITS 6, 5, & 4 (DECODE OCTAL TO 3 BIT SIMPLE)	LINE 18: BITS 45 THRU 47
31. 0 THRU 7	30 THRU 37	SERIAL BITS 3, 2, & 1 (DECODE OCTAL TO 3 BIT SIMPLE)	BITS 48 THRU 50
32. 0 THRU 7	30 THRU 37	PARALLEL BITS 51, 52, & 53 (DECODE OCTAL TO 3 BIT SIMPLE)	BITS 51 THRU 53
33. 0 THRU 7	30 THRU 37	PARALLEL BITS 54, 55, & 56 (DECODE OCTAL TO 3 BIT SIMPLE)	BITS 54 THRU 56
34. CR	OD	END OF MESSAGE (CARRIAGE RETURN IN ASCII)	MESSAGE GENERATOR

FIGURE 4. COMMUNICATIONS HANDSHAKE PROTOCOL

FIGURE 5 VIDIO EDITING OF DATA MERGE FACILITY

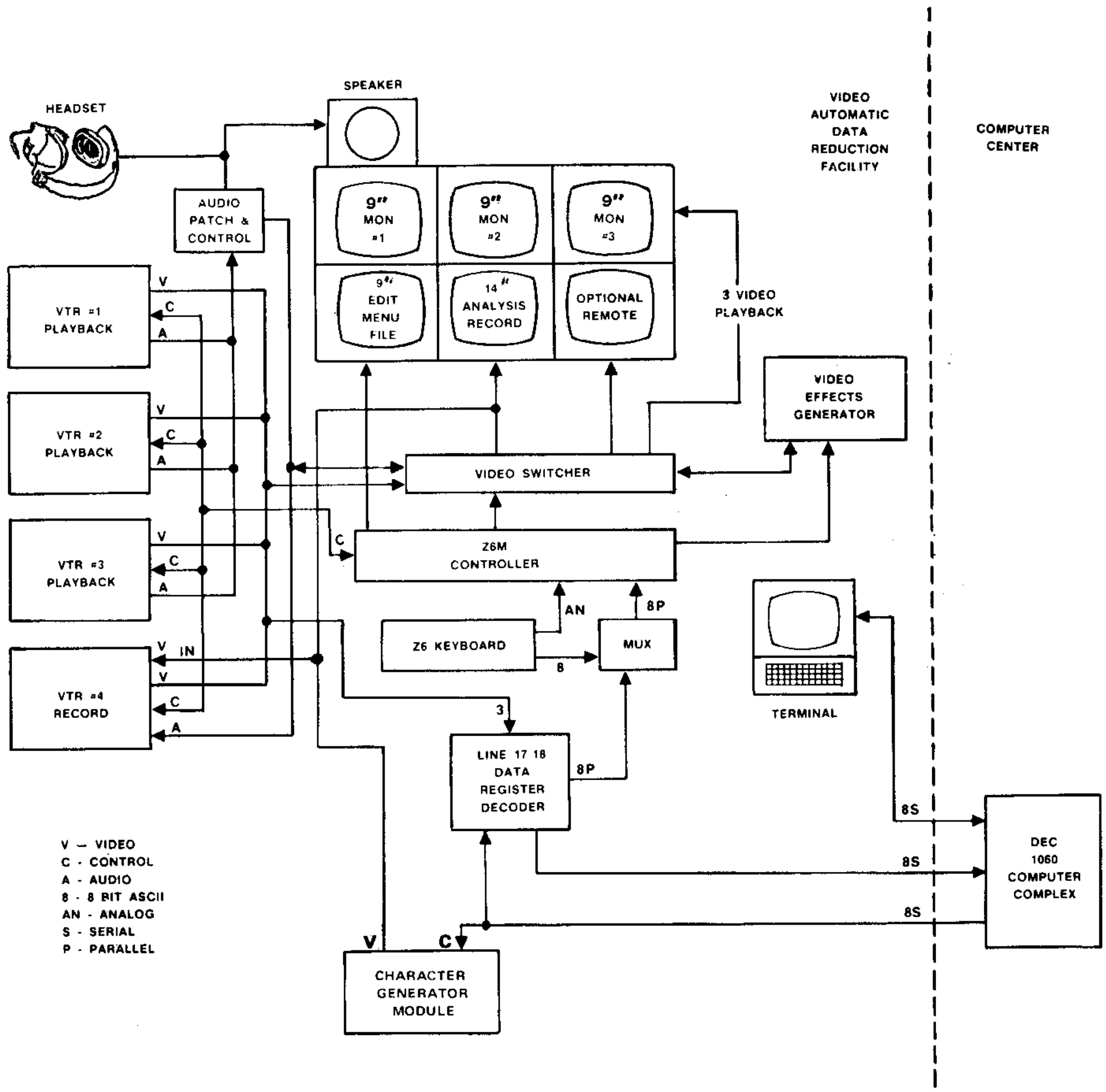

FIGURE 6 SIMPLIFIED BLOCK DIAGRAM VIDIO EDITING FACILITY