TWO INTERESTING APPLICATIONS OF DIGITAL DATA INSERTION IN VIDEO SIGNALS: THE TV DISPLAY GENERATOR AND THE VIDEO COUNTDOWN PROGRAMMER

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ABSTRACT

The recent development of compact, rugged, reliable and easy-to-use video cameras, recorders, amplifiers, digitizers and monitors has made this equipment increasingly attractive for data acquisition purposes. When analog and/or digital data is combined with video signals, the resulting configuration is a video instrumentation system. Two examples of video instrumentation systems are described in this paper.

The TV Display Generator accepts four independent analog signals, modulated IRIG B serial time code, three different standard composite video signals and several digital control signals. The analog and time code signals are digitized and inserted into the composite video input signals for recording and display.

The Video Countdown Programmer generates four color and two monochrome standard composite video signals and formats and inserts up to six sets of parallel BCD and ASCII digital data into each video signal. The output video signals are displayed by large screen monitors. As these two systems indicate, the recording and display functions of video instrumentation system provide additional capabilities in data acquisition applications.

CONCEPT

Although video signal recording and display techniques have been available for about 30 years, the recent development of a new generation of video equipment has rapidly expanded the use of this equipment in instrumentation applications. These advances in video equipment capabilities have resulted in:

a. Compact, rugged, reliable, high resolution video cameras and sensors
b. Small, portable, cost effective, easy to operate video magnetic tape cassette recorders/ reproducers (VCR)

c. Wideband video amplifiers in DIP configurations and many other video functions in integrate circuit packages
d. Inexpensive, high speed video signal digitizers with computer hardware and software interfaces
e. A variety of standard and high resolution monochrome and color monitors in many configurations

The combination of a video camera or sensor, VCR and monitor for data acquisition and display purposes is termed a basic video instrumentation system.

When it is necessary (or highly desirable) to correlate, record and/or display analog and/or digital data with video signals, then a unit is required that converts, formats and inserts this data into the video signals as indicated in Figure 1. This insertion unit has to be designed so that it does not noticeably affect video signal quality. When properly configured, the insertion unit becomes the key element in a multi-signal input video instrumentation system.

VIDEO STANDARDS

For the purposes of this paper, we will be concerned with single field, non-interlaced or standard two field, interlaced video signals. The standard raster resolution is either 525 lines (U.S. system) or 625 lines (European system) per frame. However, 825 and 1050 line high resolution systems are becoming more evident. The standard frame rates are 30 frames a second in the U.S. system and 25 frames a second in the European system. In an interlaced system, a complete frame is comprised of two fields. The major video standards in the U.S. are the NTSC specifications for broadcast television and EIA RS170 specifications for closed circuit television. The video (not RF) format in both specifications are essentially identical. Another EIA standard, RS 330, is basically a measurement specification for 525 line composite video signals.

The basic characteristics for NTSC/EIA RS170 compatible video signals are listed in Table 1. This table does not include a detailed listing of synchronization and equalization pulses. If there is a question concerning synchronization and equalization compatibility between video signals, refer to FCC 73.699 Figure 6 or EIA Standard RS170 for the standard signal format.

In an interlaced video system, resolution can be defined as the number of non-overlapping line pairs in the video frame. Achievable resolution is directly related to the video (information) bandwidth of the system. To achieve a true 525 line resolution requires about a 6.25 MHz video bandwidth. If the video bandwidth is less than 6.25 MHz, then the 525 line frame can be transmitted but it won’t have 525 line resolution when received and displayed. For example, the video bandwidth in the standard U.S. television RF signal is

about 4.5 MHz which supports about 390 line pair resolution. This situation means that some of the line pairs are squeezed together and overlap. In normal viewing circumstances, overlapping or merging of some of the line pairs is not particularly objectionable and, in fact, helps to alleviate a more objectionable visual effect called contouring. In another instance, a video sensor produced 825 line resolution but was recorded by a VCR with 3.5 MHz bandwidth. Therefore, the transmission equipment between sensor and VCR only had to have a bandwidth somewhat greater than 3.5 MHz to preserve recording resolution.

There are many other factors involved with video signal standards which are beyond the scope of this paper. However, by maintaining video equipment interface compatibility with a major standard and recognizing the relationship between video resolution and bandwidth, the data acquisition system designer can minimize signal interfacing problems.

TABLE I
BASIC CHARACTERISTICS FOR NTSC/EIA RS170
COMPATIBLE VIDEO SIGNALS

Type: Composite video, 1.0 volt peak-to-peak into 75 ohms
Number of scanning lines per frame : 525
Frame rate: 30 frames per second
Field rate: 60 fields per second
Interlace: 2 to 1
Number of scanning lines in the vertical blanking interval: 21 lines maximum
Vertical blanking initiation: Three lines before the start of the vertical sync pulse
Sync to picture amplitude ratio: 40/140 of the composite video signal
Color burst: Equal in amplitude to the synchronizing signal and centered on the blanking level (for color signals only)

TV DISPLAY GENERATOR

A versatile, modular unit, the TV Display Generator accepts four (4) independent analog signals, modulated IRIG B serial time code, three (3) different standard composite video signals and several digital control signals. Two of the video signals have common synchronization while the third signal is independently synchronized. The analog and time code signals are converted into digital format and inserted into the composite video input signals. There are two outputs for each of the composite video signals; one for recording and one for monitoring. Figure 2 is a functional block diagram of the TV Display Generator.

Environmentally tested for reliable operation in aircraft, the TV Display Generator has completely modular, plug-in electronics as shown in Figure 3. There are four (4)

independent analog to digital converters. Each analog signal is tracked and then sampled and held at video frame time (every 1/30 second). The 200 nanosecond switching (aperture) time of the sample and hold and the digitizing rate of the high speed (500 KHz) voltage to frequency converter minimizes aliasing errors. The differential analog input voltage levels are individually adjustable.

Any primary input power loss causes the electronics in the TV Display Generator to be automatically bypassed and the input video signals to be throughput without processing. Input power requirements are in accordance with MIL-STD-704A Category B requirements except for continued operation during a 50 millisecond power interruption period. If necessary, standby power can be provided during power outage intervals. A power on/off toggle switch, power on indicator and fuse holder are located on the front panel of the unit.

As shown in Figure 4, the display format is comprised of four small blocks of decimal digital data superimposed on the video picture. Each data block can contain up to two lines (rows) of eight (8) characters per line. The upper and lower data blocks are vertically aligned but can be positioned anywhere horizontally and vertically on the display screen and the horizontal and vertical separation between blocks is continuously adjustable. Either white or black characters an a background mask can be remotely selected. The background mask shading is continuously adjustable from completely black to completely white. On a nominal 7 inch high by 5.5 inch wide display screen, each digital data block is approximately 0.75 inches high by 1.5 inches wide.

Input signal and power characteristics of the TV Display Generator are contained in Table 2. Table 3 lists the TV Display Generator configurational and environmental characteristics.

TABLE 2
TV DISPLAY GENERATOR INPUT
SIGNAL AND POWER CHARACTERISTICS

ANALOG INPUT SIGNALS

Circuit type: Differential, balanced
Voltage Levels: Up to ±20 volts (scalable)
Input Impedance: 20 K ohms minimum
Digitizing Resolution: 3 decimal digits
Digitizing Accuracy: 0.1% of full scale input at 25°C

TIME CODE INPUT

Type: Standard IRIG B serial format modulating at 1000 Hz carrier
Level: 1 volt to 10 volts peak-to-peak
Input Impedance: Balanced, transformer coupled, 600 ohms minimum
Mark-to-Space Ratio: 2:1 to 6:1 at 1.0 volt peak-to-peak

INPUT POWER

Type: Single phase, 3 wire
Voltage: 115V AC ±10%
Frequency: 400 Hz ±10%
Transient Peak: Up to 180 volts for up to 3 seconds
Current: 0.5 amp at 115V AC

VIDEO INPUT SIGNALS

Type: Standard NTSC or EIA RS170 compatible composite video of 1 volt peak-to-peak into 75 ohms
Bandwidth: 0.1 to 8 MHz ±3 dB, down 6 dB at 10 MHz

VIDEO OUTPUT SIGNALS

Type: Same as video input signals
Bandwidth: 0.1 to 8 M-1z ±3 dB, down 6 dB at 10 MHz
Impedance: 75 ohm with power applied, 37.5 ohms with power off (in bypass mode)

INPUT CONTROL SIGNALS

Functions: Camera active, digital data display active, black or white character select
Type: External switch contact closure

TABLE 3
TV DISPLAY GENERATOR CONFIGURATIONAL AND ENVIRONMENTAL CHARACTERISTICS

INPUT/OUTPUT SIGNAL CONNECTORS

Video Input and Output: BNC type, UG1094A/U
Analog and Time Code Input: JT02RE18-53P receptacle
Control Lines: LJT00RT15-97S receptacle
Input Power: JT02RE16-8PB receptacle

SIZE AND WEIGHT

Dimensions: 5.25 inches high by 17 inches wide by 12 inches deep behind the front panel not including controls, connectors and handles
Mounting: Flanges and tilt slides for mounting in a standard 19 inch wide equipment cabinet
Weight: 20 pounds maximum

ENVIRONMENTAL CAPABILITIES

Operating temperature range: 20°C to +55°C
Non-operating temperature range: -54°C to +71°C
Operating humidity: Up to 95 percent, non-condensing
Operating altitude: Sea level to 12,000 ft.
Nonoperating altitude: Sea level to 40,000 feet
Operating Vibration: 2g level, 5 to 2000 Hz, sinusoidal, 0.1 inch double amplitude per MIL-E-5400, Figure 2, Curve 2
Operating Shock: ±2g, 3 axis, 11 ms per axis
Crash Safety: 16g forward, 8g down, 4g up and side crash loads

THE VIDED COUNTDOWN PROGRAMMER

The heart of a multi-source digital data display system using large screen color and monochrome monitors, the Video Countdown Programmer input and output signals are shown in Figure 5. The Video Countdown Programmer generates standard composite video color and monochrome signals. Four Greenwich Mean (GMT) and countdown (CDT) parallel BCD time words up to 30 bits wide and up to ten 8 bit parallel ASCII header characters are input to the Video Countdown Programmer for insertion into the video signals. In addition, using 8 bit parallel preset time input characters, the Video Countdown Programmer can preset up to three countdown generators. The input control signals enable loading and display of GMT and header data, presetting of the CDT generators and selection of the CDT display format and local/remote control.

The video monitor display is shown in Figure 6. There are four (4) time displays, one GMT and three CDT, and up to ten (10) alphanumeric characters of header data that can

be located between any of the time displays. Additionally, six (6) adjustable and selectable color background masks are available to separate and identify the four time displays. The six colors provided are black, white, blue, green, red and magenta. Each time and header display is individually selectable for black or white characters. Header data can have black, white or no background mask.

Input power to the Video Countdown Programmer is 115 volts ±10%, 50 to 400 Hz, 3 wire, single phase. All signal processing electronics are mounted on plug-in circuit modules. The unit is 5.25 inches high in a standard 19-inch wide equipment cabinet.

CONCLUSIONS

The development of compact, reliable, cost effective video instrumentation systems provides new capabilities for data acquisition, recording and display. By formatting and inserting analog and/or digital input data into video signals, this data can be processed and correlated with the video information for recording and display purposes. In particular, the real time display capability of video instrumentation system is very useful for data verification during recording. The applicability of video instrumentation systems for data acquisition purposes is limited only by equipment performance and the system designer's imagination.

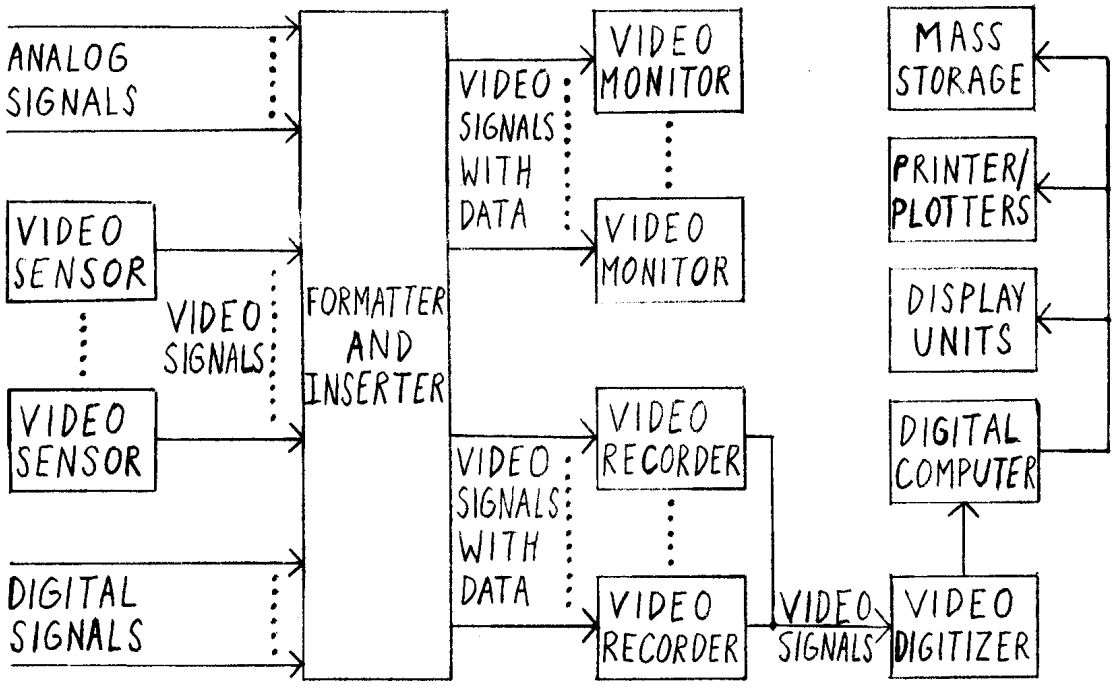

FIGURE 1. OVERALL BLOCK DIAGRAM OF A FULLY IMPLEMENTED VIDEO INSTRUMENTATION SYSTEM

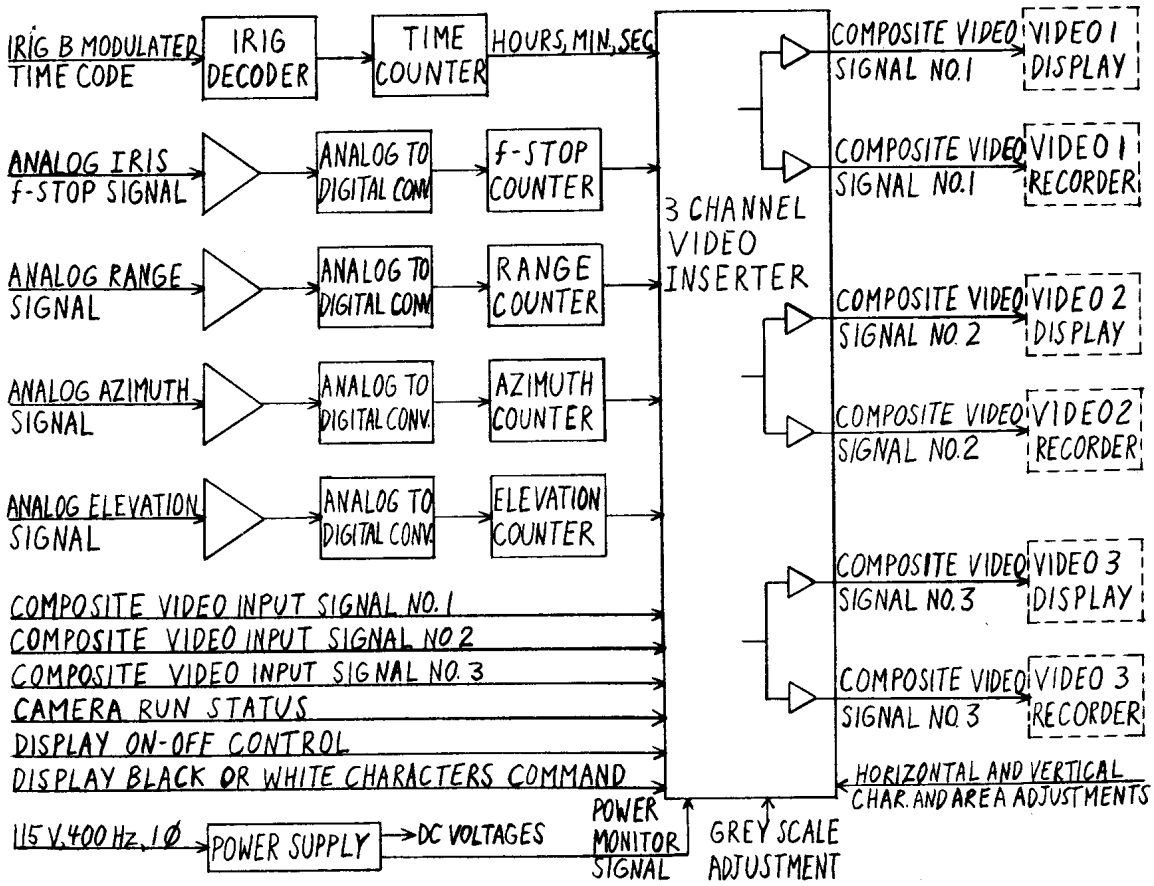

FIGURE 2. FUNCTIONAL BLOCK DIAGRAM OF THE TV DISPLAY GENERATOR

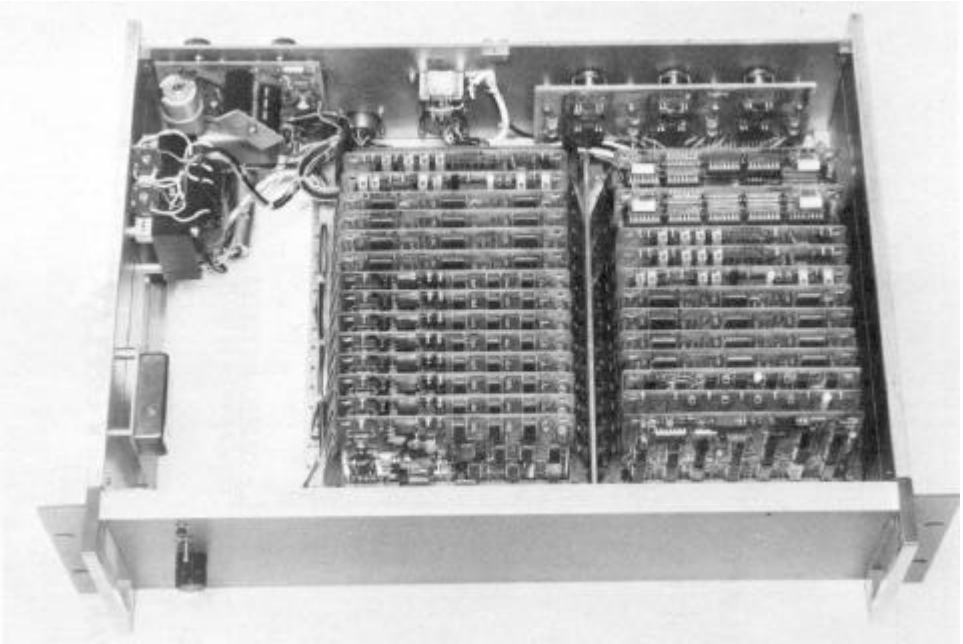

FIGURE 3. TV DISPLAY GENERATOR ELECTRONIC MODULES

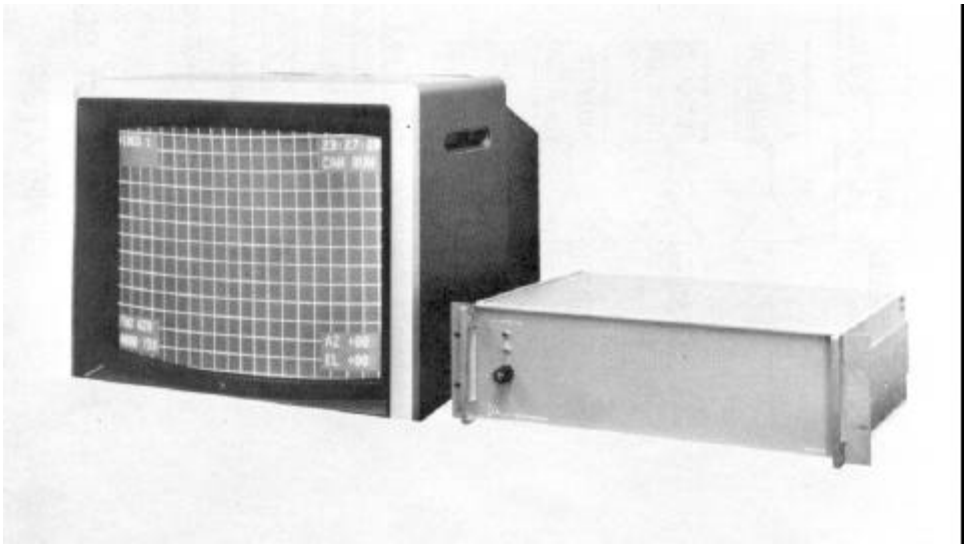

FIGURE 4. TV DISPLAY GENERATOR DISPLAY FORMAT

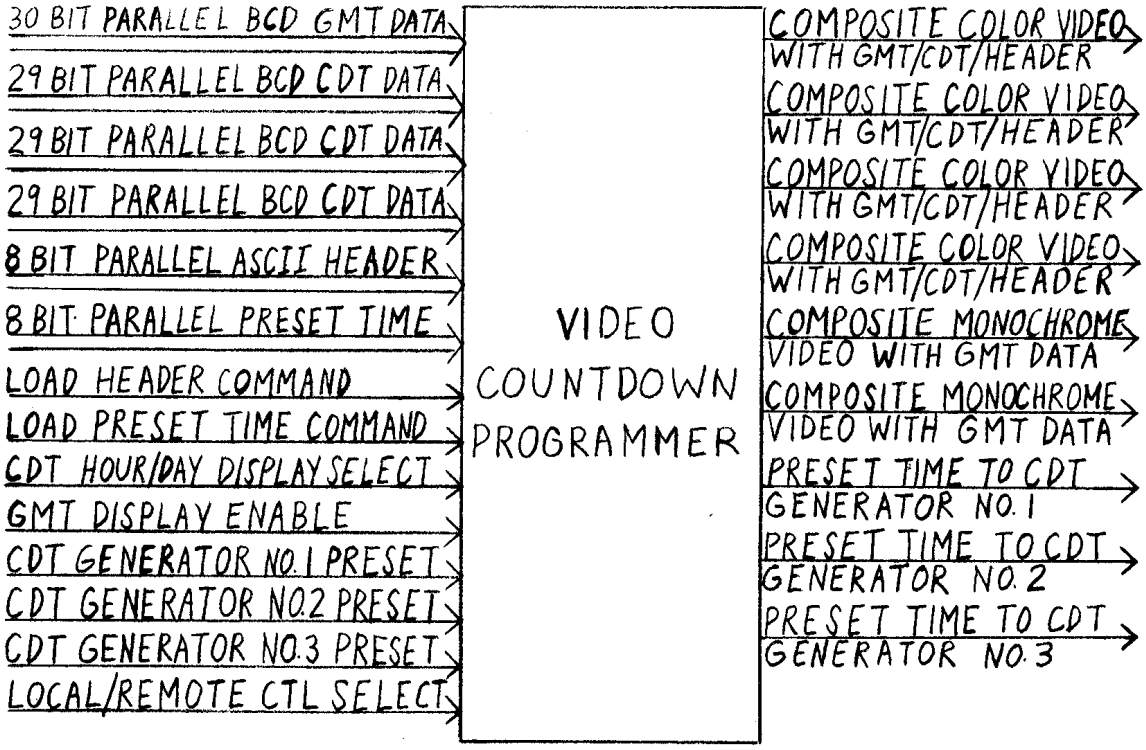

FIGURE 5. VIDEO COUNTDOWN PROGRAMMER INPUT AND OUTPUT SIGNALS

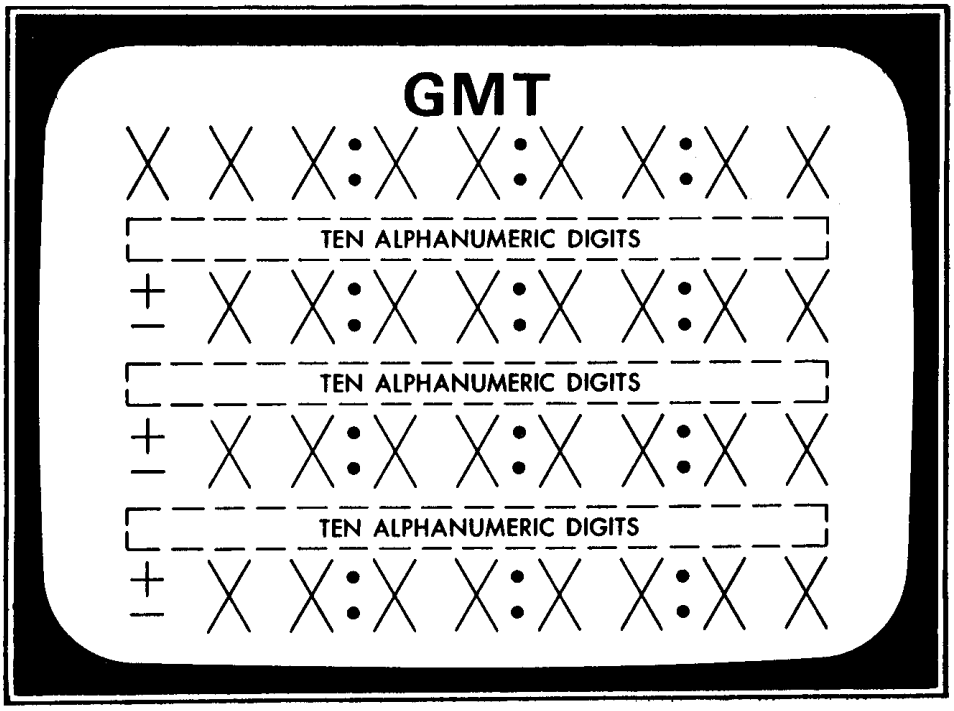

FIGURE 6. VIDEO COUNTDOWN PROGRAMMER DISPLAY FORMAT