Videotape Program Production at CBS Studio Center

By WILLIAM G. CONNOLLY

The one-inch helical videotape recorder has been utilized by CBS to configure a film-style (one VTR per camera) videotape production system at CBS Studio Center in Hollywood. Operating experience with these machines is discussed, with emphasis on observations of video, audio, and transport performance. In addition, this paper describes a unique system for synchronization of one-inch VTRs in post production that has allowed CBS to offer an alternative to traditional multi-camera videotape production methods.

Introduction

In February of 1975, CBS issued target specifications for the design of a videotape recorder with improved editing capabilities. The thrust of these specifications was for a recorder with vastly improved transport characteristics, coupled with a tape format which would permit the display of viewable pictures at a variety of speeds in both forward and reverse. The intended application was for off-line editing systems from which a work copy would be produced. The camera originals would later be conformed through automatic assembly in an on-line editing system.

It had become clear at that time that computer-assisted videotape editing facilities, such as those pioneered by CMX, had become limited, not by software, but through the inability of videotape recorders to respond efficiently to commands without continual breakdown. Moreover, the cost of interfacing various VTR types and models to computers had become an impediment to economical design. Clearly, VTRs with TTL-compatible command systems were needed.

VTR manufacturers had also identified this problem. Less than six months later the first of several laboratory prototypes was shown. The following year brought several more prototypes to light. More than meeting many of the criteria for an editing system machine, however, they had an unforeseen advantage: the audio and video signal performance challenged that of existing 2-in quadruplex broadcast recorders.

CBS chose a nonsegmented or one field per scan video format from among those 1-in helicals offered at that time. This format, later to be standardized as SMPTE Type C, has the inherent capability of producing viewable pictures at many tape speeds. Since that time a digital store has been designed to provide this capability also with the segmented formats.

CBS currently uses the Sony BVH-1000 in editing system designs and, necessarily, the data which follows describes that machine. However, there is every indication that other recorders built to the SMPTE Type C standard will be capable of equivalent performance.

The performance data were originally measured in mid-1976 on three pre-production prototypes. Machines of later production runs have been compared and the data proved to be typical of the 23 units in service or currently being installed at CBS.

Video Performance

Typical video performance is shown in Table I. All the performance data shown compare favorably with quadruplex recorders, particularly in differential gain, phase and moiré, but note especially the improved interchange performance. A typical signal-to-noise ratio of 49.5 dB, coupled with an interchange loss in SNR of only 0.2 dB, gives rise to excellent multiple-generation performance. First-generation quadruplex performance is typically 47 dB and interchange loss is 2.0 dB. This means that a tape recorded on one VTR and played back on another (the most usual kind of operation) would, typically, have an SNR of 45 dB for quad and 49.3 dB for helical. In other words, the 1-in helical product is "up" more than one generation, compared with a quadruplex recording.

Figure 1 shows plots of noise performance versus number of generations for a 1-in helical VTR.

The uppermost curve shows wide-band noise measurements out to the twelfth generation. These tests were made using three machines with a procedure which ensured that no recording was played back on the machine on which it was made. (Time-base correctors were used for each of the 12 dubs.) Each generation, therefore, included an interchange loss and a dubbing loss.

The middle and lower curves show amplitude- and phase-modulation losses as measured on a Shibasoku (of Tokyo) 925C meter. The significance of these curves can only be adequately explained in a paper on that subject alone. Suffice it to say that both the AM and PM noise curves are as smooth as the wide-band curve and that they also track that curve rather well. Our experience has shown that wide-band noise measurements do not correlate well with the subjective evaluation of videotape signal degradation. On the other hand, amplitude modulation and phase modulation do correlate well, particularly with PM noise, which is a measure of color distortions. Subjectively, the results are better than that indicated by a simple review of signal-to-noise curves. Coherent picture disturbances such as banding and first line error are usually more detrimental in dubbing operations than signal-to-noise loss. A nonsegmented format is, of course, free of those errors.

Audio Performance

As can be seen in Table II, frequency response and signal-to-noise ratio approach that of studio-quality audio recorders. Harmonic distortion of 0.7% and wow and flutter measured at 0.03% promise excellent results. These results are in large measure due to a unique push-pull dual-capstan design.

There are three audio tracks in this format, with Audio 1 and Audio 2 separated by 0.8 mil (0.2 mm). These tracks can be used to record stereo or independent audio signals. In the latter case, crosstalk of −38 dB at 50 Hz and −50 dB at 100 Hz may seem unacceptable to the audio purist. However, the ASA "A" weighting curve comes to our aid at these frequencies. Listening tests confirmed the acceptability of the 0.8-mil separation; testing included hard rock music passages which evidently have become the acid test currently in favor in the audio world.

Transport Performance

Tape transport performance meets a very high standard. Variable-speed search is controlled by a dial with still frame at a centered detent. Clockwise rotation of the dial moves the tape forward in increments from still frame through 64 times play speed, with the speed proportional to the amount the dial is moved off center. Counterclockwise motion performs the same function in reverse.

Table I. BVH-1000 video performance. (Measurements include BVT-1000 time-base corrector.)

Frequency response	±0.3 dB from 30 Hz to 4.15 MHz; −3 dB at 4.5 MHz
Signal-to-noise ratio	49.5 dB unweighted
Differential gain	3.0%
Differential phase	2.5°
K-rating (2*T* sin² pulse)	0.8%
Moiré (75% color bars)	−43.0 dB
Interchange loss (SNR)	0.2 dB

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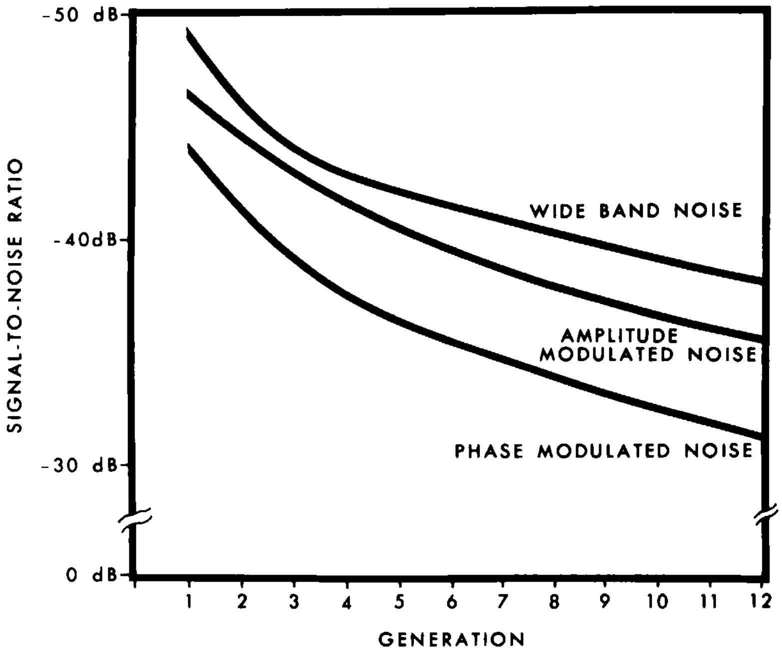

Fig. 1. BVH-1000 multiple-generation performance.

Proportional control is actuated by the same dial through operation of a mode button. Continuous clockwise rotation of the dial moves the tape forward in speeds from still frame to one-fifth normal play speed. The faster the dial is turned, the faster the speed. Counterclockwise rotation, of course, performs the same function in reverse. The best way to describe the action of proportional control is that it is akin to grabbing the reels by hand and rotating them, but with far greater control — and without the danger of tape damage.

Initial reactions of editors using these controls have been excellent. Finding the exact frame on which a camera cut was made is quickly and easily done.

Video display lock is, of course, a function of both transport and time-base corrector for a given format. A color picture is held quite satisfactorily in high-speed search at eight times play speed and a black and white picture as fast as 40 times play speed.

With the recorder placed in the standby mode, video lock is achieved typically in 2 s. Three seconds is a safe preroll time. Video lock-up time from the stop mode requires about 13 s — most of which is consumed in bringing the scanner up to speed. Also, due in part to the use of ac servos throughout, the transition between modes requiring high motor torque seems sluggish. This is no doubt due, in large part, to concern on the part of the manufacturer to avoid tape damage.

Machine control is effected by means of a TTL-compatible interface internal to the recorder. A 64-bit word is used for each command and sent over a single bus in a 200-kHz data stream. Machine status is echoed over the same bus. An application of this system will be described later.

Location of Facilities

CBS has completed three videotape post-production editing installations since June 1977. The three together use a total of thirteen 1-in helical recorders.

Two installations, each with four machines, are in television studio production

Table II. BVH-1000 audio performance.

Frequency response	±0.6 dB from 50 Hz to 15 kHz
Signal-to-noise ratio	60 dB unweighted (ref.: 3% THD at 400 Hz)
Harmonic distortion	0.7% (ref.: 8 dB below 3% THD at 1 kHz)
Wow and flutter	0.03% rms, NAB unweighted
Audio 1/ Audio 2 crosstalk	−38 dB at 50 Hz −50 dB at 100 Hz −65 dB at 1 kHz −57 dB at 15 kHz

facilities, one at CBS Television City in Hollywood and the other at CBS Studio 51 in New York. The Television City facility is described in a separate paper by William C. Nicholls entitled "A New Edit Room Using One-Inch Helical VTRs" — see p. 764 in this issue of the *Journal*.

The Studio 51 installation is unique in one important sense. The system is dedicated to a studio 30 blocks distant from CBS Broadcast Center. Prior to the advent of lower-cost machines, the recorders would have been integrated into the Broadcast Center complex for maximum utilization, with local telephone-company loops providing service to the off-premise studio. Now, however, the lower capital cost of the 1-in VTRs has allowed four machines to be dedicated to that studio alone.

The third facility is different in many ways, principally because it is located at a film production facility — CBS Studio Center in North Hollywood. (The background leading to the design of this facility is covered in a paper by Joseph A. Flaherty entitled "New Horizons in Television Program Production, Post-Production and Continuity" published in the September 1977 *SMPTE Journal*.)

The post-production editing system at Studio Center is one portion of a special multi-camera videotape unit designed by CBS to produce multi-camera film programs. In this application the electronic photography is done film-style, with a videotape machine assigned to each camera. Since all the footage from each camera angle is recorded by the VTR associated

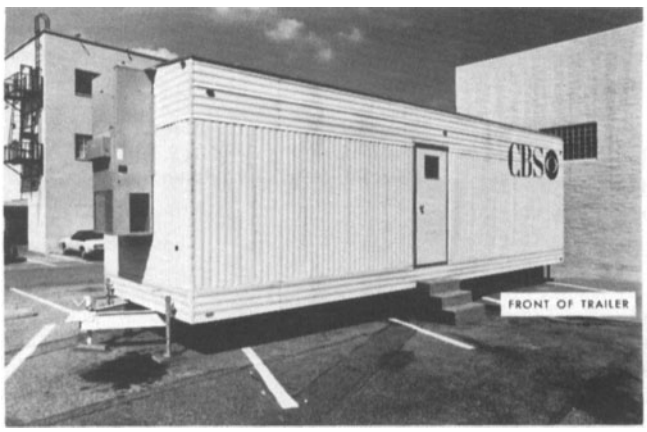

Fig. 2. CBS Studio Center trailer (exterior right side view).

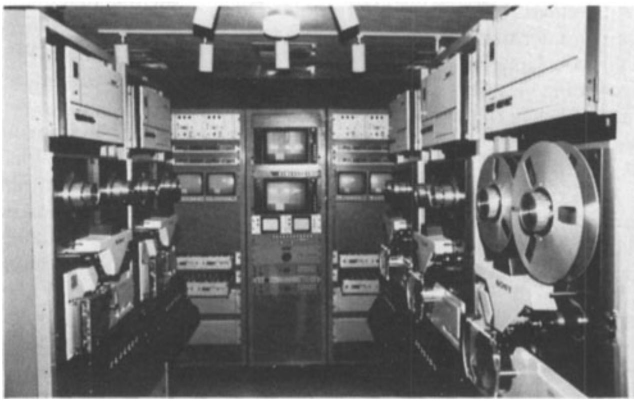

Fig. 3. Interior of CBS Studio Center trailer, showing production equipment.

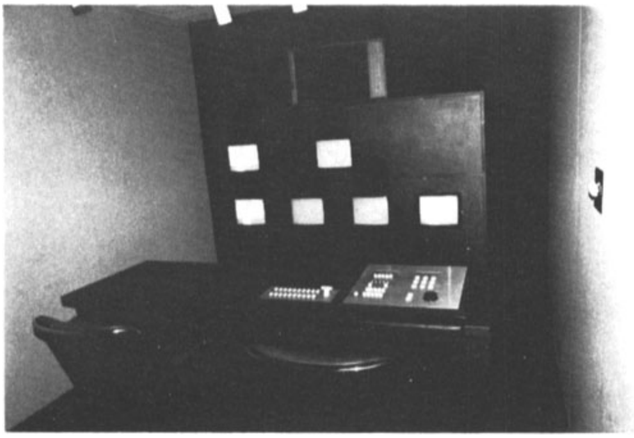

Fig. 4. Post-Production Center within the CBS Studio Center trailer.

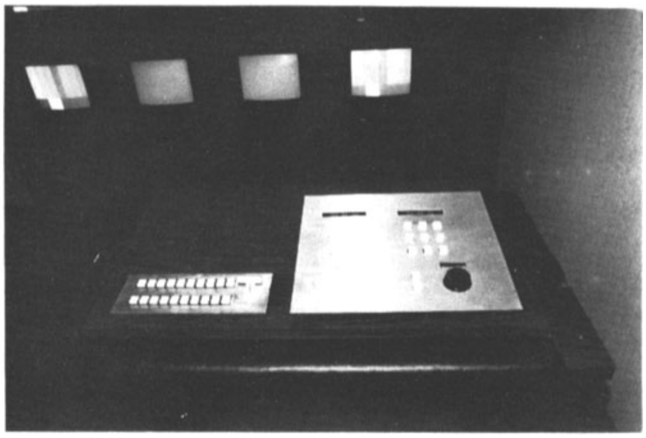

Fig. 5. Close-up of the trailer Post-Production Center.

with it, no video control room or switcher is required. The director remains on stage, shooting complete scenes of several minutes in length in front of a live audience, just as he would have done using film cameras.

Multi-Camera "Film" System

The trailer unit is shown in Fig. 2. This vehicle can be moved between film sound stages to service various productions as required. The production equipment is at the rear of the trailer, as shown in Fig. 3. Four complete channels are shown, each consisting of a camera and a videotape recorder. The fifth VTR is installed for later use in editing.

After some experimentation, the production company settled into three-camera scene coverage, a well established practice in film sit-coms. This technique places the master, or wide-angle, camera at center stage, with another camera on each side shooting the reverse angles. A fourth camera is used infrequently for party scenes or to carry the action through a difficult move.

During shooting, the fifth VTR was used to double-record the master angle. Identical SMPTE time code is required on all machines, and serves during editing as the equivalent of a crystal black tape with prerecorded color black signal. This recording also provided protection for the master camera angle — but, in the 25 episodes recorded thus far, we have not experienced a record failure.

After production has been completed, the next step in the process is to produce an intermediate edit through post-production editing. This recording is essentially the same videotape that would have resulted if the scenes had been switched in a video control room during a live television production.

The post-production editing booth is located in the rear of the trailer, as shown in Fig. 4. The lower four monitors show the four-camera videotapes and the top center monitor, the edited output. The upper lefthand monitor shows the playback of the record VTR. The editing control panel is on the left of the console, and a single set of VTR transport controls, including time-code displays, is shown on the extreme right. The helical VTR synchronizer controls are centered between them.

Helical VTR Synchronizer

To make an intermediate edit copy through post-production editing, a means for keeping up to five helical VTRs in lock-step had to be devised.

The design of the VTR synchronizer illustrates the versatility of a computer-compatible command structure. The Sony BVH-1000 uses three digital control buses and one analog control bus. One digital bus carries 200-kHz clock pulses. The second bus carries a serial 64-bit word with 32 bits for command and 32 bits for status. The third interleaves the output of two internal registers — one for SMPTE time code and the other for the mechanical tape counter. The analog bus carries a continuously variable dc-voltage capstan override control which is acted upon only in the presence of the capstan override digital command.

Typically, a scene would be edited as follows: the material is first reviewed, usually by playing the wide-angle VTR at the top of the scene. Depressing the MARK button stores the "in-point" frame code in a reference register.

When it is time to post-edit the scene, the CUE button is pushed, sending all machines to the reference time code. This is done by comparing each individual VTR time-code digital bus with the reference register and automatically issuing a series of commands forcing the difference to zero. When the difference is zero, the "still frame" command is issued.

From this point all the machines respond to a single set of transport controls as if they were one machine. When the PLAY button is pressed, all machines start and are slewed into frame coincidence. This is done through capstan control commands that force time-code differences to zero.

The scene is then edited in real time via the two-row switcher to the left of the operator, as shown in Fig. 5.

If an editing error is made at any time during the scene, the machines may be recued to a point just before the error, and editing continued from the last good cut. In fact, it is possible (with care) to repair even one bad cut in the middle of a scene.

One thing is certain: the talent can be counted upon to give exactly the same performance each time the scene is replayed!

It was stated earlier that the intermediate edit copy is essentially the same as would be produced from a performance switched in a video control room. In fact, it is *better* because no switching errors need be corrected later.

As with normal TV switched in a control room, final editing (including assembly of scenes, insertion of pick-ups, and titling) are completed in an on-line editing facility.

Conclusion

The new 1-in helical VTRs offer the system design engineer a versatile new component that is small and lightweight and attractive in terms of power consumption, tape consumption, and operating cost. Picture and audio quality are equal to, and in many ways better than, their antecedents. The system just described would not have been feasible without them. Further, these new machines, along with their portable versions, are likely to widen the use of videotape for entertainment programs previously produced on film, and to broaden ENG applications to include documentaries. Perhaps even more significantly, they may cause the television plant engineer to question the large expenditures he has been making in multi-level routing switchers in large plants and reconsider the possibility of dedicating videotape recorders to studios.