Delta T: A New Dimension in Type-C Recording

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A new Type-C VTR, the BVH-2500, was introduced by Sony at the NAB and Montreux exhibits in 1983. This machine was designed to expand the capability and flexibility of videotape recording by utilizing a new technique called Delta-T recording. The concept and theory of Delta-T recording are described in this article.

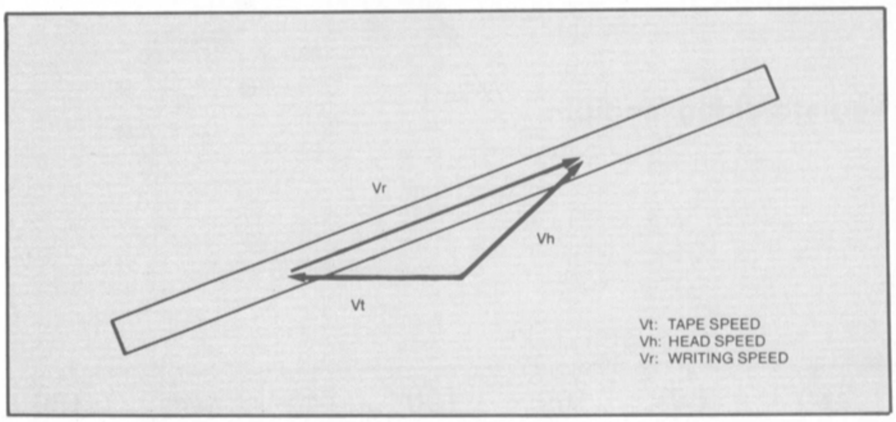

Figure 1. Normal speed recording vectors.

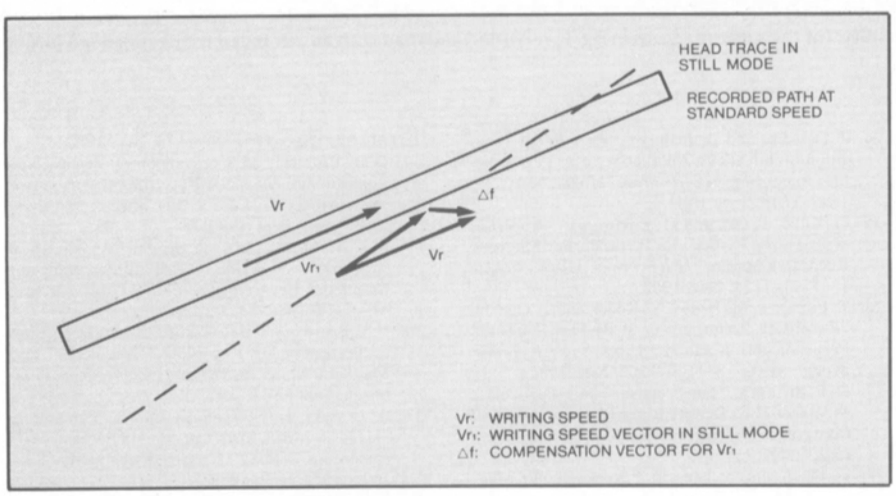

Figure 2. Writing vector with no tape movement.

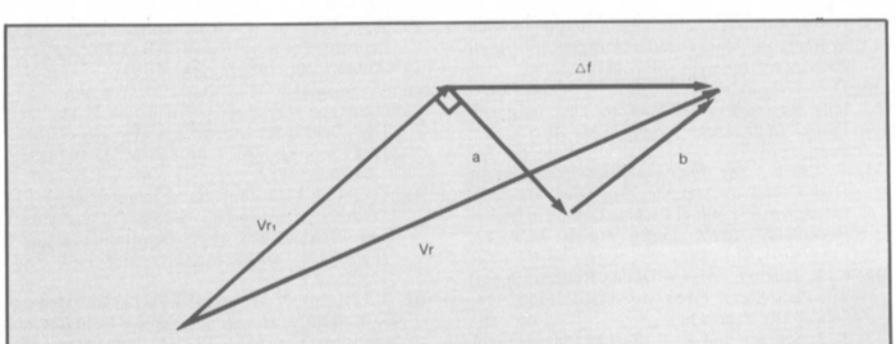

Figure 3. Compensation vector components.

In recent years, broadcast videotape recorders have utilized the freedom of playback at various speeds. This has been made possible by moving-head playback systems. However, they do not have the same freedom when recording. For example, for a single picture or a short-term recording, a complicated sequence of operations must be performed. Only the Delta-T recording system can reduce this complicated sequence to one simple operation. The VTR with both normal and Delta-T recording functions is therefore far more flexible.

Demonstration by Vector

In the description that follows, simplified vector diagrams are used to represent the parameters for C-format recording. The effects of non-standard recording conditions on these vectors is shown. One of the parameters determining the recorded magnetic pattern is tape speed. Figure 1 shows the relation between vectors representing tape speed Vt, head speed Vh, and writing speed Vr. The combination of tape speed, head speed, and the helix angle yield a writing speed vector Vr at an angle of 2° 34 min. This is the track angle. With zero tape speed the track angle will be equal to the helix angle, which is 2° 34 min 29 sec.

As shown in Fig. 2, Vector $Vr1$ is the uncompensated writing speed vector. By adding a compensating vector, Delta f, the normal writing speed vector can be reconstructed. A Type-C recorded pattern can be constructed while tape speed is other than normal by adding a total of four compensating vectors.

The first two vectors, a and b, compensate for the change in track angle. These vectors are the components of Delta f, as shown in Fig. 3. Speed vector a is added to the writing

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vector *Vr*. Vector *a* is the vertical component of head movement from the ramp waveform of the dynamic tracking (DT) driver. The ramp is determined by the tape-speed information detected by the capstan servo's frequency generator (FG) processor. The sinusoidal output of the FG sensor is digitized by an 8-bit analog-to-digital (A/D) converter.

Rate detecting software analyzes capstan rotational speed. One hundred twenty samples can be obtained within one track pitch at the slow speed of 1/60. Therefore, vector *a* can accurately compensate for the angle variation of the recorded track as a function of tape speed. Vector *b* must be added to *Vr* as compensation for the horizontal component of the writing speed. Vector *b* is added by the input time-base processor before recording (Fig. 4).

The processor consists of an A/D converter, a 16-line memory, a digital-to-analog (D/A) converter, and a memory controller. To vary the length of vector *b* in proportion to tape speed, the "read" clock is modulated (Fig. 5). For example, in still recording, the "write" clock for the 16-line memory is locked to 4 times the color subcarrier frequency, and the "read" clock frequency is reduced to 3.962 times the color subcarrier frequency. This results in a recorded track with the same horizontal-timing as a normal speed recording.

In still and step recording, tape location is predetermined by the stepping movement. In the slow mode of recording, the tape recording location may change each time. There remains a small amount of tape positioning error even in the still or step recording modes. This is the cause of the vertical component of the track displacement. Delta P (Fig. 6) cancels that component and is added to *Vr* by introducing an offset voltage to the DT head. After adding Delta P, the record location is correct. The high-resolution capstan servo accurately parks the tape, and the tape location data from the capstan FG pulse counter is used to position the record DT head precisely.

The fourth vector, Delta ϕ, is the compensating vector for the record video phase error. The "read" clock's start pulse works as a phase controller of the recorded video signal. The length of Delta ϕ is proportional to the tape location data. The use of these four vectors, *a*, *b*, Delta P and Delta ϕ, allows the BVH-2500 to record a C-

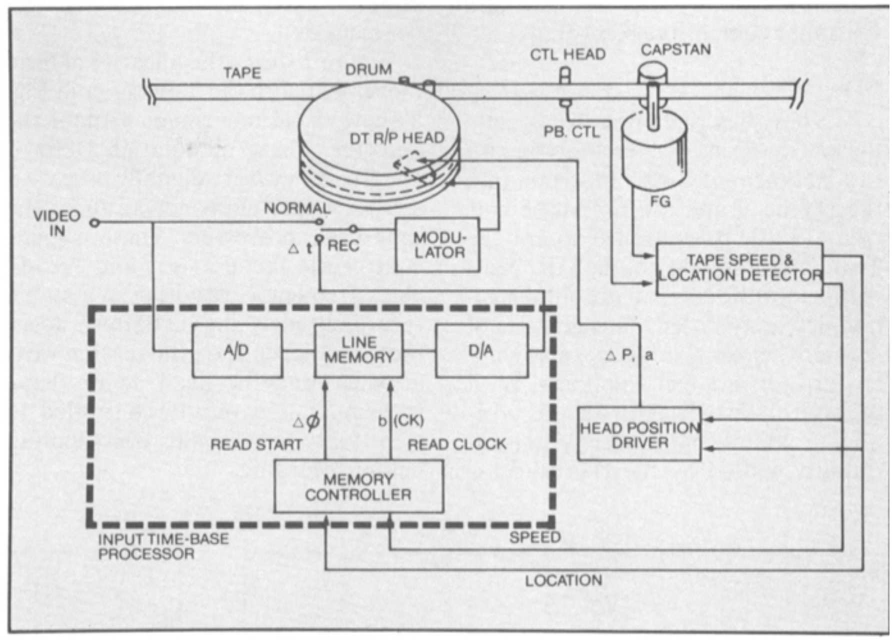

Figure 4. Block diagram of Delta-T recording.

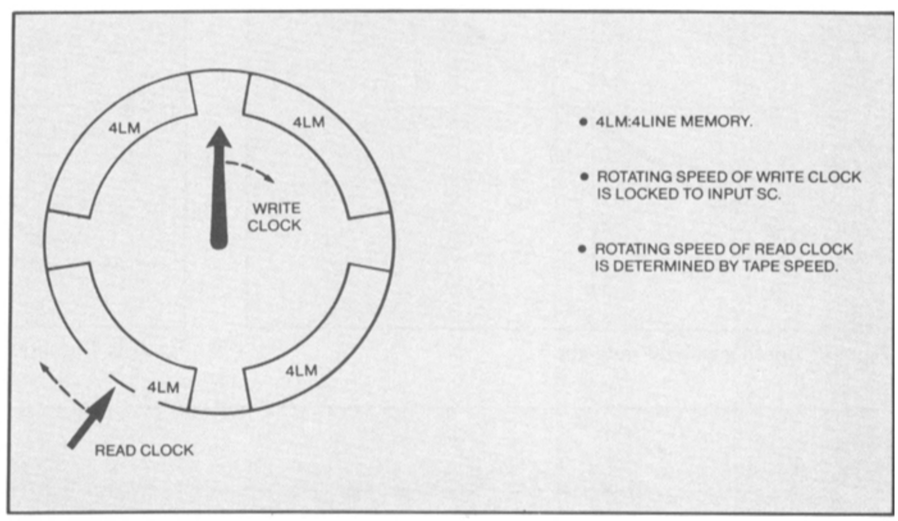

Figure 5. Memory controller.

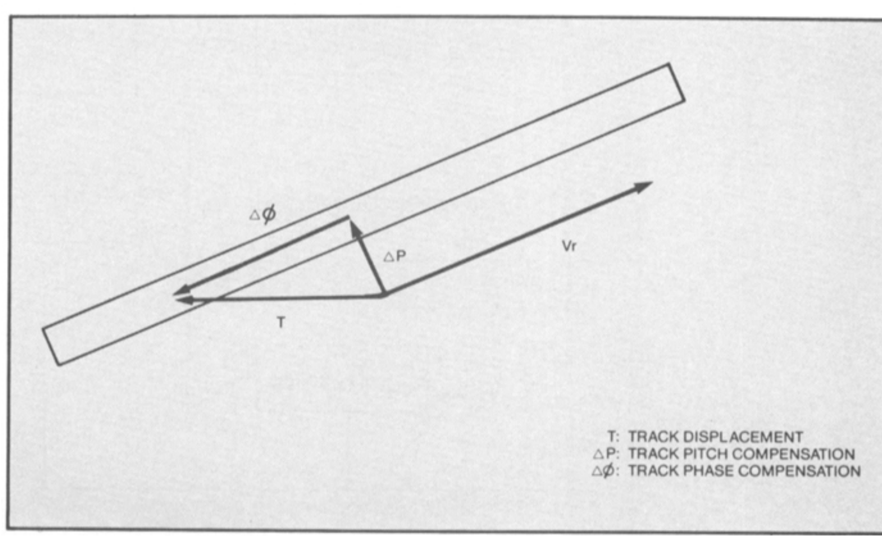

Figure 6. Track displacement compensation vector.

format magnetic footprint and thus a C-format compatible recording.

Accuracy

We have described how to calculate the four compensating vectors and how to adapt them. It is also important that the DT head and the time-base corrector (TBC) be controlled accurately. To maintain stability of the DT head's vertical positioning, an absolute position detector is used. This consists of resistant wire strain gauges and very low-drift operational amplifiers. With the use of this detector in the positioning circuit, non-linearity and instability caused by the DT head assembly's hysteresis characteristics are compensated.

Figure 7 shows the linearity of head movement with the detector, and Fig. 8 shows head movement without the detector. Phase modulation Delta ϕ and frequency b are digitally processed at the "read" clock generator of the time-base processor. These signals control the "read" start and "read" clock frequency, resulting in a stable recorded video phase. Pattern accuracy also depends on the tension variation around the head drum. Tape movement is carefully controlled to step forward without overshooting before recording.

Framing

Maintaining the field sequence during recording and editing is very important. Without continuity of the odd and even relationship between neighboring fields, the interlace of reproduced pictures is not completed. Without the continuity of the four-field sequence of recorded tracks, the reproduced signal causes horizontal picture shifts or instabilities in the TBC. The control track pulse (CTL) of Type-C format contains field, frame, and color-frame information. The system requires a prerecorded CTL signal. Playback framing is achieved by the recognition of the CTL

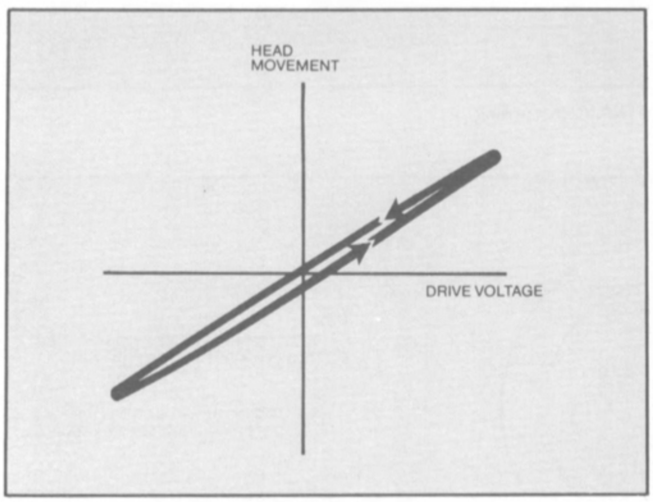

Figure 7. Linearity with the detector.

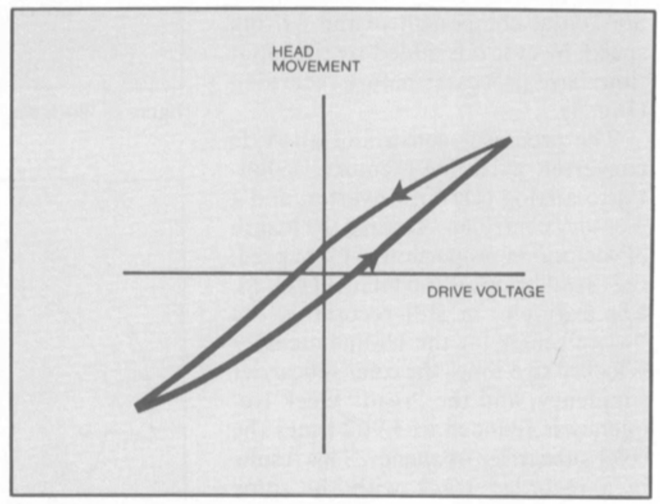

Figure 8. Linearity without the detector.

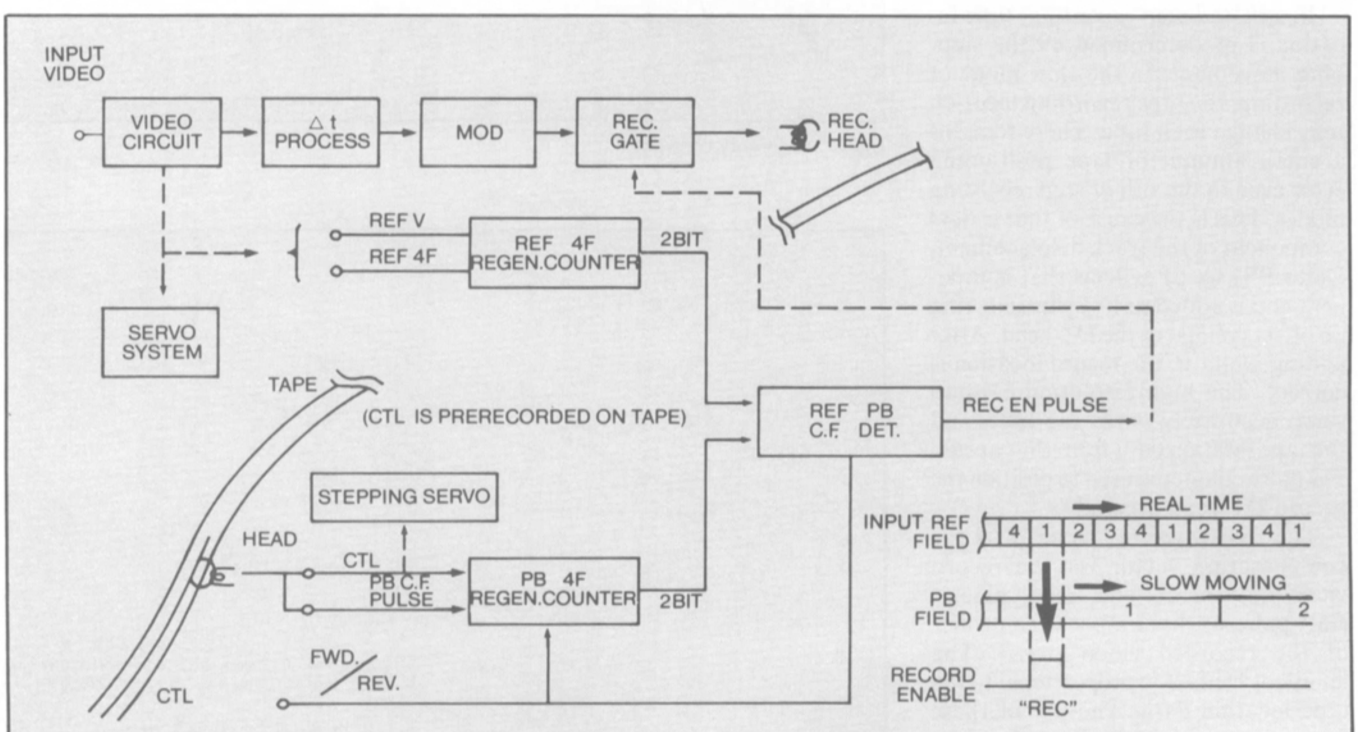

Figure 9. Framing in record mode.

polarity and the existence of the color frame marker.

In the record mode, the framing sequence is controlled by the system shown in Fig. 9. The concept of color framing in the record mode is simply explained by waiting. The BVH-2500 will wait for the desired field of the input video signal to arrive before it records. With such a framing system, Delta-T recording assures direct color processing in playback.

Operation Modes

Figures 10 and 11 show the BVH-2500 and the Delta-T controls, respectively.

There are five types of Delta-T modes, two accessing modes and three Delta-T record modes. The two accessing functions are search to cue and step playback.

Search to Cue

In the search-to-cue mode, accurate parking at the addressed track is accomplished. This consists of time-code detection, fast forward/rewind control, framing detection, and capstan step control.

Step Playback

This is the mode for field or frame stepping in preparation for accurate replay and recording.

The Delta-T record modes are as follows:

Still Record

Field or frame rewriting at the parked point is performed in this mode. A minimum of 0.2 sec is required for the erase-and-record sequence.

Figure 10. The BVH-2500.

Step Record

This is the mode in which the tape steps towards the neighboring new field or frame. Field or frame rewriting is then performed and the recorded picture appears. Approximately 0.6 secs are required for a complete record cycle.

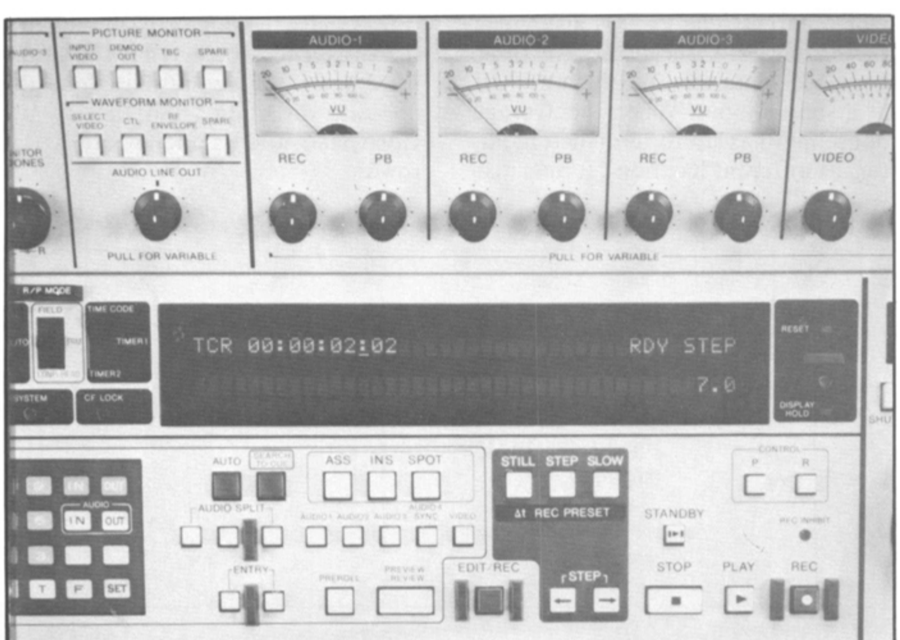

Figure 11. Control panel of Delta T.

Slow Record

This is the mode for field or frame recording while the tape is continuously moving. The tape speed is preset from the search dial on the control panel. A recording speed range of 1 field/sec to 4 frames/sec is possible.

Applications

All production and post-production applications of which the BVH-2000 was capable can also be satisfied by the BVH-2500. The BVH-2500 has retained all of the tape transport and operational features of the BVH-2000 with a Type-3 control panel. The high-speed dynamic tracking system, advanced tape transport and servo design, use of a reliable cross-roller entrance and exit guide mechanism, full-scale editing features, variable memory, and the VTR's compact size and light weight are only a few of the features that both VTRs share.

The BVH-2500's Delta-T record modes offer a broad variety of possibilities. The still and step record modes will find use in animation and computer graphics applications. The growth in speed and sophistication of computer animation systems will be enhanced by the BVH-2500. Recording and editing single frames will become a simple process. Interactive videodisk mastering is another natural application for the BVH-2500. Future requirements of videodisks will be met by this VTR, in a wide range of applications.

For still picture and slide store use, a capacity of 200,000 frames or 400,000 fields is available on a 2-hour reel.

Conclusion

Before the appearance of the BVH-2500, conventional VTRs could manipulate continuous pictures only. Now it is obvious that the BVH-2500 can manipulate any type of picture, continuous or discontinuous. We believe that Delta-T recording has added a new dimension to Type-C recording and, as a result, increased the flexibility of C format. The application of such a VTR is limited only by the creativity of the user.

References

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2. H. Tanimura, Y. Fujiwara, and T. Mehrens, "A Second Generation Type-C One-Inch VTR," *SMPTE J.*, December 1983, pp. 1274–1279.