In the News
Ampex Audio-Video Systems Article Reprint

Applied technology

Extending multigeneration limits

By Michael Arbuthnot

Twenty-three generations with a type C VTR? It sounds impossible (and is not necessarily recommended) for an analog machine, but it is possible. The problems of multiple analog generations stem from several factors. Understanding and controlling those factors can extend the format's capability.

Sources of degradation

Conventional wisdom holds that today's 1-inch type C videotape recorder can deliver only five to eight generations of broadcast-quality images before the signal becomes unusable. Most people believe noise is the chief cause of picture degradation.

Whenever a videotape is reproduced, noise is present. That noise becomes part of the video signal, which is rerecorded in post-production. With each playback, the image is degraded to some extent. After a number of dubbing passes, the result becomes objectionably obvious.

Some control over noise is possible. Filtering can reduce the amount of noise in the reproduced video, but to do an effective job, high-frequency filtering takes a toll on the signal components responsible for picture detail.

Other factors affect the signal-to-noise ratio, too, such as recording levels and track widths. These parameters have already undergone a good deal of optimization for the C format. Little, at present, can be done to improve on that.

Although noise has been considered a prime culprit of multigeneration degradation, other controllable factors have had a more significant impact. Accumulated errors in the setup of the VTR, TBC and other production equipment are one source. Accumulated uncorrected velocity errors are another form of degradation. Both are frequently mistaken for noise.

Setup errors

Typically, an operator adjusts the VTR for a recording while monitoring color bars. In accordance with the waveform and vector monitors, black level, white level, chroma amplitude and phase, differential gain and phase and record currents are adjusted.

Although the setup may *look* accurate, absolute accuracy is difficult to achieve, even for the experienced operator. A slight error in a setup parameter will adversely affect the recording. What is not immediately obvious, for example, is that a 1IRE error in black level accumulates into 10IRE units of error by the 10th generation. In the same way, a 1° error in the chroma phase adjustment becomes a 10° error by the 10th generation. Other errors are similarly compounded.

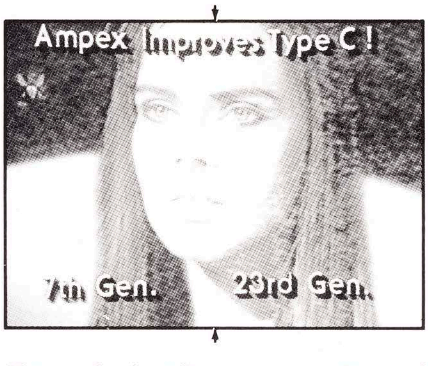

Figure 1. *A split-screen presentation of seventh- and 23rd-generation video recorded with a VPR-3 and Zeus shows little difference in the image. The arrows indicate the line between the two signals.*

Fighting fate

Dubbing degradation is a future problem. It compounds with each generation, and only becomes obvious after the damage has been done. One solution would be to see into the future, while adjusting parameters in the present. That possibility would allow reduced setup errors before they occur. But how do you see into the future?

A means to look into the future was one of the goals of Ampex design engineers. With a VPR-3 VTR and Zeus video processor, an operations menu selection called *M GEN* (multiple generations) places the machine into the insert mode. The electronics are set for playback, but armed for recording.

When the M GEN function is activated, the VTR displays 10 generations of color bars in a real time continuous loop. Starting from a first-generation recording of a color-bar signal, the operator can see the evidence of accumulated errors.

The mechanism for seeing into the future is based upon automatic scan tracking with a playback head mounted on piezoelectric material. The VTR plays a field of the original generation of a color-bar signal and passes it to the video proc-

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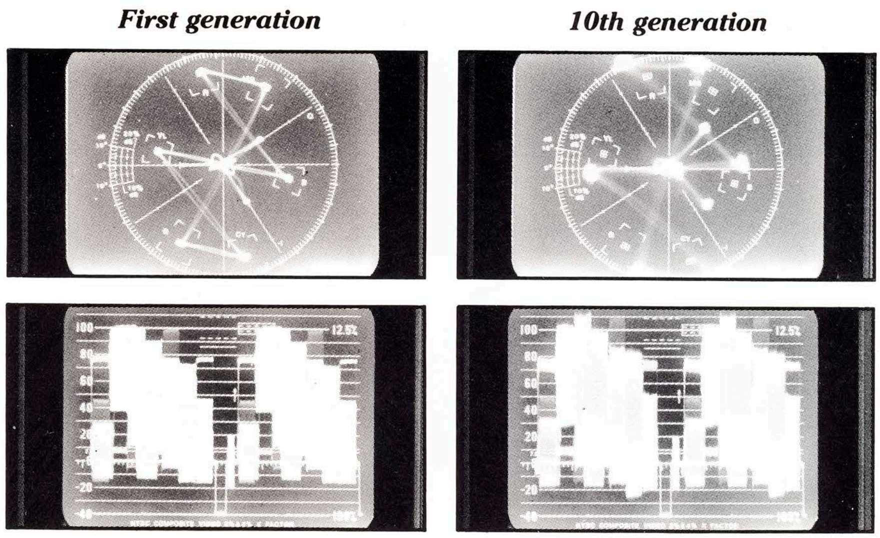

First generation ***10th generation***

Figure 2. *In a side-by-side comparison of first- and 10th-generation color bars, vector and waveform monitor displays indicate the accumulation of uncorrected errors.*

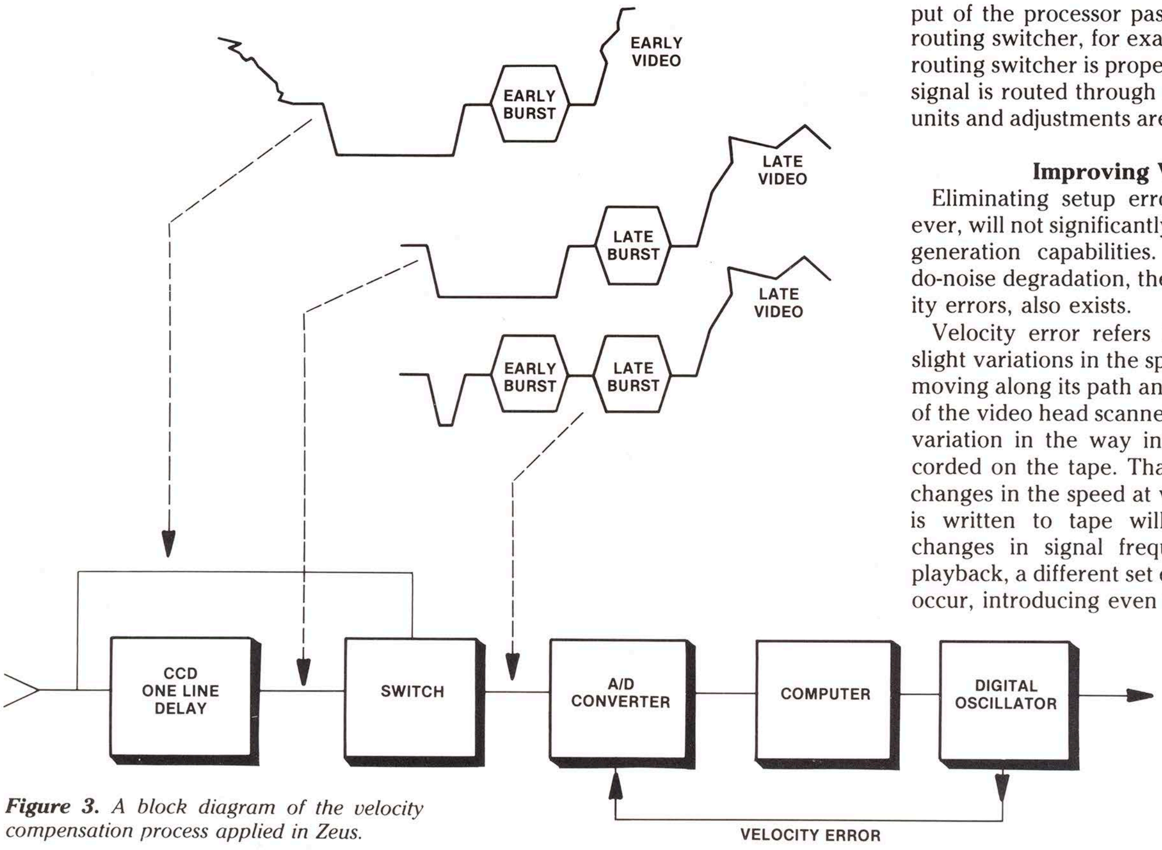

Figure 3. *A block diagram of the velocity compensation process applied in Zeus.*

essor. The signal is routed back to the VTR and recorded again. The newly recorded track is now the playback information. This loop repeats until the 10th field.

After the 10th field, the VTR exits record mode for one field in order to read one field of the original first-generation test-bar pattern. This cycling through 10 field-by-field generations is repeated three times per second.

Beyond the VTR

With the look-ahead feature, VTR parameters can be fine-tuned for a minimum degree of variation between the first and 10th generations. These parameters include black, video and chroma levels, chroma and equalization burst phases, record current and differential gain and phase. Eliminating accumulated setup errors in the VTR is only part of the solution.

All other devices in the video signal path are equally suspect in producing errors, from the TBC and machine distribution amplifier to the routing or production switcher. Unseen setup errors in the signal path of associated production equipment eventually become obvious.

The 10-cycle sequence described for the VPR-3 and Zeus processor may be used for other studio equipment. Instead of returning directly to the VTR, the output of the processor passes through the routing switcher, for example. When the routing switcher is properly adjusted, the signal is routed through other individual units and adjustments are made for each.

Improving VEC

Eliminating setup errors alone, however, will not significantly improve multi-generation capabilities. Another pseudo-noise degradation, the result of velocity errors, also exists.

Velocity error refers to compounded slight variations in the speeds of the tape moving along its path and in the rotation of the video head scanner. The result is a variation in the way information is recorded on the tape. That is, the minute changes in the speed at which the signal is written to tape will cause minute changes in signal frequencies. During playback, a different set of variations will occur, introducing even more error.

As playback progresses, variants in speeds and frequencies introduce a shift in color. Like setup errors, velocity errors compound with each generation, the previous record and current playback errors mixing with current record errors. By the 10th generation, massive color shifts can result.

Velocity error compensation is not new and nearly every TBC provides some degree of compensation. For multiple-generation work, however, an extra degree of compensation must be used to reduce the error. Digital-processing techniques can come to the rescue.

The frequency of the color in a line of video is relative to the frequency of its burst. Ideally, the frequency of each burst from line to line should be an identical 3.58MHz. Velocity error creates changes in frequency and subsequent slight differences in the phase of each burst.

Conventional time base correction is accomplished as a final step of signal processing. The phase of burst on the present line and burst of the next line at a specific point in time is sampled. A difference between the two samples is determined. A compensation can be made from an estimate of the accumulated phase error across the line. In most cases, an analog burst filter is used. Such an analog filter does not allow an accurate calculation of true velocity error of the line.

Working in the digital domain, velocity compensation can be accomplished at the beginning of processing. A line of input video is routed to a 1-line delay holding area. As the following line is received, burst from the new line is gated into the delayed line, yielding a line with two bursts.

After the A/D conversion, 32 samples taken from each of the two bursts are compared. The error is a precise measurement of the phase difference between the present and future bursts. The difference controls a digital oscillator used for the A/D clocking process. Because the oscillator frequency now includes the same error as the line of video being converted to a digital stream, the error is removed during digitization. Subsequent processing will deal only with velocity error-free data.

Combining two worlds

There has been speculation that the type C format must yield to digital-recording systems when more than a few generations of material are necessary for post-production. Noise will still exist, but in the absence of setup and velocity error, its effect is far less apparent.

Through digital and digitally controlled processing, an increase in type C generations by a factor of two can be achieved without significantly increasing signal degradation.

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