Ari Greenberg
Video Preservation I
MIAP
10/15/18

"to make the wheel round": time base correctors, then and now

Time base correctors (TBCs) have just one purpose[1]: to correct time base errors. Therefore, before discussing time base correctors, it behooves us to briefly discuss time base errors. What, exactly, are they?

As is well known, in the most basic technological terms, video images are generated from a source (that is, a camera/recording mechanism) and viewed—that is, reconstituted electronically—on a device (that is, a monitor). In order to maintain their two-dimensional visual integrity *and* their linear, temporal integrity, the source of the signal must somehow be synchronized in real time with the device. This, however, is easier said than done; in practice, playback is almost always an imperfect science, and in fact more accurately an art. That's because every playback device is mechanically different—each with its own quirks and idiosyncrasies. As Diana Weynand and Vance Piccin have explained: "When multiple sources are used in the same system…each must start their scan at the exact same moment."[2] This, in reality, is all but impossible. When both scans are out of sync—due not only to structural mechanical issues, but other reasons, as well, which will be discussed below—this misalignment, so to speak, creates what is known as a time base error.

[1] Well, most of the time, anyway.
[2] Diana Weynand and Vance Piccin (with Marcus Weise). *How Video Works.* (New York and London: Focal Press, 2016), 25.

The causes of time base errors are as varied as their visual manifestations, the term being more of an umbrella for several common types of errors: while typically associated with mechanical imperfections in the playback device (this designation would include uneven capstan rotation and poorly cared-for decks in general), causes might also include degradation of the tape itself, as well as transverse error (inconsistencies in tape width).[3]

Degradation of the tape itself results, of course, from a number of environmental causes, from temperature and humidity to the position and movement of the VCR and VTR.[4] Heat causes videotape to expand; over-cooling the tape can cause it to contract. A contracted piece of tape now also contains contracted tracks of video information, resulting in a less accurate read on the part of the playback device, due to the decreased amount of time it will now take the head to scan the tracks contained on the tape.[5] As far as VCR/VTR movement is concerned, *gyroscopic* time base errors occur when, as a result of movement on the part of the VTR operator, its spinning head drum begins to behave like a gyroscope—that is, as the VTR moves "against the plane of rotation of the head drum, the spinning drum resists and slows down," resulting again in a less-than-accurate read of the information.[6]

More granularly, time base errors have been characterized by engineers as an instance of "frequency modulation of the scanning and subcarrier frequencies of the video."[7] This inconsistency between source and playback device (the VTR, or Video Tape Recorder) can manifest in myriad forms: the usual list includes flagging or flagwaving, skewing, tearing, and

[3] Erik Piil, "Time Base Error," *A/V Artifact Atlas,* last modified November 22, 2017, https://bavc.github.io/avaa/artifacts/time_base_error.html.
[4] Hartwig, *Basic TV Technology,* 88.
[5] Ibid.
[6] Ibid.
[7] Arch Luther and and Andrew Inglis, *Video Engineering.* (New York: McGraw-Hill, 1999), 61 (footnote).

longitudinal error[8] as well as jitter, drift, hue shift, and color streaking.[9] While noticeable at times in all videotape formats, time base errors are particularly common in smaller formats like ½-inch open reel as well as cassette formats, first among them U-matic. The inconsistencies caused by time base errors are physically infinitesimal, but in the timing-is-everything world of video engineering, they begin to be human eye-detectable after only a few nanoseconds.[10] More precisely: an electron gun takes 63.5 seconds to scan a line of video; therefore, a delay of 63.5 nanoseconds will result in one line of time base error.[11] Unfortunately, tape transport systems are forever unable to play back tapes "precisely at the same speed at which [they] were recorded."[12] So for AV archivists working with analog video of any sort, time base errors are a problem that is here to stay, and a problem made more urgent by the ongoing magnetic media crisis.

This, suffice it to say, is where TBCs come in. TBCs work by storing the lines of the incoming video signal and then retrieving them at a rate on par with the signal's "correct"—that is, optimum—horizontal sync.[13] TBCs come in many forms—internal to VTRs and analog since the 1950s, and digital and external since the 1970s— and under many names, but they all share in common some essential elements. Firstly, all TBCs possess a *time delay device* to do just that (that is, *delay* the source signal). Secondly, they all contain "a means of measuring the time relationship between the video signal and a stable timing reference resulting in a correction

---

[8] Piil, "Time Base Error"
[9] Ben Turkus (2016). *Time Base Correction: An Archival Approach.* Master's thesis, New York University, New York. 3.
[10] F.V. Bucciarelli, "A Digital Synchronizer for a Video-Tape Recorder." *Proceedings of the IEEE* 61, no.4 (April 1973): 506.
[11] Hartwig, 86.
[12] Ibid.
[13] Piil, "Time Base Error."

signal used to control the delay time of the delay device."[14] Put another way, "the *write* address changes at the carrying rate from the tape, but the *read* address changes at a stable rate."[15] In short: digital technology immensely strengthened the effectiveness of TBCs by enhancing the precision of the delay mechanism.[16]

One noteworthy challenge posed by the first digital TBCs involved the use of random-access memory (RAM). In order for a digital TBC to function effectively, the RAM had to be able to read and write simultaneously.[17] However, this was beyond the range of most affordable RAM chips. Therefore, video engineers developed a solution involving a sort of proto-file compression: they grouped multiple video signal samples as one "word"—a "superword"—and thus enabled the RAM chips in digital TBCs to store several samples as one (compressed) unit.[18]

When external digital TBCs came along in the 1970s, they truly revolutionized the world of television production, helping to bend the arc of media production history toward democratization and egalitarianism. The CVS (Consolidated Video Systems) 504B Time Base Corrector was hailed upon its release as "one of the two most important breakthroughs in recent video technology" (the other being the Sony VO-2600 Videocassette Recorder).[19] Whereas independent and underground video had once been too unstable to broadcast successfully, with the advent of TBCs "the technical argument of 'no, you can't play your Portapak stuff over our broadcast system because it's not stable enough' was no longer valid."[20]

---

[14] Charles H. Coleman, "A New Technique for Time-Base Stabilization of Video Recorders," *IEEE Transactions on Broadcasting,* Vol. BC-17, No. 1 (March 1971): 29.
[15] John Watkinson, *Digital Video Tape Recorder.* (Oxford: Focal Press, 1994): pp.10-11. Italics added for emphasis.
[16] Ibid.
[17] Watkinson, pp.49-50.
[18] Ibid.
[19] Charles Bensinger, *The Video Guide*. (Santa Barbara: Video-Info Publications, 1981): 7.
[20] Ibid. Bensinger notes that despite an increase In accessibility, nonetheless "your tapes [had to] be excellent technically" to work with the 504B.

The 1972 Emmy awards provided digital TBC engineer Bill Hendershot with an special statuette for his efforts.[21]

Furthermore, TBCs were credited (again, along with increasingly portable camcorders) with enabling the creation of the field of electronic news gathering (ENG). Prior to the digital TBC, heterodyne color systems and the mechanical instability of helical scan VTRs had barred material recorded in the field from being broadcast. But the digital TBC rendered those issues moot; it was "as if someone finally figured out how to make the wheel round."[22]

Despite their deus ex machina-like implications for television production, digital TBCs did bring some undesirable side effects alongside their copious benefits. Two of these "unwanted artifacts" are particularly pervasive: over-enhancement and velocity errors.[23] Over-enhancement appears as a "ghost image" to the right of a vertical line; velocity errors appear as "several horizontal 'bars'" on the monitor image.[24] Nonetheless, some higher-end TBCs are capable of ameliorating the artifacts that they themselves have generated.[25]

While their obsolescence in the born-digital era of video *production* is a given (that is, following the disappearance of linear editing workflows), TBCs remain an essential component of any AV archivist's stack. In addition to using TBCs to stabilize analog video images during the digitization process, archivists also use TBCs to adjust brightness, contrast, hue, and color saturation. TBCs are not "one size fits all," so most preservation labs will use different TBCs for different purposes at different times. Furthermore, a more recent model of TBC is not

---

[21] http://www.labguysworld.com/Museum014.htm
[22] Bensinger, 122.
[23] Jim Wheeler, *Video Preservation Handbook.* https://amianet.org/wp-content/uploads/Resources-Guide-Video-Handbook-Wheeler-2002.pdf.
[24] Ibid.
[25] Ibid.

necessarily more effective or efficient. At the Bay Area Video Coalition (BAVC), a Sony BVT-810 TBC is used precisely *because* it is an older model. So-called “full frame” TBC models sometimes create an unwanted artifact during digitization: they produce a strobe effect in the event of an image processing failure. The BVT-810, on the other hand, only processes 16 lines at a time, making its elder status a feature for BAVC, rather than a bug.[26] However, for other material, BAVC uses a full-frame DPS TBC (software-controllable).[27] In fact, many in the field often use two TBCs *simultaneously*, especially when dealing with very old formats from the 1970s edited without color locking: “an old one that can handle historical instabilities (larger tolerances in signal timing and phase transition in the color subcarrier) and a modern one that frees the color signal from moiré distortion and adapts the signal from the historical TBC, which may still be too unstable, to the tight tolerances of the A/D [analog-to-digital] converter.”[28] In other words, contemporary usage of TBCs in AV archiving and preservation is highly contingent.

In addition to making themselves capable operators of TBCs, in the coming decades (as these machines and the institutional knowledge around them become(s) increasingly obscure), archivists will have to be able to pro-actively and innovatively troubleshoot and customize TBCs. This will require AV archivists to possess both technological know-how (hand-building custom interfaces,[29] repairing and refurbishing VTRs and external TBCs)[30] and consumer savvy (most frequently demonstrated on eBay), and, as always, to be vocal advocates for the preservation needs of their collections.

---

[26] http://www.experimentaltvcenter.org/book/export/html/5782
[27] Ibid.
[28] *Memoriav Recommends: Digital Archiving of Film and Video.* http://memoriav.ch/recommendations-digital-archiving-film-video/
[29] http://susanetheridge.com/crisis-in-videotape-preservation/
[30] Turkus, 52

This is a great breakdown of what a TBC and how it works. It's important to know the differences between internal and external TBC so I encourage you to explore that area more. Your sources could be more fully cited, not just the link.

Midterm Grade: A-