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# NTSC COLOR FRAME EDITING- BACK TO BASICS

Two problems typically encountered while editing NTSC tape are the familiar horizontal "shift" in picture centering and the "stretch" that widens horizontal color blanking. Both can be corrected with a better understanding of color frame editing.

For many reasons, the frequency of the color subcarrier was chosen to be an odd multiple (455) of one-half the horizontal scanning frequency:

Equation 1:

$$F_{Subcarrier} = \left(\frac{455}{2}\right) \times F_{Horizontal}$$

Equation 2:

$$3.579545MHz = \left(\frac{455}{2}\right) 15,734.264Hz$$

This means that exactly 455 (an odd number) half cycles of subcarrier will be generated in the time required to produce each horizontal line (approximately every 63.6 µs). This occurs line after line, field after field, frame after frame, ad infinitum. Since there is an odd number (455) of half cycles in each horizontal line, each line begins and ends with a half cycle of the same phase, whether positive or negative. This causes the phase of subcarrier to be reversed at the beginning of each successive line. All the odd-numbered successive lines begin with the same phase, as do all the even-numbered successive lines.

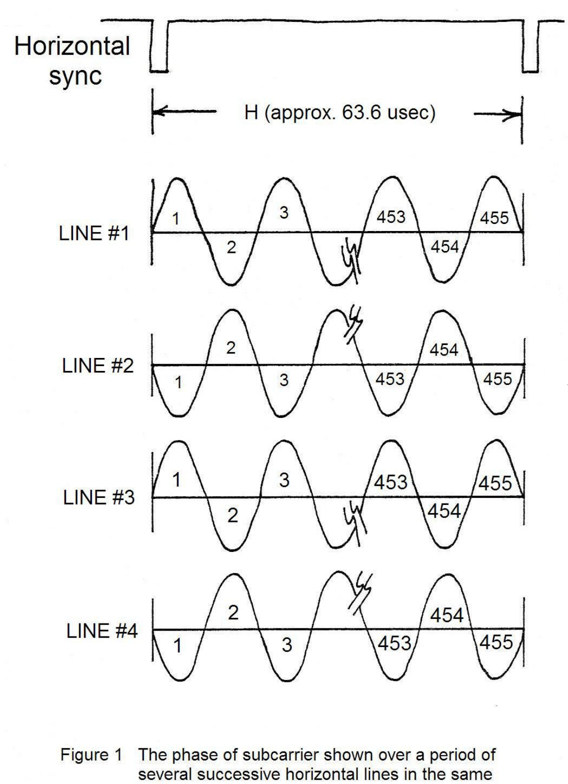


Figure 1 The phase of subcarrier shown over a period of several successive horizontal lines in the same field.

Each complete television frame is composed of two fields, or 525 consecutive horizontal lines. If we take any given TV frame and call it the A frame, then the first line of the next frame, which we can call the B frame, will be an even-numbered consecutive line: line "526," if you will. The phase of subcarrier at the beginning of this line, being even, will be reversed to that at the beginning of line number one of the A frame. The point is this: the phase of subcarrier (and burst) reverses at the beginning of the first line of video on successive frames. This is also true for any other given point on a particular line of a given field: the phase of subcarrier at this same point will be reversed exactly one frame, or 525 lines, later. The phase of subcarrier at the beginning of line one of the next, or third, frame will again be reversed and will match the phase of the first, or A, frame. This third frame will be called an A frame since its subcarrier (or burst) phase matches the first frame.

## Video Editing

With this understanding of how the four-field sequence is generated, how does it apply to videotape editing? Assume that Figure 2 represents a segment of videotape we wish to edit. Lets's say we want to make an insert edit between points X and Y, replacing the original, or base, material with four frames of video from a camera source.

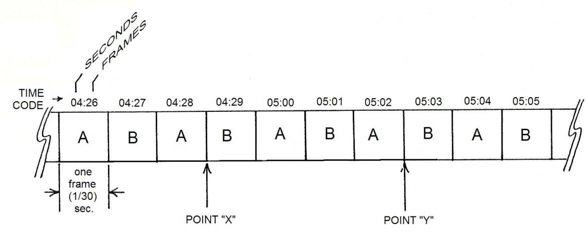


Fig. #2 The "four-field" or "two-frame video sequence generated in the NTSC system

The whole process of color framing works to accomplish one thing: The A-to-B (A/B) frame sequence (the sync-to-burst relationship) of the inserted material must be in step with that of the base material.

Figures 3 and 4 represent a properly color-framed edit and an improperly color-framed edit, respectively. Note that Figure 4 shows two disruptions in the A/B frame sequence: one at point X and one at point Y.

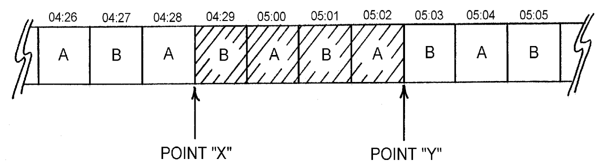


Figure 3 A representation of a properly color-framed "insert" edit. The edited video is the shaded area. Notice the entire tape has a continuous A/B frame sequence.

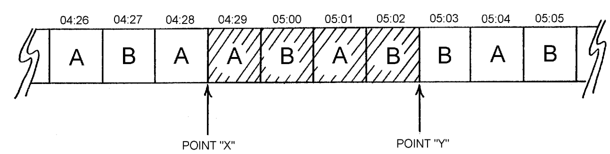


Figure 4 A representation of an improperly color-framed "insert" edit. Notice that the A/B frame sequence of the inserted video (shaded area) is out of step with the base material.

When this tape is played, the picture will experience a jump in picture centering at *both* edit points of approximately 140 ns, the period of one half cycle of subcarrier. Horizontal blanking will also be stretched for the duration of the edit. More will be said about this shortly.

For assemble edits, the new video must still be in step with the base material, but only the video entrance is a point of concern since the A/B sequence will proceed normally from this point on.

Figure 5 illustrates how color framing is properly achieved by the record, or editor, VTR. Figure 5A illustrates the A/B frame sequence as generated by the house reference signal (color black or sync and subcarrier) and camera encoder.

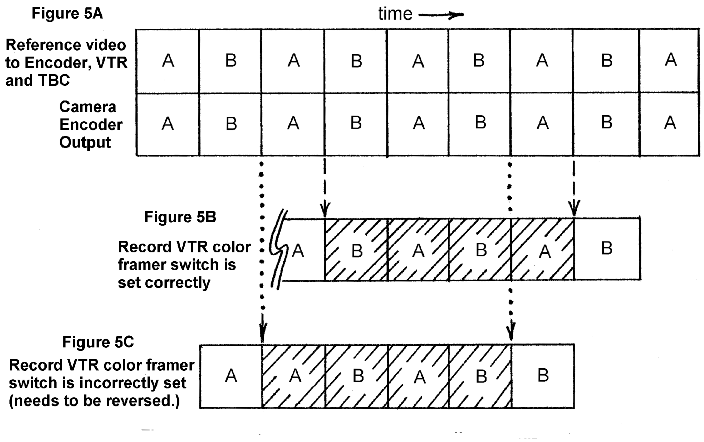


**Figure 5 The effect that the record VTR (editor) switch has on VTR lockup.**

Figure 5B illustrates how the record VTR will lock up if its color framer switch was set correctly. The A/B sequence of the tape to be edited will match the camera output; when the edit goes in (shaded area,) a properly color-framed edit will occur. If the record VTR color framer switch had been incorrectly set (Figure 5C) the VTR would have locked up improperly, being out of step with the camera and reference signal. An improperly color-framed edit would have occurred as illustrated.

The proper setting of the record VTR color framer switch is usually determined by making a test edit during color bars at the head of the tape where video content is stationary and shifts can easily be seen.

## The half-cycle shift

Present-day digital time base correctors construct new horizontal (H) and vertical (V) blanking intervals from the reference signal input. New sync and burst signals are added to the video output since they fall within the reconstructed blanking periods. The new blanking intervals effectively create a “frame” into which the time base corrected video is horizontally and vertically centered. This can best be visualized by observing a pulse cross monitor display (Figure 6.) The exact location of corrected video within this frame is dependent upon, among other things, comparisons made by

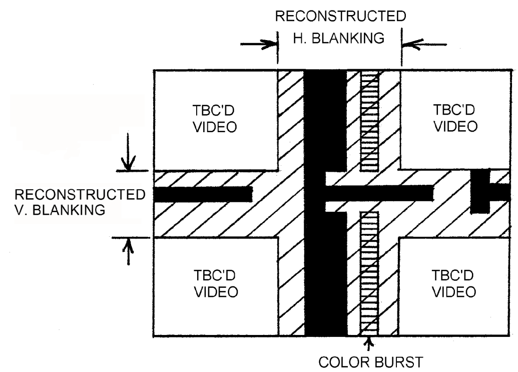


Figure 6 A pulse cross monitor display showing reconstructed H and V blanking intervals.

the TBC between tape sync and burst and reference sync and burst.

Assume that the videotape in Figure 4 containing the improperly color-framed edit is being played back. Everything runs along smoothly until, at point X, the demodulator suddenly outputs two A frames back to back. The TBC is expecting to see tape burst coming in at the correct phase, that is, in proper A/B frame sequence-matching house reference burst (see Figure 7.)

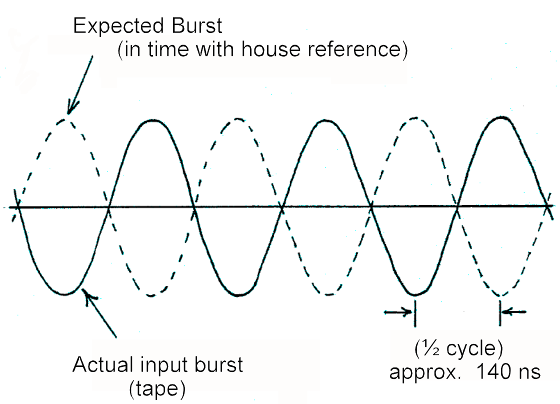


Figure 7 The 180-degree phase difference between reference burst and tape burst during a non-color framed edit.

Instead, tape burst comes in 180 degrees out of phase. The same thing would happen if the demodulator were to output two B frames back to back.

If the TBC were to take no further action, the inverted burst would result in a 180-degree chroma phase error at the TBC output since the TBC continuously replaces tape sync and burst with sync and burst derived from the reference signal input. The TBC handles this error, however, with an interesting bit of slight of hand: It simply "slides" the entire TBC'd signal horizontally by advancing or delaying it in time by one half subcarrier cycle (140 ns) within the frame of reference video. If tape video (sync, burst and picture information) were either advanced or retarded in time by one half cycle of subcarrier, proper chroma phase would be restored at the output of the TBC. So, when non-color-framed edits are played through a TBC, color errors will be "corrected," but we wind up with a half-cycle shift in "picture centering." This is why record VTR color framers should be used and correctly set for editing sessions. Without them, the editor VTR only has a fifty-fifty chance of locking up properly *each time* the VTR is rolled.

If a non-color-framed edit had been done on a camera cut, the shift probably would not have been noticeable; if similar material had been involved, however, as in matched-cut, or animation sequences, the results would have been disastrous.

## Blanking stretch

Figure 8A, 8B, and 8C illustrate how horizontal blanking parameters may be altered by improper color framing. Figure 8A represents the original camera output as it was fed to the VTR for recording. Figure 8B represents a half-cycle shift to the right (delayed) during playback of a non-color framed edit made from the signal in Figure 8A. Notice that the front porch has decreased 140 ns from 1.5µs to 1.36 µs. Sync-to-blanking-end has increased to 9.54 µs.

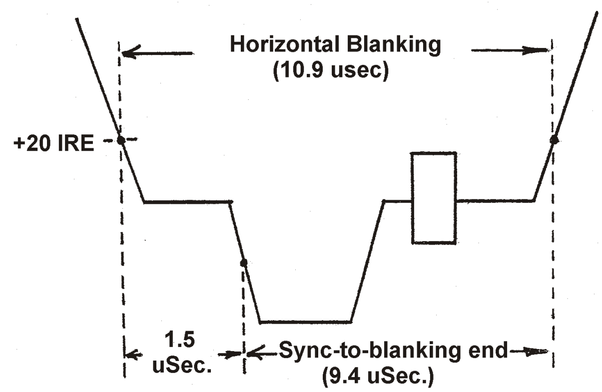


**Fig. 8A Camera output video (horizontal blanking interval) fed to the VTR for recording.**

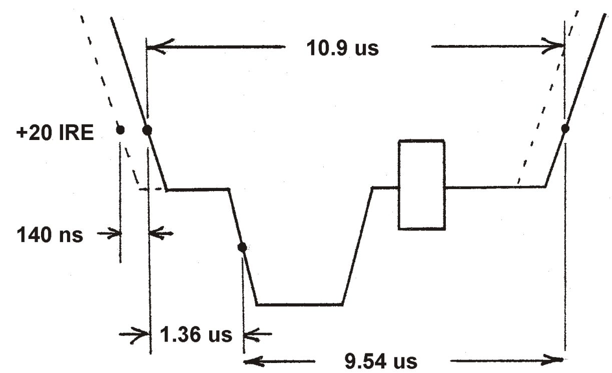


**Fig. 8B The change in horizontal blanking parameters due to a half-cycle shift to the right during playback of a non-color framed edit.**

A half-cycle shift left (advanced) would have made the front porch 1.64 µs and sync-to-blanking end 9.26 µs. The direction of the shift either left or right is usually a random decision made by the TBC. As long as horizontal blanking inserted by the TBC or a subsequent proc amp is narrow enough to permit the full shift to be visible, *total* blanking width will not change (10.9 µs.) However, if reinserted blanking was so wide that it would have permitted only the original specs of 1.5 µs and 9.4 µs to go through, then a half-cycle shift to the right would have caused 0.14 µs of video on the front porch to be lost. Total blanking width would now be 11.04 µs (Figure 8C.) Succeeding generations of the tape may only compound the problem, making blanking even wider.

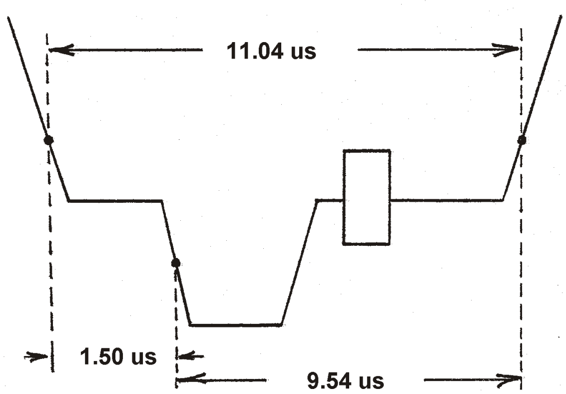


**Fig. 8C Stretched horizontal parameters when re-inserted horizontal blanking will only permit original specs to pass.**

## Random VTR lockup

One unfortunate characteristic of most VTRs is that unless color framing circuitry is also activated on the *playback* machine, this VTR will also only have a fifty-fifty chance of locking up on the correct color frame. That is, the A/B frame sequence produced at the demodulator output of the playback VTR only has an even chance of being in step with the reference signal feeding the VTR and TBC. If the playback sequence is out of step, a half-cycle shift in picture centering will occur at the TBC output just as if the TBC had been presented with a non-color-framed edit. See Figure 9.

Again, unless the playback VTR is also assisted by color framing circuitry, the probability of proper lockup is only 50 percent *each time* the VTR is rolled. For this reason, *both* the record and playback VTRs must use color framing in an editing session. If the playback VTR is allowed to be subject to half-cycle shifts, matched cuts and animation work cannot be achieved. H blanking may be stretched in the process as well. Some production/ syndication facilities routinely run playback color framers for just that reason. Playback color framers should also be used for dubbing tapes and even playback for normal air if the increase in lockup time can be tolerated.

In some editing systems, color framing of the playback VTR is handled by a computer. In others, an internal color framer switch on the VTR must be activated and a choice must be made to its proper setting, either A or B.

When editing with one or more playback VTRs, the same basic rule applies as before: The A/B frame sequence of all inserted or assembled material must be in step with that of the base material. This means the demod output of *each* VTR must be in step with the reference signal. When this has been accomplished , dissolves, cuts, etc. may be made between playback tapes without shifts or blanking stretch.

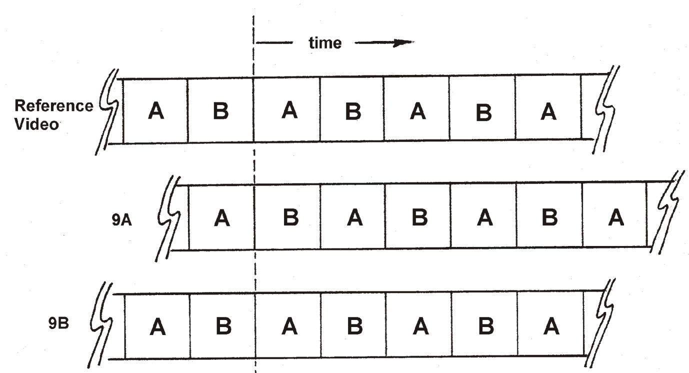


**Figure 9.**
**A representation of random playback VTR lock-up with respect to the reference signal driving the TBC.**

**Figure 9A.**
**Video from the demodulator when the VTR locked-up on the wrong color frame (out of step with the reference). A half-cycle shift will occur at the TBC output.**

**Figure 9B.**
**Demodulator output when the VTR is locked-up on the corect color frame (in step with the reference). No shift will occur at the TBC output.**

Editing sessions frequently require the use of intermaster tapes that may be several generations down. Under these conditions it is extremely important to make sure that record and playback color framers are correctly uses at *each step* of program integration and dubbing. Once a shift has been recorded in, it becomes extremely difficult, if not impossible, to match-cut with the original footage, and one may well have to live with the results.

## Setting up

The single most important factor in setting up a color frame editing system is to know how your equipment operates. This point can hardly be over-emphasized. Some VTRs achieve color framing using encoded control track pulses in one form or another. Some time code systems achieve color framing by keeping track of odd and even time code numbers. Some systems may even use either depending on the operating mode of the VTR.

Remember that color framing should not be confused with the "framing" used on (3/4") equipment, which only prevents two odd or even *field*s from being recorded back to back.

Most of the information you will need to know about how your recorders actually achieve color framing (for both record and playback VTRs) will be found by studying the manufacturers technical manuals. Also, take the time to become versed on related subjects such as time base correction and subcarrier-to-horizontal sync phase (SC/H phase, or, timing.)

In addition to reading, a good bit of experimentation with your equipment will also be required so your system can be operated in a consistent, reliable manner.

When experimenting, it is wise to figure out the record, or editor, VTR first. Determine what factors affect the setting of the record VTR color framer switch. Can edits be made on both odd and even time code numbers, or just one or the other? What happens if there is a break in control track between cuts? Do power hits alter framer settings? To make these checks, use color bars from a single source to record the "base" material and the material for the insert or assemble edit. This will help avoid much confusion as to what is or is not an H shift.

Once the record VTR has been figured out, use this same color bar source to record tapes to be used as a playback video source for edits. As these tapes are used, determine what factors affect proper playback VTR lockup. Do requirements change for "A-B-C" rolls? Does staggered recording of audio and video ("split-edits" or "L-cuts") affect color framing? Do power hits affect proper playback VTR lockup? (Turn off power to the VTR and TBC for a few seconds to simulate a power hit.) Edits should be repeated several times to verify operation. Remember, a playback VTR still has a fifty-fifty chance of proper lockup even if color framer circuits are turned off.

In normal day-to-day operation an initial test edit will usually be required on each tape to be edited to determine the correct setting of the record VTR color framer switch. The correct setting is determined on a hit-or-miss basis, usually during bars at the head of the tape. Again, use a single source for recording bars.

Make sure all the "basic" work has been done on your system. All video sources must be properly vertically, horizontally, and color-timed into the production switcher. Timing deficiencies can introduce more errors (shifts, etc.) into a video system than those caused by improper color framing, thereby negating any benefits you may hope to achieve. Also, don't assume vertical timing and centering are always "taken care of" by VTR servos. Check it. Don't assume anything.

Make sure all video processing/distribution equipment like proc amps, routers, and video DAs don't' have excessive envelope delay problems, as this can cause an alteration of video sync-to-subcarrier (SC/H) phase and blanking stretch.

On the subject of SC/H phase, *A fixed in-house standard must be established and maintained*. If SC/H phase is allowed to drift i.e., the SC/H phase of the TBC no longer matches the video on tape, some amount of horizontal picture shifting and blanking stretch will always be present. The author highly recommends the SCH standard set forth in the "EIA Industrial Electronics Tentative Standard #1.[4] See "Note #7" on this document at SC/H relates to "program integration." This Tentative Standard is generally referred to as "RS-170A, " although the complete revision of the November 1957 EIA RS-170 document is not yet complete.

[2007 Note: This article was originally published in 1984. The complete revision of RS-170 was never finished and "RS-170A" never came into being. However, the drawing of the tentative standard did establish the standardized relationship between sync and color burst (SC/H phase). This relationship was incorporated into SMPTE standard (170M-2004) "Composite Analog Video Signal-NTSC for Studio Applications." This standard is available from SMPTE.]

Of necessity, full investigation of SC/H phase is beyond the scope of this article.

## Digital Time Base Corrector Centering

At this point, digital time base corrector "centering" should be mentioned. Time base correctors operate by writing, or clocking, digitized video information into memory synchronous with *varying* tape burst and sync rates, (i.e., containing time base errors) and then reading, or clocking, that information out of memory some time later at a stable rate synchronous with reference signals. Hence, "time base" correction has occurred. It is possible for the corrected signal (sync and burst) to be in phase with the reference, but for the entire picture (during active picture time) to be advanced or delayed in time ("picture centering") by *whole* cycles of subcarrier (279 ns increments.) Normally an adjustment is provided on the TBC to control this, and it should be checked. Figure 10 illustrates a simple way of checking digital time base corrector centering.

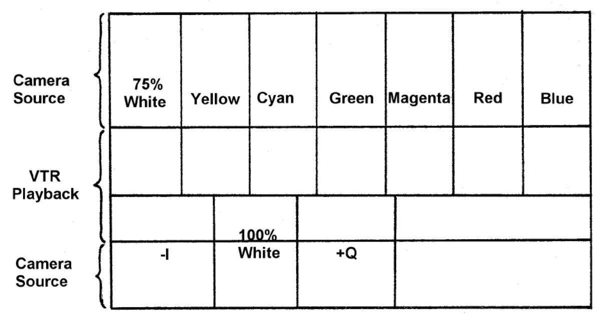


**Fig. 10 A visual method for checking digital time base corrector centering utilizing a split-screen between VTR playback and a camera bar source.**

Route camera color bars through the production switcher and make a short recording. Play back the recording just recorded. Then, using the special effects generator on the switcher, make a split screen between the color bar source and the playback VTR output. Adjustment of TBC centering (279 ns increments) can now easily be made to horizontally align the vertical edges of the two signals. If a half-cycle (140 ns) error in centering still exists preventing the lines from being "dead-on," it may simply mean that the VTR has just locked up on the wrong color frame. Momentarily unlock the VTR's capstan oscillator until the capstan servo "slips" the tape by one frame, The two sources can now be made to be "dead-on." When doing preliminary experimentation with the equipment this method can also be used to tell whether the playback

VTR actually has locked up on the correct color frame or not: an improper lockup will be shifted either left or right by (140 ns). When monitoring this signal with an oscilloscope, observe a large luminance edge well into active picture time. Wide regenerated horizontal blanking will mask shifts near the blanking interval. To use this method all sources must be properly timed through the production switcher. It is good to remove or bypass proc amps in the video path during this procedure unless it is certain that they are not altering vertical or horizontal phase.

Some systems have adjustments so that the VTR will recognize the in-house SC/H relationship as "standard." Make sure these have been done.

If it hasn't been done already, make sure audio phasing on VTRs and mixing consoles is correct. Production personnel frequently "pot-up" two tape sources into a single audio monitor to check for sync between two tapes having the same audio but different video signals. e.g., between "line" and "iso" feeds. If the two tapes are in-sync the sound level will add in the monitor output. If they are out, even by one frame, the sound will tend to cancel or echo. Maintaining audio sync is important when match-cutting tapes where scene content is moving. If sync is out by two frames (or multiples of two) color frame circuits will work just fine, but the picture will still appear to jump at the edit because two frames of the action will have been deleted or repeated.

## A word about Time Code

Until relatively recently (see ANSI V98.12M-1981) there was no industrial document which established a standard relationship between odd and even time code numbers and the four-field video sequence. As a result, time code generators generally make a random decision when assigning frame numbers to A or B frames. This assignment will frequently reverse from one tape to the next, or even from one "cut" on a tape to the next on the same reel. Among the reasons for this are power hits, interruptions in the video signal feeding the time code generator, or resetting the microprocessor in the editing system itself.

Normally this is not a problem for non-color framed editing systems since each frame still has a unique frame number. But this randomness is a problem for editing systems where a computer keeps track of odd/even time code numbers for color framing purposes.

The obvious solution is to lock down the assignment of time code numbers to the four-field video sequence.

[2007 Note: A SMPTE standard, (12M-1999) re-affirmed that if color frame information in time code is required, the assignment of even time code numbers shall be to "A" video frames (color fields 1 and 2) and even time code numbers will be assigned to "B" video frames (color fields 3 and 4). ]

Understanding the basics of color frame editing will help the user to set-up and maintain a NTSC video editing system where edit decisions can be quick, reliable, color-framed and matched-cut accurate.

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