

## SC/H PHASE in NTSC Composite Analog Video

What is SC/H phase?

Why is it important?

How is it measured?

### What is SC/H phase?

SC/H is an acronym for subcarrier-to-horizontal (sync) phase. SC/H describes the inherent timing, or, phase, relationship that exists between color burst and a reference point on the leading edge of horizontal sync in all NTSC composite analog color video signals. A similar relationship exists in the PAL system, but this discussion will be limited to NTSC.

### Why is SC/H phase important?

When color television was developed, the relationship between sync and subcarrier (the burst) was not specified. Indeed, equipment design of the time couldn't maintain a fixed SC/H relationship. This wasn't a serious problem when color broadcasting began. However, when video editing came into its own and the effects of varying SC/H became apparent, it was decided to standardize this relationship.

The NTSC signal actually uses two reference signal components: horizontal and vertical sync, which coordinates receiver scanning (and other functions) and the color burst, which synchronizes the color reproduction system. Both reference components are used when NTSC signals are processed and a timing change in either will affect the composite signal as a whole.

Varying SC/H phase will result in the horizontal blanking stretch and horizontal picture movement (centering) with respect to sync. With a fixed SC/H relationship, videotape recorder color-framing circuits can properly be used to eliminate the random half-cycle "jump" in picture centering that occurs at edit points. Matched-cut/ animation-style videotape editing can be performed on a routine basis. SC/H also provides a precise definition of all four color fields in the NTSC video sequence.

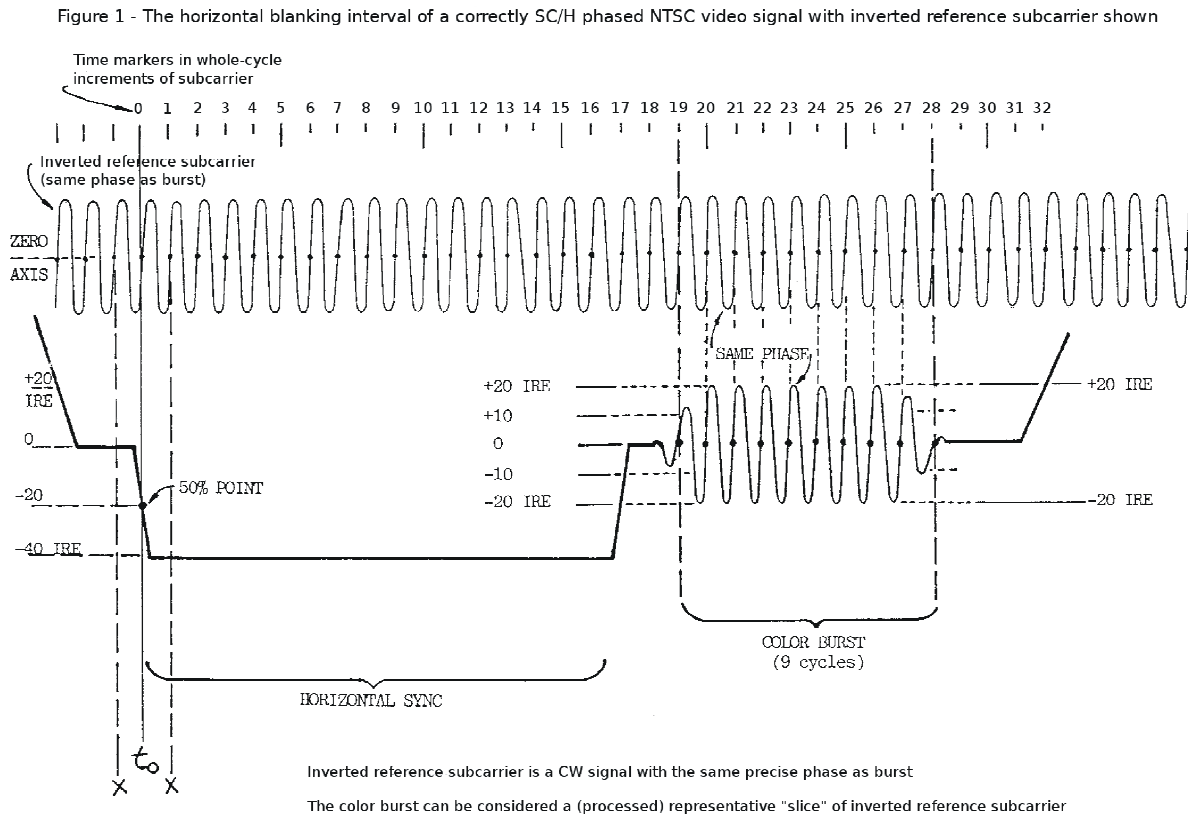
Sidebar– In November 1977, the Electronics Industries Association (EIA) issued the EIA "Industrial Electronics Tentative Standard No. 1 Color Television Studio Picture Line Amplifier Output Drawing." This important document established a standard relationship for SC/H phase and provided the definition for all four color fields in the NTSC sequence. This tentative standard was to have been included in a revision of the EIA RS-170 document, and was to have been known as "RS-170-A." This revision work, however, was never completed and RS-170-A never actually came into being, but the EIA Tentative Standard was circulated and its specifications were

adopted by the broadcast industry.

In the 1990's, the Society of Motion Picture and Television Engineers (SMPTE) issued SMPTE Standard (170-M) which used many of the provisions of the EIA Tentative Standard, but was much broader in scope. After some revisions, we now use SMPTE 170M-2004 "Composite Analog Video Signal-NTSC for Studio Applications." A companion document: SMPTE Engineering Guideline (EG 27-2004) "Supplemental Information for SMPTE 170M and Background on the Development of NTSC Color Standards" provides very interesting reading on the development of the NTSC television system. (Copies of these documents are available from SMPTE at a nominal cost . See [www.smpte.org](http://www.smpte.org))

### How is SC/H phase measured?

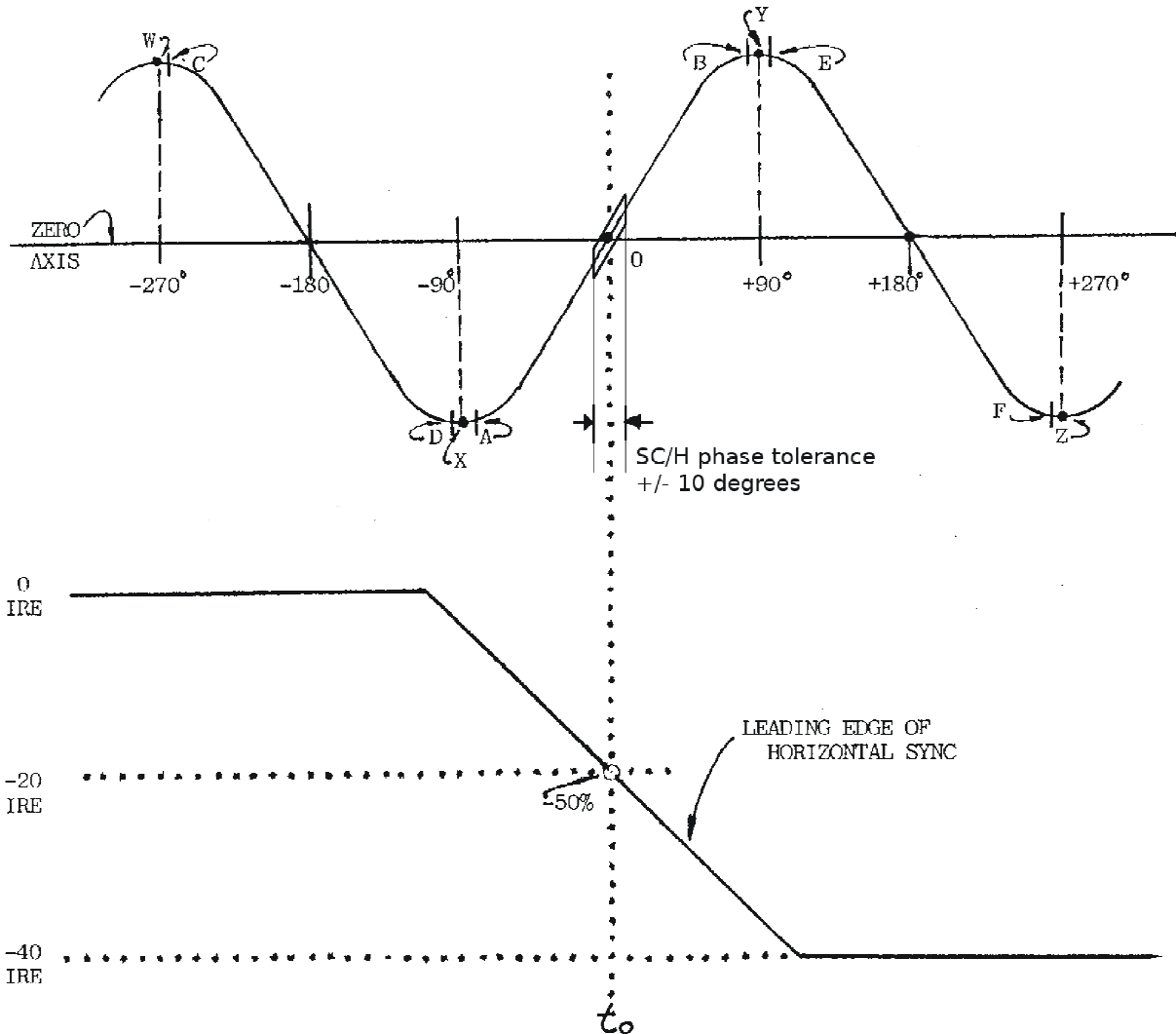
Now lets take a look into the details of SC/H phase: Figure 1 shows the horizontal blanking interval of a properly SC/H- phased NTSC color signal.



SC/H phase refers to the timing relationship that exists between what can be called *inverted* "reference" subcarrier and horizontal sync. "Reference" subcarrier is the CW signal used to encode the two color-difference signals: (R-Y & B-Y) or (I & Q) into chroma. If reference subcarrier were displayed on a vectorscope (it is not) it would be a vector at zero-degrees. The color burst, which is displayed on a vectorscope, is a vector at 180-degrees. Inverted reference subcarrier has the same precise phase as the color burst; it is shown in Figure 1. The color burst could, therefore, be considered a processed, amplitude-adjusted representative "slice" of inverted reference subcarrier.

Let's see how the timing relationship between sync and reference subcarrier is measured. To compare any two quantities, we need points of reference on each. Refer to Figure 2. This is an expanded view of Detail (X-X) from Figure 1.

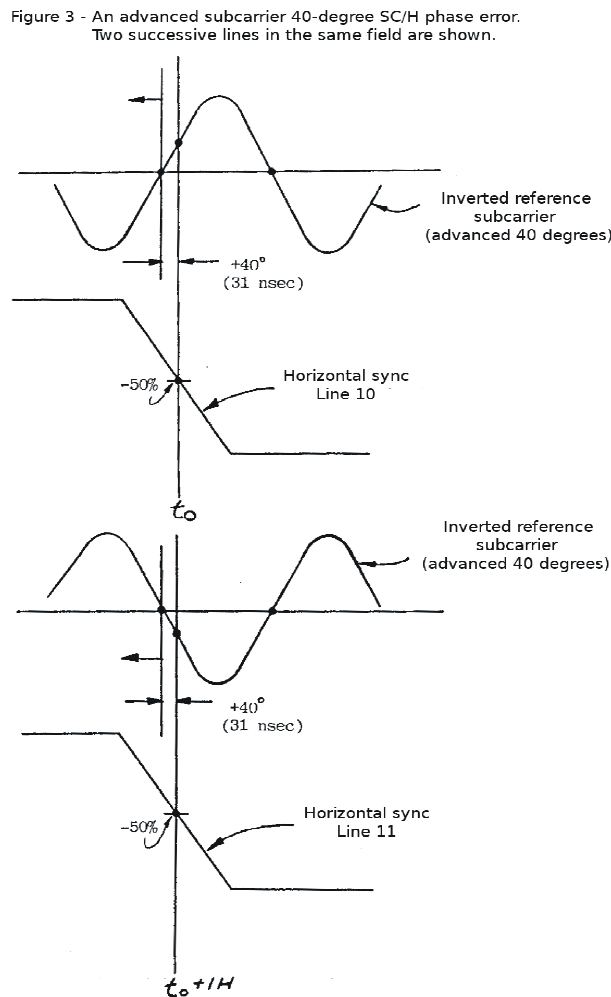
FIGURE 2 DETAIL X-X FROM FIGURE 1



The reference point for horizontal sync is the minus 50% point on its leading edge, nominally the minus 20 IRE unit level. For subcarrier, the reference point is the "zero-crossing" -that point either at zero degrees, where the subcarrier waveform is positive-going as it crosses the zero axis ( $t_0$  on Figure 2) or, at  $\pm 180$  degrees where the waveform crosses the zero axis in a negative-going direction. For the purposes of determining SC/H phase, either polarity may be used. As long as a zero-crossing of subcarrier of either polarity coincides with the minus 50% point on the leading edge of horizontal sync there is zero SC/H phase error. (Because of the frequency relationship between subcarrier and sync, the phase of burst reverses on each successive horizontal line.)

The time difference between our two reference points, expressed in degrees of subcarrier (or nanoseconds) is the measure of SC/H phase.

Assume for the moment that the sync waveform in Figure 2 is fixed in time with the minus 50% point at  $t_0$ , but that the subcarrier waveform can be advanced in time (to the left) or delayed in time (to the right) with respect to the sync waveform. Figure 3 illustrates an advanced subcarrier phase error of (40 degrees).



The phase of subcarrier reverses on every horizontal line in the NTSC system.

If we limit our discussion to whole-degree increments, then there are only (360) possible subcarrier phase angles which could occur at  $t_0$  (0-359), a whole cycle of subcarrier. That is, the subcarrier waveform in Figure 2 must be advanced or delayed a full 360 degrees before another positive-going "zero-crossing" would occur at  $t_0$ .

Three items to note at this point are:

- 1) A shift of only plus-or-minus 180 degrees will put another zero-crossing, of opposite polarity, at  $t_0$ .
- 2). The maximum phase error for a *single* video signal is only  $\pm 90$  degrees since a zero-crossing, of either polarity, is never more than 90 degrees away from  $t_0$ .
- 3). The distinction between SC/H phase and chroma phase should be made: Refer to Figure- 4. SC/H phase is the time (phase) relationship between inverted subcarrier (burst) and horizontal sync. Chroma phase is the time (phase) relationship between chroma and the color burst. As the phase of subcarrier is changed, the absolute phase of the burst and chroma information change *together* in the same direction and magnitude. A change in SC/H phase does not change hue.

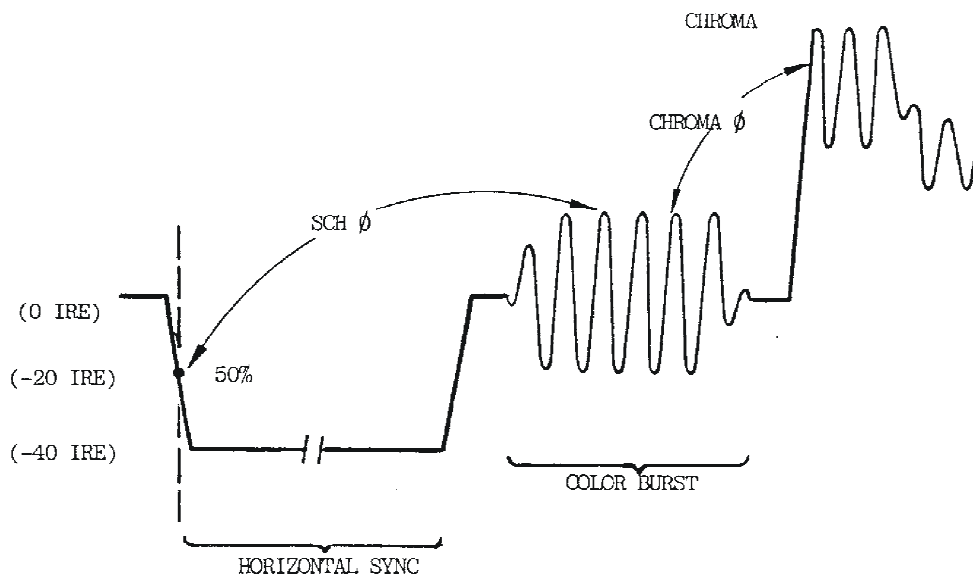


Figure 4 - The difference between SC/H phase and chroma phase.

SC/H phase is the phase or timing relationship between the minus 50% point on the leading edge of horizontal sync and the zero-crossing of inverted reference subcarrier. The color burst is a processed "slice" of inverted reference subcarrier.

Chroma phase is the phase or timing relationship between chroma and the color burst.

A change in subcarrier phase changes the absolute phase of the burst and chroma information together. A change in SC/H phase does NOT affect hue.

Now all this talk about subcarrier is fine and good, but how does it apply to an encoded video signal when raw subcarrier is no longer present? The answer lies in the fact that the burst is a representative slice of the inverted reference subcarrier. We can extract the zero-crossing timing information we need to determine SC/H phase by regenerating inverted subcarrier from the burst, and then sampling it at  $t_0$ . Alternately, we could sample the color burst at a whole-cycle increment of time measured from the minus 50% point of sync.

Post production/ editing environments have the greatest need to maintain tight control of SC/H phase. SMPTE 170M-2004 limits SC/H phase error to ( $\pm 10$  degrees.)

## **Color Field Identification**

SC/H phase is also the basis absolute identification of all four color fields in the NTSC sequence. Identification is made by examining SC/H phase at specified intervals in the video waveform.

Ignoring subcarrier for the moment, color fields 1 and 3 correspond to the old RS-170 and FCC definitions for "monochrome" field 1 of 2. That is, a whole line interval exists between the first equalizing pulse in the vertical blanking interval and the preceding horizontal sync pulse. Color fields 2 and 4 correspond to "monochrome" field 2 of 2. The distinction between the color fields is made on the basis of subcarrier phase.

The point usually taken to make color field/frame identification is line 10, an even numbered horizontal line, of a "monochrome" field 1. Line 10 is readily identified since it is the first line in the vertical blanking interval that contains a color burst.

Refer again to Figure 2. If any portion of the subcarrier waveform on line 10 occurs between points A and B at  $t_0$ , the zero-crossing of the subcarrier waveform is positive-going and color field one-of-four has been identified. If any portion of the subcarrier waveform on line 10 occurs between points E and F at  $t_0$ , the zero-crossing is negative-going and color field three-of-four has been identified. Only when points W, X, Y, or Z on Figure 2 occur at  $t_0$ , is the SC/H phase error exactly 90-degrees and color field identification is impossible. This point is often overlooked.

Once color-field identification has been made, the other color fields occur and repeat in numerical sequence: 1,2,3 and 4... ad infinitum. Color fields 1 and 2 comprise color frame A; color fields 3 and 4 comprise color frame B. Color frames occur and repeat in sequence A, B, A, B... ad infinitum. Color frame editing keeps the alternating A-B sequence going. If either two A frames or two B frames are edited back-to-back, a half-cycle in picture centering will occur at the edit.

The maximum phase difference that can occur between any two video sources (or any two sine waves for that matter) is 180 degrees. That is, one is operating on color frame A, while the other is operating simultaneously on color frame B. Usually this is an undesirable condition if both signals coexist in the same video system.

One last point. Burst start time is defined in terms of being so many (19) cycles of subcarrier) away from  $t_0$ , and burst width is defined as (9) cycles wide. Refer again to Figure 1: Equipment "breezeway" and "burst width" adjustments have no effect on SC/H phase. As long as SC/H phase is correct, zero crossings of burst will occur at whole-cycle increments (e.g. 21,22, 23) away from sync. The zero-crossings of burst remain stationary even if burst start and stop times vary.

oOo

-Al Stephens