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tech tips

Measuring Phase Shifts With Your SC61 Waveform Analyzer™

The SC61 Waveform Analyzer is useful for checking any phase shift that may occur between two signals. Since the SC61 is a dual trace waveform analyzer, you can compare the phases with automatic digital accuracy or by using conventional CRT methods. This Tech Tip explains how you can use the SC61 to measure these phase shifts.

Why Would Two Waveforms Have To Be In Phase?

Many circuits use timing pulses referenced to another signal for proper operation. If the signals are not properly phased and timed, the circuit may not work as designed.

For example, if the 19 kHz pilot is not phased properly with the 38 kHz subcarrier in an FM receiver, the receiver will not play in stereo. The mistiming of these two signals results in improper separation of the left and right channel audio signals. A problem of this nature could be caused by a defective coil or capacitor in the 19 kHz pilot circuit.

What Is The Best Way To Measure Phase Shift?

A dual-trace oscilloscope is the best way to measure the phase between two signals since you need to view both signals at the same time. Once you have both traces displayed on the CRT, the SC61 lets you measure phase shift several different ways, depending on your application or need.

Visual Comparison Of Two Signals

Sometimes the best method to check the phase shift or timing of two signals is a simple visual comparison of the two signals with the SC61. A simultaneous inspection of two waveforms sometimes will reveal the problem faster than any other method. One example would be comparing the color burst signal to the timing of the horizontal keying pulse (figure 1).

The color killer detector in a television uses a reference horizontal keying pulse from the flyback transformer to extract the 3.58 MHz color burst signal from the composite video. When the color killer detector sees a burst signal of sufficient amplitude, it turns the color circuits on. The keying pulse and the burst signal must occur simultaneously so the color killer detector receives the proper burst information. If the signals are mistimed, the color circuits will turn off resulting in a no color-symptom.

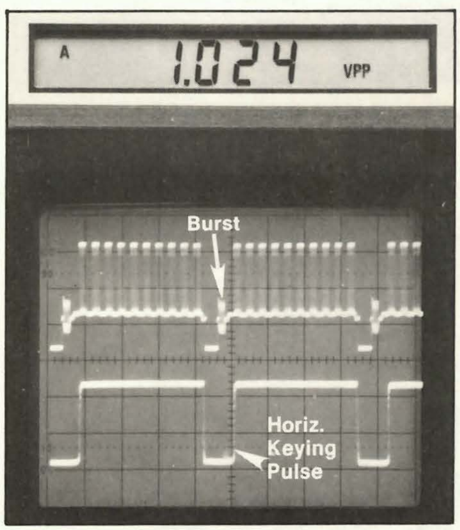

Fig. 1: The horizontal keying pulse must be timed properly with the composite video signal so the color burst signal can be retrieved properly.

To view the phase between two signals:

1. Connect the channel A probe to the reference signal and the channel B probe to the second signal.

2. Adjust the size of both signals with the VOLTS/DIVISION switches and vertical verniers until the signals are between 2 and 4 vertical divisions on the CRT (amplitude is not important when measuring phase).

3. Adjust the channel A VERTICAL POSITION control until the channel A trace is in the top half of the CRT, and the channel B VERTICAL POSITION control until the channel B trace is in the bottom half of the CRT.

4. Compare the transition points of the waveforms for the correct timing. Adjust the VERTICAL POSITION controls to position the traces closer or farther apart for easier comparisons.

Measuring The Time Delay Between Two Signals

The △(Delta) TIME function simplifies the procedure for measuring the time delay between two signals. The intensified area is adjusted to cover the area from a transition on the reference waveform to the same transition on the timing waveform. The digital display then automatically shows you the time difference between the two points. Figure 2 shows an example of two waveforms displayed on the SC61 with the Delta bars adjusted for a time delay reading.

To determine the time delay between two signals:

1. Position the two waveforms on the CRT so the comparison points are easily visible in both traces.

2. Press the △ TIME button.

3. Observe the reference (top) waveform as you adjust the △ BEGIN control until the moving end of the intensified bar is

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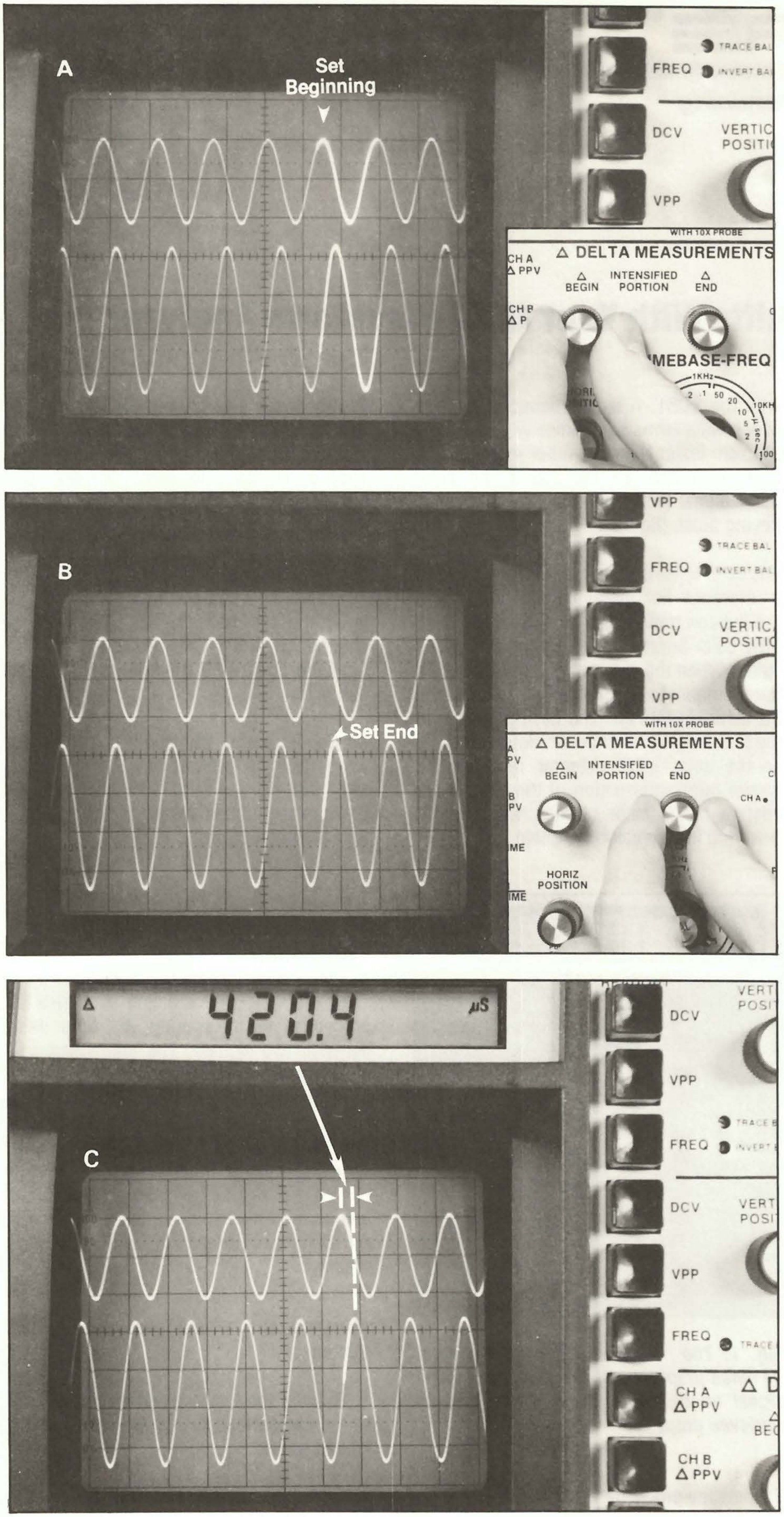


Fig. 2a, 2b, and 2c: To measure the delay between two signals: (A) Adjust the Delta Begin control until the bar is on the top waveform transition. (B) Adjust the Delta End control until the bar is on the bottom waveform transition. (C) Read the delay on the digital display.

positioned exactly at the selected comparison point in the waveform.

4. Observe the timing (bottom) waveform as you adjust the (Delta) END control until the other end of the intensified bar is positioned at this waveform's comparison point.

5. Read the digital display to determine the amount of time delay between the two signals.

Measuring Phase Shift With The Delta Function

The 1/△ TIME function may be used to determine the phase shift between two signals much faster than using conventional analog scope methods. The Delta function is used to measure the time delay between the two signals. The time delay is converted to an equivalent frequency by pressing the 1/△ TIME button. The equivalent frequency is then compared to the actual frequency of the waveform measured with the FREQ function. The ratio of these two frequency readings is the fractional part of 360 degrees represented by the phase shift between channels.

For example, figure 3 shows two 1MHz waveforms with 180 degrees phase shift between channels. When the Delta Time function is set between the peak of the signal in channel A and the peak of the signal in channel B, the measured time is 5 microseconds, or one-half the period of the entire signal. The equivalent frequency of 5 microseconds (displayed when the 1/△ TIME button is pressed) is 2MHz. Dividing 2MHz into 1MHz gives a ratio of 0.5, and multiplying this times 360 degrees yields an answer of a 180 degree phase shift between channels.

The zero reference signal should always be connected to the channel A input in order to tell whether the phase of the second signal is leading or lagging the reference signal. Procedures follow for calculating either leading or lagging phase angles. Most phase measurements are made as a lagging angle.

To calculate lagging phase:

1. Press the 1/△ TIME button.

2. Observe the top waveform as you adjust the △BEGIN control until the beginning of the Delta Measurement Bar is at the very top of the trace.

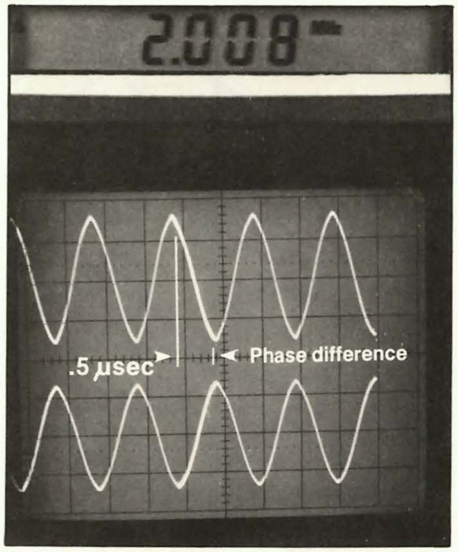


Fig. 3: The phase shift between the signals is measured by intensifying the difference of the two signals and reading the 1/Δ Time frequency. Here, the 2MHz reading compared to the 1MHz signal indicates 180 degree phase shift.

3. Adjust the ΔEND control until the end of the Delta Measurement Bar is at the very top of the first cycle of the bottom waveform to the right of the Bar's beginning point.

4. Read the equivalent frequency from the digital display.

5. Press the FREQ button for channel A and read the frequency on the LCD display.

6. Divide the actual frequency (step 5) by the equivalent frequency (step 4) and multiply the results times 360 degrees. Use the following formula:

$$\text{Phase Shift} = \frac{\text{FREQ. of Signal}}{1/\Delta\text{TIME reading}} \times 360 \text{ degrees}$$

Note: If the channel B signal is leading the channel A signal phase (lagging time > 180 degrees), you may calculate the leading phase by subtracting 180 from the above calculations, or use the following procedure.

To calculate leading phase:

1. Press the 1/Δ TIME button.

2. Observe the top waveform as you adjust the ΔBEGIN control until the beginning of the Delta Measurement Bar is at the very top of the signal.

3. Adjust the ΔEND control until the end of the Delta Measurement Bar is at the very top of the first cycle of the bottom waveform to the left of the beginning point.

4. Read the equivalent frequency from the digital display.

5. Press the FREQ button for either channel A or B (the frequency will be the same for both channels).

6. Divide the actual frequency (step 5) by the equivalent frequency (step 4) and multiply the results times 360 degrees.

Phase Measurements Using The Vector (X-Y) Mode

The closely matched vertical and horizontal deflection amplifiers of the SC61 allow Vector (X-Y) measurement of two signals for their phase difference. The signal applied to channel A causes vertical (Y) deflection, and the signal applied to channel B causes horizontal (X) deflection. The resulting Lissajous (liss-a-jew) pattern compares the phase and frequency relationships of the two signals. The special design of the SC61 provides accurate phase comparisons to 4 MHz with less than 3 degrees of phase shift between channels.

The vertical gain is controlled by the channel A VOLTS/DIVISION switch. The channel A VERTICAL POSITION control adjusts the pattern's vertical position. The channel B VOLTS/DIVISION switch

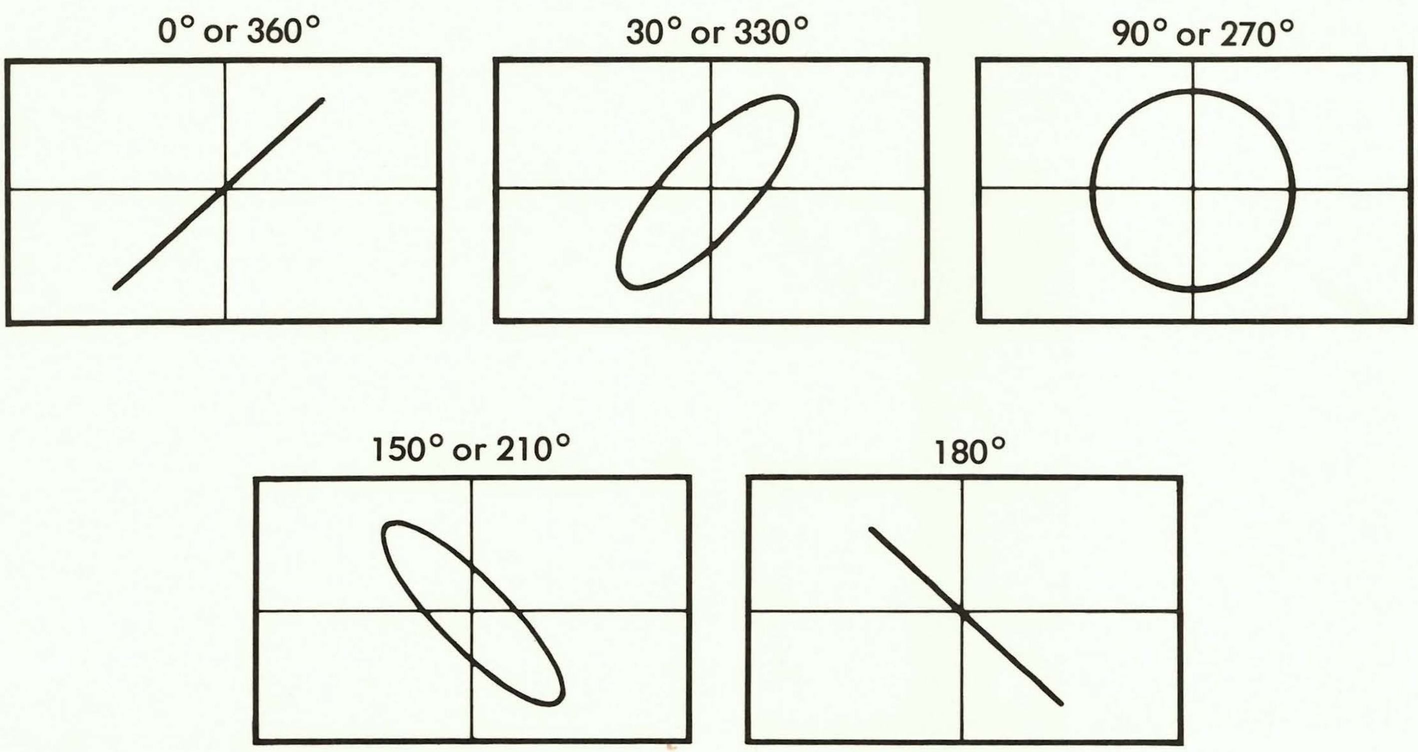


Fig. 4: Typical phase relationships represented by the Vector function of the SC61.

controls the amount of horizontal gain. The horizontal position is adjusted by the HORIZ POSITION control (the channel B VERTICAL POSITION control has no effect on the trace when the vector function is selected).

Figure 4 shows typical phase relationships as shown in the vector mode. The following procedure may be used to calculate phase angle.

To measure the phase difference of two signals using the VECTOR mode:

1. Apply the signals to the two SC61 inputs, channel A and channel B.

2. Depress the VECTOR display pushbutton.

3. Set the channel B INPUT COUPLING switch to the "ground" position and the channel A INPUT COUPLING switch to the "AC" position.

4. Adjust the channel A VOLTS/DIVISION and VERNIER control for 4 divisions of display.

5. Set the channel A INPUT COUPLING SWITCH to the "ground" and the channel B INPUT COUPLING switch to "AC".

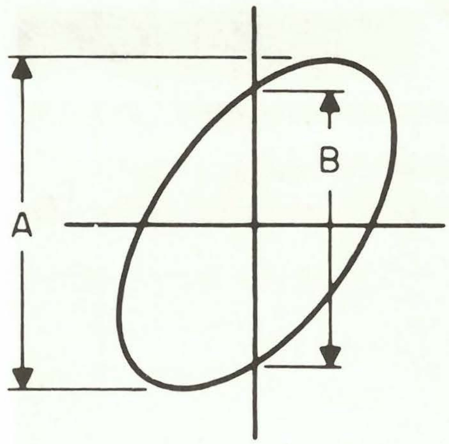
6. Adjust the channel B VOLTS/DIVISION switch and VERNIER control for exactly 4 divisions of display along the horizontal axis.

7. Return the channel A INPUT COUPLING switch to the "AC" position.

8. Use the channel A VERTICAL POSITION control and the HORIZ POS. control to center the displayed pattern around the center of the graticule.

9. Measure the number of divisions between the points where the oval touches the vertical graticule line and divide this figure by "4" (the total number of divisions of the outside oval) as shown. The result is the sine of the phase angle. Use a calculator or trig table to determine the phase angle.

$$\text{Sine of the phase angle} = \frac{\text{Divisions inside of the oval}}{\text{Divisions outside of the oval}}$$



$$\text{Sine } \emptyset = \frac{B}{A}$$

Where Ø = Phase Angle

Fig. 5: You can calculate the phase angle of two waveforms using the VECTOR function of the SC61.

for more information

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