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tech tips

# Learning To Use The SC61 Waveform Analyzer

This Tech Tip is a self-study guide to help you become familiar with the main features of the Sencore SC61 Waveform Analyzer. You will use the the SC61 to fully analyze the signal supplied by the "probe compensation" jack. The same techniques used to analyze this signal will apply to any other waveform testing you encounter.

## Sample Signal

The PROBE COMP connector provides a convenient source of a test signal. The main use of this signal is to adjust each probe for correct frequency response. Don't worry about adjusting the probes just yet, since you first have to learn how to get the signal locked onto the CRT.

The signal is about 1 volt peak-to-peak, with a frequency of about 2 kHz. It has fast rising and falling edges, with a duty cycle close to a square wave. It has a DC bias, as well. All of these factors makes it an ideal signal to practice using the various SC61 features.

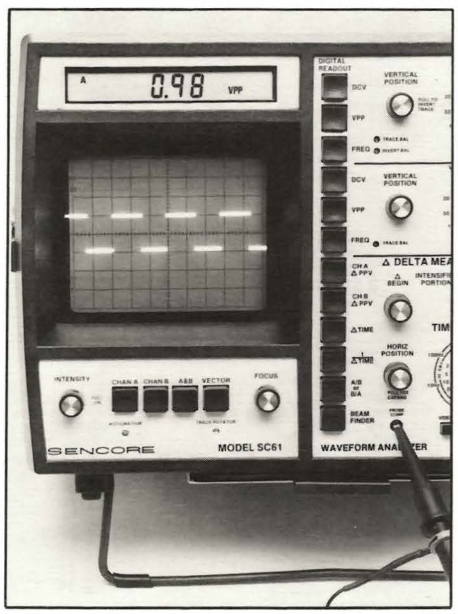


***Fig. 1: The "Probe Comp" signal, from the SC61's front panel provides a signal you can use as you learn to operate the controls.***

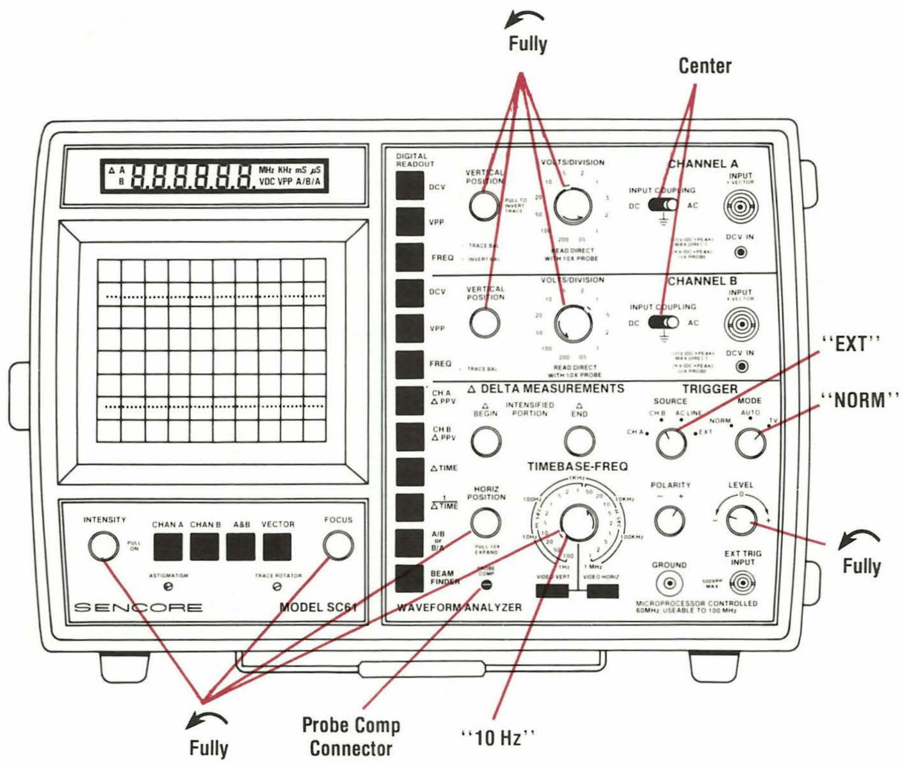


***Fig. 2: Follow these steps to intentionally mis-adjust the SC61 controls before you start.***

With the probes connected to the channel A and B input connectors, connect both of the probes to the PROBE COMP connector. Normally, you should connect a ground clip from each probe to the circuit ground. In this case, however, it is not necessary to connect ground clips, since the signal is generated within the SC61 itself.

After connecting the probes, you'll learn two simple steps of operating the SC61. First, you'll get the signal locked onto the CRT. Then, you'll use the SC61's digital display to fully analyze the signal. As we do this, you'll learn about some of the hidden features that make the digital display such a help in waveform analysis.

## Displaying The Signal

Setting up the SC61's CRT is much easier than setting up most conventional oscilloscopes. In order for you to learn the most, we'll start by setting all of the front panel controls as far out of their correct position as possible. In most cases, the controls won't be this far out of adjustment, but you'll learn more about setting up the SC61 if you start with them in this combination.

Follow Fig. 2 as you misadjust the front panel controls as follows:

| Control | Adjust |
|---|---|
| Intensity | Fully to the left |
| Focus | " " " |

| | |
|---|---|
| Vertical Position | Fully to the Left |
| Volts/Div. | " " " |
| "Cal" Control | " " " |
| Input Coupling | To the center position |
| Horiz Position | Fully to the Left |
| Timebase-Freq | To the "10 Hz" position |
| Trigger Source | To "Ext" |
| Trigger Mode | To "Norm" |
| Trigger Polarity | Doesn't Matter |
| Trigger Level | Fully to the Left |

Now, we'll follow three basic oscilloscope rules to get the signal locked onto the CRT. These rules are so basic and so simple that they may sound silly. But, they are easy to remember. Your best bet is to go back to these rules any time you have a problem getting the pattern you want on the scope.

**Three Basic oscilloscope rules:**

1. **Get a blue line.**
2. **Get a FAT blue line.**
3. **Get a LOCKED blue line.**

Now, let's see how to put these simple rules to use as we set up the CRT to display the signal. Be certain that you've connected the probes to the PROBE COMP signal before you start. The instructions tell you **why** you are making each adjustment. There will be a control setting shown in square brackets **[SETTING]** in each instruction. This indicates the correct setting of each switch to double-check your work.

## Basic Rule #1: Get A Blue Line (Fig. 3)

The first rule reminds you to get the trace on the screen before you try to get the signal locked in. Turn on the power and give the SC61 a moment to warm up. If you've misadjusted the controls, as explained earlier, there should be no trace on the CRT. The first step is to "rough-in" the front panel controls until a trace appears somewhere on the CRT.

The BEAM FINDER helps you adjust the controls which affect the CRT setup. This button overrides the normal CRT functions, to force the beam onto the screen. Its relative placement tells where the vertical and horizontal controls are set. If they are set correctly, the resulting trace will be near the center of the CRT. If it is near the top, bottom, or either side, the corresponding position controls need to be adjusted to bring it back to the center of the screen.

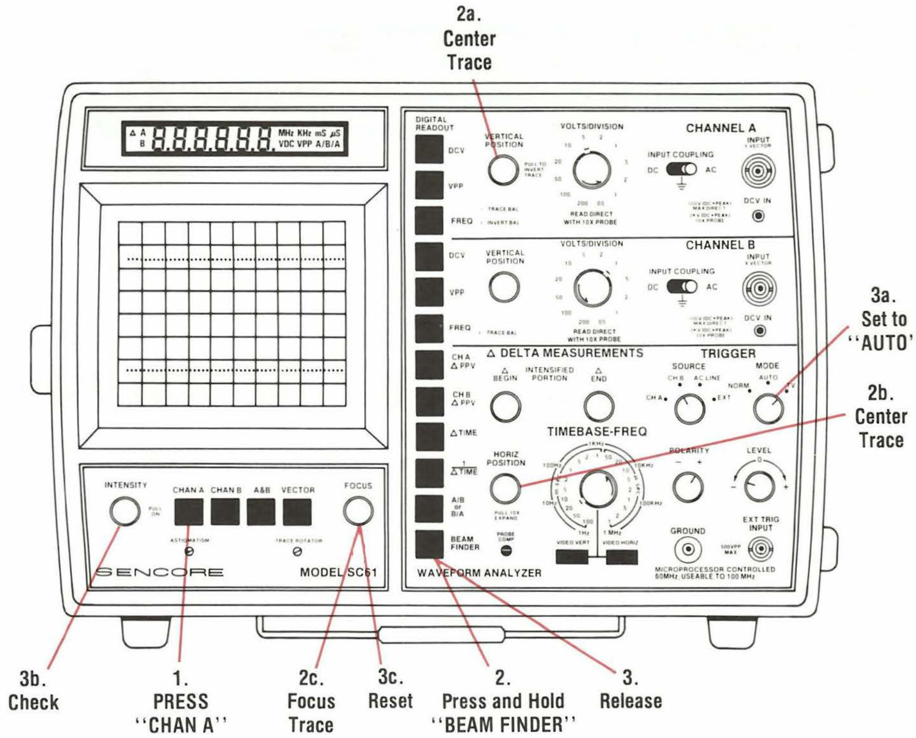


*Fig. 3: Step #1: GET A LINE. Following these steps always returns a trace to the CRT, no matter how badly the front-panel controls are mis-adjusted.*

1. Select the Channel A trace by pushing the **[CHAN A]** CRT selector button.
2. Press the BEAM FINDER button, at the bottom of the row of pushbuttons that run on the right-hand side of the CRT. Continue to hold this button as you:
   a. Adjust the CHANNEL A "VERT POSITION" control until the beam is centered from top to bottom.
   b. Adjust the "HORIZ POSITION" control until the beam is centered from left to right.
   c. Adjust the "FOCUS" control until the beam is sharply focused.
3. When you let go of the BEAM FINDER button, the trace should be on the screen. If not:
   a. Check that the TRIGGER MODE switch is in the **[AUTO]** position.
   b. Check that the INTENSITY control is adjusted to midrange.
   c. Reset the FOCUS control for a sharp trace.

You should now have a focused trace on the screen. You have "gotten a blue line."

## Basic Rule #2: Get A Fat Blue Line (Fig. 4)

The second rule tells you that you must have enough vertical deflection on the CRT before trying to adjust the horizontal or the triggering circuits. You don't worry about sweep speed or getting the trace stable at this point. Simply adjust the vertical input until the signal is at least one large division tall on the screen.

1. Always check the "INPUT COUPLING" switch first. For most tests, it should be set to **[AC]**. (NOTE: Unlike conventional scopes, you do not need to set the switch to "DC" to make DC measurements when using the digital display.)
2. Turn the "VOLTS/DIVISION" switch to a smaller number (clockwise) until

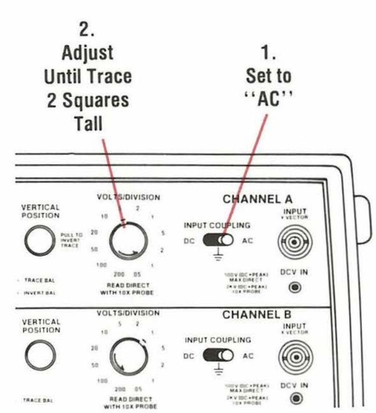


*Fig. 4: Step #2: GET A FAT LINE. After the trace is on the screen, these steps ensure that the signal is large enough to measure.*

the signal on the screen is about 2 squares tall on the CRT. **[0.5 volts/division]**
(The "fat" line will look like two separate lines because it is a square-wave. Get the two lines about 2 squares tall.)

You now have enough signal to ensure proper triggering when you go to the third step of setting up the waveform.

## Basic Rule #3: Get A Locked Blue Line (Fig. 5)

The final steps involve adjusting the triggering circuits until they are locked to the incoming signal, and then adjusting the horizontal sweep speed until you have a signal that looks good on the CRT. We will take advantage of the "Normal" triggering function first. The Normal function causes

*NOTE: Unlike other scopes, you will **almost always** leave the TRIGGER LEVEL control set to the zero, center position. The only exception will be when viewing signals with high levels of noise.*

3. *If there is no trace:* Adjust the TRIGGER SOURCE switch to **[CH A]**.
4. Return the TRIGGER MODE switch to **[AUTO]**.

*NOTE: You normally should set the MODE switch to "AUTO" or "TV" because these two positions provide a trace on the screen, even if the circuits are not locked.*

5. Turn the "TIMEBASE-FREQ" switch until you see about 3 square waves horizontally across the CRT. **[0.1 mS]**
6. Readjust the FOCUS and INTENSITY controls for a comfortable viewing level.

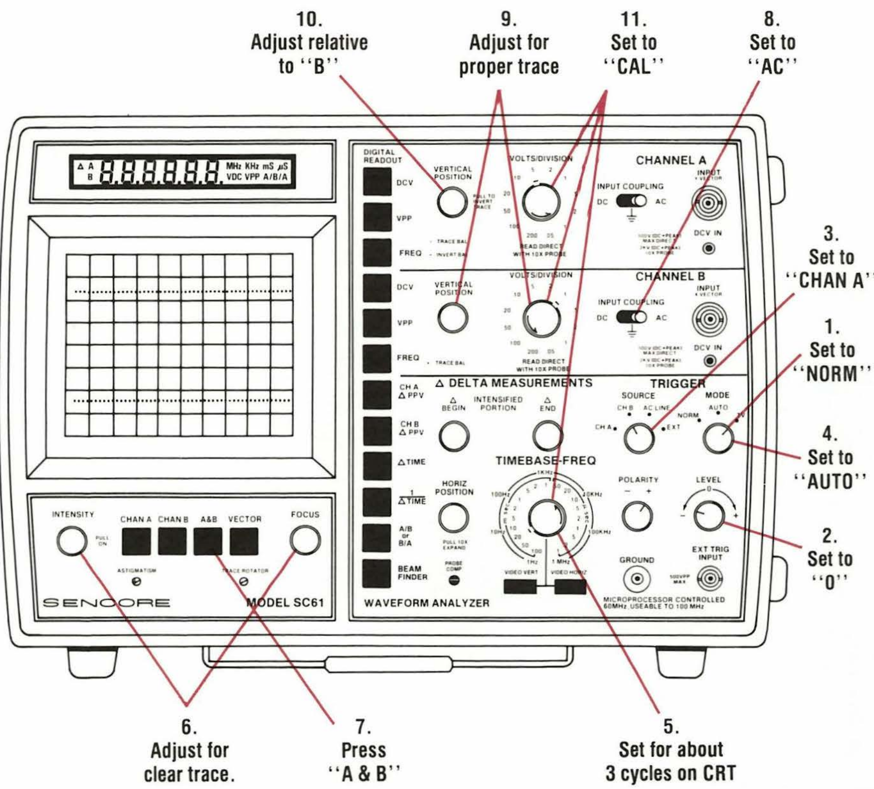


***Fig. 5: Step #3: GET A LOCKED BLUE LINE. These final steps guide you as you adjust the SC61 triggering circuits to lock the trace.***

the trace to disappear when the circuits are not triggered. You will simply adjust the triggering circuits until the trace returns, and you will then know that the trace will be stable after changing the sweep time with the "TIMEBASE-FREQ" switch.

1. Turn the TRIGGER MODE switch to **[NORM]**.
2. Set the TRIGGER LEVEL control to **[0]**.

*NOTE: If the beginning of the signal shows an overshoot, or a rounded or sloped shape, the probes need to be adjusted. Follow the instructions on page 18 of the SC61 instruction manual.*

Now, you have a LOCKED BLUE LINE on the screen. You have used channel A as the trigger reference, and only showed that one signal on the CRT. The next steps will simply have you match the channel B signal, allowing dual-trace comparisons.

7. Press the **[A&B]** pushbutton below the CRT.
8. Set the Channel B "INPUT COUPLING" switch to **[AC]**.
9. Adjust the Channel B "VERT POSITION" control and "VOLTS/DIVISION" switch until the second trace is about the same size as the first one. **[0.5 Volts/Division]**
10. Adjust the Channel A and Channel B "VERT POSITION" controls until the channel A signal is in the top half of the CRT and the channel B signal is in the bottom half of the CRT.
11. As a final step, set the three "CAL" controls to the clockwise position.

(You don't need to calibrate the controls when using the SC61, but having them calibrated will ensure that our sample tests work about the same as intended. You'll see why the SC61's "CAL" controls can't cause measuring errors.)

## The Digital Readout

So far, we've gotten the two SC61 traces on the CRT. If you were using a conventional oscilloscope, you would have to use the graduations on the CRT graticule to measure vertical or horizontal displacement, and then multiply these measurements by the settings of the vertical or horizontal controls. The SC61 eliminates all of these measurements and calculations with the digital readout. There are two groups of tests: the AUTO-TRACKING™ tests and the Delta tests. The next steps will take you through each.

Fig. 6 shows the seven tests needed to fully analyze any waveform. The CRT lets you test the first: waveshape. The remaining functions are all measured with the SC61's digital readout. If you run through all of these tests, you will have fully analyzed the signal, no matter how simple or complex the waveshape.

The AUTOTRACKING digital readings measure the entire waveform, as the digital readout automatically tracks the CRT signal. The Delta tests let you measure any portion of the signal you want to measure. Unlike most oscilloscopes that have added digital readings, the SC61 readings are accurate for nearly any CRT setting. They *are not based on the displacement of the electron beam* on the CRT. This simply means that you can have your waveform adjusted any way you want, without causing reading errors. In fact, you don't even need to have the waveform locked or displayed for most of the tests.

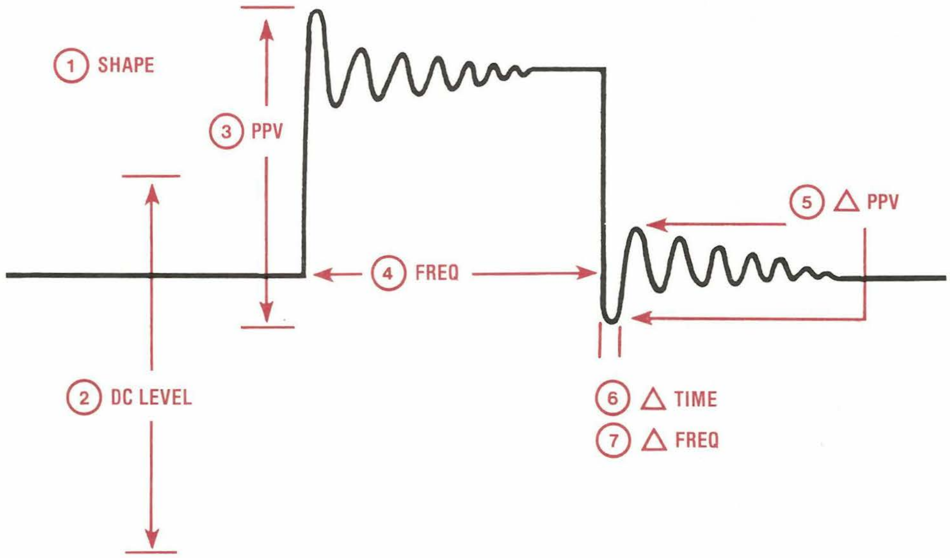


*Fig. 6: These seven steps let you fully analyze any waveform. With the SC61, you only use the CRT for step #1. The digital readout provides steps #2 through #7.*

## AUTOTRACKING™ DC Volts

Step one will involve determining the average DC level of the signal in channel A. Normally, you only need to press the "DCV" button and read the digital display. We will take you through several steps to show how the other adjustments don't affect the AUTOTRACKING DC readings.

1. Press the Channel A **[DCV]** button.
   (The reading will show about 1/2 volt.)

Now, we'll mis-adjust several controls, so that you can see that they do not affect the DC reading.

2. Un-trigger the CRT by moving the TRIGGER SOURCE switch to **[EXT]**.

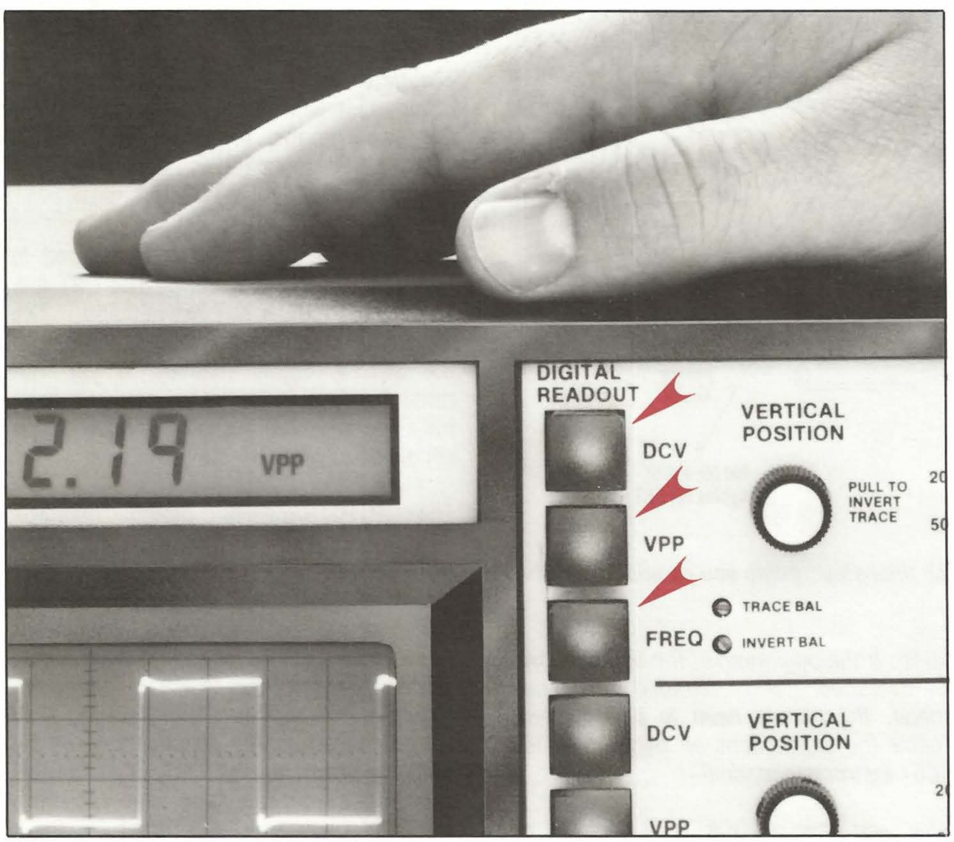


*Fig. 7: The AUTOTRACKING™ functions are DC volts, peak-to-peak volts and frequency. Each automatically tracks along with the CRT to measure the parameter from the entire waveform.*

(The DC reading does not change.)

3. Re-trigger the CRT by moving the TRIGGER SOURCE switch back to the **[CH A]**.
4. Move the Channel A "INPUT COUPLING" switch to **[DC]**.
   (The Channel A trace moves up, but the DC reading does not change.)
5. Move the Channel A "INPUT COUPLING" switch to the "ground position. [⏚]
   (The Channel A trace changes to a straight line, throwing the sweep out of sync, but the DC reading does not change.)
6. Move the Channel A "INPUT COUPLING" switch back to **[AC]**.
7. Turn the Channel A "CAL" knob out of the calibrated position by rotating it fully counter-clockwise.
   (The Channel A trace becomes smaller, but the DC reading does not change.)

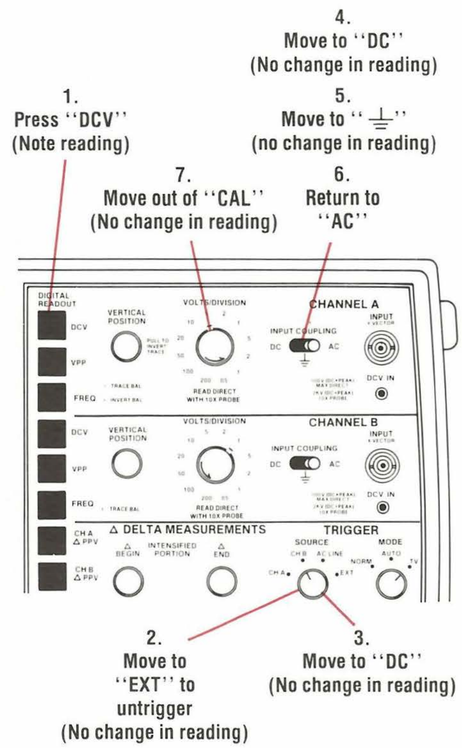


*Fig. 8: Follow these steps as you learn to make DC voltage readings.*

**CONCLUSION:** The DC voltage readings are independent of the CRT controls. They are, however, measured through the same probe used to feed the waveform to the CRT, for single-probe hookup of all tests.

## AUTOTRACKING Peak-To-Peak Volts

The AUTOTRACKING peak-to-peak voltage tests are nearly as independent from the CRT settings as the DC voltage tests.

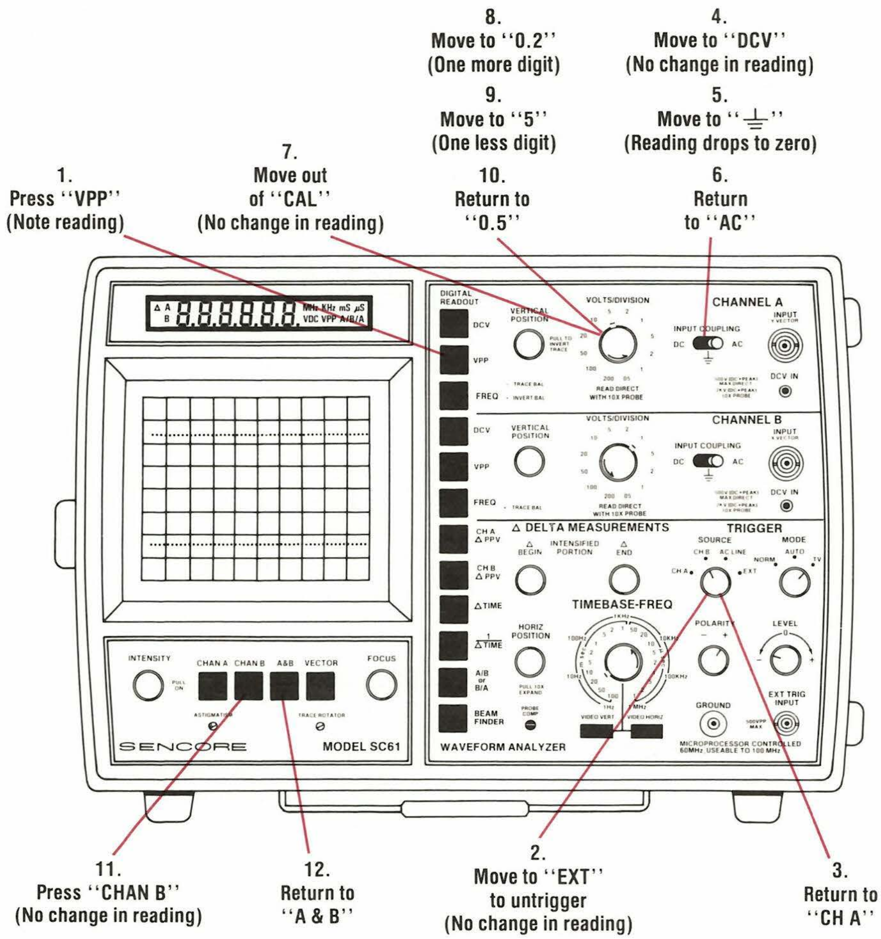


*Fig. 9: Notice how most of the CRT controls have no effect at all on the PPV function.*

Compared to DC, there are two minor differences: 1) The "INPUT COUPLING" switch cannot be in the "ground" position, and 2) The number of digits displayed depends on the setting of the "VOLTS/DIVISION" switch. Other than these two factors, the CRT can be set any way you want, including having no trace on the screen.

1. Press the Channel A **[VPP]** button.
(The reading will show about 1 VPP.)

Now, we'll misadjust several controls, so you can see how they affect the VPP reading.

2. Un-trigger the CRT by moving the TRIGGER SOURCE switch to **[EXT].**
(The VPP reading does not change.)
3. Re-trigger the CRT by moving the TRIGGER SOURCE switch back to the **[CH A]** position.
4. Move the Channel A "INPUT COUPLING" switch to **[DC].**
(The Channel A trace moves up, but the VPP reading does not change.)
5. Move the Channel A "INPUT COUPLING" switch to the "ground" position. **[⏚]**
(The VPP reading drops to zero, because a signal is needed for this test.)
6. Move the Channel A "INPUT COUPLING switch back to **[AC].**
7. Turn the Channel A "CAL" knob out of the calibrated position by rotating it fully counter-clockwise.
(The PPV reading does not change.)
8. Move the Channel A "VOLTS/DIVISION" switch to the **[0.2]** position.
(The VPP reading has *one more digit* than in the 0.5 volt position. The last absolute value may shift slightly as more digits are added, because the extra digits provide slightly better accuracy.)
9. Move the Channel A "VOLTS/DIVISION" switch to the **[5]** position.
(The trace may lose sync. The digital display shows *one less digit* than in the 0.5, 1, or 2 positions.)
10. Return the Channel A "VOLTS/DIVISION" switch to **[0.5].**
11. Press the **[CHAN B]** CRT display button below the CRT.)
(The channel A trace is no longer displayed, but the AUTOTRACKING display still shows the correct peak-to-peak voltage level.)
12. Press the **[A&B]** CRT display button.

**CONCLUSION**: For the most part the peak-to-peak function is independent of the CRT. The "VOLTS/DIVISION" switch selects one of four internal ranges. No other CRT controls affect the accuracy of the peak-to-peak readings.

## AUTOTRACKING Frequency

The SC61's AUTOTRACKING frequency tests automatically select the number of digits for best results. At frequencies over 10 kHz, the display has 6 digits. Frequencies from 1 to 10 kHz have 0.1 Hz resolution, which produces 5 digits. Frequencies from 100 to 999 Hz also have 0.1 Hz resolution, resulting in 4 digit display. Frequencies from 1 Hz to 99 Hz have 0.01 Hz resolution, providing 3 to 4 digits.

The microprocessor monitors the front-panel switches to route the signal through the internal circuits to provide high levels of stability. The logic, circuits, and signal flow are quite complex (see Tech Tip #110 for details). As a user, there are only two things to remember: 1) If you want the frequency of the same channel that is triggering the CRT, the trace must be locked on the CRT, and 2) If you are measuring a channel *not used for triggering*, you need at least 1.5 divisions of signal on the CRT. Other than these two rules, you can have the CRT controls set any way you want without affecting the accuracy of the measured signal. Once the signals are set, the waveform *does not have to be displayed* in order to be measured.

1. Confirm that the TRIGGER SOURCE switch is set to **[CH A]** and that the TRIGGER LEVEL control is at **[0].**
Press the Channel A "FREQ" push-button. **[FREQ]**
(The digital display will show a reading near 2 kHz.)
2. Adjust the TRIGGER LEVEL control fully clockwise (to the right).
(The traces will be out of sync. After a few seconds, the digital display will drop to zero, indicating that the trigger circuits are not supplying a signal to the frequency circuits.)
3. Move the TRIGGER SOURCE switch to **[EXT].**
(The trace will still be out of sync, but the frequency reading will return. This is because the channel you've selected for the frequency reading — Channel A— is no longer the selected trigger channel. The displayed wave-

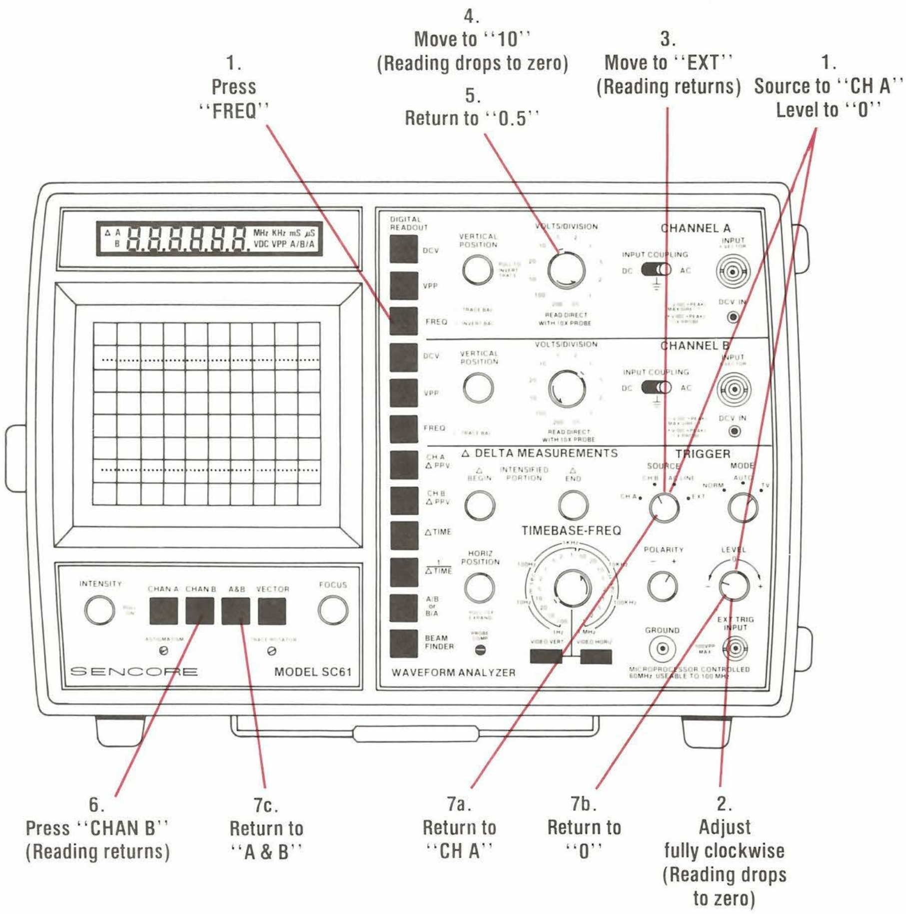


*Fig. 10: The frequency function needs the triggering circuits to be properly adjusted, and then automatically displays frequency.*

form is large enough for reliable readings.)

4. Move the Channel A "VOLTS/DIVISION" switch to the **[10]** position. (The display drops to zero because the amplitude of the signal is too low to detect. Always set the trace for 1.5 divisions, or more, for reliable counting.)
5. Return the Channel A "VOLTS/DIVISION" switch to the **[0.5]** position.
6. Press the **[CHAN B]** CRT selector switch (below the CRT).
(Only the channel B trace is now displayed—still out of sync—but channel A continues to read correctly. You *do not need to have the signal on the CRT* in order to measure it, as long as you have enough signal applied.)
7. Return the controls to their normal positions:
   a. TRIGGER SOURCE to **[CH A]**
   b. TRIGGER LEVEL TO **[0]**
   c. CRT Selector to **[A&B]**

**CONCLUSION:** The AUTOTRACKING frequency function needs enough signal to measure. After that, the CRT controls can be set any way you want without affecting the accuracy of the measurement.

## Delta Peak-To-Peak Volts

The Delta functions let you define which part of the waveform the digital circuits measure. Pressing any of the four Delta buttons (the functions marked with the Δ symbol) cause an intensified bar (the "Delta Bar") to appear on the trace. You position this bar on the trace with the Δ BEGIN and the Δ END controls.

The PROBE COMP signal may have a small amount of high frequency noise riding on its top or bottom. We will determine how much with the Δ PPV test.

1. Press the **[CH A ΔPPV]** pushbutton.
2. Adjust the INTENSITY control until you can see the intensified portion of the waveform.
3. Adjust the Δ BEGIN and Δ END controls until the Delta Bar is on the top part of the squarewave signal. (The exact placement is not critical. Just be sure that the intensified zone *does not include* the rising or the falling part of the signal.)
4. Set the Channel A "VOLTS/DIVISION" switch to the **[0.2]** position to give an extra digit of resolution. If there is a little noise, you will now see a reading. If the display remains at zero, there is less than 1 mV of noise.)
5. Press the AUTOTRACKING Channel A **[VPP]** button.
(The intensified portion of the waveform will now disappear. The digital readout will show the amplitude of the entire waveform.)
6. Press the **[CH A ΔPPV]** button again.
(The Delta Bar returns, and the digital display again measures only the highlighted area.)
7. Slowly adjust the Δ BEGIN control until the intensified portion includes the leading edge of the square-wave signal.
(The digital display will now show the entire peak-to-peak level, since the highlighted area includes the point of maximum change in the waveform.)

**CONCLUSION:** The Δ PPV function lets you measure the amplitude of any small portion of the waveform. Since the readings are true peak-to-peak values, you can have the CRT set up nearly any way you want and still get valid readings.

## Delta Time

This function lets you measure any waveform time relationship. It can be used to measure time intervals within one signal, or the delay between two signals. The readings are all referenced to a high accuracy crystal, so they are correct when the horizontal circuits are out of their "CAL" position. We will measure the "off time" of the calibration signal as our example.

1. Press the **[ ΔTIME]** pushbutton.
2. Adjust the Δ BEGIN control until the beginning of the intensified portion of the waveform *just touches the falling edge* of the signal (the beginning of of the BOTTOM part of the waveform).
3. Adjust the Δ END control until the end of the intensified portion of the waveform *just touches the rising edge* of the signal (the end of the bottom part).
4. Read the digital display and remember or record this reading.

We will now see how the crystal accuracy is unaffected by the setting of the horizontal sweep vernier.

5. Adjust the horizontal vernier control in the center of the "TIMEBASE-FREQ"

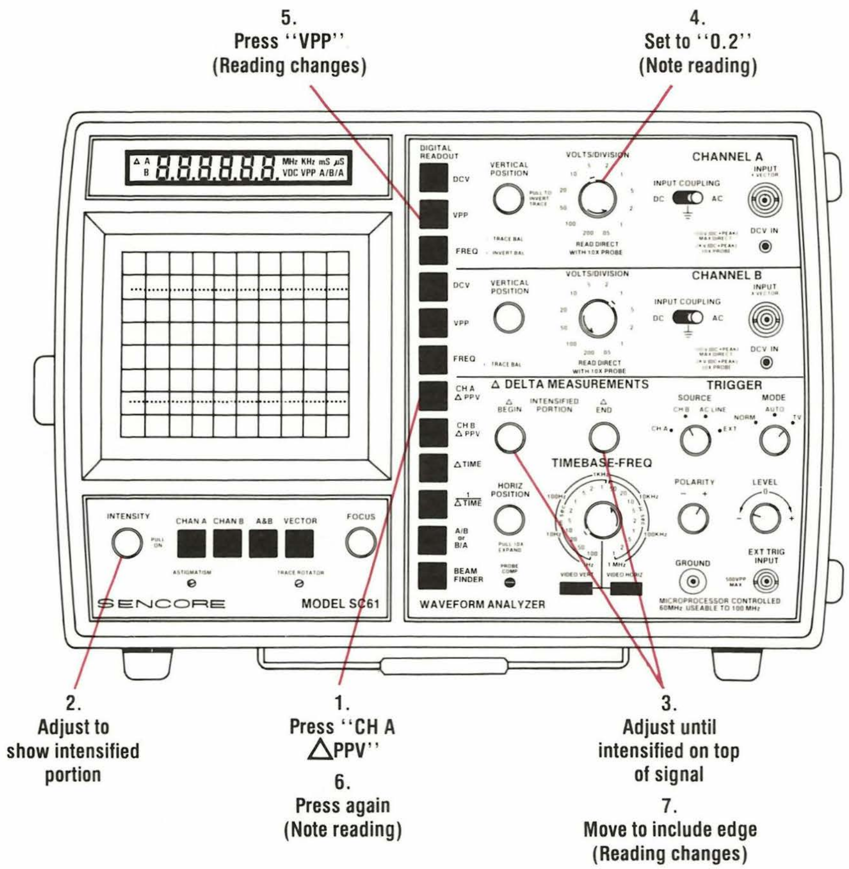


***Fig. 11: The Δ PPV function lets you measure the amplitude of any small part of a waveform.***

switch) out of the "CAL" position.
(The Delta Bar will no longer cover the waveform area marked earlier. The digital display will read a different number.)

6. Readjust the Δ BEGIN and Δ END controls until the bottom of the waveform is again the only part intensified. (The digital display will measure nearly the same as in step 4.)

**CONCLUSION:** The Δ TIME test is accurate whether the horizontal circuits are calibrated or uncalibrated, because they measure the actual time of the intensified bar.

## Delta Frequency

The SC61 microprocessor can perform the mathematics needed to convert a time reading to its equivalent frequency. This offers higher accuracy than using a conventional scope because the Delta Bar is part of the waveform. This eliminates parallax error, and reduces interpretation questions. When highly accurate frequency tests are needed, however, you should use the AUTOTRACKING frequency function, since it is a true frequency test instead of a derived time function.

1. Press the **[1/Δ TIME]** pushbutton.
2. Adjust the Δ BEGIN and the Δ END controls until the intensified portion just covers one complete cycle of the waveform.
   (The digital display will show the approximate frequency of the signal.)
3. Press the Channel A **[FREQ]** pushbutton.
   (The digital display will show the exact signal frequency.)

**CONCLUSION:** Delta frequency readings are easier and more accurate than a conventional scope. They are especially helpful when you need to know the approximate frequency of a signal riding on top of another signal. The results will be as accurate as you estimate the starting and stopping point, so you should use the AUTOTRACKING test if you need exact measurements.

## Frequency Ratio

This special test lets you confirm that a frequency multiplier or divider stage is working correctly without using a calculator. Pressing the "A/B or B/A" button causes the microprocessor to calculate the frequency ratio between the signal applied to the channel A and the

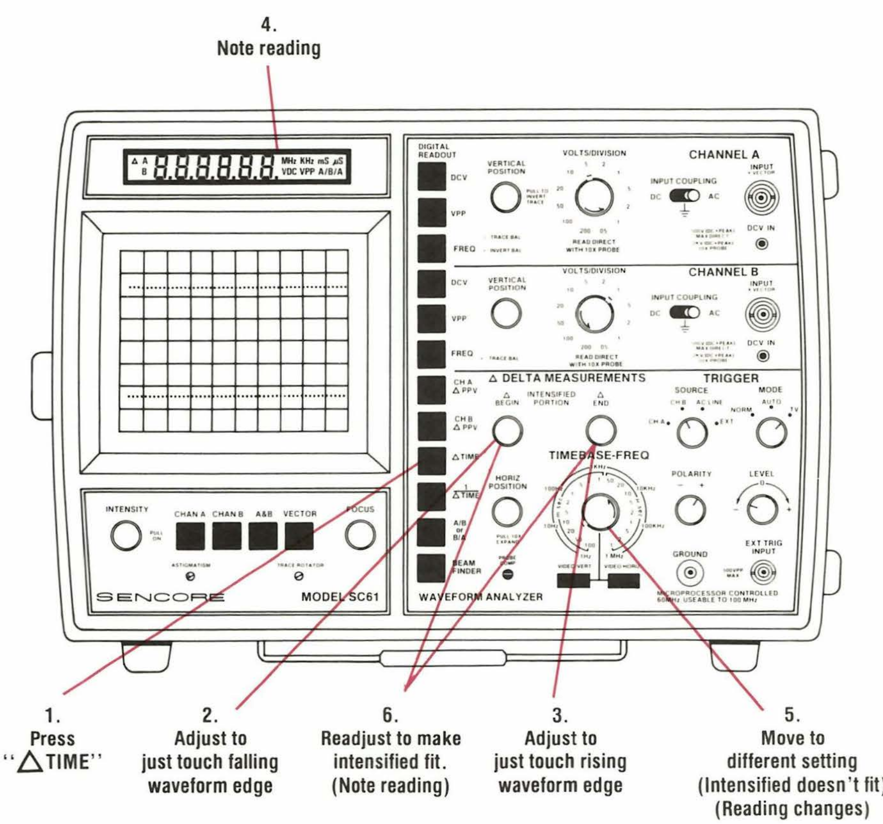


***Fig. 12: The Δ TIME readings are accurate whether the horizontal circuits are in or out of the "cal" mode.***

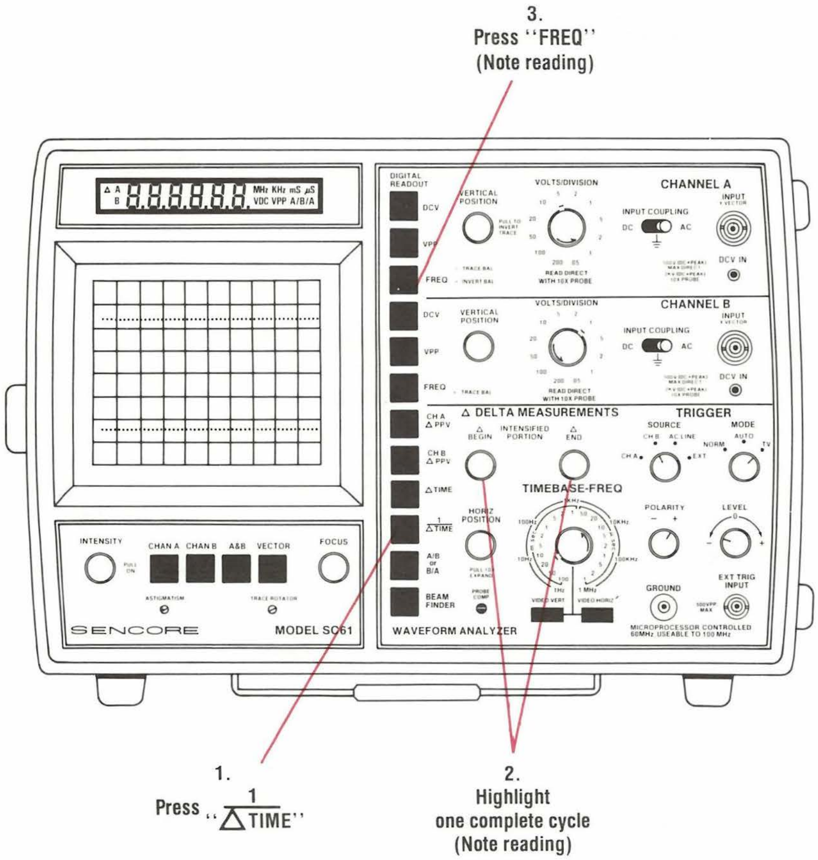


*Fig. 13: The 1/ΔTIME function lets you measure frequency more accurately than a conventional scope. But, always use the AUTOTRACKING FREQ function if high accuracy is needed.*

channel B inputs. The channel with the higher frequency will be indicated by the display annunciator; "A/B" appears if A is higher, or "B/A" if B is higher.

1. Press the **[A/B OR B/A]** pushbutton. (The digital display shows 1.0000 since both inputs have the same frequency. Either the A/B or the B/A annunciator will come on.)

You have now completely analyzed the square wave signal. Use these same techniques to analyze some signals you encounter in your normal work. At first, take a little extra time to run through all of the tests. Then, you only need to make the tests you want for a particular application. Soon, the SC61's operation will be as easy and direct as using your favorite voltmeter.

***For more information***
***Call Toll Free 1-800-SENCORE***
***(1-800-736-2673)***

SENCORE
3200 Sencore Drive Sioux Falls, South Dakota 57107



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