FLORIDA INTERNATIONAL UNIVERSITY

ELECTRICAL & COMPUTER ENGINEERING

LAB INSTRUMENTS USER MANUAL

Contents

1. Digital Multimeter-HP34401A 6

- Quick Start 6
- Introduction 7
- Resistance Measurement 9
  - Two-wire Method 9
  - Null Function 9
  - Range Selection 10
  - Min/Max and Average 11
- Resistance Color Code and Power Rating 11
- Voltage Measurement 13
- Current Measurement 14
- Frequency Measurement 16
- Specifications 17

2. Programmable Power Supply-HP E3631A 18

- Quick Start 18
- Introduction 18
- Basics of Power Supplies: CV, CC and CV/CC 18
- HP E3631A Triple Output DC Power Supply 20
  - A Simplified View of a Power Supply 21
  - Constant Voltage 22
  - Constant Current 23
  - Disabling the Outputs 23
  - Other Features 23
- Specifications 24

3. Digital 2 Channel 100 MHz Osciloscope-HP54600B 25

- Quick Start 25
- Features 26
- Getting Familiar with the Scope 27
  - Front Panel Controls 27
  - Display Features 27
  - Helpful Hints 28
  - Setting Probe Attenuation Factor 28
- List of Procedures 28
  - Adjusting The Oscilloscope Display 29
  - Vp-p 29

- Vrms 29
- Frequency 29
- Period 30
- Risetime 30
- Offset 30
- Selecting the Trigger Source 30
- Setting the Trigger Mode 30
- Averaging 31
- Measuring Signal Amplitudes 31
- Measuring the Phase Shift between Channels 31

o Taking Measurements (Examples) 32

- Peak-Peak Voltage Measurements 32
- Rise Time 32
- Rise Time With Delayed Sweep 33
- FFT 33
- Storing Waveforms 34
  - Auto Store 34
  - Saving to Trace Memory 34

o Specifications 36

4. Function Generator/Arbitrary Wave Generator-HP33120A 37

o Quick Start 37
o Introduction 37
o Basics of the Function/Waveform Generator (HP 33120A) 40

- Functions and use of HP 33120A 42

a. Front Panel Number Entry 42
b. Selection of Standard Functions 43
c. Frequency Selection 43
d. Amplitude Selection 43
e. Offset Selection 44
f. Duty Cycle Selection 44
g. Output of an Arbitrary Waveform 44

- Front Panel Menu 45

a. Selection of the Output Impedance (50 Ohm or High Z) 45
b. Advanced Modification of a Standard Waveform 45

- Storing Arbitrary Waveforms 47

o Specifications 48

5. HP 53131A DC-225MHZ 10 Digit Universal Counter.....…….49

- Quick Start..... 49
- Key Features..... 50
- The Front Panel at a Glance..... 51
- The Front Panel Indicators at a Glance..... 52
- The Front Panel Menus at a Glance.....54
- Making Measurements..... 56
- To Control Measurement..... 72

6. Function/Arbitrary Waveform Generator HP33220A 20 MHz.....73

- Specification..... 73
- The Front Panel at a Glance..... 74
- The Front Panel Display at a Glance..... 74
- Front-Panel Number Entry..... 75
- To Set Output Frequency..... 76
- To Set Output Amplitude..... 77
- To Set a DC Offset Voltage..... 78
- To Set the High-Level and Low-Level Values..... 79
- To Set 'DC Volts'..... 80
- To Set the Duty Cycle of a Square Wave..... 80
- To Configure a Pulse Waveform..... 81
- To View a Waveform Graph..... 82
- To Output a Stored Arbitrary Waveform..... 82
- To Use the Built-In Help System..... 83
- To Select the Output Termination..... 84
- To Output a Modulated Waveform..... 84
- To Output an FSK Waveform..... 86
- To Output a PWM Waveform..... 88
- To Output a Frequency Sweep..... 89

1. Digital Multimeter-HP34401A

QUICK START

Turn ON the unit; the unit will test itself and will show Adds # 22. Also, will set to mV (milivolts) which is the default.

D**C (Default).**

The unit will also be set at Auto Range (Automatic Voltage Reading) which will allow you to check any voltage from 0 to 200V DC at the 200 V terminals, and 0 to 1000V DC at the 1000 V terminals (Red buttons at front panel).

Note: For any voltage over 30V, check with the instructor "BEFORE YOU ATTEMPT TO MEASURE.

To measure AC Voltage, press the AC voltage button and be sure that the leads are now in the correct position for the correct amount of voltage to be measured.

Note: See the Lab instructor if any doubt.

For DC current, press the blue (shift) button, then V DC Volt button. Before this test, leads must be placed as fallows:

Positive lead to the current terminal (Red button outlet) while the ground lead remains at the same position.

Note: To measure currents, the meter must be in series with the part of the circuit under test. **Never** measure current **across** a circuit component.

To measure AC Current, press the blue (shift) button and AC Volt button.

Remember, test cables must be placed in correct terminals to measure currents.

To measure current at any part of your circuit on the board, connect the multimeter in series with the components or wire in that part of your circuit. **Do not** connect the meter **across** (in parallel) any component or wire. **See your lab instructor for help**.

NOTE: **For any current over 1 Amp, see your Lab Instructor for assistance, BEFORE YOU MEASURE!**

To check Resistance:

First, be absolutely sure that there is **"NO" POWER"** connected to the resistance under test. It is recommended to place the resistor(s) at an empty part of the Proto Board, not connected to the other part of the circuit, to do the measurement.

Leads will be place as if were to measuring voltage, press the **Ω** from the front panel

After the measurement has been made, reconnect the right resistance(s) back into the circuit, and then, reconnect the power.

NOTE: Range at the resistance meter's panel is auto, but can be adjusted manually By pressing the arrows (▲, ▼) at the front of the unit 's panel .

See below for more details.

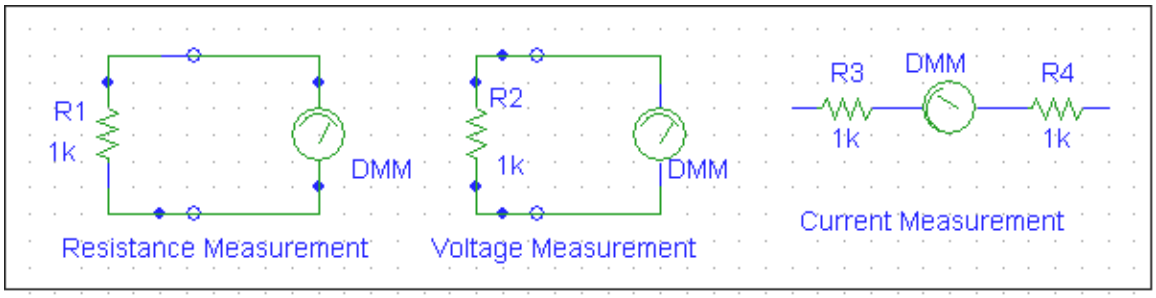


Figure 1: Measurement of resistance, voltage and current with a multimeter

Introduction

One of the most important functions of ECE Lab is to provide an understanding of the functions of instruments. For ECE students, this knowledge is essential to conduct laboratory assignments and develop independent design projects.

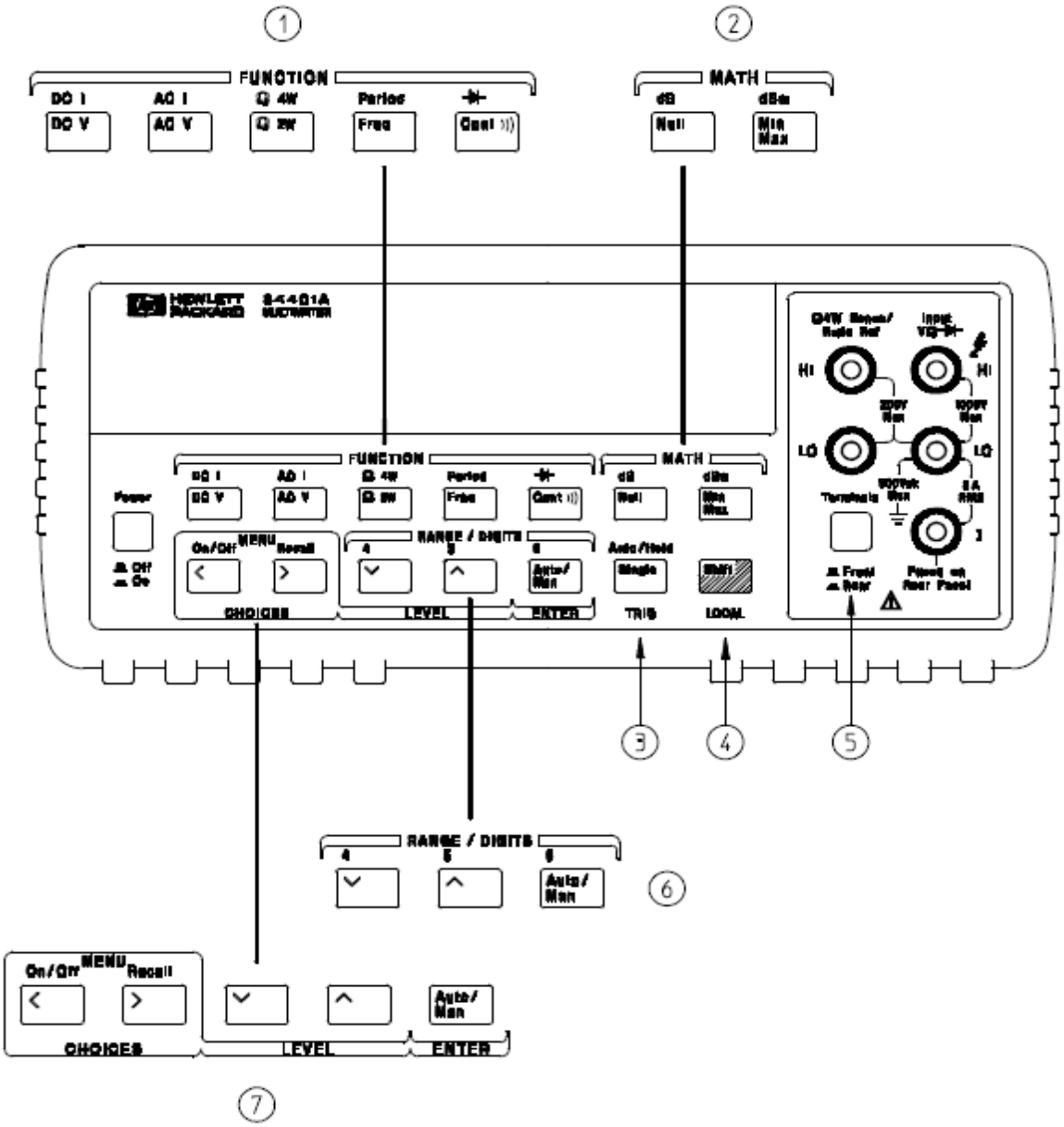
Currents and voltages are the basic circuit variables of interest. In this Lab we are mainly concerned with accurately measuring *resistance, DC voltage and currents* using a digital multimeter (DMM). We will use the HP34401A digital multimeter which is a high performance instrument capable of measuring resistance, DC and AC voltage and current, as well as frequency. The HP34401A has a built-in microprocessor, memory and other electronics components that give it numerous features such as built-in math functions, recording and storing up to 512 readings, giving the maximum, minimum and average of the readings. In addition, it

can be remotely programmed using the SCPI (Standard Commands for Programmable Instruments) language and read by computer via a General Purpose Interface Board (GPIB) port.

The use of the instrument for measurement of resistance, current and voltage is in principle very simple. Figure 1 shows the set up for resistance, voltage and current measurements.

For resistance measurements, one connects the DMM over the resistor. Notice that for voltage measurements one puts the multimeter in ***parallel*** with the circuit element so that one measures the voltage *across* the element. In case of a current measurement, one must put the DMM in ***serial*** with the element in order to measure the current *through* the element. That involves breaking the circuit in order to insert the multimeter in the circuit loop.

The Front Panel at a Glance



1 Measurement Function keys
2 Math Operation keys
3 Single Trigger / Autotrigger / Reading Hold key
4 Shift / Local key
5 Front / Rear Input Terminal Switch
6 Range / Number of Digits Displayed keys
7 Menu Operation keys

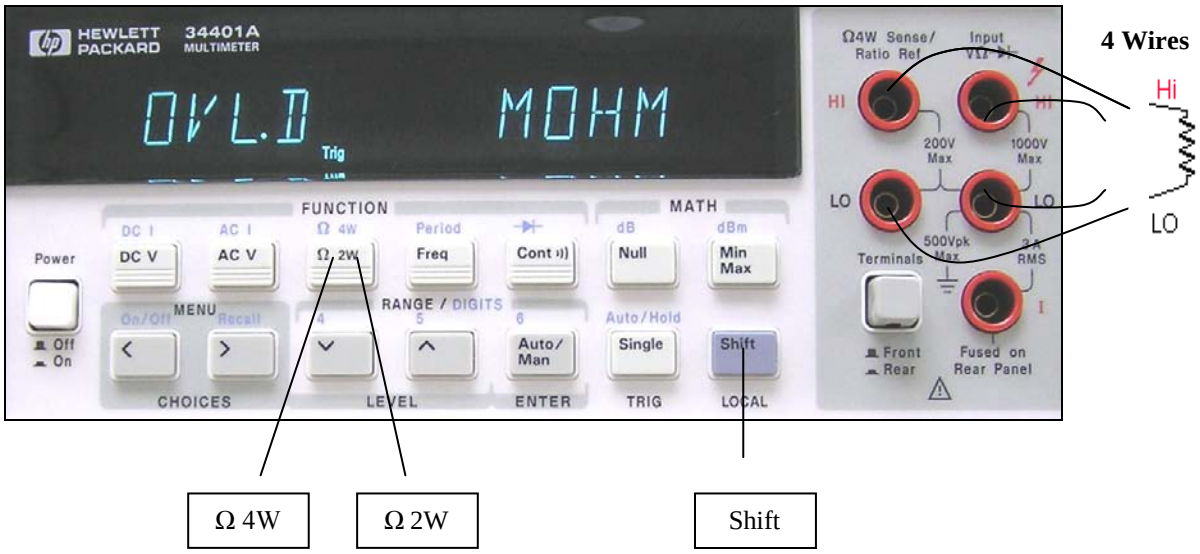
Resistance measurements with the HP34401

To Measure Resistance

Ranges: 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 M Ω, 10M Ω, 100MΩ

Maximum resolution: 100 $\mu\Omega$ (*on 100 ohm range*)

4 wire measurement



Principle of 2 wire measurement

The DMM measures a resistance by applying a known DC voltage over unknown resistance in series with a small resistance R_m . It measures the voltage over the resistance R_m as shown in Figure 2. The DMM can then calculate the unknown resistance R.

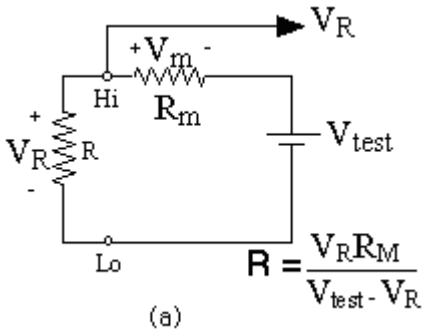


Figure 2: Two-wire resistance measurement

To use the DMM for resistance measurements, connect the resistor to the terminals labeled **HI (V Ω)**and **LO**, select the resistance measurement function by pushing the **[Ω]** button (one of the function keys) on the front panel as shown below in Figure 3. Please notice that the selection keys are annotated in black and blue. To select the function in blue, please press the blue **SHIFT** key.

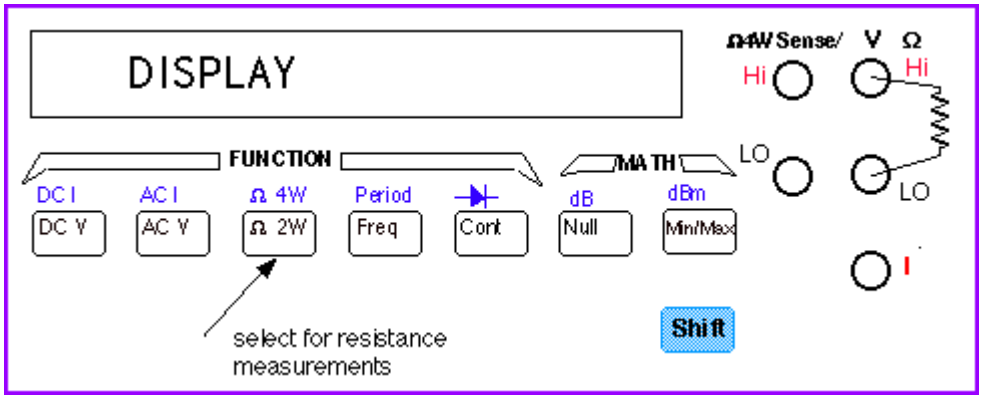


Figure 3: Function buttons to select resistance, voltage, current or frequency

Measurement errors and Null function.

If using DMM to measuring the small value of resistor with cables, the resistance of cables may even larger than small resistor. The HP34401A DMM can overcome this problem by using the Null feature. The front panel of the DMM (see Figure 3) has a 'Null' button. To null the wire resistance, short the ends of the test wire and then press the 'Null' button. You can disable the Null function by pushing the button again.

CAUTION: To test resistance, the **safest way is disconnect all voltage sources** before connecting the DMM to the circuit. A large voltage input terminals of the DMM may **damage the meter**.

Range selector

The multimeter automatically selects the range using the auto-ranging feature. However, you can

also manually select a fixed range (e.g. 1KΩ or 1MΩ) using the **Auto/Man** button on the front panel (under Range/Digits) buttons (Figure 4). The 'down' arrow selects the lower range and the 'up' arrow the higher range.

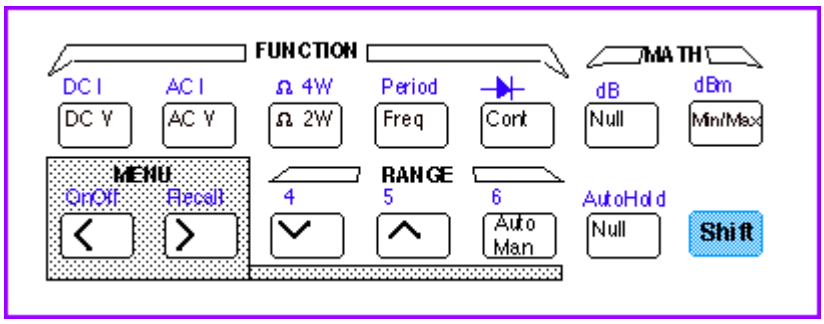


Figure 4: Function, Math, Range, and Menu keys

Additional features of the HP34401A: average, max and min value

To find the average value, maximum and minimum values of variable test points, HP34401A has built-in features. To enable this feature, push the **Min/Max** button (one of the Math buttons) on the front panel. The *Math* annunciator will lit on, and DMM will make short beeps indicating it is taking readings and storing the MAX, MIN, Average value, and the total COUNT. Push the **Min/Max** button again to stop the readings.

To access these stored numbers, just turn the Menu on by pressing the **On/Off** key (SHIFT <) on the front panel (see Figure 4). Then, use the > or < keys until you are in the MATH (B) menu. You can now *go down* to the "parameter level" of the selected MIN-MAX menu by pressing the "down" button until you see the desired parameter menu (1:MIN_MAX) displayed. Press "down" button again, you are in the MIN-MAX menu. Please use the > or < buttons to scroll through the menu and read the values. The menu is organized in three levels, as Fig. 5.

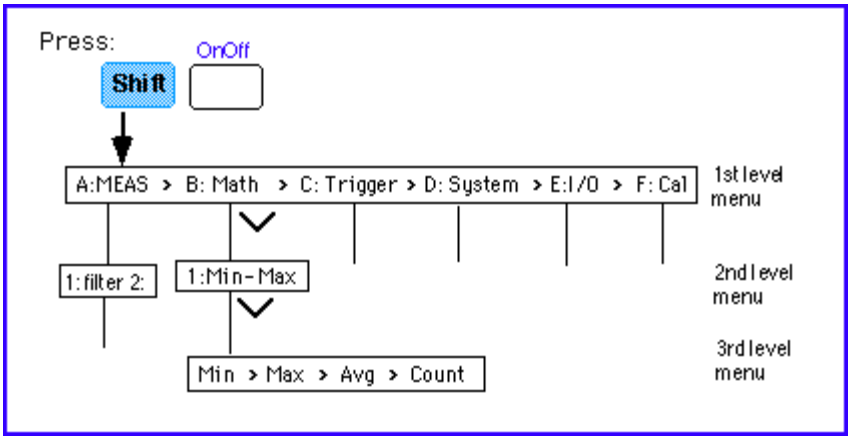
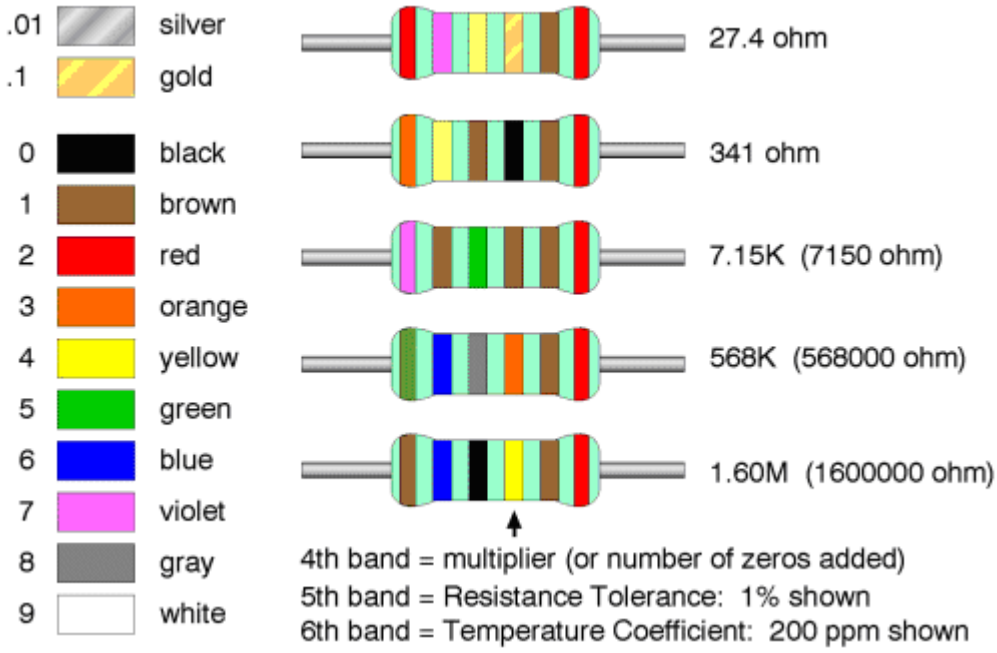


Figure 5: The front panel menu organization.

The MIN-MAX feature can be used for resistance measurements as well as for voltage, current, and frequency measurements.

The resistance color code and power rating

Resistors are usually color coded using color banding as shown in Figure 6. Two digits and a power 10 multiplier determine the resistance value. The color band on the most left is the 1st significant digit, followed by the 2nd digit and the multiplier. The fourth band is usually present as well and indicates the tolerance of the specified resistance.



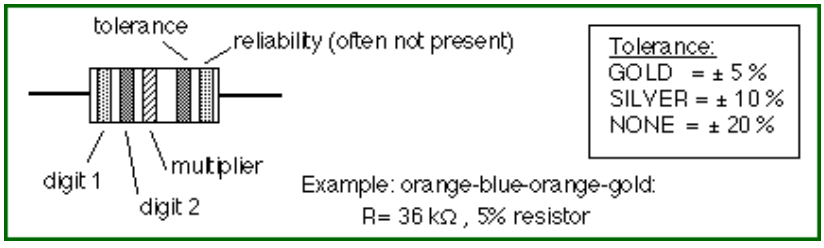


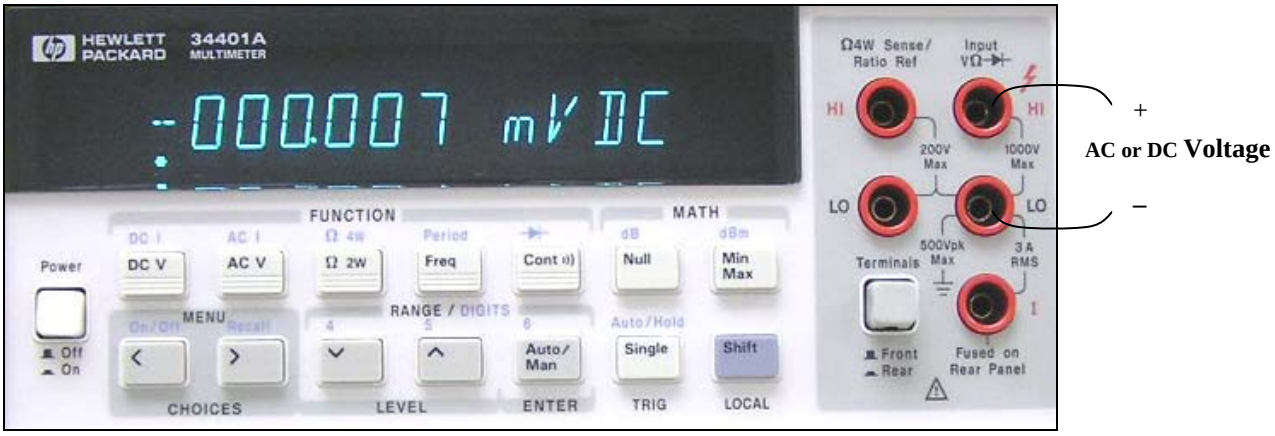
Figure 6: The 5% Resistor Color Code.

Power rating of resistors

In addition to the value and tolerance of a resistor, the power rating is another important characteristic. It tells how much power the resistor can dissipate before being damaged by overheating. Resistors come in different power ratings: 1/8, 1/4, 1/2, 1 and 2 Watts are typical values.

Voltage measurement

Ranges: 100mV, 1V, 10V, 100V, 1000V (750 Vac)
Maximum resolution: 100nV (on 100 mV range)
AC technique: true RMS, ac-coupled



Principle of measurement

A DC voltage is measured by using a voltage amplifier and an analog-to-digital converter as schematically shown in Figure 7. A microprocessor further manipulates the data before displaying the results.

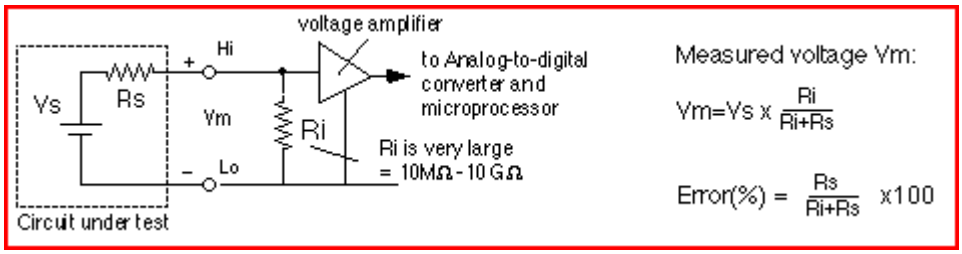


Figure 7: Schematic of the DMM as a DC voltage meter.

To measure a voltage, connect the nodes over which one wants to measure the voltage between the HI and LO input terminals of the DMM (Figure 3). In order to activate the DMM for DC measurements you have to select the DC Voltage function by pushing the **DC V** button on the front panel (see Figure 3). The Math functions, such as Max/Min and average, can be activated in a similar fashion as was done for the resistance measurements. Also, the range can be selected manually by pushing the Man/Auto key in the Range menu.

If you have the probes connected for measuring currents and you try to measure the voltage of low-impedance voltage source (such as power supply), you will blow a fuse in the instrument. ***In order to avoid this, always remember to check the connection of your probes before making voltage measurement.***

Errors due to the internal resistance
An ideal voltmeter has an infinite input resistance so that it will not draw any current from the circuit under testing. However, in reality, there is always a finite input resistance R_i, as shown in Figure 7. As a result, one has a voltage divider that will cause the voltage V_m one sees at the input of the voltmeter to be slightly different from the actual voltage V_S one wants to measure. The HP34401A has a relatively large input resistance of at least 10Mohm (depending on the selected voltage range) so that the error will be small as long as $R_s << R_i$.

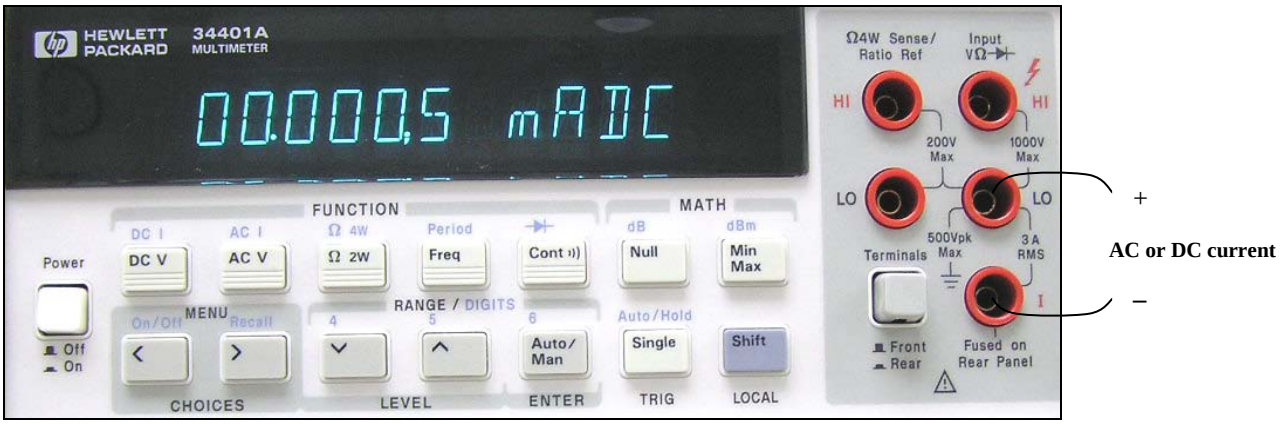
CAUTION: Do not exceed the maximum allowable voltage input (1000V DC). Also, never apply a voltage over the current input terminal (I) of the DMM.

Current measurement

To Measure Current

Never connect across any component or supply!

Range: 10 mA (DC only), 100 mA(DC only), 1A, 3A
Maximum resolution: 10 n**A (*on 10mA range*)**
AC technique: true RMS, AC-coupled



Principle of the measurement

An ammeter senses the current flowing through its input terminals. The ammeter (or DMM) must be connected in ***series*** with the circuit such the same current flows through the DMM and the test circuit. The principle of the current measurement is quite simple. The ammeter has a small resistance at its input terminals and *measures the voltage* that the test current generates over this resistance (Figure 8).

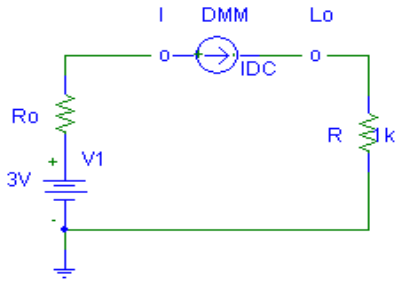


Figure 8: Principle of DC current measurement.

To use the DMM as an ammeter, one connects the leads in which the current flows to the *current* (**I**) and Lo terminals (see the front panel in Figure 3). To activate the ammeter, one must also select the DC I key by pushing SHIFT and DC V button as shown in Figures 3 or 4.

Error due to the non-zero input resistance

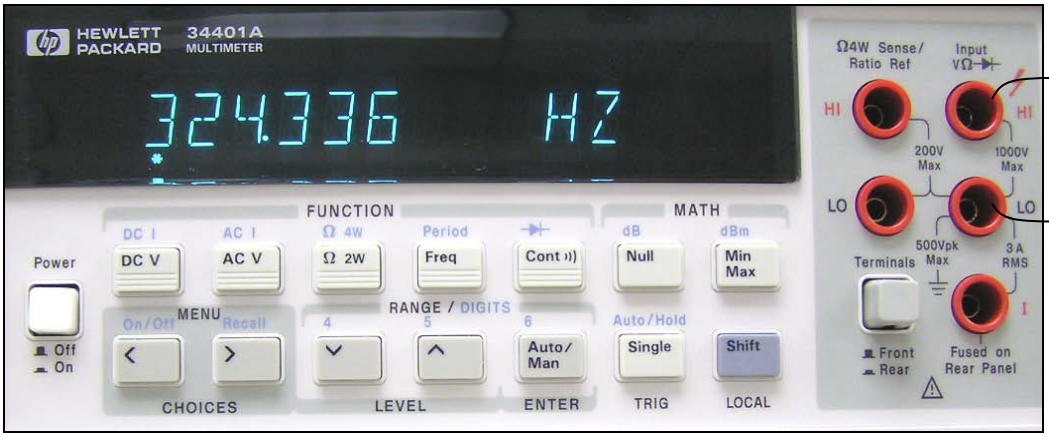
An ideal ammeter has a zero input resistance so that it does not disturb the current under test. The small input resistance will cause a small voltage drop which gives a small error. Fortunately, the input resistance of the HP34401A is pretty small (Ro = 0.1Ω for 1 and 3 A range, and 5 Ω for the 10mA and 100mA ranges) and can, in most cases, be ignored as long as R >> Ro.

CAUTION: Do not exceed the maximum allowable current input (3A DC). Also, never apply a voltage over the current input terminal **(I)** of the DMM. This will cause a large current to flow through the small input resistor Ro and can damage the DMM.

Frequency measurement

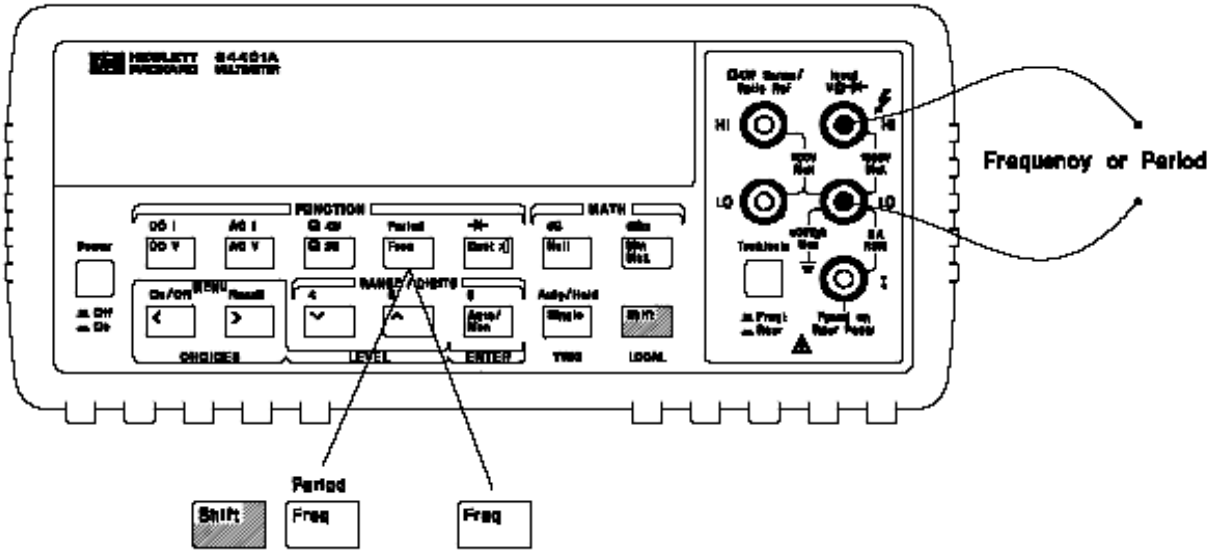
To Measure Frequency (or Period)

Measurement band: 3 Hz to 300 KHz (0.33 sec to 3.3μsec)
Input signal range: 100 mVac to 750 Vac
Technique: Rrecip



To Measure Frequency (or Period)

Measurement band: 3 Hz to 300 kHz (0.33 sec to 3.3 µsec)
Input signal range: 100 mVac to 750 Vac
Technique: reciprocal counting



Specifications **(HP 34401A)**

DC Characteristics:

- DC Voltage range and input resistance:

  0.1V, 1V, 10V: input resistance selectable 10MΩ or > 10GΩ

  100V and 1000V: Rin = 10MΩ

- DC Current range and shunt resistance:

  10mA, 100mA: Rshunt= 5 Ω

  1A and 3A: 0.1 Ω

- Resistance range: 2-wire and 4-wire method

  - 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ and 100 MΩ
  - Input protection: 1000V

- AC Characteristics: true RMS

  AC Voltage: from 3 Hz to 300 kHz (for accuracy specs consult the manual)

  AC Current from 3 Hz to 5 kHz

Frequency and Period measurement:

Frequency range: 3 Hz - 300 kHz

Input voltage range: 100 mV to 750 V

2. Programmable Power Supply-HP E3631A

Quick Start

Do not connect to your circuit yet!
Turn the unit On. The unit will self test and show you Addr)%, then will go to the default setting: 6 V DC (max). The unit is ready to operate. Power will be accessible from the 6 V outlet, (+ -); voltage can be adjusted by moving the blinking digits with the arrows (→ ←)and turning wheel from the from panel. Once the output voltage is adjusted, turn the power OFF, inspect your circuit for any mistakes; then proceed to turn the output voltage ON.

NOTE: Turn the Output voltage OFF before you make any changes on your circuit board.

For higher voltage, use the ± 25 V (max) terminals. Sert the 25 + voltage first by pressing the +25V from the front panel, turn the output voltage On , then, turn the adjusting knob to the desired voltage. After reaching the desired voltage, turn the output voltage Off.
For the -25V (max), press the -25 V key from the from panel, turn the voltage On, them turn the adjusting knob to the desired voltage. Then turn the voltage output Off.
Now, you are set to connect power to your circuit board.
Before turning On the output voltage, re-check your circuit for any problem; after that, turn your OUTPUT VOLTAGE ON.
Make any measurements necessary, after finishing, PLEASE TURN THE UNIT OFF.

NOTE: If any problem occurs while working in your circuit, turn the output voltage Off, re-check your circuit (more carefully), fixed if any problem and then re-connect the power ON.
Also, make sure the supply is set for enough current your circuit.
See below for more details.

Introduction

Hewlett-Packard E3631A triple output power supply It is a 80-watt triple output supply and offers three independent 0 to +6V/5A and 0 to +/-25V/1A outputs. The 6V output is electrically isolated from the +/-25V supply to minimize any interference between circuits under tests. +/-25V outputs can be set to track each other. E3631A is dependable regulation and fast transient response with built-in GPIB and RS-232 interface.

Basics of Power Supplies

A regulated power supply provides electrical energy which is precisely controlled. Power supplies can be of the type *Constant-Voltage*, *Constant-Current*, and the *Constant-Voltage /Constant-Current* sources. A Constant-Voltage (CV) supply provides a DC voltage that can be set to any desired value over a specified range. An ideal constant-voltage supply has a zero output impedance, as illustrated in Figure 1a. On the other hand, a constant-current (CC) supply gives a regulated current independent of the voltage over the load (up to the maximum allowable voltage), as shown in Figure 1b.

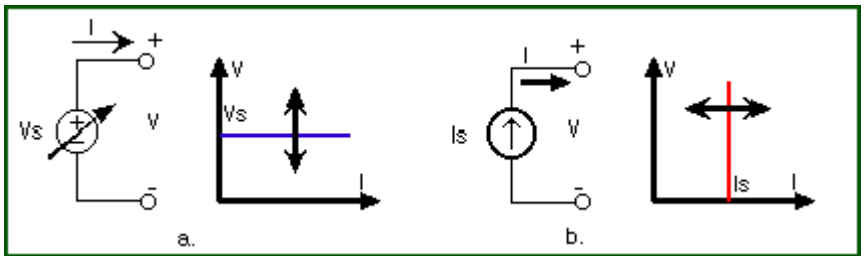


Figure 1: Output characteristic of a constant-voltage (a) and constant-current (b) supply.

A more versatile power supply is the *Constant-Voltage/Constant-Current* supply which can be used to provide either a constant voltage or a constant current. Figure 2 illustrates the I-V characteristic of such a supply. The values V_s and I_s are selected by the operator from the front panel or programmed through the GPIB interface.

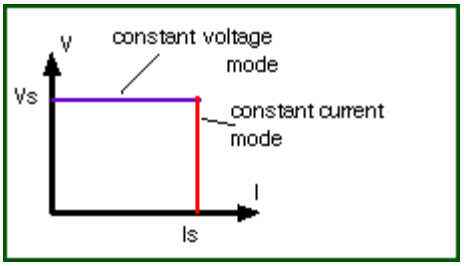


Figure 2: Output characteristic of a constant-voltage/ constant-current supply.

Let's look at the operating modes of CV/CC power supply. Assume that one connects a resistive load to the power supply as shown in Figure 3. The supply has been set at a voltage $V=V_s$ and current $I=I_s$. The current through the resistor: I=V/R. As long as the current is below the maximum value I_s, the voltage over the resistor will be constant and equal to V_s. The power

supply operates thus in the *CV mode* as shown in Figure 3. However, if one decreases the resistance such that the current exceeds the maximum allowable value I_s, the current will be limited to I_s and the power supply operates in the *CC mode*. The resistance $R_c=V_s/I_s$ is called the critical resistance and determines whether one operates in the CV ($R_L>R_c$) or CC ($R_L>R_c$) mode.

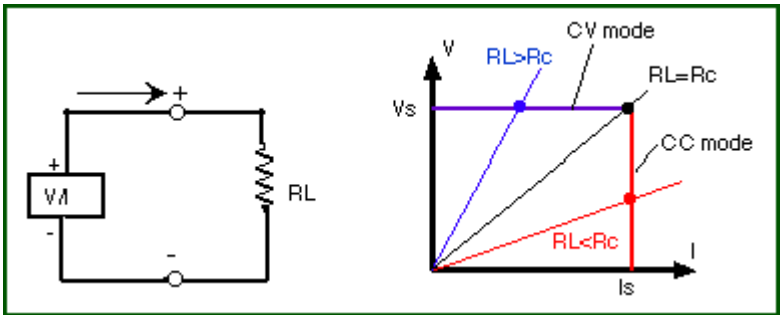


Figure 3: Operating point of a CV/CC power supply.

HP E3631A Triple Output DC Power Supply

The HP E3631A is a *constant-voltage/constant-current* type and can be adjusted to various range controls of the power supply on both positive and negative voltages.

Figure 4 shows the front panel of the HP E3631A. Italicized print indicates the switch functions. The shaded switches control more advanced features built into the equipment and will not in this write-up.

Figure 4: Front panel of the HP E3631A triple output power supply.

The power supply has a triple output: +6V/5A, +25V/1A and -25V/1A supplies. These outputs (binding posts) are located at the bottom right of the front panel (see Figure 4). In addition, the

power supply has an earth ground terminal (with ⊥ sign) which is connected between chassis and earth ground by 3-wire ground receptacle. This is for safety considerations.

A Simplified View of a Power Supply

Let's look at the power supply in the constant-voltage (CV) mode. A CV power supply can be considered to be a "near-ideal" battery with a very low internal resistance. Its voltage will remain constant if its current rating is not exceeded. Figure 5 illustrates this view of the power supply. The +25V and -25V outputs have a common output terminal (denoted by "com") which is isolated from the case or chassis ground. The positive or negative terminals of each output can be grounded or each output can be left floating with respect to the ground (must be kept within +/- 240V from the chassis ground).

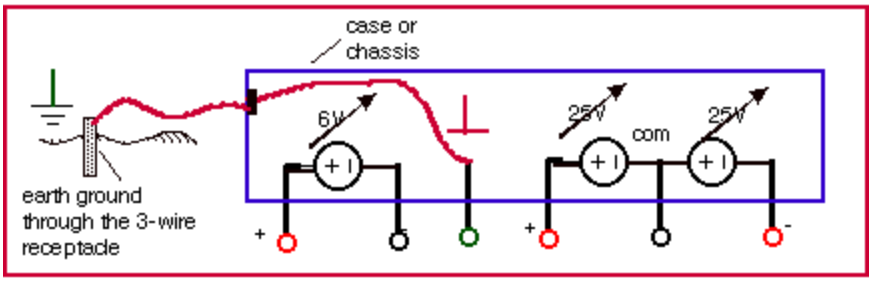


Figure 5: Simplified view of the triple output power supply

Figure 6 shows the case where one uses the +25V, -25V and -6V power supplies in one circuit. All supplies have a common connection (the reference node) which can or cannot be connected to the ground. (For most circuits, our reference node is grouded).

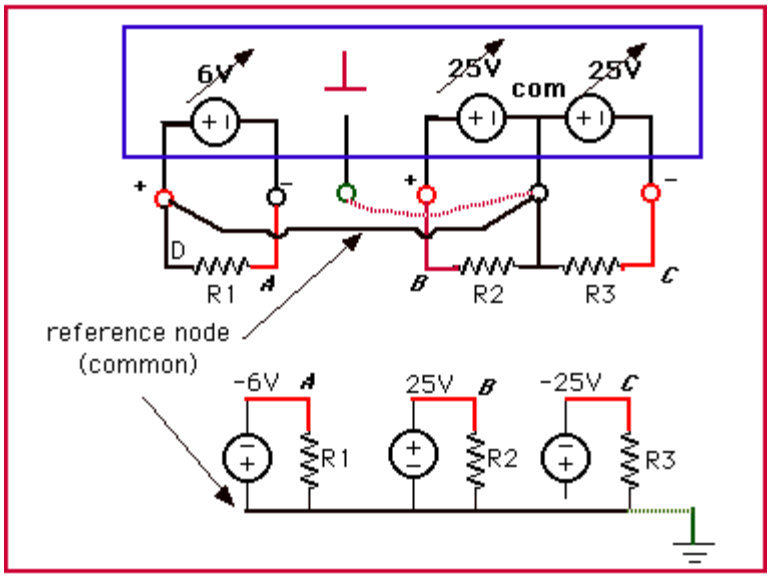


Figure 6: Power supply connection using the three power supplies; the top figure shows the actual connection and the bottom one gives the circuit schematic.

Constant Voltage(CV) Operation

1. Turn the power supply on. Output of power supply is disabled as default. 'OFF' annunciator is on.
2. Enable the outputs by pressing the **Output On/OFF** key (see Figure 7) The CV and +6V annunciators is on and +6V is selected. You can adjust the *blinking* digit to select the desired output voltage by turning the knob on the top right of the front panel. The display is in the *meter* mode, and shows the *actual* output voltage and current.
3. To set up the +25 V power supply, press the **+25V** key to select the display and adjust the +25V supply voltage, same way to adjust -25V supply.

To Set Limit Mode:

The next step is to select the maximum current (limit I). Setting the current limit will ensure that the supply can provide enough current and does not go into the constant current mode. It will protect your circuit from drawing too much current and from being damaged.

1. Set the display for *limit* mode by pressing the **Display Limit** key. 'LMT' annunciator is blinking. The display shows the actual voltage and current *limit* values of the selected supply.
2. Connect the desired circuit to the power supply's output terminals.
3. Press the **Vol/Cur** key. The second digit of the ammeter will be blinking. Adjust the knob to set the desired current limit (make sure the 'LMT' annunciator is still blinking). Using '>' or '<' buttons to switch to another digit.
4. When you press the **Vol/Cur** key again the voltage digit will be blinking. You can now adjust the voltage output.
5. Return to the *meter* mode by pressing '**Display Limit' key** or let the display time-out and back to the *meter* mode automatically.

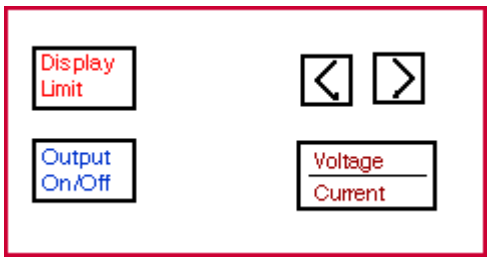


Figure 7: Front panel selections

NOTE: to check that you are operating in the *constant voltage* mode for the +25V or -25V supplies make sure the +25V or -25V annunciator is on. For the +6V supply, the +6V and CV annunciators will be on. If the CC annunciator is on, choose a higher current limit.

Constant Current (CC) Operation

The power supply can be used as a current source.

1. Turn on the power supply. The power supply's outputs is disabled (The annunciator of 'OFF' is on) as default.
2. Enable the outputs by pressing the **Output On/OFF** key (see Figure 8) The CV and +6V annunciators is on, +6V is selected. The display is in the *meter* mode and shows the actual output voltage and current.
3. To set up the +25 V power supply, press the **+25V** key to select the display and adjust the +25V supply voltage by knob, same way to adjust -25V supply.
4. Turn off output by pressing '**Output On/OFF'** key.
5. Connect the desired circuit to the power supply output terminals.
6. Turn on output by pressing '**Output On/OFF'** key.

To Set Limit Mode :

1. Set the display for *limit* mode by pressing the **Display Limit** key. You will notice the LMT annunciator blinking to indicate that the display is in the *limit* mode. The display shows the actual voltage and current limit values of the selected supply.
2. You will notice that the second digit of the voltmeter is blinking. Turn the large knob to set the desired voltage *limit* (make sure the LMT annunciator is still blinking).
3. Press the **Vol/Cur** key. The second digit of the ammeter will be blinking. Adjust the desired output current that the current source will supply.
4. To return to the *meter* mode press the **Display Limit** or let the display time-out, it will automatically back to *meter* mode. The LMT annunciator will be off.

NOTE: To verify that you are operating in the *constant current* mode make sure the +6V and CC annunciator is on if you are using +6V supply, the +25V or -25V annunciator is on if using +25V or -25V supply. If the CV annunciator is on, choose a higher voltage limit.

Disabling the Outputs

Sometimes you need to disable the voltage or current outputs. This can be done without turn off the power supply so that you do not lose the settings. To disable the outputs, press the **Output On/OFF** key. The **OFF** annunciator will go on. To enable the outputs, press **Output On/OFF** again.

Other features.

The HP E3631A has several other useful features. They include tracking operation (the +25 and -25V outputs track each other); storing and recalling operating states (up to 3 different settings can be stored); system related controls, and remote interface configuration (GPIB and RS-232).

Performance Specifications

Output Ratings (@ 0°C - 40°C)

+6V Output	0 to +6 V ; 0 to 5 A
+25V Output	0 to +25 V ; 0 to 1 A
-25V Output	0 to -25 V ; 0 to 1 A

Programming Accuracy[1] 12 months (@ 25°C ± 5°C), ±(% of output + offset)

	+6V Output	+25V Output	-25V Output
Voltage	0.1% + 5 mV	0.05% + 20 mV	0.05% + 20 mV
Current	0.2% + 10 mA	0.15% + 4 mA	0.15% + 4 mA

Readback Accuracy[1] 12 months (over GPIB and RS-232 or front panel with respect to actual output @ 25°C ± 5°C), ±(% of output + offset)

	+6V Output	+25V Output	-25V Output
Voltage	0.1% + 5 mV	0.05% + 10 mV	0.05% + 10 mV
Current	0.2% + 10 mA	0.15% + 4 mA	0.15% + 4 mA

Ripple and Noise (with outputs ungrounded, or with either output terminal grounded, 20 Hz to 20 MHz)

	+6V Output	+25V Output	-25V Output
Voltage	<0.35 mV rms	<0.35 mV rms	<0.35 mV rms
	<2 mV p-p	<2 mV p-p	<2 mV p-p
Current	<2 mA rms	<500 μA rms	<500 μA rms
Common mode current	<1.5 μA rms		

Load Regulation, ±(% of output + offset)

Change in output voltage or current for any load change within ratings

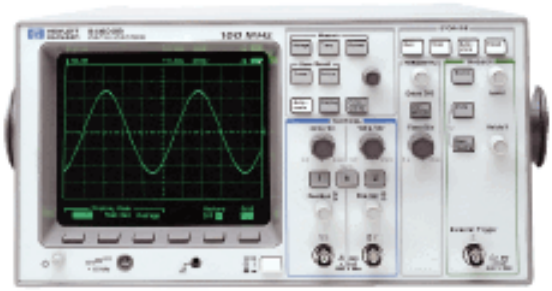
Voltage	<0.01% + 2 mV
Current	<0.01% + 250 μA

Line Regulation, ±(% of output + offset)

Change in output voltage and current for any line change within ratings

Voltage	<0.01% + 2 mV
Current	<0.01% + 250 μA

3. Digital 2 Channel 100 MHz Osciloscope-HP54600B



QUICK START

Turn ON the unit, after the self test, this unit will display Normal Screen.

NOTE: Before any reading is made, press the SET-UP key, all the soft keys under the screen are displayed now.

Press the default set-up key, then save the setting by pressing the save key from the soft key panel under the screen.

Now you are ready to use this unit!

When the unit is connected to any Source, (or your circuit) or from the OUTPUT of the Function Generator, it will display your signal at the scope. Pressing the auto range key, you will have a better look of the signal at the scope

To measure the Amplitude of the signal:

Press the Voltage key from the from panel of the scope; all the soft keys under the scope screen will change to:

Source(1 & 2), V_{p-p} , V_{avg} , V_{rms} are now available. By pressing any of these keys, the unit will show them. Clear them (any measure you did) by pressing the Clear_Meas key; then the unit is ready for new set of measurements instructions.

If any adjustment in the circuit is needed, turn off the power source, make the required change, restart the power supply, and press the auto-scale key for a new set of measurements.

To Measure Frequency:

Press the Time Key, you are now in time domain mode, all the soft keys under the screen will change to Source (1 & 2), frequency, Period, Duty Cycle. All these measurements can be made by pressing the key for the desired task. If new measures are needed, adjust the circuit (if necessary), press auto scale key, and continue with your measurements.

Note: Change the source for the proper reading of your input (Channel 1 or Channel 2).

Other measurements possible with the scope are Voltage (eg, rms) or Time (T_1 and T_2) can be made by pressing the Cursor key and take the cursor to the desired type of measure (horizontal or vertical value).

Accordingly with the Mode selected at the moment of this operation, you will be able to check ($Voltage_{pp}$) if in Voltage Mode by moving the cursor knob for up or down. If in Time Mode, T_1 and T_2 can be measured by moving the left or right knob for T_1 or T_2 values.

Note: After using these units, be sure "ALL of these units are turned OFF" before you leave the lab.

Before attempting to operate this unit as Spectrum Analyzer see your Lab Instructor for HELP !

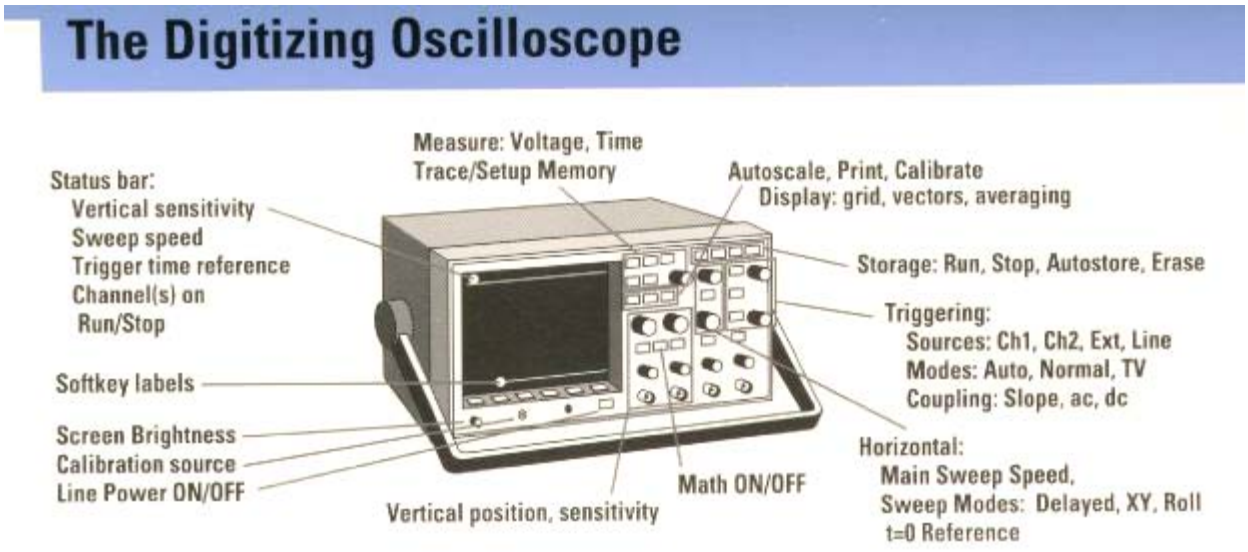
See below for more details.

Features

- 100 MHz bandwidth
- 2 Channels
- Sweep speeds from 5 s/div to 2 ns/div
- Up to 1.5 Million points/sec screen update rate

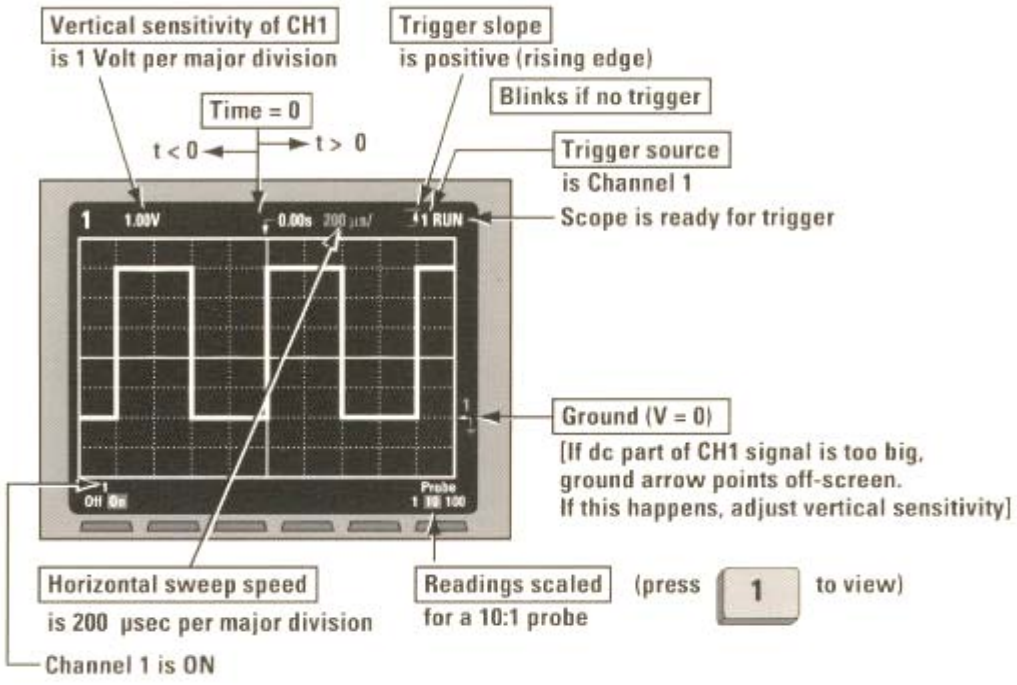
Getting Familiar with the Scope

Front Panel Controls



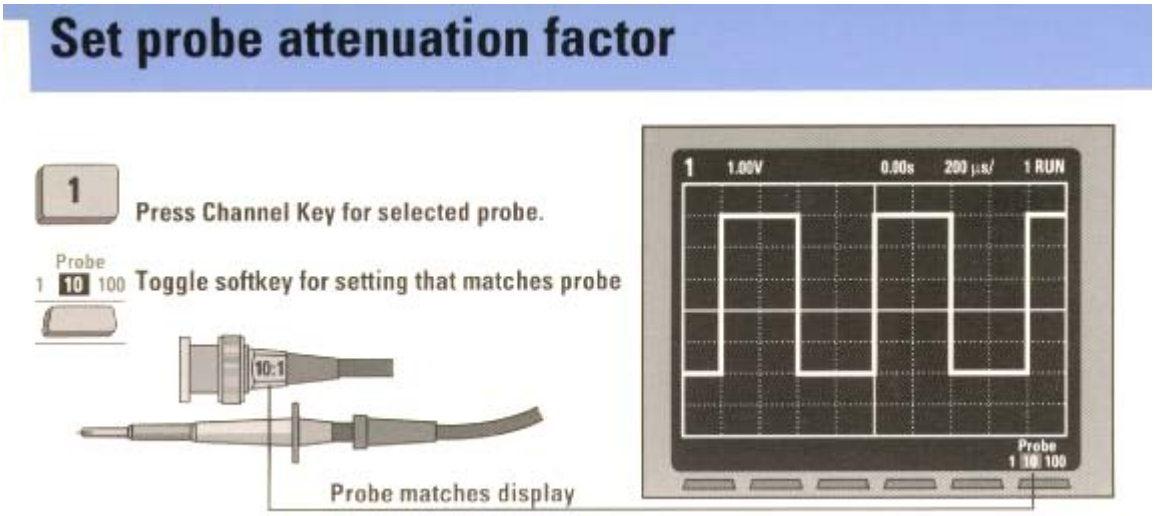
Display Features

What the display says:



Helpful Tips

- The BNC shield is at earth ground. Use only the probe TIP for measuring high voltages. Connecting the BNC shield to a high voltage will cause a safety hazard.
- Make sure probes are compensated and set to proper scale (X1, X10, X100).
- If you can't get the signal on screen:
  - -Check probe connection
  - -Touch: SETUP, Default Setup
  - -Touch: AUTOSCALE
  - -Check for offset (ground symbol). If offscale, adjust vertical sensitivity
  - If still offscale, touch:
  - -Trigger Source
  - -Set Mode Auto



List of Procedures

The procedures used in the processes of making measurements with the HP 54645A oscilloscope in the various labs are listed in this section for easy referencing.

Adjusting the Oscilloscope Display

- Press Autoscale

OR

- Press Display followed by the **Full** softkey
- Press 1 and press the leftmost softkey until ***On*** is highlighted
- Position the signal on the display using the position knob
- Adjust Time/Div until at least 2 periods are displayed
- Change the vertical sensitivity with the **Volts/Div** knob until the waveform fills the
- display without clipping
- Press 2 and press the leftmost softkey until ***On*** is highlighted and repeat previous
- Steps

Vp-p

1. Hook calibrator signal to CH1
2. Press Display key
3. Press **Voltage** Key

4. Press soft key **Vp-p** 

5. Vp-p value will move toward to the bottom left on the screen.

Vrms

1. Hook calibrator signal to CH1
2. Press 

key
3. Press **Voltage** Key
4. Press soft key **Vrms** 

5. Vrms value will move toward to the bottom midle on the screen.

Frequency

1. Press 

key
2. Press **Time** Key
3. Press **Frequency** soft key
4. Frequency value will move toward to the bottom left on the screen.

Period

1. Press 

key
2. Press **Time** Key
3. Press **Period** soft key
4. Period value will move toward to the bottom on the screen.

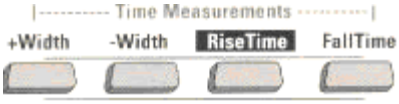
RiseTime

1. Press 

key
2. Press 

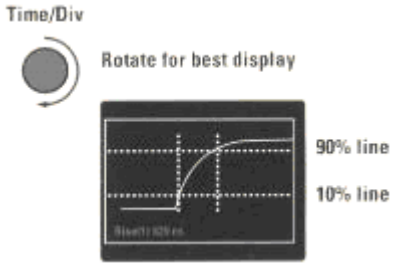
Key
3. Press 

soft key

4. Press soft key RiseTime 

5. RiseTime value will move toward to the bottom on the screen.

6. If answer needs more resolution, rotate for best display:



Offset

1. Press ' ±' key
2. Press soft key **Menu**
3. Press Soft key **Offset**
4. Use the **Cursor** knob to adjust

Selecting the Trigger Source

1. Press Source
2. Press the softkey corresponding to the desired source

Setting the Trigger Mode

1. Press Mode Coupling
2. Press the softkey corresponding to the desired mode

Averaging

To turn averaging on:

1. Press Display
2. Press the **Average** softkey
3. Press the # **Average** softkey until the desired number of averages is selected.

To turn averaging off:

1. Press Display
2. Press the **Normal** softkey

Measuring Signal Amplitudes

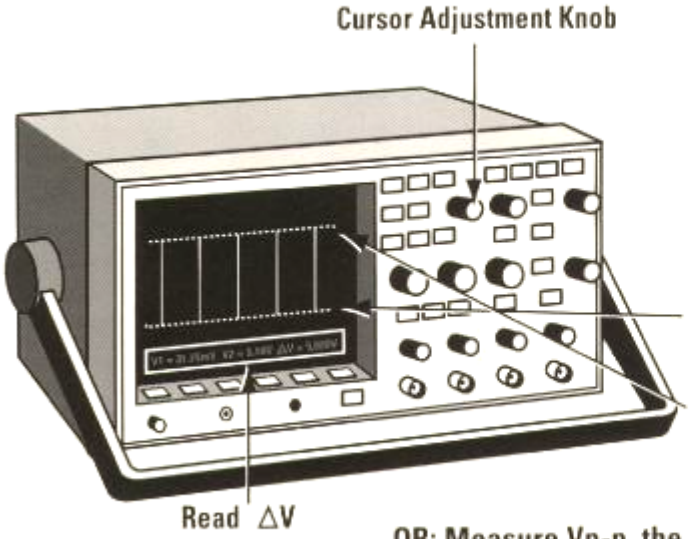
1. Press Voltage
2. Press the **Clear Meas** softkey to clear the last measurement
3. Press the **Source** softkey until channel 1 is selected
4. Press the **Next Menu** softkey until the $\mathbf{V_{AMP}}$ softkey is displayed
5. Press the $\mathbf{V_{AMP}}$ softkey to display the amplitude of the waveform
6. Repeat for channel 2 (Don't clear the last measurement)

Measuring the Phase Shift between Channels

1. Press TIME
2. Press the **Next Menu** softkey until the **Define Thresholds** softkey is displayed on the far left side of the screen
3. Press the **Measure Phase** softkey

Taking Measurements (Examples)

Making Measurements: Vp-p



Measure Vp-p, using cursors:

1) Hook Calibrator signal to CH1

2) Display → Grid: None

3) Clear any cursors already on the screen: Cursors → Clear Cursors

4) Source: 1 2 — Set for the correct channel

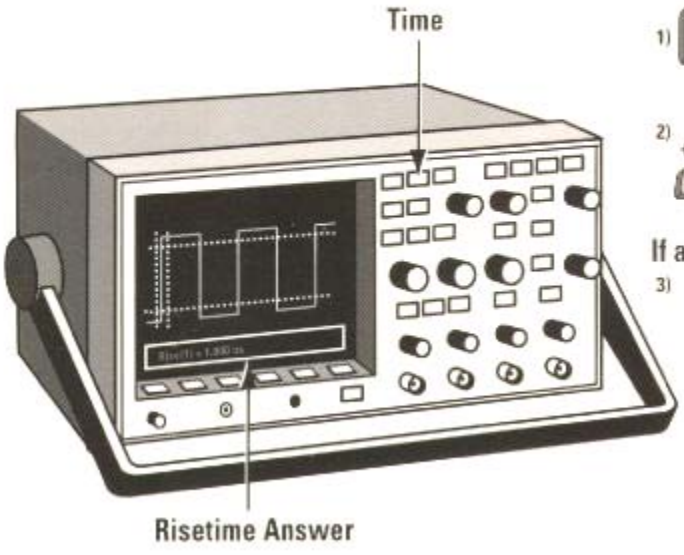
5) Toggle to highlight the V1 cursor; Rotate cursor knob for waveform minimum: |--- Active Cursor ----| V1 V2 T1 T2

6) |--- Active Cursor ----| V1 V2 T1 T2 — Change to V2 cursor; Use knob to set to waveform maximum

OR: Measure Vp-p, the easy way:

Simply select Vp-p from the Voltage menu: Display → |--- Voltage Measurements ----| Vp-p Vavg Vrms

Making Measurements: RISETIME

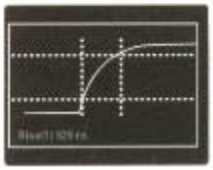


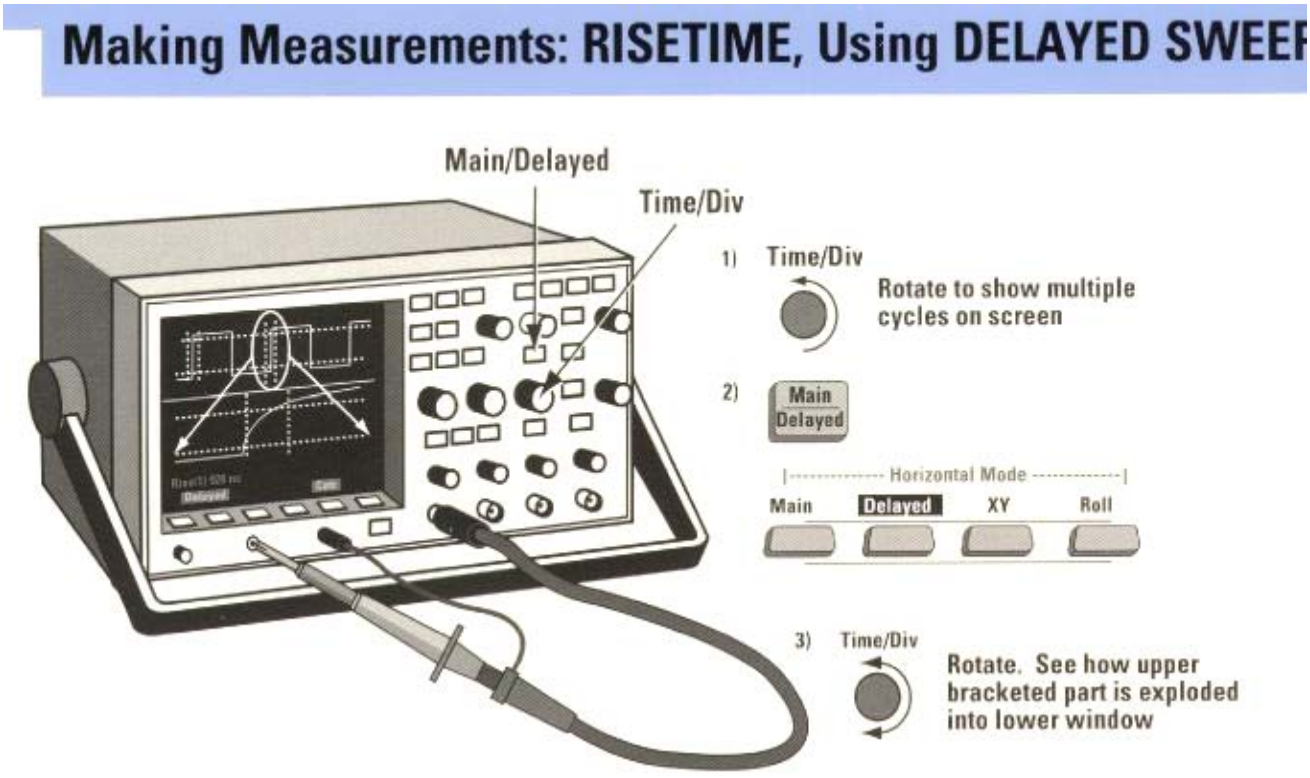
1) Time → Next Menu

2) |---------- Time Measurements ----------| +Width -Width RiseTime FallTime

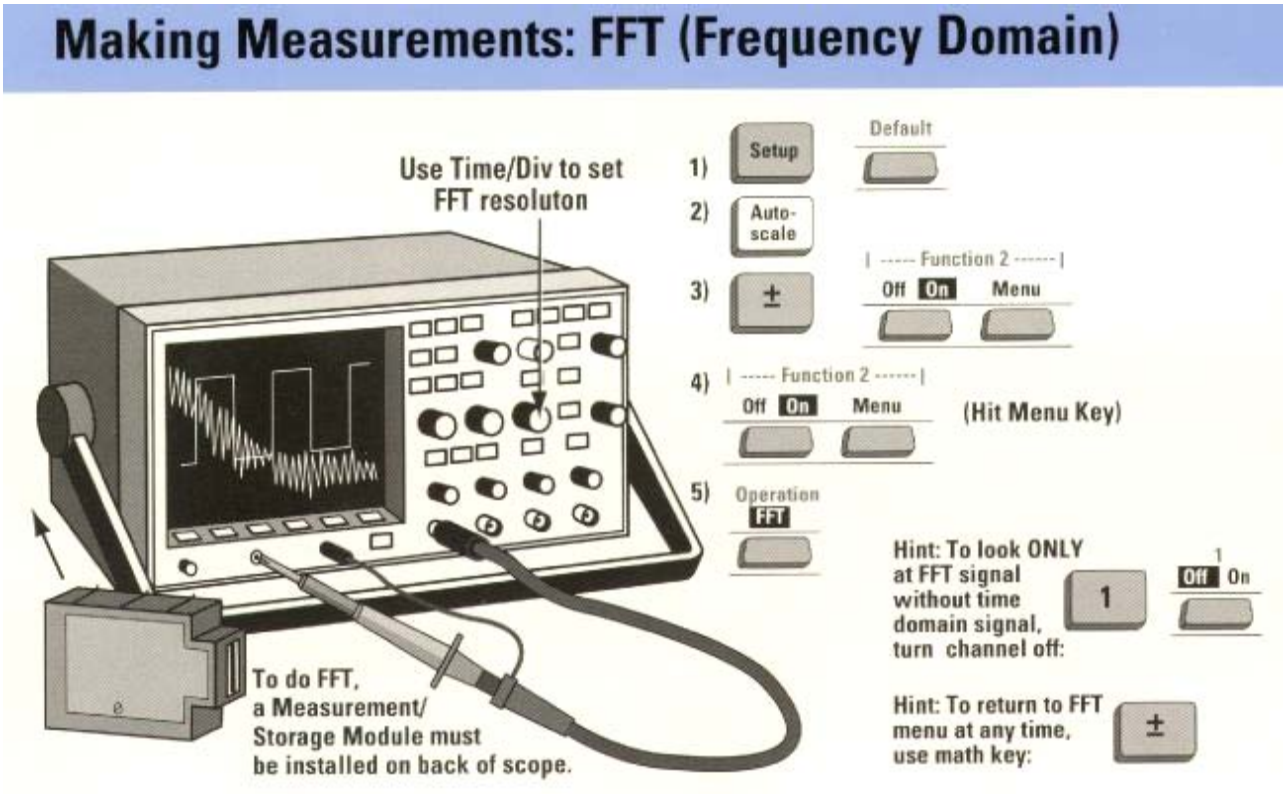
If answer needs more resolution:

3) Time/Div — Rotate for best display

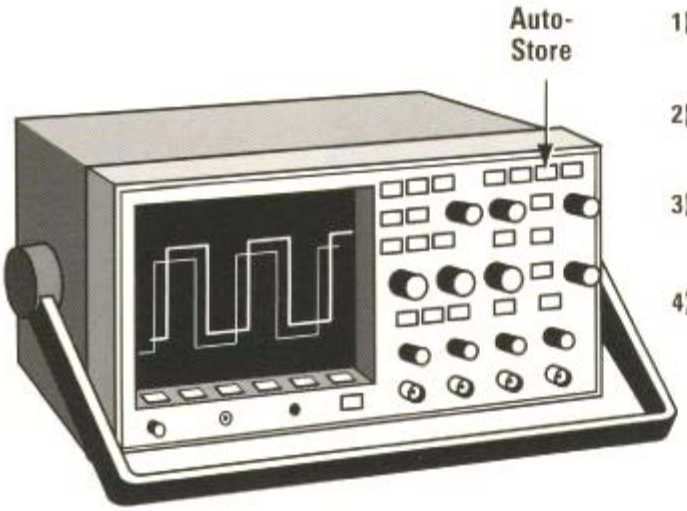



Making Measurements: RISETIME, Using DELAYED SWEEP
Main/Delayed
Time/Div
1) Time/Div
Rotate to show multiple cycles on screen
2) Main Delayed
Horizontal Mode
Main
Delayed
XY
Roll
3) Time/Div
Rotate. See how upper bracketed part is exploded into lower window

FFT


Making Measurements: FFT (Frequency Domain)
Use Time/Div to set FFT resoluton
1) Setup
Default
2) Auto-scale
3) ±
Function 2
Off On Menu
4) Function 2
Off On Menu
(Hit Menu Key)
5) Operation FFT
Hint: To look ONLY at FFT signal without time domain signal, turn channel off:
1
Off On
Hint: To return to FFT menu at any time, use math key:
±
To do FFT, a Measurement/ Storage Module must be installed on back of scope.

Storing Waveforms: AUTOSTORE:



1) [Auto-Store] Displays all waveforms (Good for looking at jitter, noise, glitches)

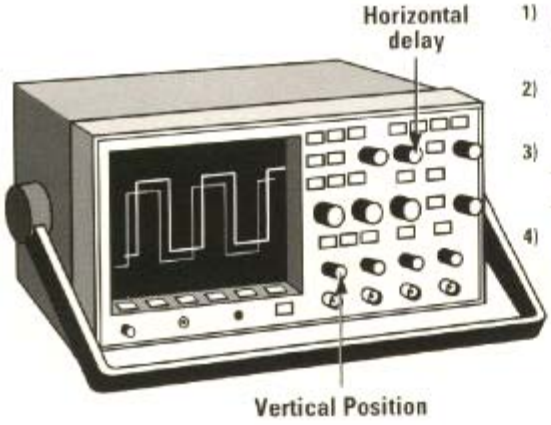
2) Example: Calibrator signal in CH1. Setup Default. Autoscale. Touch Autostore.

3) Now move horizontal delay knob and watch all waveforms stay on screen, making an overlapping pattern.

4) [Auto-Store] Touching Autostore again returns display to normal mode.

5) [Erase] Erase eliminates the stored image.

Storing Waveforms: TRACE MEMORY



1) Example: Calibrator signal in CH1. Setup Default. Autoscale

2) [Trace] Save to Trace 1

3) Trace 1 Off On

4) Now move waveform with horizontal delay and vertical position knobs. Note that Trace 1 still stays on screen, allowing comparison with stored waveform.

Specifications

HP 54600B Performance Characteristics

Form Factor	Bench top
Bandwidth	100 MHz
Number of Channels	2 ch
Simultaneous Channels	2 ch
Simultaneous Maximum Sampling Rate/Ch	20 MSa/s
One Ch. only max. sampling rate	20 MSa/s
Max. Single Shot bandwidth	2 MHz
Max. Record Length	4000 pt/sec
Min. Vertical Sensitivity	2 mV/div
Maximum Vertical Sensitivity	5 V/div
Rise time	3.5 ns
Number of Bits	8 bits
Input Impedance	1 MΩ
Input Coupling	AC,DC,GND
Maximum Input Voltage	400 Vrms
Main time base - lowest	2 ns/div
Main time base - highest	5 s/div
Time base accuracy	0.01 %
Trigger Source	External, Internal
Trigger Modes	Auto, Single, Trigger
Trigger Sensitivity	3.5 mV
Minimum Glitch Trigger	1 ns
Display Type	CRT Monochrome
Display Size	17.78 cm

4. Function Generator/Arbitrary Wave Generator - HP33120A

QUICK START

Turn ON the unit, it will self test and Addr 10 will come on.

1 KHz at 100 mV_{pp} sinusoidal is the Default for this unit.

The shape of the signal can be changed by pressing the proper key from the front panel of the unit.

To change the frequency: Press the frequency key, then, rotating the knob at the front panel will adjust the frequency from 0.1 Hz to 15 MHz.

To change the magnitude of the signal: Press the Amplitude (Amp) key. Rotate the same knob used to adjust frequency, and select the desired unit (Hz, KHz, MHz), until you reach the desired frequency.

For Signal Modulation Mode (AM, FM, FSK): Press the blue key (+ **AM).** From the scope, rotate the **Time/Division knob** until the signal appears at desired shape. You can stop the scope to have a better view of the modulated signal by pressing stop key from the front panel of the scope. After viewing the signal, press the **Run key**.

To change the amount of modulation; while in modulation mode, press the **(blue key + the Amp (level) key)**. By rotating the adjustment knob will change the % of modulation from 1 to 120 % of modulation.

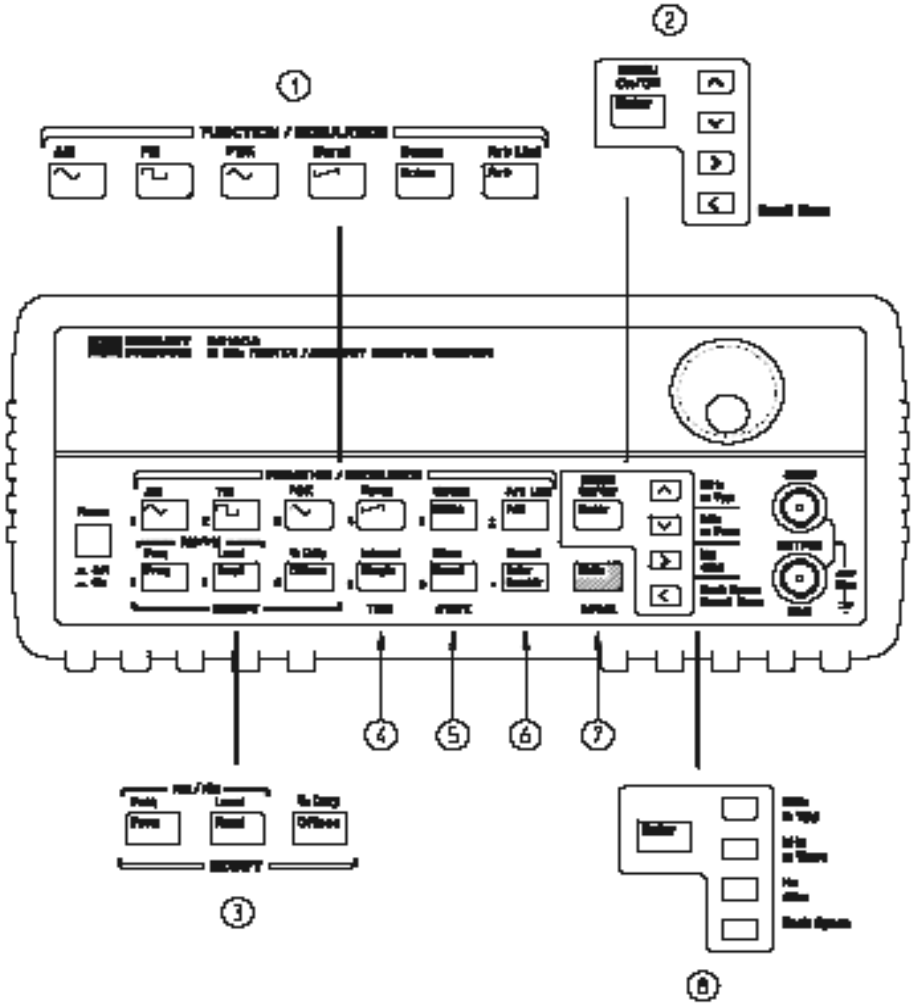
Note: When connecting the generator to the scope, be sure that the correct measurement is read, adjust the Function Generator to High Impedance reading with these steps:

1. **Press Blue Key then Enter**
2. **Press 3 times the ► key**
3. **Press 2 times ▼ key.**
4. **Press 1 time ► key.**
5. **Finally, press the Enter Key**

The unit is now in High Impedance and in Sync with the scope!
Also, remember to press the Auto-Scale at the scope to reset the measurement.

Introduction

The Front Panel at a Glance



1 Function / Modulation keys
2 Menu operation keys
3 Waveform modify keys
4 Single / Internal Trigger key
(Burst and Sweep only)
5 Recall / Store instrument state key
6 Enter Number key
7 Shift / Local key
8 Enter Number "units" keys

A function generator allows you to create a wide variety of synthesized electrical signals and waveforms. Figure 1 shows the most common functions such as the sine, square, triangle and ramp functions.

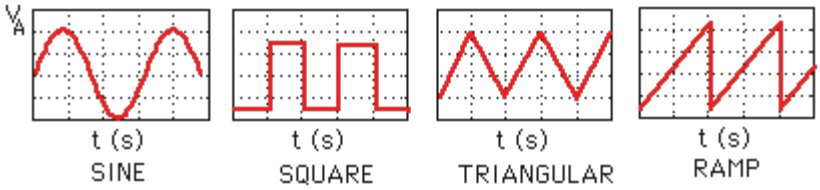


Figure 1: Waveforms generated by a function generator

Each of the waveforms can be adjusted through the front panel controls or remotely for frequency, amplitude and DC offset voltage. For example, a sine function described by the following equation,

$$v(t)=V_A\sin(2*pi*ft) + V_{OFF}$$

in which 'f' is frequency, V_A the amplitude, and V_{OFF} if the offset voltage as shown in Figure 2. Instead of amplitude one often uses the RMS (Root Mean Square) value to express the signal voltage level. For a sine wave the RMS value is the amplitude divided by the square root of 2 or $V_{RMS} = V_A/1.41$. The RMS is the most useful way to specify AC signal amplitudes.

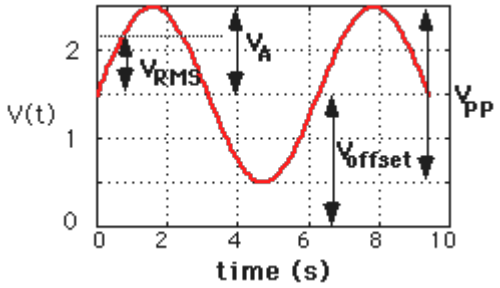


Figure 2: Sine wave with amplitude V_A, frequency f, and offset V_{OFF}

The generator can be remotely programmed and read by computer via a General Purpose Interface Board (GPIB).

Basics of the Function Generator (HP33120A)

The function generator in the ECE lab is based on digital signal processing (DSP) methods. The DSP is able to generate complex and arbitrary functions. A simplified block diagram is shown in Figure 3.

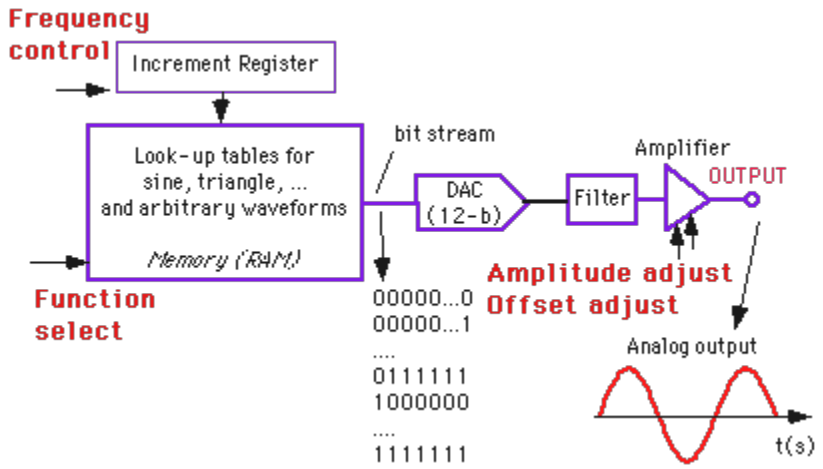


Figure 3: Block diagram of the HP33120A waveform generator.

Any circuit can be represented by the Thevenin's equivalent circuit. This is shown in Figure 4a. V_{gen} represents the waveform (sine, pulse, etc.) and R_T is the Thevenin resistance (= output resistance).

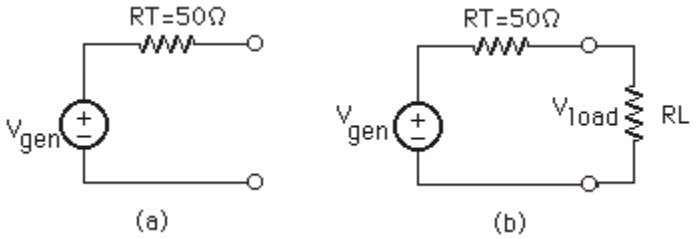


Figure 4: (a) Thevenin's equivalent circuit; (b) voltage divider between the output and load resistors.

Important is that this *output resistance of the function generator is 50 Ohm*. This implies that the actual output voltage one measures over the load will **vary with the load resistance** because of the voltage divider, as shown in Figure 4b. The output amplitude is calibrated for a 50 Ohm load resistance, which means that the voltage shown on the function generator's display panel corresponds to the actual voltage V_{LOAD} over the load only *when the resistance is equal to 50 Ohm*. In other words, the value of V_{gen} is double of the value displayed (or selected) by the function generator. If the function generator's output is measured with no load connected (=open circuit or infinite resistance), the output voltage will be *twice* the displayed amplitude. Thus, be careful when applying the output voltage of the function generator to a circuit which input resistance is different from 50 Ohm.

To get accurate test result, you have to set function generator to high-impedance load (High-Z) mode.

How to set function generator to high-impedance load (High-Z) mode, please refer **II.2.*a.***

Functions and Use of HP 33120A

The front panel of the HP 33120A is shown in Figure 5. There are two outputs on the right of front-panel. One is '**OUTPUT'--** the regular output terminal at which the specified waveform appears. The other output '**SYNC'** is often used as a trigger signal. Both output terminals are of the "BNC" type, which can be connected to a coaxial cable (a shielded cable).

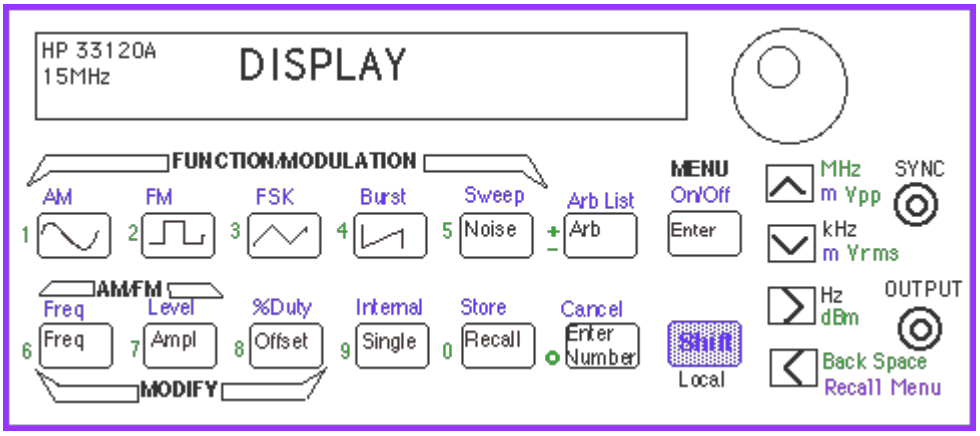


Figure 5: Front panel of the HP 33120A function generator/Waveform generator

a. Front Panel Number Entry

To set the amplitude, frequency and offset voltage of a waveform, just enter numbers. Numbers can be entered in three ways:

1. Use big knob. One of the digits will be blinking on the display. During you turning knob, the blinking number will increase or decrease.
2. Use the arrow keys '<', '>', '^', 'v'.
3. Use the 'Enter Number' mode. Press 'ENTER NUMBER' key, followed by the number (see green number keys on the front panel) and the units, and then press 'ENTER' key(see Figure 6). To cancel the number mode, press 'SHIFT' and 'CANCEL' keys.

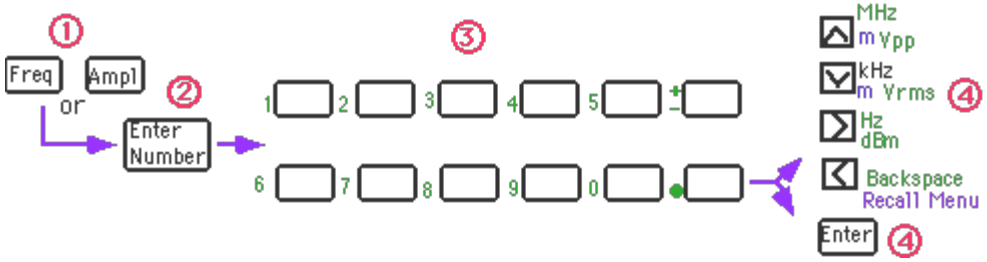


Figure 6: Entering numbers using the "Enter Number" mode.

At power-on the function generator will output a sine wave of 1 KHz and amplitude of 100mV peak-to-peak (for a 50 Ohm load resistance). You can select another function or change the frequency, amplitude and offset voltage by pressing MODIFY keys.

b. Selection of a standard waveform

1. Press the key with the icon of the desired waveform (sine, pulse, triangle, or ramp) as shown in Figure 5. An annunciator will show the selected waveform
2. Arbitrary waveforms can be selected, see details on coming section.
3. Press 'Modify' key to modify the amplitude, frequency (and duty cycle in case of a pulse). See details on coming section

c. Frequency selection

Procedure:

1. Press the 'FREQ' key (Figures 5 and 7).
2. Enter frequency with number key, the frequency annunciator will display.
3. Press one of the arrow keys to set the units (MHz, KHz, HZ).

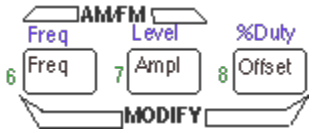


Figure 7: Using the Modify Keys to select the frequency, amplitude, offset or duty cycle

d. Amplitude selection

Select the Amplitude Mode by:

1. Press the AMPL key (Figure 7).
2. Enter the number for the amplitude.
3. Press the arrow keys to select amplitude in (m) V peak-to-peak (VPP), in (m) V RMS or dB.

Notice:

The function generator is calibrated for a 50 Ohm load which implies that the output voltage will be different from the one selected when the load resistance is different from 50 Ohm.

The minimum amplitude is 50 mV_{PP} and the maximum 10 V_{PP} for a 50 Ohm load (and 100mV_{PP} and 20 VPP, respectively, for an open circuit).

e. Offset Voltage selection

The waveforms default offset voltage is 0V, which means that the waveform will vary between a positive and negative value. If you want to offset the waveform, you will need to add an offset voltage as defined in Figure 2. To set the offset voltage:

1. Select the Offset Modify Mode.
2. Enter the number for the offset voltage.
3. Press 'ENTER' key.

f. Duty Cycle selection

This applies to square waves only, and default duty cycle is 50% and can be changed by:

1. Press the key with the square wave icon.
2. Press the 'SHIFT' and '%DUTY' keys (see Figure 7).
3. Enter the number in %.
4. Press the 'ENTER' key.

g. Output of an arbitrary waveform

There are five built-in arbitrary waveforms stored in memory. It includes sinc, exponential rise and fall, negative ramp and a cardiac function (which simulates the heart beat of human), refer Figure 8. In addition, one of five waveforms can be user-defined.

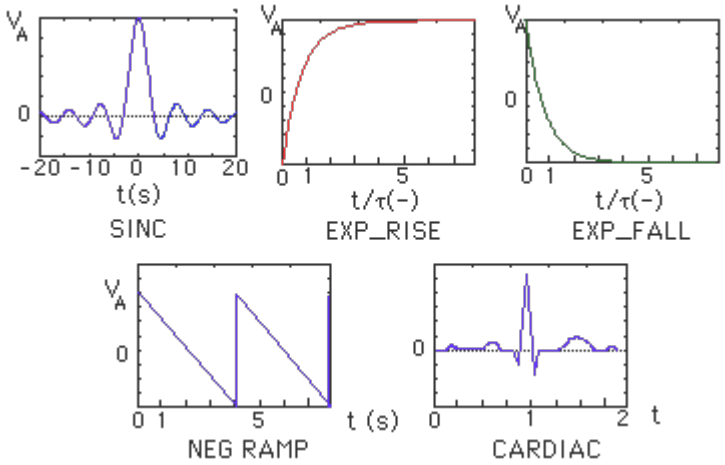


Figure 8: The five built-in arbitrary functions

To see the list of arbitrary functions:

1. Press ‘SHIFT’ key.
2. Press ‘ARB LIST’ key.
3. The first choice displayed is SINC. The display will show SINC for about 10 seconds. Press the ‘**>**’ keys or Round knob to change the functions (EXP-RISE, EXP-FALL, NEG-RAMP, and CARDIAC).
4. When the desired function is displayed press the ‘ENTER’ key.
5. Now, the amplitude, frequency and offset voltage are able to be changed.
6. Once you have selected an arbitrary waveform, this function will be assigned to the ‘ARB’ key. Every time you press ‘ARB’ key, this waveform will be selected.
7. And then, the parameters of this function can be changed.

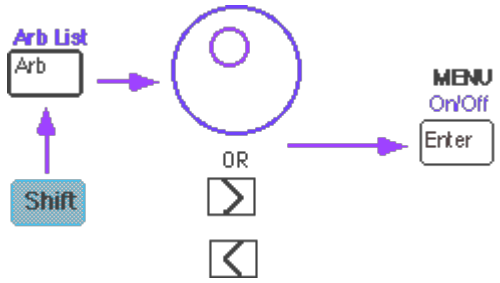


Figure 9: Selecting the Arbitrary Functions by pressing the SHIFT and ARB LIST keys

Front-panel Menu of the HP33120A Waveform Generator

a. Selection of the output impedance (50 Ohm or High Z)

To get accurate test result, you have to set function generator to high-impedance load (High-Z) mode. How to set function generator to high-impedance load (High-Z) mode:

1. Press ‘Menu On’ (Shift-Enter). You can see ‘A: MOD MENU’ on the display.
2. Press ‘>’ key three times, you can see ‘D: SYS MENU’ on the display.
3. Press ‘v’ key once, you can see ‘1: OUT TERM’ on display. It means ‘output termination’—Resistance of your load.
4. Press ‘v’ again, you can see ’50 OHM’ on the display.
5. Press ‘>’ key, you can see ‘HIGH Z’ on display.
6. Press ‘Enter’, the equipment is set as high impendence loads.

To get ‘High-Z’, this procedure must go through by manually each time turn on the HP 33120A.

b. Advanced modification of a standard waveform

Modulation waveform using amplitude or frequency (AM and FM), generate Frequency Shift Keying (FSK) signal, frequency sweep, or a burst waveform.

The menu is organized in a top down tree structure as shown in Figure 10. You move down the menu tree using the '^' or 'v' keys, and move within a level using the '>' and '<' keys. The top level lets you select the main functions, the 2nd level is the command level, and the 3rd level is the parameter level.

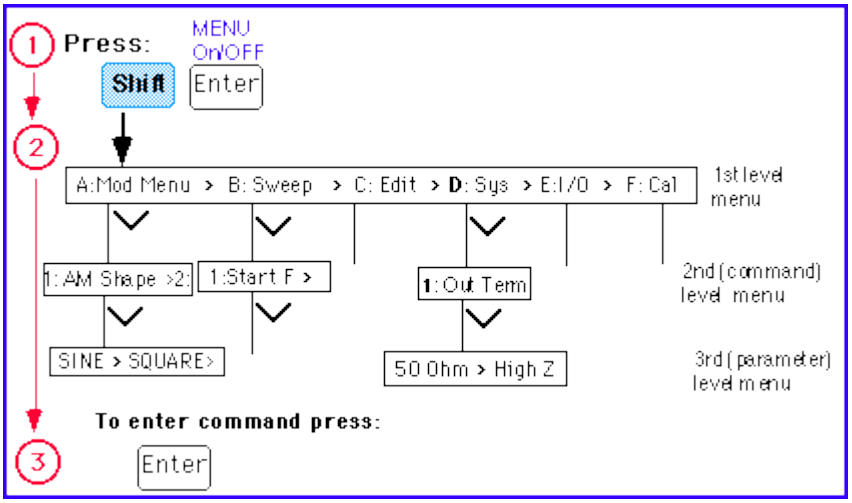


Figure 10: Menu organization

- To turn the menu on press the 'SHIFT' and 'MENU On/Off ' keys;
- Press the '>', '<', '^' and 'v' keys to navigate the menu;
- To enter a command press the 'ENTER' key;
- To recall the last menu command that was executed, press the 'SHIFT' 'RECALL_MENU' keys.

Example: Advanced modification of standard waveforms

The standard waveforms can be modified to create more complex ones which can be used in various applications. As an example, one can modulate the amplitude (AM) or frequency (FM) of the waveforms in Figure 11 for an AM modulated sinusoid. The carrier frequency amplitude is being modulated by the lower frequency - sinusoid, and is called modulating signal. The modulating signal could be any signal (For example: a speech signal or music, as the case for AM radio transmission).

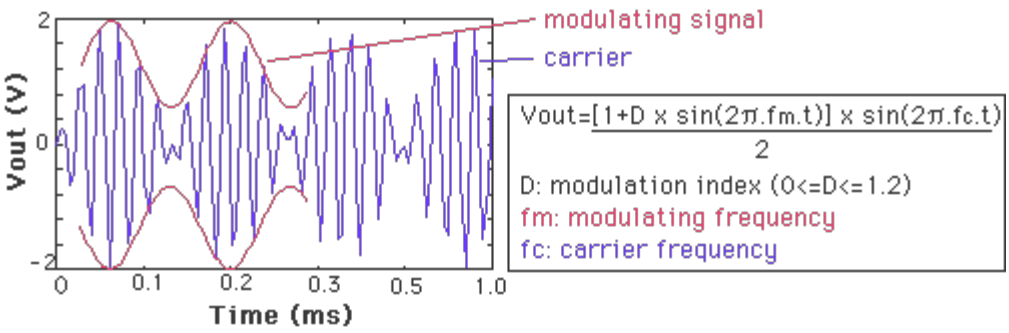


Figure 11: AM modulated sinusoid

To modulate a sinusoid:

1. Select the sine function by pressing the key with the sine icon.
2. Adjust the frequency and amplitude using the modify keys.
3. Select AM mode by pressing the 'SHIFT' and 'AM' keys (see Figures 5 and 12). AM annunciator will be on.
4. Select the shape of the modulating waveform on 'Menu'.
5. Press 'SHIFT' and 'RECALL_MENU' buttons, it will get in 'AM' menu and displays 'AM SHAPE'.
6. Press 'v' to select 'SINE' waveform.
7. Press 'ENTER'.
8. Set the modulating frequency by pressing 'SHIFT' and 'FREQ' key (Figure 12). 'AM' annunciator will flash.
9. Set the frequency of the modulating signal by number keys.
10. Press 'SHIFT' and 'LEVEL' key to set the modulation depth. The modulation depth is between 0 and 120%. (Please see Figure 10 for the definition).

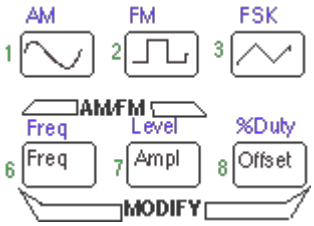


Figure 12: Selecting the AM mode

Storing arbitrary waveforms

Once you have set up your arbitrary waveform such as the AM modulated waveform, you can store them for later use and recall it any time. You can store them up to 4 waveforms. To store a waveform:

1. Press the ‘SHIFT’ key.
2. Press ‘STORE’ key.
3. Press the number (from 1 to 4) of the register where you want to store the function.

To recall the waveform:

1. Press ‘RECALL’ key.
2. Press number of the register.

Specifications:

- Frequency characteristics:
  - Sine and square: 100µHz - 15 MHz
  - Triangle and Ramp: 100µHz-100KHz
- Arbitrary waveform:
  - Length: 8 to 16,000 points
  - Resolution: 12 bits
  - Sample rate: 40 MSa/sec
  - Non-volatile memory (arbitrary waveforms): four 16k
- Output: (into 50 Ohm):

  Amplitude: 50mVpp - 10 Vpp.

  Offset: +/- 5Vpk ac+dc

  Output impedance: 50 Ohm

5. HP 53131A DC-225MHZ 10 Digit Universal Counter

QUICK START

Turn the unit ON; the unit will self test, given Address 03 and will set to Channel 1 (Default).

Connect your leads cables from channel 1 to the circuit under test. See the counter manual for how to measure frequencies below 100 Hz. The unit will show the exact frequency.

To select another channel, press **Frequency button until Freq 2 appears**. Connect the circuit under test to channel 2 and read the measurements from the display of the unit.

New frequency checked will be held for convenience reading when needed.

Also, ratios from freq 1 to 2 or freq 3 can be obtained by pressing frequency button until the desired ratio appears.

Note: Both channels under test "Must be connected" during ratio reading.

Other readings can be made, such as:

The period T_1 to T_2, Rise time 1, Falltime 1, (Positive Width 1, and Negative Width 1), obtained by pressing the Time and Period button on the front panel until the desired measurement is found.

Other measurements are possible, such as:

Phase of signal 1 to signal 2 (phase difference between both signals).

Duty cycle: defined as the positive pulse width divided by the period.

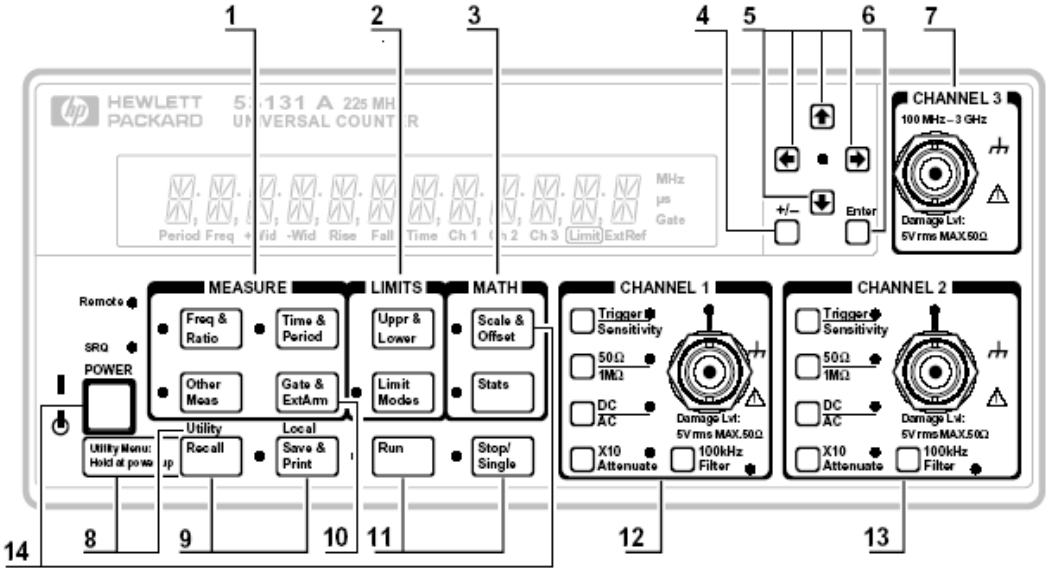
Also, **Volts Peak: Voltage 1 and Voltage 2 for both signal strength.**

See more details below.

Key Features

- 225 MHz Basic Bandwidth on both channels
- Basic Universal Counter with Time Interval Capability
- 500 pixels single shot Time Interval resolution
- GP-IB and RS232
- Fast Continuous-Count measurement technique
- Intuilink Software included

The Front Panel at a Glance

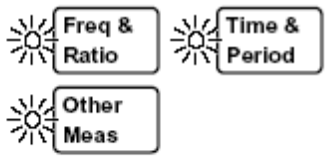
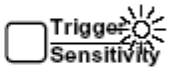
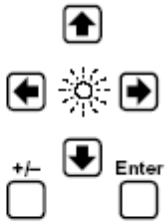


Note: Unit shown with Option 030.

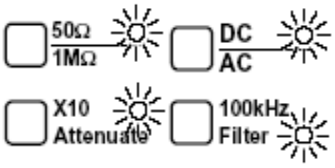
1 Measurement function menu keys
2 Limits menu keys
3 Math menu keys
4 Sign (+ or –) selection toggle key
5 Data Entry/Select (or arrow) keys
6 Enter numeric data (terminate) key
7 3.0/5.0/12.4 GHz RF input channel (optional)
9 Recall, Save and Print menu keys
10 Gate and External Arm menu key
11 Measurement control keys
12 Channel 1 Trigger/Sensitivity menu key and input conditioning keys
13 Channel 2 Trigger/Sensitivity menu key and input conditioning keys
14 Calibration menu key (Hold Scale &

The Front Panel Indicators at a Glance

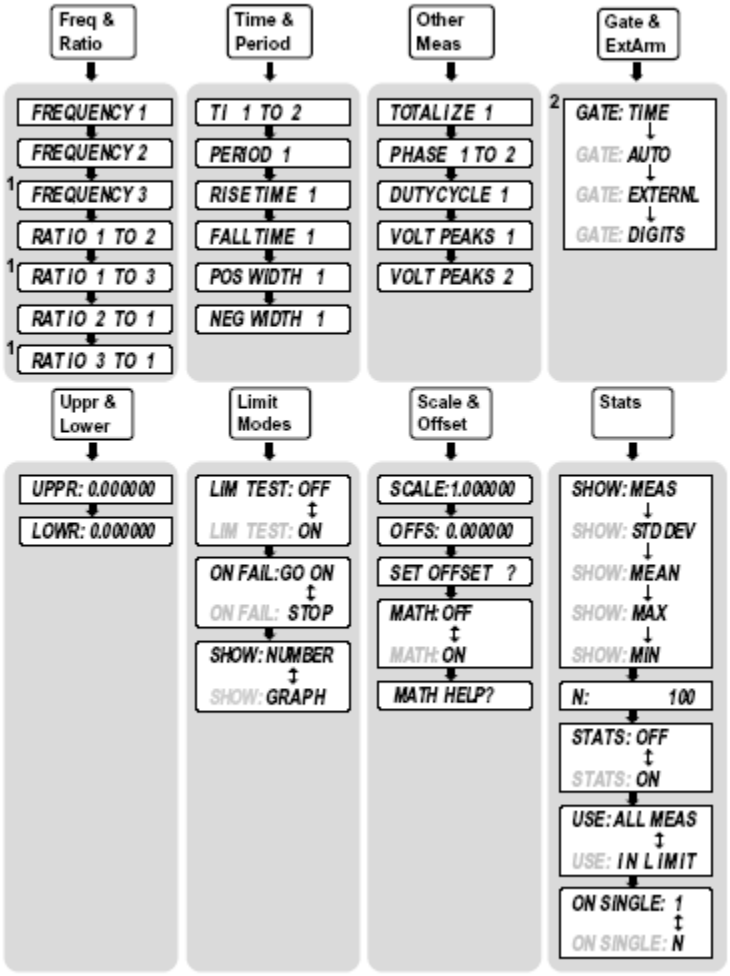
There are eight different groups of indicators or LEDs. They are listed and described in the following table.

Indicators	Description of the Indicators
	When one of these indicators is lit, it simultaneously indicates which key's menu (for example, Time & Period key) and its menu item (for example, TI 1 to 2) is enabled.
	When these indicators are lit, the key's "enable" menu item (that is, Limit Modes/LIM TEST, Scale & Offset/MATH, Stats/STATS, and Save & Print/PRINT) is enabled.
	When this indicator is lit, it indicates that you are in the Trigger/Sensitivity menu for the corresponding channel.
	When this indicator flashes, it indicates that the arrow keys can be used to modify or enter data.
	When one of these indicators is lit, it indicates that the Run or Single function is enabled.

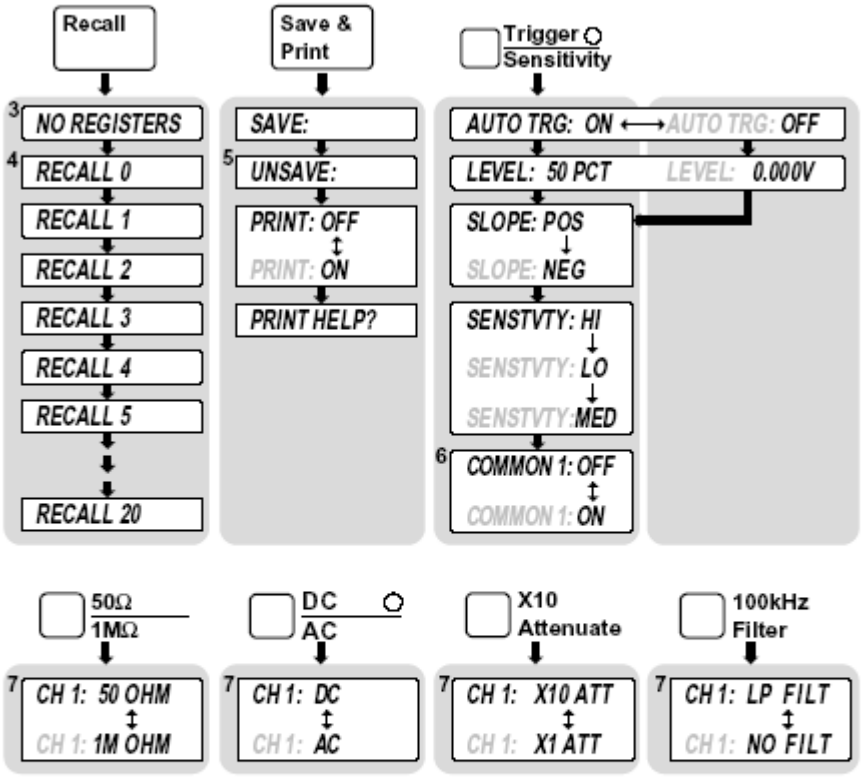
The Front Panel Indicators at a Glance (Cont.)

Indicators	Description of the Indicators
	When this indicator flashes, it indicates that the Counter is triggering on the input signal. If the input signal is too high, this indicator remains ON. If the input signal is too low, this indicator is OFF.
	When one of these indicators is lit, it indicates that the adjacent choice (that is, 50Ω, DC, X10, or 100kHz Filter) is enabled or active. Note that when these indicators are not lit, then the other choice (that is, 1MΩ, AC, X1, or no filter) is active.
Remote 	A lit Remote indicator indicates that the Counter is in remote mode (Note: In the remote mode, the Save & Print key becomes the Local key.) If (while in remote) an error occurs, the Remote indicator will flash. The indicator will continue flashing until the controller has read or cleared the error queue, or until the front panel returns to local mode. An unlit Remote indicator indicates that the Counter is in local mode.
SRQ 	The SRQ indicator indicates that the Counter has requested service from the controller. The SRQ indicator will remain lit until the controller has recognized the service request and serial polled the Counter, or taken specific action to cancel the request (for example, *CLS command).

The Front Panel Menus at a Glance



The Front Panel Menus at a Glance (Cont.)



---

[3] This appears when nothing can be recalled.

[4] Only registers which can be recalled will appear in this menu.

[5] This menu item only appears if an instrument setup has been saved.

[6] COMMON 1 only appears when the Counter is operating in the Time Interval measurement function (TI 1 TO 2).

[7] Channel 2 is the same, except "CH 2" instead of "CH 1" is displayed. These menus will terminate after two seconds.

Making Measurements

This quick manual is designed to give you hands-on experience in using the 53131A counter. Universal Counter can make various measurements.

Required Equipments

1. 53131A Universal Counter
2. Signal Source (Example: 33220A Function/Arbitrary Waveform Generator)
3. 1 BNC cable

Measuring Common Signals – That's easy.

1. counter displays the measured frequency around 1 KHz. The frequency is not exactly 1 KHz, it is due to the calibration of both the counter and the function generator.

   Notice that a few of the digits shown on the counter are changing.

2. Change the function generator output to a square wave by pressing the [Square] button.

Observe that the counter's digits are changing less than before. This demonstrates the general fact that counter works better with fast edge signals (square wave) rather than slow edge signals (sine wave). This is due to trigger errors that are greater with the slower edge signals.

Low Frequency Measurements – A little less automatic.

Let's see what happens if we try to measure a low frequency.
Turn the power off on both the function generator and the counter.

Function Generator Set-up

1. Power the Function Generator on. The default frequency of 1 KHz appears.

2. Change the frequency to 2 Hz. First pressing '<' and '>' locate the digit you want to change on the generator's front panel. Second press 'V' and 'Λ' to change the value to be 2 Hz.

3. Connect the 33220A Output BNC to the 53131A CHANNEL 1 input BNC.

4. Power on the counter. It passes self-test, and displays ---------.
   This is a problem sign which is typically caused by either no frequency signal or an incorrect frequency signal that is not stable. You set a stable 2Hz frequency on the function generator so…What could be wrong?

Counter Set-up

Notice the 5 buttons associated with Ch 1 on the Counter.

5. Press the [Trigger Sensitivity] button. The display shows Auto Trg On. The "ON" is flashing. Whenever a portion of the display is flashing, that means that there are choices for the flashing element. This element can be changed by pressing one of the arrow buttons just to the right of the display.

6. Set AUTO TRG: OFF. Auto trigger does not work at frequencies below 100 Hz. The counter may be set at the wrong trigger voltage.

7. Press [Trigger Sensitivity] again. You can manually set the trigger level. The generator is outputting a 2 Hz signal symmetric about 0 V (no offset) so an appropriate trigger level is 0 V.

8. Use the arrow buttons to set the trigger level to 0V. Use the horizontal arrows to select the digit. When the correct digit is flashing, use the vertical arrows to increment/decrement the digit's value.

9. Press the [Enter] button next to the arrows.

10. Press [Run] on the main keyboard panel. You will now get a reading around 2 Hz. For low frequencies you should also use DC coupling. Here is how:

11. Set DC coupling for Ch 1 (press the [DC/AC] button near Ch 1). You should see a good solid measure of the 2Hz frequency.

Time Interval Measurements

The counter can do time interval measurements between a signal edge on Ch 1 (start edge) and an edge of a different signal on Ch 2 (stop edge). The counter can also make time interval measurements on one signal. The start edge and stop edge are both on one signal. To do this, the counter is set to put a single signal on both channels at the same time by selecting "common" signal routing as explained below.

Cycle the power for both the counter and the generator to make sure you are starting at a known state

Function Generator Set-up

Do not connect the BNC to counter, yet.

Soft keys are buttons just below the display. Their function / labels change depending on where you are at within the configuration menu. When instructed to press a soft key , look for the label in the display and press the corresponding button.

1. Turn the functions generator on

2. Select pulse by press pulse button.
3. Set frequency to 2 KHz.
4. Set amplitude to 1 Vpp. (Press **Ampl** key, press '<' and '>'move flash digit and set value by pressing 'V' and 'Λ')
5. Set offset to 0V. (Press **Offset** key, change the value to be '0').
6. Set pulse frequency to be 2KHz. (Press **Freq** key, set value to be 2KHz)
7. Connect BNC to counter Ch1.

Counter Set-up

8. Turn the counter on and wait for it to complete the start-up sequence.
9. Press the [Time and Period] button. T1 to 2 is displayed.
10. Press the Ch 1 [Trigger Sensitivity] button. "AUTO TRG: ON" is displayed.
11. Pressing the [Trigger Sensitivity] button again, it shows "LEVEL: 50 PCT" Make sure to set "50" by pressing [Enter] before continuing.
12. Press [Trigger Sensitivity] again, "SLOPE: POS.
13. Press again, "SENSTVTY: HI"
14. Press again to see "COMMON 1: OFF". This means Ch 1 is not connected to Ch 2 internally inside the counter. Note that the "OFF" portion of the displayed message is flashing. That means it can be changed by pressing one of the arrow buttons to the right of the display.
15. Set "COMMON 1: ON" Now Ch 1 is connected internally to Ch 2 and they see the same signal.
16. Press the same buttons (steps 10 through 15) for Ch 2 that you did for Ch 1 to ensure that the settings are the same for both Channels.
17. Press the [Run] button. The display shows the time interval measurement between the rising edges of two adjacent pulses in the signal. For a 2 KHz signal this should be 1/2000 = 500 u sec. You are most likely seeing a time interval considerably smaller than 500usec.
18. Press the [Gate and Ext Arm] button until it displays "DELAY: NONE" Note that the "None" portion of the display is flashing.
19. Press an arrow button (to the right of the display) to display "DELAY: TIME".
20. Press the [Gate & Ext Arm] button to display 'TIME: .01000 s'.
21. Set the time to 100 usec using the arrow buttons. (set .00010s by using the horizontal arrows to move digits, use the vertical arrows to increment/decrement numbers)
22. Press [Enter] located by the arrow buttons.

Note: You must press [Enter], otherwise, your setting will be lost.

23. Press [Run]. You should see a display of 500 usec.

Slowing Down the Display by Using Stats

Counter Set-up

1. Press the [State] button.
2. Set SHOW MEAS to display SHOW MEAN by pressing the arrow key.
3. Press [Stats] again and set N to 02
4. Press [Enter]
5. Press [Run]

Notice that the display has slowed down and is easier to read.

Totalize Measurements

The counter's totalize feature simply means counting triggered edges. For instance, we now have a signal from the 33220A that is a pulse occurring at a 2 kHz rate. So, if we were to totalize this signal for 1 second, the total shown should be 2000 ±1 count.

Counter Set-up

1. Press the [Other Meas] button once to display TOTALIZE 1. If you wait a moment, you will see the display show 200. Now press the [Gate & ExtArm] button and see GATE: TIME. Notice that TIME is flashing. Check the available choices with the arrow buttons. The choices are TIME, AUTO, and EXTERNAL.
2. Set the flashing field to TIME.
3. Press the [Gate & ExtArm] button again to display .100 seconds.
4. Use the arrow buttons to set the gate time to 1 second.
5. Press [Enter].
6. Press [Run]. The display now shows 2000. That is, the counter is counting 2000 pulses in 1 second on channel 1. CAUTION here. The 1-second gate that you set is not very accurate. Instead of deriving the 1-second gate from the precision clock time base, it is derived from the u-processor clock. Why the count that they expected is not being displayed? The reason is, most likely because of an error in the time gate, not the count mechanism itself. To make really accurate time gated TOTALIZE measurements you must supply a precision time length pulse to the

external gate.

7. Press [Gate & ExtArm] twice to display GATE: TIME (with time flashing).
8. Set GATE: AUTO using the arrow buttons.
9. Press [Run]. The counter counts and counts in a continuous mode until you Press the [Stop/Single] button. Pressing [Run] again resets the totalizer back to zero. There is no way to just pause the Totalize function; you must stop it and that automatically resets it. The last choice, External, allows you to set a positive or negative going edge as the start for TOTALIZE. It also allows you to set a positive or negative going edge as the stop for TOTALIZE.

Limit Testing

It is possible to do limit testing with the 53131A counters. For example, you may want to know whenever a measured frequency goes outside a predefined upper limit or lower limit.

Cycle the power on the counter and the function generator to ensure a known starting point.

Function Generator Set-up

Turn the function generator on. It will be set to a default 1 KHz sine wave with an amplitude of 100 mVpp.

Counter Set-up

1. Turn the counter on. After the start up sequence, the counter will read approximately 1 KHz.
2. Press the [Limit Modes] button. Note that the LIM TEST: OFF is displayed.
3. Press an arrow button to turn LIM TEST: ON.
4. Press the [Limit Modes] button twice to display SHOW: NUMBER.
5. Press the [Uppr & Lower] button and set the upper limit of 1010 Hz using the arrow buttons.
6. Press [Enter].
7. Press the [Uppr & Lower] button again and set the lower limit to 990 Hz.
8. Press [Enter].
9. Press [Run]. The counter should be displaying a measurement of about 1 kHz.
10. Change the frequency of the function generator to frequencies above and below the limits. (Use the horizontal arrow to move digits, turn the knob to Increment / decrement frequency).

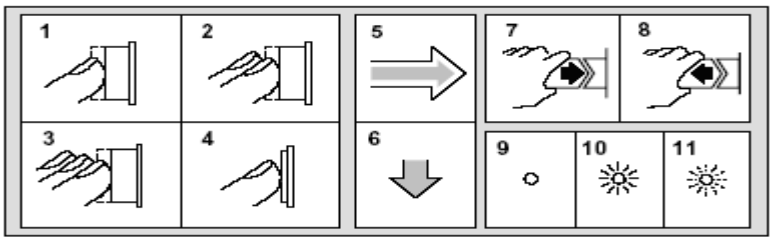
Note: The Limit light comes on on the counter display when the frequency is above or below the limit.

Limit test graphic mode

There is a convenient and unique way to display in and out of limit conditions using these counters.

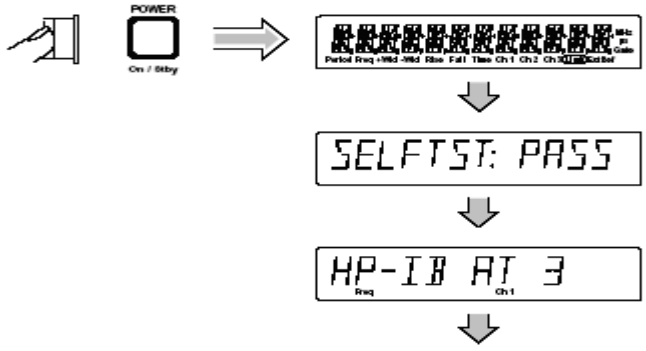
1. Press the [Limit Modes] button until SHOW: NUMBER is displayed.
2. Press the arrow buttons to display SHOW: GRAPH.
3. Press [Run]. Notice that an asterisk and two colons are shown in the counter's display.
4. Change the generator's frequency slowly so that it exceeds both the lower and upper frequency limits. The asterisk represents the current frequency with respect to the limits (two colons).

Legend

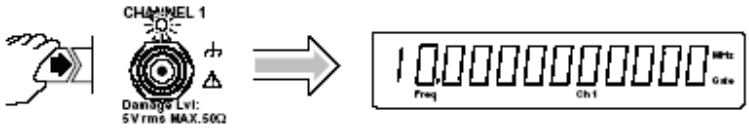


1 Press key one time and release
2 Press key two times and release
3 Repeated key presses
4 Press and hold
5 Result
6 Auto operation
7 Connect signal
8 Disconnect signal
9 Indicator off
10 Indicator on
11 Indicator flashing

To Measure Frequency

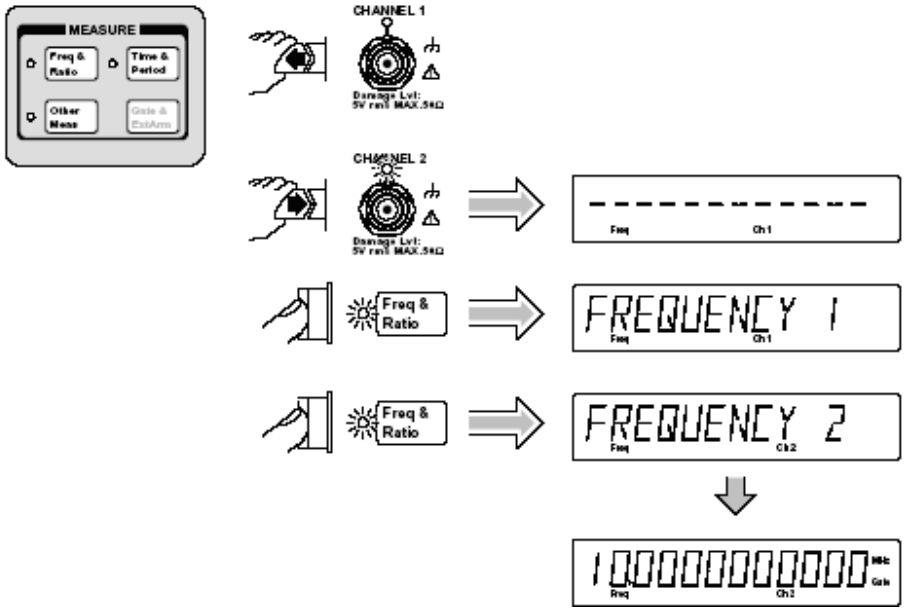


Connect (for demonstration purposes) the Counter's rear-panel **10 MHz Out** signal to CHANNEL 1 input as shown in the illustrated procedure, below.

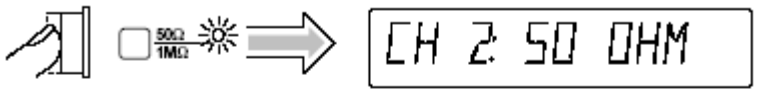


The Counter will automatically display the measured frequency of the input signal.

Disconnect the demonstration signal from CHANNEL 1, and connect it to CHANNEL 2 as shown in the following steps.



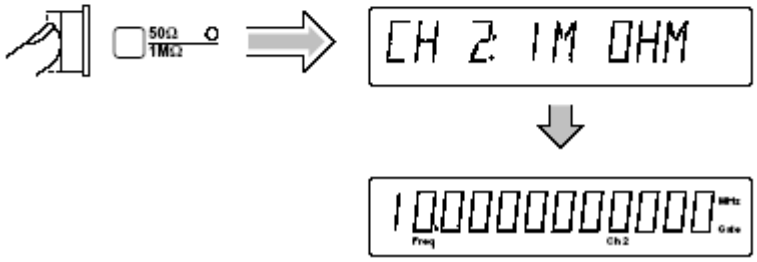
Selecting Input Impedance



Channel 2's input impedance is now set to 50Ω.

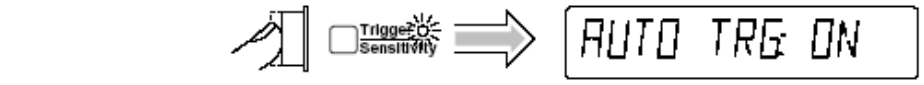
The "arrow" keys can also be used to toggle the state of toggle keys (DC/AC, 50Ω/1MΩ, etc.) as indicated by the flashing indicator within the arrow keys. However, for simplicity in this procedure, use the corresponding toggle key to change states.

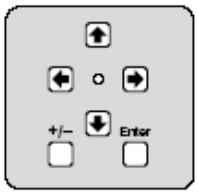
If you want to change the input impedance back to the default 1 MΩ impedance, perform the following step.



To Set Input Channel Trigger Level/Sensitivity

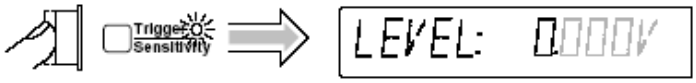
Changing Trigger Mode



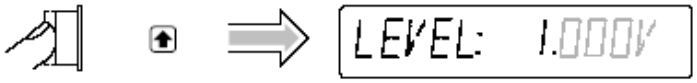


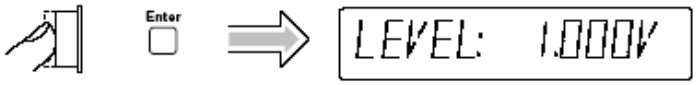
Press any one of these arrow keys to toggle to the next state of Auto Trigger.

Modifying Input Trigger Level



The leftmost "0" digit in the LEVEL display is highlighted, indicating that if you press the ▲ key once the displayed value will increase to 1.000 volt as shown in the following step.



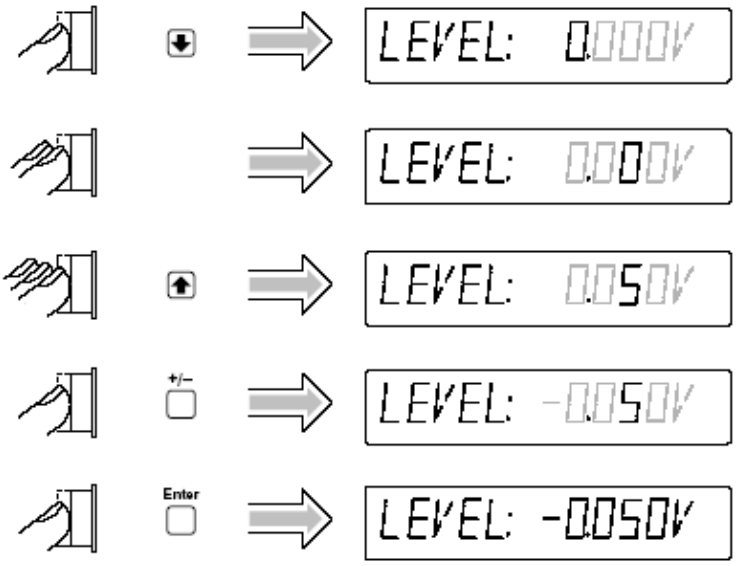


NOTE

BE SURE to always press the Enter key to complete numeric data entries.

Channel 2's trigger level is now set to +1V.

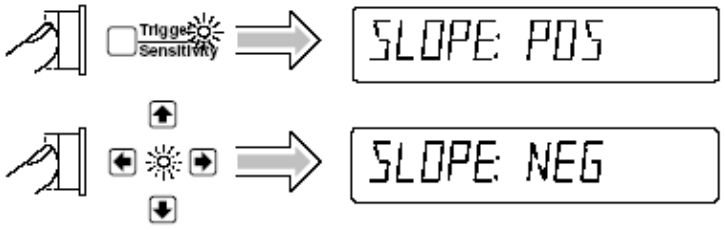
To set the trigger level to –0.05V, perform the following steps.



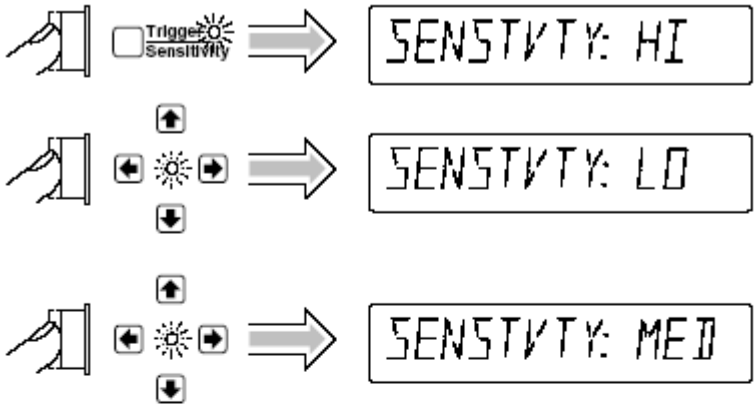
NOTE **BE SURE to always press the Enter key to complete numeric data entries.**

Channel 2's trigger level is now set to –0.05V.

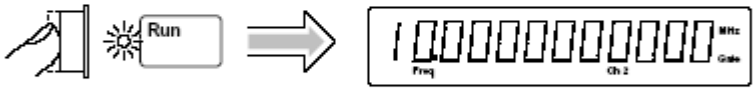
Selecting Input Trigger Slope



Selecting Input Sensitivity



Starting the Measurement



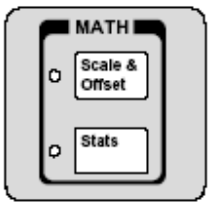
The **Run** key initiates repetitive measurements, and is described in the section titled "To Control Measurement" at the end of this chapter.

To Select Scale and Offset

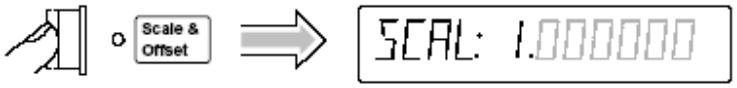
The **Scale & Offset** key allows for multiplication and addition, respectively, of the measurement by user-specified constants. Modification of the displayed measurement by these Math operations is represented by the following equation:

$$(\text{Measurement} \times \text{Scale}) + \text{Offset} = \text{Displayed Results}$$

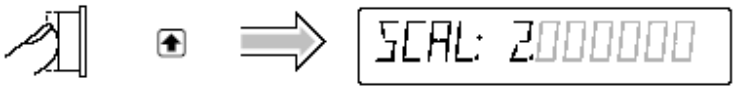
The Scale and Offset Math operations can be used, for example, to subtract systematic errors or display the percentage difference between signals.



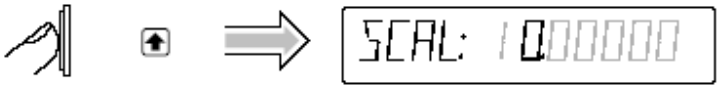
Entering the Scale Value

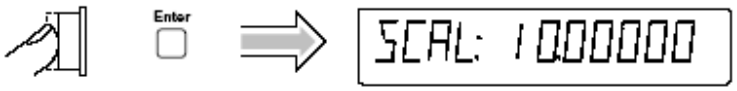


To demonstrate the Scale Math operation, set Scale to 10 as shown in the following steps.



Press and hold the ▲ key until the value of Scale is 10 as shown in the following step.





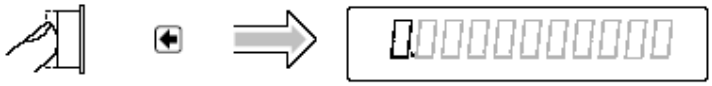
NOTE **BE SURE to press the Enter key to enter the value of 10.**

The Scale is now set to 10, and MATH has been enabled.
The Scale & Offset indicator is now lit to show that MATH is enabled.
Since MATH is enabled, the results are being scaled and offset.

Entering the Offset Value

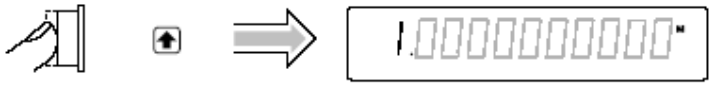
To demonstrate the Offset Math operation, set the Offset to 1 MHz as shown in the following steps.

At this point, pressing the ◆ key will cause the Counter to display the full display of the Offset value as shown in the following step.



Press the ◆ key six more times to cause the Counter to display your entry in Mega units as shown in the following step.

The leftmost "0" digit in the OFFSet display is highlighted, indicating that if you press ▲ key once the displayed value will increase to 1 Mega (that is, 1E6) as shown in the following step.



NOTE **BE SURE to press the Enter key to enter the 1 Mega value.**

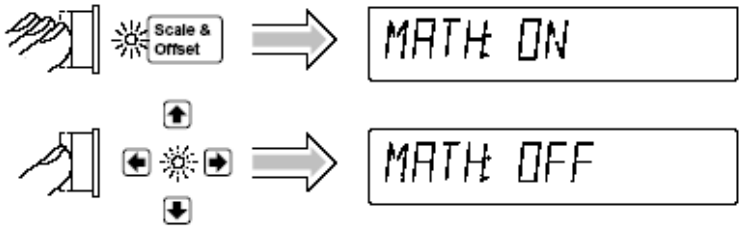
The Offset is now set to 1 Mega.

Displaying the Math Results

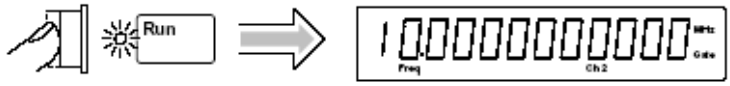
The Counter displays the modified measurement results, which are based on the scale and offset values that you selected in the previous steps. That is, the 101 represents the original 10, scale multiplied by 10, then offset by 1.

(For more details and real applications of the Math Scale and Offset operations, refer to the appropriate section in Chapter 2, "Operating Your Universal Counter.")

Disabling Math



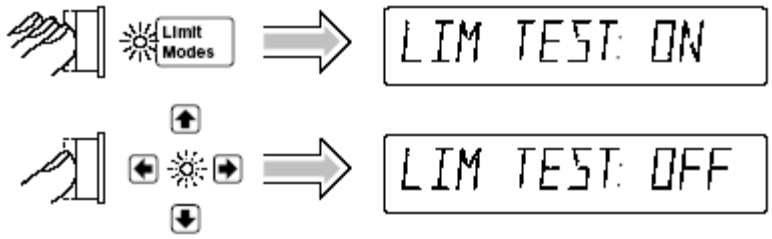
Note that the **Scale & Offset** key indicator is now off.



NOTE

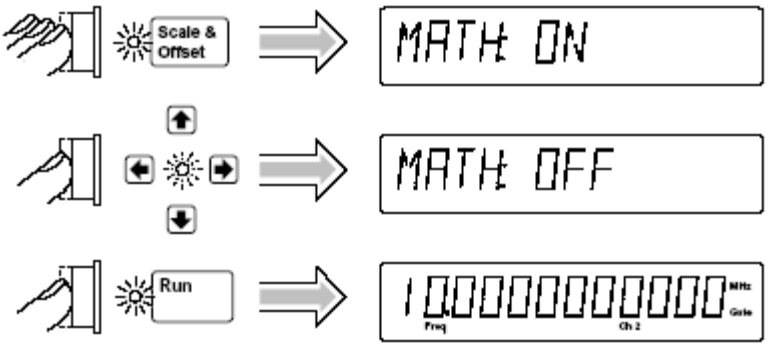
DO NOT cycle **POWER** because you will need to use these Scale and Offset values in the following procedure "To Set Limits of Measurements." Continue to the following procedure.

Disabling Limit Testing



The Counter is now making measurements without limit testing.

Disabling Math



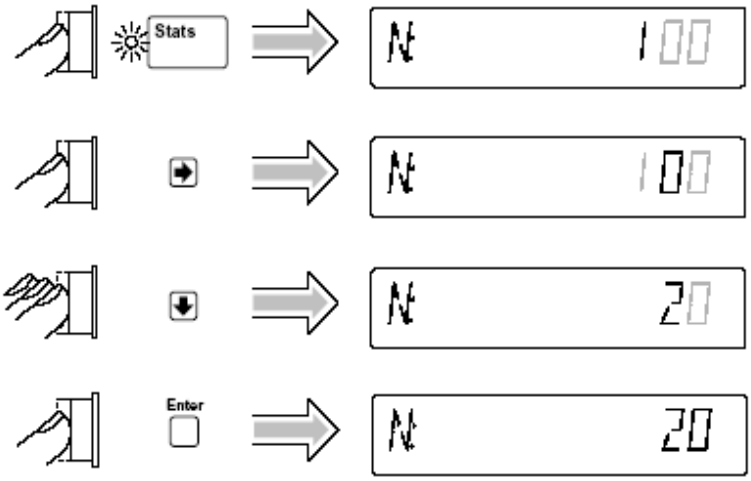
The Counter is now making measurements without the scale/offset values calculated into the measurements.

To Perform Statistics on Measurements

Selecting the Type of Statistics (Stats)

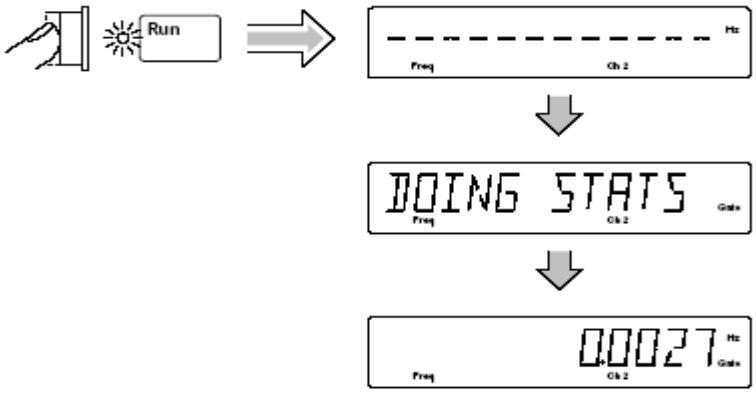
Suppose you want the Counter to compute and display the **standard deviation** of the current input data (which is the 10 MHz signal applied to CHANNEL 2). Also, you want the Counter to make 20 measurements before it computes the standard deviation. Perform the following steps.

Updating the SHOW configuration caused Stats to be enabled. The Stats indicator is now lit.



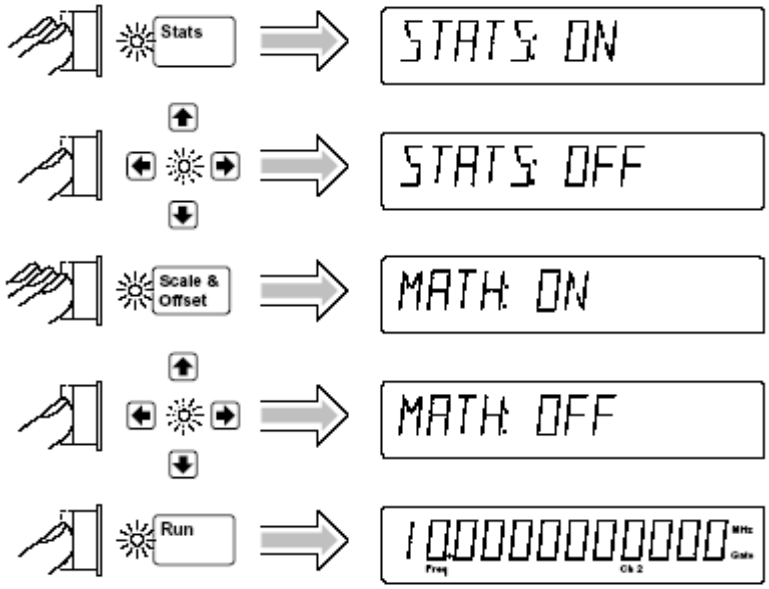
NOTE **BE SURE to press the Enter key to enter the value of 20.**

The Counter is now set to make statistics based on 20 measurements.



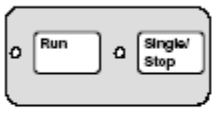
In this case, the displayed standard deviation value is computed on all measurements of the 10 MHz signal since no limits were set.

Disabling Stats and Math



The Counter is now making and displaying normal measurements (that is, the Counter is not showing statistics or scale/offset results).

To Control Measurement



Use these two keys to control the measurement of the Counter. The **Run** key provides repetitive measurements, whereas the **Stop/Single** key allows you to make one measurement.

With the 10 MHz signal still connected to CHANNEL 2, perform the following steps so you can better understand the Run and Stop/Single operations.

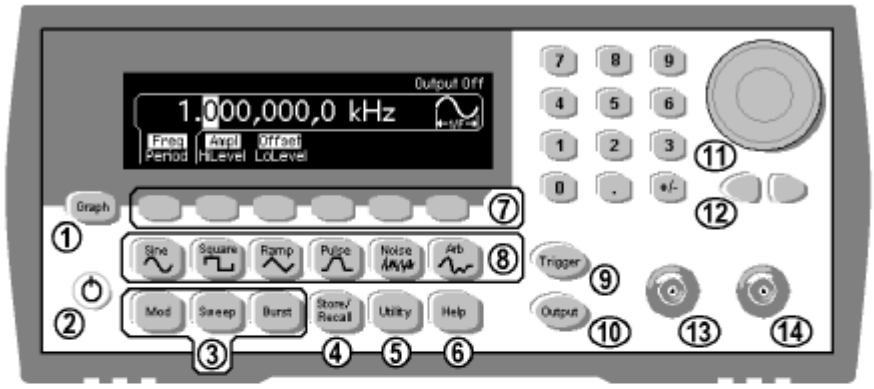
6. Function/Arbitrary Waveform Generator HP33220A 20 MHz

Specification

HP 33220A function/arbitrary waveform generator uses direct digital synthesis (DDS) techniques to create stable, low-distortion output signals and provides easy access to standard sine, square, ramp, triangle, pulse waveforms, and also, you can create custom waveforms using the 50 MSa/s, 14 bit, 64 K-point arbitrary waveform function. It supports variable-edge pulse function and create PWM. The 33220A includes USB, LAN and GPIB interfaces.

- 20 MHz sine and square waveforms
- Ramp, triangle, pulse, noise, and DC waveforms
- 14-bit, 50 MSa/s, 64 K-point arbitrary waveforms
- AM, FM, PM, FSK, and PWM modulation types
- Linear & logarithmic sweeps and burst operation modes
- Graph mode for visual verification of signal settings
- USB, GPIB and LAN interfaces included

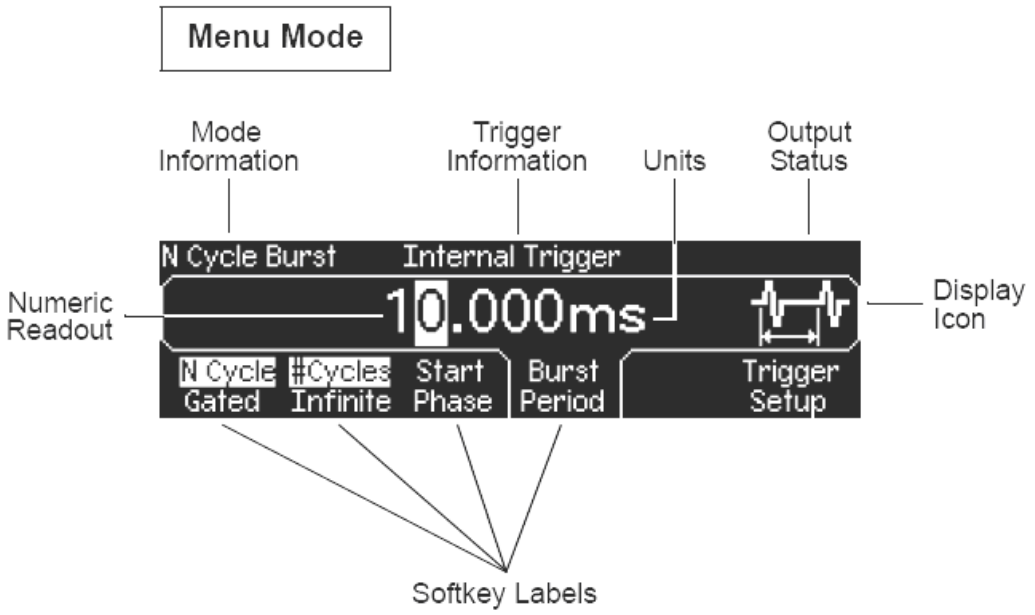
The Front Panel at a Glance

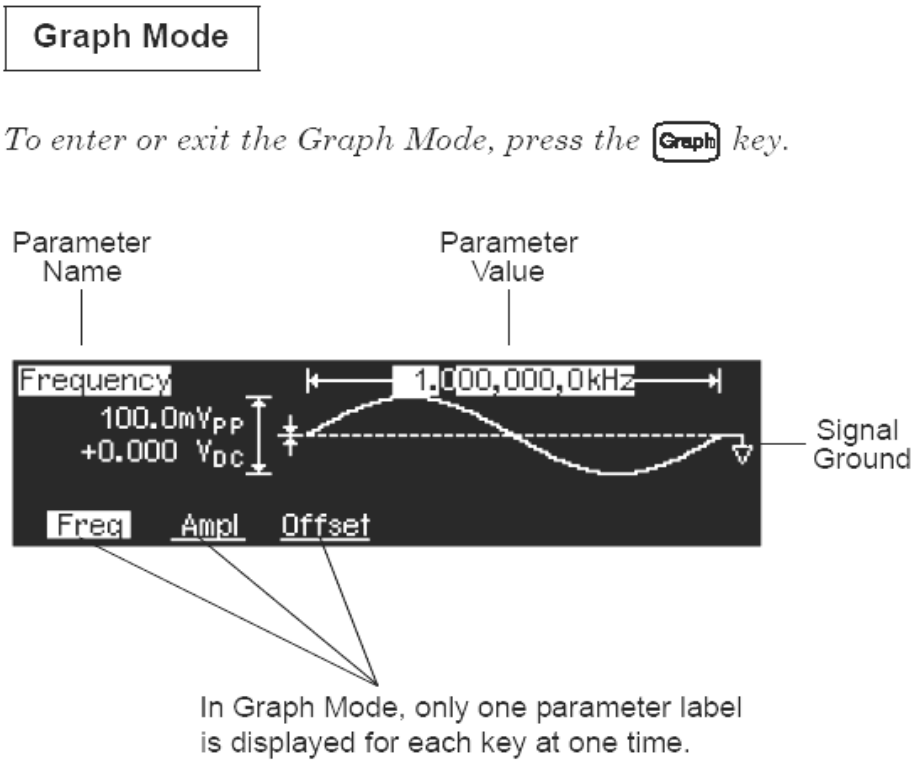


1 Graph Mode/Local Key
2 On/Off Switch
3 Modulation/Sweep/Burst Keys
4 State Storage Menu Key
5 Utility Menu Key
6 Help Menu Key
7 Menu Operation Softkeys
8 Waveform Selection Keys
9 Manual Trigger Key (*used for Sweep and Burst only*)
10 Output Enable/Disable Key
11 Knob
12 Cursor Keys
13 Sync Connector
14 Output Connector

Note: *To get context-sensitive help on any front-panel key or menu softkey, press and hold down that key.*

The Front Panel Display at a Glance

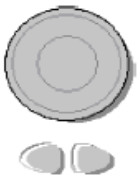




Front-Panel Number Entry

You can enter numbers from the front-panel using one of two methods.

Use the knob and cursor keys to modify the displayed number.



1. Use the keys below the knob to move the cursor left or right.
2. Rotate the knob to change a digit (clockwise to increase).

Use the keypad to enter numbers and the softkeys to select units.

1. Key in a value as you would on a typical calculator.
2. Select a unit to enter the value.

To Set the Output Frequency

At power-on, the function generator outputs a sine wave at 1 kHz with an amplitude of 100 mV peak-to-peak (into a 50Ω termination).
The following steps show you how to change the frequency to 1.2 MHz.

1 Press the "Freq" softkey.

The displayed frequency is either the power-on value or the frequency previously selected. When you change functions, the same frequency is used if the present value is valid for the new function. To set the waveform *period* instead, press the **Freq** softkey again to toggle to the **Period** softkey (the current selection is highlighted).

2 **Enter the magnitude of the desired frequency.**

Using the numeric keypad, enter the value "1.2".

3 **Select the desired units.**

Press the softkey that corresponds to the desired units. When you select the units, the function generator outputs a waveform with the displayed frequency (if the output is enabled). For this example, press **MHz**.

Note: *You can also enter the desired value using the knob and cursor keys.*

To Set Output Amplitude

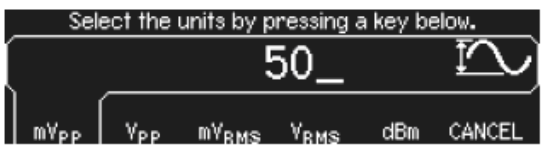
At power-on, the function generator outputs a sine wave with an amplitude of 100 mV peak-to-peak (into a 50Ω termination).
The following steps show you how to change the amplitude to 50 mVrms.

1 **Press the "Ampl" softkey.**

The displayed amplitude is either the power-on value or the amplitude previously selected. When you change functions, the same amplitude is used if the present value is valid for the new function. To set the amplitude using a *high level* and *low level*, press the **Ampl** softkey again to toggle to the **HiLevel** and **LoLevel** softkeys (the current selection is highlighted).

2 **Enter the magnitude of the desired amplitude.**

Using the numeric keypad, enter the value "50".



3 Select the desired units.

Press the softkey that corresponds to the desired units. When you select the units, the function generator outputs the waveform with the displayed amplitude (if the output is enabled). For this example, press **mV_{RMS}**.

Note: *You can also enter the desired value using the knob and cursor keys.*

You can easily convert the displayed amplitude from one unit to another. For example, the following steps show you how to convert the amplitude from Vrms to Vpp.

4 Enter the numeric entry mode.

Press the (+/-) key to enter the numeric entry mode.

5 Select the new units.

Press the softkey that corresponds to the desired units. The displayed value is converted to the new units. For this example, press the **Vpp** softkey to convert 50 mVrms to its equivalent in volts peak-to-peak.

To change the displayed amplitude by *decades*, press the right-cursor key to move the cursor to the units on the right side of the display. Then, rotate the knob to increase or decrease the displayed amplitude by decades.

To Set a DC Offset Voltage

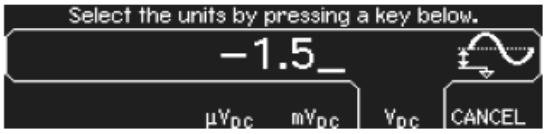
At power-on, the function generator outputs a sine wave with a dc offset of 0 volts (into a 50Ω termination). *The following steps show you how to change the offset to –1.5 mVdc.*

1 **Press the "Offset" softkey.**

The displayed offset voltage is either the power-on value or the offset previously selected. When you change functions, the same offset is used if the present value is valid for the new function.

2 **Enter the magnitude of the desired offset.**

Using the numeric keypad, enter the value "–1.5".



3 **Select the desired units.**

Press the softkey that corresponds to the desired units. When you select the units, the function generator outputs the waveform with the displayed offset (if the output is enabled). For this example, press **mVDC**.

Note: *You can also enter the desired value using the knob and cursor keys.*

To Set the High-Level and Low-Level Values

You can specify a signal by setting its amplitude and dc offset values, as described previously. Another way to set the limits of a signal is to specify its high-level (maximum) and low-level (minimum) values. This is typically convenient for digital applications. In the following example, let's set the high-level to 1.0 V and the low-level to 0.0 V.

1 **Press the "Ampl" softkey to select "Ampl".**

2 **Press the softkey again to toggle to "HiLevel".**

Note that both the **Ampl** and **Offset** softkeys toggle together, to **HiLevel** and **LoLevel**, respectively.

3 **Set the "HiLevel" value.**

Using the numeric keypad or the knob, select a value of "1.0 V". (If you are using the keypad, you will need to select the unit, "V", to enter the value.)

4 **Press the "LoLevel" softkey and set the value.**

Again, use the numeric keypad or the knob to enter a value of "0.0 V".

Note that these settings (high-level = "1.0 V" and low-level = "0.0 V") are equivalent to setting an amplitude of "1.0 Vpp" and an offset of "500 mVdc".

To Select "DC Volts"

You can select the "DC Volts" feature from the "Utility" menu, and then set a constant dc voltage as an "Offset" value. Let's set "DC Volts" = 1.0 Vdc.

1 **Press** Utility **and then select the DC On softkey.**

The **Offset** value becomes selected.

2 **Enter the desired voltage level as an "Offset".**

Enter 1.0 Vdc with the numeric keypad or knob.

You can enter any dc voltage from -5 Vdc to +5 Vdc.

To Set the Duty Cycle of a Square Wave

At power-on, the duty cycle for square waves is 50%. You can adjust the duty cycle from 20% to 80% for output frequencies up to 10 MHz. *The following steps show you how to change the duty cycle to 30%.*

1 **Select the square wave function.**

Press the Square key and then set the desired output frequency to any value up to 10 MHz.

2 **Press the "Duty Cycle" softkey.**

The displayed duty cycle is either the power-on value or the percentage previously selected. The duty cycle represents the amount of time per cycle that the square wave is at a *high* level (note the icon on the right side of the display).

3 **Enter the desired duty cycle.**

Using the numeric keypad or the knob, select a duty cycle value of "30". The function generator adjusts the duty cycle immediately and outputs a square wave with the specified value (if the output is enabled).

To Configure a Pulse Waveform

You can configure the function generator to output a pulse waveform with variable pulse width and edge time. *The following steps show you how to configure a 500 ms pulse waveform with a pulse width of 10 ms and edge times of 50 ns.*

1 **Select the pulse function.**

Press the Pulse key to select the pulse function and output a pulse waveform with the default parameters.

2 **Set the pulse period.**

Press the **Period** softkey and then set the pulse period to 500 ms.

3 **Set the pulse width.**

Press the **Width** softkey and then set the pulse width to 10 ms. The pulse width represents the time from the 50% threshold of the rising edge to the 50% threshold of the next falling edge (note the display icon).

4 **Set the edge time for both edges.**

Press the **Edge Time** softkey and then set the edge time for *both* the rising and falling edges to 50 ns. The edge time represents the time from the 10% threshold to the 90% threshold of each edge (note the display icon).

To View a Waveform Graph

In the *Graph Mode*, you can view a graphical representation of the current waveform parameters. The softkeys are listed in the same order as in the normal display mode, and they perform the same functions. However, only one label (for example, **Freq** or **Period**) is displayed for each softkey at one time.

1 **Enable the Graph Mode.**

Press the Graph key to enable the Graph Mode. The name of the currently selected parameter, shown in the upper-left corner of the display, and the parameter's numeric value field are both highlighted.

2 **Select the desired parameter.**

To select a specific parameter, note the softkey labels at the bottom of the display. For example, to select period, press the **Period** softkey.

- As in the normal display mode, you can edit numbers using either the numeric keypad or the knob and cursor keys.
- Parameters which normally toggle when you press a key a second time also toggle in the Graph Mode. However, you can see only one label for each softkey at one time (for example, **Freq** or **Period).**
- To exit the Graph Mode, press Graph again.

To Output a Stored Arbitrary Waveform

There are five built-in arbitrary waveforms stored in non-volatile memory. *The following steps show you how to output the built-in "exponential fall" waveform from the front panel.*

1 **Select the arbitrary waveform function.**

When you press the [Arb] key to select the arbitrary waveform function, a temporary message is displayed indicating which waveform is currently selected (the default is "exponential rise").

2 **Select the active waveform.**

Press the **Select Wform** softkey and then press the **Built-In** softkey to select from the five built-in waveforms. Then press the **Exp Fall** softkey. The waveform is output using the present settings for frequency, amplitude, and offset unless you change them.

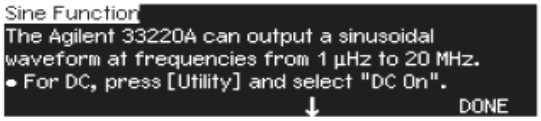
The selected waveform is now assigned to the [Arb] key. Whenever you press this key, the selected arbitrary waveform is output. To quickly determine which arbitrary waveform is currently selected, press [Arb].

To Use the Built-In Help System

The built-in help system is designed to provide context-sensitive assistance on any front-panel key or menu softkey. A list of help topics is also available to assist you with several front-panel operations.

1 **View the help information for a function key.**

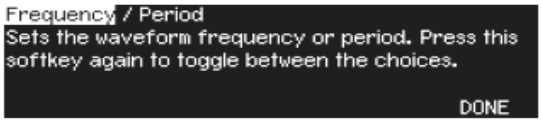
Press and hold down the [Sine] key. If the message contains more information than will fit on the display, press the ↓ softkey or turn the knob clockwise to view the remaining information.



Press **DONE** to exit Help.

2 **View the help information for a menu softkey.**

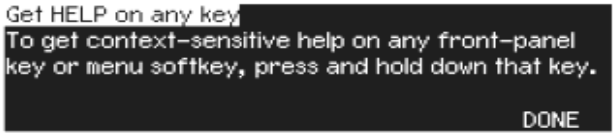
Press and hold down the **Freq** softkey. If the message contains more information than will fit on the display, press the ↓ softkey or rotate the knob clockwise to view the remaining information.



Press **DONE** to exit Help.

3 View the list of help topics.

Press the Help key to view the list of available help topics. To scroll through the list, press the ↑ or ↓ softkey or rotate the knob. Select the third topic "*Get HELP on any key*" and then press **SELECT**.

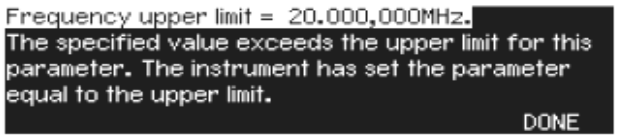


Press **DONE** to exit Help.

4 View the help information for displayed messages.

Whenever a limit is exceeded or any other invalid configuration is found, the function generator will display a message. For example, if you enter a value that exceeds the frequency limit for the selected function, a message will be displayed. The built-in help system provides additional information on the most recent message to be displayed.

Press the Help key, select the first topic "*View the last message displayed*", and then press **SELECT**.



Press **DONE** to exit Help.

To Select the Output Termination

The Agilent 33220A has a fixed series output impedance of 50 ohms to the front-panel *Output* connector. If the actual load impedance is different than the value specified, the displayed amplitude and offset levels will be incorrect. The load impedance setting is simply provided as a convenience to ensure that the displayed voltage matches the expected load.

1 Press Utility.

2 Navigate the menu to set the output termination.

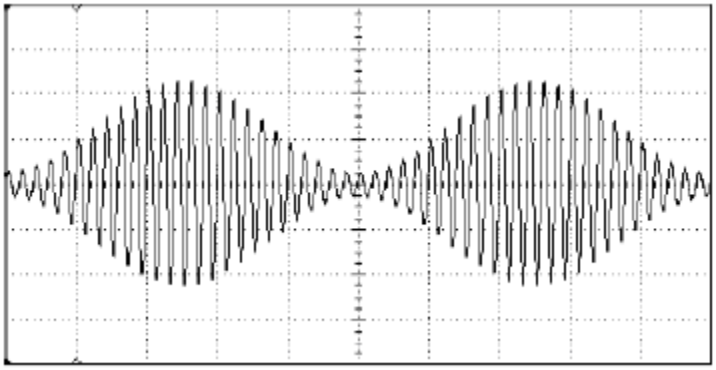
Press the **Output Setup** softkey and then select the **Load** softkey.

3 Select the desired output termination.

Use the knob or numeric keypad to select the desired load impedance or press the **Load** softkey again to choose "High Z".

To Output a Modulated Waveform

A modulated waveform consists of a *carrier* and a *modulating waveform*. In AM (amplitude modulation), the amplitude of the carrier is varied by the amplitude of the modulating waveform. For this example, you will output an AM waveform with 80% modulation depth. The carrier will be a 5 kHz sine wave and the modulating waveform will be a 200 Hz sine wave.



1 Select the function, frequency, and amplitude of the carrier.

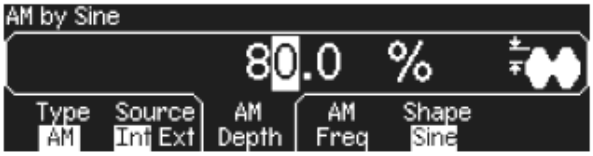
Press Sine and then press the **Freq**, **Ampl**, and **Offset** softkeys to configure the carrier waveform. *For this example, select a 5 kHz sine wave with an amplitude of 5 Vpp.*

2 Select AM.

Press Mod and then select "AM" using the **Type** softkey. Notice that a status message "AM by Sine" is shown in the upper-left corner of the display.

3 Set the modulation depth.

Press the **AM Depth** softkey and then set the value to 80% using the numeric keypad or the knob and cursor keys.



4 **Set the modulating frequency.**

Press the **AM Freq** softkey and then set the value to 200 Hz using the numeric keypad or the knob and cursor keys.

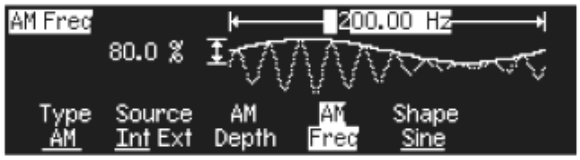
5 **Select the modulating waveform shape.**

Press the **Shape** softkey to select the shape of the modulating waveform. For this example, select a sine wave.

At this point, the function generator outputs an AM waveform with the specified modulation parameters (if the output is enabled).

6 **View the waveform.**

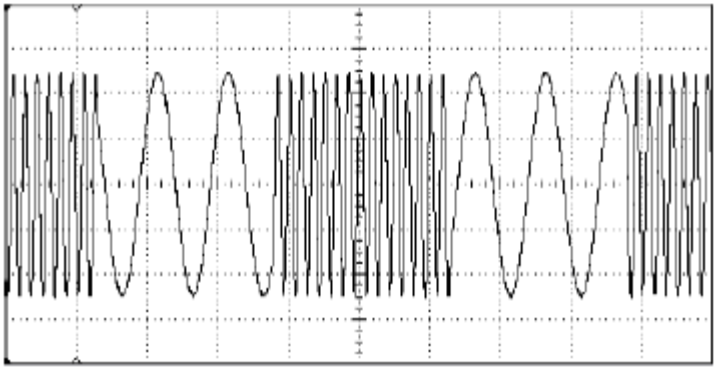
Press Graph to view the waveform parameters.



To turn off the Graph Mode, press Graph *again.*

To Output an FSK Waveform

You can configure the function generator to "shift" its output frequency between two preset values using FSK modulation. The rate at which the output shifts between the two frequencies (called the "carrier frequency" and the "hop frequency") is determined by the internal rate generator or the signal level on the rear-panel *Trig In* connector. *For this example, you will set the "carrier" frequency to 3 kHz and the "hop" frequency to 500 Hz, with an FSK rate of 100 Hz.*



1 Select the function, frequency, and amplitude of the carrier.

Press Sine and then press the **Freq**, **Ampl**, and **Offset** softkeys to configure the carrier waveform. *For this example, select a 3 kHz sine wave with an amplitude of 5 Vpp.*

2 Select FSK.

Press Mod and then select "FSK" using the **Type** softkey. Notice that a status message "FSK" is shown in the upper-left corner of the display.

3 Set the "hop" frequency.

Press the **Hop Freq** softkey and then set the value to 500 Hz using the numeric keypad or the knob and cursor keys.

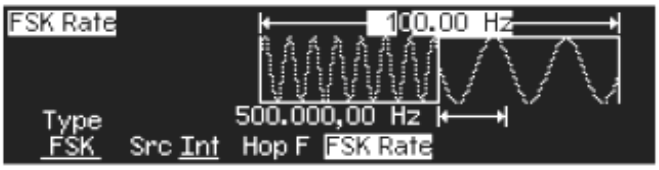
4 Set the FSK "shift" rate.

Press the **FSK Rate** softkey and then set the value to 100 Hz using the numeric keypad or the knob and cursor keys.

At this point, the function generator outputs an FSK waveform (if the output is enabled).

5 View the waveform.

Press Graph to view the waveform parameters.



To turn off the Graph Mode, press Graph again.

To Output a PWM Waveform

You can configure the function generator to output a pulse width modulated (PWM) waveform. The Agilent 33220A provides PWM for pulse carrier waveforms, and PWM is the only type of modulation supported for pulse waveforms. In PWM, the pulse width or duty cycle of the carrier waveform is varied according to the modulating waveform. You can specify either a pulse width and width deviation, or a pulse duty cycle and duty cycle deviation, the deviation to be controlled by the modulating waveform.

For this example, you will specify a pulse width and pulse width deviation for a 1 kHz pulse waveform with a 100 Hz sine wave modulating waveform.

1 Select the carrier waveform parameters.

Press Pulse and then press the **Freq**, **Ampl**, **Offset**, **Width**, and **Edge Time** softkeys to configure the carrier waveform. For this example, select a 1 kHz pulse waveform with an amplitude of 1 Vpp, a zero offset, a pulse width of 100 µs, and an edge time of 50 ns.

2 Select PWM.

Press Mod (PWM is the only modulation type for **Pulse**). Notice that a status message "PWM by Sine" is shown in the upper-left corner of the display.

3 Set the width deviation.

Press the **Width Dev** softkey and set the value to 20 µs using the numeric keypad or the knob and cursor keys.

4 **Set the modulating frequency.**

Press the **PWM Freq** softkey and then set the value to 5 Hz using the numeric keypad or the knob and cursor keys.

5 **Select the modulating waveform shape.**

Press the **Shape** softkey to select the shape of the modulating waveform. For this example, select a sine wave.

At this point, the function generator outputs a PWM waveform with the specified modulation parameters (if the output is enabled).

6 **View the waveform.**

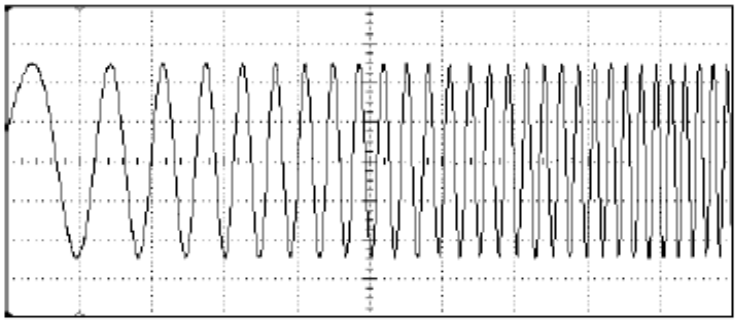
Press Graph to view the waveform and parameters.

To turn off the Graph Mode, press Graph again.

Of course, to really view the PWM waveform, you would need to output it to an oscilloscope. If you do this, you will see how the pulse width varies, in this case, from 80 to 120 µs. At a modulation frequency of 5 Hz, the deviation is quite visible.

To Output a Frequency Sweep

In the frequency sweep mode, the function generator "steps" from the *start frequency* to the *stop frequency* at a *sweep rate* which you specify. You can sweep up or down in frequency, and with either linear or logarithmic spacing. *For this example, you will output a swept sine wave from 50 Hz to 5 kHz. You will not change the other parameters from their default settings: internal sweep trigger, linear spacing, and 1 second sweep time.*



1 Select the function and amplitude for the sweep.

For sweeps, you can select sine, square, ramp, or arbitrary waveforms (pulse, noise, and dc are not allowed). *For this example, select a sine wave with an amplitude of 5 Vpp.*

2 Select the sweep mode.

Press Sweep and then verify that the linear sweep mode is currently selected. Notice that a status message "Linear Sweep" is shown in the upper-left corner of the display.

3 Set the start frequency.

Press the **Start** softkey and then set the value to 50 Hz using the numeric keypad or the knob and cursor keys.

4 Set the stop frequency.

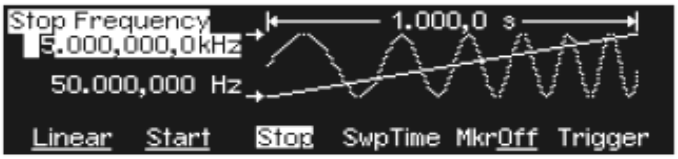
Press the **Stop** softkey and then set the value to 5 kHz using the numeric keypad or the knob and cursor keys.

At this point, the function generator outputs a continuous sweep from 50 Hz to 5 kHz (if the output is enabled).

Note: If desired, you can set the frequency boundaries of the sweep using a *center frequency* and *frequency span*. These parameters are similar to the start frequency and stop frequency and are included to give you added flexibility. To achieve the same results, set the center frequency to 2.525 kHz and the frequency span to 4.950 kHz.

5 View the waveform.

Press Graph to view the waveform parameters.



To turn off the Graph Mode, press Graph *again.*