EXPERIMENT I

INTRODUCTION TO LABORATORY EQUIPMENT FOR CHARACTERIZATION OF BASIC ELECTRICAL PARAMETERS

OBJECTIVE: In this experiment, you will learn:

1. **i.** To read the color codes of resistors.
   ii. To use a potentiometer.
   iii. To use the multimeter for resistance measurements.
2. Use of power supply and multimeter for parametric I-V characterization.
3. Basic usage of an oscilloscope.
4. Measuring the amplitude and frequency of a periodic AC signal.

EQUIPMENT LIST:
Function Generator
DC Power Supply
Digital Multimeter
Digital Oscilloscope
Carbon Resistors (1 kΩ, 4.7 kΩ, 18 kΩ),
Potentiometers (1 kΩ POT and 10 kΩ POT)

PRELIMINARY WORK:

1. **Read the laboratory instructions document. Do not forget to bring graph papers and A4 papers and a ruler for preparing the laboratory report of this experiment.**

2. **Lab Equipment**

   A. Agilent 33220A 20 MHz Function Generator

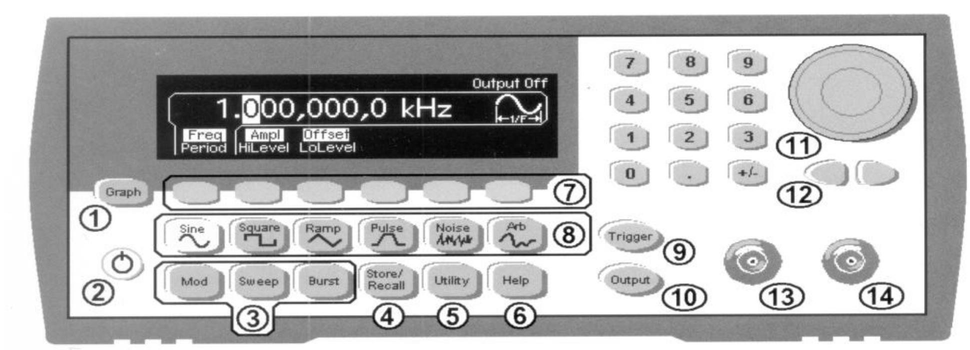


Fig: Agilent Function/Arbitrary Waveform Generator (Model 33220A)

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

Usage Description:

STEP 1: TURN ON

Press the On/Off Switch:

The self test takes a few seconds, and then the instrument defaults to Menu Mode with the sine wave function selected:

Note: To protect your equipment, no signal is output until the Output key is pressed (lighted).

STEP 2: SELECT WAVEFORM

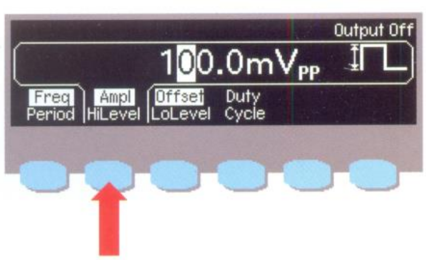
To select a waveform, press the appropriate key. For example, press the Square key to select a square wave. Try it!

The square wave menu is displayed:

STEP 3: SELECT PARAMETER

Use the six softkeys to select parameters. Some softkeys toggle between related parameters (for example: **Freq** and **Period**).

For example, press the **Ampl** softkey to select amplitude:



STEP 4: CHANGE WAVEFORM PARAMETER

Now let's change the value using the knob.

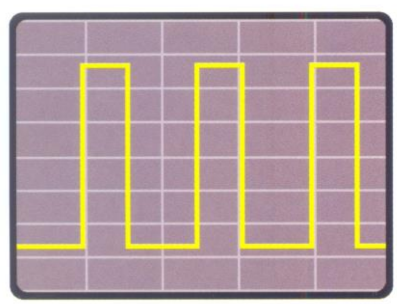
First, use the cursor keys ( ) to select the first digit. Try it!

Now, use the knob to change the value (turn clockwise to increase). Set it to **500 mVpp**:

NOTE: Parameters can also be changed using the numeric keypad

STEP 5: OBSERVE OUTPUT

You can view the waveform at any time on an oscilloscope if one is connected. Press Output to activate the Output connector.



33220A Function Generator Critical Specifications:

20 MHz Sine & Square Waveforms
Pulse, Ramp, Triangle, Noise, And DC Waveforms
Frequency resolution = 1 µHz   Amplitude resolution = +/- 1 mV_{pp}
10 mV_{pp} to 10 V_{pp} amplitude range for 50 Ω load (doubles in open circuit mode)
Typical output impedance is 50 Ω

B. Agilent E3631A Programmable DC Power Supply

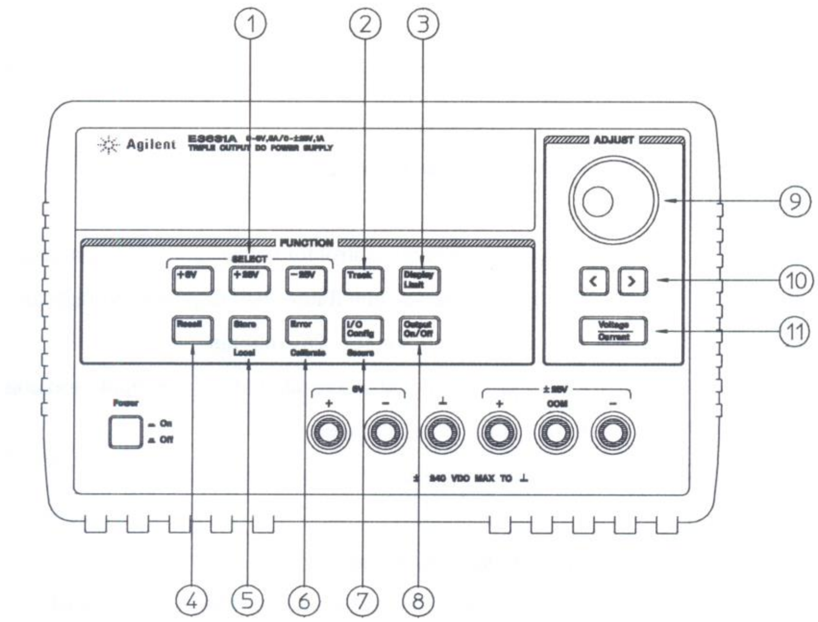


Fig: Agilent Triple Output DC power Supply (Model: E3631A)

1. Meter and Adjust Selection Key	7. I/O Configuration / Secure Key
2. Tracking Enable/Disable key	8. Output On/Off Key
3. Display Limit Key	9. Control Knob
4. Recall Operation State Key	10. Resolution Selection Key
5. Store Operation State/Local Key	11. Voltage/Current Adjust Selection Key
6. Error/Calibrate Key	

Usage Description (By Key Number):

1. Select the output voltage and current of any one supply (+6V, +25V, or -25V output) to be monitored on display and allow knob adjustment of that supply.
2. Enables / Disables the track mode of ±25V supplies.
3. Shows the voltage and current limit values on the display and allow knob adjustment for setting limit values.
4. Recalls a previously stored operating state from location “1”, “2”, or “3”.
5. Stores the operating state in location “1”, “2”, or “3” / or returns the power supply to local mode from remote interface mode.
6. Displays error codes generated during operation, self-test and calibration / or enables calibration mode (the power supply must be unsecured before performing calibration).
7. Configures the power supply for remote interface / or secure and unsecure the power supply for calibration.
8. Enable or disables all three power supply outputs. This key toggles between two states.
9. Increase or decrease the value of the blinking digit by turning clockwise or counter clockwise.
10. Move the flashing digit to the right or left.
11. Selects the knob function to voltage control or current control.

E3631A Power Supply Critical Specifications:

Independent Outputs → 0 – 6V / 5A 0 – +25V / 1A 0 – -25V / 1A
Resolution 0.5 mV / 0.5 mA
Maximum Output Power → 80W

C. Agilent 34401A Digital Multimeter

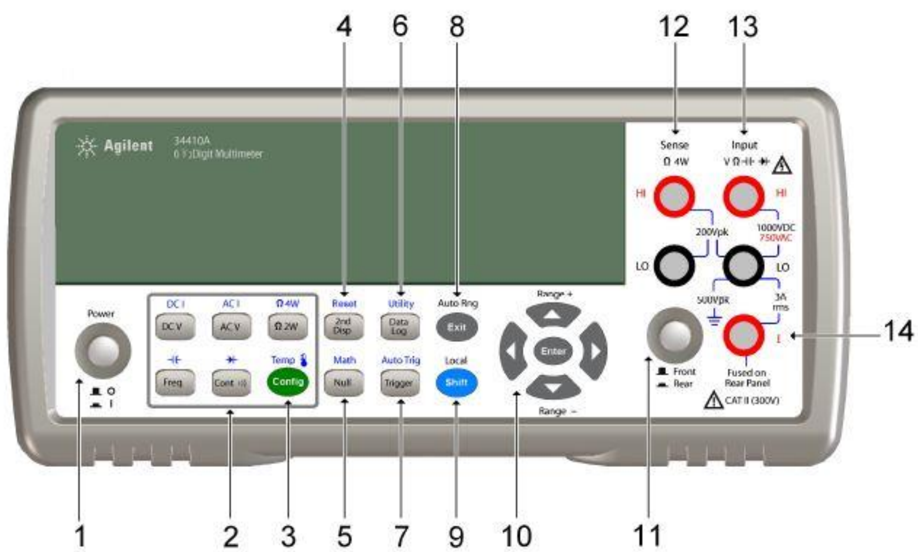


Fig: Agilent Digital Multi-meter (Model: 34401/34410 A)

1. On/Off Switch	8. Exit Key (Auto Range)
2. Measurement Function Keys	9. Shift Key (Local)
3. Configuration Key	10. Menu Navigation Keypad (Range)
4. Second Display Key (Reset)	11. Front/Rear Switch
5. Null Key (Math Function)	12. Hi & LO Sense Terminals (4-wire meas.)
6. Data Logger Key (Utility)	13. Hi & LO Input Terminals (all functions except current)
7. Trigger Key (Auto Trig)	14. Current Input Terminal (AC & DC Current)

Usage Description:

a) Function keys help to switch between measurement Functions which include DC V (DC Voltage), AC V (AC Voltage), and Ω 2W (Resistance).

b) To measure Current, same function keys are used along with Shift (Key # 4) to toggle between DC I (DC Current), AC I (AC Current), and Ω 4W (Resistance) respectively

Digital Multimeter Critical Specifications:[1]

Characteristics	Measurement Function	Range	% Error
DC	Voltage	100 mV	0.0060
		1 V	0.0026
		10 V	0.0019

		100 V	0.0026
	Current	100 µA	0.0300
		1 mA	0.0130
		10 mA	0.0270
		100 mA	0.0140
		1 A	0.0560
Resistance	Resistance	100 Ω	0.0060
		1 KΩ	0.0025
		10 KΩ	0.0025
		100 KΩ	0.0025
		1 MΩ	0.0030
		10 MΩ	0.0110
AC	Voltage (100 mV – 750 V)	3 Hz – 5 Hz	0.5200
		5 Hz – 10 Hz	0.1200
		10 Hz – 20 KHz	0.0400
		20 KHz – 50 KHz	0.0900
	Current (100 µA – 3A)	3 Hz – 5 KHz	0.1400
		5 KHz – 10 KHz	0.2400

[1] For detailed specifications of device accuracy measurement, please refer to the datasheet provided on webpage

D. Agilent Oscilloscopes

Oscilloscope Critical Specifications:

Bandwidth	60MHz Limit → 20 MHz
Vertical Sensitivity	2mV/div to 5V/div 5ns/div to 50s/div
DC gain accuracy	±3% for 10mv/div to 5V/div ±4% for 2mv/div to 5mV/div

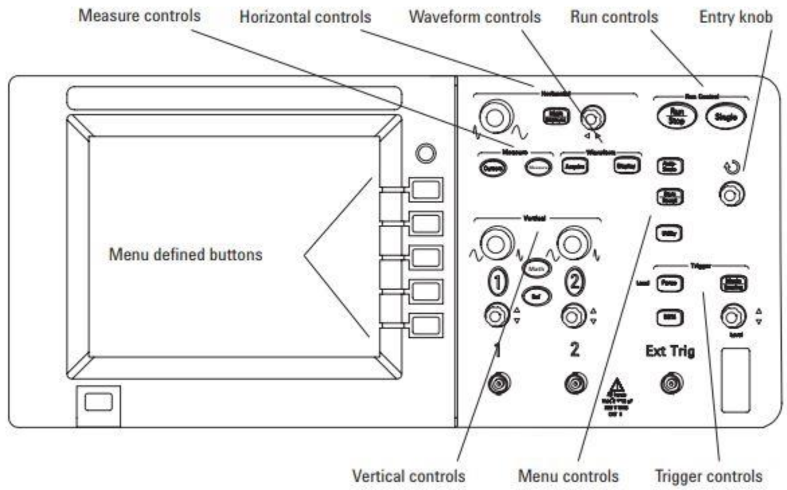


Fig: Agilent Oscilloscope (Model DSO3062A)

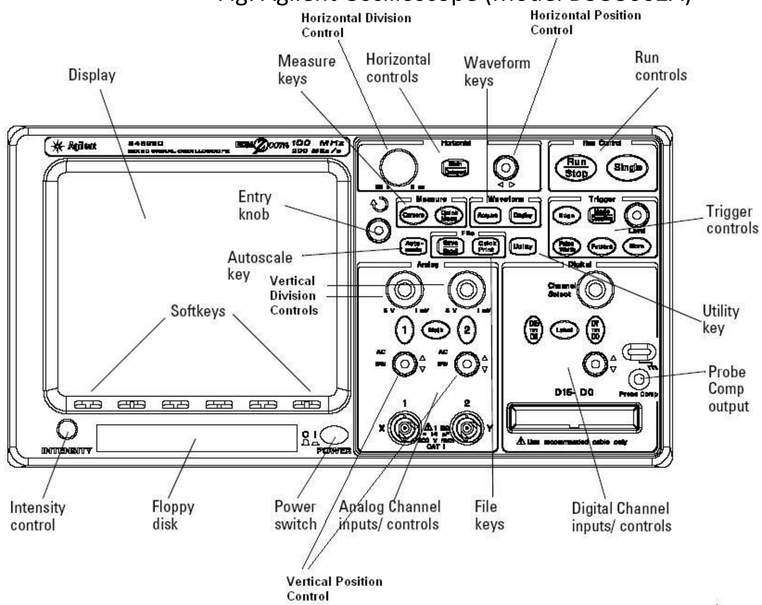


Fig: Agilent Oscilloscope (Model 54622D)

EXPERIMENTAL WORK:

1. Comparison of Resistance Measurements with Specifications

- **i.** Reading the color codes, determine the nominal value and tolerance of each carbon resistor and record them.
- **ii.** Measure the value of the resistor from Part ‘a’ with the digital multimeter.
- **iii.** Document specified (color code) and measured values of the resistors in tabular form, as below, as well as the deviation of the measurements from expectation.

Comment on how the measurements perform against the specified tolerance from the vendor.

Table 1

Resistor #	Spec value (k)	Spec tolerance (%)	Measured value (k)	Error (%) with respect to spec
1				
2				
3				

- **iv.** Measure the minimum and maximum values of the potentiometers 1 kΩ POT and 10 kΩ POT using the digital multimeter.

Table 2

POT #	Spec Resistance Range ( )	Measured Min value ( )	Error (%) with respect to spec	Measured Max value ( )	Error (%) with respect to spec
1					
2					

2. Comparison between Resistance Measurement Methods based on Measurement Accuracy

Set up the circuit given in Fig.1.1 to find the resistance of the carbon resistor. Initially, set the output voltage of the power supply, V, to following values: 2, 4, 6 and 8 volts. For each value of V, measure I by using the multimeter and record those values.

- **a.** Plot I versus V graph. Determine the slope and evaluate the resistance R.
- **b.** Measure and record the resistance of the resistor using the multimeter.
- **c. Compare the results obtained in parts a and b against the expected value. Which resistance characterization method (between a and b) do you think is more accurate ? Why ?**

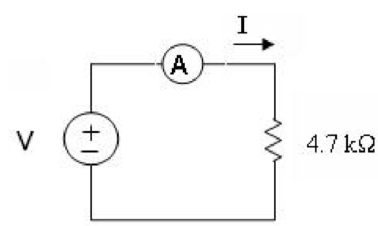


Fig 1.1

Table 3

Voltage (V)	Measured Current (A)	Spec value (k)	Spec tolerance	Measured value (k) using multimeter (part b above)	Measured value (k) using I-V method (part a above)	Error (%) of the resistance measurement using I-V method with respect to spec
2						
4						
6						
8						

3. Getting Familiar with the Oscilloscope

a) Basic Waveform Amplitude and Frequency Measurements using Oscilloscope

Turn the oscilloscope on. Connect the signal lead of the probe corresponding to Channel 1 to the "Probe Comp" output of the oscilloscope. Press the "Autoscale" key. At this instant you observe a square wave signal generated by the oscilloscope. Observe the reference point, which is shown by (⏚) sign, in the left side of the display which corresponds to the ground level of the waveform. Plot this waveform onto a graph paper and measure the peak-to-peak amplitude and the period of the signal by counting the squares in the display. Record these values. Then calculate the frequency of the signal using the recorded period.

- **i.** Play with the "Vertical Division Control" of the Channel 1 and observe the changes in the waveform. What is happening? Measure the amplitude again in one of the positions when you change the "Vertical Division Control". Is there any change in the amplitude value of the signal?
- **ii.** Play with the "Horizontal Division Control" of the oscilloscope and observe the variations in the display. What is happening? Measure the period again in one of the positions when you change the "Horizontal Division Control". Is there any change in the period of the signal?
- **iii.** Play with the "Vertical Position Control" and observe the changes in the display.
- **iv.** Play with the "Horizontal Position Control" and observe the changes in the display.

b) Channel inversion

Press Channel 1 selection button. Be sure that Channel 1 is active. At this instant you should be observing a menu in the bottom/left side of the display. Now press the "Invert" soft key from the menu. Observe and explain the change in the waveform. After observation, cancel the "Invert" mode operation

c) Automatic waveform measurements

Press "Quick Meas" button. A menu will appear in the bottom of the display. The second soft key from left determines the measurement you want to make.

- **i.** Press that soft key and select the amplitude from the submenu. Now measure the amplitude by pressing "Measure Ampl" soft key.
- **ii.** Using the submenus, measure the frequency of the waveform.
- **iii.** Measure the period of the signal in the same way. Check the period and frequency measurements to ensure they are consistent (Frequency = 1 / Period).

Use the "Clear Meas" soft key to clear all of the existing measurements. The usage of the "Quick Meas" and "Cursors" for Channel 1 is similar to the ones in Channel 2.

d) Sinusoidal signal generation and characterization

Turn the function generator on. Set the function generator to "High Z" mode

Press UTILITIY → I/O Setup → High Z ON → Done/Save

Select the sinusoidal waveform mode. Adjust the amplitude to 3 V_{pp} and frequency to 1.205 kHz. Then connect the Channel 1 probe of the oscilloscope to the output of the function generator. Enable the output of the function generator by pressing the "Output" button of the function generator. Press the "Autoscale" button on the oscilloscope. At this instant you will be observing a sinusoidal signal on the display.

- **i.** Plot this waveform and measure the amplitude and the period of the signal by counting the squares on the screen.
- **ii.** Make these measurements also with the help of "Quick Meas" function
- **iii.** Do the measurements in (a) and (b) match the expected values?