LAB I: INTRODUCTION TO THE OSCILLOSCOPE, FUNCTION GENERATOR AND DIGITAL MULTIMETER

A) OSCILLOSCOPE (SCOPE)

- AN OSCILLOSCOPE (SCOPE) IS AN INSTRUMENT WHICH CAN DISPLAY VOLTAGE VERSUS TIME

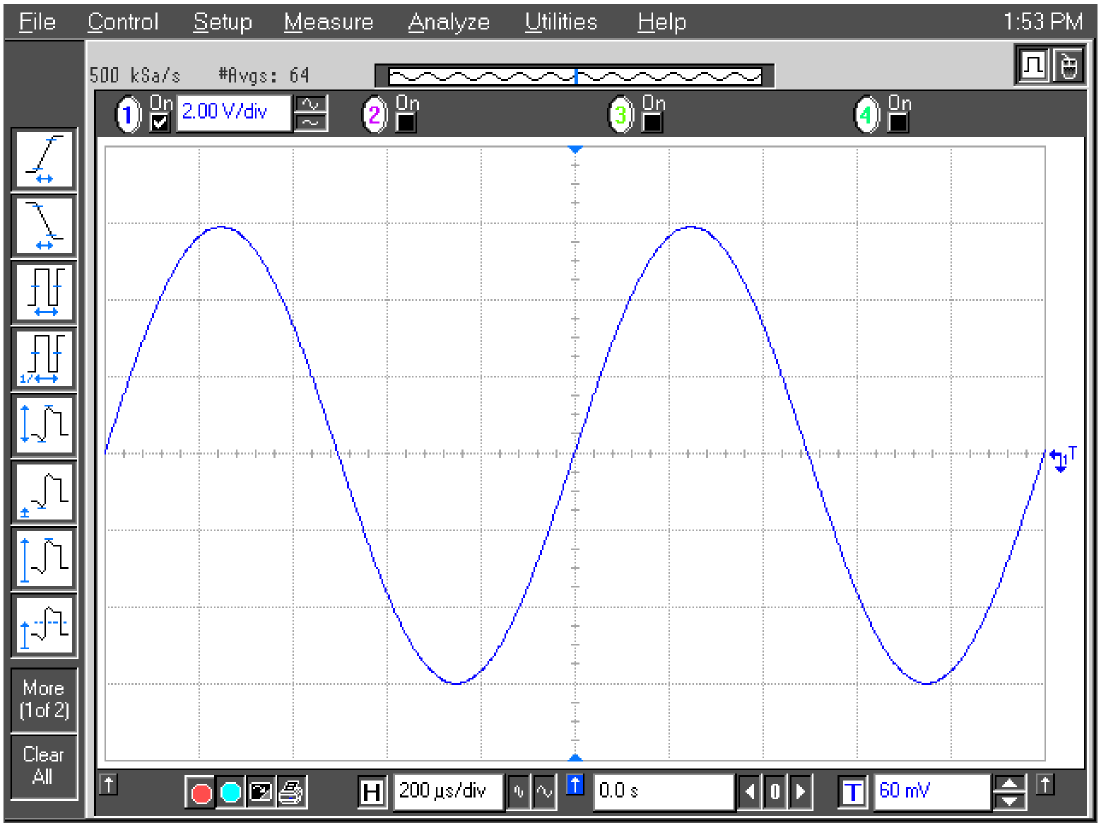
- THE SCOPE USED IN THIS LAB IS A TWO-CHANNEL DIGITAL STORAGE SCOPE.

- THE "TWO-CHANNEL" MEANS THAT WE CAN OBSERVE TWO DIFFERENT VOLTAGES AT THE SAME TIME.

- THE "DIGITAL STORAGE" MEANS THAT A VOLTAGE IS CONVERTED TO A SERIES OF BINARY NUMBERS (0,1) WHICH ARE THEN STORED IN MEMORY AND THEN CONVERTED FOR A MONITOR TO DISPLAY.

– DISPLAYED BELOW IS $6 \sin(2\pi \cdot 1000 t)$

y-AXIS SCALE ↙



↖ X-AXIS SCALE

WHERE ⬇ = 0 VOLT REFERENCE FOR THE CHANNEL

– NOTE: THE X-AXIS AND y-AXIS SCALES REFER TO THE MAJOR (LARGE) DIVISIONS

– FOR THIS WAVEFORM, 6 MAJOR DIVISIONS × 2V/DIV = 12 VOLTS (PEAK-TO-PEAK) AND FOR ONE PERIOD 5 DIVISIONS × 200µs/DIV = 1000µs

$$\therefore \text{PERIOD} \triangleq T = \frac{1}{\text{FREQUENCY}} \triangleq \frac{1}{f} \Rightarrow f = \frac{1}{1000\mu s} = 1\,\text{KHZ}$$

B) Resistors

– Color Code

Color	Value	Color	Value
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet	7
Orange	3	Gray	8
Yellow	4	White	9

Tolerance	
Gold	5%
Silver	10%
None	20%

$$R = \underline{\text{Band 1}}\ \underline{\text{Band 2}} \times 10^{\underline{\text{Band 3}}}$$

$$\text{Tolerance} = \pm\ \underline{\text{Band 4}}$$

– Example : Red - Violet - Yellow - Gold

$$\underline{2}\ \underline{7} \times 10^{\underline{4}} = 270\,k\Omega \pm 5\%$$

$$270k(1-0.05) \le R \le 270k(1+0.05)$$

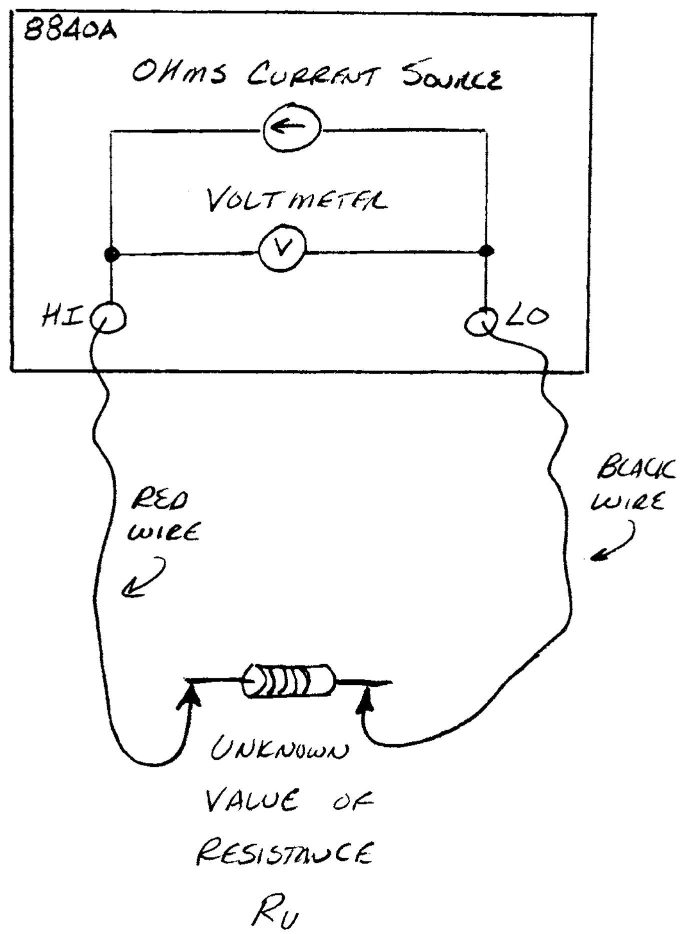
$$256.5\,k\Omega \le R \le 283.5\,k\Omega$$

C) FLUKE DIGITAL MULTIMETER (DMM) - MODEL 8840A

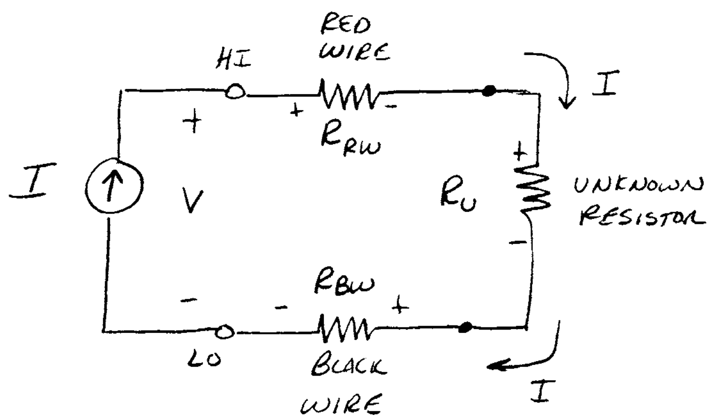
– 2-WIRE RESISTANCE MEASUREMENT

THE FLUKE DMM USES A CURRENT SOURCE TO CREATE A VOLTAGE DROP ACROSS AN UNKNOWN RESISTOR.

BY MEASURING ITS VOLTAGE, THE METER CAN CALCULATE THE VALUE OF RESISTANCE, R_U, USING OHM'S LAW



- WE COULD MODEL THIS WITH THE FOLLOWING CIRCUIT :



$$V = I R_{RW} + I R_U + I R_{BW}$$

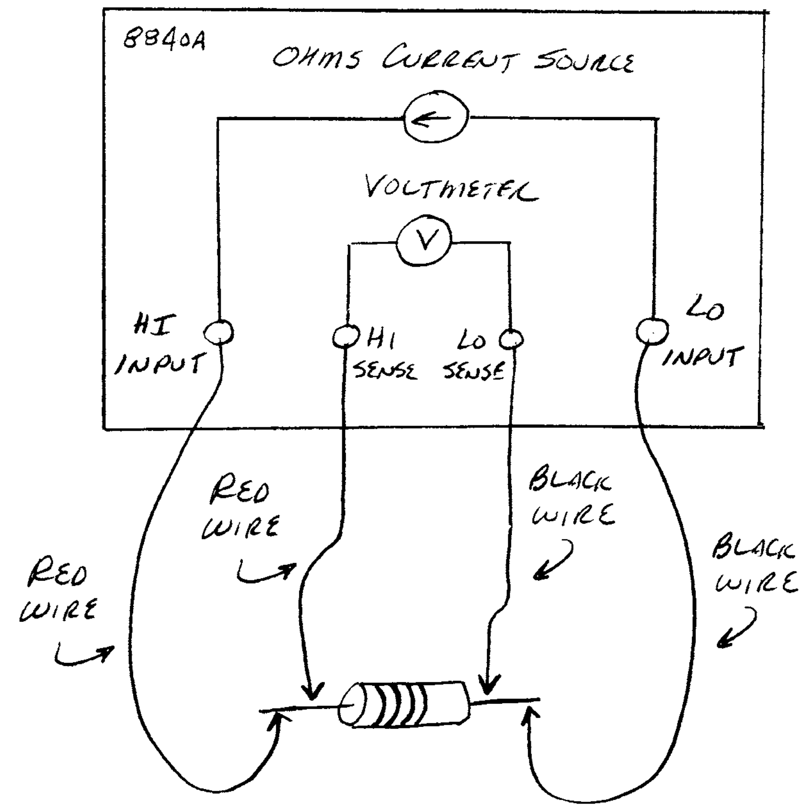
$$\therefore \quad \frac{V}{I} = R_{RW} + R_U + R_{BW}$$

$$\cong R_U \quad \text{IF} \quad R_{RW} + R_{BW} << R_U$$

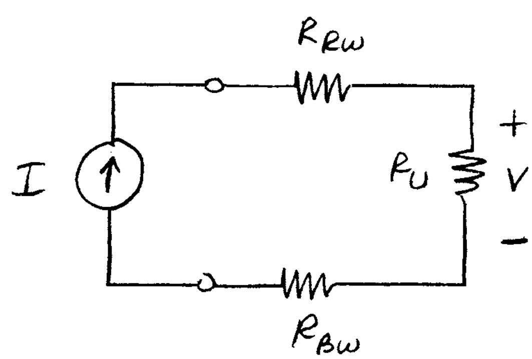
- THE WIRES IN LAB HAVE A SMALL VALUE FOR THEIR RESISTANCE WITH TYPICAL VALUES OF $0.05\,\Omega$ TO $0.5\,\Omega$

- SUPPOSE WE NEED TO MEASURE A RESISTANCE THAT IS IN THE RANGE OF 1 TO $10\,\Omega$. IS THERE A WAY TO MEASURE THIS ACCURATELY ?

– 4-WIRE RESISTANCE MEASUREMENT



– WE COULD MODEL THIS AS:



NOW $\frac{V}{I} = R_U$

E) ACCURACY

- THE FLUKE 8840 A IS A $5\frac{1}{2}$ DIGIT MULTIMETER WITH DISPLAYED VALUES FROM

  0 0 0 0 0 0 TO 1 9 9 9 9 9

  (the leading 1 is) CALLED A "$\frac{1}{2}$" DIGIT

- ALL DIGITAL DISPLAYS HAVE AN ACCURACY THAT IS SPECIFIED IN TERMS OF A TOLERANCE AND ERROR DIGITS

  FOR EXAMPLE, ON THE $20K\Omega$ RANGE THE FLUKE 8840A HAS AN ACCURACY OF

  $\pm$ [0.0028% OF READING + 2 DIGITS]

- EXAMPLE: $R = 13.3413\ K\Omega$

  THEN $(0.000028)(13.3413K) = 0.0003735564K$

  $+ \quad 2 \text{ DIGITS} = 00.0002 \quad K$

  ACCURACY $= \pm 0.0005735564K$

THIS MEANS THAT THE ACTUAL VALUE OF R FALLS BETWEEN

$$13.3413\,K - 0.0005735564\,K = 13.34072644\,K$$

AND

$$13.3413\,K + 0.0005735564\,K = 13.34187355\,K$$

THAT IS

$$13.34072644\,K\Omega \le R \le 13.34187355\,K\Omega$$

OR IN OTHER WORDS, WE CAN COUNT ON THE FIRST 4 PLACES DISPLAYED OF

$$R = \boxed{1\ 3\ .\ 3\ 4}\ 1\ 3\ K\Omega$$

⇐ THIS IS REALLY VERY GOOD!

(TRY THIS EXAMPLE ON YOUR OWN:

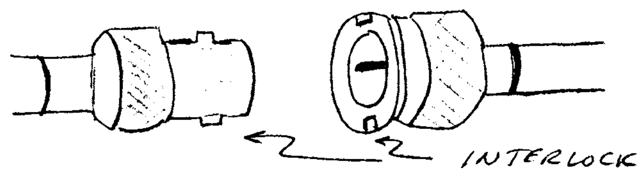
$$R = 0.3\ 2\ 7\ 8\ 6\ M\Omega$$

WHERE THE TRUE VALUE OF R FALLS BETWEEN

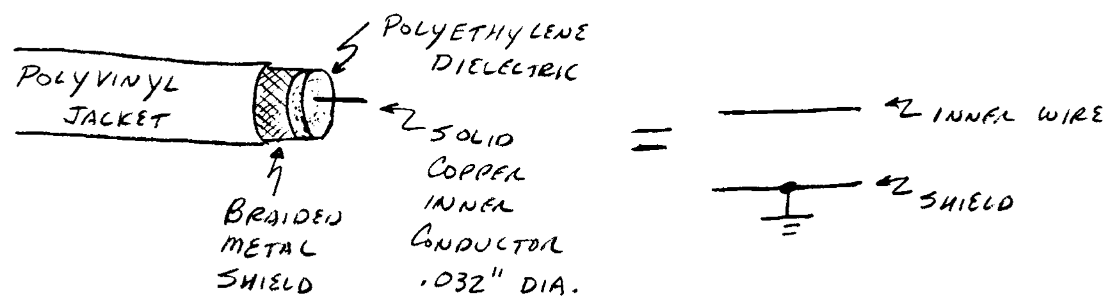
$$327.8308199\,K\Omega \le R \le 327.8891801\,K\Omega$$
)

F) WIRES AND CONNECTORS

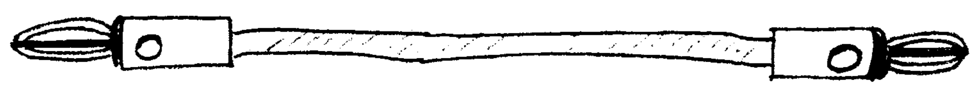
1) BNC CONNECTORS AND WIRES



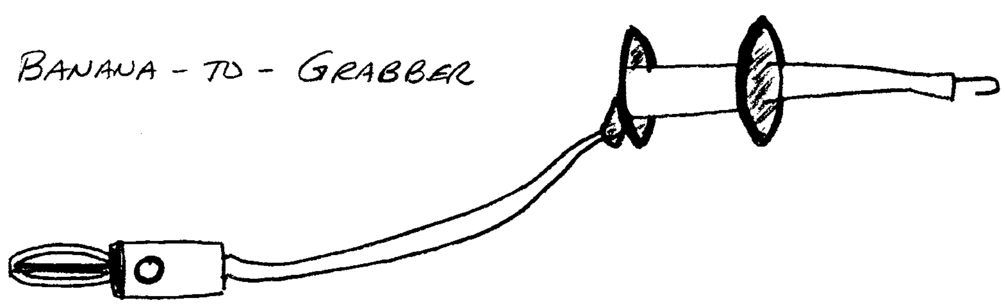
— COAXIAL CABLE



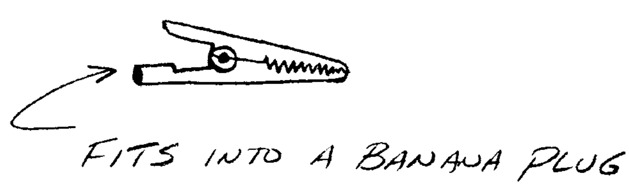
2) BANANA - TO - BANANA



3) BANANA - TO - GRABBER

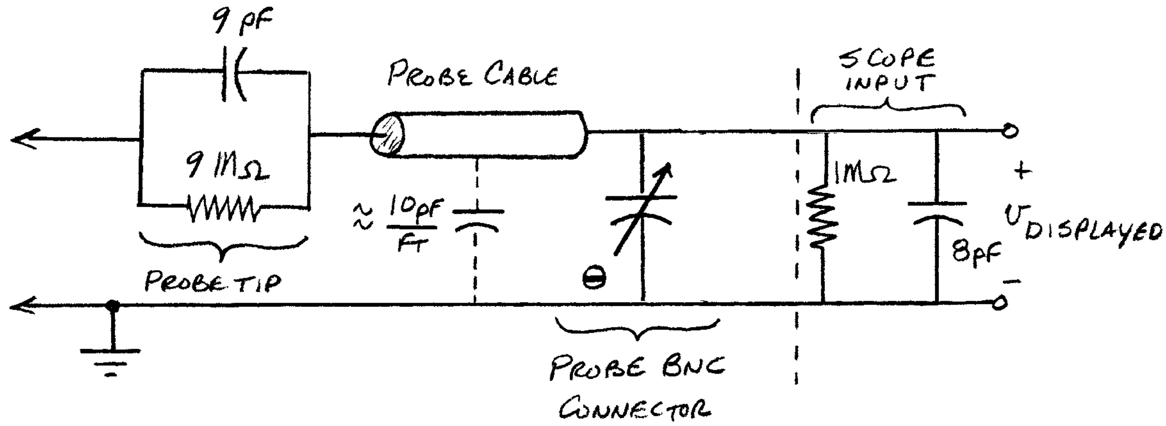


4) ALLIGATOR CLIP



G) Probes

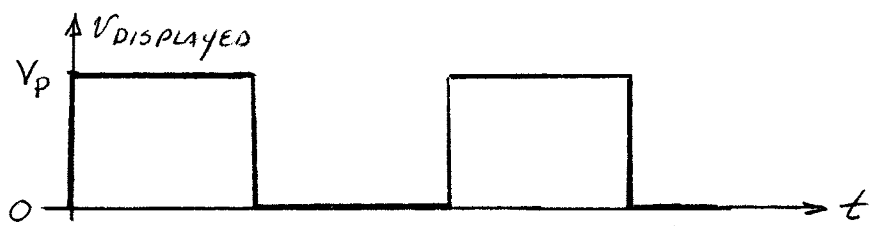
– The 10:1 Probe



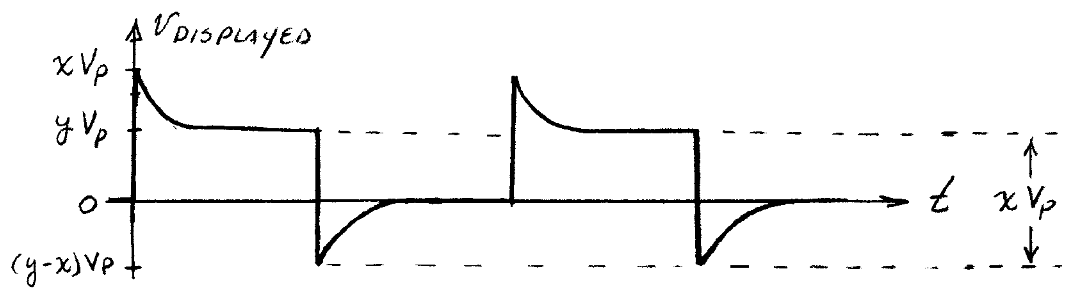
1) Square-wave Response

x = Cap. Volt. Divider $\qquad$ y = Res. Volt. Divider

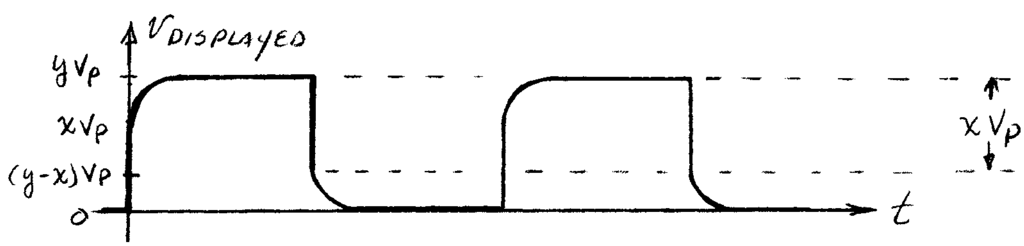
a) Balanced $(x = y)$



b) Over-compensated $(x > y)$



c) Under-compensated $(x < y)$



ECE 404L: RF ELECTRONICS LABORATORY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

MICHIGAN STATE UNIVERSITY

I. **TITLE:** Lab I - Introduction to the Oscilloscope, Function Generator and Digital Multimeter

II. **PURPOSE:** The oscilloscope, function generator and digital multimeter are the basic tools in the measurement and testing of circuits. This lab reviews the operation of these instruments along with the use of a compensated probe.

The concepts covered are:

1. equivalent circuits of the oscilloscope inputs, function generator output and digital multimeter inputs;
2. the use of a balanced bridge to compensate for the stray capacitance of a measuring cable and the equivalent impedance of the oscilloscope;
3. accuracy of components and instruments.

The laboratory techniques covered are:

1. voltage amplitude and time measurement with an oscilloscope;
2. a procedure for compensating an oscilloscope probe;
3. measurement of resistance including small values.

III. BACKGROUND MATERIAL:

See Lab Lecture Notes.

IV. EQUIPMENT REQUIRED:

1	Agilent 54833A Infiniium Oscilloscope
1	Agilent 33250A Function / Arbitrary Waveform Generator
1	Fluke 8840A Digital Multimeter
2	Agilent 1161A 10:1 Miniature Passive Probes

V. PARTS REQUIRED:

1	12 Ω ± 5% (Brown-Red-Black-Gold) resistor
1	330 Ω ± 5% (Orange-Orange-Brown-Gold) resistor
1	5.6 kΩ ± 5% (Green-Blue-Red-Gold) resistor

VI. LABORATORY PROCEDURE:

A) Initial Operation of the Infiniium Oscilloscope

1. If the 10:1 probes are connected to the scope, carefully disconnect them by holding the tab underneath the BNC connector unit to the right while *gently* pulling. If you have ANY difficulty please ask your lab instructor for help. These probe are very delicate. Place them to the side for now

2. Press in the power switch button (ϕ) found in the lower left corner of the front panel of the scope. It takes a few minutes to boot-up the scope. The scope can also be viewed with the monitor on your lab bench. **Hit the scroll lock key on the keyboard twice to toggle the display between the PC and the scope.** (Please note that there are two logins, one for the scope and one for the PC. We only need to do the scope login for now. It is easy to confuse the two.)

   Wait until a grid appears on the screen before going to the next step.

3. Press the **Default Setup** button located near the top center of the scope. The display will pause momentarily while the scope is configured to its default settings. This will clear what the last user had set.

B) Agilent 33250A 80 MHz Function / Arbitrary Waveform Generator

1. The laboratory function generator is a precision voltage source of sine waves, square waves, ramping waves, pulse waves, random noise and arbitrary waveforms which includes built-in functions such as cardiac waveforms and exponential waveforms. It can also generate almost any waveform with up to 65,536 (64k) data points by using external software.

2. Press in the power switch button (ϕ) found in the lower left corner of the function generator. The display should light up with **1.000,000,0 kHz** displayed.

C) Waveform Measurement

1. Coaxial cable is the most common method of connecting an oscilloscope to signal sources and equipment having output connectors. The outer conductor of the cable shields the central signal conductor from hum and noise pickup. These cables are usually fitted with a BNC connector on each end. *(BNC is short for **B**ayonet **N**eill **C**oncelman and is named after Paul Neill of Bell Labs and Amphenol engineer Carl Concelman. BNC connectors are generally designed to operate reliably up to at least 4 GHz.)* You can find BNC cables hanging on the wall.

   Connect a BNC cable from the **Output** of the function generator found on the lower-right side of the function generator to the channel ❶ input terminal of the scope found on the lower-center of the scope.

Our first task will be to generate a voltage equal to 0.3 sin (2π 500 t).

2. Press the button on the function generator with the sine wave symbol on it. This is the upper-left button in a set of twelve rectangular buttons. A sine wave symbol should be displayed on the far right of the display and the button should be lit. This indicates that we have selected this particular waveform. This is also the default when the generator is first turned on.

3. We next need to set the frequency of the waveform. This is done with the **Freq** option. This is selected with the dark gray button under the display. Locate this button and press it. The word **Freq** or **Period** will be highlighted. Press the button until **Freq** is highlighted. The value is entered by rotating the knob on the upper right side. Rotate it until **500.000,00 Hz** is displayed. The frequency is now selected to be 500 Hz.

4. The amplitude of our waveform is set with the **Ampl** option. This is located to right of the **Freq** option. Highlight this option and the peak-to-peak value of the waveform can be set. Rotate the knob until a value of **600.0 mVPP** is displayed. To connect this waveform to the output terminal of the function generator, you need to press the oval button labeled **Output** which is located on lower right side of the function generator.

   You now have generated a voltage with the expression 0.3 sin (2π 500 t).

5. The function generator is calibrated for a connection to a circuit with a 50 Ω input resistance. Our scope has one built inside of it. Press the **Input** button on the scope for channel ❶. This is located in the center of the scope above a small knob with a yellow dot in its center. A red light with 50 Ω should be on.

6. Press the **Auto-Scale** button located near the top-center of the scope. The display will pause momentarily while the scope adjusts the x- and y-axes. A waveform should now appear on your scope screen. If not, ask your lab instructor for help.

7. The number found in the top-left of the screen is the value for each of the vertical major divisions. These are the large squares of the screen grid. Counting the number of these divisions from the highest to lowest point of your sine wave and multiplying this times the setting displayed in the top-left of the screen is the peak-to-peak value of your sine wave. This may be difficult to read depending on what the autoscale function selected.

You can adjust the value of the vertical volts/div by using the large knob in the group labeled **Vertical** located in the center of the scope. Note that the channel ❶ input has a yellow dot painted on the knob and the channel ❷ input has a green dot painted on the knob. The display colors also agree with this color coding, that is, channel ❶ traces are displayed in yellow and the channel ❷ traces are displayed in green.

If your volts/div setting is not **100 mV/div**, turn the large knob for channel ❶ and adjust the volts/div scale to this value. (If you turned the small knob with a yellow dot painted on it by mistake, press the Auto-Scale button and repeat the above step).

Note that there is a ground symbol with a number 1 on the far right of the screen. This indicates where the zero volt reference is located for your displayed waveform. (There may also be a letter T displayed next to the ground symbol. This is the reference for the triggering of the display.)

8. Detach the Lab Report section of this lab. You will hand this in at the end of lab. A Lab Report is required for each member of your group.

   Calculate the measured peak-to-peak value of your sine wave using the setting of the scope, that is, the voltage per division times the number of major divisions. Record this, and all data that follows, as indicated in the Lab Report. If your calculated peak-to-peak voltage is not 0.6, ask your instructor for help.

9. The number in the lower-center-left of the scope screen is value of the horizontal divisions per unit of time. This may be set to **500 μsec/div**. The large knob in the group labeled **Horizontal** in the center of the scope allows the user to adjust the seconds/division. Turn this knob to **1.00 msec/div** and **200 μsec/div** and observe what happens. Now set this to **500 μsec/div**.

   Count the number of major divisions per cycle and calculate the period of your sine wave. The frequency of your sine wave is the reciprocal of the period. Calculate the frequency and record in your Lab Report. If this is not 500 Hz, ask your instructor for help.

10. To obtain a hard copy of the scope's screen we need to put the scope in the graphical interface mode. This is done by moving the mouse pointer to the mouse icon in the upper-right corner and clicking once with the left mouse button. Do this and then move the mouse around and verify that the pointer follows on the screen.

    Move the mouse pointer to the menu bar on top and find **File**. Under this find **Print...** in the pull down menu. Click on this. There are three check boxes at the bottom left of the screen labeled Waveforms Only, Invert

Waveform Colors and Include Setup Information. Only Invert Waveform Colors should be checked. (Not selecting the Include Setup Information will save paper and in general the information is not needed for lab reports. You must reset these options every time you turn off the scope. They cannot be saved.)

Select OK to print. In a few seconds or so your output will appear at the printer. (It may have a watermark indicating your lab station number which is on the top shelf of your lab bench.) Make additional copies of your waveform for each member of your lab group by repeating this procedure.

Mark this section letter and number on the top right side of your plot and attach it as indicated in the Lab Report.

11. Now that you are familiar with the generation of a sine wave, let's look at another waveform. Press the button of function generator with the square wave on it. It is to the right of the sine wave button. You should see a 0.6 volt peak-to-peak square wave with a frequency of 500 Hz. You don't need to print this result.

    Likewise press the button with the ramp wave on it which is to the right of the square wave button. Observe the screen but do not print.

    Likewise press the button with the pulse wave on it which is to the right of the ramp wave button. Observe the screen but do not print.

    Likewise press the button with the noise wave on it which is to the right of the pulse wave button. Observe the screen but do not print.

12. Return to the sine wave by pressing the appropriate button. The amplitude of our waveform should still be displayed. Highlight the **Freq** option to display the frequency of your sine wave. One digit should be highlighted. When you rotate the knob it is this digit that varies.

    Press the button above the **Output** terminal with the shape **>**. The highlighted digit should move to the right. Press it a second time. Rotate the knob and watch what happens.

    Likewise, press the button with the shape **<**. Rotate the knob and watch what happens.

13. Using the knob and directional shape button, set the function generator to display 3.25 sin (2π 833 t). [Remember that the function generator's amplitude is set as peak-to-peak.]

    Your waveform should be chopped off at the top and bottom of the screen.

Hit the **Auto-Scale** button on the scope. The scope attempts to place the waveform on the screen. The most accuracy is obtained when the waveform is the largest on the screen. Adjust the **Vertical** scale of the scope using the large knob to display as large a waveform as possible without clipping of the top or bottom of the waveform.

The same is true for the time base accuracy. Adjust the **Horizontal** scale of the scope using the large knob to display between one and two periods.

14. Counting minor divisions is difficult if the peaks of waveform are not directly on the center vertical line. The waveform can be moved from left to right using the small knob in the group **Horizontal** of the scope.

    Count the number of major and fraction of major vertical divisions by moving the waveform to the left or right and calculate the peak-to-peak amplitude of your waveform. The waveform may be noisy. In order to calculate the peak-to-peak amplitude estimate where the center of the noise envelope is for the maximum and minimum parts of the waveform. Record. Likewise calculate the period and frequency. Record.

15. Print this waveform for each member of your group. Mark this section letter and number on the top right side of your plot and attach it as indicated in the Lab Report.

D) Measurement Toolbar

1. Set the function generator to display 0.3 sin (2π 500 t). [Remember that the function generator's amplitude is set as peak-to-peak.] Press the **Auto-Scale** button located near the top-center of the scope.

2. If your volts/div setting is not **100 mV/div**, turn the large knob for channel ❶ and adjust the volts/div scale to this value. If your s/div is not **1 ms/div**, turn the large knob for the horizontal and adjust to this value.

3. In the last section, we have measured levels and periods on the scope by counting divisions. This was done to familiarize you with how the scope display is organized. We will now turn to the auto measurement features of the Infiniium.

   A measurement toolbar should be along the left side of the screen. The pictures indicate the measurement but if you place the mouse arrow over the icon a short word description will appear. Locate and click on the peak-to-peak voltage (Vp-p) measurement icon. This is the fifth icon from the top.

   Because the scope is sampling and measuring continuously, the numbers that appear on the bottom of the screen may be constantly changing. You can stop the scope with **Stop** button on the top-center of the scope. Do so at this time.

Record the current value of Vp-p (1) in section VI-D-3 of the Lab Report

4. The vertical accuracy of the scope is approximately ±1.25% of the full scale. Calculate the accuracy of your expected reading, that is,

$$\pm 0.0125 \cdot (100\ \text{mV/div}) \cdot (8\ \text{div}) = \pm\ 10\ \text{mV}$$

Thus if we accurately generate a 600 mVp-p sine wave then our scope reading should be somewhere between 590 mV and 610 mV. Was this the case in step VI-D-3?

If not your signal is probably noisy due to the very large bandwidth of this scope. We will show, later in the course, that the noise present in a circuit is proportional to the circuit's bandwidth. Also most noise is random and on the average has a value of zero. Our scope has a feature called averaging where **n** samples are stored and the average is displayed. The larger **n** is the longer it will take to display the results. The scope will appear to “slow down” when using averaging in that a change in input will appear a few seconds to many seconds later.

To activate averaging, move the mouse pointer to the menu bar on top and find Setup. Under this find Acquisition in the pull down menu. Click on this and find Averaging in the resulting dialog box. Click on the box next to Enable. Set the # of Averages to 64, by clicking on the up or down arrow until you find this value. Your waveform should now appear to be smoother than before. Close the dialog box.

Press the **Run** button on the top-center of the scope to activate the scope again followed by **Stop**. Is your reading now between 590 mV and 610 mV. If so revise your last recorded data.

5. Change the vertical scale to **200 mV/div**. Press the **Run** button followed by the **Stop** button. Record the current value of Vp-p (1) in your Lab Report.

This time you calculate the range of the expected reading and record this range in your Lab Report. Does your measurement fall within this range?

6. Change the vertical scale to **500 mV/div**. Press the **Run** button followed by the **Stop** button. Record the current value of Vp-p (1) in your Lab Report.

Calculate the range of the expected reading and record this range in your Lab Report. Does your measurement fall within this range?

7. Given that you did not change the settings of the function generator in sections VI-D-3, VI-D-5 and VI-D-6, what conclusions can you draw from these three measurements? Record your response in the Lab Report. Answer all questions in complete sentences.

8. Turn off Averaging.

E) Function Generator - Amplitude Calibration

1. Change the vertical scale back to **200 mV/div**. Press the **Run** button.

2. The function generator's settings for amplitude is defaulted to the case where it is assumed that the function generator is connected to a 50 Ω load. Let's see what happens if this is not the case.

   Press the **Input** button on the scope for channel ➊. The red light with 50 Ω should now be off and the yellow 1 MΩ light for channel ➊ should now be on. Your waveform will register as approximately 1.2 V peak-to-peak on the bottom of the scope screen. This is very different from what we set our amplitude to be.

3. We will see later in the course that very high speed digital or pulsed circuits will not work properly if the cables used to send the signals are not terminated in the characteristic impedance of the cable which is typically 50 Ω load.

   In most of this course we will need to use the function generator in audio and low frequency applications where the load is typically much larger than 50 Ω. We can reset the function generator's default load of 50 Ω to a high resistance load by using the **Utility** button located in the second row of rectangular buttons. Press it and highlight **Output Setup**. Then select **High Z** and **Done**.

   This resetting of the high resistance termination option will remain in effect until we turn off the function generator. So please do not turn off the function generator until instructed to do so.

   You should now see **1.200 Vpp** displayed on the function generator and likewise on the bottom of the scope screen.

4. Our next task is to add a dc offset to generate $0.2 + 0.6 \sin(2\pi\ 500\ t)$.

   To add a dc offset to our waveform, we need to highlight **Offset** on the function generator display. Besides rotating the knob we can enter values with the keypad. Enter a value of **.2 VDC** by pressing **.** and **2** and highlighting **VDC**. We now have a voltage of $0.2 + 0.6 \sin(2\pi\ 500\ t)$.

5. You currently should be in the **DC** (directly coupled) mode of the scope and at 200 mV/div. This is indicated by the **DC** light under the large **Vertical** knob. Your waveform still has a zero reference at the center line of the screen. (Try disconnecting and reconnecting the BNC cable to see why this is called the zero reference line.)

Calculate the average (dc) level of your waveform by counting the number of major divisions peak-to-peak, dividing this by 2 and adding the result to the bottom of your waveform. If this is not 1 major division above your zero reference line or 0.2 volts, ask your instructor for help.

6. Press the **Coupling** button for channel ❶. The **AC** light should now come on. What is the displayed average (dc) level of your waveform? The function generator is still set at $0.2 + 0.6 \sin(2\pi\ 500\ t)$.

What is the purpose of the **DC/AC** coupling button?

7. Place the scope display back to **DC** coupling by pressing the **Coupling** key again. The **DC** button should be lit yellow.

8. Print this waveform for each member of your group. Mark this section letter and number on the top right side of your plot and attach it as indicated in the Lab Report.

9. To clear the Toolbar click on the bottom toolbar button named Delete All. Disconnect the BNC cable from the function generator and the scope.

F) Probe Compensation and Use

1. Locate the scope 10:1 probes and obtain one.

Hold the base upside down such that the set screw of the adjustment capacitance trimmer is face up. Connect the probe to the channel ❶ input connector by pushing it in. Next pull back on the probe flange to expose the hook on the tip of the probe and attach to the eyelet connector on the lower-center of the scope. (A small square wave symbol is also adjacent to the eyelete.) Hit the **Auto-Scale** button.

Your waveform may appear to be noisy or jumpy. The black ground alligator clip of the probe ideally isn't needed because this reference signal is internally connected to ground. However, the black ground alligator clip is acting as an antenna and picking up noise. In general, you want to connect this alligator clip to ground near where you are making your voltage measurements to minimize noise pickup.

Connect the black ground alligator clip to the grounded eyelete next to the calibration square wave. The noise may be greatly reduced but still present.

2. If your signal is still noisy it is probably again due to the very large bandwidth of this scope. Activate Averaging.

   It is still possible that your waveform is still "jumpy." This can be due to high frequency pulses picked up by the trigger circuitry of our scope. These pulses can come from transmitters, like WKAR which is located across the street, or even someone using a cell phone. These pulses can cause a false or erratic triggering of our desired waveform. Although we will discuss triggering in a later lab, for now let's reject any high frequency noise. Press the **Trigger Coupling** button until **HF Reject** is lit.

3. Now measure the peak-to-peak value of this calibration signal using the Toolbar and record it's value.

4. Measure the period and frequency of this calibration signal by locating the appropriate Toolbar icons and record their values.

5.

   > **CAUTION**: You are about to perform a procedure described below that can permanently damage a piece of equipment. Excessive turning of the adjustment trimmer screw on the probe past its plastic stop will permanently damage the probe. The replacement cost of one probe is approximately $100. Follow the directions below carefully.

   With the small tuning tool found in the blue box on your lab bench, adjust the set screw (in the large hole on the right side - only) of the capacitance correction trimmer of the probe **no more than a 1/4 of a full turn in either direction** to display an under-compensated waveform (rounded edges). Print this waveform for each member of your lab group.

   Adjust the probe to display an over-compensated waveform (edges with peaks). Print this waveform for each member of your lab group.

6. Adjust the probe so that the waveform is a correctly compensated square wave.

7. Connect the second 10:1 probe to channel ❷ and verify that it is correctly compensated.

G) Fluke 8840A Digital Multimeter

1. The Fluke 8840A is a 5½ digit, six function, autoranging precision multimeter. The measurement functions are DC and AC Voltage, 2-Wire and 4-Wire Resistance, and DC and AC current. All six functions have manually selectable ranges. These functions may also be automatically ranged by pressing the AUTO button.

   You will need two pairs of banana-to-grabber wires. These are on racks on the wall. Connect a pair of banana-to-grabber wires to the **HI** and **LO INPUT** terminals. Press the green **POWER** push button located in the lower right corner. Press the **kΩ 2 Wire** white buttons. Press the **AUTO** range button.

2. The list of parts you need is in Section V. Get these from your Parts Box. Record the color code of each resistor. Using the color code found in the Lab Lecture, calculate the nominal resistance value, the lower limit of tolerance, the upper limit of tolerance and place in the table found in the Lab Report.

   Measure the resistors by connecting the grabber clip to each end of the resistor. The last digits may drift due to the “aging” of the resistor. If your values are very unstable it may be due to a high contact resistance between the grabbers and the wire of the resistor. This is caused by oxidation of the metal. One quick way to clean the contact is to hold the resistor firm and rotate each grabber clip. Try not to bend the resistor wire.

   Record all digits of the reading of the digital multimeter including zeros at one instant of time even if the last digit is still drifting. Assuming that the digital multimeter has no error, are your resistors within the tolerance limits?

3. Assume that the Resistance Accuracy specifications for the digital multimeter are that given in the Lab Lecture. For the largest measured resistor in your table, calculate the instrument lower resistance limit and instrument upper resistance limit. Under what conditions is the assumption made in the last question of 2. reasonable?

4. In order to understand the function of the **AUTO** range button, press the other gray range buttons to the left of AUTO to see which range was automatically selected. What conclusions can you draw from these observations?

5. Connect the second pair of banana-to-grabber wires to the **HI** and **LO SENSE** terminals. Connect the smallest resistor as shown in the Lab Lecture on page 6. Press **AUTO**. Record (again) the resistance in the **kΩ**

2 Wire mode. Press the **kΩ 4 Wire** white button. Record the resistance. From this data, what is the resistance of the wires and grabber clips?

H) Clean up

Put your used resistors in the Parts Box. Leave the 10:1 probes connected to the scope. Please return all wires to the racks from which they were taken. Turn off all equipment. Assemble your lab report, staple it and hand it in to your instructor. Please read and sign the Code of Ethics Declaration on the cover.

VII. ASSIGNMENT FOR NEXT WEEK

1. Your lab report for this experiment is due at the end of the lab period. Your graded report will be returned next week. Purchase a three ring binder. Place this lab and the following experiments in this binder. Also include graded reports when returned. Bring this binder to lab each week. You will need it to look up procedures or methods of measurement.

2. Listen to the next recorded lab lecture and read the Lab Procedure portion of that experiment. A short quiz will be given at the beginning of the next lab period covering this material.

Lab Report

Lab I - Introduction to the Oscilloscope, Function Generator
and Digital Multimeter

Name: . . . .

Partner: . . . .

Date: . . . .

Lab Section Number . . . .

Lab Station Number . . . .

Code of Ethics Declaration

All of the attached work was performed by our lab group as listed above. We did not obtain any information or data from any other group in this lab.

Signature . . . .

VI-C-8

Voltage per division = ________________

Number of divisions = ________________

Measured Voltage Peak-to-Peak = ________________

VI-C-9

Seconds per division = ________________

Number of divisions = ________________

Measured Period = ________________

Measured Frequency = ________________

VI-C-10

Mark VI-C-10 on the top right side of your plot and attach as the next page.

VI-C-14

Voltage per division = ________________

Number of divisions = ________________

Measured Voltage Peak-to-Peak = ________________

Seconds per division = ________________

Number of divisions = ________________

Measured Period = ________________

Measured Frequency = ________________

VI-C-15

Mark VI-C-15 on the top right side of your plot and attach as the next page.

VI-D-3

Measured Voltage Peak-to-Peak = ________________

VI-D-5

Measured Voltage Peak-to-Peak = ________________

Lower voltage limit = __________________________

Upper voltage limit = __________________________

Measurement within limits? ___________________

VI-D-6

Measured Voltage Peak-to-Peak = ________________

Lower voltage limit = __________________________

Upper voltage limit = __________________________

Measurement within limits? ___________________

VI-D-7

____

____

____

____

VI-E-6

Displayed DC level = ________________

____

____

____

____

VI-E-8

Mark VI-E-8 on the top of the plot and attach as the next page of the report.

VI-F-3

Measured Voltage Peak-to-Peak = _____________

VI-F-4

Measured Period = ________________

Measured Frequency = ________________

VI-F-5

Mark VI-F-5 on the top of each plot, indicate which one is under-compensated and which one is over-compensated and attach after VI-E-8 as the next two pages of the report.

VI-G-2

Color Code	Nominal Resistance	Lower Limit	Upper Limit	Measured Resistance	Within Limits?

VI-G-3

Measured resistance = ________________

Calculation of accuracy. (See page 8 of the Lab Lecture Notes.) Record below.

Instrument accuracy = ________________________

Calculation of instrument lower resistance limit. (See page 8 of the Lab Lecture Notes.) Record below.

Instrument lower resistance limit = ________________________

Calculation of instrument upper resistance limit. (See page 8 of the Lab Lecture Notes.) Record below.

Instrument upper resistance limit = ________________________

____

____

____

____

VI-G-4

VI-G-5

2 Wire Method R = ______________

4 Wire Method R = ______________

Resistance of the probe wires and grabber clips = ______________