Safety Agreement for working in the ELEN 214 Lab

Because our laboratory can contain equipment that must be treated with care and with due respect to safety, we ask that all students who are working in the lab agree to the following conditions. You should be prepared to explain to your TA that you understand the information you are agreeing to. Keep a copy of this sheet for your records.

By signing the sheet my TA gives me, I agree to the following:

#1 – When working in the lab, I will only use the equipment in the way the lab manual says the equipment should be used.

#2 – If I have a correction or suggestion regarding the lab manual, I will discuss it with my TA before implementing my idea.

#3 – I acknowledge that because of the possibility of harm or injury, I will be respectful of my fellow students, my TA and myself at all times while I am in the lab.

#4 – I agree to follow all warnings given in the lab manual about any piece of equipment and to follow all instructions.

#5 – I understand that any horseplay or rough-housing in the lab will not be tolerated. I understand if I exhibit such behavior I can be removed from lab and receive a zero for my work that day.

#6 – I will not remove any equipment and/or components from the laboratory.

#7 – I will not attempt to use any equipment in the lab for personal experiments that I have not discussed first with my TA.

#8 – I understand that if I make a habit of not listening to the TA, not obeying the instructions I am given in lab, or not following any of the above rules I have agreed to, I can be removed from lab permanently and even be asked to drop the course.

Introduction to the Laboratory Portion of ELEN 214

The laboratory manual for ELEN 214 has been rewritten and developed for the current semester. To that end, many of the experiments have changed or have been expanded in one way or another. The grading of the lab portion of the course has changed as well. Therefore, you must use the current lab manual this semester. You will find the correct labs on WebCT on the Lab page.

There will be 11 experiments spaced throughout the semester. Every experiment, prelab, lab write-up and lab quiz is important. Attendance at lab is mandatory. If you must miss a lab, you will need a university approved excuse to make up the lab. You must arrange with your TA to make it up as soon as possible. Absence from lab can result in failing the course.

The laboratory portion of the course will count for 15% of your final grade. The way the grading for lab breaks down will be as follows:

Lab Reports	35%
Lab Quizzes each week	35%
Prelab Assignments	20%
Lab Practicum in October	10%
Total:	100%

You cannot adequately perform the experiment each week if you have not completed your prelab first. Therefore, if you do not turn in your prelab at the beginning of the lab period, you will receive a zero on your prelab for that week. There will no exceptions to this.

A sample of how the lab will be run each week is:

1. Turn in Prelabs and Lab Reports
2. Take the Lab Quiz
3. The TA will explain any difficult details of the experiment to be performed
4. Perform the experiment
5. Have the TA check your results and initial your written data tables before leaving lab

Lab Reports –

One week after each lab experiment, you will be required to submit a lab report. For each lab performed, the lab report should include:

1. A title page
2. A brief summary of what the procedure you performed and how it demonstrated a specific electrical engineering theory
3. Data Tables with results
4. Example calculations and derivation of equations for any calculations needed in the data tables

5. Any graphs of data requested in the lab
6. Comments about each task for a lab, the theory you learned by doing the experiment, and any explanation of results that are more than +/- 10% of the expected value
7. A conclusion that summarizes why the experiment was performed and suggestions for further study of any theoretical concept

At the end of each procedure, there will be instructions as to which data tables are required and what data should be graphed in order to complete the lab report for the specific lab. Occasionally, you may be asked to answer certain questions in your discussion of a task or in the conclusion. Your individual lab TA will give you more specifics on what is required each week.

Lab TAs can decide their own penalties for accepting late lab reports. **However, lab reports submitted more than 1 week late should receive 0 credit.** Each group should submit one lab report. Each student will need to understand all aspects of the write up in order to do well on the lab quiz each week.

There are a couple of general guidelines that all students and TAs will be expected to follow when preparing their lab reports:

1. Lab reports must be typed. (This includes any formulas) MS Word is now installed on the lab computers to help with this.
2. Graphs must be done using a computer aided graphing program. MS Excel is now installed on the lab computers to help with this.
3. Everyone in the group should understand every aspect of the lab write-up.
4. Your lab report should be ready to hand in as soon as you come to lab. Do not finish putting it together during the quiz time. If you hand in your lab report after the lab quiz, it should be considered late.

Lab Quizzes –

At the beginning of each session of lab, there will be a brief lab quiz. The material to be covered on the lab quiz will include what was studied in the previous labs (usually just the week before, but at the discretion of the individual lab TAs). The material that should have been covered for the prelab will also be covered in the weekly lab quiz. Each lab quiz should last less than 15-20 minutes. If the lab write-up, prelab, and reading of the current lab are completed each week by the student, then the student should have no trouble scoring 100% on each lab quiz. Lab quiz grades are individually assigned. Throughout the lab manual, there are questions posed in the procedure and in the theory sections. A student should be able to answer these questions each week before taking the lab quiz. You individual lab TA will give you more information regarding the quizzes you will take each week.

Prelab Assignments –

Each week, you will have a prelab assignment to turn in. The prelab assignment will include any PSPICE we expect you to do regarding the experiment. The prelab will indicate which PSPICE simulations you should perform and hand in. A CD copy of PSPICE with a useful manual comes

with your textbook. However, if you do not have a copy of PSPICE, you can get one at:
http://www.cadencepcb.com/products/downloads/PSpicestudent/default.asp

Many weeks, you will also be required to write or work on an existing virtual instrument in LabVIEW. To aid you in preparing your prelab, LabVIEW has been installed on the computers in 113D, the Crystal Palace, and other electrical engineering computer labs

In order to get the full benefit of the lab experiment, you must complete your prelab before coming to lab. If you have problems, seek help from your TA before the scheduled meeting of your lab.

Lab Practicum –

In the middle of the semester, there will be a lab practicum. You will be required to demonstrate that you have learned how to use the physical equipment in the lab as well as the virtual instruments on NI ELVIS. More information on this will be given closer to the time you take the lab practicum.

We have tried to match the concepts being studied in the course with the concepts being explored in the lab sections. However, this is rarely perfect. It is strongly suggested that a student start prelabs and finish lab reports several days before they are due in order to have an opportunity to seek help from a TA if needed. The lab experiments have tried to include an exploration of the theoretical concepts as well as direct references to your text book where you can find more information. Please take advantage of these resources.

Finally, this manual is a work in progress. We hope that the experiments are becoming more relevant, interesting and challenging as we continue to improve the manual. We ask that students submit comments on the lab manual and any corrections and changes through the semester directly to your TA, on the website, or by emailing rfm@tamu.edu. On WebCT, you can download copies of an Evaluation of Experiment form. **Please fill out this form out for at least 3 labs throughout the semester. Your comments and criticisms will help make lab better for future students.**

Lab #1: Introduction to ELEN 214 Lab

Theory & Introduction –

Goals for Lab #1 –
The main goal for this lab is to become familiar with the lab equipment and how to implement simple circuits using the lab equipment.

Theory -
In this lab, we are going to become familiar with some of the equipment you will be using throughout the semester. In the theory section of each lab, we will often include some hints on working in PSPICE and LabVIEW as well as explanations of important electrical engineering concepts you will be exploring in the lab. In order to complete the required pre-lab, you will need to read and understand the theory and procedure sections of the lab. **Often, you will not be able to perform the lab without completing the pre-lab.** There **will be a short quiz** at the beginning of each lab that will test your understanding of the experiment to be performed. Both the prelab assignment and the lab quiz will count significantly in your grade. Therefore we strongly recommend that you read the lab manual carefully each week. If you encounter errors or questions regarding the information contained in this lab manual, you can consult your TA or email Rebecca Morrison at rfm@tamu.edu.

For the theory included in our first experiment, we will discuss safety, and describe how to use several pieces of equipment you will need to use in your first lab meeting. Hints on where to find buttons on the instruments and how to operate the equipment will be given. If while you are performing the experiment you become confused, be sure to consult the theory section of your lab manual. Often an answer to your question can be found there. Any suggestions of further information that should be included can be emailed to the above address.

All words enclosed in [brackets] indicate the name of the button on the particular apparatus being discussed. So if you see a word in brackets, expect to see the same word on the button you are supposed to press to perform the desired task.

The engineering theory that will be used for calculations in this experiment is constrained to Ohms Law ($V = I*R$), KVL (i.e., the voltage potentials around a closed loop sum to zero) and KCL (i.e., the currents entering and leaving a node sum to zero.).

Please consult your textbook in Chapters 1 and 2 for more information on these topics.

Safety Issues and Rules in Lab

Here is a list of things to NEVER do in the lab.
   A. Never connect the output of a power supply directly to ground.
   B. To avoid a mistake such as the one mentioned above, never turn on the power to your circuit until you have checked and double checked the circuit. Be sure all wires are properly connected and there is no short from positive to ground. When in doubt, please have your TA check your circuit before connecting power. By convention, positive is a red wire and ground is a black wire. Ground is often abbreviated GND. Positive is often abbreviated POS.
   C. Never connect a voltage source across your body. If you connect a powerful enough source to your body and you touch a ground that is across your body from the source, you might die. Most of the equipment we use in this experiment is not powerful enough to generate enough current to kill you, but you could be injured, suffer burns or worse.
   D. Never have an open container of liquid in the lab. If something happens and water is poured on a circuit, the source could be grounded. This would result in damaged equipment. Also, you run the risk of electrocution by connecting yourself to a power supply.
   E. **Never eat or drink anything in the lab.**
   F. Never perform a task in a lab that you do not understand. Be sure you are prepared to do the lab before you come to your lab session.

Here is a list of things to ALWAYS do in the lab:
   A. Before you come to lab, **read** the entire experiment, **do** the pre-lab, and **understand** what you are supposed to do for the experiment.
   B. Always double check your circuits before you turn the power on. Be sure that you and your partner both understand how the circuit works.
   C. When in doubt, have your TA look over your circuit before you turn the power on.
   D. Have fun. These experiments are designed to be interesting as well as to emphasize the electrical engineering concepts you are learning in lecture.
   E. Follow regular building procedures as far as fire alarms and safety in the building goes.

Of special note: In case of Electrical Shock.
Electrical shock is dangerous for you and others. Sometimes shock can throw people. Sometimes it can glue them to the voltage source preventing them from escaping. For one of your design studio problems this semester, you will probably calculate the amount of electrical current needed to stop a heart. For more information on the ways current can kill you, please see your textbook.

If you see **someone who is suffering from an accident in lab, DO NOT touch them or move them.** Instead, notify your TA who will take the proper procedure. Call 911. If your TA is not available for any reason, Call 911 and then quickly go to 111-A to bring a lab technician to the lab. (The exception to this is if you are certified in a relevant First Aid that is needed.)

Most of the time electrical shock is not severe enough to cause serious injury, but be aware that accidents can happen. **Safety in lab is EVERYONE'S responsibility**.

Equipment that will regularly be used in lab

We have included pictures of some of the equipment that will remain on your bench through the entire semester. Following is a short introduction to some of the equipment we will be using in the lab this semester. Several of these instruments will be used throughout your engineering career. Becoming familiar with the equipment now will help you perform the labs throughout the semester.

Bench Digital Multimeter (DMM): HP Model 34401A

Figure 1.1a: The Digital Multimeter
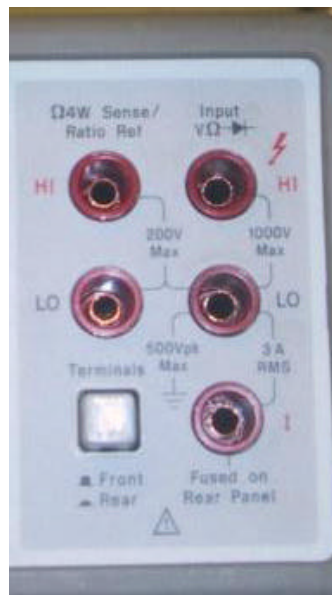
Figure 1.1b: Connection sockets for the DMM

The HP Digital Multimeter (DMM) is a versatile tool that can be used to measure voltage, current, resistance or frequency in either DC or AC. You do not need to adjust the sensitivity of

the DMM. The measurements are done automatically by pressing the button corresponding to the desired parameter. Look at the probe wires that come from the DMM. Notice that one end is fitted with connector pins for easy insertion into the breadboard while the other end is attached to a twin banana plug. The black pin is connected to the plug labeled common, which should be plugged into the common socket of the DMM. For voltage or resistance measurements the non-common side of the twin banana plug is inserted into the HI socket above the common socket. For current measurements, the non-common side of the twin banana plug is inserted into the I socket below the common socket. Be sure to have the leads correctly inserted into the DMM before measuring anything. To take a measurement, the pins will generally be inserted into a breadboard. When not using a breadboard, extra instructions will be provided.

Bench Oscilloscope Tektronix: Model 3014

Figure 1.2

The Tektronix oscilloscope is an instrument that allows you to view and analyze electrical waveforms in a graphical form. The oscilloscope will be used to analyze voltage signals from the circuits that you create in lab. Its primary function is to graph instantaneous signal voltage as a function of time.

The waveforms sampled by the oscilloscope are displayed on a color digital phosphor screen. This oscilloscope is capable of displaying four signals at once, thus it is a four channel scope. The bandwidth or resolution of the scope is up to 100 MHz. The horizontal time scale can be extended from 1 ns to 10s.

The probes that you will use with the Tektronix Oscilloscope are the professional probes that come with the oscilloscope. We would like all students to become family with using these types of probes. However, you must be **VERY CAREFUL** when using these probes. Treat them with respect.

If you look on the PC at your bench, you will notice there is a manual for the Tektronix oscilloscope already installed. Feel free to read the manual at your leisure. The more you know about the equipment you will be using, the easier it will be to use.

In order to be able to use any data from this oscilloscope, **you will need to bring a floppy disk to lab**. You can save the readings you take as either *.bmp files to insert into your document or *.cvs files to use the data in another graphing program.

Bench Function Generator: HP Model 33120A

Figure 1.3

The HP Sweep/Function Generator provides four waveforms: sinusoidal, triangle, square, and ramp. The amplitude of the waveforms are voltages and can range from a low of 100mV peak-to-peak (V_{pp}) and a high of 20 V_{pp}. The waveforms can be generated at designated frequencies ranging from 0.1 mHz to 15MHz. A DC offset can be set. The nominal output impedance is 50 Ω, but it can be adjusted to unmatched loads. When you need to adjust the function generator to High Z, as you will in later labs, instructions will be provided.

NI ELVIS SYSTEM

The National Instruments Educational Laboratory Virtual Instrumentation Suite (NI ELVIS) is a LabVIEW and computer based design and prototyping environment. NI ELVIS consists of a custom-designed bench top workstation and prototyping board, a multifunction data acquisition device, and LabVIEW based virtual instruments. This combination provides an integrated, modular instrumentation platform that has comparable functionality to the DMM, Oscilloscope, Function Generator, and Power Supply found on the laboratory workbench.

Figure 1.4

The NI ELVIS Workstation can be controlled either via manual dials on the stations front or thru software virtual instruments. Throughout the labs you will be asked to either use pre-built virtual instruments or build your own virtual instruments in LabVIEW. Figure 1.5 shows a screen shot of the virtual instrumentation suite that is included with NI ELVIS.
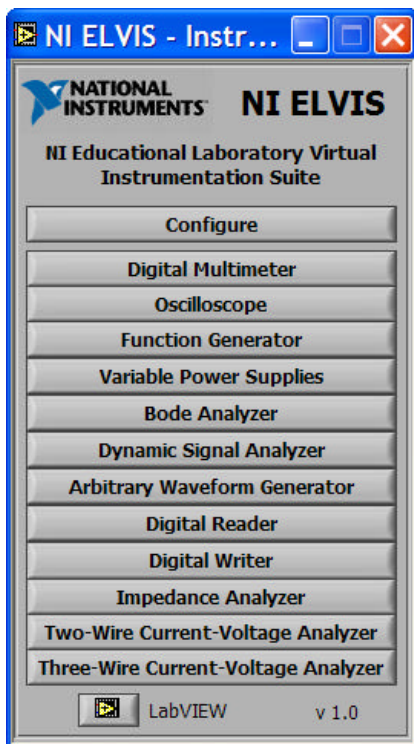

Figure 1.5

The NI ELVIS software suite contains virtual instruments that enable the NI ELVIS workstation to perform functions similar to a number of much more expensive instruments. For example, the Digital Multimeter button to the left will launch a DMM virtual instrument that will allow you to measure voltage, current, capacitance, inductance, and resistance through the workstation and data acquisition device. Keep in mind, the DMM virtual instrument has been built in LabVIEW and can be modified in LabVIEW if needed. Throughout the semester, you will gain experience using and building virtual instruments in LabVIEW. For more information, the NI ELVIS user manual has been provided on the WebCT course pages.
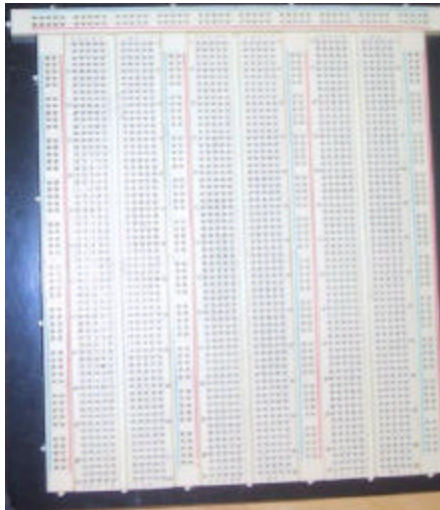
Breadboard
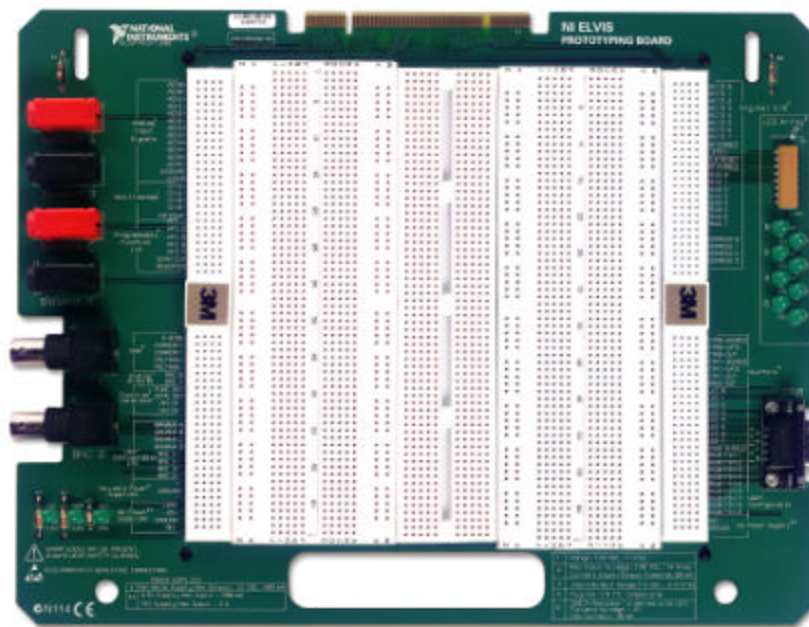

Figure 1.6

NI ELVIS Protoboard

Figure 1.7

In order to implement a circuit drawing in lab, we are generally going to have to use a breadboard. (No, a breadboard cannot be used in place of lunch.) If you are not familiar with breadboards, the following explanation should give you a little insight on how to use one. There are two types of breadboards that you may use during the semester. The first is a generic breadboard. The second is a special breadboard that hooks to the NI ELVIS system. Luckily, the two breadboards are used in a similar manner. Any special connection nodes on the NI ELVIS breadboard will be to the far right or the far left of the connection board. For now, let's focus making connections in the center of the board.

When we consider a circuit, we know we have elements and nodes in the drawing. There are two types of nodes on the breadboard. The first are the nodes created with the horizontal holes, labeled ABCDE across the top. Each column, which is five holes wide, will form a separate node. Therefore, if two elements should be connected to the same node, they could connect (one side only) in the same five hole row.

Figure 1.8: Details of the 5 Hole Nodes

A second type of node is created with the holes that run in two parallel lines. We usually use the vertical nodes for our power sources or as our grounds. On the NI ELVIS board, they are labeled with W, X, Y and Z.

To connect two elements in series, we make sure the elements share only one node in common. To connect two elements in parallel, we connect both sides of the elements to the same nodes. For details see Figure 1.9 and Figure 1.10.
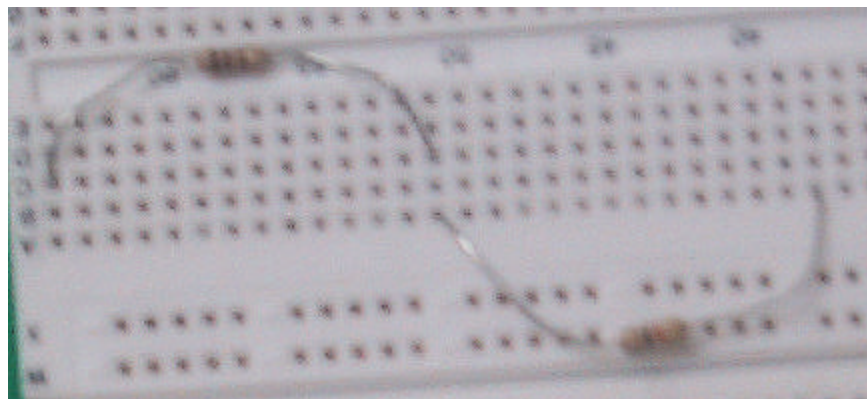

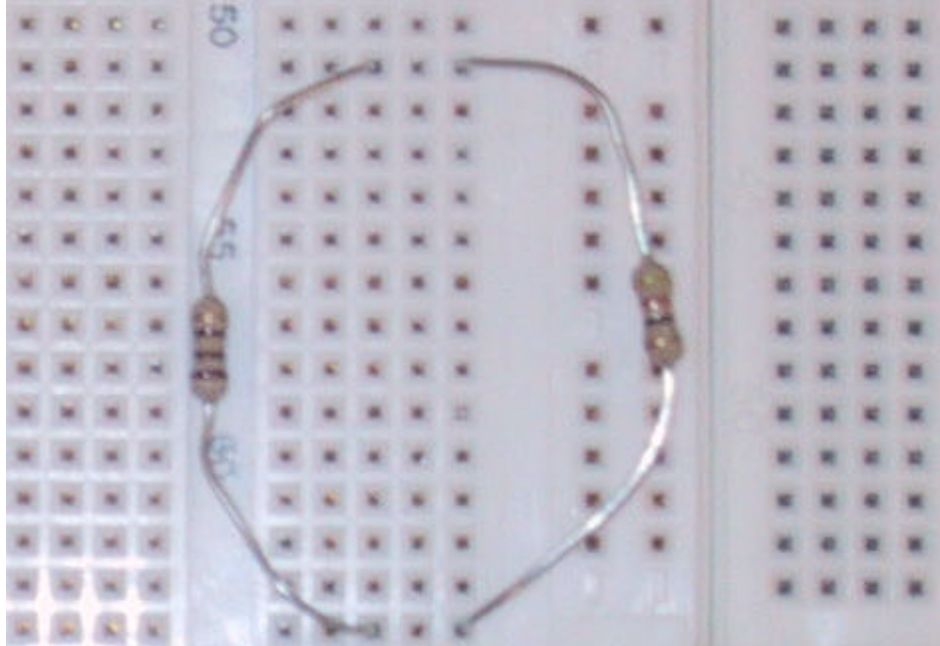Figure 1.9: Two resistors connected in series

Figure 1.10: Two resistors connected in parallel

There is other equipment, you will notice, on the bench in the lab. You will be introduced to these pieces of equipment as the semester continues.

Be prepared to answer questions about the theory section of this lab when you come to your lab session week #2. You will have a lab quiz before the lab begins.

Prelab –

Be sure to read the entire document for Lab #1. **Be sure to bring a floppy disk to lab. You will not be able to save your screen shots from the Tektronix Oscilloscope if you do not have a floppy disk!**

Using the circuit analysis techniques you have learned in class to determine the three values of the mystery resistor, Rx, in the circuits below. See Task #1 of the procedure to determine what the color bands of Rx would be. Also give the color bands of R1 and R2.
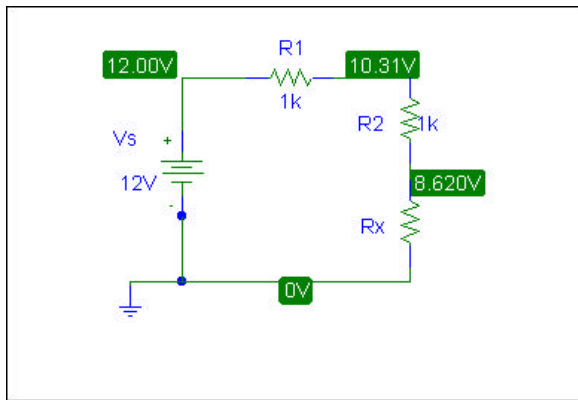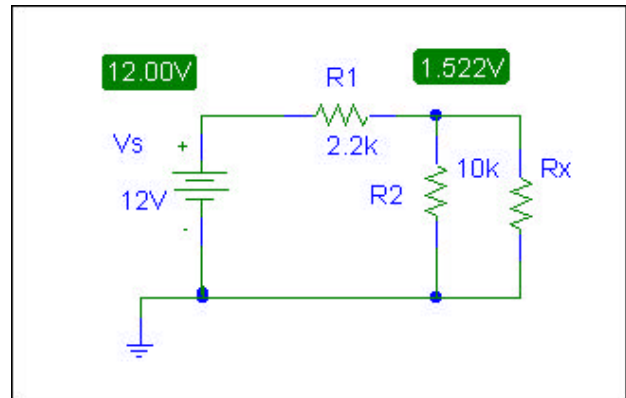

Figure 1.11a

Figure 1.11b

Model the circuits above in PSPICE. Use the resistor values calculated and the source values given. Be sure to display voltages and currents at every node in your drawings. Print a copy of this to turn in. Hints for working in PSPICE can be found on WebCT.

Below are instructions for creating your first virtual instrument in LabVIEW. Some parts of this VI will need to be completed as part of the procedure. Be sure to print out a copy of your block diagram to hand in with your prelab. For help with LabVIEW you can go to www.ni.com/academic/lv_training/default.htm.

1. Load LabVIEW 7.0 from the Start Menu.

2. Click [New…] Select a [Blank] template

3. Create a While Loop
    A. Two windows should be open, select the one titled Block Diagram
    B. Alternately, you may go to the Window menu and select [Block Diagram]
    C. Right click on the main area of the block diagram in order to bring up the Functions Palette. This menu will go away as soon as you click somewhere else. If you would like to have the Function Palette become a permanent menu, click on the tack shaped button in the upper left of the Functions Palette window.
    D. Select [Exec Ctrl]
    E. Select [While Loop]
    F. Click and drag on the block diagram to create a rectangular shaped while loop.

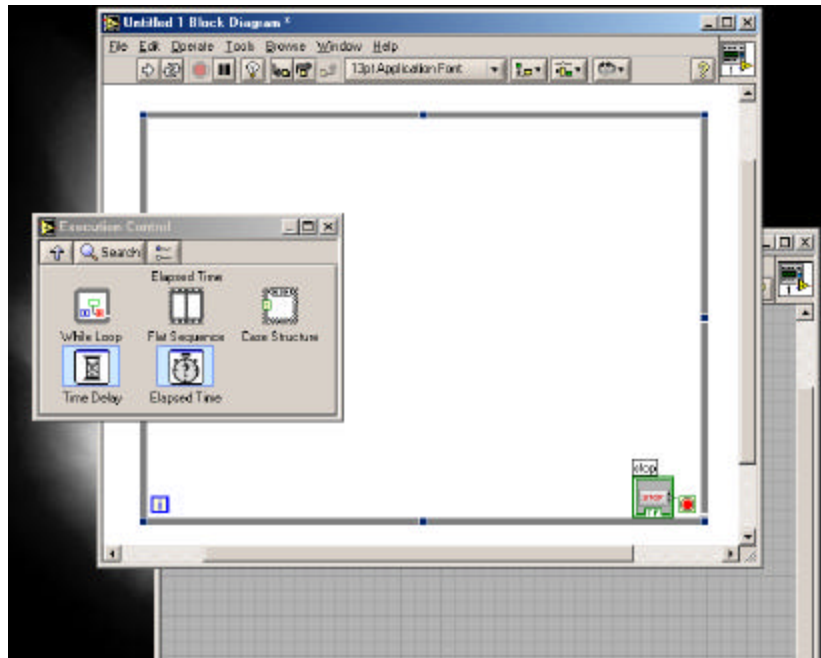G. You may have to adjust the size of the while loop later. To Resize, click and drag the edges of the loop.

Figure 1.12

4. Create an Input

> *Note: All LabVIEW programming can be done on any of the EE lab computers except for inputs and outputs. Inputs and Outputs must be configured and programmed in the ELEN214 lab. You can access the ELEN214 lab when lab is not in session to complete your virtual instrument.*

> A. Select [Input] from the Functions Palette

> B. Select [DAQ Assist] and place this inside the while loop on the block diagram

> C. Select [Analog Input] from the input wizard that pops up when you place the input block onto the block diagram.

> D. Select [Voltage] as the measurement type from the next menu

> E. Select the appropriate input channel as [ai0]

> F. Set the Input Range to +10V and –10V

> G. When you click [OK] you will have an input set up to go into to Analog Input Channel 0 on the ELVIS Breadboard.

> H. These input instructions will not work on a machine that does not have all the appropriate National Instruments hardware. You will have to do this section of programming in the ELEN214 lab.

5. Create a Numeric Indicator

> A. Go to the Front Panel Window. The front panel is the part of the VI you look at when the program actually runs. The block diagram is like the code and the front panel is like the user interface.

> B. Right click on the front panel to bring up the Control Palette

> C. Select [Num Inds]

D. Select [Meter] and place the meter on the front panel

6. Wire the Blocks Together
      A. Go back to the block diagram and note the new numeric indicator block that corresponds to the indicator you placed on the front panel.
      B. Make sure that the numeric indicator is inside the while loop.
      C. Wire the input block to the numeric indicator block by moving the mouse over one of the nodes. The cursor should change into a wire spool. Click and then move the mouse to the next node you want to connect to and click again. If you have trouble making the auto tool switch into a wiring spool, bring up the Tools Palette from the Window Menu and select the wiring spool. By default, the auto tool feature is turned on, but you may turn it on and off as you wish by using the tools palette.

7. Complete the Program.
      A. Your VI should look something like Figure 1.13.
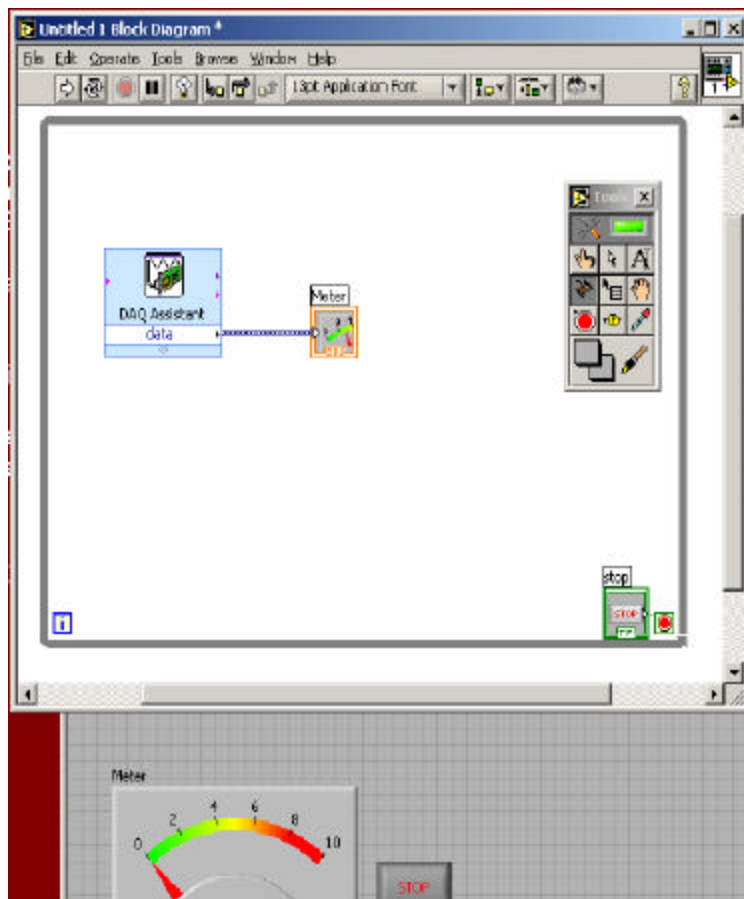

Figure 1.13

      B. The program is ready to run. To run it, click the large white 'run' arrow in the upper left corner of either the block diagram or the front panel. Switch to the front panel in order to view the voltage that your VI is measuring.

Procedure –

Equipment needed for this Experiment:
>   1 – 9V Battery
>   1 – 9V Battery connectors
>   A selection of ¼ W resistors (a variety for each bench)
>   *Enclosed DC Motor Box (will be provided for the instrument room along with instructions on how to make more.)

Task #1 – Resistor measurement and use of the breadboard

I.   Reading Resistors.
Reading resistor values is like learning a code. Engineers use a code to determine the values for the normal ceramic resistors that are commonly used in lab. Each resistor is labeled with 4 bands which, when read from left to right, will tell you how much resistance the resistor is supposed to have.

The code is the color bands on the resistors. The way to read them works as follows. For the formula $WX \times 10^Y$ +/- Z, W is the first band, X is the second band, and Y is the third band. Z refers to the tolerance of the resistor. To know which color relates to which numeral, we use the following the table below.

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

Do you remember Roy G. Biv from physics? If you look down the color column, you can see that the letters ROYGBV are used in order going from 2 to 7. Note: Indigo is not included in this. The 4th band, Z, is usually silver or gold. Silver refers to a 10% tolerance and Gold Refers to a 5% tolerance.

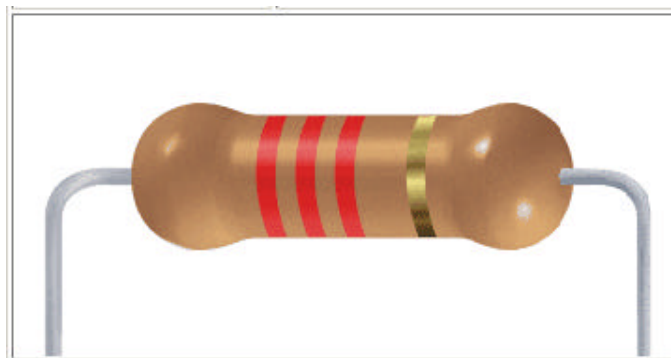You need to be careful when reading the bands. For example consider the follow resistor:

Figure 1.14

To read this, we say it is 22 x 10^2 +/- 5%. However, when we talk about it, we would call it 2.2 kΩ or perhaps 2200 Ohms. There are several resistors at each bench. Choose 3 or so to work with in this task. In Table 1 at the end of this lab, write the band colors and then tell the value first in the form WX x 10^Y +/- Z% and then in our standard Ω or kΩ. Be sure to record at least 3 resistors.

If you still find this procedure confusing, check out the Lab page on WebCT. There are 2 links available to use to help you understand how to determine the value of resistors and other circuit components.

II. Measuring the resistance of a single resistor on the breadboard
A. Pick 2 nodes on the breadboard. As shown in Figure 1.15, place the first resistor from your previous table in these two nodes. Although Figure 1.15 shows two resistors in parallel, you can measure one resistor the same way. (Note: Sometimes you have to wiggle the end of the resistor to insert it into a hole on the breadboard. If one hole is too difficult, pick another hole or node.). Because we are measuring resistance, we will measure in parallel to the element of interest. We also measure voltage in parallel to the element of interest. In the future, when we measure current, we need to measure in series with respect to the element of interest. More on this will be discussed when we start to measure current.
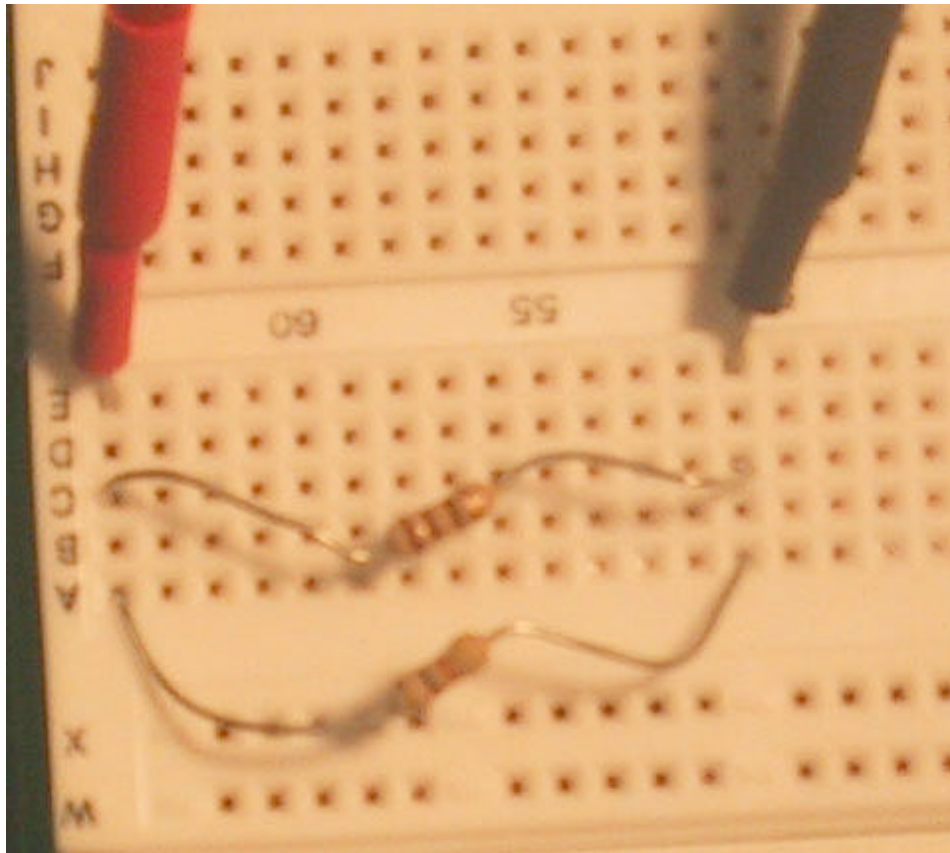

Figure 1.15

B. We will measure the resistance of each resistor with both multimeters available to you. One is part of the NI virtual instruments that come with the NI ELVIS system. Launch the NI Instrument panel discussed in the theory section of the lab. Open the DMM from the instrument panel. You will need to take two wires to make leads from the pre-determined nodes along the far left side of the NI ELVIS board. Figure 1.16a shows the NI ELVIS nodes you will be using. Place one wire in the DMM Current + node and one wire in the DMM Current – node. You must be sure that all three manual switches are off on the front of the NI ELVIS unit as shown in Figure 1.16b below. The manual switches are off when the lights are off beside the manual switches. Take one wire and put it in the node of one side of the resistor and the other wire into the other node with the resistor in it.
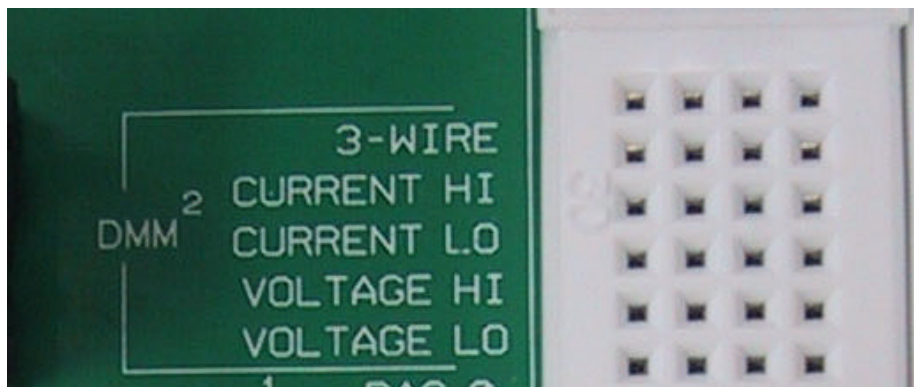

Figure 1.16a

Figure 1.16b

Be sure the Ω button is selected on the computer. Record the value you measure in Table 1.

C. Remove the wires from the NI ELVIS DMM. You cannot use both DMMs at once. With the leads from the HP DMM on the bench, measure the resistance of the same resistor. Record the value in the Table 1.

D. Repeat the procedure until you have measured at all the resistors you recorded the color bands for. Be sure the NI ELVIS board is off when you are done.

Questions to consider: Do both multi-meters give the same reading? Which is closer to the color-coded value? Calculate the % difference form the color band values. Are they within the given tolerance?

Task #2 – DC Voltage Measurement

The first DC voltage source to be measured today is that of a 9V battery. We will be using the HP DMM, the NI ELVIS DMM and the NI ELVIS oscilloscope to take the measurements.

HP DMM

A. Use the provided battery jumpers to connect the 9V battery to the breadboard. Pick two separate nodes for this measurement.

B. Connect the HP DMM probes to the breadboard nodes. Remember, we measure voltage in parallel.

C. Record the voltage of the 9V battery as measured by the DMM in Table 2.

NI ELVIS DMM:

A. Remove the HP DMM probes.

B. Move the two wires from the Current+ and Current- nodes on the far left of the NI ELVIS board to the Voltage+ and Voltage- nodes. Connect those wires to the two nodes of the battery. Use care to ensure that you are connecting the battery to the voltage input and not the current input of the NI ELVIS DMM.

C. Turn on the power to the NI ELVIS hardware and record the voltage of the 9V battery as measured by the NI ELVIS DMM.

NI ELVIS Oscilloscope:

A. Return to the NI ELVIS – Instrument Launcher and load the Oscilloscope.

B. Turn CHANNEL A ON and CHANNEL B OFF.

C. Check the following settings within the NI ELVIS Oscilloscope:
· Source for CHANNEL A is set to BNC/Board CHA
· Scale for CHANNEL A is set to 2 V / div
· Trigger type is set to immediate
· Run is selected

D. Turn off the power to NI ELVIS hardware. Never make changes to the breadboard with power applied.

E. Move the two wires from the Voltage+ and Voltage- nodes on the far left side of the NI ELVIS breadboard to the Oscilloscope CHA + and CHA – nodes which are shown in Figure 1.17. Connect the wires to 9V battery.
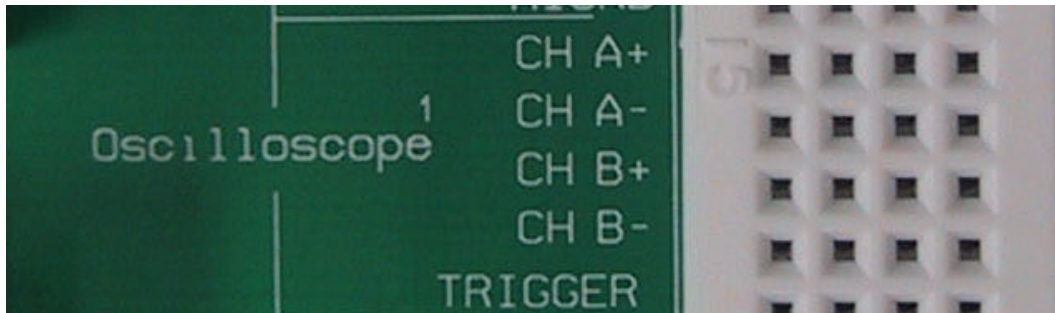
Figure 1.17

F. Turn on the NI ELVIS board. You will see two straight lines going across the oscilloscope display. The lower line marks 0 V. The upper signal is the voltage of the battery. Press the [*MEAS*] button for CHANNEL A.

G. Record the RMS voltage displayed on the Oscilloscope in Table 2. (RMS, the root mean squared, of a constant is the same as the value of a constant. Different functions have different formulas for the RMS. This will explained later in the semester.)

Task #3 – Using the Oscilloscope with the function generator (AC voltage measurement)
Using the HP Function Generator
A. Turn [*on*] the Tektronix oscilloscope.
B. Use the probe from channel 1 from the Tektronix oscilloscope to connect to the output of the function generator. Connect the probe to the red lead and the ground to the black lead as shown in Figure 1.17. **BE VERY CAREFUL WHEN USING THE PROBES. THESE CONNECTORS ARE VERY EXPENSIVE ND YOU MUST TREAT THEM WITH RESPECT!**

Figure 1.18

C. Turn [*on*] the function generator.

D. Press the [*Freq*] button on the function generator to set the frequency of the function generator. The [*Freq*] button is in the lower left.
E. Use the knob to set the frequency to 500 Hz.
F. Notice that you can use right and left cursors to change which digit the knob controls. The cursors are in the lower right corner and are also used to control the menus.
G. Set the frequency to 3 kHz.
H. Press the [*Ampl*] button on the function generator to set the amplitude. The amplitude button is next to the [*Freq*] button in the lower left side.
I. Use the knob to set the amplitude to 5V.
J. The waveform you are generating with the function generator should now be visible on the oscilloscope.

Adjusting the Oscilloscope
A. Press the [*Auto Set*] button on the oscilloscope to automatically adjust the view of the waveform.
B. Take a screen shot of the current wave form and save it to a disk.

HOW TO SAVE A SCREENSHOT FROM THE OSCILLOSCOPE:

In order to save a screen shot of a waveform on the Tektronix Oscilloscope, **you must use a floppy disk.** You need to be sure the scope is set to print to a file on your disk instead of trying to print to a printer. (There is no printer connected to the scope, so you will have to save it on a disk.) To set the Tektronix Oscilloscope so it is going to save your information to a file, press the [Utility] button. Along the front bottom of the display, the left most button is now labeled [System Config]. See Figure 1.19 below.
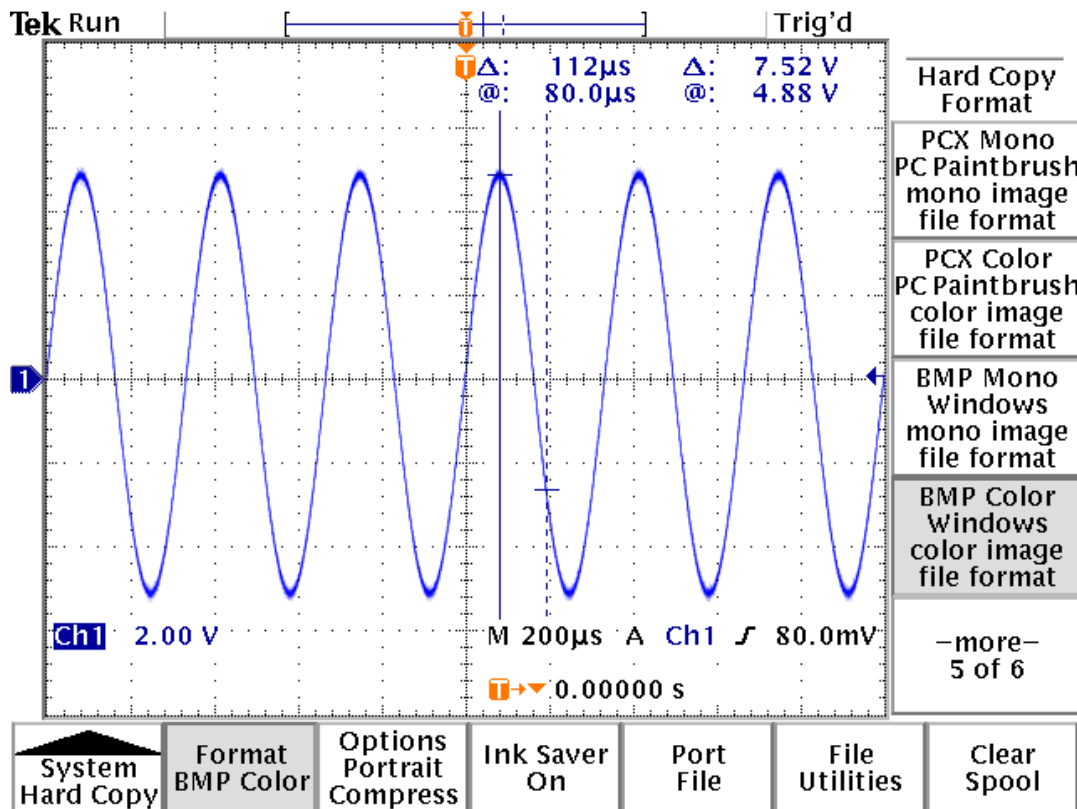

Figure 1.19

Now, hit the [System Config] button until Hard Copy is highlighted. The menus in Figure 1.19 should display.. The important information you need to see is that the Format is BMP color, the Port is to File and the options are to compress. Figure 1.20 shows the menu for compression. If you ask it to compress, the file will be saved a *.gz zipped file. This is to save space on your disk. To go back to your wave form, hit the button [Menu Off] along the right bottom of the display of the oscilloscope.
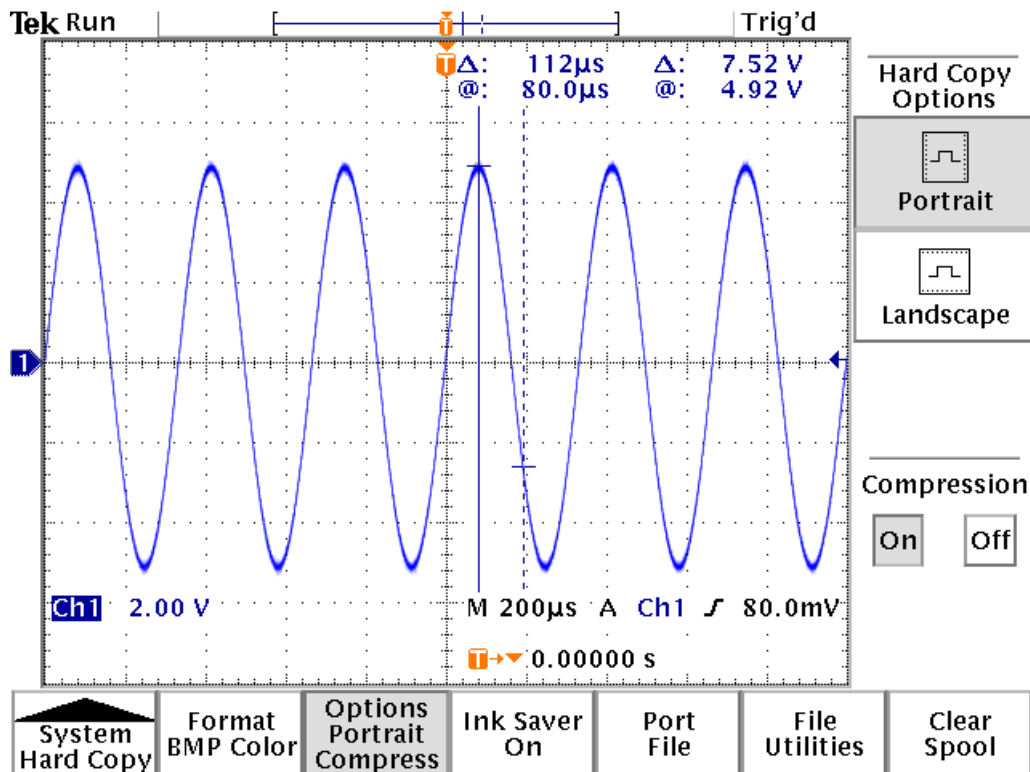
Figure 1.20

In order to save a screen shot, now that you have the oscilloscope set to save to a file, press the button that looks like a printer on the left side of the display of the oscilloscope. Each time you print it, a new picture will be saved.

C. To carry out manual adjustments, use the Vertical and Horizontal [*Scale*] adjustment on the oscilloscope to adjust the voltage and frequency divisions. The lower knob in the vertical section controls how zoomed in you are vertically, changing it will change the visible amplitude. The lower knob in the horizontal section controls the zoom settings with respect to frequency. These controls only affect how you view the waveform, not the characteristics of the waveform.

D. Change the function generator [*Ampl*] to 100mV.

E. Take another screen shot to use in your lab report.

F. **Manually** adjust the oscilloscope to view the wave better.

G. Use [*Measure*] on the oscilloscope to find the frequency, amplitude, and root mean square voltage

       1.   Press [*Measure*].

       2.   Scroll through the measurement tasks by pressing [*-more-*].

       3.   Find the [*frequency*] task and press its button.

       4.   Find the [*amplitude*] task and press its button.

       5.   Find the [*RMS*] task and press its button.

       6.   Leave the measurement menu by pressing [*Menu Off*].

H. Take a third screen shot to use in your lab report.

I. It is a VERY good idea to open your files on the PC at your bench to be sure you saved the right information before you leave. See you TA if you need help with this.

Other Waveforms – For this save at least 4 screen shots to show you were able to adjust to other waveforms. Comment on which signals seem the most useful to you.

    A. Change to a square wave, 1 MHz, 1 V wave by pressing the square wave button and setting the other parameters as you have done earlier. The square wave button is in the upper row of buttons near the left side. The other waveforms have their own buttons also.

    B. Adjust the oscilloscope to show two full periods, and the $V_{p\text{-}p}$ covers 70% of the screen.

    C. Record the oscilloscope measurements and compare them to the function generator.

    D. Change to a triangle wave, 150 Hz, 2.5 V. The triangle button is near the square wave button.

    E. Adjust the oscilloscope to show two full periods, and the $V_{p\text{-}p}$ covers 70% of the screen.

    G. Turn [*Off*] the function generator. Turn off the oscilloscope and gently disconnect the probe from the function generator.

Task #4 – Implementing your VI

A. Turn on the NI ELVIS prototyping board power. Open the virtual instrument you created for the prelab.

B. Look at the front of your NI ELVIS unit. Besure the variable power supply is set to manual. Connect the node on the far left of the NI ELVIS unit for Variable Power Supply [Supply +] to [ACH 0+] and connect [ACH 0-] to ground.

C. Go back to the Front Panel, and run the program by pressing the white arrow on the toolbar. Adjust the Variable Power Supply on the front of the NI ELVIS unit in order to change the voltage applied to CH0. The Voltage CH0 indicator should now be measuring the output of the Variable Power Supply. Terminate the program by pressing the STOP button.

D. Take a screen shot on your computer of the working front panel of your virtual instrument. Be sure to include it in your lab report.

Task # 5 – DC motor and photo interrupter

1. The DC motor and photo interrupter circuitry is pre-built and enclosed in a Plexiglas project box. The box has four color coded wires coming out of it that we are going to connect to the NI ELVIS breadboard as follows.

       a. BLACK wire – This wire is the common ground (GND) for both the DC motor and photo interrupter. Connect this wire to the [GROUND] of the NI ELVIS Variable Power Supply.

b. RED wire – This wire is the DC motors positive voltage. Connect this wire to the [SUPPLY+] of the NI ELVIS Variable Power Supply.
c. WHITE wire – This is the 5V DC voltage used to power the photo interrupter circuitry. Connect this wire to the [+5V] NI ELIVS power supply.
d. GREEN wire – This is the photo interrupter signal output. Connect this to the NI ELVIS analog input channel 0 [ACH0+]. Connect [ACH0-] to the common ground.
e. Connect the [SUPPLY+] voltage to analog input channel 1 [ACH1+] and connect [ACH1-] to the common ground.

2. To verify that the power is routed correctly, place the ELVIS Variable Power Supply SUPPLY+ in [MANUAL] and apply a voltage to the motor with the positive supply knob. If the disk attached to the motor does not rotate contact your TA before proceeding.
3. Switch the SUPPLY+ [MANUAL] switch into the lower position, this allows the VI to control the variable power supply.
4. If LabVIEW is not all ready running, please launch it as before. Open the VI called "Lab 1 DC Motor.vi".
5. Select the second tab [DC Motor Interface] on the Lab 1 DC Motor.vi.
6. From the front panel set a value of 3.5 in the [Motor Power] control and press the run arrow. Notice that the graph on this VI is actually plotting pulses as the motor rotates. Note: If you go below 3.0V, you may get an error. If this happens, you must stop the virtual instrument and restart it.
7. Adjust the voltage using either the [Motor Power] dial or numerical control and see what effect this has on the RPM indicator and the Pulse Train graph.
8. The program has been set up to record both the voltage reading from analog channel 1 and the RPM calculation. To record a data point, press [LOG DATA]. If you select the [Data Storage] tab you will see a table of the data values. Each time you press [LOG DATA] a point is added to the [Data Storage] table.
9. [LOG DATA] points from 3.5 V to 10 V in 0.5 V intervals.
10. You can select the data from the Data Storage tab on the virtual instrument. You can cut and paste the data from this page to an EXCEL or WORD DOCUMENT. Save the document to a floppy disk OR to your H:\ drive. We also suggest printing a copy of your data.

Lab Report Requirements –

Be sure to include all lab report requirements as outlined in the introduction.

Be sure to include ALL screen shots taken from an oscilloscope.

Plot the DC Motor Voltage versus RPM (rotations per moment) obtained in Task #5. Use a computer program to plot and comment on the plot.

Check with your TA for any other requirements.

Tables and Results –

Table 1: Task #1 Parts I and II

Colors	Value	HP DMM	% difference with color indicated value	NI ELVIS DMM	% difference with color indicated value

Table 2: Task #2

Device	Voltage
HP DMM	
NI ELVIS DMM	
Oscilloscope	