Familiarization With Laboratory Equipment

I. OBJECTIVES

-To provide advanced knowledge of laboratory equipment such as, power supply, function generator, digital multi-meter and oscilloscope.

-To provide the basis for good measurement practices for waveforms, alternating current (AC) and direct current (DC) values, and accuracy.

-To learn about the sources of error of equipment such as oscilloscope, digital multi-meter (DMM) and function generator (FG).

**Laboratory dressing requirements:** shoes must hold the ankle. It means no flip flops

II. LABORATORY EQUIPMENT

2.1 Power Supply

A power supply is used to provide energy to electronic circuits. There are two types of power supplies in the lab:

* 3-channel custom made fixed voltage supply that provides +15, -15 and +5V.
* GPS-3303, which also has 3 output channels. The output for two channels can vary between 0-30V and 0-3A. The third channel output is fixed at +5V.



Figure 1: A typical bi-polar power supply connection

If there is a need for a power source that has three terminals, positive, negative, and common, it can be built using two channels of any of abovementioned power supplies as shown in Figure 1.

2.2 Digital Multimeter

A DMM can be used to measure any of the following: voltage between two nodes, current passing through any circuit branch and DC resistance. Although these are basic measurements needed for DC circuit analysis, some recent DMMs are equipped with extra functions such as measurement of frequency, capacitance, and inductance.

IMPORTANT: The DMM’s internal resistance affects the accuracy of the reading. The ideal voltmeter has an internal resistance equal to infinity, while the ideal current meter has zero internal resistance. A real voltmeter shunts the circuit it is connected to. A real ammeter adds its internal resistance to the branch it is connected to. The reading provided by the multi-meter while measuring AC volts or current is called *RMS* (Root-Mean-Square) value.

We have 2 types of DMM in the lab: Agilent 34405A 5 ½ and Fluke 8010A. The first one has some advanced features.

2.3 Function Generator

A function generator produces a signal with desired frequency, amplitude, and shape. In this laboratory we use Agilent model 33220A.This can be done using three group of push–buttons mounted on the front panel. The first is frequency selector with range from 1 μHz to 20 MHz in several overlapping ranges. The second is an amplitude control with range 20 mV to 20Vp-p. One can generate several types of waveform such as sinusoidal, triangle, square and arbitrary. One can add a DC component (offset) to this signal to obtain another useful signal, for example square wave (symmetric) + offset (equal to the peak value) = square pulse. The figure below shows the generated signal offset.



Figure 2: Signal examples

2.4 Oscilloscope

Oscilloscope is considered an essential part of any electronic test and measurements lab. The Tektronix Digitizing Oscilloscope (MDO 3014) is used in the lab to display and obtain all necessary measurements from the experimental waveforms.

* The VERTICAL control button changes the vertical scale and position and the HORIZONTAL control button changes the horizontal scale and position.
* You can choose between DC and AC coupling when you press the illuminated button for any channel. It opens a menu for this purpose. You can remove this menu when you press the MENU OFF button located at the bottom of the screen.
* There is a CURSOR button at the top. You can press it once to bring x-y cursors on the display screen. There are two of them. The circular knobs adjacent to it allow you to move the cursor position. A rectangular box on the display indicates the values of the cursor position and the ∆x and ∆y values. Pressing the cursor button second time removes the cursors from the display screen.

**III. PRE-LAB:**

**Unless otherwise specified, all table and figure numbers in the pre-lab section refer to the report template.**

1. Obtain a datasheet or user manual for the Instek GPS-3303 power supply and fill in Table 1.

You can do a simple search by the model number, something like “GPS-3303 manual”.

The search result might give you something like this:

<http://www.testequipmentdepot.com/instek/pdf/gps-4303-gps-3303-gps-2303_datasheet.pdf>

<http://www.testequipmentdepot.com/instek/pdf/gpsx303_manual.pdf>

Or you can go to the manufacturer web-site:

http://www.gwinstek.ca

and search for the model number “GPS-3303”:

<http://www.gwinstek.ca/products/137/gps3303-3channels-195w-dc-power-supply>

You can look at the pdf documents or/and online descriptions (ex.: “Specifications”, “Information”, etc.)

1. Using your skills acquired while completing step 1, based on the Table 1, create your own table (Table 2) and fill it in with the following parameters for the Agilent 34405A 5 ½ DMM:

* Maximum measurable DC voltage, V
* Maximum measurable resistance, Ohm
* Maximum measurable AC voltage (RMS), V
* Minimum and maximum measurable capacitance value, uF
* Pick two parameters from the manual that you think are important for assuring proper measurement results.

The table should contain a total of 7 parameters.

1. Repeat the task for the Agilent 33220A Function Generator (note that the units of measurement for the parameters below are missing. Please include them in your report):

* Available frequency range for sine wave
* Available frequency range for an arbitrary function
* Available amplitude range for high Z (open circuit) load, sinusoidal signal
* DC offset range for high Z (open circuit) load
* Pick two parameters from the manual that you think might be useful for experiments.
* Pick two parameters from the manual that you think are important for assuring proper measurement results.

1. Design an experimental setup to measure the output impedance of the function generator. Sketch it in Figure 1. Choose an appropriate engineering tool.
2. Repeat task (2) for oscilloscope model MDO3014:

* # of analog channels
* Analog channel bandwidth
* Types of input coupling available
* Time base range
* Sample Rate when sampling all 4 channels
* Maximum input voltage for **each** of three input impedances (termination).

1. Figure 2 shows a square wave signal measured with a properly compensated probe. Sketch in Figure 3 and 4 how probe compensation affects the signal you observe on the screen.
2. Design an experiment to measure voltage across R2 using:

* a DMM (Figure 5)
* an oscilloscope (Figure 6)

Show how you are going to connect the probes in each case.

1. In order to properly set the oscilloscope to display the desired signal, you need to know how the expected parameters of the signal correspond to the oscilloscope settings. Table 5 will help you understand the basic settings. You have to fit the sinusoidal signal described in the first row of Table 5 in the screen. At least one but not more than two periods should be displayed. The oscilloscope’s screen has 8 vertical and 10 horizontal divisions. Assume that the input is set to **“DC” coupling** mode. Do not fill in “Autoset” column – you will do it in the lab.
2. Consulting the operating manual, write down the steps you need to take to set the oscilloscope to measure (see p.122 and up of the manual):
   1. Peak-to-peak voltage on Channel 1
   2. RMS voltage on Channel 2
   3. Mean of the signal on Channel 1 (Coupling must be set to DC)
   4. Frequency of the signal on Channel 1
3. Read the “Experiment” section and think about how you are going to execute the experiments.
4. Prepare all data tables that will be necessary for the lab.

IV. THE EXPERIMENTS

Power Supplies

Use the dual power supply (GPS-3303) to construct a bi-polar voltage source. Assemble the circuit as shown Figure 3. R1=1 kOhm, 1/4W; R2=240 Ohm, 1W. Both resistors are carbon film, axial, 5% tolerance. For more details search for manufacturer part number CF14JT1K00 at www.Digikey.ca.



Figure 3: Bi-polar power supply measurements

* Measure the currents through R1 and R2 using DMM. Think of how you can do it directly and indirectly. Fill in Table 6 in the report template. *(Hint: you might think of how you can fill in the “indirect” values before doing the lab – you already have all necessary data.)*

*Note: if you see that the “CV/CC” light on the power supply turns red, what does it mean and what should you do?*

* Set V1=V2=12V. Turn the current limiter knob so the “A” display (What channel should you work with, DC1 or DC2? See the hint in the Table 7.) shows values from 0.00 to 1.00. Fill in Table 7. Explain the results and comment.
* Using the DMM Measure IR1 in “Manual” mode at different ranges such as 10mA, 100mA etc. Then compare the result. Which one is more accurate? Why? Note that all measurement results must be rounded to the same number of significant figures.

Familiarization with the MDO3014 oscilloscope.

1. Fill in the “Autoset” columns of the Table 5 (report template) by setting the Function Generator output to the values listed in the first row and pressing “AUTOSET” on the oscilloscope.
2. Verify if your calculated values for “Horizontal Scale” and “Vertical Scale” yield the desired oscillogram. If not, adjust the knobs to display at least one but not more than two periods of the signal using the maximum possible area of the screen. Read the knobs’ values. Cross your calculated value(s) out and write the correct one(s) next to it (them).
3. Comment on what you observed. In other words explain why you are not seeing a sinusoidal wave on some settings of the function generator.

Oscilloscope & DMM measurements



Figure 4: Contact sensor output measurement

The circuit shown in Figure 4 represents a typical contact sensor NOT. (Since switch S1 never closes for this experiment, you can just imagine that it is there. No need to use a real part.) Since S1 is always open, there is no current going through R1. Thus, there is no voltage drop across R1. Therefore, the voltages on both terminals of R1 are supposed to be same and equal the output voltage of the FG. In this experiment you will see how the input (termination) impedance of measurement device affects the precision of measurements. When you calculate measurement errors, use the signal parameters you set at the FG as your reference (true) signal.

1. Connect the  using 1X probe to Vout.
2. Set the function generator for 1 kHz, 4V amplitude, and 1.25V offset sinusoidal output and do not change it through steps 3-12.
3. Make sure that the FG’s load resistor parameter is set to “High Z”.
4. Set the oscilloscope’s input (termination) impedance to 1 MOhm.
5. Display a sinusoidal waveform on the .
6. Fill in rows 1 and 2 (“Value” columns) of Table 9. *Hint: The oscilloscope allows you to display more than one measurement at the same time. Think how you can use this feature to make your work in the lab more efficient. You might also think of using Ch1 with DC coupling and Ch2 with AC coupling.*
7. Set the oscilloscope’s input impedance to 75 Ohm.
8. Fill in rows 3 and 4 (“Value” columns) of Table 9.
9. Set the oscilloscope’s input impedance to 1 M Ohm.
10. Replace 1X probe with 10X one.
11. Fill in rows 5 and 6 (“Value” columns) of Table 9.
12. Replace the  with the .
13. Fill in rows 7 and 8 (“Value” columns) of Table 9.
14. Set the function generator for 1 kHz, 4V peak-peak, and 0V offset “Cardiac” output.
15. Following necessary steps fill in Table 10. (Table 10, which is similar to Table 9, must be prepared in the pre-lab. Include only the four bottom rows.)

V. QUESTIONS AND DISCUSSION

1. Make all necessary calculations and fill in all missing information in the data tables.
2. Write answers to all questions in the report.
3. While commenting on the results in Table 9 explain the relation between the error and:
   1. Type of engineering tool used. Which parameter of the tools had the most dramatic effect on the precision of the measurements and why?
   2. Type of coupling of the oscilloscope and DMM.
4. Explain the use and purpose of the **AC-DC** button in the channel menus.
5. Will an oscilloscope interfere with a circuit under test? Justify your answer.
6. For a dual power supply, show the necessary connection to obtain -5V and -8V with respect to a common (chassis) ground. Repeat for -5V and +8V.
7. Explain the use of the current limiting feature for the dual-voltage power supply.
8. What happens to the output current and voltage when the power supply is shorted?
9. Explain the function of the AC/DC selector on the DMM.
10. For the waveform shown in Fig. 7 what would the DMM read on the AC setting? On the DC setting? What is the RMS value of this waveform?



Figure 5: Understanding of AC/DC settings of DMM

Appendix 1.

Table 1 Some of IEC60617 standard symbols used in this lab

|  |  |  |  |
| --- | --- | --- | --- |
| IEC60617 reference number | Symbol | Name | Usage |
| S01225 |  | Signal generator, general symbol | Waveform generator |
| S01226 |  | Sine-wave generator, 500 Hz |  |
| S01229 |  | Sine-wave generator with adjustable frequency |  |
| S00910 |  | Indicating instrument, general symbol | Instrument |
| S00922 |  | Oscilloscope |  |
| S00913 |  | Voltmeter |  |
| S00200 |  | Earth, general symbol; Earthing, general symbol; Ground (US), general symbol; Grounding (US), general symbol |  |
| S01409 |  | Functional equipotential bonding | Functional bonding conductor; Functional bonding terminal |
| S01410 |  | Functional equipotential bonding (simplified form) | Functional bonding conductor; Functional bonding terminal |
| S00001 |  | Connection, general symbol | conductor; cable; line; transmission path |
| S00016 |  | Junction; Connection point |  |
| S00555 |  | Resistor, general symbol |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |