PRINCIPLES AND APPLICATION OF MICROCONTROLLERS
Lab0: Introduction to Lab Instruments

Introduction

The primary goal of this lab is to study the operation and limitations of several commonly used pieces of instrumentation:

- Tektronix TDS2002 60MHz oscilloscope
- GW Instek SFH-2110 10MHz function generator
- GW Instek GPC-3030D DC power supply
- Digital multimeter

The instruments provide powerful tools for the testing and measurement of analog and digital circuits. Proficient use of these instruments will be extremely beneficial during the later part of the course and your entire engineering career. Although this lab may not be as glamorous as some of the other labs, you are strongly advised to be patient and go through the procedures. You are also advised to make good use of the user manuals. Refer to them as often as needed. The devices will be used to study the behavior of a first-order system. The system will be the series combination of a resistor and a capacitor (i.e., RC circuit). After completing this lab, you should be able to:

- Explain how loading occurs and how it affects measurements
- Understand why the oscilloscope has AC/DC coupling and when it should be used

Parts List

- A breadboard
- Resistors
- A capacitor

General Information

Oscilloscope:

Oscilloscopes are versatile instruments used to display constant or time varying voltages. The Tektronix TDS2002 oscilloscope used in the lab is a two-channel unit with a maximum sensitivity of 2mV/division and a useful frequency range from 0 to 60MHz. To use the oscilloscope, turn on the unit by pressing the power button. The front panel of the oscilloscope contains a series of knobs and buttons. Knobs are used most often to make adjustments. Buttons are used for run controls and to change other oscilloscope settings via menus. Figure 1 shows a picture of the front panel controls for the oscilloscope. The definitions for the specific buttons and knobs are as follows:

- Vertical Controls: Vertical position knobs, vertical scale knobs, channel (1, 2) and math buttons
- Horizontal Controls: Position and scale knobs
- Trigger Controls: Trigger level knob, 50%, and force buttons
- Menu Buttons: Save/recall, measure, acquire, display, cursor, and utility buttons

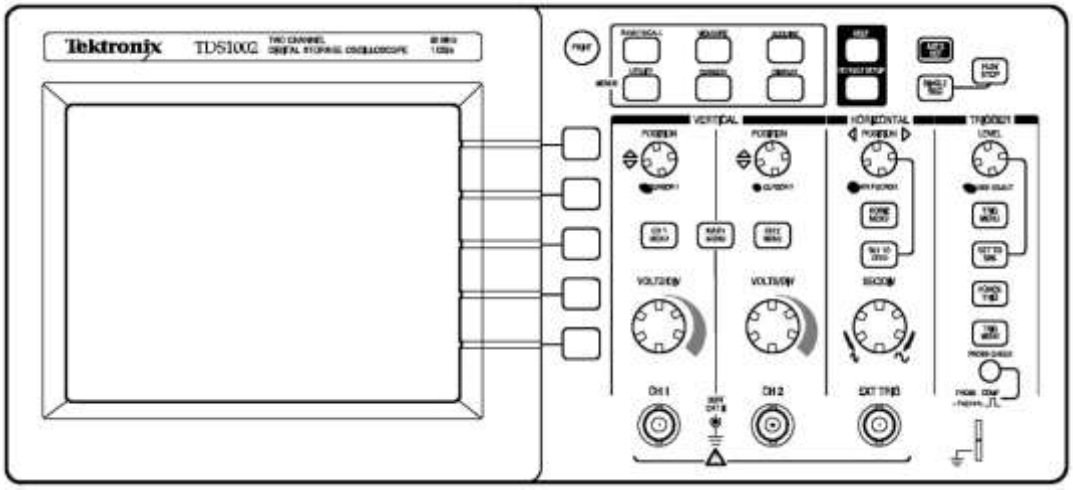

Figure 1: Front panel controls of Tektronix TDS2002 oscilloscope

Function Generator:

GW Instek SFH-2110 function generator can be used to generate sine, square, triangle, ramp, pulse, noise, arbitrary and random waveforms from 0.1 to 10MHz (for sine wave). The output voltages of the output signals range from 40mV to 10V peak-to-peak (Pk-Pk) into a circuit with a load of 50Ω. To use the function generator, turn on the unit by pressing the power button on the lower left corner of the display. The front panel of the function generator contains a series of knobs and buttons. Figure 2 shows a picture of the front panel controls for the function generator.

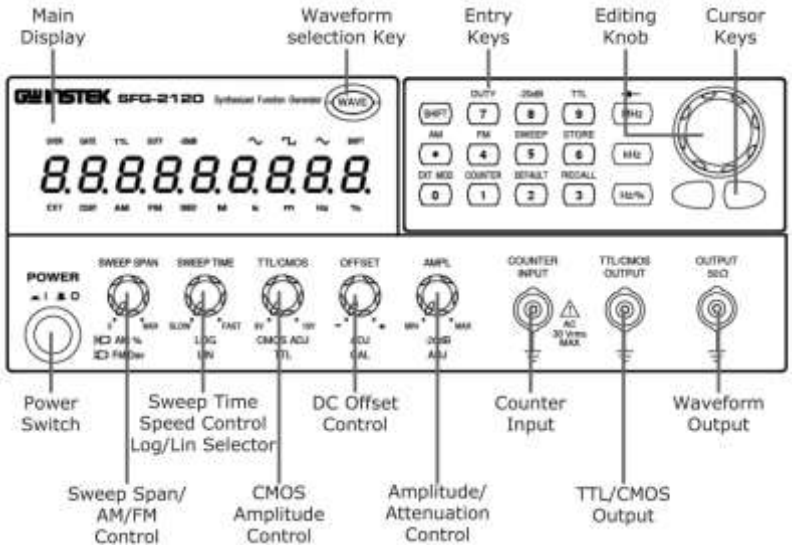

Figure 2: Front panel controls of GW Instek SFH-2110 Function generator

Power Supply:

GW Instek GPC-3030D DC power supply used in the lab consists of two identical, independently adjustable DC power sources. Each source is controlled separately, and can provide up to 30V in voltage and 3A in current. Figure 3 shows a picture of the front panel controls for the DC power supply.

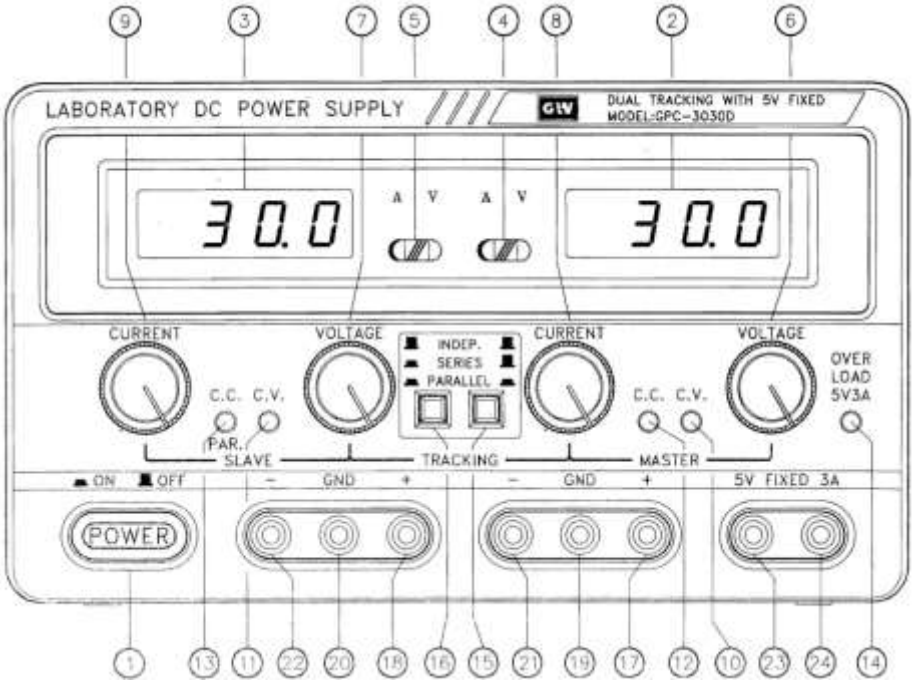

Figure 3: Front panel controls of GW Instek GPC-3030D DC power supply

Digital Multimeter:

Digital multimeter (DMM) is a versatile tool for measuring constant and time varying signals. Figure 4 shows a picture of a digital multimeter. The central knob has lots of positions. To use the multimeter, choose the one that is appropriate for the measurement you want to make. Once this is completed, the unit is ready to gather data.

Figure 4: Digital multimeter

Procedure

Measurement of Time Varying Signals Using Oscilloscope:

Set the function generator so that its output is a 200Hz sine wave with an amplitude of 2V Pk-Pk with a DC offset of 1V. Press the WAVE button to selection sine wave. Once pressed, rotate the knob or press the number pad and to vary the frequency, amplitude, and offset. Connect the output connector of the function generator to the channel 1 input connector of the oscilloscope. Observe the effect of changing each of the following oscilloscope controls.

1. Rotate the bottom knob in the Horizontal Controls region
2. Rotate the top knob in the Vertical Controls region
3. Rotate the bottom knob in the Vertical Controls region

Q1) How does each knob affect the viewing of the periodic signal?

Internal Impedance of Digital Multimeter:

The digital multimeter (DMM) can be used to measure DC voltage and current, AC voltage, and resistance. Resistance measurements can be made by applying a known current through the unknown resistance and measuring the resulting voltage. When the center knob is turned to the Ω area, a known current is applied to the unknown resistance automatically by the meter. This results in a voltage drop which can be measured by the DMM. This is shown in the circuit diagram in Fig. 5.

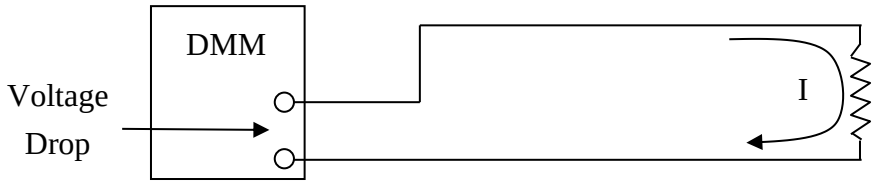

Figure 5: Resistance measurement using digital multimeter

Obtain two resistors of 10MΩ and verify the resistance values using the DMM. Connect them on the breadboard as shown below in Fig. 6.

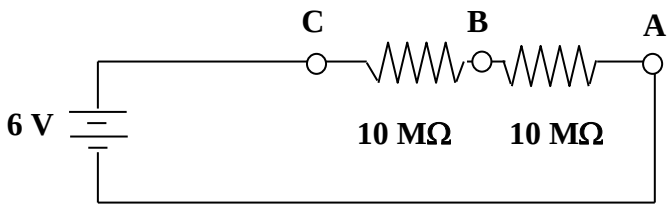

Figure 6: Circuit diagram to demonstrate loading effect

Measure the voltages between A and C, A and B, and B and C.

Q2) Report and explain your results.

Internal Impedance of Function Generator:

Setup the function generator to output a sine wave of 1V Pk-Pk at a frequency of 1000Hz. Connect the output of the function generator to a resistor, and connect the oscilloscope into the resistor to measure the V_{out} as shown in the circuit below.

Figure 7: Circuit diagram to demonstrate loading of function generator

Vary the resistors and note the peak to peak voltage being read by the oscilloscope. This is done by looking in the Menus region of the oscilloscope and pressing the Measure button. On the right hand side of the screen, press the first button. Press the button next to 'Type' until Pk-Pk shows up.

Q3) Report the Pk-Pk voltage and explain your results.

Resistance	Peak to Peak Voltage
5.1 MΩ	
5.1 kΩ	
510 Ω	
50 Ω	

The problem that is occurring has to do with loading of the function generator. The internal processing of the function generator has to know the load in the circuit in order to supply the accurate output voltage. As demonstrated, if the impedances (load or resistance) are not matched, an erroneous output voltage will be supplied. There are two ways to safeguard against this error. The first is to manually adjust the function generator supplied voltage until the desired output voltage is

reached. The other is to match the impedance of the circuit to the impedance in the function generator.

With the circuit wired to the 50Ω resistor, adjust the Pk-Pk voltage of the function generator until the oscilloscope reads 1V peak to peak.

Q4) Measure the actual voltage provided by the function generator and report it.

Triggering of Oscilloscope:

To provide a more stable trace, modern oscilloscopes have a function called trigger. When using the Trigger Controls, the oscilloscope will pause each time the sweep reaches the extreme right side of the screen. The scope then waits for a specified event before drawing the next trace. The trigger event is usually the input waveform reaching a user-specified threshold voltage. The effect of triggering is to resynchronize the time base to the input signal, preventing horizontal drift of the trace. In this way, triggering allows the display of periodic signals such as sine waves and square waves. Trigger circuits also allow the display of non-periodic signals such as single pulses or pulses that don't recur at a fixed rate.

Set the function generator so that its output is a 750Hz sine wave with amplitude of 1.75Vs Pk-Pk with zero offset. Connect the output connector of the function generator to the channel 1 input connector of the oscilloscope.

On the oscilloscope, look at the Trigger Controls region. Press the TRIG MENU button. A menu will appear on the screen. Press the button next to 'Mode' until it reads Normal. Look at the Trigger Controls region. Twist the Level knob until it reads +0.5Vs. Now, change the trigger level to +2Vs.

Q5) What happened to the signal? Can you explain your results?

Return the trigger level to its default setting by pressing the SET TO 50% button in the Trigger Controls region.