CPE 2211 COMPUTER ENGINEERING LAB

EXPERIMENT 1 LAB MANUAL

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LABORATORY EQUIPMENT

OBJECTIVES

In this experiment you will

- Learn about signal characteristics such as AC, DC, RMS, and DC offset.
- Learn about signal coupling to oscilloscopes and multi-meters.
- Become familiar with the laboratory layout and equipment.

LAB REPORTS

The format of lab reports should be such that the information can be used to reproduce the lab, including what values were used in a circuit, why the values were used, how the values were determined, and any results and observations made. This lab manual will be used as a guide for what calculations need to be made, what values need to be recorded, and various other questions. The lab report does not need to repeat everything from the manual verbatim, but it does need to include enough information for a 3rd party to be able to use the report to obtain the same observations and answers. Throughout the lab manual, in the Preliminary (if there is one), and in the Procedure, there are areas designated by **Qxx followed by a question or statement**. These areas will be **bold**, and the lab TA will be looking for an answer or image for each. These answers or images are to be included in the lab report. The lab TA will let you know if the lab report will be paper form, or if you will be able to submit electronically.

BACKGROUND

AC and DC signals

There are two types of signals that can be used to power electronic circuits, namely DC and AC. A DC signal is constant value of voltage that has an average value equal to the value of the DC signal. An AC signal has an alternating value of voltage that has an average value equal to zero.

RMS

The Root Mean Square (RMS) value of a signal refers to the portion of an AC signal that does work. This is equivalent to the mean value of a DC signal. It has the same lighting and heating effect as an equivalent DC signal. A Digital Multi-Meter (DMM) only measures the RMS value of an AC signal. For sinusoids, it can be calculated by multiplying the peak AC value by 0.707. For example, the 120 V power that you connect to in your home refers to the fact that the voltage provided is 120 VRMS, but it has a peak value of 169.7 V.

DC Offset

DC Offset refers to the mean value of an AC waveform, which is typically non-zero. The functionality allows a DC signal to be added to an AC signal. By doing so, it shifts the AC waveform up or down if the DC offset is positive or negative, respectively.

DC and AC Coupling

Channel coupling means that a signal is either directly coupled (DC) or connected through a capacitor (AC). Directly coupled let's all frequency content of the signal through to the sampling head. AC coupling will remove any DC Offset from the signal to the sampling head. When using an oscilloscope, the channel measuring the incoming signal can be AC or DC coupled. When using a DMM to measure AC voltage or current, the connection is AC coupled. And when using a DMM to measure DC voltage or current, the connection is DC coupled.

Digital Multi-Meter (DMM)

When using the DMM, it is very important to select the correct quantity, be it voltage, current, or resistance, to be measured. Auto ranging is useful if the signal level is not known. For measuring voltage, the meter should be selected to measure voltage and be connected to the circuit in parallel or across the device of interested. For measuring current, the meter should be selected to measure current and be connected in series with device of interest. For measuring resistance, the meter should be selected to measure resistance and be connected in parallel or across the resistor.

Warning: Do not connect the meter to measure voltage with the selector set to measure current. This will create a short circuit across the voltage source and blow the fuse of the meter. Reason being, the ammeter function of the multi-meter presents a very low internal resistance, while the voltmeter function presents a relatively large internal resistance.

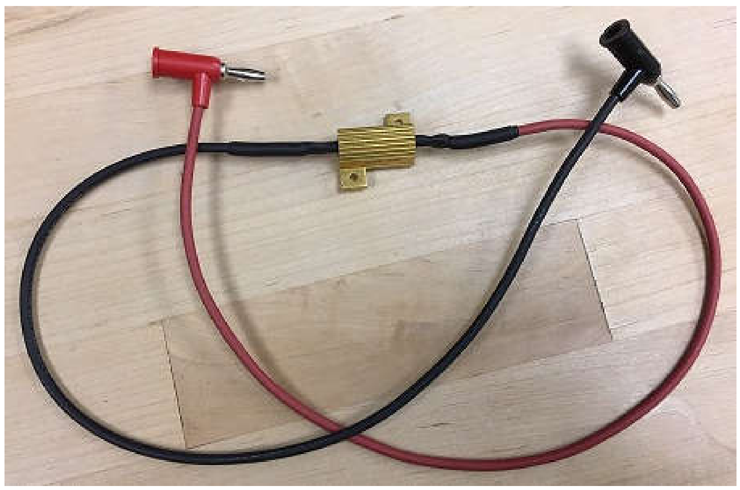
PROCEDURE

To properly use the instruments there are several concepts and some terminology you will need to become familiar with:

1. **Digital Multi-Meter** (DMM) (TENMA 72-410A): Typical functions included in DMMs is to read AC and DC voltages and current, resistance, diode test, and continuity. Some have extended functionality such as capacitance meter, and frequency detection, and more. When measuring AC waveforms the meter responds to the average of the internally rectified AC waveform and is calibrated to read out the RMS value. In AC VOLTS or AC mA settings the input is capacitively coupled and the meter displays only the RMS value of the waveform. It does NOT indicate the true RMS value of waveforms which have both an AC and a DC component. The TENMA 72-410A is usually used in a "floating" mode to make voltage, current, or resistance measurements. That is, unless it is connected to the ground of an external circuit which is grounded, neither terminal of the DMM is at ground potential.

   Because the DMM has a very high input impedance in the voltage reading mode, or very low input impedance in the current reading mode, and is actually a source of voltage (electrical current) in the resistance mode, it is very important to have the meter set to the expected mode of use before connecting it to a circuit. A DMM set to read current presents a short circuit to the system when connected (in parallel) to read a voltage. A fuse is used to protect the meter and will be blown as a minimum, but other damage to the meter may also take place.

A common tendency using DMMs is to try to take measurements to more digits of significance than is necessary. In order to have a stable non-flickering display of a voltage or current measurement, the meter measurement range should be selected so that no more than three significant figures is displayed. For example, to measure 0.1, 0.25 and 0.50 mA, three decimal places would be the maximum need to display on the meter, and two decimal places would generally be sufficient. The general rule is to not record data with more "significance" than can be graphed with accuracy.



47 Ω / 20 W power resistor.

Q1. Use the meter in Resistance mode to measure the 47 Ω / 20 W resistor provided in the lab, and record the value.

2. <u>**DC Power Supply** (TENMA DC Power Supply 72-6615):</u> This instrument is used to produce an average value or direct current (DC) voltage. The supply has three different outputs, two of which can be configured to work in series, parallel, or independently. The third supply, located on the bottom right is a constant 5 V output.

   Referring to the first two supplies; on the front panel there are knobs for setting the voltage and current levels, and two buttons for selecting the output configuration. These supplies automatically determine whether the output regulation is Constant Voltage (CV) or Constant Current (CC), depending on the knob settings and the load. To observe this supply behavior;

   a. Attach one of the 47 Ω / 20 W power resistors to one of the controllable outputs
   b. Rotate ***all Voltage and Current*** control knobs fully counter clockwise
   c. Set the supply outputs to ***Independent Operation***
   d. Rotate the Current control knob ***of interest*** fully clockwise

e. **Q2 Note the supply mode CC or CV?**
f. Rotate the Voltage control knob ***of interest to 20 V***
g. Slowly rotate the Current control knob ***of interest*** counter clockwise, while watching the CC and CV LEDs
h. **Q3 When does the supply switch modes (current level)?**
i. **Q4 Why does the supply switch modes?**
j. Turn ***both the Voltage and Current*** control knobs fully counter clockwise
k. ***Disconnect the resistor***

The output configurations are, series, parallel, and independent. The series configuration internally forces the two supplies to be connected in series, thereby increasing the maximum applicable voltage **to _____ times (Q5)** the capability of a single supplies voltage. **Q6 What is the maximum possible current for this configuration?**

The parallel configuration internally forces the two supplies to be connected in parallel, thereby increasing the maximum applicable current **to _____ times (Q7)** the capability of a single supplies current. **Q8 What is the maximum possible voltage for this configuration?**

The independent configuration provides two separate supplies, with name plate voltage and current capability.

Using the resistor measured in the DMM section perform the following:

l. Set the Power Supply to independent mode
m. Turn all Current and Voltage knobs fully Counter Clock Wise (CCW)
n. Connect the resistor to one of the two controllable supply outputs (black and red connections)
o. Turn the Current knob to the 12 o'clock position
p. Slowly rotate the Voltage knob to read ~10 V
q. Slowly rotate the Current knob fully CW, then CCW and observe the Constant Current (CC) and Constant Voltage (CV) indicators. **Q9 Write down your observations. Q10 When in CC mode, does V/I still correspond to the measured resistance from Q11?**

3. **<u>Function Generator</u>** <u>(TENMA 72-7650):</u> Although this instrument has a wide variety of functionality including; AC waveform generation, frequency counter, and AM, FM and External modulation, this lab will only investigate the AC waveform generation aspect of the equipment.

   The function generator can output a Sine, Triangle, or Square wave waveform over the frequency range of 0.01 Hz to 15 MHz. It also has the capability to affect the waveform amplitude, symmetry, and DC offset. Amplitude refers to the peak value of the waveform, and can range from a few mV to 20 V. Symmetry refers to the wave shape of the first 180^o of waveform relative to the last 180^o. In particular, the Triangle waveform can be made to look like a Sawtooth waveform by rotating the Symmetry knob fully CW or CCW. And the Square wave duty cycle, or ON state time relative to period, can be affected by the Symmetry knob. DC offset refers to the ability to add a DC level to the AC waveform. The Symmetry and DC offset must be turned on by pressing the button below their respective knobs.

The Function Generator is a fairly straightforward device. The output waveform, frequency, and amplitude are set or adjusted by separate front panel controls. The SYNC OUT connector provides a rectangular waveform output which can be used to externally trigger an oscilloscope and/or provide a signal to a frequency counter for display of the signal frequency or period. The TENMA 72-7650 Function Generator OUTPUT can easily be set to exceed the 5V limit on TTL integrated circuits and damage them. When using the TENMA 72-7650 as a clock for a digital logic circuit be sure to adjust the output amplitude and offset and waveform to get a 0 to 5 volt square wave with an appropriate frequency. The specifications of the waveforms to be generated from the function generator are described in the upcoming sections.

4. **Frequency Counter/Timer (**MASTECH Multi-Function Counter MS6100**):** The MS6100 Multi-Function Timer provides the capability to measure the frequency of periodic signals, to measure the period between events, or to totalize (count) the occurrence of events. The FREQ. button selects the range of the frequency measurement.

   By pressing the FREQ. button once, a range of 10 MHz is selected. If pressed once more the 100 MHz range is selected, and pressing the FREQ. button for a third time the 1300 MHz is selected.

   Connect the SYNC OUT output of the TENMA 72-7650 function generator (described in section 3) to the input of the MS6100 Multi-Function Timer:

   a. Adjust the TENMA 72-7650 frequency selector to 1 kHz
   b. Adjust the frequency range selector on the counter/timer to a proper value
   c. **Q12 Measure the frequency**
   d. **Q13 Measure the period of the generated signal**
   e. **Q14 Generate signals of 10 kHz and 50 kHz, and repeat the above measurements for them**

5. **Mixed Signal Oscilloscope** (Agilent Technology 6012A): The lab oscilloscope is referred to as Mixed Signal because it has 2 analog measurement channels, and 16 digital measurement channels. The oscilloscope has a 100 MHz bandwidth meaning that it can measure a signal with no more than 3 dB of attenuation up to 100 MHz. One way to set the oscilloscope to initial settings once a signal is connected is to press the Autoscale button at the top of the control panel. A signal must be present so that the oscilloscope can take readings off the signal and setup the display accordingly. Note that this method is not fool proof and an understanding of what the signal you are trying to view looks like is a must. This will help facilitate proper viewing of the signal. Autoscale may miss-interpret the signal and not set the display to the correct settings. Display settings can be accessed via

the various knobs and menu buttons on the front panel. Take a few moments to explore the labeled buttons and notice each of the menu items displayed. Be sure to keep notes in your lab report as you go along.

Use one of the BNC terminated coaxial cables to connect the TENMA 72-7650 Function Generator to Channel 1 of the oscilloscope. Set the function generator for a 10 kHz square wave and press the Autoscale button on the oscilloscope to display the waveform. Adjust the signal amplitude to get a 5 V peak to peak square wave and then adjust the DC offset to get a square wave that switches between 0 and 5 V. Be sure the Offset switch on the function generator is ON; otherwise, the offset adjustment will have no effect. **Q15 Record an Image of the waveform.** Use the oscilloscope to determine the highest frequency square wave you can generate with the function generator and have the waveform still look like a square wave, rather than a "rounded edge" square wave, or sinewave. **Q16 Record an image of the waveform. Q17 What is the highest frequency determined to still provide a valid square wave?**

This laboratory course is concerned with instrumentation and measurements in digital electronic circuits. It should be noted that a good understanding of what you are doing will be essential in coming to a satisfactory conclusion in the following experiments. No effort has been made to fully explain everything that you will be doing or to provide a "cookbook" for you to follow. Your co-requisite computer engineering course and programming course background are assumed, and you should be able to draw on them for your understanding of the labs.