CpE 112
LABORATORY EQUIPMENT

Most of the equipment that will be used to perform computer engineering experiments in CpE112 will be different from equipment that you have used before. The following description of the equipment should be read before you begin the first experiment so that you might understand the capabilities and limitations of the instruments you will be using.

The equipment package on your workbench contains a dc power supply, a variable frequency function generator, a digital multimeter (DMM), and a frequency counter. A PC and an 18 channel 100 MHz Agilent Technology 6012A Mixed Signal Oscilloscope (MSO) (http://cp.literature.agilent.com/litweb/pdf/54695-97015.pdf) is also provided at your lab workstation.

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: This is the value of an AC signal that has the same lighting and heating effect as a DC signal. The Digital Mulitmeter (DMM) only measures RMS.
It is calculated by multiplying the peak AC value by 0.707.

DC offset: 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: When using the oscilloscope, the channel measuring the incoming signal can be AC or DC coupled. When the channel is AC coupled, it will allow only AC signals to pass through to be measured (a capacitor is coupled to the input channel). Therefore, it will reflect an AC signal without a DC offset. When the channel is DC coupled it will allow both AC and DC signals to pass through. Therefore, it will reflect an AC signal with a DC offset. Selecting to measure AC current or voltage on the DMM automatically selects AC coupling.

Digital Multimeter (DMM): When using the DMM, it is very important to select the correct quantity (AC or DC voltage, AC or DC current, resistance) to be measured and the range you expect it to cover. Also, the multimeter needs to be connected correctly.
For measuring voltage, the meter should be selected to measure voltage, with the correct expected range, and be connecting to the circuit in parallel.
For measuring current, the meter should be selected to measure current, with the correct expected range, and be connecting in series in the circuit.

For measuring resistance, the meter should be selected to measure resistance, with the correct expected range, and be connecting in parallel with 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 multimeter presents a very low internal resistance, while the voltmeter function presents a relatively large internal resistance.

To properly use the instruments, there are several there are several concepts and terminology you will need to know about each instrument. Observe the instruments in the package as you read the following material:

1. **DC Power Supply (TENMA DC Power Supply 72-6615):** This instrument is used to produce an average value direct current (DC) voltage. On the front panel, you will find controls for operating this instrument in series, parallel, and independently.

   Record the difference between each function. **Note the fixed 5 v DC output on the bottom right. This very useful in digital circuits which use 5v as 1 and 0v as a 0.**

2. **Function Generator** (TENMA 72-7650): This 15 MHz Sweep Function Generator is used for generating a alternating current (AC) waveform. Therefore it offers the capability to modify **Amplitude, Frequency, and Phase.**

   It also offers the capability to add a DC signal to your generated signal. **This is called DC offset.** A DC offset control on the function generator front panel provides the capability to internally add a DC voltage to the AC waveform. In order to add DC offset to the signal, make sure you turn the Offset switch on before turning the Offset knob. If you want to generate an AC signal without offset, turn the Offset switch off.

   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.

   Generate a square wave with an amplitude of 3 v and frequency of 900 Hz. Following this step, add DC offset of 2 volts.

3. **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 you press it once more, the 100 MHz range is selected, and by pressing the Freq button for the third time the 1300 MHz gets selected.

Connect the SYNC OUT output of the TENMA 72-7650 function generator to the input of the MS6100 Multi-Function Timer. Adjust the TENMA 72-7650 frequency selector to 1 kHz. Now adjust the frequency range selector on the counter/timer to a proper value, and measure the frequency. Also measure the period of the generated signal. Generate signals of 10 kHz and 50 kHz, and repeat the above measurements for them.

4. **Digital Multimeter (DMM)** (TENMA 72-410A)**:** The Digital Multimeter reads AC and DC voltages and current. 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 capacitor coupled so that the meter displays only the RMS value of the ac part 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 digital multimeter has a very high input impedance on the voltage reading scales, a very low input impedance on the current readings scales, and is actually a source of voltage (electrical current) on the resistance scales, it is very important to have the meter adjusted to the proper scale before connecting it into the circuit. A multimeter set to read current presents a short circuit to the system when connected (in parallel) to read a voltage. A fuse will be blown, as a minimum, and other damage to the meter may also take place. You are responsible for learning and using the proper measurement techniques.

A more likely problem than electromagnetic interference in these experiments is the tendency to try to make measurements to more digits of significance than is necessary. In order to have a stable, non-flickering display of your voltage or current measurements, always select a scale or range so that no more than three significant figures will be displayed. For example, to measure .1, .25 and .50 milliamps, three decimal places would be the maximum that you would want to display on the multimeter, and two decimal places would generally be sufficient. The general rule is not to take or write down data with more "significance" than you can graph with accuracy.

Generate 7v DC on the power supply and measure it using the DMM.

5. **Mixed Signal Oscilloscope** (Agilent Technology 6012A)**:** The CpE 112 lab oscilloscope is an 18 channel 100 MHz digital scope. It is controlled by an internal microcomputer and most adjustments can quickly be made by simply pressing the Autoscale button at the top of the control panel. Use a piece of coax cable with a BNC connector at each end to connect the TENMA 72-7650 Function Generator to Channel 1 of the Agilent Technology 6012A Oscilloscope. Set the TENMA 72-7650 for a 10 kHz square wave and

press the Autoscale button on the scope to display the waveform. Adjust the TENMA 72-7650 amplitude to get a 5V peak to peak square wave and then adjust the DC offset on the TENMA 72-7650 to get a square wave that switches between 0 and 5V. Be sure the Offset switch on the function generator is on; otherwise, the offset adjustment will have no effect. Use the oscilloscope to determine the highest frequency square wave you can generate with the TENMA 72-7650 and have the waveform still looks "square".

The Autoscale button can make a lot of the scope adjustments for you but it can't do everything. Much of the functionality is accessed via the various menu buttons. 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 notebook as you go along. Hit Display and then Clear Display softkey to clear the menu area at the bottom of the screen.

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 corequisite computer engineering course and programming course background are assumed, and you should be able to draw on them for your understanding of the labs.