EE 112 20 January 2015

Lab Project 1 Report Due 4 February 2015

LOGIC CIRCUITS - EQUIPMENT AND MEASUREMENTS

GENERAL LAB WRITE-UP INSTRUCTIONS:

In this lab project and all subsequent projects, you will be required to document your work in the form of a lab report as well as answer questions in this handout that relate to the project. I will expect one lab report from each group of two students. You are required to work in groups of two. Exceptions are with instructor consent only.

Provide data and written answers to the questions as required and asked for in the Lab Handout. Be as quantitative as possible. Avoid nebulous answers like "signal A was greater than signal B". I don't know what "greater" means.

Reports are due at date specified by the instructor.

Format for the Lab Report write-up will be as described in the "Guidelines For Lab Reports". Points will be taken off if you do not follow these guidelines.

OBJECTIVE:

The objective of this lab is threefold:

1) To learn and/or review the operation and the characteristics of some of the lab equipment you will use in this course. (Scope, DMM, Signal Generator, Power Supplies, input and output impedances, voltage ranges, frequency ranges, etc.)

2) Use the lab equipment to make measurements on some simple logic circuits.

3) Build some logic circuits and measure the input/output to verify performance. Later in the course you will simulate the circuits and verify the performance by building the circuit and measuring the input and output.

INTRODUCTION:

Oscilloscope (Mixed signal: analog and digital)

The Digital Oscilloscope is a sophisticated instrument that allows us to measure the amplitude of a voltage waveform as a function of time. It also has the capability of allowing us to measure up to four analog signals simultaneously as a function of time, or to create a "voltage transfer characteristic", that is, we can measure two voltages in an X - Y relationship.

In addition to the analog signals, the scope has 16 digital channels and can measure up to 16 digital signals. This is like a logic analyzer as we will see in the lab.

Features of the scope include the following:

a) Storage of the signals in a manner which will allow the operator to not only view, but perform some operations on the signals such as time and amplitude scaling and certain mathematical operations as well.

b) Triggering at various points in the waveform to allow the operator to look at very specific events in the waveform.

c) Display capability with information relating to time base, amplitude sensitivity and overall setting of scope controls.

The basis of the operation of the Digital Oscilloscope is that of digitizing the input waveform and storing the data in a digital memory. This then, allows the operator to manipulate this stored data. Also the display is not an analog display. Rather, the data from memory is scanned out and run through a Digital-to-Analog Converter which is subsequently used to control the LCD (screen) output.

Signal Generator

The signal generator is a device capable of generating digital signals and analog signals of varying shape, magnitude, and frequencies. In addition to being able to generate various waveforms, it is also capable of adding a DC level to the signals, to create offsets, so a large variety of signals can be generated.

It is used as a signal source for the experiments you will be performing.

Operation is self explanatory from the controls and display on the front of the instrument.

As will all devices, there are limitations, and it is your responsibility to understand what these limitations are such as output impedance, maximum frequency, drive capability.

Power Supply

The power supply is a device capable of outputting a DC voltage(s) and current to a circuit. The output voltage is adjustable by the controls on the front panel. It has limited voltage range and current capability, so make sure you understand the limitations. Note that there is a current limit control, which can be set to protect circuits from damage. Make sure you understand what the controls do.

The power supply will be used as the main source of power for the experiments you will be performing. Operation is self explanatory from the controls on the front of the instrument.

Digital Multimeter (DMM):

The digital multimeter is a device capable of performing measurement functions which include DC and AC voltages, frequency and characteristics of some electronic devices, DC and AC currents, capacitance, and resistance.

To measure AC and DC voltages, set the DMM to the proper function and range *(highest range if voltage is unknown)*, and connect the DMM in **PARALLEL** with the element that you want to measure the voltage across.

To measure AC or DC currents, set the meter to the proper function and range (highest range if voltage is unknown), and connect the DMM in **SERIES** with the circuit element so you can measure the current through the element.

To measure resistance, connect the DMM across the element you wish to measure the resistance of, but ***make sure that there are no other sources supplying power to that element*****, or other elements in parallel with the element you are measuring.** Remember, to measure resistance, the DMM has a built-in constant current source that it uses to create a voltage drop across the element, and a digital voltmeter internal to the DMM measures the voltage across the element which results from the current. Any other source of power would only serve to interfere with the measurement, and possibly damage the meter.

Capacitance is measured in a similar fashion to resistance. Make sure that the capacitor you are measuring is discharged and not connected to any source of power in a circuit.

Grounding:

Before connecting any circuits, it is important to understand what is meant by the term "*ground*" (abbreviated as *GND*). Sometimes this is referred to as "*Common*". Instruments that produce voltages and those that measure voltages all operate with a voltage difference, i.e. voltage between two points. It is convenient in most circuits to consider one point of the circuit a common point and then "refer" (hence reference) to the voltage elsewhere with respect to this point. This point is a local or relative ground. Different circuits can have a separate reference ground, or there may be one ground common for many circuits. By convention ground is labeled as zero volts.

For most lab work using electronic instrumentation and signal processing equipment, it is good practice to make the circuit ground common with the building ground at one and only one point. The building ground is a connection to earth somewhere in the building foundation. In the case of this lab, it is the ground of the three prong power outlet plug. This connection is carried through to the chassis of the electronic equipment such as the scope.

If you would like to know more about grounding, power, and neutral connections in a house, just ask the instructor.

PROCEDURE:

Part 1:

In the first part of this lab, you are to measure the rise and fall times of the 0 to 5 volt square wave signal out of the signal generator. Using the scope, adjust the signal generator to output a 0 to 5 volt square wave at a frequency of 1kHz. **MAKE SURE THE SCOPE IS DC COUPLED FOR THESE MEASUREMENTS!** Then use the scope with the analog channel inputs to measure the rise and fall times.

Record this data and note any anomalies you observe. By “anomalies” we mean do you observe anything that results in the waveform being something other than what you’d expect. In this case, less than a perfect square wave. Describe your observations in the write-up of the report for Project 1.

Part 2:

In the second part of this lab, you are to measure the propagation delay (using the digital capability of the scope) and the rise and fall times (using the analog channel capability) of the devices which you will be subsequently using to build a logic circuit. Measure the propagation delay and the rise and fall times of one gate from each IC's; the Quad, two input NAND gate (7400); the Quad, two input NOR gate (7402); and the Hex Inverter (7404). To make the measurements, connect the circuits up as shown in Figure 1. Set the signal generator for a 0 to 5 volt, 1kHz. square wave to measure the rise and fall times, and the output of the signal generator to measure the propagation delay. Verify, using the scope, that the voltage and frequency of the square wave out of the signal generator is correct. If not, explain why.

Note that the unit being investigated is marked UUT (Unit Under Test).

How do the three devices compare? Is one faster than another? Note any anomalies you observe in the response. Again, by “anomalies” we mean do you observe anything that results in the waveform being something other than what you’d expect. Describe this in the lab write-up.

Part 3:

In the third part of this lab, you are to measure the Voltage Transfer Characteristic (VTC) of the devices and note where the device transitions from one value to another. Use the circuit of Figure 1 again, with the signal generator set to a 0 to 5 volt, 1 KHz, “**TRIANGULAR**” waveform. Now observe the voltage transfer characteristic by setting the scope to the X-Y mode, where the input is the X value and the output is the Y value. Measure the VTC of one gate from each IC package, that is, for the 7400, the 7402, and the 7404.

What value of voltage do you observe for the transition from a logic "1" to a logic "0" for each of the devices? Use the midpoint of the output transition as the measured value. Describe this in the lab write-up.

What value of voltage do you observe for the transition from a logic "0" to a logic "1" for each of the devices? Use the midpoint of the output transition as the measured value. Describe this in the lab write-up.

How do the devices compare? How close are the switching transition voltages (within what percent)? Be Quantitative! Note any anomalies you observe. Describe this in the lab write-up.

Part 4:

In the fourth part of this lab, you are to measure the input/output characteristics of the logic circuit shown in Figure 2 as well as the time response.

For the input/output characteristic, use the "Switch Board" switches to generate the inputs and four digital channels on the scope to indicate the status of the inputs, and one to indicate the output.

Then, by applying the various inputs to the circuit, determine the ***Truth Table*** for the circuit. Note any anomalies you observe. Describe this in the lab write-up.

Then measure the time response. This is the propagation delay of the circuit of Figure 2. Perform this measurement by using the signal generator TTL output (set to a frequency of 1 kHz) to toggle one of the inputs, the one with the longest path, specifically the “X” input, and measure the propagation delay between “X” and “F”. Set inputs W, Y, and Z so the output F will change state as X changes. Remember to describe your observations this in the lab write-up.

Part 5:

In addition to the items describe above to be included in the lab write-up, answer the following questions as part of this lab write-up. Include the answers to these questions as a separate section in the lab write-up.

1) Note that the switches on the "Switch Board" are "debounced". What does that mean?

2) Why is the “propagation delay” of the device an important parameter?

3) What does “DC coupled” mean on the Oscilloscopes, and why do the scopes have to be "DC coupled" when used in this experiment?

4) When do you think the scope should be used to measure electrical signals and when should the multimeter be used?

LAB PROJECT FIGURES

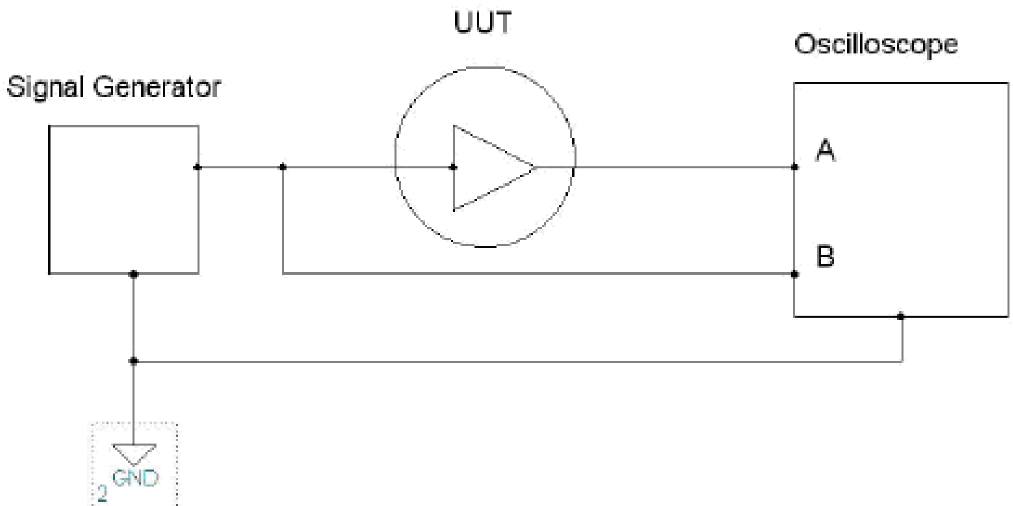

Figure 1

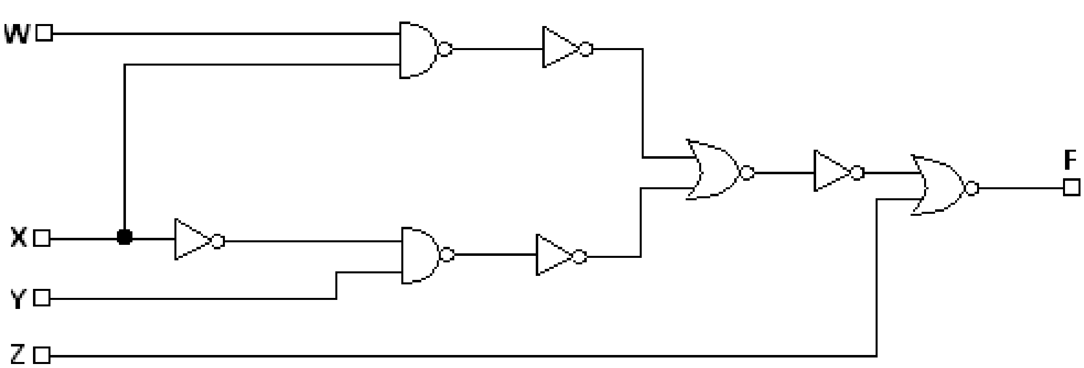

FIGURE 2