Faculty of Engineering and Applied Science
Memorial University of Newfoundland
ENGI 3861 - Digital Logic
Fall 2017

Laboratory 0:
Lab Instruments and Simple Logic Circuits

Pre-lab

All students must review the complete lab prior to the lab period. Each group must complete all sections marked as "**PRE-LAB**". The pre-lab will be checked by a TA at the start of the lab. If a group's pre-lab work is not complete, the group may not be allowed to complete the experiment.

Lab Report

Each group is expected to complete a lab report. At the end of the lab, hand in the lab report, which should include the pre-lab, along with the lab observations and comments requested. Where indicated, demonstrate the correct operation of your circuit to a TA and have them sign your lab report. Cleanliness and neat wiring (colour coding, using wires that are of the right length, not crossing over IC chips, etc.) will be worth 10% of the mark for this as well as other lab experiments in this course.

1. Introduction

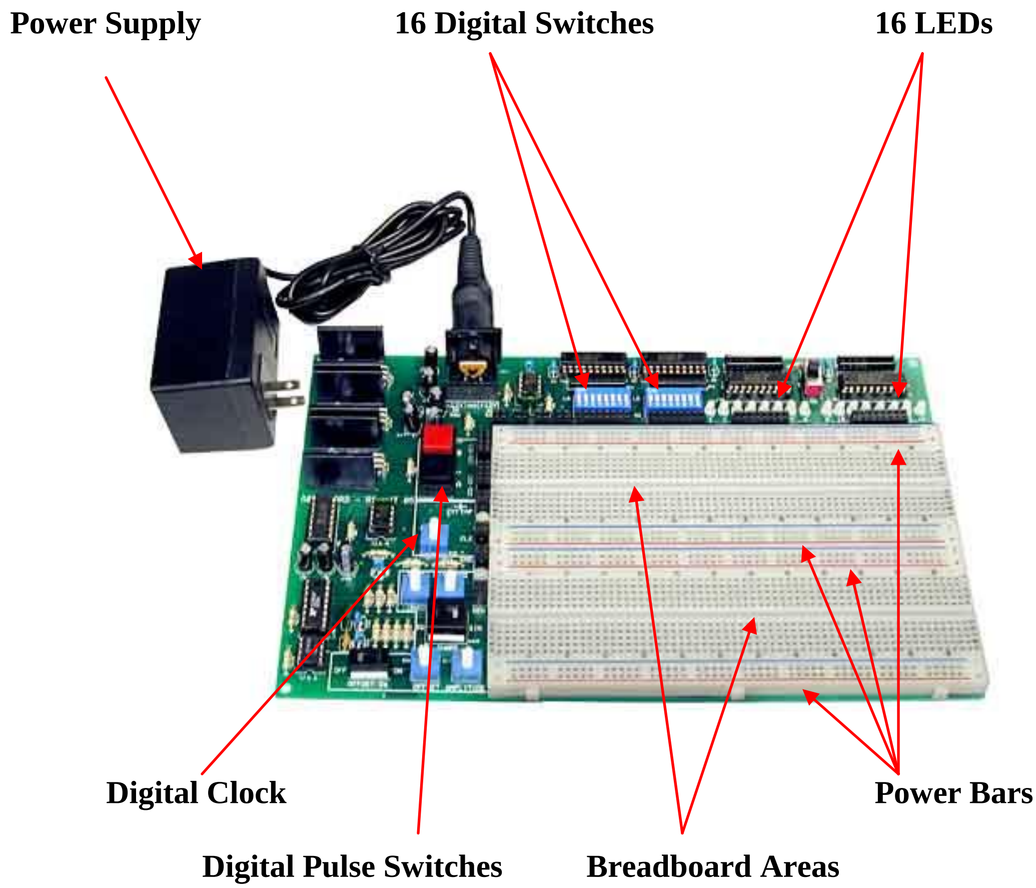
The purpose of this lab is to become familiar with the different types of test instruments used in the building, debugging, testing and repair of discrete digital electronic circuits and to construct some simple combinational logic circuits. Although modern digital circuits are typically integrated in chips containing many thousands, even billions of gates, the labs undertaken in this course will often involve wiring up individual gates in order to verify a circuit's design.

The instruments experienced in this lab include digital logic board (with breadboard, power supply, and digital clock), logic probe, and digital multimeter. As well, although not used during this experiment, logic analyzers are frequently used in the design and test of digital circuits.

2. Equipment

In this course, you will build circuits on a board that has special features for testing and debugging simple digital logic circuits. See the following figure. The board has sufficient breadboard area to assemble circuits with several integrated circuits (ICs) and other components. Along the edges of the breadboards, long *power bar* strips are provided; these are used to connect power lines (i.e., ground (GND) and V_{CC} = + 5 V). You will find it convenient to connect GND and + 5 V input supply voltage to power bars on the board; for example, any contact along the same bar to which GND is connected will be at ground level and can be used as ground input. After carefully planning the layout of ICs on the board, each IC should be inserted into the chosen location, across the middle bridge in a breadboard, making sure that the pins are not bent. The digital board also has 16 debounced digital switches that are used to provide input signals to circuits, and 16 LEDs that are used to display the outputs of the circuits. The digital pulse switches may be used to generate either edges, low-to-high or high-to-low, that can be used as input signals or clock pulses to your circuit.

The power supply requirement for the simple digital circuits that will be built in this lab is fixed +5 V and this is available through the power adapter, which converts AC power to DC power at +5V, –9V and +9V. Always be sure to connect the ICs in your circuit to the GND and +5V supply.



3. 74xx Series ICs and Data Sheets

[Complete all of this section as PRE-LAB. You will find it helpful to refer to the data sheets of several devices required for this lab, namely, 7400, 7404, 7408, and 7432, which are found on the course website.]

In this course, you will be constructing circuits using the 74xx series of integrated circuits. Each IC is manufactured using high speed CMOS technology as indicated by the “HC” notation in the component label. For example, an IC labelled SN74HC00 is a 74xx series device from Texas Instruments (“SN”), that is manufactured using high speed CMOS and where the “00” identifies the device as containing NAND gates. It is straightforward to find data sheets describing the properties (both functional and electrical) of the ICs by googling the appropriate chip number or going to the manufacturer's web page. For convenience, the data sheets for many of the devices used in this course can be found on the course website. Answer the following questions using data sheets, the Internet, or any other resource:

(a) Sketch the pin configuration for 7400 and 7404 DIP (dual inline packaging) chips.

(b) Get an estimate of the cost of purchasing 1000 74HC00 "through hole" (that is, not “surface mount”) DIP components. Specify the supplier and the location of their website. Repeat for 74HC04.

4. Some Simple Measurements

In this section of the lab, you will use 7400 and 7404 chips to get familiar with typical equipment used in the lab, including the digital board, logic probe, and digital multimeter. **Complete this section in the lab.**

(a) Insert the 7404 chip on the digital board and connect the power supply and ground to the appropriate pins on the chip. Connect one of the inverter inputs to a switch. Ensure that power is supplied to the board. ***Using the logic probe, verify the correct input and operation of the inverter, recording the results. Using the digital multimeter, measure and record the voltages of input and output for each different input level. Comment on whether the results are as expected.***

(b) Insert the 7400 chip on the board and connect power and ground to the appropriate pins and switches to the inputs of one of the chip's NAND gates. Ensure that power is supplied to the board. ***Using the logic probe, verify the correct operation of the NAND gate, recording the results. Using the digital multimeter, measure and record the input voltages and output voltage for each possible input combination. Comment on whether the results are as expected.***

5. Simple Combinational Circuits

(a) As **PRE-LAB**, determine how to use 2-input NAND gates to produce (1) an inverter, (2) a 2-input OR function, and (3) a 2-input AND function. **In the lab**, using a single 7400 IC (quad 2-input NAND), connect a circuit that produces each gate above.
Verify your circuits by checking its truth table using the switches on the digital board as input sources and the logic probe to observe the output. ***Record the results of your testing in your lab report.***

(b) Consider a digital circuit with two inputs for which the output is a "1" when the two inputs are the same and a "0" when they are different. As **PRE-LAB**, determine the circuit to realize the function based on 2-input AND, 2-input OR, and NOT gates. (Note, in order to save time in the lab, it would be best to mark pin numbers on your circuit diagram.) **In the lab**, implement and test a circuit that does the same logic function using only 2-input AND, OR, and NOT gates. (That is, using 7404, 7408, and 7432 ICs.) ***Record the results of your testing in your lab report.***

6. Implementation of a Digital Logic Circuit Specification

Consider the following truth table specification for a digital logic circuit to implement a Boolean function F.

XYZ	F
000	1
001	1
010	1
011	1
100	0
101	0
110	0
111	1

As **PRE-LAB**, determine a minimized sum-of-products representation of function F and draw the circuit using AND, OR and NOT gates. Redraw the circuit to implement F using only NAND gates and inverters. For convenience when implementing the circuit, mark the pins on the NAND circuit diagram.

In the lab, construct and test the circuit using only NAND gates and inverters to implement F. ***Record the results of your testing in your lab report. Demonstrate the correct operation of your circuit to a TA and have them sign your lab report.***

Be sure to submit your lab report at the end of the lab period, including pre-lab data, circuit diagrams, recorded observations and results, comments, and TA signature.