ECE241 - Digital Systems - Lab 1 FALL 2013

Building Circuits using 7400-Series Chips

1.0 Introduction to the Digital Lab

The purpose of this lab is to illustrate the process of building logic circuits by using chips that contain individual logic gates. Although circuits are no longer built in this way in the industry, it is useful to see how the chips are connected together to understand the basic electrical connections.

Below is a description of the different pieces of equipment you will use: the protoboard, logic probe, wire strippers and digital switch/light board. **BEFORE the lab,** do the preparation specified in Section 2.0. During your lab, read through these sections and do the actions.

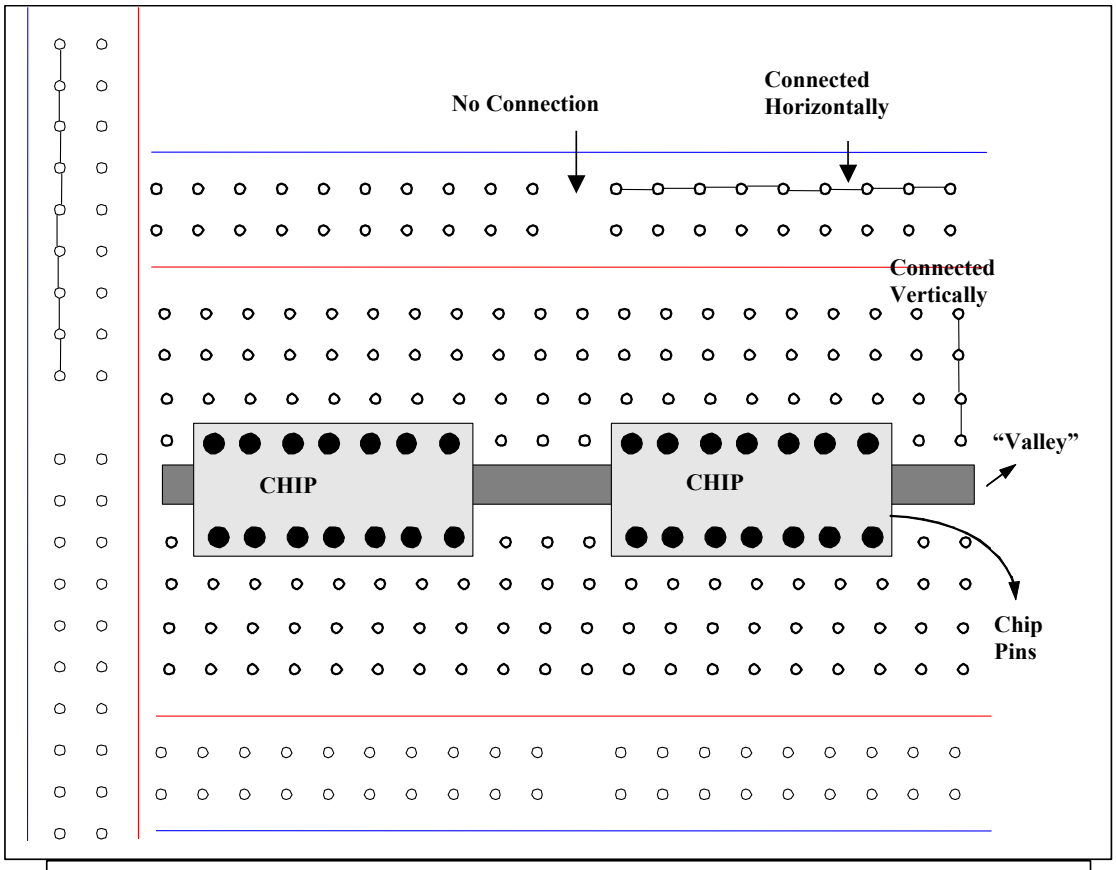


Figure 1 - Picture of the Protoboard

1.1 Protoboard

The protoboard (breadboard) is for holding and connecting chips. As illustrated in Figure 1, chips are inserted across the middle "valley" in the protoboard. The set of holes in a vertical line above the valley are connected electrically, as are the vertically aligned holes below the valley. So, each pin of the chip in the board is connected to the holes above (or below) the pin. To make a connection to a specific pin, you need only make connections between the holes by plugging the bare end of a wire into the holes above or below the pins.

In the figure the horizontal lines at the top and bottom of the board delineate holes that are connected horizontally; note that the space in the middle indicates a disconnection. The horizontally-connected holes at the top and the vertially connected holes at the side are usually connected to the power and ground provided by the external connector. The power and ground of the chips are then connected to these strips of holes. The first thing you should do in the lab is connect power and ground to these horizontal and vertical strips.

1.2 Digital Switch Board

The digital switch board provides switches that have digital output (5V = logic **1**, 0V = logic **0**) and lights that can be driven by logic signals (logic 1 turns a light on, logic 0 turns it off). Test the board by connecting the switches to the lights. The board also provides a clock, which can have its frequency varied by inserting different capacitors into the holes next to it, and a seven-segment display.

1.3 Logic Probe

The logic probe is used for measuring the logic values of signals on the board. Be sure that it has power attached, to the correct terminals. To test the probe, touch it to the +5V on the protoboard and ground, to ensure that it correctly indicates the values high (1) and low (0) respectively.

1.4 Wire Strippers and Chip Puller

The wire strippers are attached to each workstation to make sure they don't get lost. If you haven't ever stripped a wire, try it!

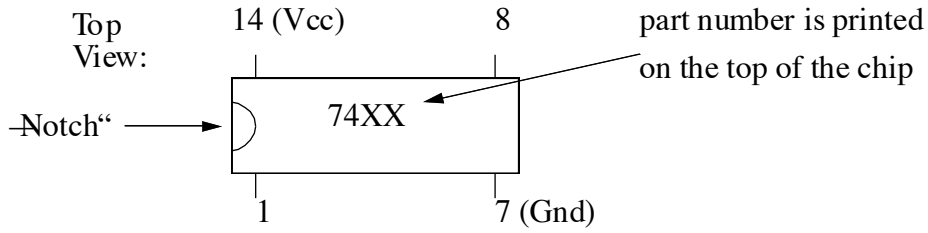
The chip puller should always be used to remove chips from the protoboard. Doing it with your fingers will bend the pins and ultimately break them, so don't!

1.5 7400-series Chip Packages

The chips that you will use in this lab are Small Scale Integration (SSI - meaning there's not much logic on a single chip) 7400 series. Depending on exactly which chip you end up using

in the lab you may have to set the logic probe to one of two settings: TTL or CMOS. This setting depends on the type of technolgy used for the transistors in the chips.

All of the chips you will use are "Dual In-line Packages" or DIPs. Most of the packages are 14 pins, and the pins are number from looking at the chip from the top: Below the "notch" is pin 1 to pin 7, and above the notch is pin 14 down to 8.



NOTE that Pin 14 must always be connected to VCC (+5V) and pin 7 to ground (0V).

2.0 Preparation for Lab #1

Design each of the circuits specified below using **only** 74LS04 (NOT), 74LS08 (AND) and 74LS32 (OR) series chips, **as given on the attached sheets**. Choose the actual pin numbers of the chips that you will use when you build your circuit and show them on your circuit diagram - this will make the construction of your circuit easier.

In each case, show all of the steps required to go from the specification given below, to the final circuit, including: assigning variable names to inputs and outputs, deriving a truth table, the logic function, and then a schematic picture of the final circuit, with pin numbers and chip types.

Make sure to paste all your preparations into the lab book to show the TA.

Important: You are allowed to use **only** the following packages (see sheet attached): 74LS04 (NOT gates), 74LS08 (AND gates) and 74LS32 (OR gates).

i. The logic function (note that b' means b inverted)

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f = ab' + c'
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ii. Design a circuit that has two inputs (**x** and **y**) and one output (**f**) that functions in the following way: when input **x** is false (0), the function **f** is equal to **y**; otherwise, when input **x** is true (1), the function **f** is equal to **y'**. (Observe that input **x** "selects" either the true or complemented version of **y** as the output **f**.)

iii. Design a circuit with three inputs (a,b, and c) and three outputs (**f1**, **f2, and f3**). The first output (**f1**) should be true (1) when *exactly* one input is true (1). The second output (**f2**) should be true when *all* three inputs are true (1). The third output (**f3**)

should be true (1) when *exactly* two inputs are true. In all other cases, the outputs should be false (0).

Optional: using all of the gates available (i.e. the other types of gates), can you build a cheaper implementation (using fewer gates and/or wires)?

3.0 Lab

The purpose of this lab is to get familiar with the equipment *and* to build and test several combinational circuits, and get a sense of how to debug circuits that don't work.

3.1 Equipment Familiarization

Read through Section 1 of this handout, and test your equipment as indicated in that section.

3.2 Building, Testing and Debugging Circuits

i. For each of the logic functions you designed in the preparation, build the circuit on the protoboard using chips which are available in the lab. Use switches on the switch board as input and the lights as output. Remember to hook up the power!

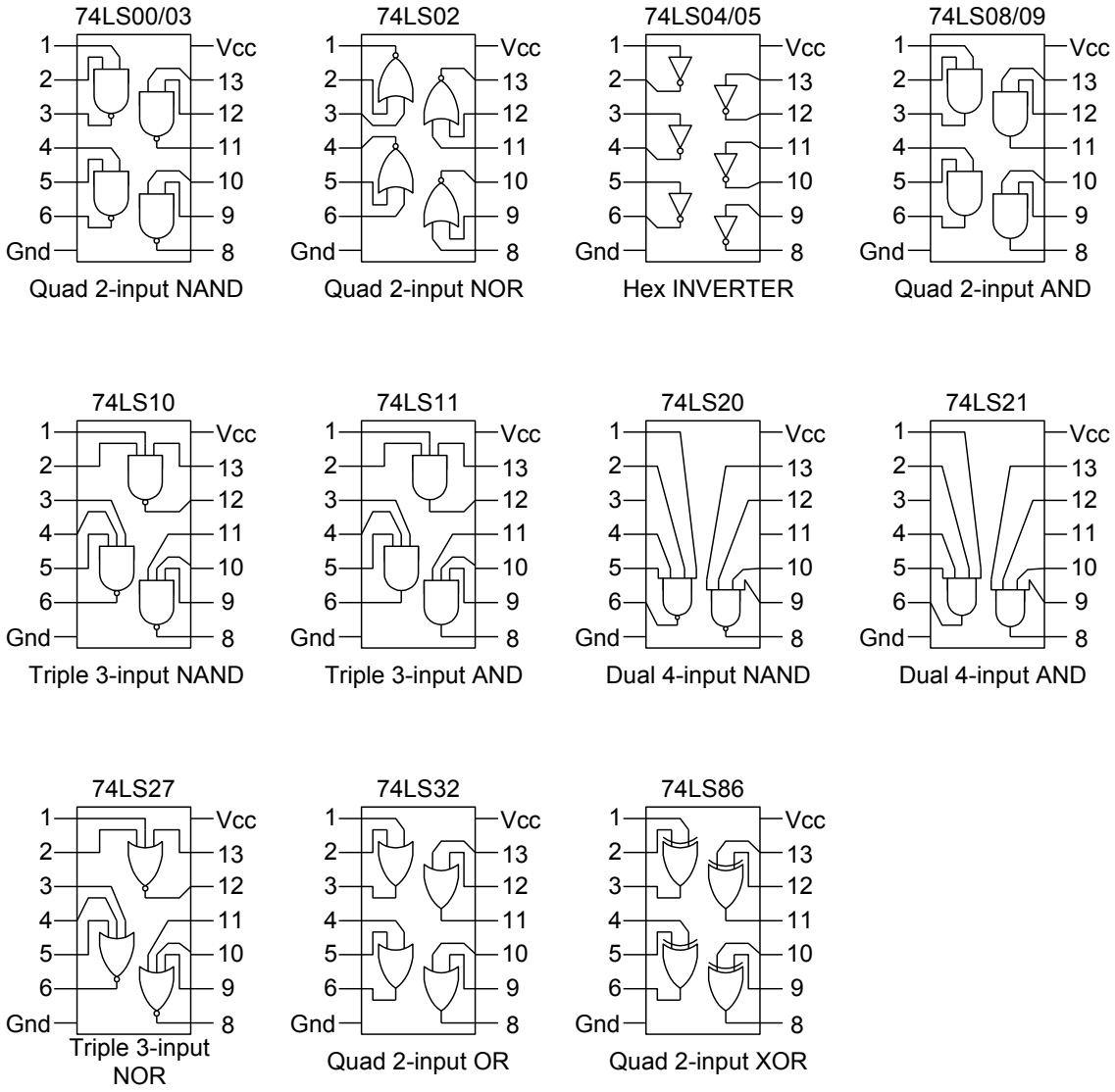
   Show your teaching assistant that each circuit works correctly once it does.

ii. Once the final circuit is working, the teaching assistant will *break* your circuit by inserting a faulty wire or component or doing something nasty. You are required to determine what the cause of the non-function is. To do this you must show concrete proof of the cause.

ECE 241 Digital Systems
Pin-Out Information for 7400-series Chips and Digital Board

Here are the Pin-out numbers and schematics for all of the chips used in Lab 1:

Pin-out of Selected TTL Chips



Here is the pin out connections for the header on the digital switch board:

Digital Board Header Pin Assignment					
Pin#	**Description**			**Description**	**Pin#**
1	Switch #1	o	o	Switch #2	2
3	Switch #3	o	o	Switch #4	4
5	Switch #5	o	o	Switch #6	6
7	Switch #7	o	o	Switch #8	8
9	Ground	o	o	NC	10
11	Ground	o	o	NC	12
13	Ground	o	o	NC	14
15	Ground	o	o	NC	16
17	LED #1	o	o	LED #2	18
19	LED #3	o	o	LED #4	20
21	LED #5	o	o	LED #6	22
23	LED #7	o	o	LED #8	24
25	Ground	o	o	NC	26
27	Ground	o	o	NC	28
29	Ground	o	o	NC	30
31	Ground	o	o	NC	32
33	Clock	o	o	NC	34
35	NC	o	o	NC	36
37	NC	o	o	Pulse Button	38
39	NC	o	o	NC	40