Physics 335
Notes for Lab 1 - Intro to Digital Logic Transparent Logic

March 9, 2009

Lab manual sections **“13-0”, 13-3, 13-4, 13-5, 13-1, 13-2**.

We’ll be introducing you to digital logic this quarter. Some things will be easier for you than analog . . . Some more difficult. Digital is an all together different animal than analog and you’ll rarely be concerning yourself with exact voltage values this quarter. Rather you’ll mostly be concerned if a signal is one of two values “Hi” or “Low” (Frequently “True” and “False”).

We’ll be using mostly 5 Volt logic this quarter. Hi will be “close” to 5 Volts, Low “close” to ground. (What we mean by “close” will vary slightly, depending on the logic family – More on this in a few.) Because we only care about a signal being high or low, a range of voltages are acceptable for each logic family.

For this quarter, unless we note otherwise, you’ll be using the 5 Volt FIXED supply for your digital logic circuits. Tie the black terminal to ground of the 5 Volt fixed supply so it’s +5 Volts relative to ground. You should also get in the practice of wiring chip supply voltages from the bus strips and bypassing the supply busses with some moderate capacitors to ensure good, solid supply voltages.

“13-0” Logic Probes

We’ll be using logic probes for much of the quarter. They’re a simple device, but useful and easy to understand.

You’ll use them mostly to determine 3 states:

- Hi – Close to 5 Volts –
- Low – Close to Ground –
- Floating – Not connected to a voltage source

The third state is an important one – and an advantage of the logic probe at times over just using a scope probe.

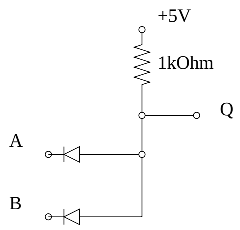
Clip the logic probe to the 5 Volt supply. There are two switches on most of the logic probes - pulse/memory and TTL/CMOS. Set them to pulse and CMOS respectively for the moment.

Note that at first, no indicator LED’s are lit. Touching the probe to Ground (Low) lights up the low indicator LED – Similarly for the +5 V (Hi) side. You’ll notice if you give the logic probe a HI signal, the “pulse” light will also flash . . . This can be captured by switching the pulse/memory switch to "memory". This is useful for capturing a brief glitch on a logic line. Depending on the particular logic chip you are testing, select for TTL (all chips with an "LS" in their chip name) or CMOS (All chips with a C, HC, HCT or CD in their chip name).

The SYNC output from the function generator is also specially designed for digital logic. This output is a square wave of 5V amplitude. Look at the output on the scope, DC coupled, and confirm the amplitude and that LO is at 0 volts. Also, look at the SYNC output with the logic probe and confirm it behaves the way you would expect it to.

13-3 Inside the Black Box - Making Logic from Pieces you know.

The cathode ends of the diodes are the two inputs (A B). The output is the cathode end "below" the resistor. i.e.



What logic function is Q?

13-4 Active and Passive Pull Ups

We will use the CD4007 chip. The pinout is on page 315.

Section a - Build the simple inverter shown. Drive the inverter with the SYNC square wave. Draw the waveforms at the output as asked. Make an estimate of the capacitance at the output from the time constant $\tau = RC$. Notice this is just an inverting amplifier. You could have made the same thing, of course, with a bipolar transistor. (You practically did, actually, back when you made a common emitter amplifier (which had some aditional circuitry for transistor bias, etc. But things are remarkably similar.)

Section b - Again do as asked. Draw the waveform of the output at 1 and 100 kHz.

13-5 CMOS NAND

13-1 Logic Levels

Now that you can "make" logic gates out of pieces... Here are some finer details to keep in mind.

Different logic families have different logic threshold levels. Let's briefly look at them.

Consider two 74XX00 chips: 74HC00 and 74LS00. Both perform the same logic function (NAND) indicated by the 00 in their part number. They are not, however, completely interchangable.

Complete the table for section 13-1a on page 312 for both chips. You can just plug the wires into ground of +5 Volts for the input. Use the logic probe for logic levels and the voltmeter for voltages. Be sure to connect ***all*** CMOS ***inputs*** (But do NOT connect an ***OUTPUT*** to a voltage source or power supply (why?).

Floating CMOS inputs cause high currents to flow in the chip because AC fields in the lab bias the gates partially ON.

13.1b Do as stated. For part 2, use the 300mA setting on the Fluke and record the maximum and minimum current as you vary the Pot Setting.

13-2 "Making What You Have Into What You WANT"

Clever use of logic will allow you to make one function out of another. Enter DeMorgan's Theorem.

Do 13-2 as described. DeMorgan's Theory will be handy. You may omit section c, or try it, noting that an XOR gate may be implemented as follows with 4 NANDS: