LABORATORY # 1
LAB MANUAL

Digital Signals

Objectives

Lab 1 contains 3 (three) parts and the objectives are to get familiar with:

1. Bread-board components wiring;
2. Usage of hardware test and diagnostic equipment;
3. Generation of digital signals and fundamental measurements;
4. Usage of diodes and oscilloscopes as part of hardware logic circuit debugging;
5. Hardware based decoding of logic information

WARNING

Polarized Capacitors must be handled with great caution:

1. Polarized capacitors must be properly connected in a circuit: "+" terminal of a cap to "+" terminal in the circuit, "-" to "-". Otherwise the cap can be permanently damaged;
2. **Never** touch both legs of a polarized capacitor with your fingers after usage since it may contain a substantial amount of charge that can electrocute you or at best burn the skin;
3. **Never** discharge a polarized capacitor by short-circuiting the legs. Such a discharge will create a great amount of current that can overheat the cap and cause an explosion (<u>no kidding</u>). Since polarized capacitors contain liquid chemical acid matter such an event may cause permanent damage to your eyes. It is **<u>a good habit to wear safety glasses</u>** while handling polarized capacitors;
4. **Never** discharge a capacitor while still in circuit;
5. In order **to safely discharge a capacitor** after handling, use a high wattage low value resistor (say, 100 Ohm, 1W), connect the resistor to the cap legs and wait for a couple of seconds to fully discharge the cap (10-20 seconds may be enough but it may vary, easy to compute though by RC circuit analysis);
6. **Never** store (long-term storage) used polarized capacitors without properly discharging them.

Equipment

- PC or compatible
- DMM (digital multimeter)
- Function generator
- Oscilloscope
- Power supply (+5V, +12V)
- Wires to interconnect parts on solderless breadboard
- Solderless breadboard (you need to bring one)

Parts

- 1 each photodiode
- 1 each 7-segment LED display
- 1 each resistors (all 1/4W): 1k, 6.8k, 16k
- 1 each 4.7 kΩ x 5, bussed resistor network (SIL)
- 1 each 330 Ω x 8, independent resistor network (DIP)
- 1 each capacitor (ceramic disc) 0.01 uF
- 1 each capacitor (polarized) 47 uF
- 1 each 4-bit DIP switch (piano type)
- 1 each HEF4511BP BCD-to-7 decoder IC
- 1 each NE555 Timer IC

Specification

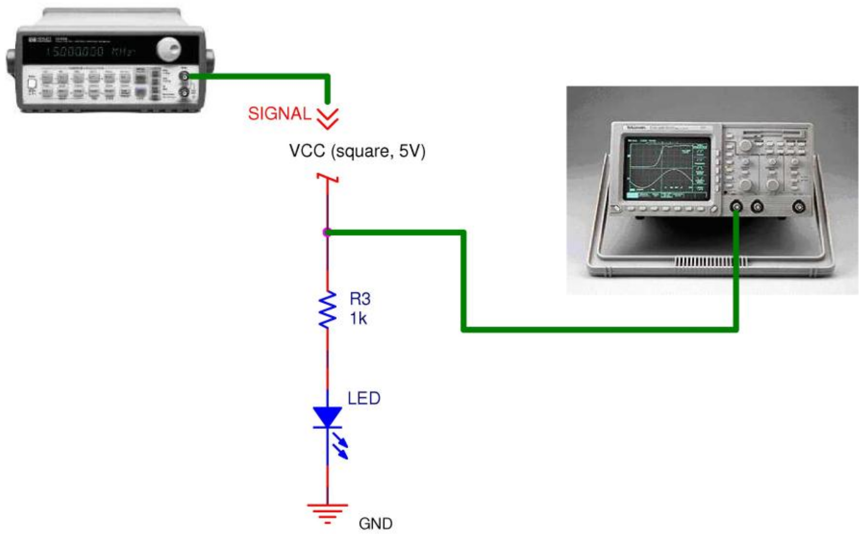
PART 1. Digital Clock Generation with a Function Generator

In this experiment, we will generate a clock signal with a function generator and observe it in two ways:

1. Flashing photodiode;
2. Observing the analog signal on the oscilloscope

Schematics (Lab 1, Part 1)

The following diagram shows a hardware set-up to be used in this assignment:



The signal generator must provide 5V p-p (peak-to-peak) from TTL/SYNC output.

Demonstration

Demo that

1. The photodiode is flashing according to different frequencies set in the signal generator (1Hz, 2Hz, 5 Hz, 10Hz);
2. The signal can be observed on the oscilloscope and the procedures are known how to modify and read the oscilloscope information (time, voltage, run/stop, horizontal/vertical position shifting, etc)

Questions

1. Is the signal clean or noisy. If noisy, what is the level of noise percentage-wise with respect to 5V?
2. Is the diode flashing with the same intensity or it takes some time to reach maximum level of intensity? Why?
3. Would a diode survive if we placed a resitor of R3=1 Ohm instead of the one given? Why?

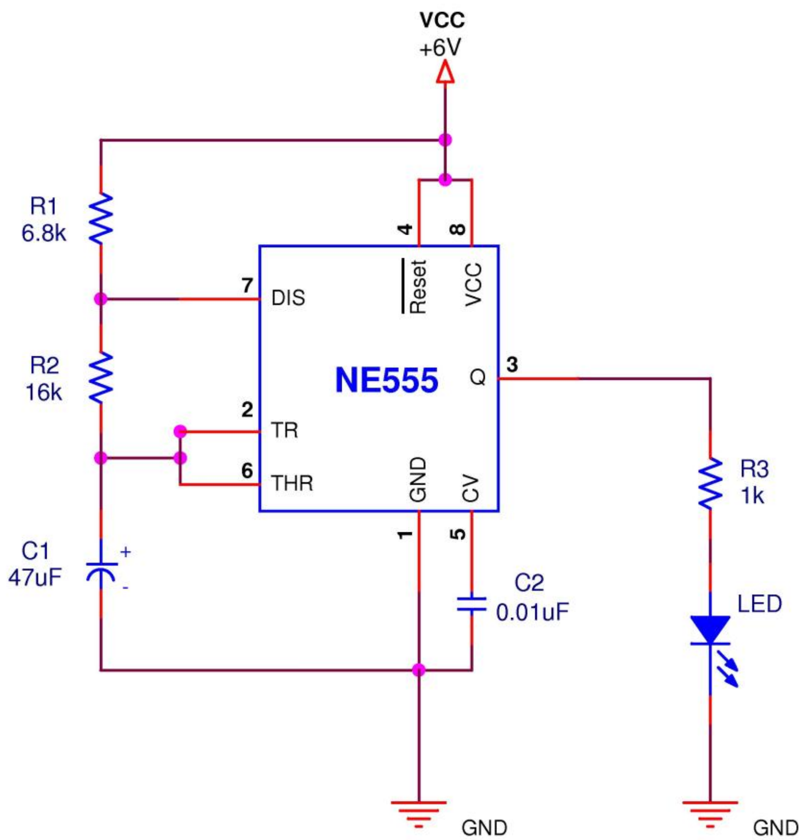
<u>PART 2</u>. Digital Signal Generation with a Timer 555 IC

In this experiment, we will generate a digital signal with a Timer 555 IC and observe it in two ways:

1. Flashing photodiode;
2. Observing the analog signal on the oscilloscope;

<u>Schematics</u> (Lab 1, Part 2)

The following diagram shows a hardware set-up to be used in this assignment:



<u>Demonstration</u>

Demo that

1. The photodiode is flashing;
2. The digital signal is observed on the oscilloscope;

Questions

1. Compute the period and duty cycle of the generated digital signal.
2. Does it agree with the reading from the oscilloscope?
3. What is the amplitude of the generated signal?
4. Vary the power supply voltage from 6V to 0V and back. What is happening to the brightness of the flashing diode? Why?

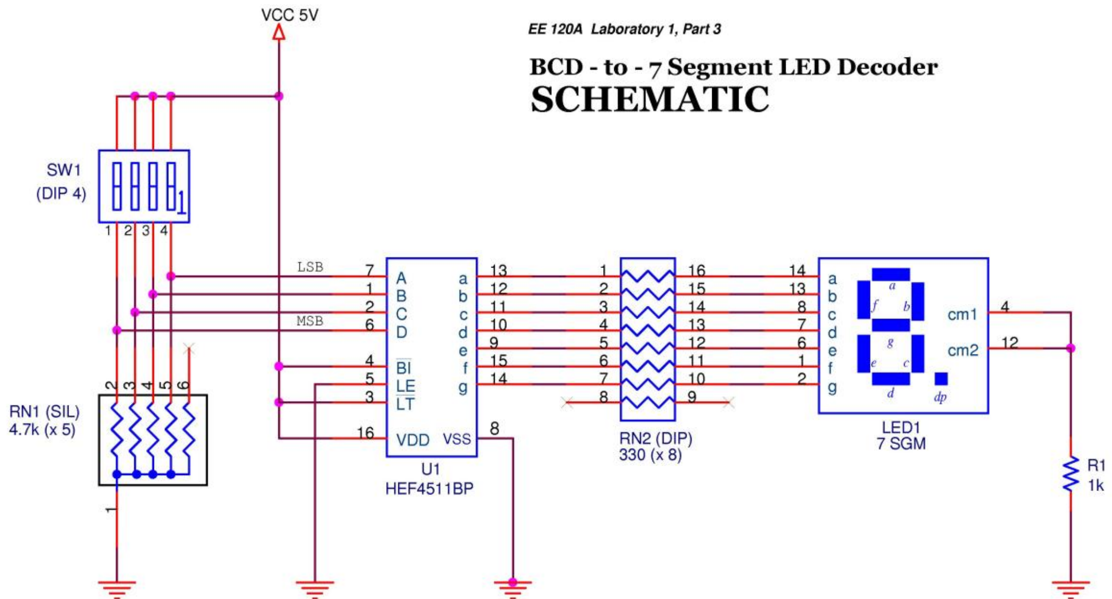
PART 3. BCD-to-7 Segment LED Decoding

In this experiment, we will:

1. Generate a digital voltage level signals with a 4-bit DIP switch;
2. Decode the 4-bit switch values to a corresponding decimal digital and display it on a 7 segment LED.

Schematics (Lab 1, Part 3)

The following diagram shows a hardware set-up to be used in this assignment:



<u>Demonstration</u>

Demo that:

1. **<u>ALL</u>** decimal digits can be displayed on the LED according to the bit values set in the switch;
2. Using a multimeter that inputs to the decoder 4511 IC are of CMOS logic voltage levels (> 3.5V)

<u>Questions</u>

1. What can be said about the brightness of the LED display with and without the R1 resistor? Why?
2. Reduce the voltage from the power supply from 5V to 0V while the LED shows some number. What happened?

Procedures

1. Properly wire the components on the breadboard;
2. Function generator must be connected to the SYNC output;
3. Properly connect the oscilloscope to the correct pins on the breadboard circuit

Presentation and Report

Must be presented according to the general EE120A lab guidelines posted in iLearn.

Prelab

1. Familiarize yourself with safety policies, lab report guidelines, lab equipment handling provided in the materials posted in iLearn;
2. Read the basic bread-boarding manual posted in iLearn;
3. Study Lecture 2
4. Familiarize with part specifications posted in iLearn;
5. Try to answer all the questions, do all necessary computations