CPE 301 Embedded Systems Design Lab

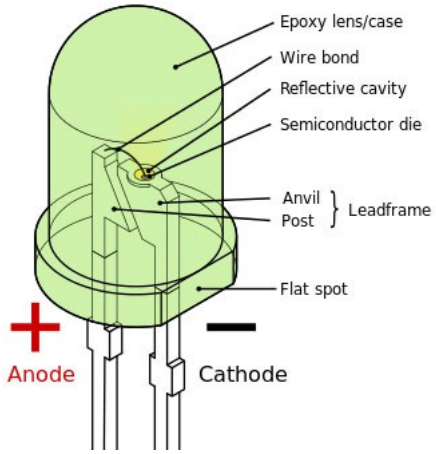
Lab # 04 Fall 2017 - Week of September 25

Objectives:

- Use the lab oscilloscope to understand the basics of an LED
- Start using the Arduino IDE and understanding the basics of GPIO.

Background:

"A **light-emitting diode** (**LED**) is a two-lead semiconductor light source. It is a p–n junction diode, which emits light when activated.[4] When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor." (Wiki1)



"In a semiconductor diode, the anode is the P-doped layer which initially supplies *holes* to the junction. In the junction region, the holes supplied by the anode combine with electrons supplied from the N-doped region, creating a depleted zone. As the P-doped layer supplies holes to the depleted region, negative dopant ions are left behind in the P-doped layer ('P' for positive charge-carrier ions). This creates a base negative charge on the anode. When a positive voltage is applied to anode of the diode from the circuit, more *holes* are able to be transferred to the depleted region, and this causes the diode to become conductive, allowing current to flow through the circuit." (Wiki2)

"In a diode, the cathode is the negative terminal at the pointed end of the arrow symbol, where current flows out of the device. Note: electrode naming for diodes is always based on the direction of the forward current (that of the arrow, in which the current flows "most easily"), even for types such as Zener diodes or solar cells where the current of interest is the reverse current." (Wiki3)

Preparation:

1. Follow the guide in Chapter Three of the textbook "*Introduction to Embedded Systems: Using ANSI C and the Arduino Development Environment*" to install the Arduino development tools on your computer, laptop, or tablet for use in the lab. If you need to use one of the lab PCs then you may need to install the Arduino tools on it.

2. Chapter Three uses the Arduino Duemilanove SBC as an example. You will need to make slight changes for the Arduino Mega SBC.

> NOTE: The Arduino Duemilanove uses the ATMEL Atmega328P microcontroller while the Arduino Mega uses the ATMEL ATmega2560 microcontroller. The 2560 is upwords compatible with the 328P processor. That is, it has the same special function registers for control of the timers, LEDs, serial ports, etc. The 2560, however, has more devices than the 328P. For example, the 328P has one serial port while the 2560 has four. We will discuss some of the differences in class.

Procedure:

Construct and document the circuits in the list below. For each circuit:

a. List the components used.
b. Draw a diagram of the circuit.
c. Answer the supplemental questions, if any.

PART I – Basic Components

1. Light an LED using a power supply, a 330 Ohm resistor and an LED. Connect the resistor between +5 Volts and the LED anode. Connect the LED cathode to ground.

a. What is the voltage drop across the resistor?
b. What happens to the LED if you increase the resistance to 1000 Ohms?
c. What happens when you flip the LED around? (exchange anode and cathode)

2. Light an LED using a power supply, a switch, a resistor, and an LED. Connect the parts as in 1a. above, except put the switch between the LED cathode and ground.

3. Light an LED using a power supply, a button, a MOSFET, a resistor, and an LED. Connect the LED cathode to the MOSFET output instead of to ground.

a. What purpose does the transistor serve? (see #2)

4. Light an LED using the circuit from #3 in a different configuration (connect the MOSFET output to the anode instead of the cathode, but keep the LED polarity the same).

a. What changed?

PART II –ArduinoGPIO

1. Plug in your Arduino and run the blinky example.

2. Change the speed of the internal LED.

3. Light an external LED using an Arduino, a resistor, and an LED. Use the ***Arduino Library Functions***. Use GPIO PIN PB0 to drive the LED.

    a. Find the Arduino's current limit per I/O pin, what is the smallest resistor you would dare use to light an LED? **DO THIS BEFORE APPLYING POWER TO YOUR ARDUINO AND LED!**

    b. What happens to the LED if you blink it fast? Try 10Hz, 30Hz, 100Hz, and 1000Hz.

4. Light an external LED using an Arduino, two resistors, a MOSFET, and an LED. (as shown in lab)

    a. What is now limiting the current that you can supply to the LED?
    b. What are the advantages of this circuit over the previous?

5. Repeat the circuit but in the opposite logic. If in #4 the LED's cathode was switched, make a circuit with the LED's anode switched. If in #4 the LED's anode was switched, make a circuit with the LED's cathode switched.

PART III – Arduino Library (NOTE: Part III can be finished after your lab period if necessary.)

1. Open Arduino.h & wiring_digital.c

    a. What is the advantage of using preprocessor definitions like HIGH, LOW, etc?
    b. What is the advantage of using macros bitRead, bitWrite?
    c. Copy the pinMode function into your report, and add comments explaining each line of the function.
    d. Copy the digitalWrite function into your report, and add comments explaining each line of the function.
    e. Copy the digitalRead function into your report, and add comments explaining each line of the function.

2. Open main.cpp.

    a. Explain how the setup and loop functions get called from main.

3. What did the TA say about using Arduino Library functions for the rest of the semester? What happens to assignment or test answers that contain Arduino Library functions?

REFERENCES

Wiki1: https://en.wikipedia.org/wiki/Light-emitting_diode, September, 22, 2016

Wiki2: https://en.wikipedia.org/wiki/Anode, September 22, 2016

Wiki3: https://en.wikipedia.org/wiki/Cathode, September 22, 2016