EE241 Laboratory Exercise
Circuit Prototyping

The goal of this lab is to design and create a battery-powered electronic circuit of your own devising that can operate outside of the lab. In addition to honing our design skills, we will also learn the electronics prototyping process. This process consists of the following stages:

1. Develop system specifications (i.e. what you want the circuit to do)
2. Consider different solution approaches.
3. Design the system block diagram
4. Design internal circuits for each block
5. Breadboard the circuits and test the system
6. Make adjustments to the design to improve performance
7. Layout the circuit on a printed circuit board (PCB)
8. Assemble the circuit
9. Test the final system

Your circuit must involve one 9V batteries, an on/off switch, at least one sensor (photoresistor, thermistor, microphone, etc.), at least one electronic device (diode, op-amp, BJT, etc.) and at least one actuator (LED, buzzer, motor, etc.). The department will provide your components and circuit boards but you will need to buy your batteries (although there will be some batteries available in the lab for device testing). You must be able to lay your circuit out within the confines of a 1.9" by 2.5" circuit board, which will fit with a 9V battery inside a standard Altoids-type tin. We will design and fabricate our PCBs through Express PCB, and the PCB layout software is available as a free download from www.expresspcb.com.

The "pre-lab" for this activity is that you should come to lab on Mar 28 having consulted with your partner and having already determined what sort of project you'd like to attempt. Four lab periods and four lecture periods will be dedicated to this activity. Since we are sending out the boards for fabrication, the deadlines are critical in this project.

You should document your design as you proceed in your lab notebook. In lieu of a formal lab report, a poster *for each lab group* that explains your design and reflects all of the stages of the prototyping process is due during the last week of classes, when we will show off our projects and compete for a yet-to-be-named prize.

KEY DEADLINES:
Project Definition (pre-lab) – Mar 28
PCB Layout Tutorial HW Due – Mar 28
Initial Schematic Due – Mar 30
Demo of Working Project on Breadboard – Apr 3
PCB Layout and Parts List – Apr 10
Poster and Final Demonstration – May 1

Suggestions for Projects

Keep it simple. The breadboarding, PCB layout and assembly tasks for this project are not insignificant, and the simpler the original concept, the higher your chances of overall success. Here are some projects you may want to consider:

Burglar Alarm Revisited: You could enhance the Burglar Alarm we built earlier in lab in a number of ways. For example, a comparator IC (an op-amp specifically designed for the comparator function) such as the LM311 would perform better in that circuit than the LM741. Also, a capacitor could be added to introduce a delay in the alarm, or you could replace the buzzer with a circuit that sounds like a police siren (through the use of a 555 timer and a speaker).

BJT Switch Lab Revisited: In a similar way, you can also re-tool the lab where a thermistor was used to control a fan.

Real Light Organ: Add some filters to the "sound to light" lab and now you can make the lights responsive to frequency as well as volume.

Metronome: Build a circuit that produces a steady beat or light flash where you can control the tempo with a potentiometer. The 555 timer is a handy IC for generating an AC signal from a DC supply (much easier than the function generator built in lab 4).

Electronic Instrument: Extend the burglar alarm concept to use multiple light sensors to control the generation of AC signals of different audio frequencies, that then drive a speaker. This would be a tricky project but you've got all the pieces!

Rube Goldberg Machine: Use lots of unnecessary steps to do something simple, just for the sheer joy of it.

Do you have a hobby where a particular circuit would be useful? I'm open for consultations on other ideas. There are also more project ideas on the web. The key is to pick something that you think will be fun and manageable. Nothing that involves electronics will be too simple.

Components available in the lab:

You can use anything you can find in the supply cabinet, but the following components should definitely be present:

Sensors:
Photoresistors (Digikey part #PDV-P9003-ND)
Thermistors (Digikey part # PNT113-ND)
Microphones (Knowles MD9745APZ-F, Digikey part # 423-1023-ND)

ICs and Diodes:
LM555 timer
LM741 op-amp
LM311 comparator
BJTs (2N1711)
Diodes (1N4005, 1N4006, and 1N4148 (1N914))
Zener Diodes (1N748, 1N751, 1N752, 1N754, and 1N756)

Actuators:
8 Ω Speakers
Motors (Mabuchi EG530AD-6F, 6V DC motor)
Buzzers
Red, green and yellow LEDs (w/ resistors, 5V)

Other:
Standard selection of 5% resistors
Standard selection of capacitors (1 pF to 100 μF)
9V battery straps (Digikey part #232K-ND)
SPDT Switches (Digikey part # SW101-ND)
Potentiometers (10K) (Digikey part no. P3A1103-ND)
8-pin DIP sockets
Ziplock baggies for storing components after design is complete