ECE411 Practicum Lecture 1

Discussion of Project Requirements

“Build all the things!!!!”

2014/10/01

Practicum Project Overview

- Has ≥ 1 sensor.
- Has ≥ 1 actuator.
- Has some kind of digital or analog processor.
- Fits on a two layer PCB
- Will be assembled by hand (by you).
- Works.

REAL requirements use
“Must”, “Should” and “May”

Requirements for Requirements

- **MUST**
  - You absolutely must implement this requirement
  - Missing a ‘MUST’ is a **project failure** (project “redefinition”)
- **SHOULD**
  - You really should implement this requirement.
  - Missing a ‘SHOULD’ is a big deal, but it's not a failure.
- **MAY**
  - Wouldn't it be great if you implemented this requirement?
  - “OMG PONIES!!11!!”

See the “ECE411 Project Specification” Document

Emphasis on “working”

- Your project **must**:
  - not be trivial; it actually has to do something.
  - not be overly complex.
  - be able to be hand soldered by you.
  - be able to be debugged.
  - BE FULLY WORKING IN 10 WEEKS.

Team vs individual

- Each team must design a single device.
- All team members should help with all phases.
- Certain team members may “be in charge” of stages.
- Each individual in that team should assemble and debug their own device.

Intellectual Property

- NO LICENSE = BAD.
- Choose a license before posting to your repo.
- This is an education project, let me suggest the open source **GPL v3 license.**
- We consider your projects “open source” under the **MIT License** unless you say otherwise.

Money

- All required software tools are free and cross platform.
- PCB fabrication will be as cheap as we can make it.
- You will have to purchase all of your own components.
- All necessary assembly tools will be available in the Capstone lab. Optionally, you can use the EPL.

- **If your team has no money for components please talk to me ASAP. Do not come to me halfway through the course, come to me NOW.**

Grading and Prizes

- Your grading on three things, roughly in order:
  - Whether your device **works**.
  - The quality of your **documentation**.
  - The **originality** of design.
- There will be (possibly lame) prizes at the end of the quarter for:
  - Coolest functionality.
  - Best documentation.
  - Most elegant design.
  - Best construction quality.
  - Most dangerous (KIDDING! I AM JUST KIDDING!)

Practicum Deliverables

- Mini Product Design Specification (PDS)
  - Overview, Requirements, Specifications, Design info
- Timeline
- Bill of Materials with price at qty 1 and 1,000
- CAD files + firmware/software
- Final presentation
- **Demonstration of at least one working unit**

Defining Terms

What’s a Sensor?

- A microswitch is a sensor. Albeit a lame one.
- Direct measurements of voltage, current, phase, power, etc.
- Inertial sensors
  - accelerometers, gyroscopes
- Environmental
  - temperature, pressure, light, magnetometer
- Length
  - ultrasonic sonar, IR distance devices, laser distance scanners
- Input devices
  - trackballs, mice, joystick, touch sensors
- Others?
- NB: Sensors can be on daughterboards

What’s an Actuator?

- An LED is an actuator. Albeit a lame one.
- Motors! Solenoids! Electromagnets! Pumps! Rail guns!
- Output voltage or current
  - Output to a trace on a scope? Example: power supply.
- Heating, cooling, like a Peltier device! Or a fan.
- Display
  - Blinking LEDs, 7 segment LCDs, graphical LCDs, NTSC video.
- Logging/sending data could be considered an “action”
  - Memory and/or a communication channel to a PC
- Others?
- NB: Actuators may be on daughterboards

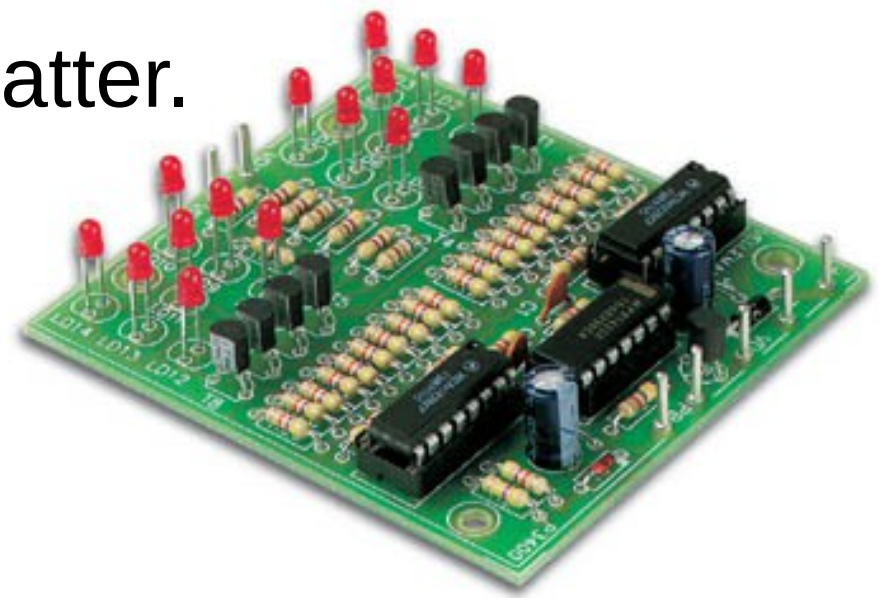
What’s a Processor?

- A processor converts inputs to outputs, usually with some form of computation or state machine.
  - Microcontroller
  - CPLD or FPGA
  - Analog filter circuitry
  - Others?
- Officially supporting the Atmel ATMegaXXX 8 bit microcontroller.
  - You may use others, but at your own risk.
  - A few ATMEL programmers will be available in the Capstone lab
  - Purchase your own for programmer for $15 - $35 (highly recommended)
  - Slightly lame: using “Arduino” chips / language / bootloader
- NB: Processors may NOT be on daughterboards

Example Projects

Bad Example: LED dice

- Concept
  - Push button to come up with a number 1 - 6 on a set of LEDs in a die-like pattern.
- Sensors: Switch.
- Actuator: LEDs.
- Processor: Doesn’t even matter.
- Why bad: trivial.



Good Example: Acceleration Light

- Concept
  - Small, throw-able battery-powered PCB that lights up RGB LED based on measured acceleration.
- Sensor: 3 axis accelerometer
- Actuator: RGB LED.
- Processor: Atmel AVR microcontroller
- Pros
  - Extremely simple
- Cons
  - May not work like you expect (what happens when you throw it?)

Good Example: Guitar Effects Pedal

- Concept
  - Digitize audio, do some DSP on it, and output it to a monitor.
- Sensor: ADC input digitizing guitar pickup or “audio in” line, and maybe a “foot pedal” for switching filters.
- Actuator: DAC output to speaker or “audio out” line.
- Processor: Atmel AVR microcontroller
  - Could be Analog!
- Pros
  - Fairly simple hardware
- Cons
  - Complicated firmware (intensive DSP)

Good Example: DAQ System

- Concept
  - Interface your PC using Analog in/out and digital I/Os
- Sensor: ADC/Digital inputs
- Actuator: DAC/digital outputs
- Processor: Atmel AVR microcontroller which talks serial, or using their serial device library, USB to the host
- Pros
  - Simple hardware
- Cons
  - Need to write PC software to display I/O

Things to Desperately Avoid

- Algorithmically complexity
  - No heavy DSP. No fast floating point. No graphics.
  - You only have a 16 MHz 8 bit AVR microcontroller!
- Complicated standards
  - WiFi? Bluetooth? Ethernet? Wireless X?
  - New serial interface modules do help, but it's a **huge increase in complexity**.
- High bandwidth anything
  - Again, you only have a 16 MHz 8 bit AVR.
- “Magic” technologies
  - If it's “magic”, this means **you don't understand the complexity and can't cogently deal with design tradeoffs .**

Prediction: 1-2 projects will completely fail because of unexpected subsystem or algorithmic complexity.

Make me wrong!

Further Inspiration

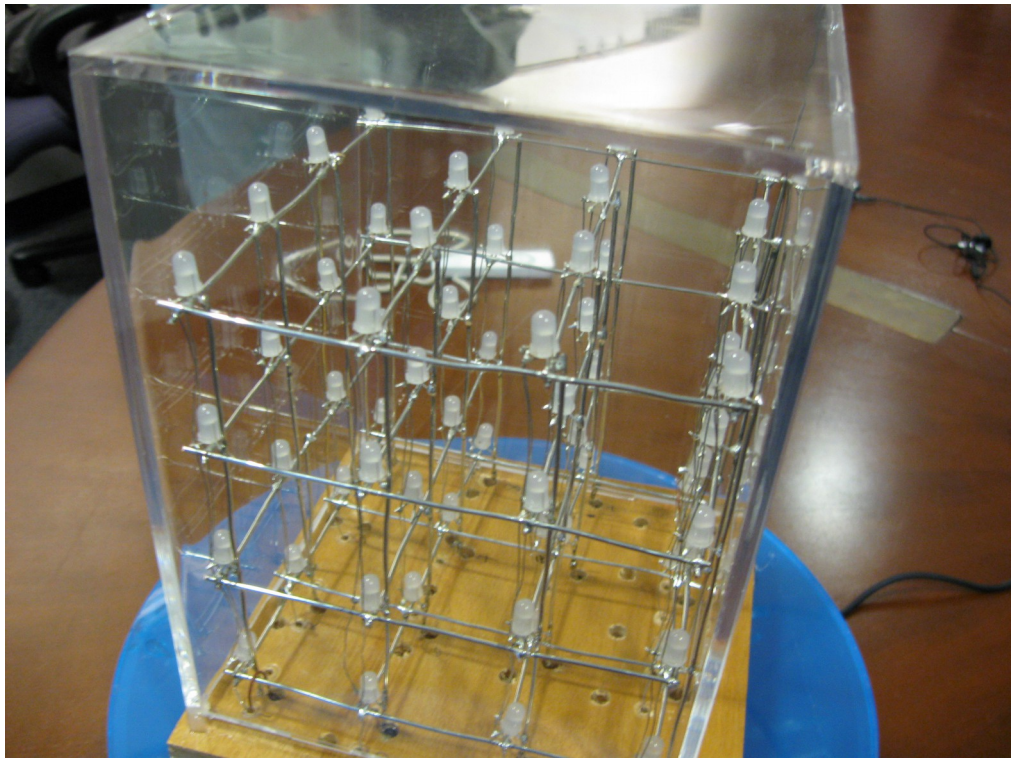
- Hobbies
- Measurement problems
- Control problems
- Time/material tracking needs
- Current tools that could use an upgrade
- Gifts for Significant Associates
- Ideas from SparkFun Electronics (http://www.sparkfun.com/)

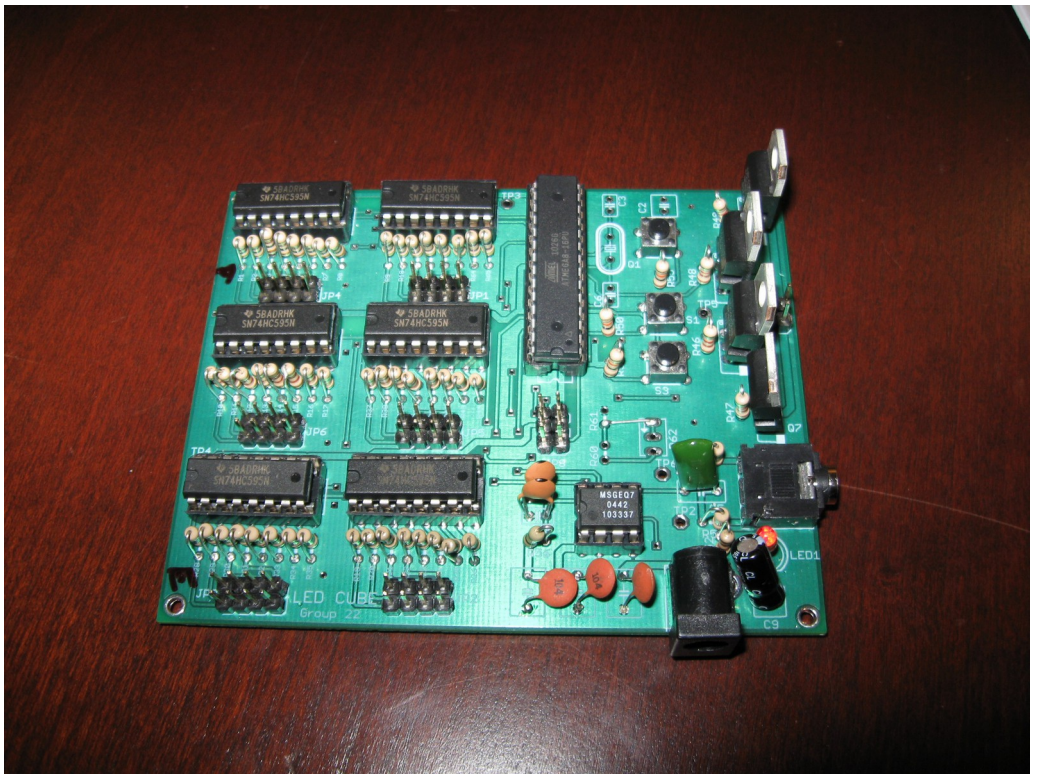
Notable Past Capstone Projects

LED Cube

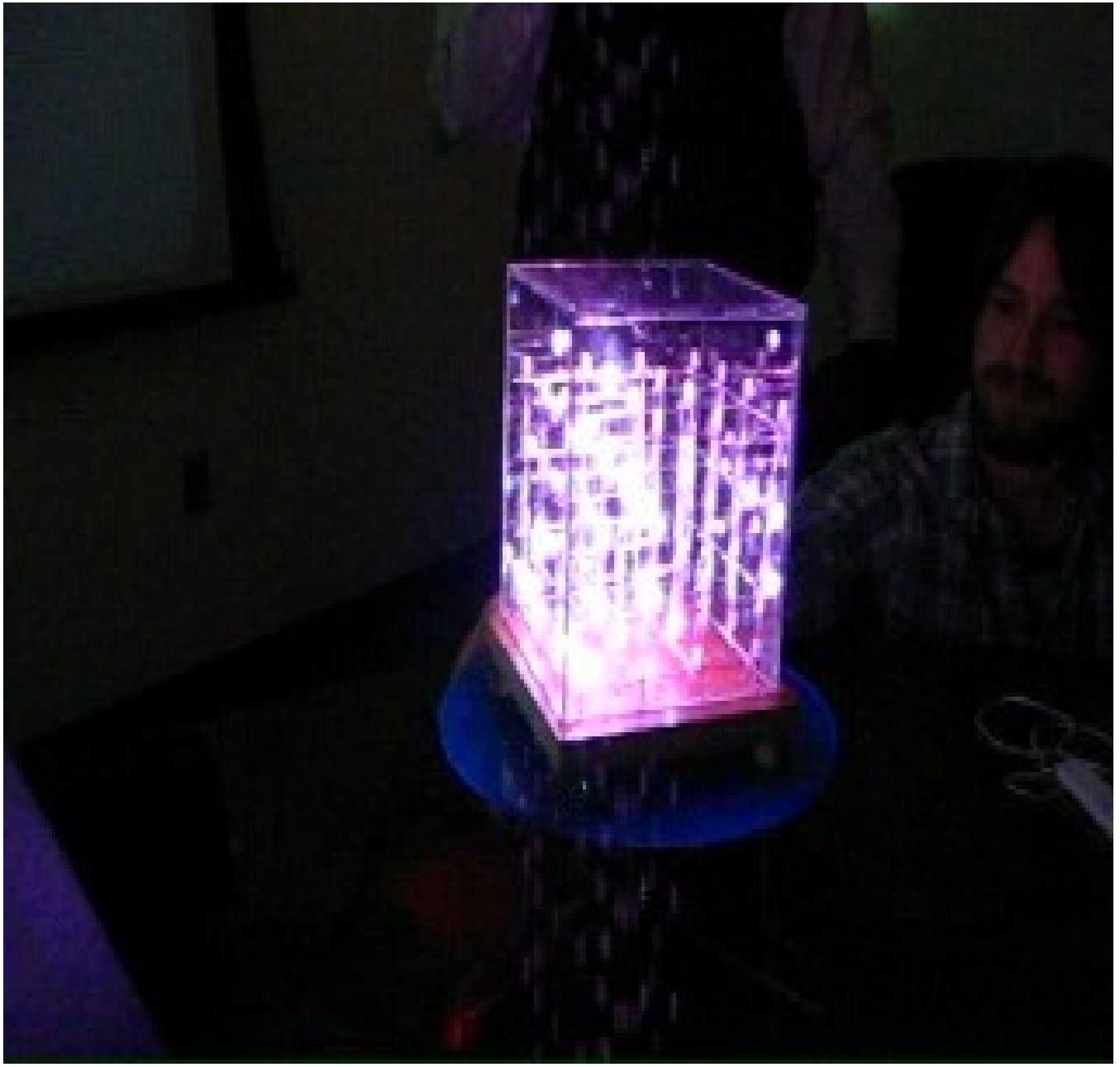
- Sensor: Audio input
- Actuator: 48 RGB LEDs
- Processor: AVR with I2C GPIO expanders
- Operation: Many display modes:
  - Random colors
  - Random patterns.
  - Microphone input for “sound display”
- On display in the ECE office

LED Cube





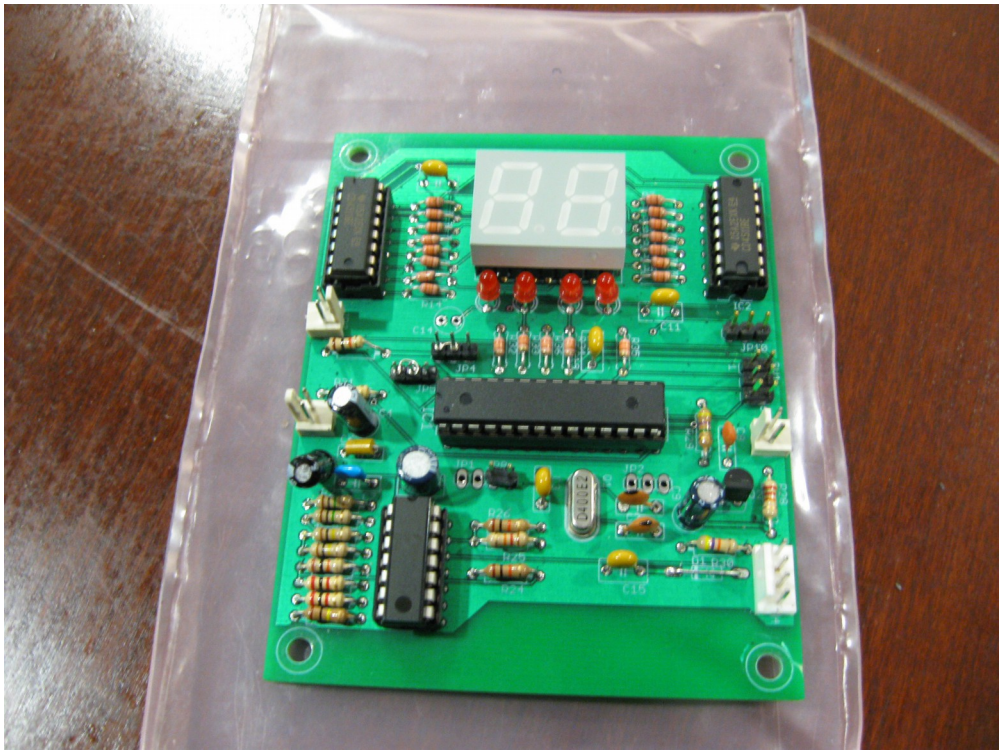
LED Cube



Lightning Distance Calculator

- Sensor: Photodiode and microphone
- Actuator: 7 segment LED display
- Processor: AVR
- Operation: Photodiode detects light flash, counts until microphone receives impulse, calculates distance to lightning

Lightning Distance Calculator

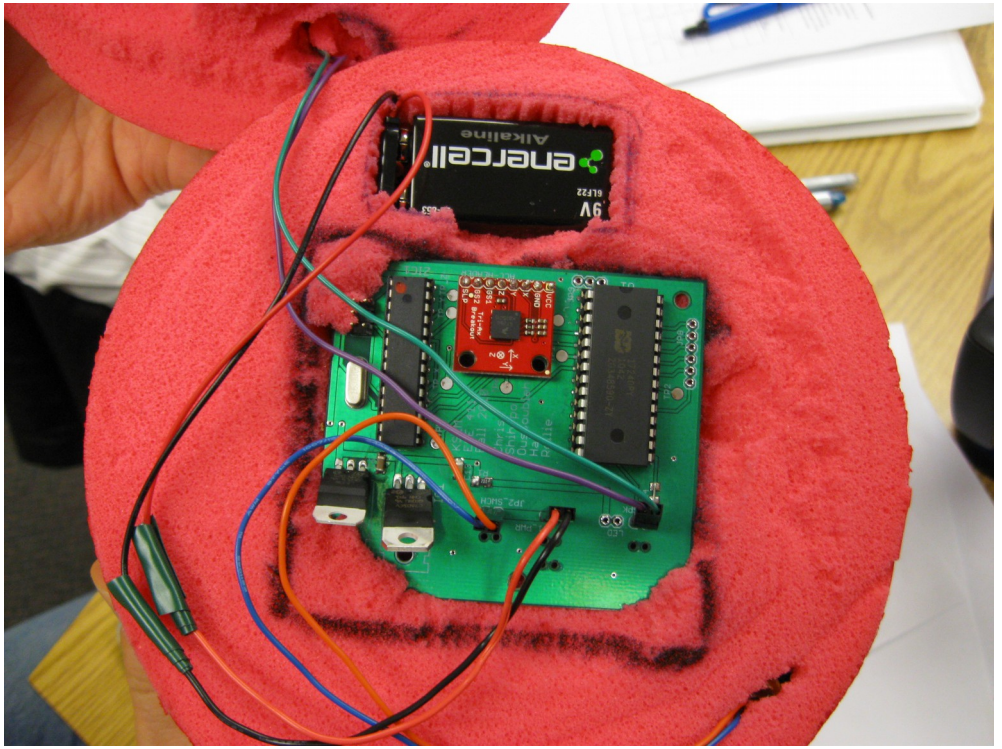


Lightning Distance Calculator

Sound Ball

- Sensor: 3 axis accelerometer
- Actuator: ISD sound chip
- Processor: AVR
- Operation: Play random sound when ball hits something.

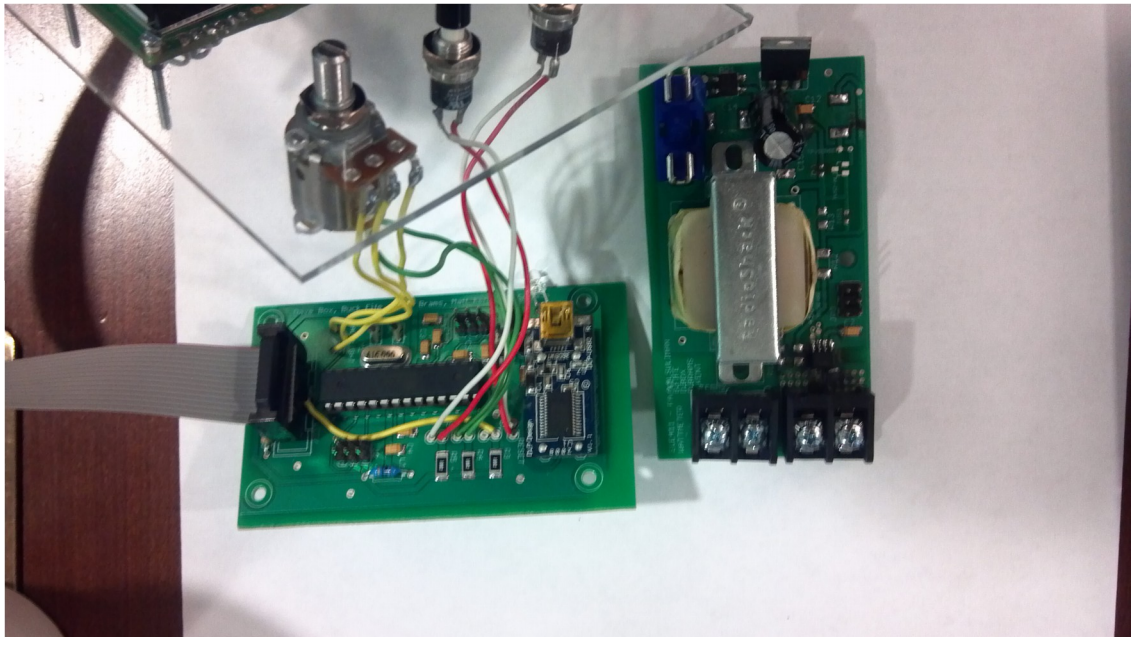
Sound Ball



Power Meter

- Sensor: voltage and current measurements
- Actuator: LCD panel and serial output
- Processor: AVR
- Operation: Measures voltage and current, calculates power and power factor, displays to LCD and outputs to serial port for logging.

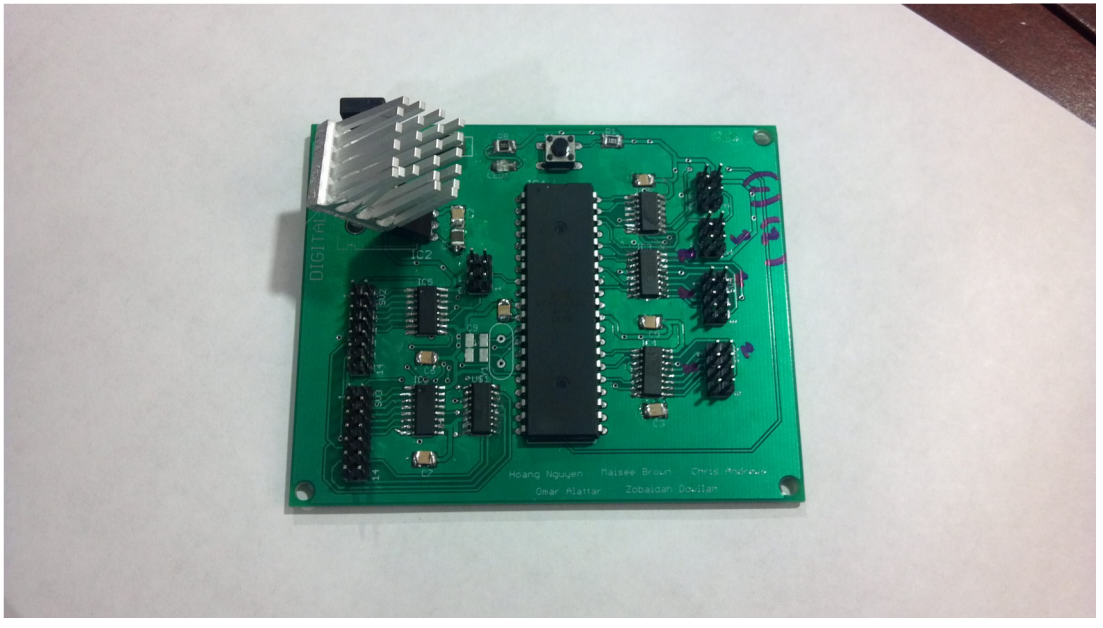
Power Meter

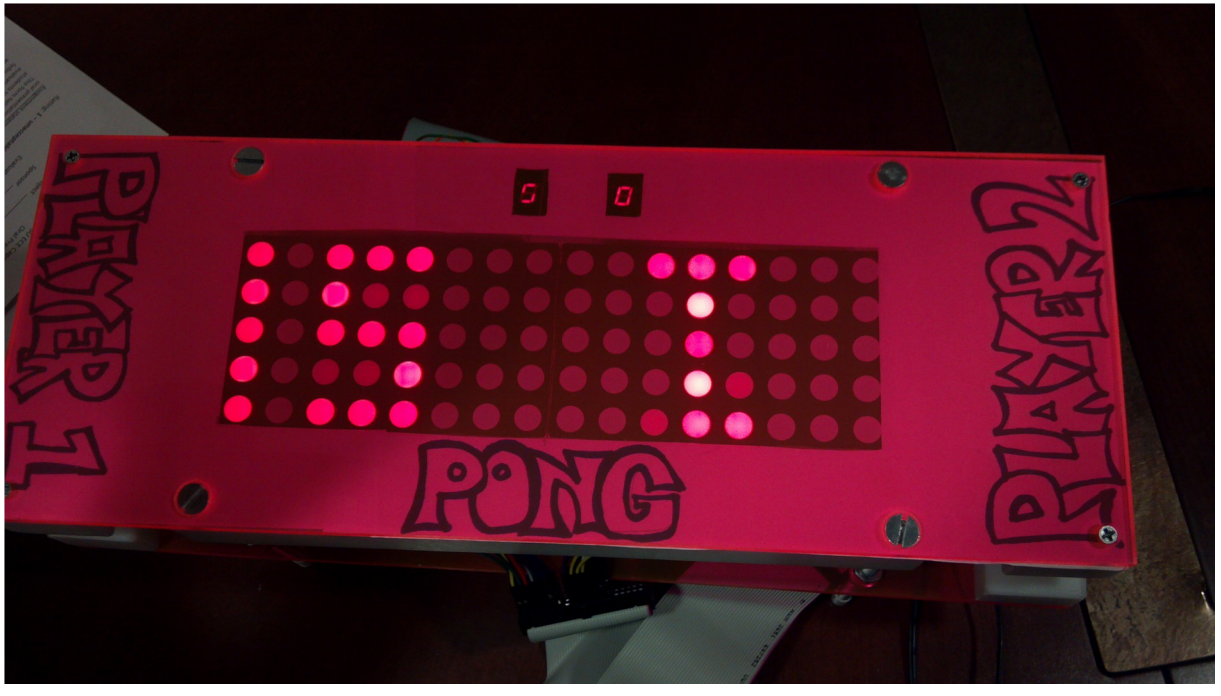


Pong

- Sensor: Microswitch inputs
- Actuator: LED array
- Processor: AVR
- Operation: Pong!

Pong



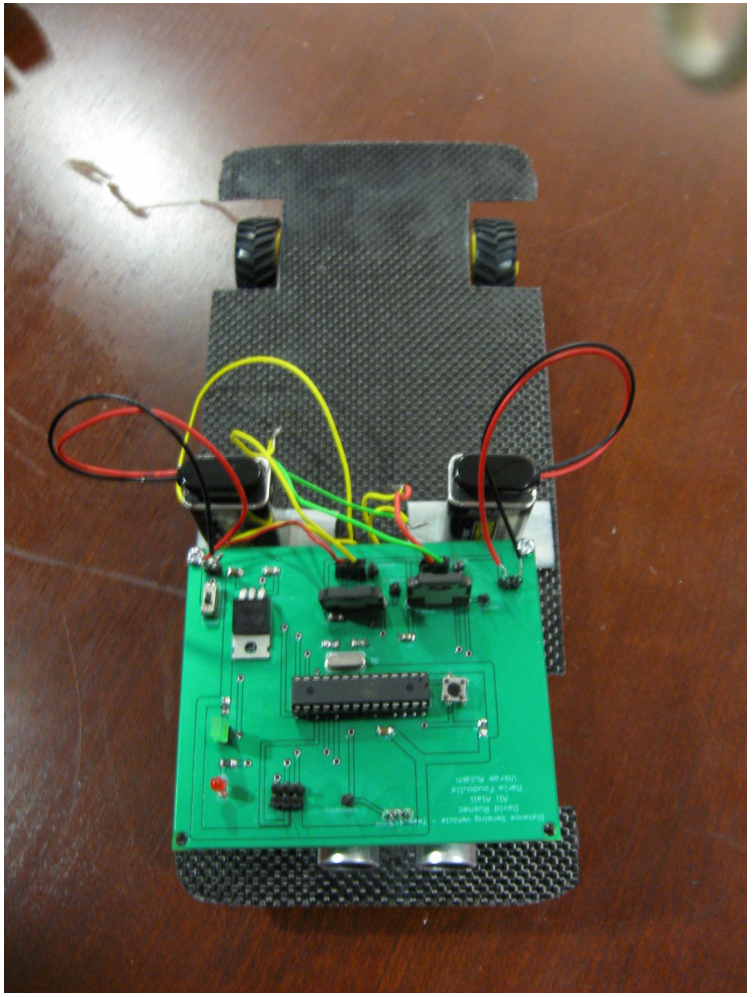


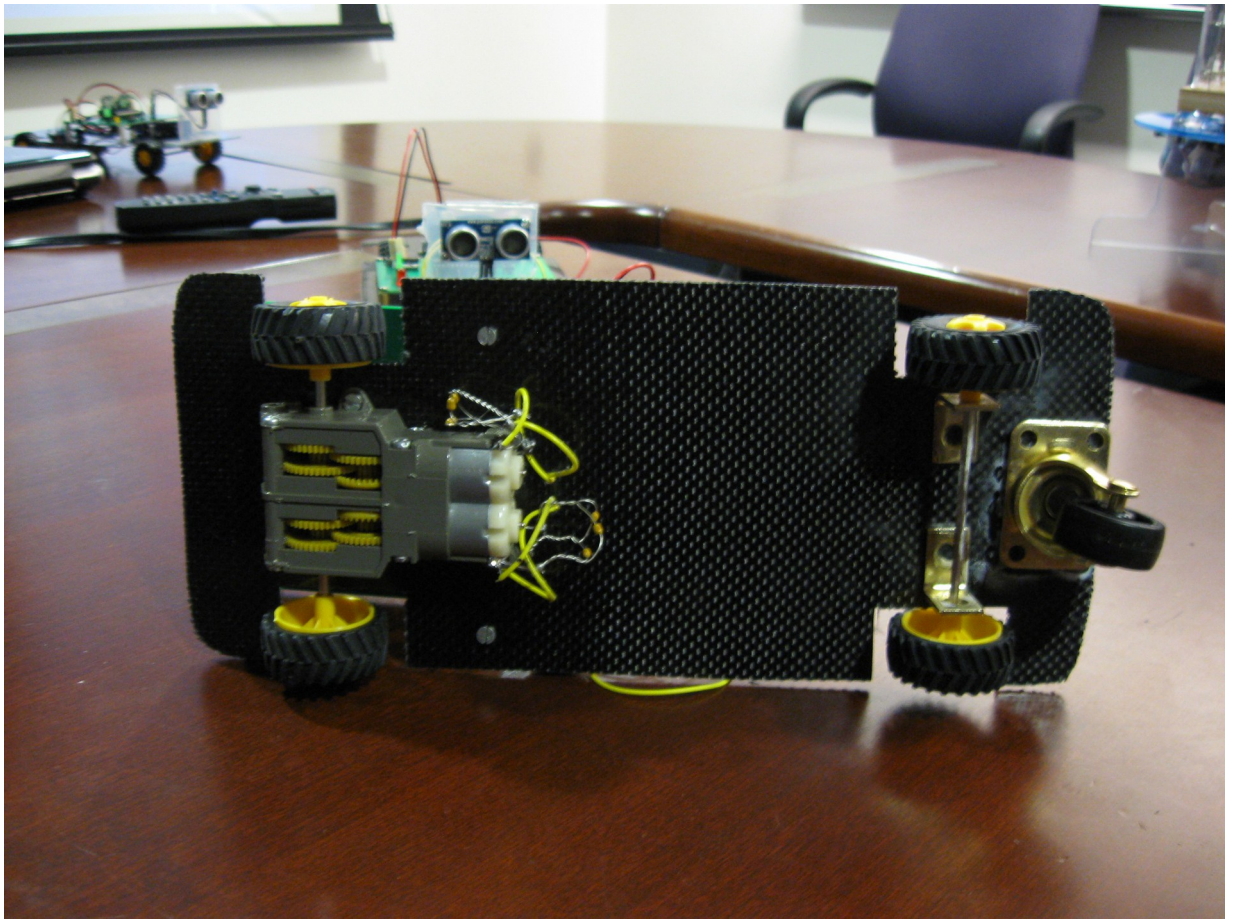
Pong

Distance Measuring Robot

- Sensor: Microswitches and ultrasonic sonar
- Actuator: Motors
- Processor: AVR
- Operation: Continue forward until obstacle, turn.

Distance Measuring Robot





Distance Measuring Robot

Choose based on your experience

- Easy
  - Simple: LEDs, microswitches, simple motors
  - Good for the inexperienced!
- Medium
  - Segmented LCD displays, sensors, power measurement and control, PC interface, novel and creative ideas, etc.
  - I hope most of you target “medium”.
- Hard
  - WiFi or Ethernet modules, inertial sensor processing, DSP, heavy duty mechanicals (hexapods, etc), complexity
  - Danger danger Will Robinson! You really do have to build this.