Portable Coilgun

Sponsored by Boeing

Group 1

Daniel Bears Ian Fuentes

Daniel Josol Omeed Baboli

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Motivation

- Project provides design work for both Computer and Electrical disciplines
- Designing a mobile firearm that doesn't rely on gunpowder
- Projectiles accelerated by magnetism will act as a natural silencer
- Creating a hand held coil gun

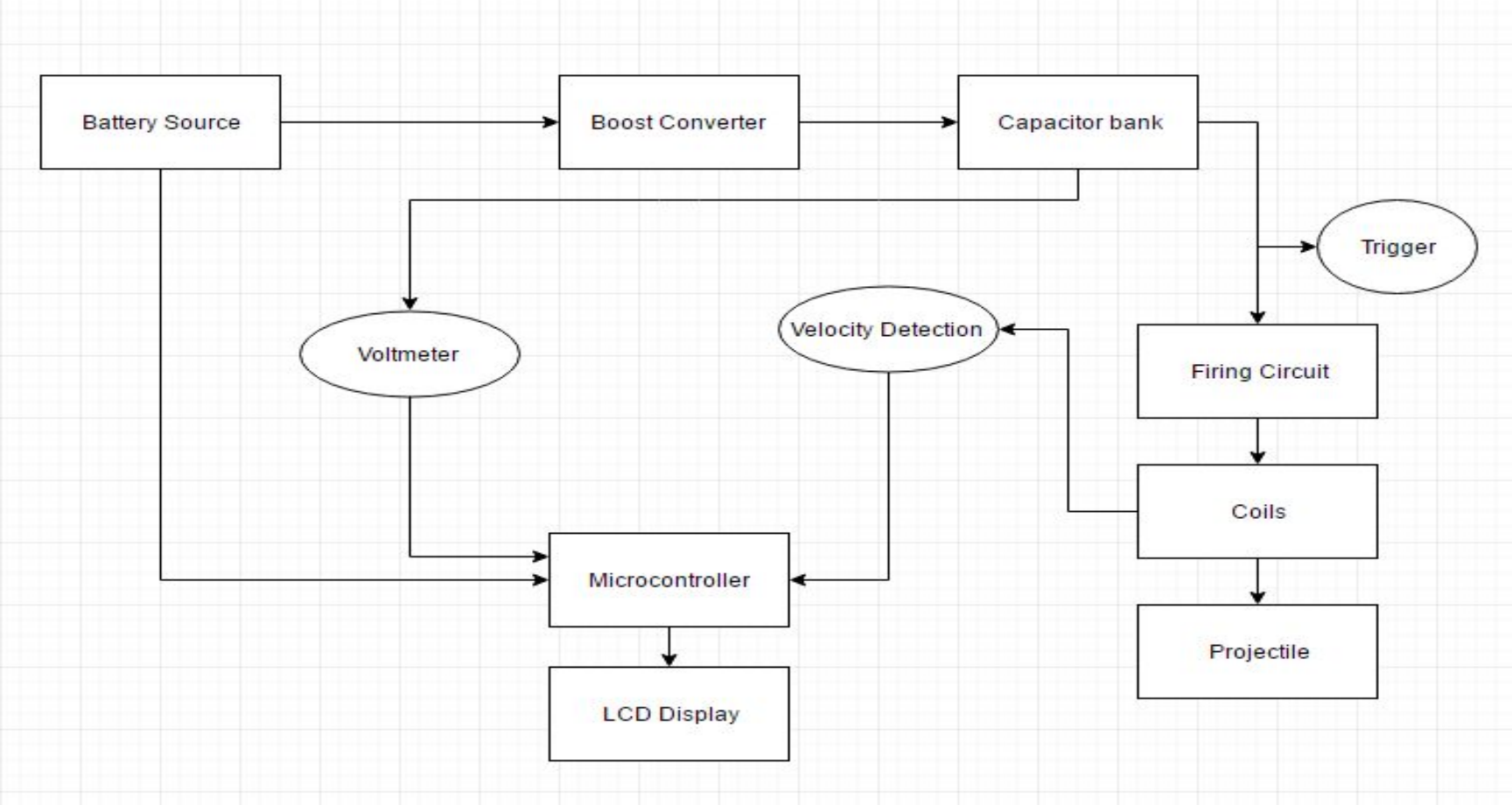
Task / Roles

Name	Primary Objective	Secondary Objective
Daniel Bears	Charging Circuit	Firing Circuit
Ian Fuentes	Firing circuit	Coil Design
Omeed Baboli	Microcontroller	Sensors
Daniel Josol	Microcontroller	Frame

Project Goals and Specifications

Product Capabilities	Desired	Accomplished
Charge Time	<20 secs	27 secs
Muzzle Velocity	100 feet per second	TBT
Accuracy	< 6 in. from desired target shot at 5 yards	TBT
Firing rate	single - shot	Achieved
Hand Held	lightweight, able for the user to be relatively mobile	Achieved

Project Block Diagram



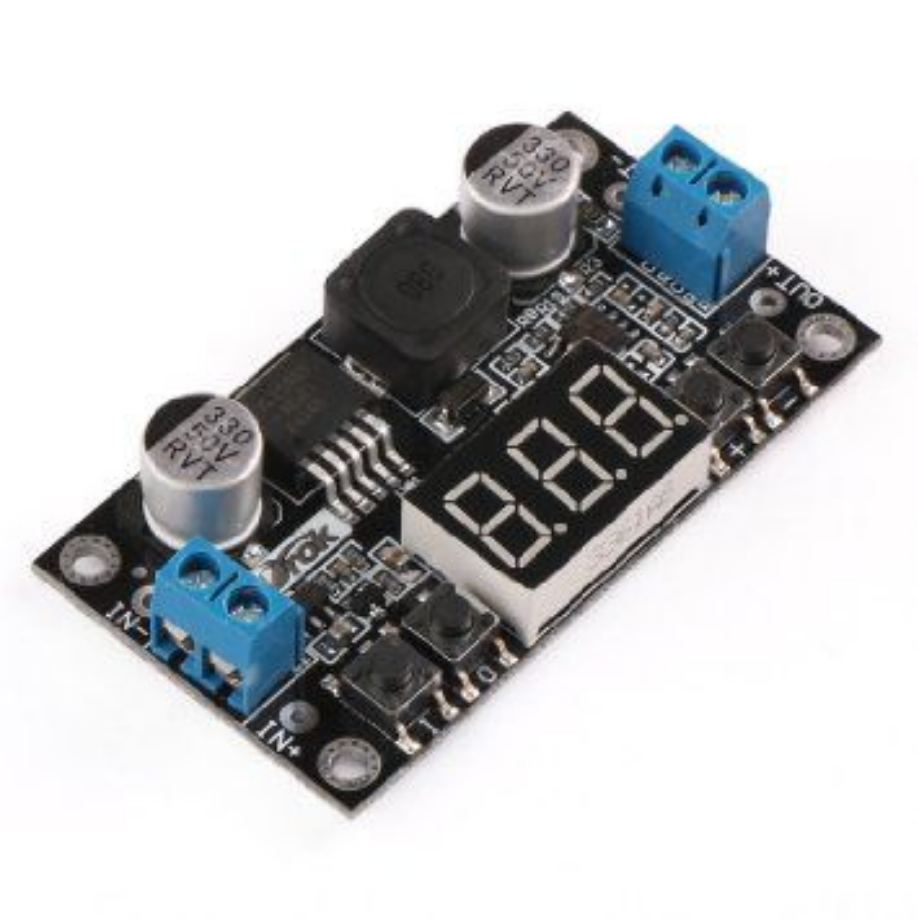
Power Supply

Battery	Tenergy
cost	$24
Type	Nickel Metal Hydride (NiMH)
Voltage	12V
Capacity	2000mAh
Dimensions	2.8”X 2”X 1.2”
Weight	9.6 oz

Power supply(cont.)

Battery	Tenergy
cost	2x$12=$24
Type	Nickel Metal Hydride (NiMH)
Voltage	9.6V
Capacity	2000mAh
Operating Voltage	3.3V
Dimensions	4”x2.3”x0.5”
Weight	8 oz

Buck Converter



Brand	DROK
cost	$8.00
Input Voltage	5-35V
Output Voltage	0-33V
Output Current	1.5A
Operating Voltage	5V
Dimensions	5.6” x 3.1” x 1.3”
Weight	1.6 oz

Boost Converter

Brand	DROK
cost	$8.00
Input Voltage	10-32V
Output Voltage	45-390V
Output Current	0.2A
Operating Voltage	390V
Dimensions	60mm x 50mm x 22mm
Weight	2.4 oz

Capacitors

- 2x 400V 6300uF electrolytic capacitors
- U=(½)C*(V)^2

Ideally,

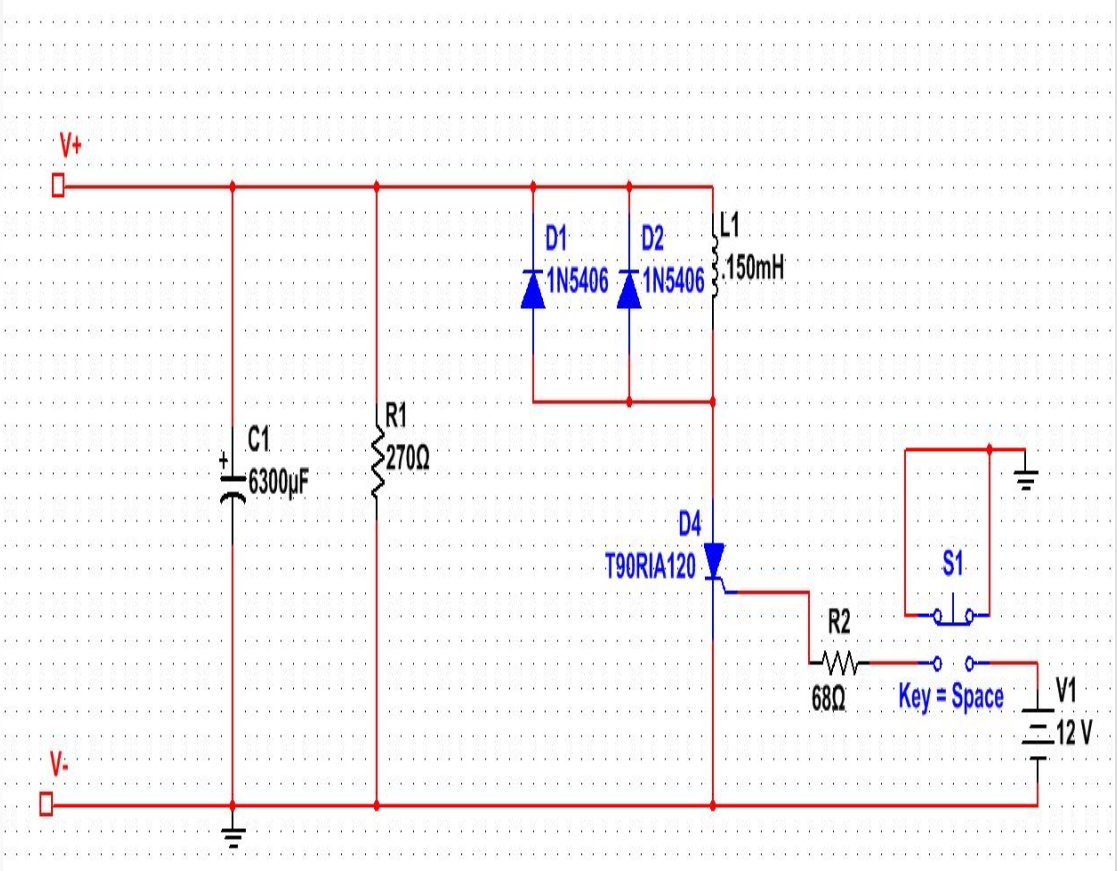
U=(½)*(6300e-6)*(360)^2

U=408.24J

2*U= 816.48J

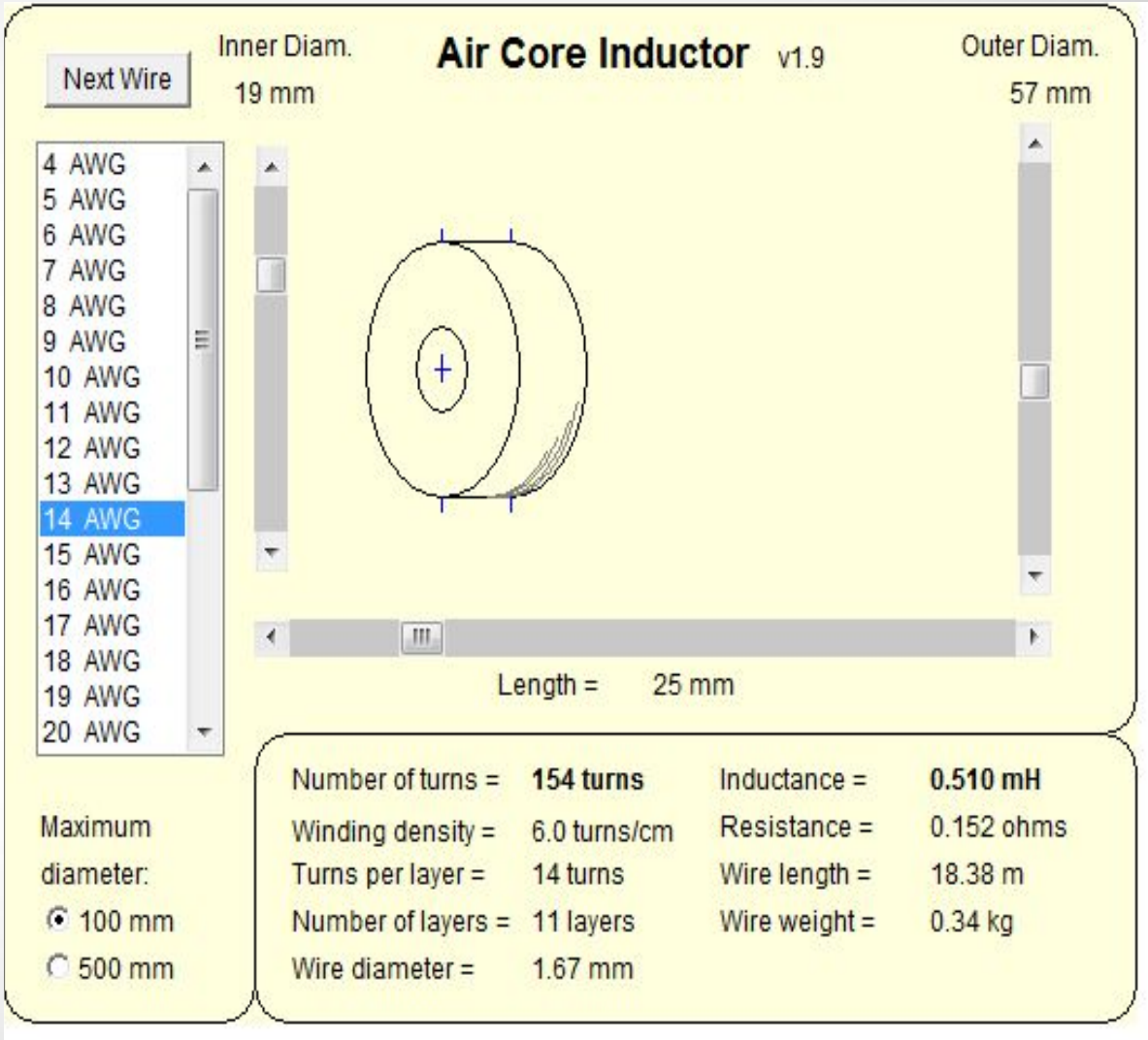
Firing Circuit

- Input is the the 360v from the charging circuit.
- Using an SCR to control the current flow into the coils.
- Switch 1 is the trigger
- The inductor is the coil which is going to fire the projectile



Coil Design

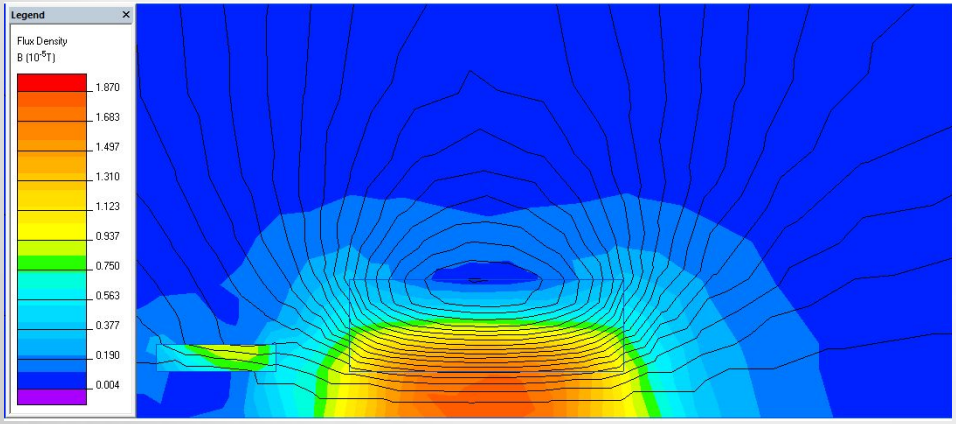
- 14 AWG Magnet Wire
- Magnet wire was chosen because it's thinner than regular copper wire and is also insulated.
- The coil is going to be wrapped tightly around the barrel to minimize air gaps.
- The magnetization of the projectile will be maximum at a given input when the outer radius is three times the inner radius.

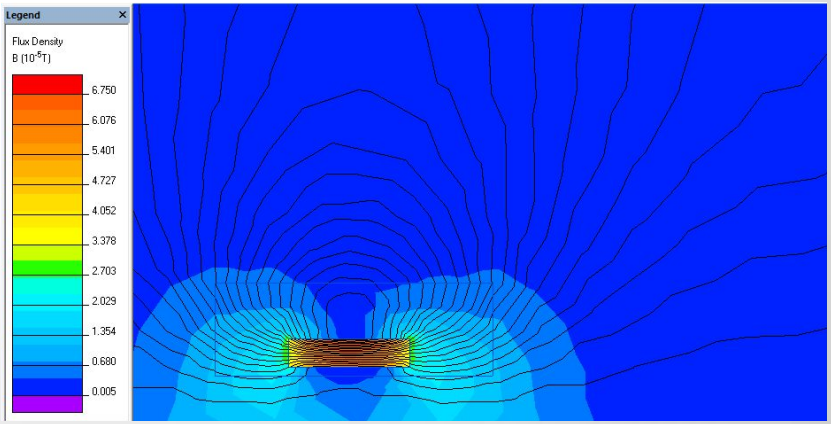


Projectile

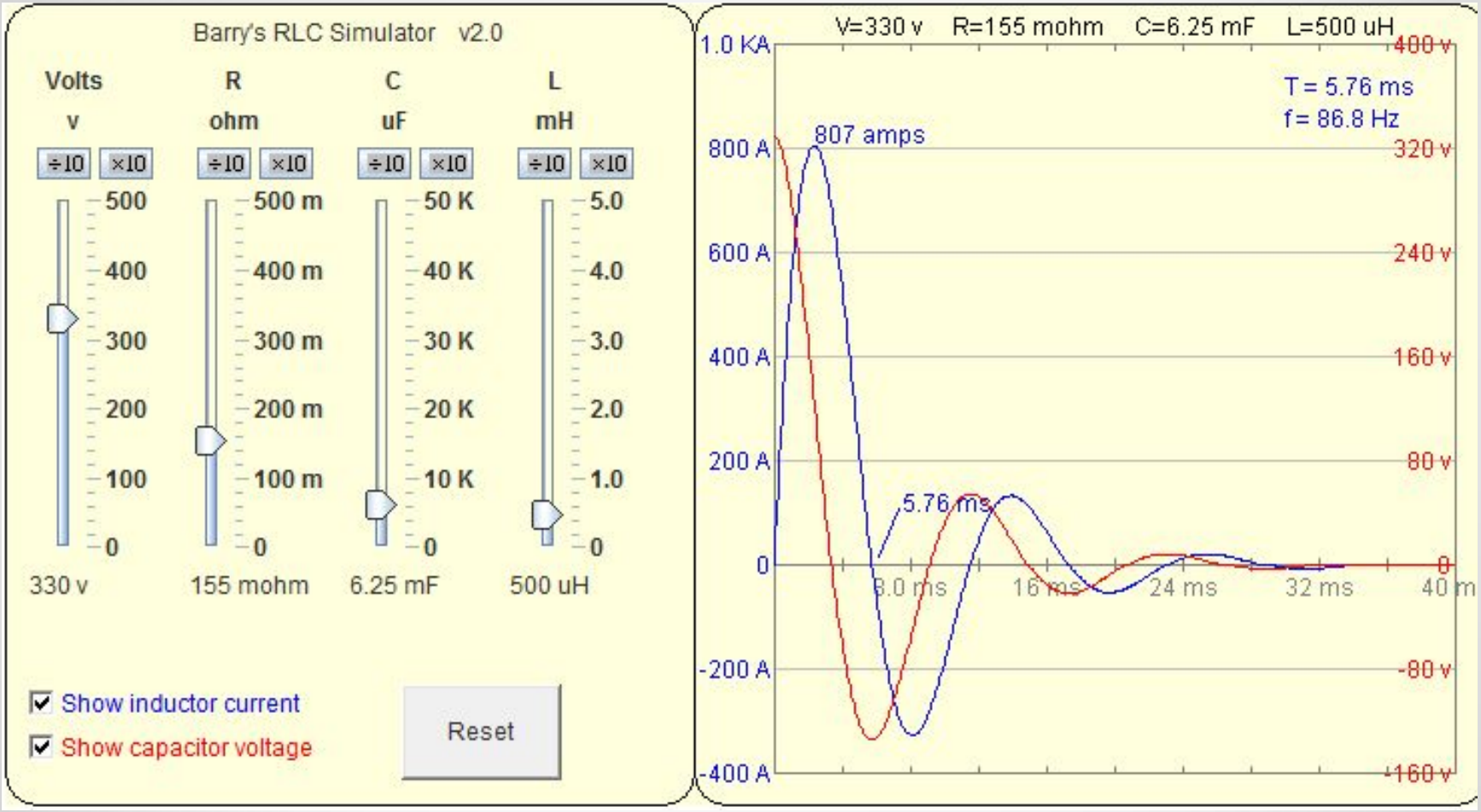
- Projectile made out of ferromagnetic material due to high magnetic permeability.
- The projectile should also be long and thin in order for magnetic field to maximize its effect on projectile (most common case is a nail).

	Material	μ_r (H/m)
Diamagnetic	bismuth gold silver copper water	0.99983 0.99986 0.99998 0.999991 0.999991
Paramagnetic	air aluminum platinum	1.0000004 1.00002 1.0003
Ferromagnetic (nonlinear)	cobalt nickel iron (99.8% pure) iron (99.96% pure)	250 600 5000 280,000





Discharging



Velocity Calculations

- PE=(1/2)CV^2
- KE=e(PE)
- KE= (1/2)mv^2
- Mass of the projectile is going to be about 10 grams
- The common efficiency found amongst other coil gun project is around 10%

PE= (.5)(6300uF)(360V)^2
= 408.24 j

KE = (.10)PE = 40.824 j

KE = (.5)(.010kg)(V)^2

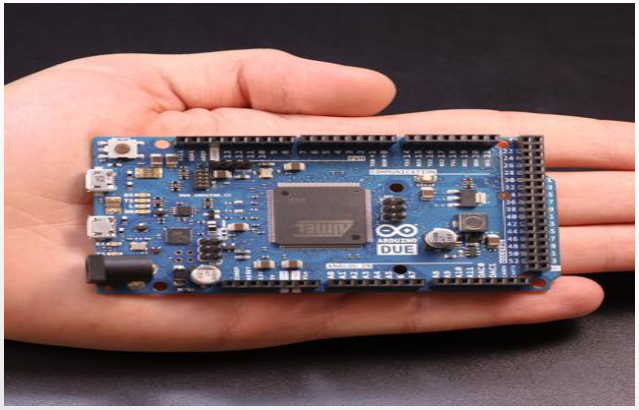
V= 90.359 m/s = **296.453412 ft/s**

Microcontroller choice

Increase user experience by providing the shooter with real time data of temperature, voltage, and velocity of the projectile after the shot.

Main Benefits

- ❑ Easy Development/Arduino IDE
- ❑ Open Source (access to design files)
- ❑ 12 Analog Inputs (ADC) with 12-bit resolution and high speed mode
- ❑ High amount of memory



Dev board	Arduino Due
Dev board Cost	$40
Microcontroller	32-bit Atmel SAM3X8E (ARM Cortex-M3 CPU)
Microcontroller Cost	$12
CPU Clock	84 MHz
Operating Voltage	3.3V
Digital Pins	54
Analog Pins	12
Flash Memory	512KB
SRAM	96KB
Input Voltage	7-12V

Programming Design

Goal:
Read in multiple inputs at a fast and accurate rate, output that data immediately to the Display.

User Arduino Scheduler library to allow us to run multiple functions/tasks at the same time.
Tasks:

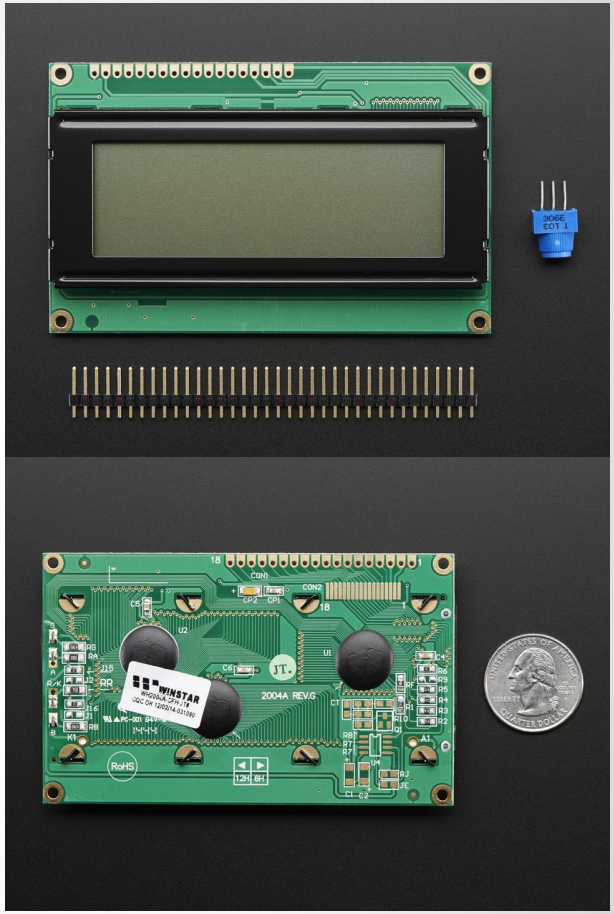
1. Write a task to gather data
2. Write a task to display new data
3. Add them to the queue
4. Let Scheduler handle the rest

Display

RGB backlight positive LCD 20x4
HD44780U dot-matrix liquid crystal display controller
Supply Voltage: 5V
Cost: $18
Controlled by 6 digital lines

- 4 Digital Lines for data
- RS line lets the display lets the microcontroller tell the LCD whether it wants to display that data (as in and ASCII character) or whether it is a command byte (change position of cursor)
- EN line tells the display when data is ready

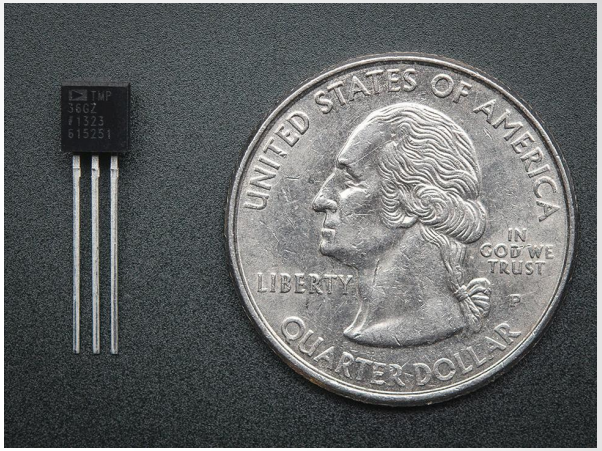
To ease the development side of controlling display we will use the Liquidcrystal library developed for Arduino. Library is operational with Atmel ASAM3x8E CPU.

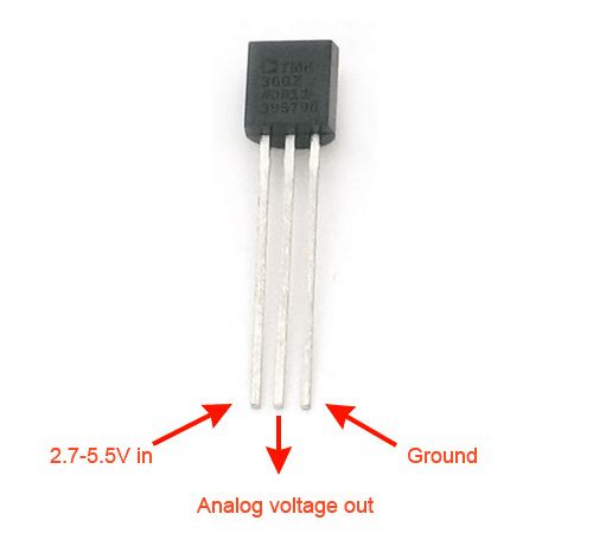


TMP36 Analog Temperature Sensor

Goal: Use multiple temperature sensors to monitor heat in critical sections of coilgun.

- 1st temperature sensor will be measure temperature of the capacitors
- 2nd temperature sensor will measure temperature of coils



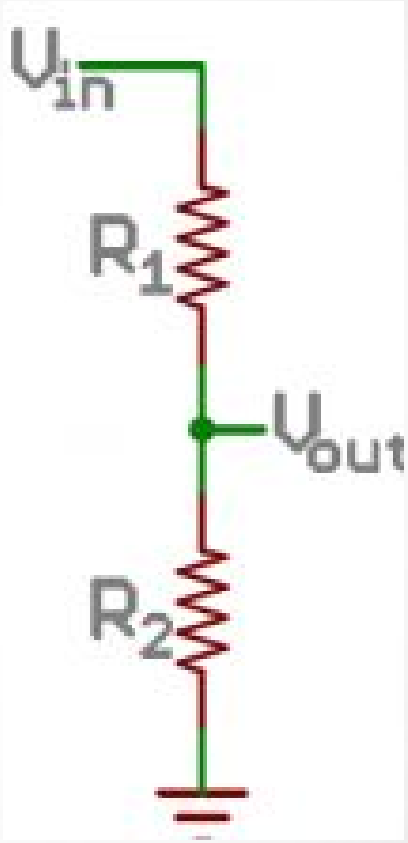


Manufacturer	Analog Devices
Cost	$1.50
Temperature	Up to 150 Celsius
Operating Voltage	2.7-5.5 V

Voltmeter

Goal: Read the Voltage across the capacitor which will be 360V when full

User voltage divider to drop the voltage to 10V when its full. This is within the recommended input voltage for Arduino Due



Velocity Sensors

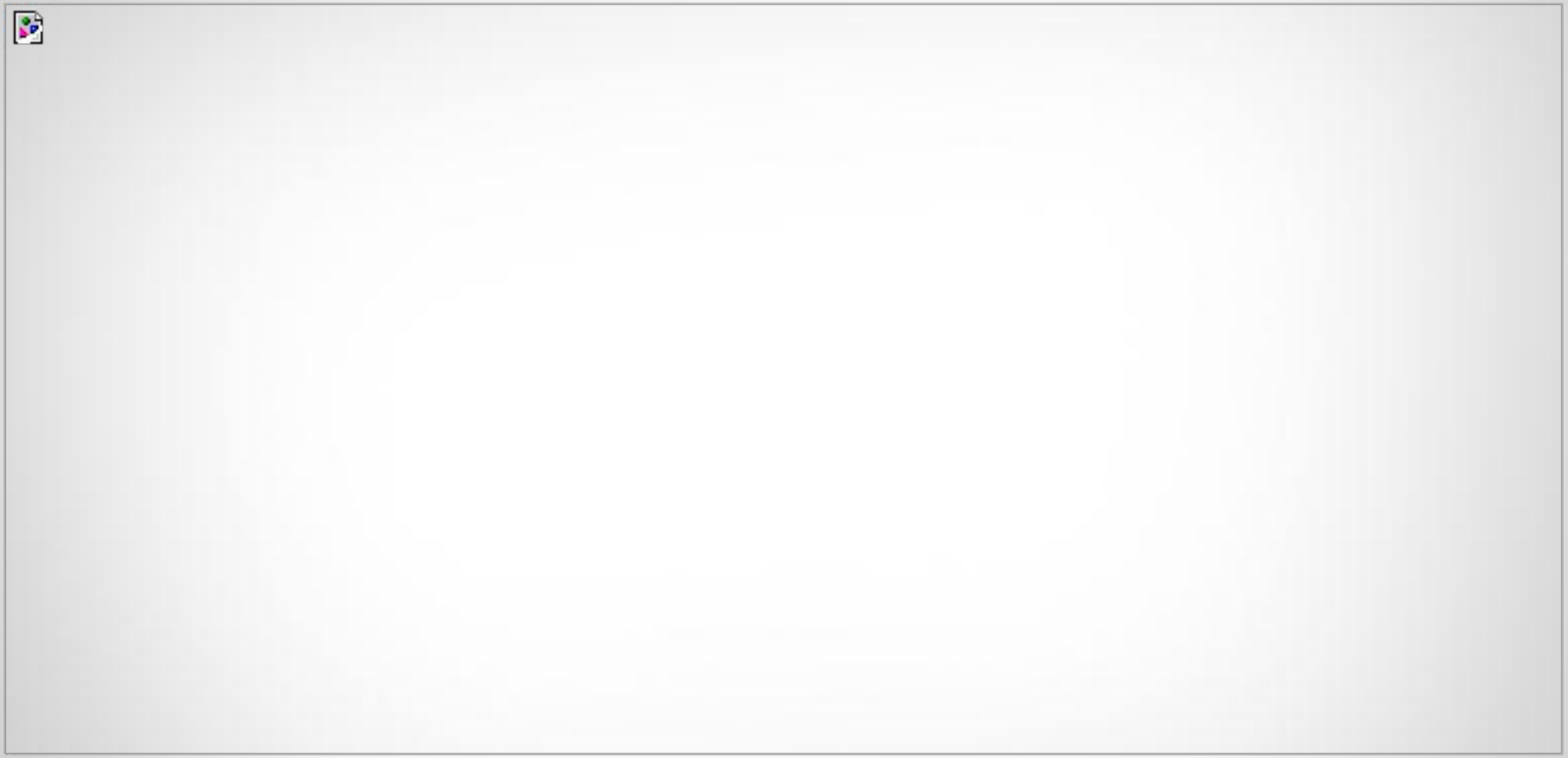
Goal: To determine performance of gun

We will two Infrared LEDS and two infrared detectors

- When the projectile breaks the first beam the detector will send a signal
- Our microcontroller will take that signal and start a counting
- When the projectile breaks the second beam the detector sends another signal
- The microcontroller will take that signal and stop the counter

Distance between sensors to be determined

Microcontroller Pin Mappings



Frame Design

Purpose of the frame is to keep the gun and all of its components in tact. It also helps out in the following areas:

- ❑ aesthetics
- ❑ exposure
- ❑ stability
- ❑ ease - and reuseability

Frame Design

Laser-cut wood was chosen as the desired frame over 3d-printed Asb plastic

Advantages

- ❑ Very cheap ($7.00 for a 2x4 ft board)
- ❑ Faster to make (20 minutes vs several hours
- ❑ Laser-cut can create larger objects vs 3d printer
- ❑ Does not bend easy
- ❑ Larger room for error if design is not perfect

*Comparisons made between policies / performance of the laser cutter and 3d printer in the Texas-Instruments lab

Frame Design

Three boxes were created and glued together

- Large box (3.5x3.5x21 in) held the two capacitors
- Small box (2.5x2.5x14) for the pcb
- Medium box (3x3x15 in) held the rest of the components
- LCD displays attached on the outside of the frame
- Boxes were created with interlocking edges using makercase.com

Frame Design

Prototype (K-nex was used)

Wooden frame (naked)

Final Product

Problems

- Temperature of the coils
- Velocity Measurements
- Frame Aesthetics

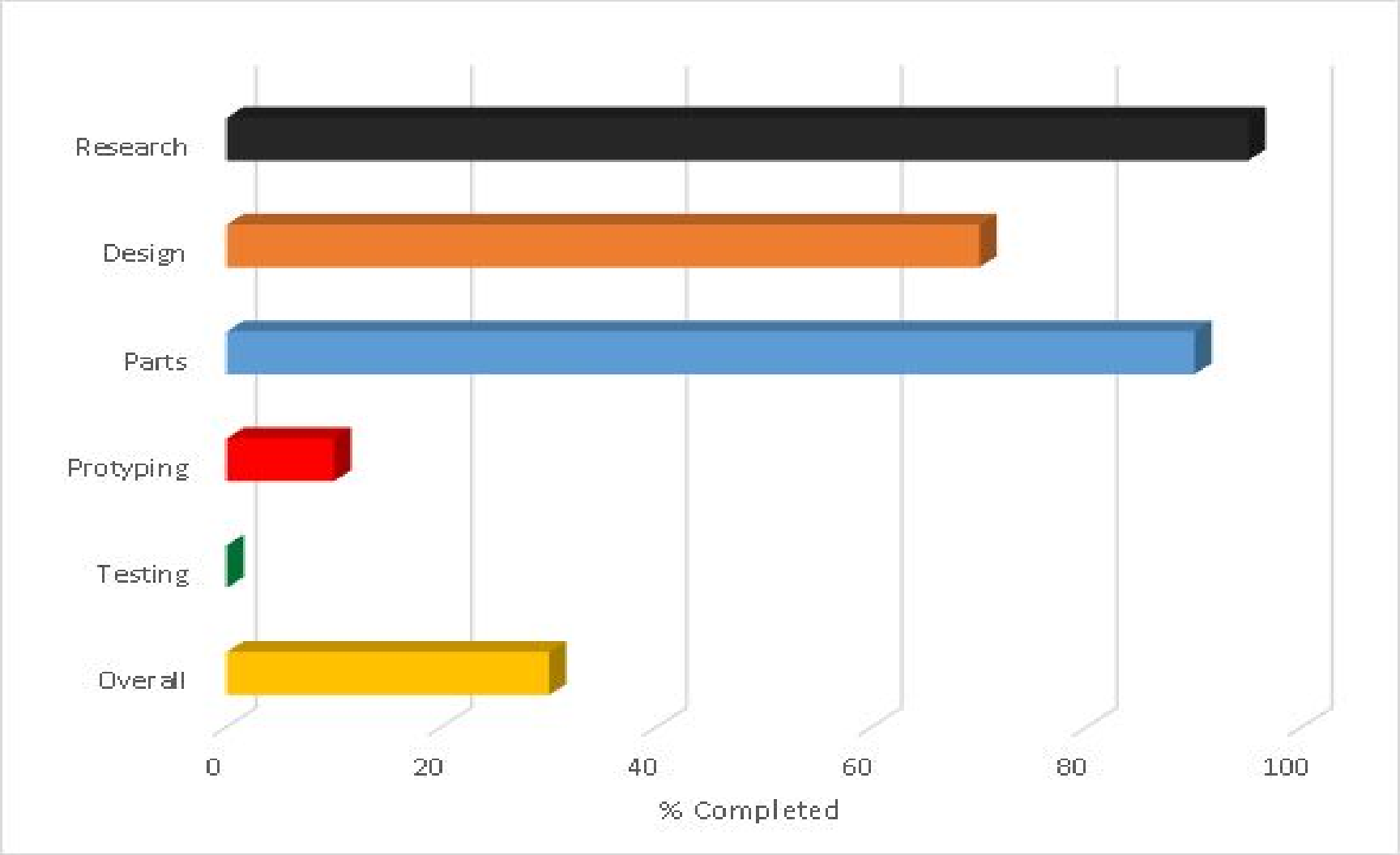
Budget

Quantity	Part(s)	Cost/unit
3	Battery	$48.00
4	Capacitor	$15.00
4	Wood	$7.00
4	Copper Wire	$15.00
1	Arduino dev board	$40.00
1	Boost Converter	$15.00
1	LCD Display	$15.00
1	Battery Charger	$15.00
1	Buck Converter	$8.00
4	Molded Plastic Pipe	$5.00
1	PCB	$40.00
Total	**27**	**$180.00**

Part List

- ❑ 4x 400V 6300uF electrolytic Capacitors
- ❑ 6x1N5408 Diodes
- ❑ 12V Tenergy 2000mAh NiMH Battery
- ❑ 9.6V Tenergy 2000mAh NiMH Batteries
- ❑ 1x Boost Converter
- ❑ 1X Buck Converter
- ❑ ½” diameter PVC pipe
- ❑ Arduino Due
- ❑ RGB backlight positive LCD 20x4
- ❑ Sheet plastic
- ❑ 2x Infrared LEDS
- ❑ 2x Infrared Detectors
- ❑ 1x PCB
- ❑ 2 x ¼ in wooden sheets (2x4 ft)

Project Progress



Demo