SP13 ECE 445 Senior Design

Brain-controlled Portable Programmable Embedded System

Group 44

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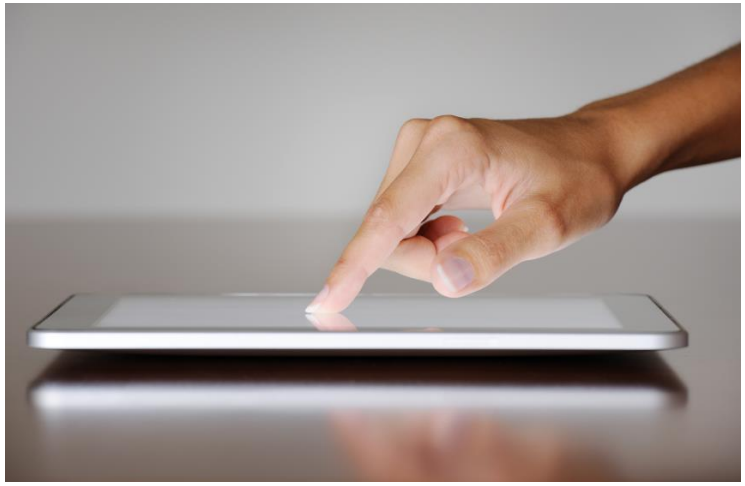
TA: Lydia Majure

Sponsored by: Jamie Norton and his lab

Introduction

- **More innovative controlling method**
- Technology of electroencephalography (EEG)
- A device that allows you to "control with you brain"

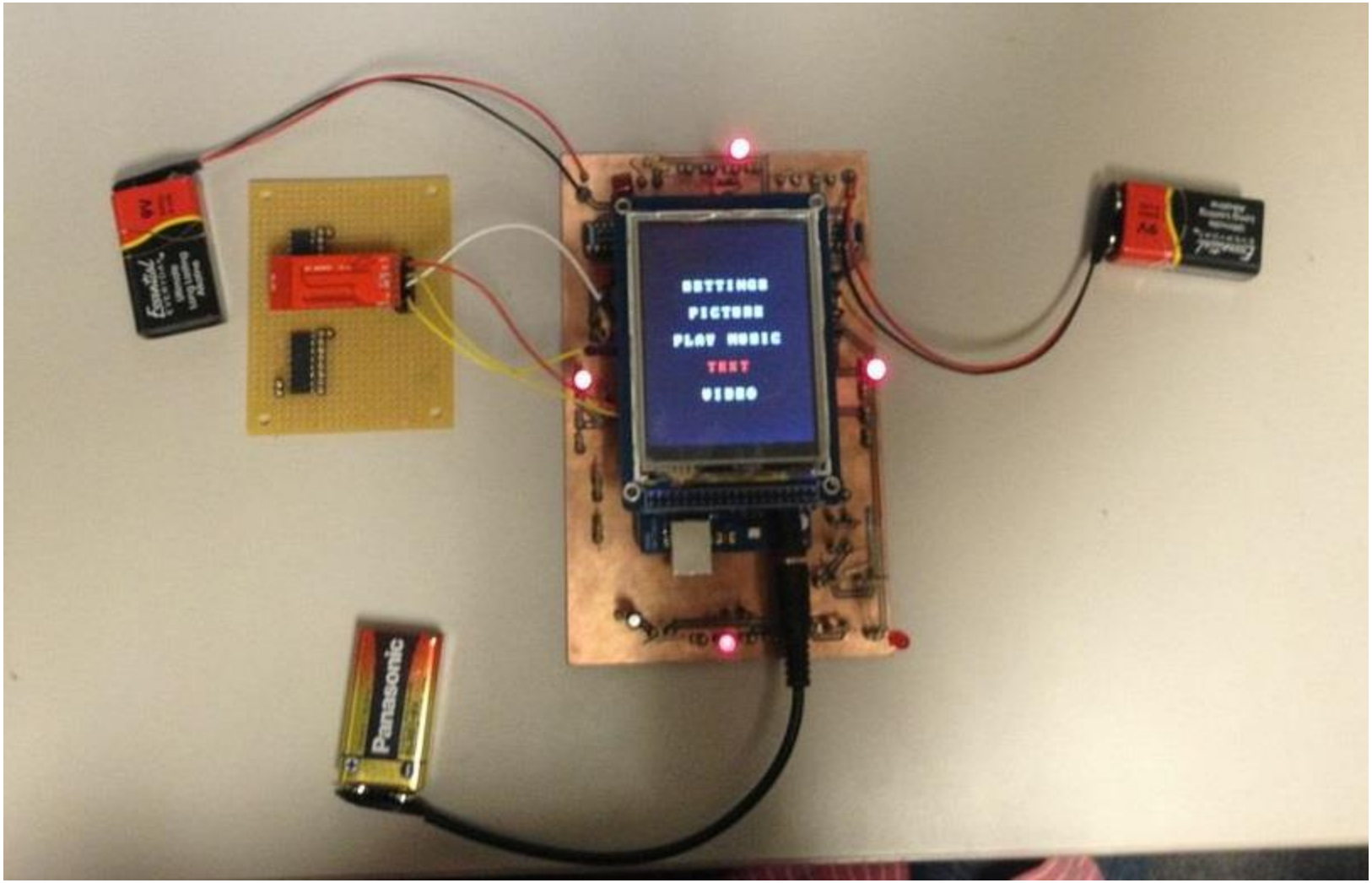


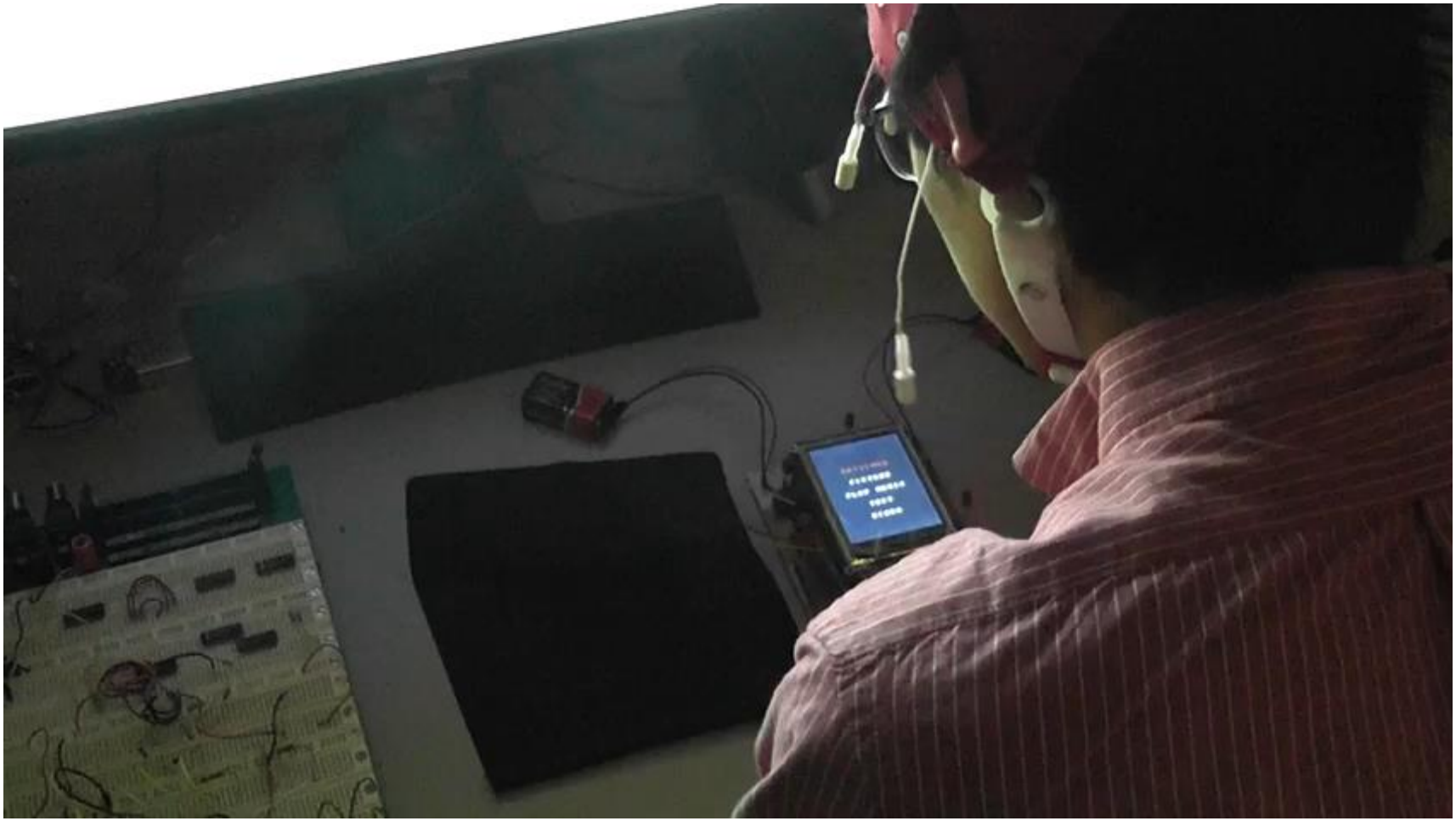
Introduction

- More innovative controlling method
- **Technology of electroencephalography (EEG)**
- A device that allows you to "control with you brain"

Introduction

- More innovative controlling method
- Technology of electroencephalography (EEG)
- **A device that allows you to "control with you brain"**


SETTINGS
PICTURE
PLAY MUSIC
TEXT
VIDEO
Panasonic



If the embedded video didn't quite work,

http://youtu.be/pE1Xmq7yvJk

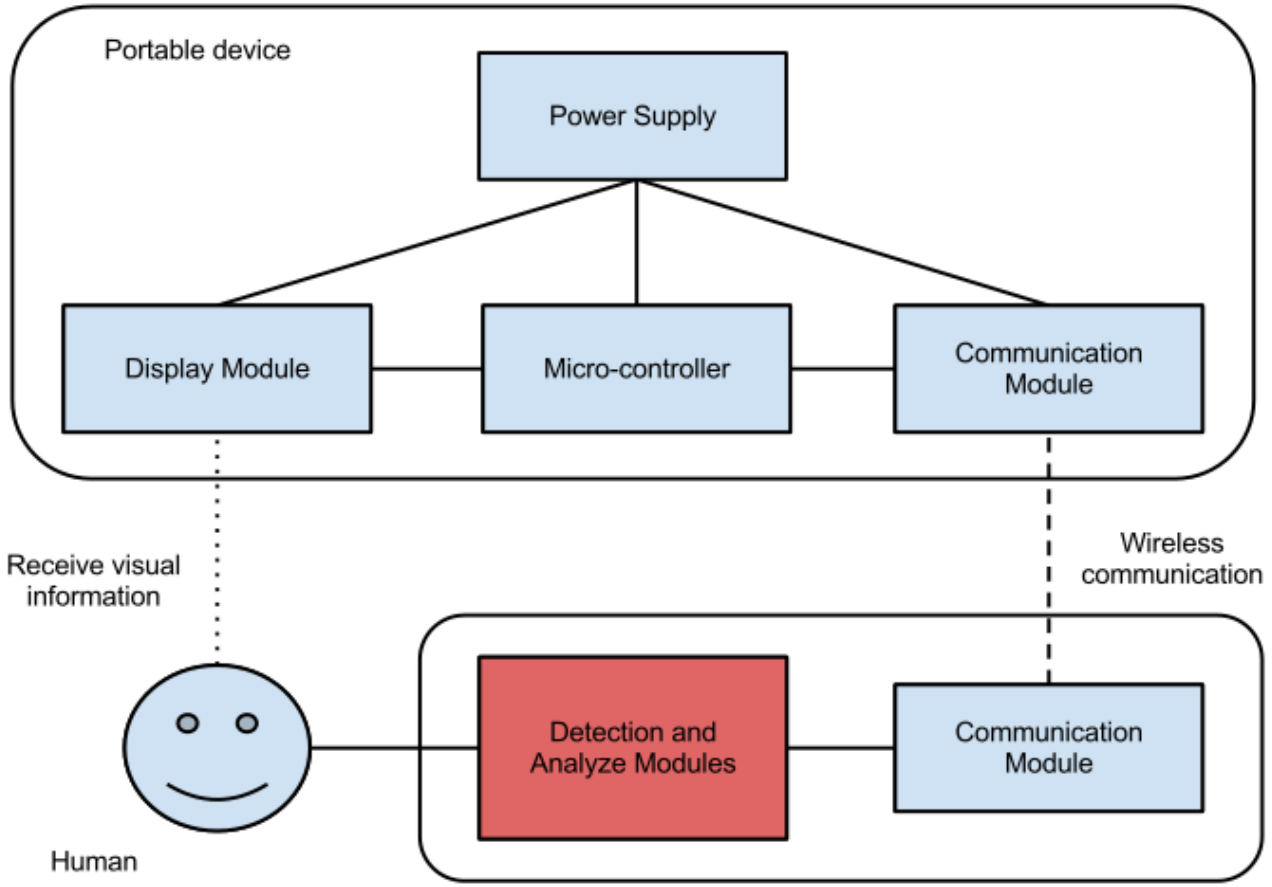
Features

- Wireless signal transmission (Bluetooth)
- Interactive displays (LCD)
- Effective signal stimulation (LEDs)
- EEG signal detection (Sponsored)
- Brain-control-friendly software system

System Overview

- Hardware:
  - Power Supply
  - Micro-controller Unit
  - Bluetooth (communication)
  - LCD screen, LEDs (display)
- Software:
  - Arduino-based embedded programming
- Sponsored:
  - EEG detection module (device & software)

Block Diagram

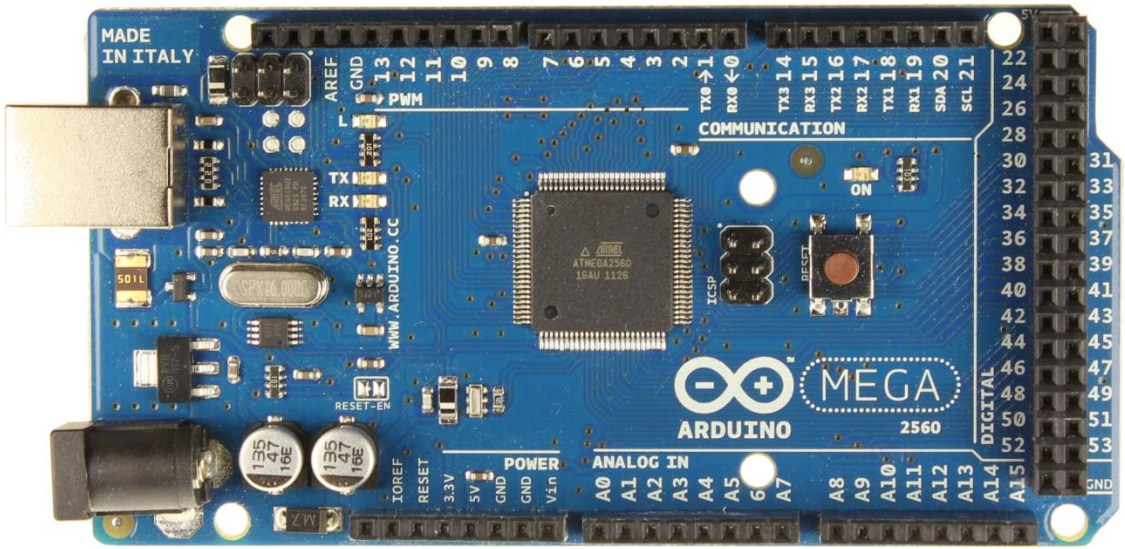


Hardware – Power Supply

- 9V Alkaline batteries
- 5V/3.3V modulator on Arduino board

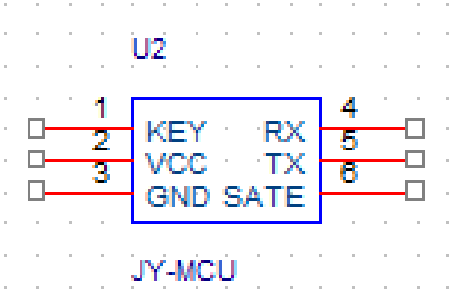
Hardware – Micro-controller

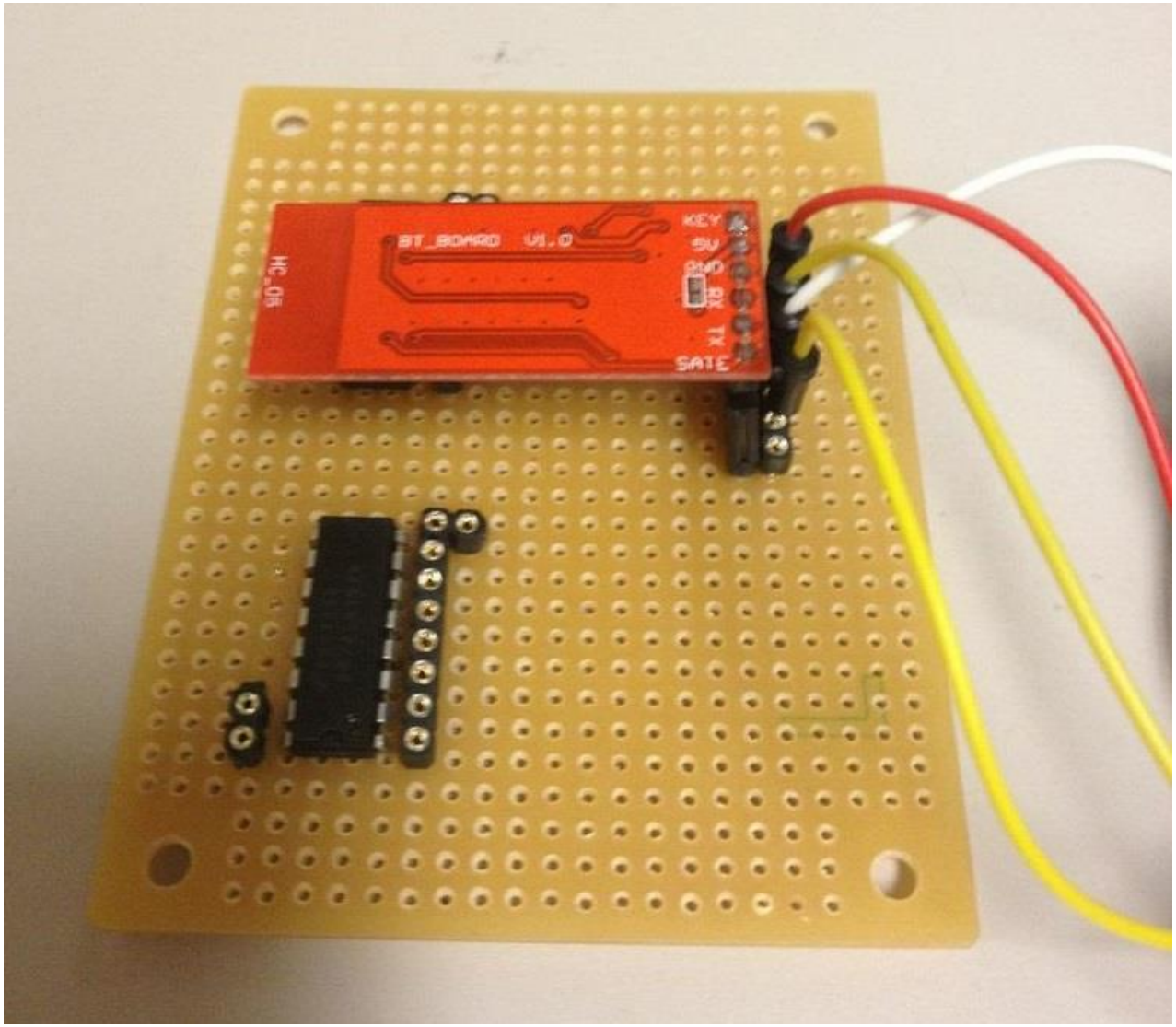
- Arduino Mega 2560 board



Hardware – Bluetooth

- HC-05 Bluetooth tranceivers (slave)
- USB Bluetooth module for PC (master)
- Serial connection set-up using Matlab




BT_BOARD V1.0
KEY
5V
GND
RX
TX
STATE

Bluetooth Matlab Sample Code

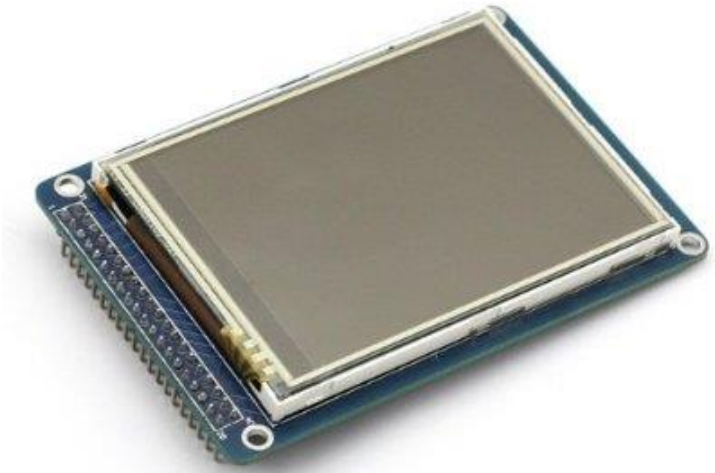
- `b = Bluetooth('S1', 1);`
- `fopen(b);`
- `up = 'w'; down = 's';`
- `fwrite(b, up, 'uchar');`
- `fwrite(b, down, 'uchar');`
- `fclose(b);`
- `clear(b);`

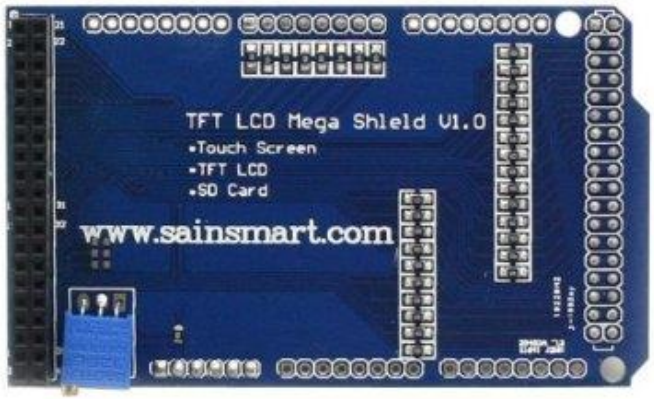
Bluetooth Arduino Sample Code

- `Serial.begin(9600);`
- `val = Serial.read();`

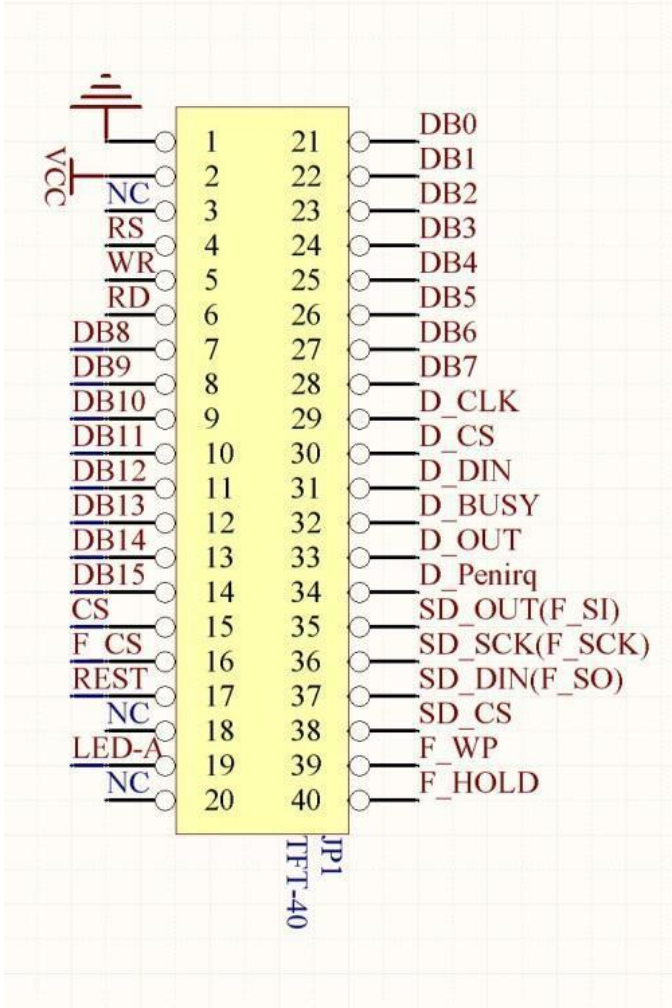
Hardware – Display (LCD)

- SainSmart 3.2” TFT LCD screen w/ touch panel
- Screen shield for Arduino Mega 2560






www.seeedstudio.com
TFT LCD Mega Shield v1.0
MEGA

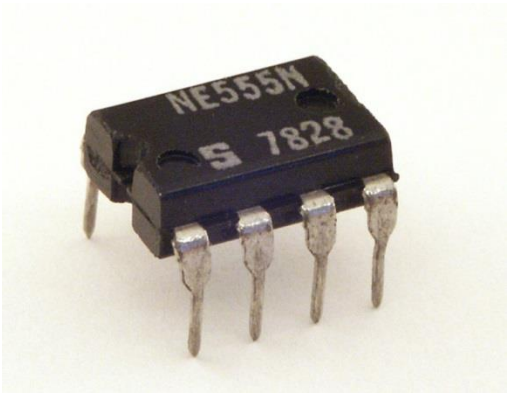

VCC
NC
RS
WR
RD
DB8
DB9
DB10
DB11
DB12
DB13
DB14
DB15
CS
F_CS
REST
NC
LED-A
NC
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
D_CLK
D_CS
D_DIN
D_BUSY
D_OUT
D_Penirq
SD_OUT(F_SI)
SD_SCK(F_SCK)
SD_DIN(F_SO)
SD_CS
F_WP
F_HOLD
JP1
TFT-40

Hardware – Display (LED)

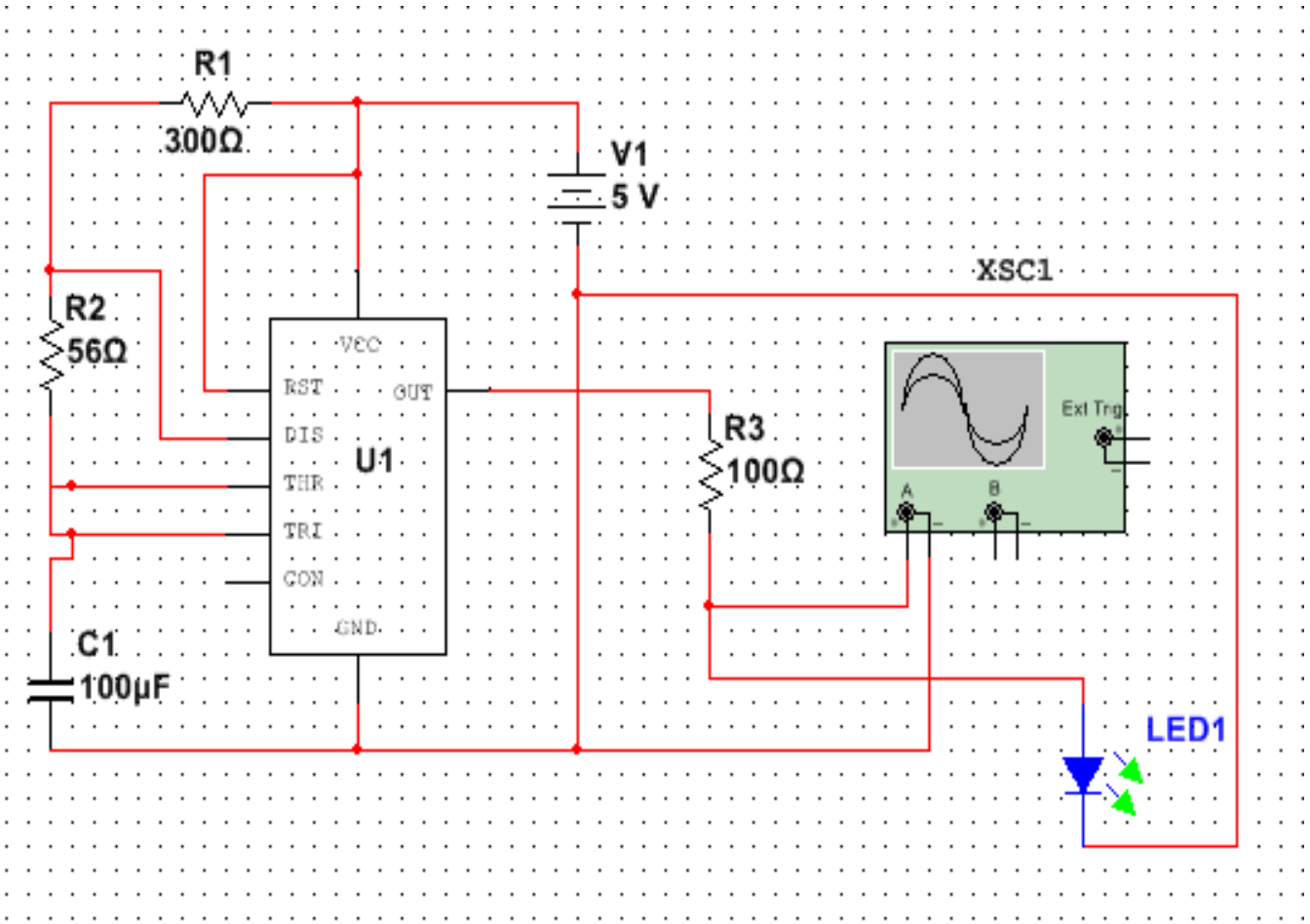
- LED flashing circuitry
- 4 groups of LEDs flash at 4 different frequencies (combinations of capacitors and resistors of different values):
  - 5.7Hz, 7.1Hz, 7.9Hz, 9.4Hz
- LM348 Op Amp chip

LED Flashing Circuit (Original)

- **Timer 555 IC**
- Associated issues/problems:
  - Duty cycle is not 50% on/off
  - Frequencies not stable
  - Failed to stimulate/detect signals



Schematics (Timer 555)



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- Timer 555 IC
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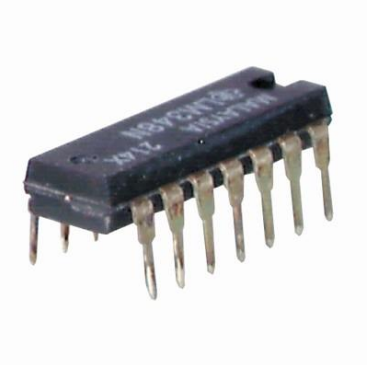
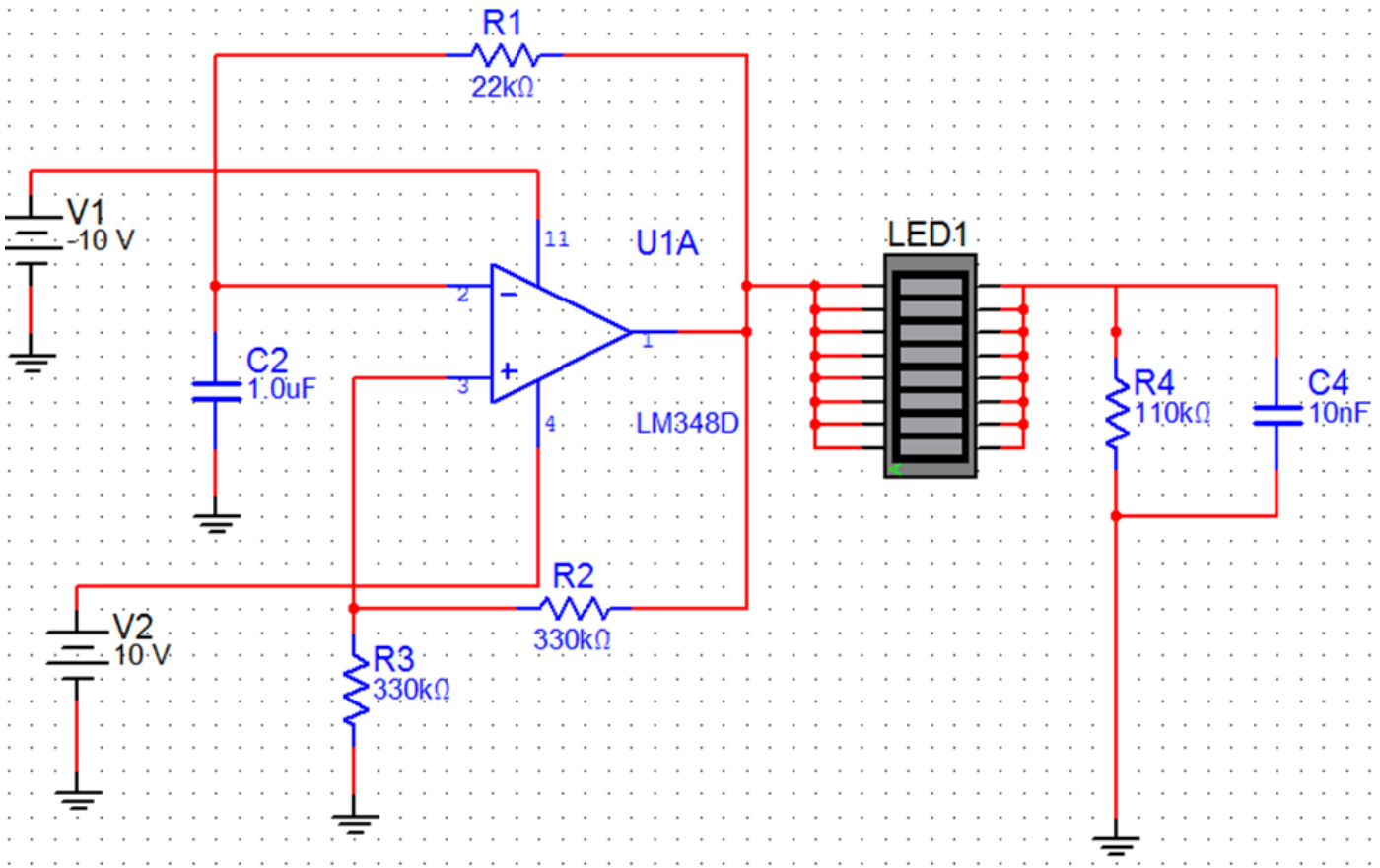
Waveform (Timer 555)

LED Flashing Circuit (Revised)

- **LM348 Op Amp Chip**
- Improvements
  - Duty cycle is 50% on/off
  - Frequencies are stable
  - Cleaner square wave
  - Capable to stimulate/detect signals



Schematics (LM348)



Simulation & Calculation (LM348)

The **theoretical** value of the frequency is:

$$T = 2\,R1 * C2 * ln\left(\frac{1+k}{1-k}\right) = 0.04834\ second$$

$$k = \frac{R3}{R2+R3} = \frac{330}{330+330} = 0.5$$

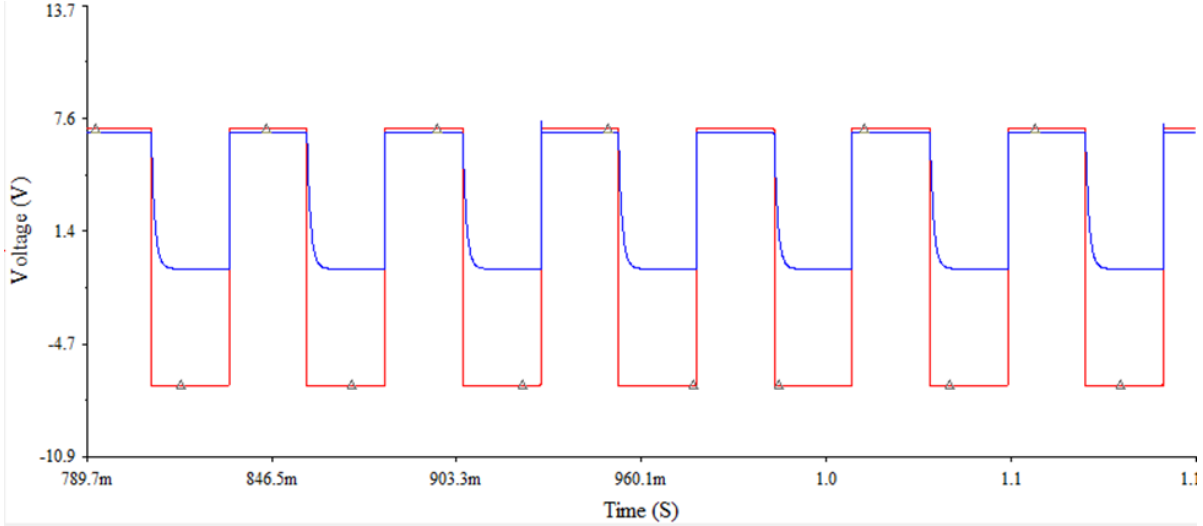
$$f = \frac{1}{T} = 20.69\ Hz$$

The **simulated** result of the frequency is:

$$T = 0.492\ second$$

$$f = \frac{1}{T} = 20.32\ Hz$$

Voltage(V)



Time(s)

LED Flashing Circuit (Revised)

- LM348 Op Amp Chip
- **Improvements (with specific combinations of capacitors and resistors)**
  - Duty cycle is 50% on/off
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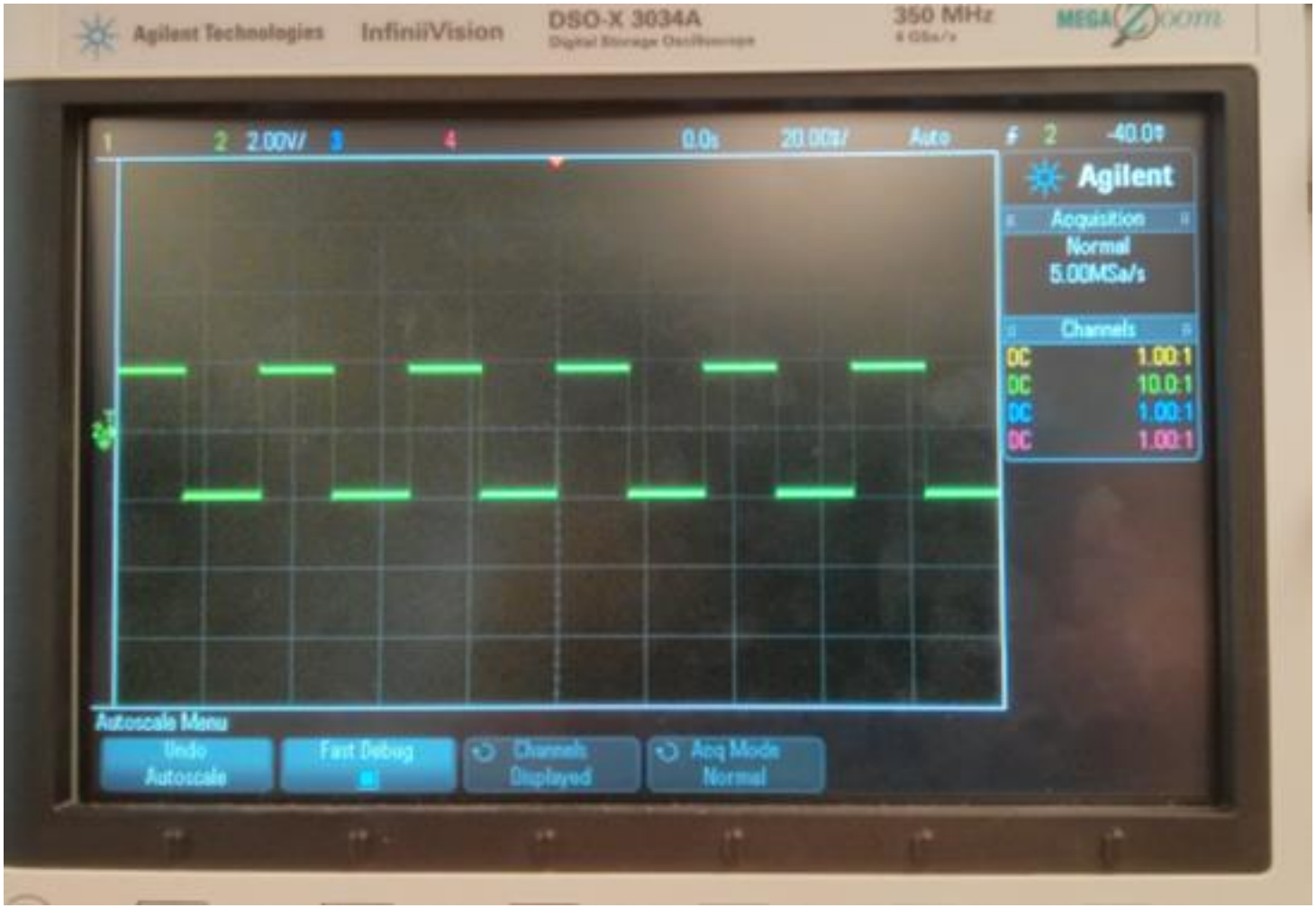
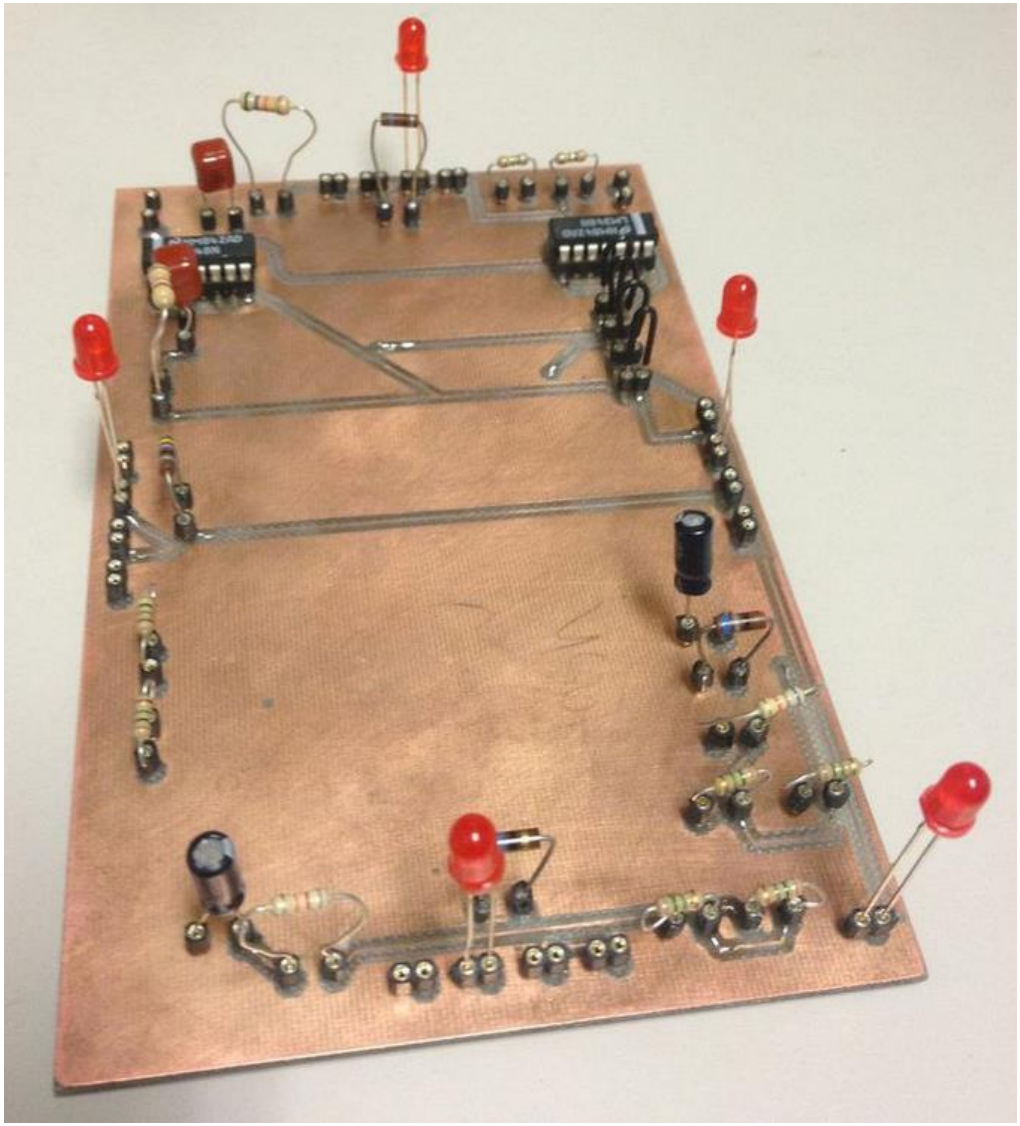
Waveform (LM348)





Software – Embedded System

- **Arduino Programming Environment**
- UTFT library support for graphical design and programming
- Two-level menu-content design as a prototype for demonstration
- Possible further development

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UTFT Sample Code

- `ITDB02 myGLCD(19,18,17,16);`
- `myGLCD.initLCD(0);`
- `myGLCD.setColor(255,0,0);`
- `myGLCD.print("Hello World",CENTER,0);`
- `myGLCD.drawBitmap(0,0,64,64,image,2);`

Software – Embedded System

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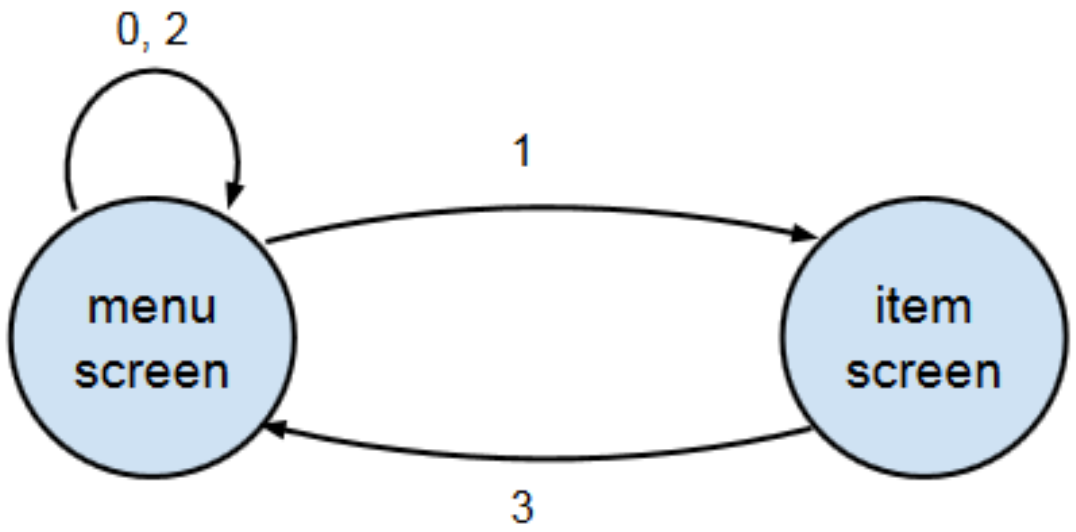
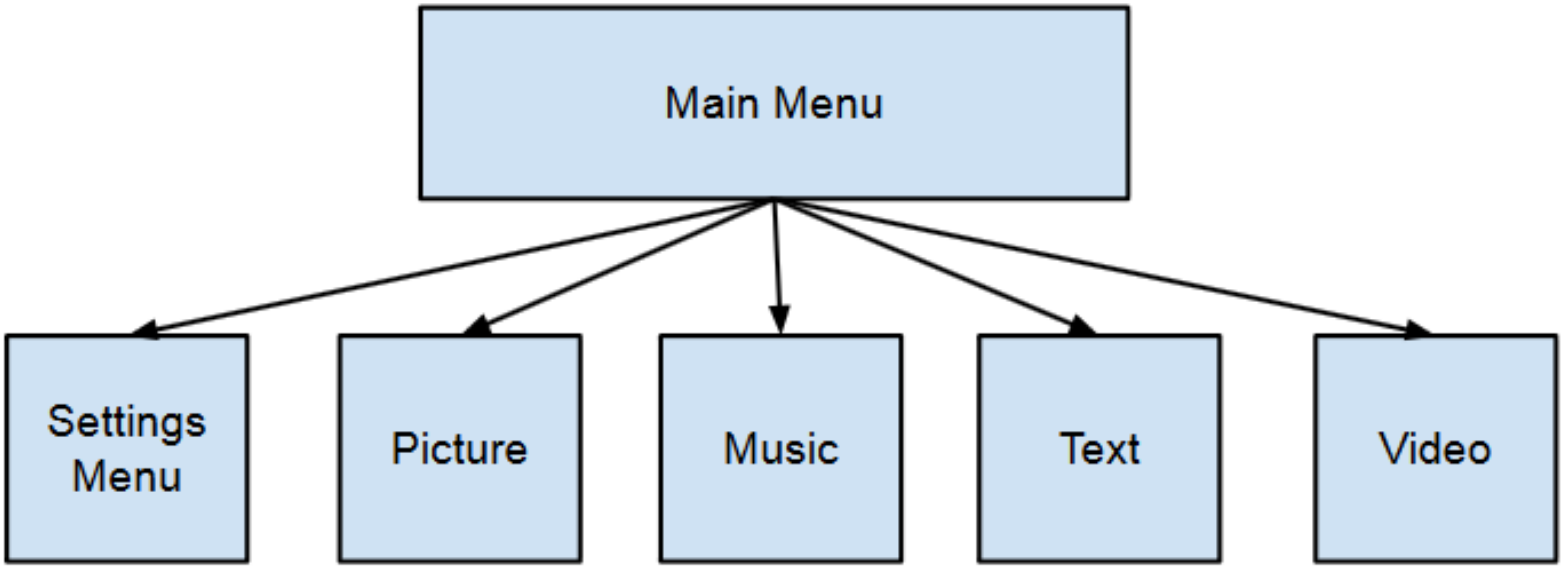
Software Logistic Flow Chart



Inputs:
0 - top selected (scroll up)
1 - center selected (select)
2 - bottom selected (scroll down)
3 - bottom-right selected (exit)

Software Logistic Hierarchy



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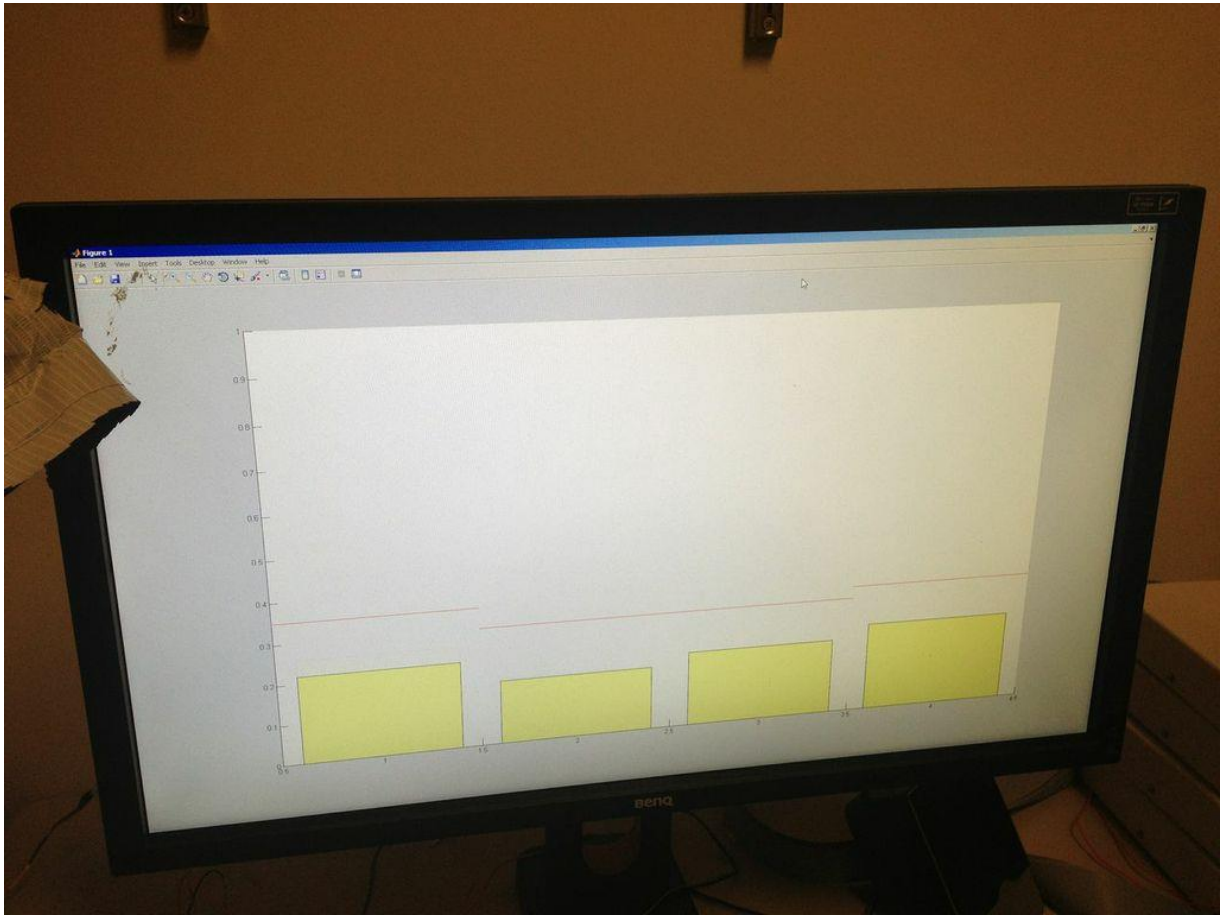
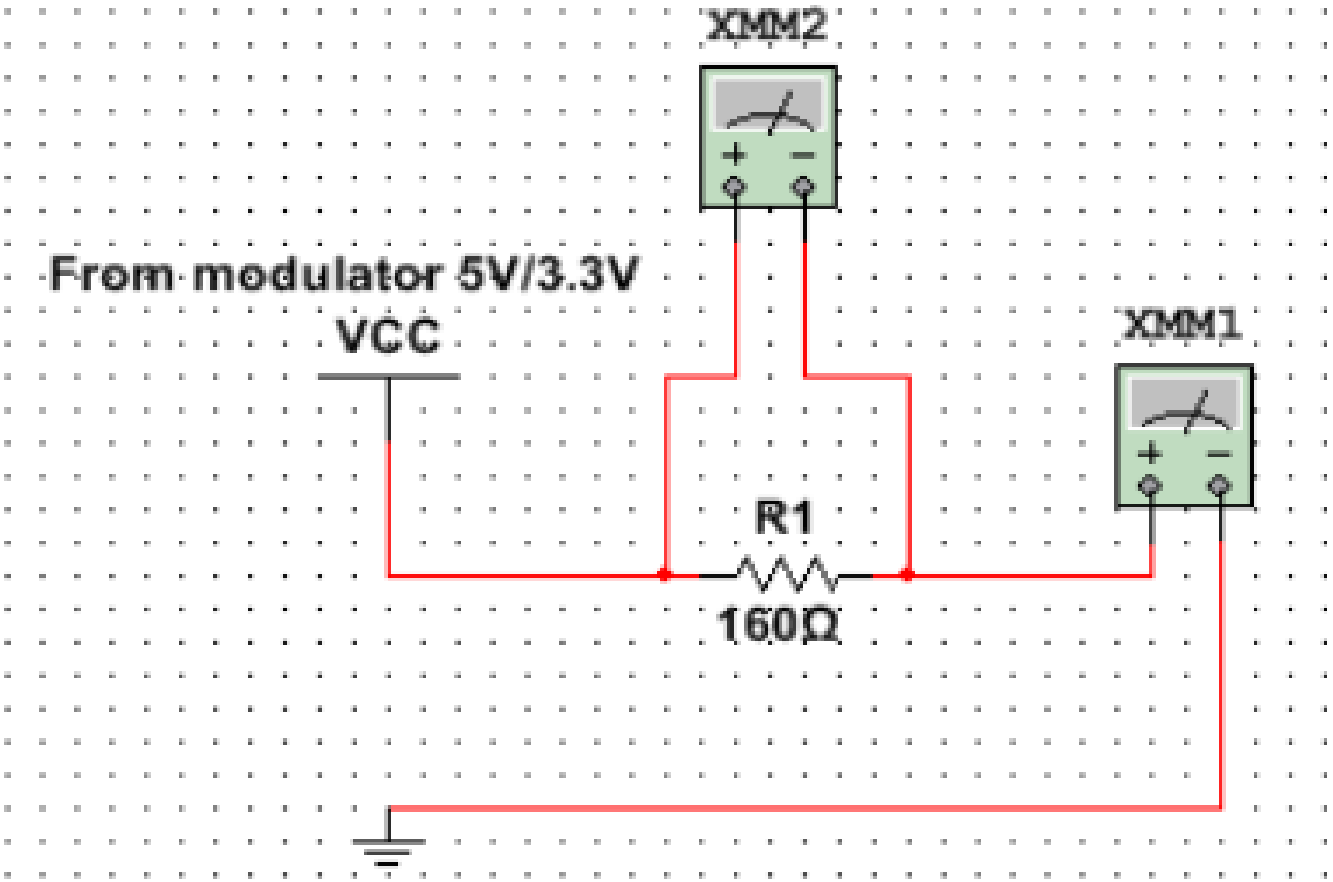
Sponsored – Detection module



Requirements – Power Supply

- Supply steady 9V input to Arduino board and LED flashing circuit
- Output steady 5V from modulator to drive Bluetooth module

Verification – Power Supply (5V)



Verification – Power Supply (5V)

- Use a set of different configurations (R1) and obtain result by measuring the currect across R1.

Resistance (Ω)	Voltage (V)
33	4.83
45	4.83
56	4.86
78	4.84
88	4.86

Requirements – Bluetooth

- Receive transmitted input signal correctly and pass it to Arduino microcontroller
- On detection module side, once a EEG signal detected, a transmission should be triggered

Verification – Bluetooth

- Use Bluetooth app on Android cellphone to send commands to HC-05 module and check if the indicator on Arduino responds; Repeat 10 times
- Use detection device and check if the indicator on Arduino responds every time there is a signal detected; Repeat 10 times

Verification – Bluetooth (RESULTS)

Test#	Result (indicator)
1	Y
2	Y
3	Y
4	Y
5	Y
6	Y
7	Y
8	Y
9	Y
10	Y

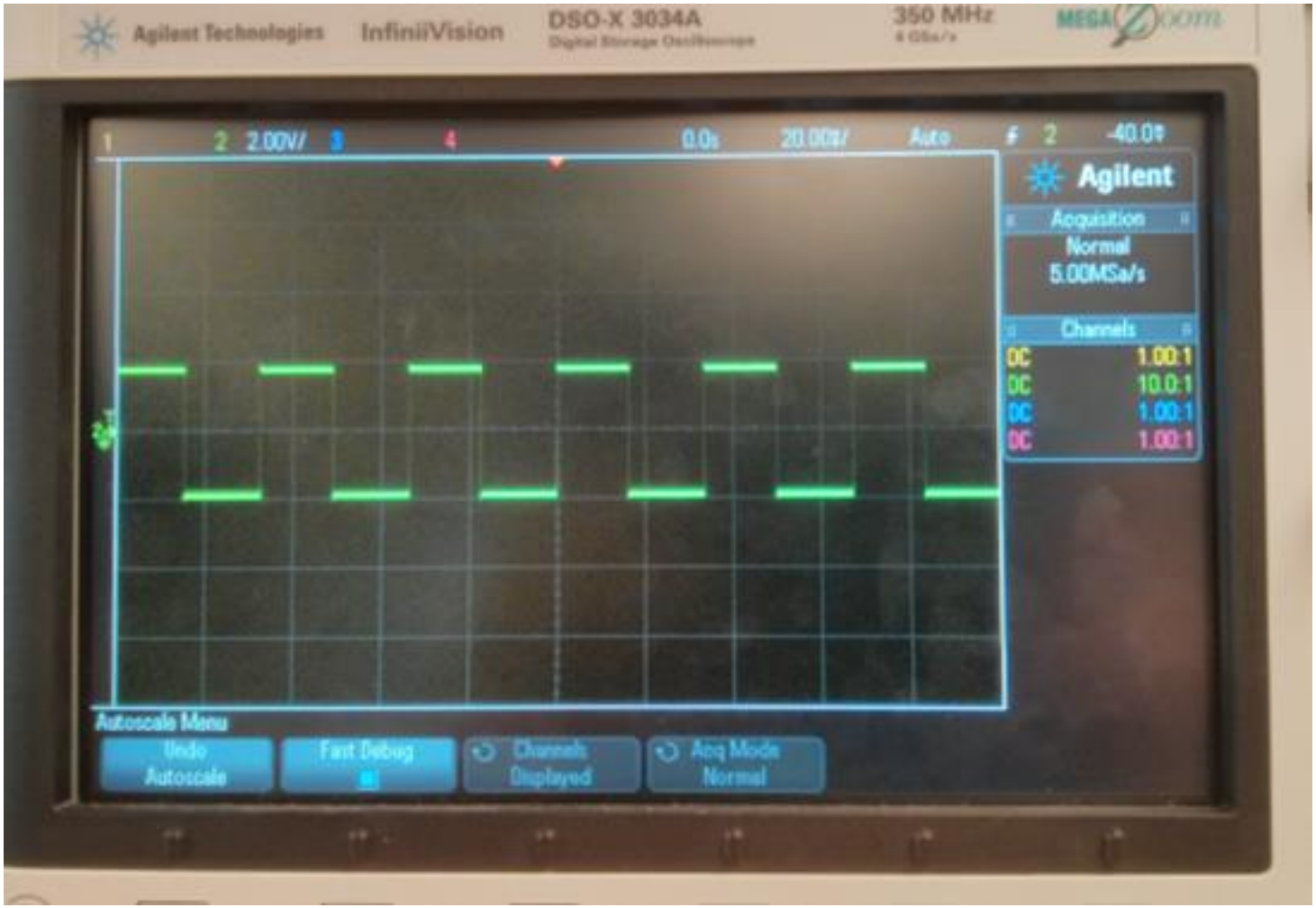
Requirements – Display (LED)

- Blinks at frequencies (5hz to 15hz) with 50% duty cycle, and stable waveforms
- LEDs at different frequencies not interference to each other so that detection module can tell which LED is being stared at

Verification – Display (LED)

- **Use oscilloscope to observe the waveforms and check duty cycles and stability**
- Set up detection module and 4 groups of LEDs; Look at one LED and check if correct frequency is detected; Repeat 20 times

Waveform Observation



Verification – Display (LED)

- Use oscilloscope to observe the waveforms and check duty cycles and stability
- **Set up detection module and 4 groups of LEDs; Look at one LED and check if correct frequency is detected; Repeat 20 times**

Verification – Display (LED) (RESULT)

Frequency intended (Hz)	Frequency detected (Hz)
5.7	5.7
7.1	7.1
7.9	7.9
9.4	5.7
5.7	5.7
7.1	7.1
7.9	7.9
9.4	9.4
5.7	5.7
7.1	7.1

Frequency intended (Hz)	Frequency detected (Hz)
7.9	7.9
9.4	9.4
5.7	5.7
7.1	7.1
7.9	7.9
9.4	9.4
5.7	5.7
7.1	7.1
7.9	7.9
9.4	9.4

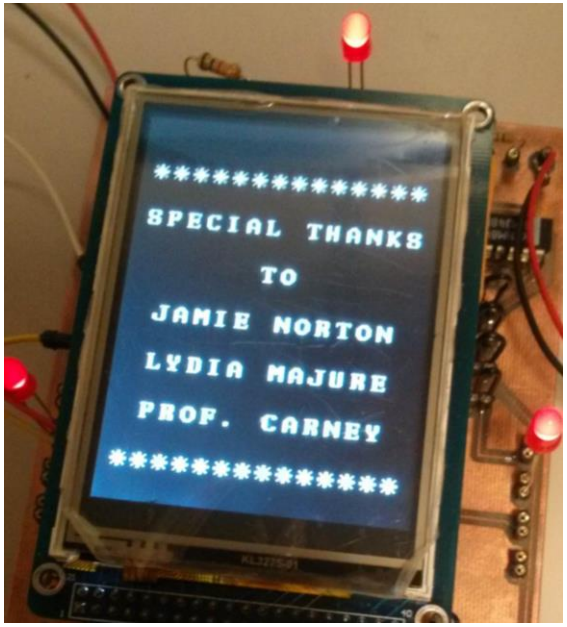
%Accuracy = (20 – 1 mis-detection)/20 = 95%

Future Work

- Add logic circuit (or muxes) to turn off some LEDs when not being used
- Add frosted plastic/glass covers on top of LEDs to defuse light for better detection
- Integrate Arduino/LCD screen better with PCB (a more integrated product)

Credits

- Jamie Norton
- TA: Lydia Majure
- Prof. Carney
- Ryan May and Dennis Yuan
- Staff at ECE Part Shop



Questions

Thank You!