Electrocardiogram

Jorge Duarte

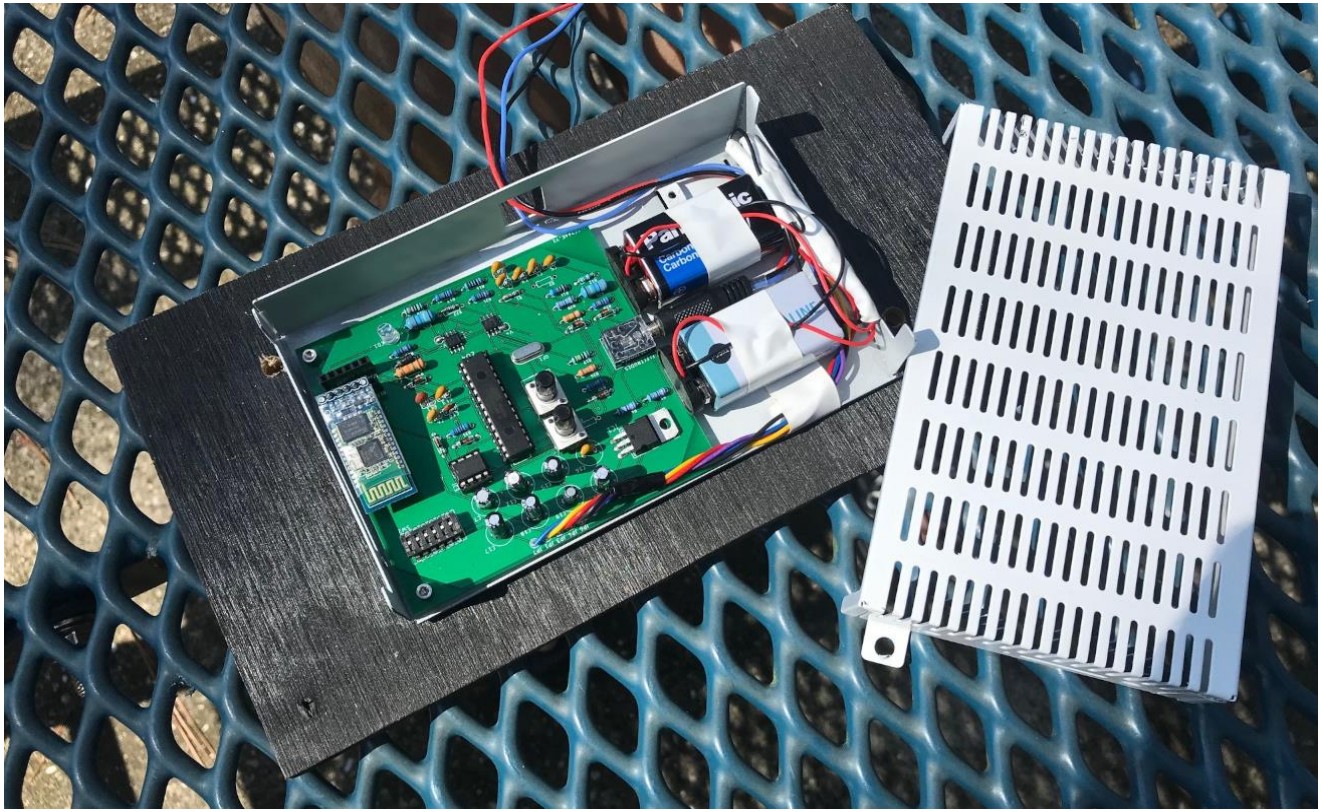
Mark Nguyen

Krystian Plaskota

Zack Briones

Motivation

- Applying knowledge that is acquired from school.
- Challenging with the idea that has much better products out there already in the market.
- Learning to adapt to changes while the working environment has changed.



Portable ECG Reader

Project Description

- Our ECG is small, low cost, and portable.
- We constructed a single lead ECG system that is primarily used for basic heart monitoring and pulse measuring.
- AFE (Analog front end)
- Mobile Application
- Only to be used for educational purposes.

Objectives

- Build a working ECG to showcase the skills we’ve learned in school
- Build a unique project that is unfamiliar to us
- Work together as a team with a diverse backgrounds

Operations

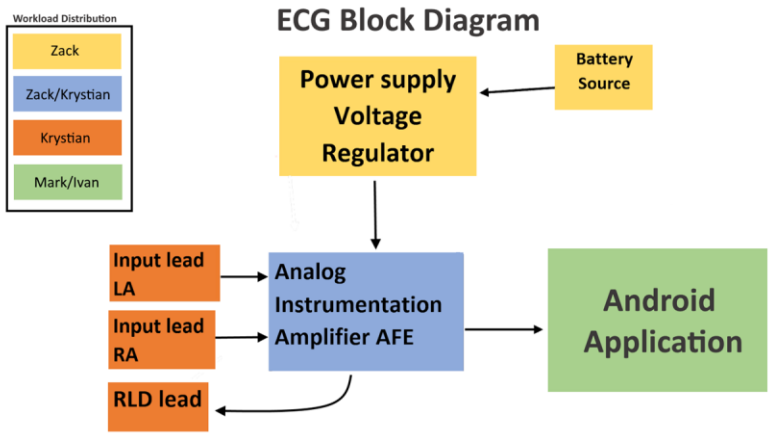
- **Front-end:** Machine detects and amplifies a heart signal then displays it on a phone application

- **Back-end:** Application receives heart signal and displays it on users phone screen

Engineering Specifications

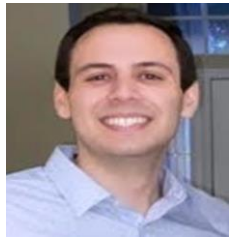
- The device should be portable and battery powered.
- The device should pair and connect with an Android phone via Bluetooth.
- The device should be able to amplify and filter a signal in the 1-100 mV range.
- The software will acquire and analyze the heartbeat signal that is transmitted through Bluetooth.
- The application will be easy to use.

Block Diagram



- The first group is the input sensors called electrodes that collect the cardiac signals.
- The second group is the signal processing unit that will process the input from the electrodes.
- The third group is the power supply unit that supports DC sources of power.
- The last group is the output group which consists of a mobile application that serves as the ECG display.

Team Distribution (Hardware)



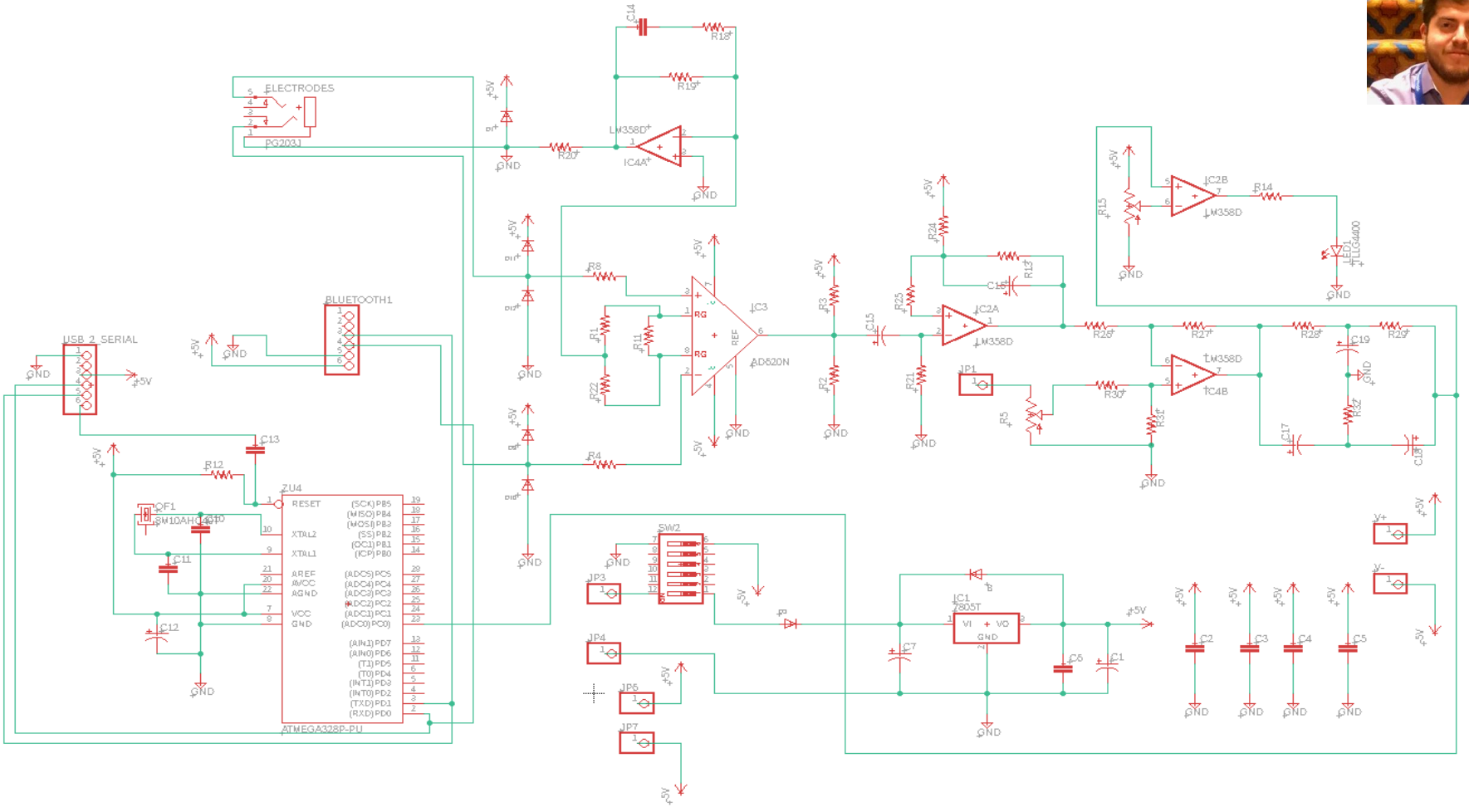
- **Zack Briones:** Primary responsibility is the design of the power supply. The role also includes researching how to properly regulate voltage across the analog front end. Zack's other responsibility is to help Krystian design and test the analog front end of the design.
- **Krystian Plaskota:** Co-designer of the analog front end, analog circuitry of the RLD amplifier, and lead off detection with Zack. This involves researching various chips and amplifiers appropriate for amplifying ultra low voltages and designing filters that negate noise so the ADC can accurately sample the input signal.

Team Distribution (Software)

- **Mark Nguyen :** Software developing for the GUI of the EKG machine. Website development, soldering PCB, and testing.

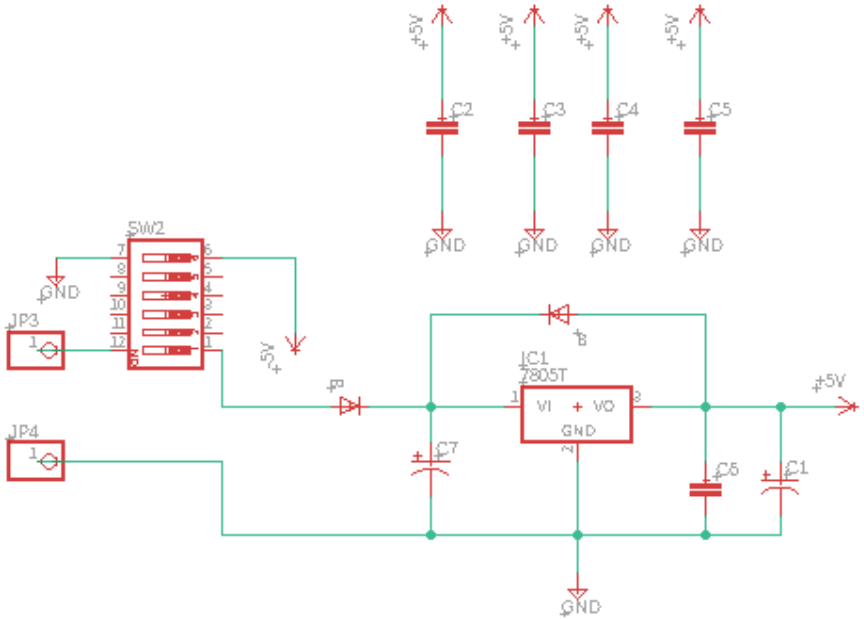
- **Jorge Duarte :** Main Focus is Software programming and Hardware interactions, through the given data acquired by peripherals. PCB construction, soldering, and component implementation.

HARDWARE

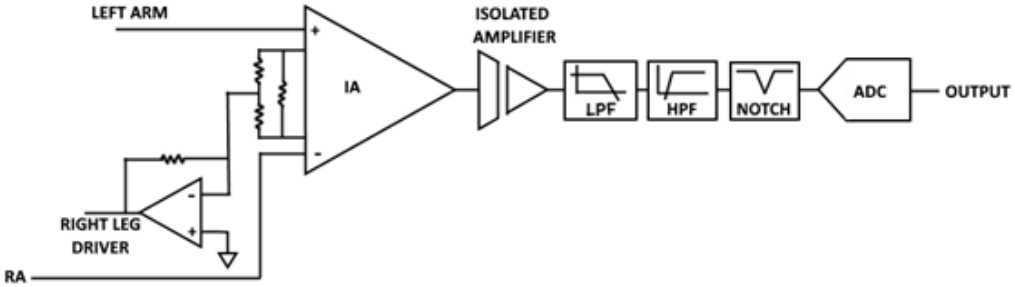

ELECTRODES
PG203J
R20
LM358D
IC4A
C14
R18
R19
BLUETOOTH1
USB_2_SERIAL
R8
R1
R11
R22
IC3
AD620N
R4
R3
R2
C15
R24
R25
C16
R13
IC2A
R21
JP1
R26
R27
IC4B
R30
R31
R5
R32
C17
C18
C19
R28
R29
IC2B
R14
R15
LED1
LED4400
C13
R12
ZU4
ATMEGA328P-PU
RESET
XTAL2
XTAL1
AREF
AVCC
AGND
VCC
GND
QF1
SM10AHC
C10
C11
C12
SW2
JP3
JP4
JP5
JP7
IC1
7805T
VI
VO
C7
C6
C1
C2
C3
C4
C5
V+
V-
+5V
GND

Power

- 9 volt to 5 volt converter with filtering capacitors.
- Linear voltage regulator to step down the voltage
- Linear regulators provide clean output signals at the cost of efficiency compared to other regulators



Analog Front End

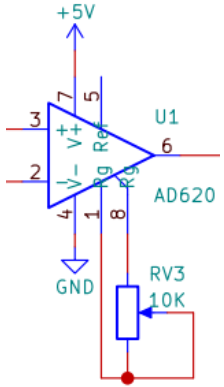


- The front end of an ECG must be able to handle weak signals ranging from 0.5 mV to 5.0 mV, combined with a dc component of up to ±300 mV and a common-mode component of up to 1.5 V, resulting from the potential between the electrodes and ground.
- Our circuit design must account for several different sources of noise: Power line interference, electrode contact noise, motion artifacts, muscle contractions, and electromagnetic interference.

Analog Front End

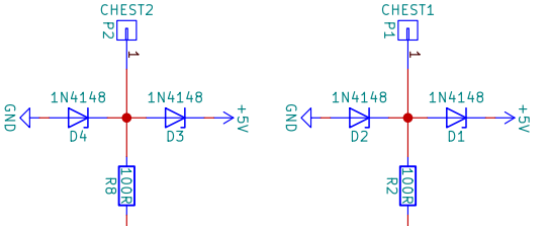
Instrumentation Amplifier:

We used an AD620 to take the difference between two voltages on the patient while removing common mode noise.



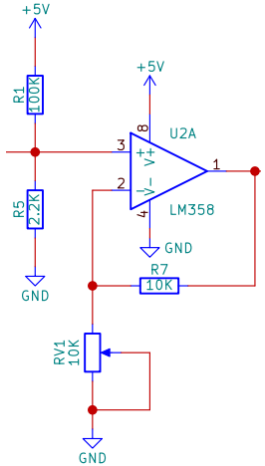
ECG Leads and Protection:

We used zener diodes in reverse bias orientation to protect the user from dangerous amperage.

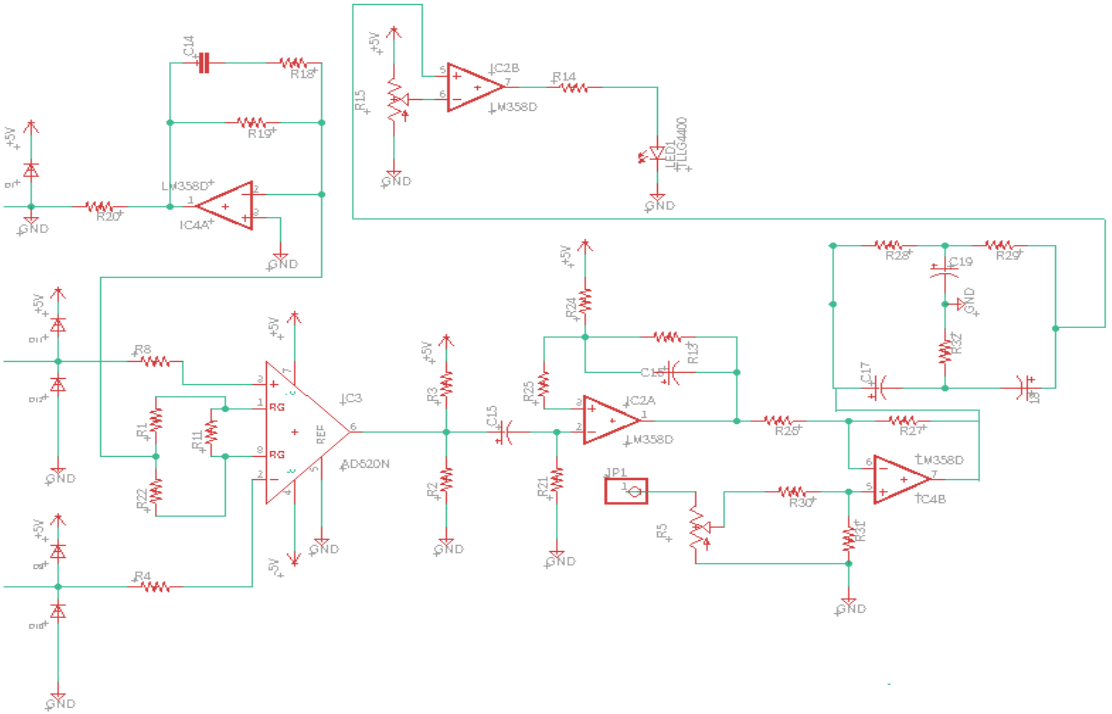


Amplification:

We used an LM358 amplifier to amplify the small signal from the instrumentation amplifier. This was fine tuned using a 10k potentiometer.

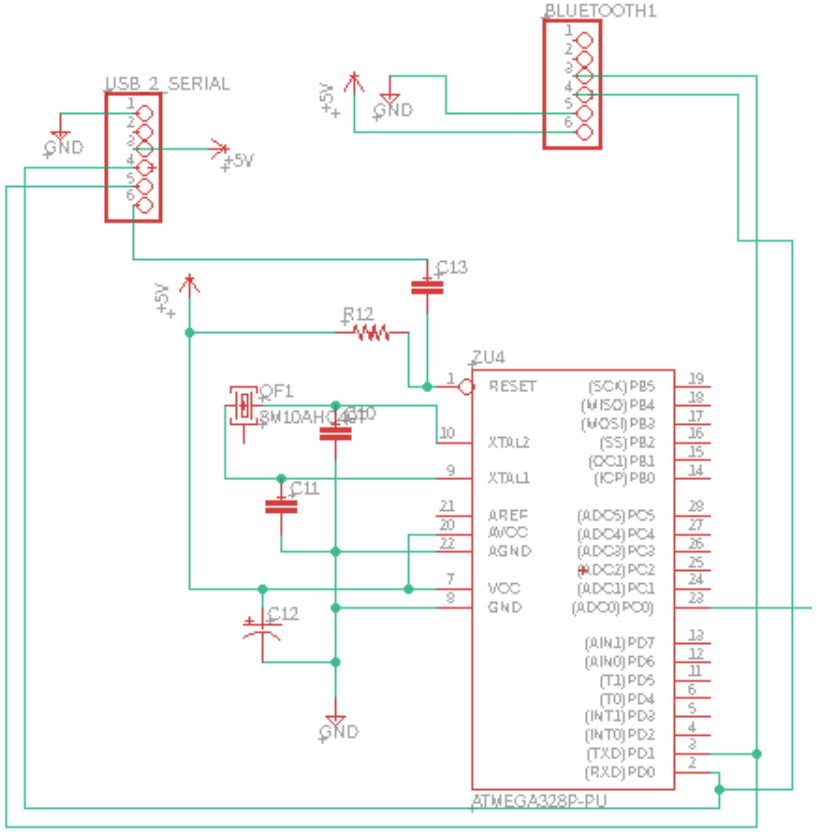


Analog Front - End Schematic



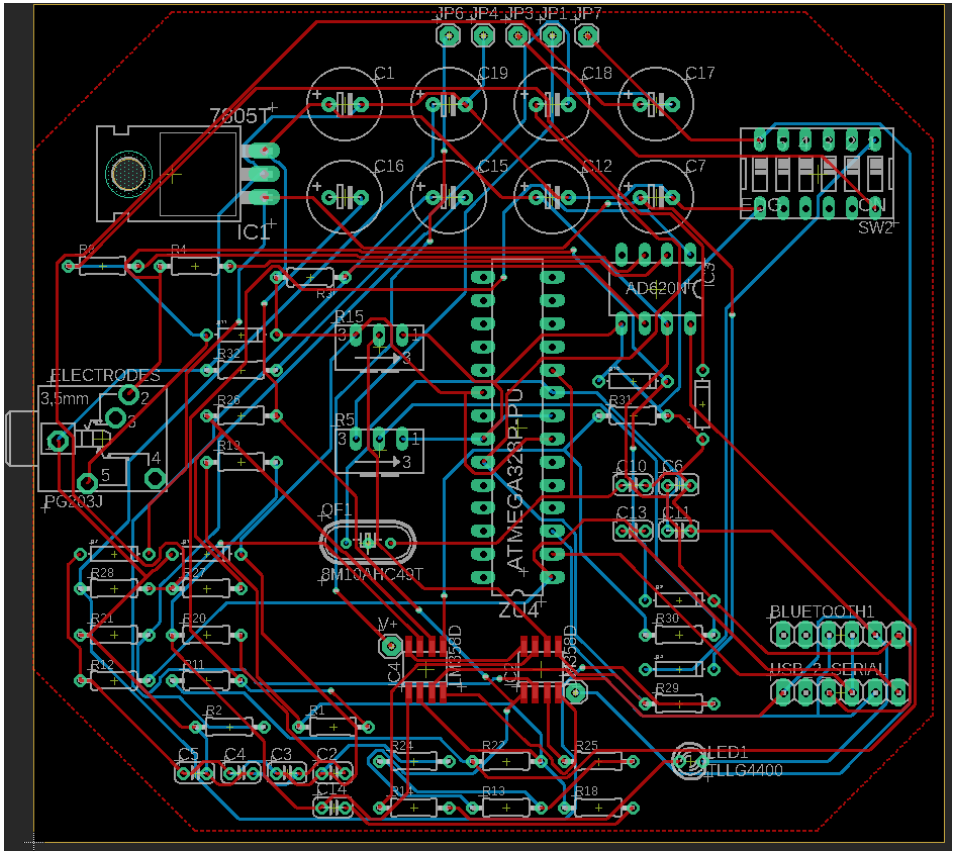
MCU Schematic

- ATmega328p
  - 2 X 22pf capacitors
  - 1 X 10kOhm resistor
  - 1 X 16MHz crystal
- MCU programmer
- Bluetooth

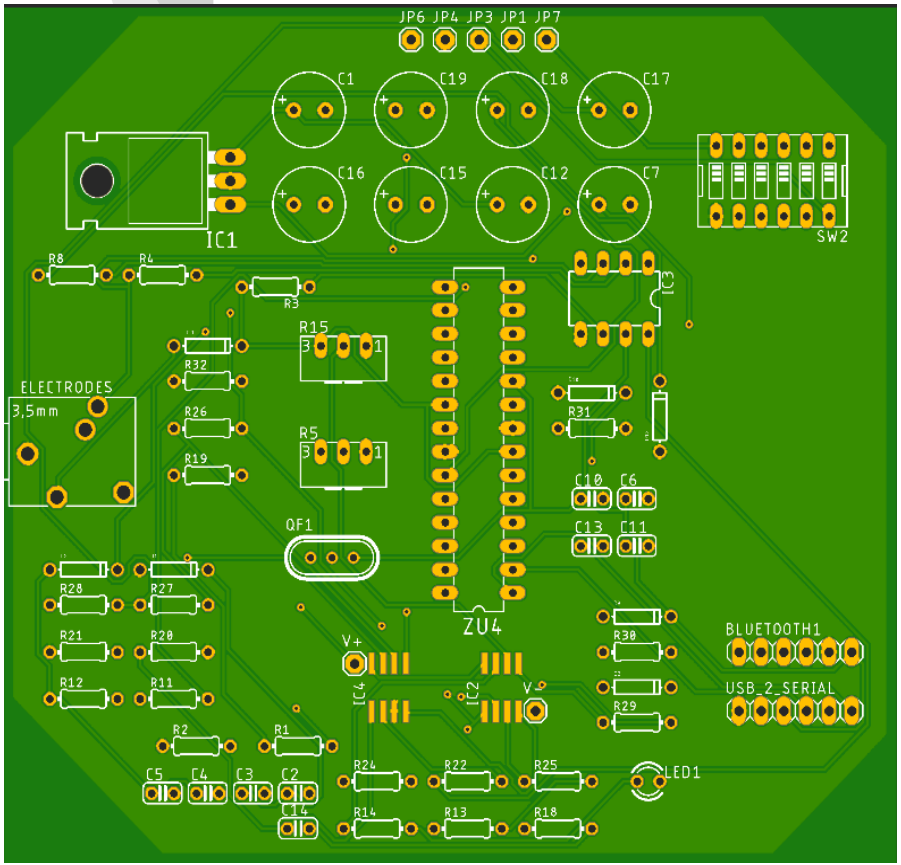


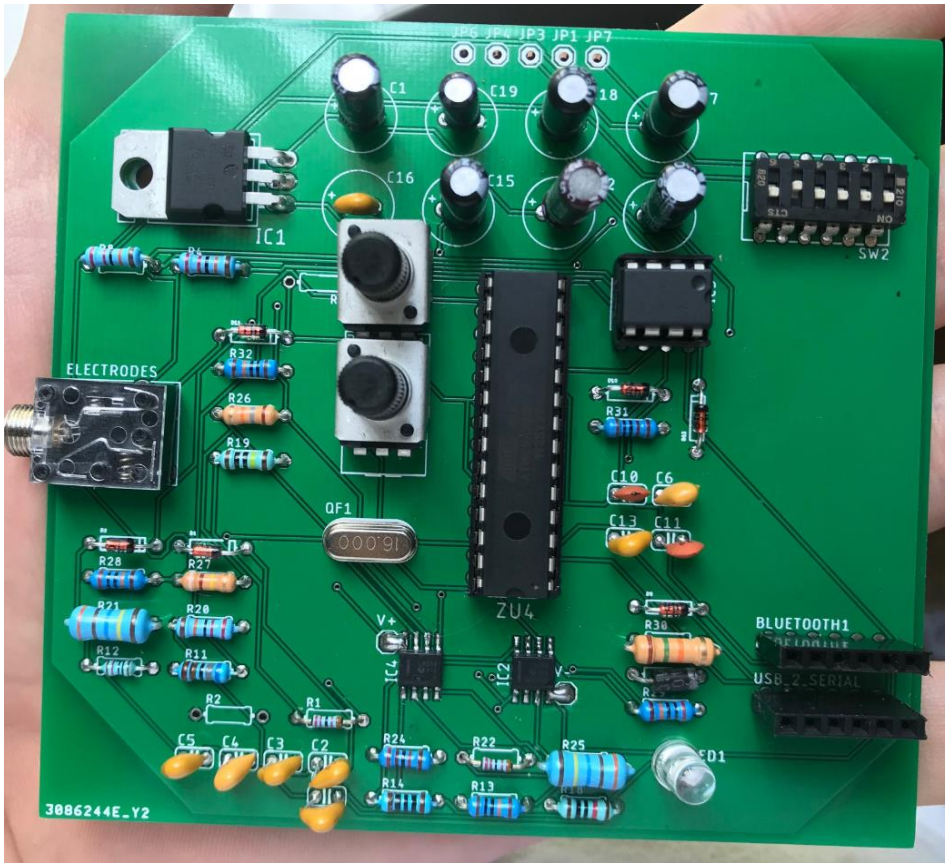
PCB routing

- Ground Plane
- Less components
- Surface mount components
- Circuit isolation protector



PCB


JP6 JP4 JP3 JP1 JP7
C1
C19
C18
C17
C16
C15
C12
C7
IC1
SW2
R8
R4
R3
R15
R32
R26
R19
R5
R31
C10
C6
C13
C11
ELECTRODES
3,5mm
QF1
R28
R27
R21
R20
R12
R11
ZU4
V+
IC4
IC2
V-
R30
R29
BLUETOOTH1
USB_2_SERIAL
R2
R1
C5
C4
C3
C2
C14
R24
R22
R25
LED1
R14
R13
R18


JP6 JP4 JP3 JP1 JP7
C1
C19
18
7
C16
C15
IC1
SW2
ELECTRODES
R32
R26
R19
R31
C10
C6
C13
C11
QF1
16.000
R28
R27
R21
R20
ZU4
V+
R30
BLUETOOTH1
R12
R11
IC4
IC2
V-
USB_2_SERIAL
R2
R1
C5
C4
C3
C2
R24
R22
R25
LED1
R14
R13
3086244E_Y2

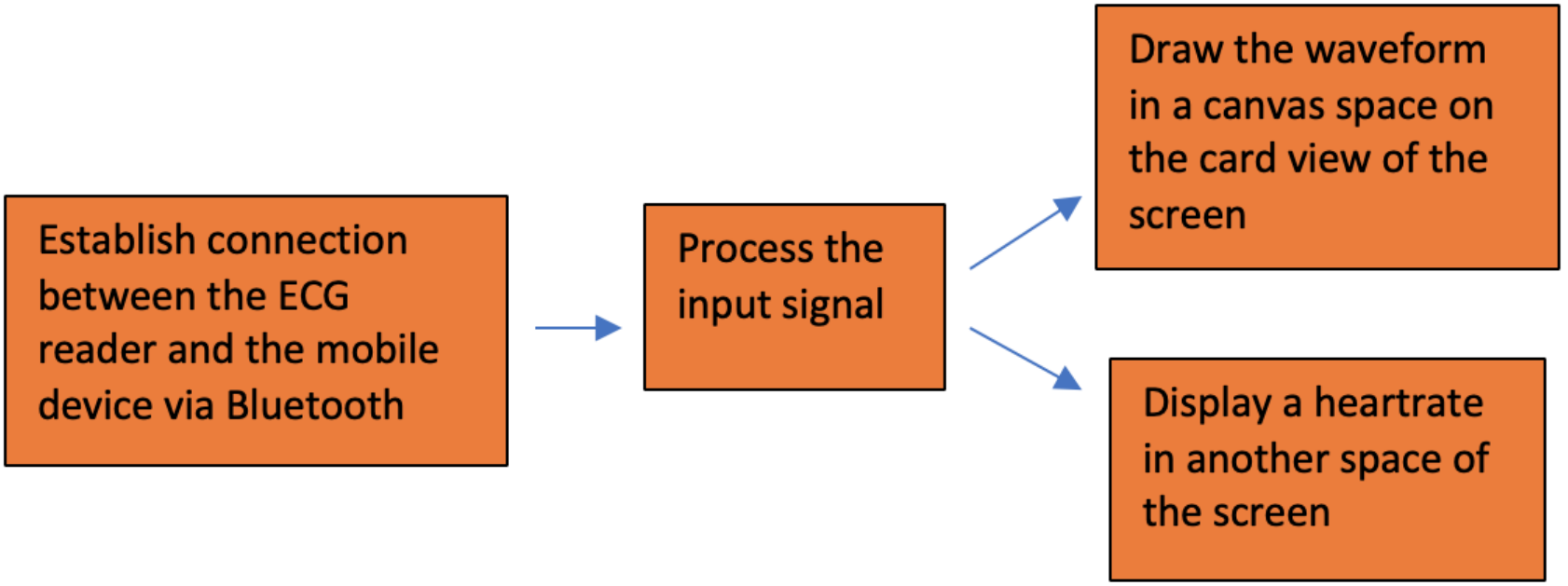
SOFTWARE

Design Decisions

- Using Mobile devices as our ECG displays
- We go with wireless connection

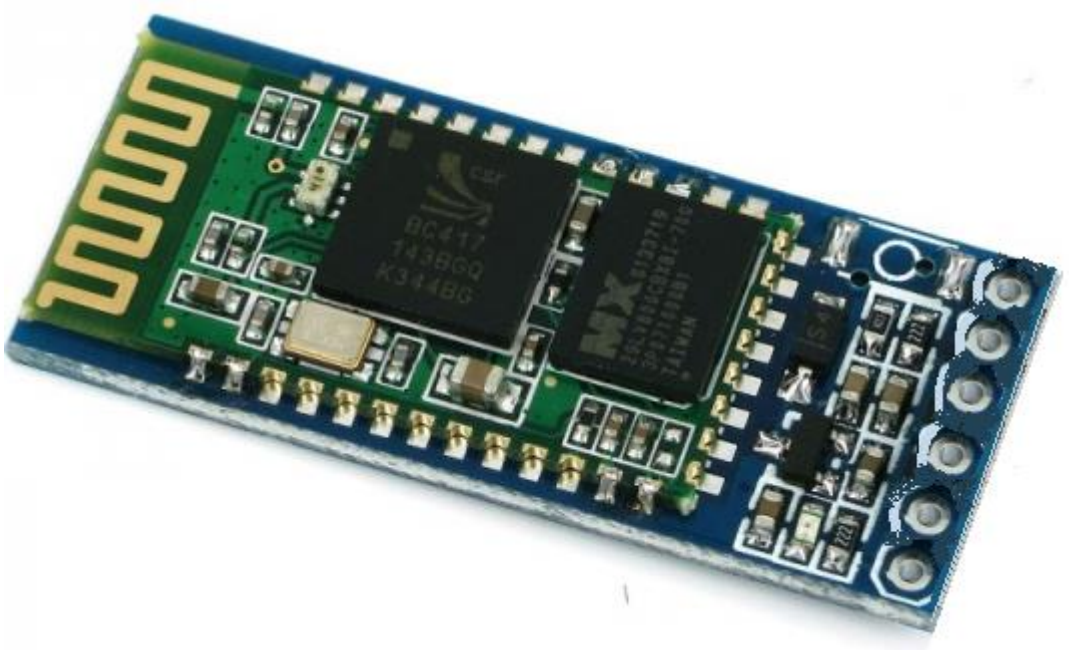
- The Simplicity philosophy of mobile App is fully applied for our App design.

Software Block Diagram

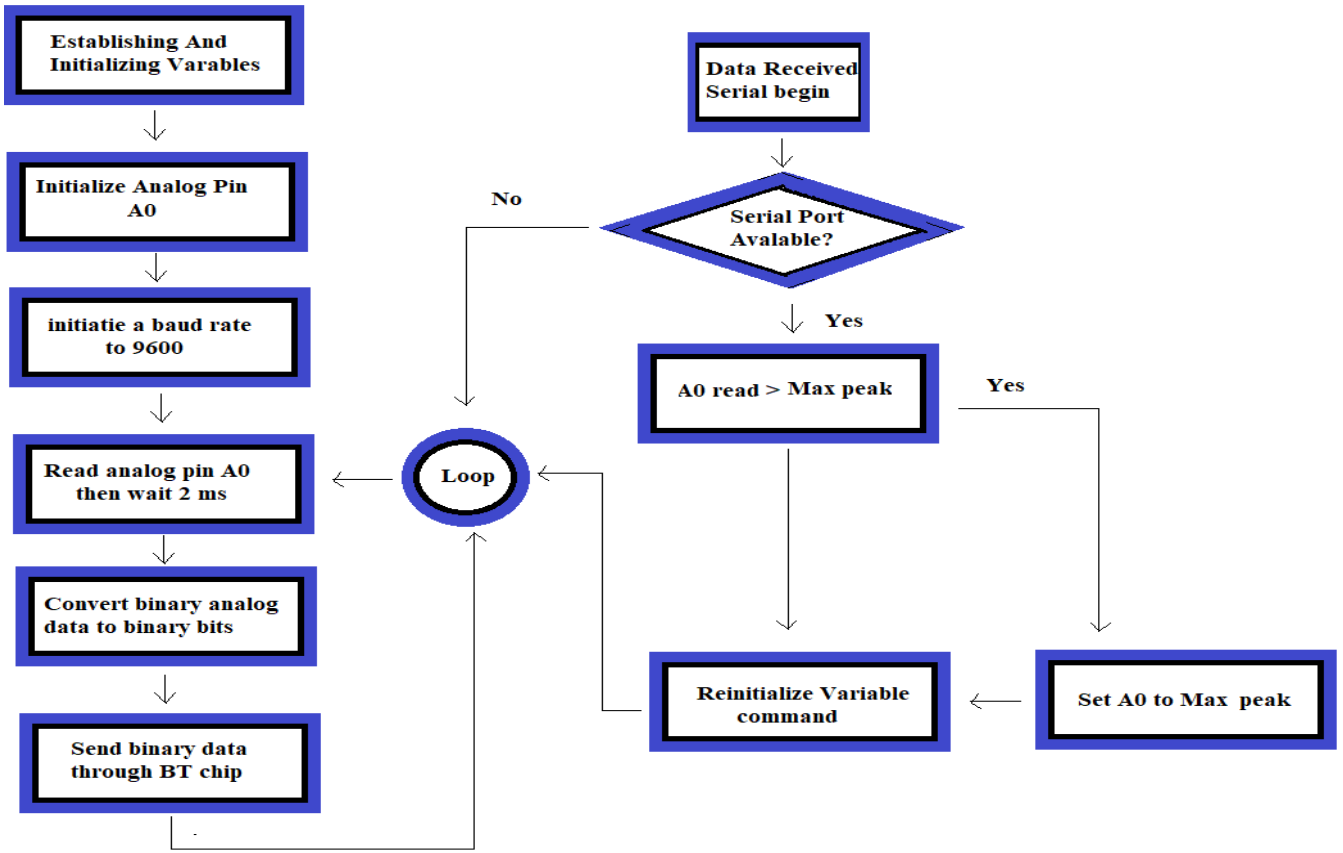


Bluetooth Interface

Hc-06

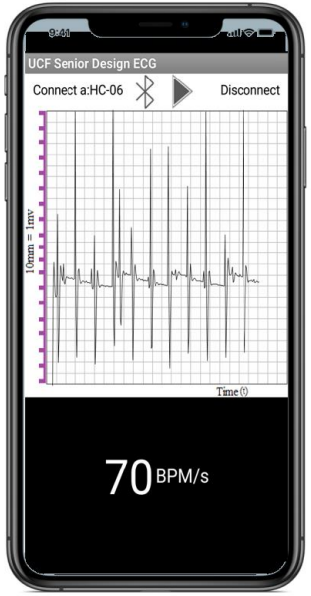


Interface Flow Chart



Android Application

- Using Android mobile devices as the ECG displays through Application



Waveform and Heart rate

- ECG waveform

- Heart Rate monitor

Final version of the Application

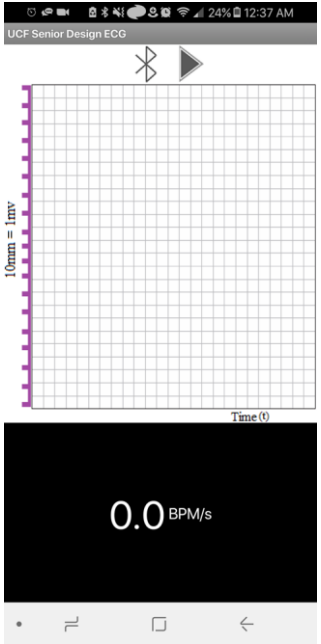
ECG waveform drawing

Grid to scale

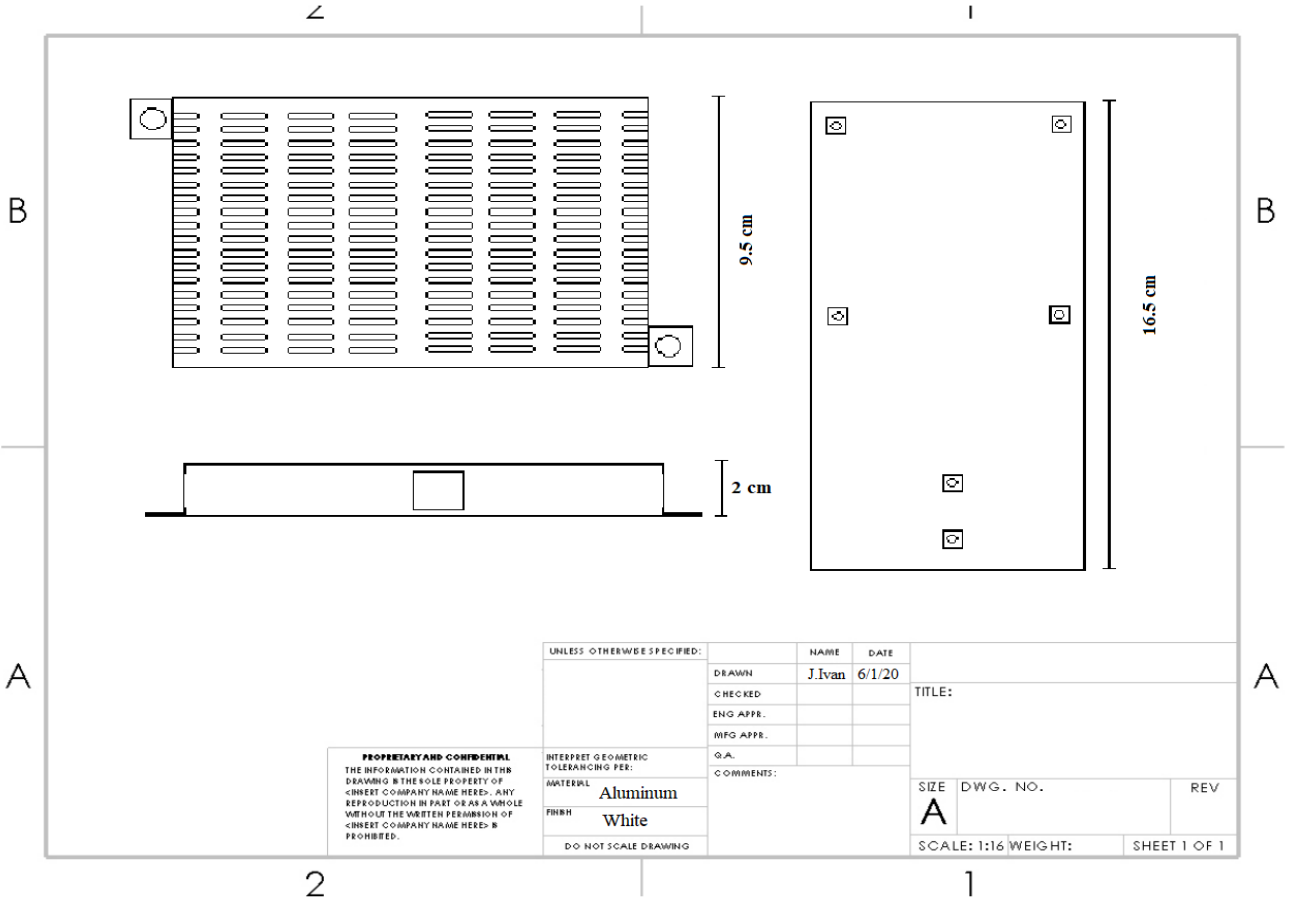
Beat per minute counter

Landscape and Portrait orientation

Bluetooth Connectivity

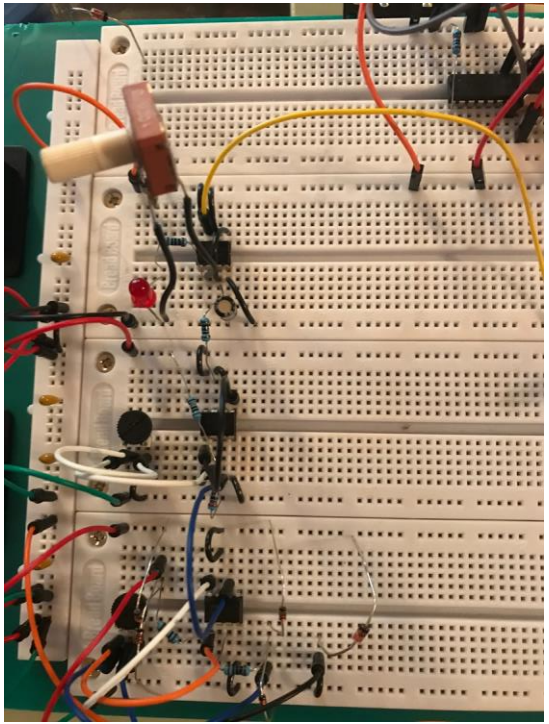


Enclosure

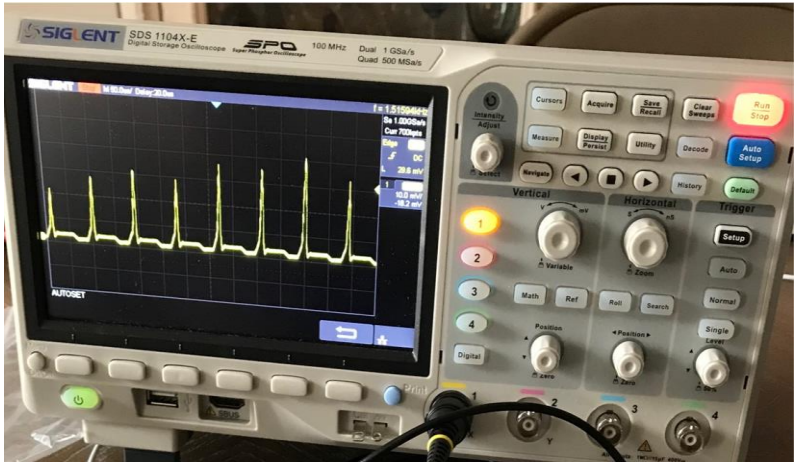

9.5 cm
16.5 cm
2 cm
UNLESS OTHERWISE SPECIFIED:
NAME
DATE
DRAWN
J.Ivan
6/1/20
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
Aluminum
FINISH
White
DO NOT SCALE DRAWING
SIZE
A
DWG. NO.
REV
SCALE: 1:16
WEIGHT:
SHEET 1 OF 1

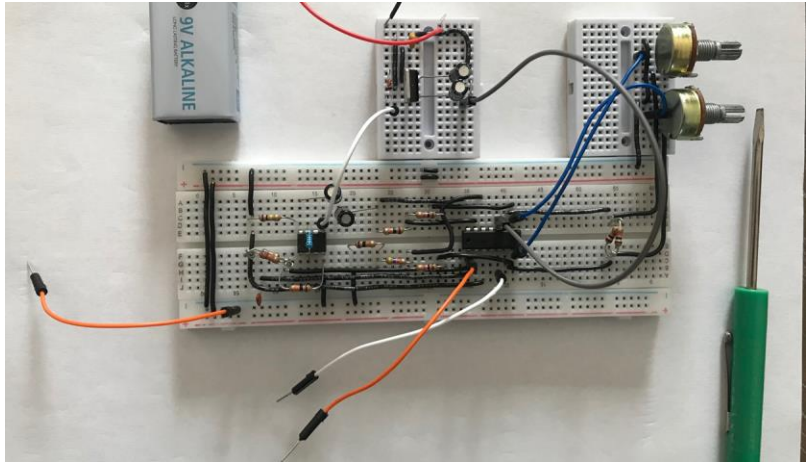
TESTING

Prototype Testing Hardware

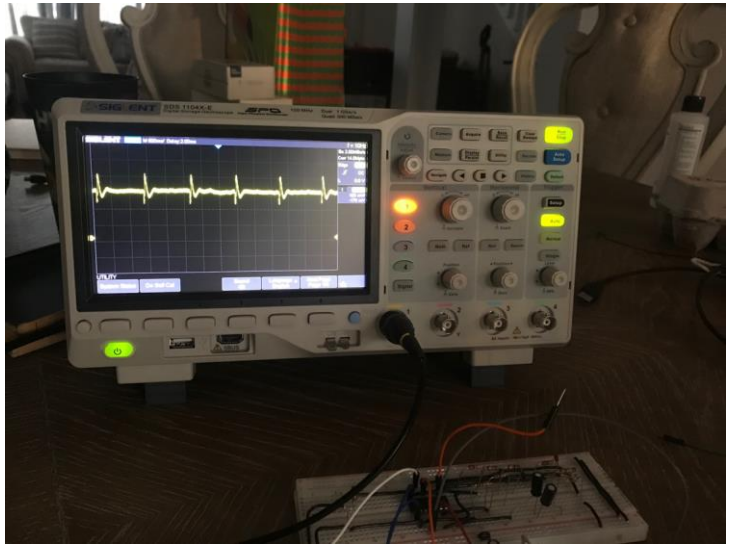


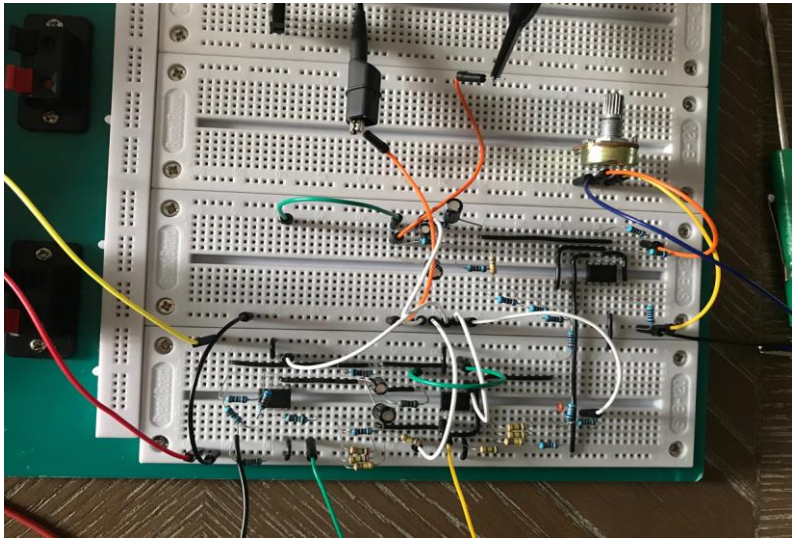
Prototype Testing Hardware





Final hardware testing





Final Testing

- Using new AFE prototype, tested the circuit on the oscilloscope
- Acquired new and updated PCB
- Soldered PCB and demoed final project

Software Testing

- Connection testing
- Signal integrity testing with function generator
- Final testing with our ECG signal

BUDGET

Product		Quantity	Unit Cost ($)	Total Cost
Electrodes		Pack of 50	13.85	13.85
ATmega328		2	6.94	13.98
HC06 Bluetooth	Bluetooth module	4	7.88	31.52
LM741	Op amp	5	0.87	4.35
Rocker Switch	Rocker Switch	2	1.40	2.80
AD620	Instrum Amp	2	11.26	11.26
LM358N	Op amp	6	0.84	5.04
1N4148	Diode	50	0.089	4.45
PCB	PCB	2	20.41	40.82
Jumpers	BB jumpers	1	6.98	6.98
Alligator Clips	Clips	1	9.35	9.35

Product		Quantity	Unit Cost ($)	Total Cost
22 AWG wire	wire	1	10.99	10.99
Stereo Jack	Stereo	2	2.10	4.20
1k	resistor	20	0.20	4.00
10k	resistor	20	0.20	4.00
10M	resistor	20	0.20	4.00
916	resistor	20	0.20	4.00
22k	resistor	20	0.20	4.00
33k	resistor	20	0.20	4.00
3.19M	resistor	20	0.20	4.00
200k	resistor	20	0.20	4.00
519k	resistor	20	0.20	4.00

Product		Quantity	Unit Cost ($)	Total Cost
Potentiometer	resistor	2	1.2	2.40
Crystal	Oscillator	2	2.31	4.62
Breadboard	breadboard	2	4.50	9.00
22pF	capacitor	5	0.33	1.65
10uF	capacitor	5	0.33	1.65
100uF	capacitor	5	0.33	1.65
47uF	capacitor	5	0.33	1.65
Batteries	9 volt	Pack of 4	13.98	13.98
Total				232.18

Resolved issues

Problem	Solution
1st AFE prototype was not outputting an accurate waveform	Built improved AFE prototype
Connecting front-end to back-end	Fixed bluetooth connection
Excess noise	Thorough tests/Ground plane

Possible improvements

- Heart arrhythmia detection
- Better noise reduction
- Expand the availability of our mobile application to more platforms. First goal would be porting the App to iOS.

Demonstration

Demo video link

Questions

Please, give us your questions during our review session at 5:00 PM on July 22nd

Thank you!