Emotional Intelligence Device

Design Review

ECE 445 Senior Design

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February 24 , 2015

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1. Introduction

1.1 Statement of Purpose

We live in a digital world where people can become lost in their devices, decreasing the daily amount of personable social interaction. As a result, their communication skills deteriorate; specifically, their ability to identify and express their own emotions in a constructive manner becomes more difficult. There are also people with medical disorders that are unable to identify emotions in their peers, such as people with autism.

We want to design a wearable device that will help people identify their emotions, give the option to display their emotions, and provide constructive suggestions to the users to help alleviate stressful social situations. Our device aims to help someone explore the root cause of their feelings as well as offer the ability to display his/hers broad emotional state to help others identify with him/her. We think this concept would allow people to effectively communicate their emotional state, leading to less conflict on a daily basis and a better quality of life for all involved.

1.2 Objective

1.2.1 Goals

a. Ability to identify emotions the user is experiencing
b. Helps the user communicate their emotions better
c. Allow the user to look at their emotional history to track the cause of their emotions
d. Give the user an option to display emotional state to other people

1.2.2 Functions

a. Process the audio received by the microphone and identify the tone that reflects emotion
b. Use biosensors to identify physiological signals
c. Classify emotions based upon spoken tone as well as physiological signals
d. Record and update average emotional state for a 24 hour period
e. Option of displaying their emotions or only showing it to the user himself/herself

1.2.3 Benefits

a. Help people quickly identify and manage their emotions
b. Increase effectiveness when communicating with other people
c. Decrease stress from social interactions with and for people that have medical disorders

1.2.4 Features

a. RGB LEDs for non-discrete display of emotional state
b. Button for discrete/non-discrete display selection
c. Rechargeable lithium ion polymer battery
d. Lithium-ion battery pack safety sensor and automated detach from user
e. OLED Display
f. Microphone with high quality sampler
g. Temperature sensor, heart rate sensor

2. Design

2.1 Block Diagrams

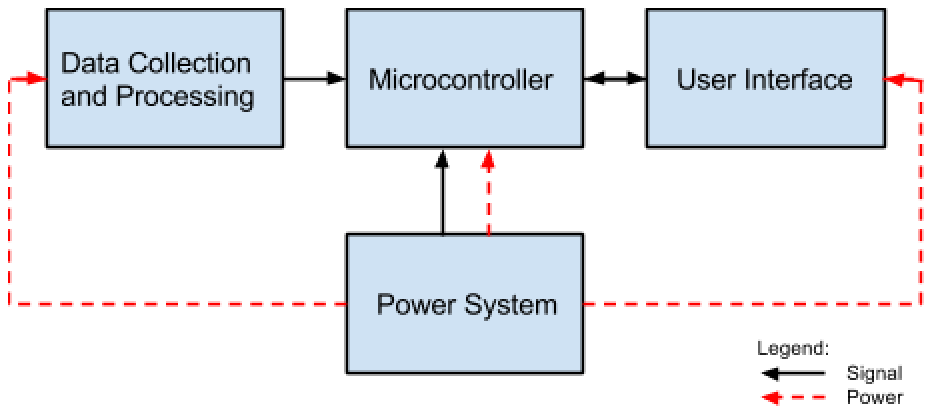


Figure 1. Top Level Block Diagram

2.1.1 Data Collection and Processing

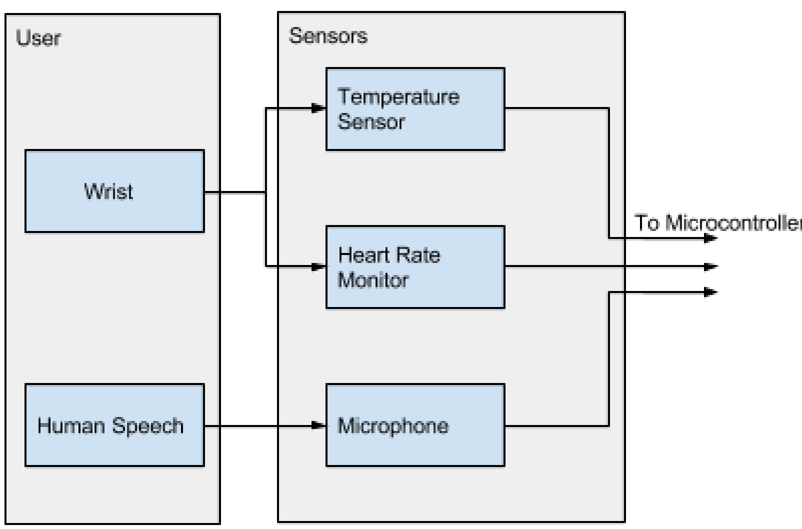


Figure 2. Data collection and Processing block diagram

2.1.2 User Interface

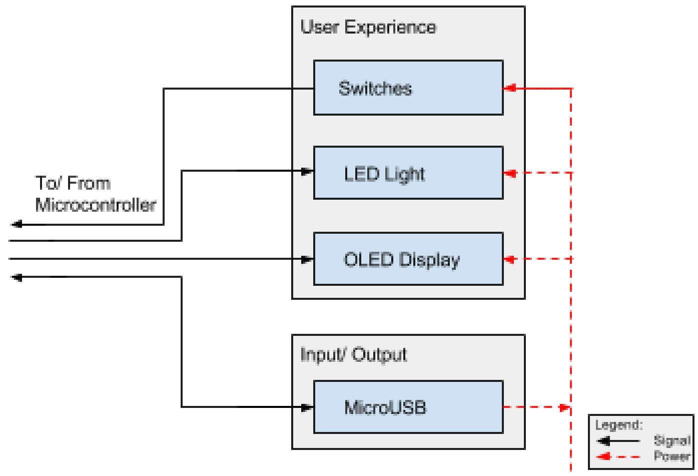


Figure 3. User Interface Block Diagram

2.1.3 Power System

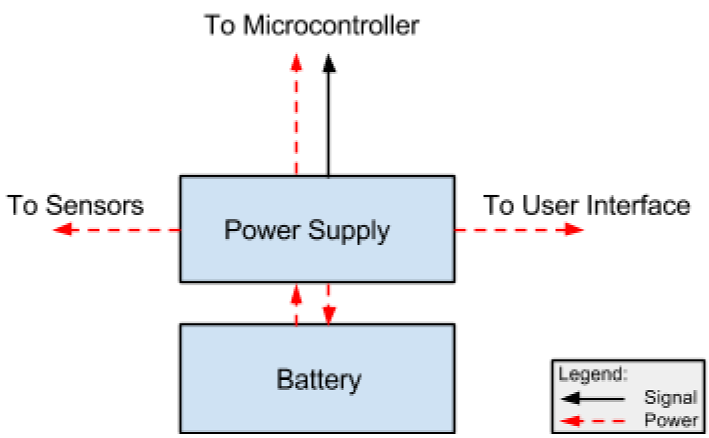


Figure 4. Power System Block Diagram

2.2 Block Descriptions

2.2.1 Data Collection and Processing Module

In order for the emotional state of the user to be measured, we choose to combine three methods of measuring the user's emotion and process that information with decision algorithms to arrive at the user's emotional state. The result is sent to the User I/O. The state of the overall machine is also monitored, such as battery power.

2.2.1.1 Temperature Sensor

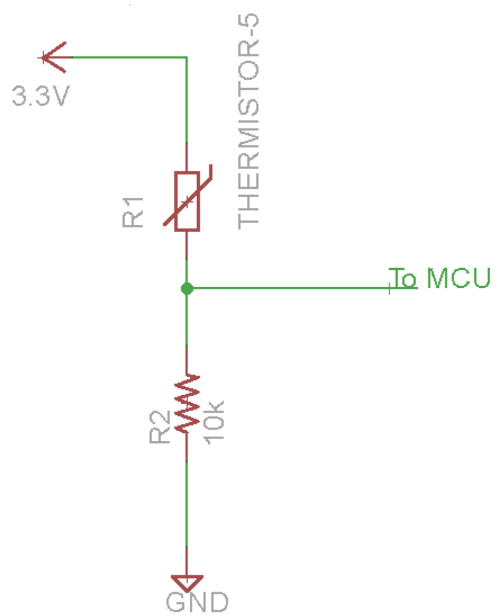
A thermistor will be used for temperature detection. The thermistor would need to have high accuracy since human skin surface temperature does not vary more than ±0.5°C due to emotions.
The temperature sensor block in the design consists of a skin contact sensor in the wristband and a separate temperature sensor thermally insulated from the heat of device that will measure the ambient temperature. This second sensor is required for false-positive determination when the ambient conditions will result in a raised temperature of the user. A sudden change of the measured skin temperature will raise a flag to the microcontroller as it might represent a change of emotional state. Both temperature sensors are digital. Power is received directly from the battery. The temperature sensor will be packaged such that the surface of the chip is making contact with the user.
The thermistor model picked is a US Sensor, Curve J thermistor. The thermistor will be connected to an ADC input on the microcontroller. The microcontroller will then compute the temperature detected based on the equation below:

$$V out = V in\left(\frac{R2}{R1+R2}\right)$$

$$V out = 3.3V\left(\frac{10k\Omega}{10k\Omega+R_{thermistor}}\right)$$

$$R_{thermistor} = \frac{3.3V*10k\Omega}{3.3V-V out} - 10k\Omega$$

$$T = \frac{B*T_N}{B+ln\left(\frac{R_T}{R_N}\right)*T_N}$$



2.2.1.2 Heart Rate Sensor

The heart rate sensor measures the user's beats per minute, this would be an important factor when the device tries to detect the person's emotion. The sensor package required a photodiode, Green LED and a 8MHz oscillator. The LED shines a light and the photodiode records the reflected light in mV. Operation of the BPM sensor will require an ADC as well as amplifiers before this signal is sent to the microcontroller.

In order to calculate the heart rate, the three beat average calculation will be made with microcontroller:

$$Heart\ rate\ per\ minute\ =\ \frac{sampling\ frequency * 60 * 3}{number\ of\ samples\ in\ 3\ beats}$$

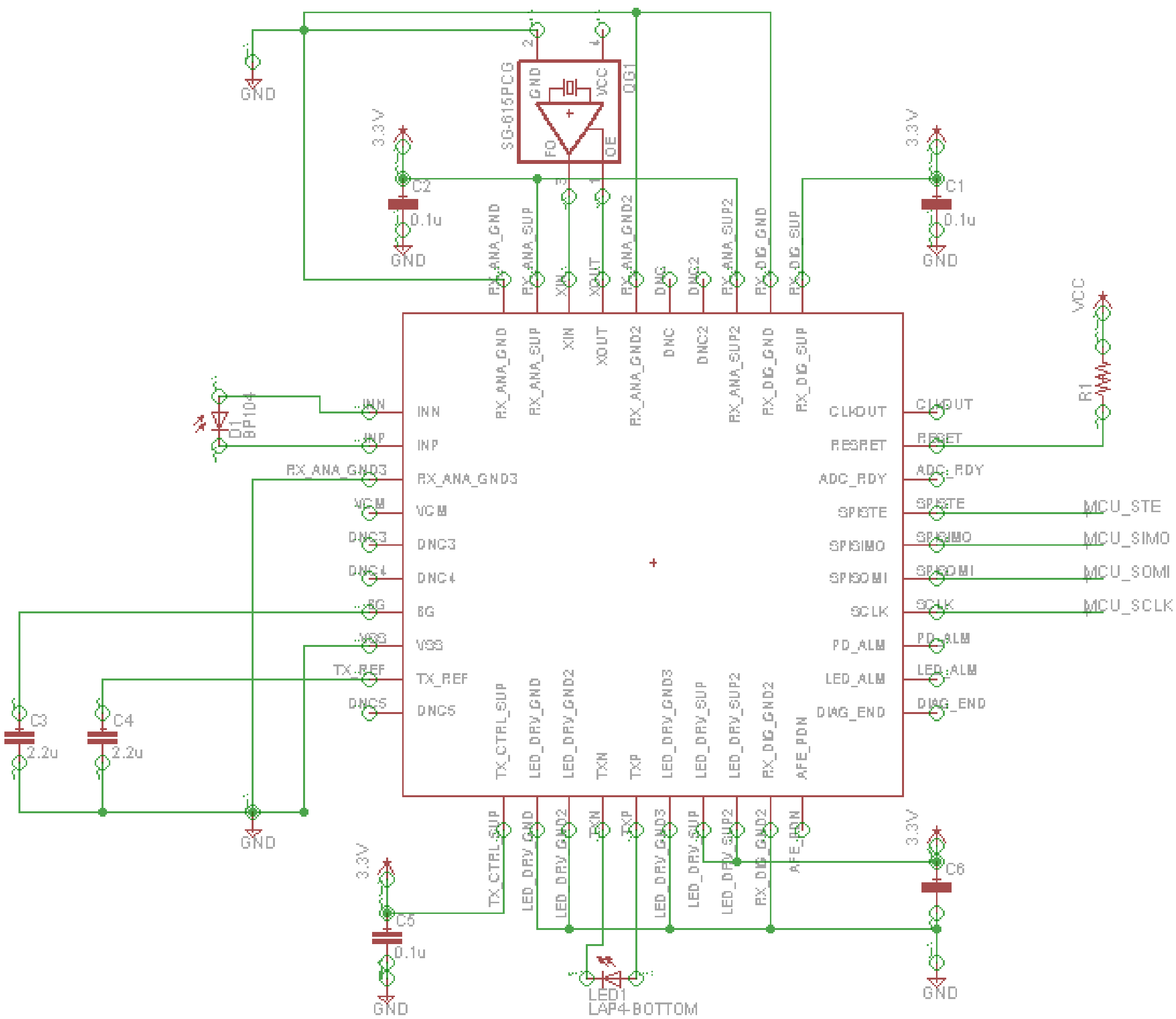


Figure 5. Schematic of analog front end chip

2.2.1.3 Microphone

The microphone's purpose is to record the user's speech volume and the pitch of the speech, these are parameters that can reflect a person's emotion. Therefore, the microphone needs to cover the human speech frequencies from 80 Hz to approximately 300 Hz. The microphone that has small circuit area and low power consumption as well as a good SNR is the InvenSense ICS-40300 MEMS microphone. The output characteristics are listed in **Table X1** from its datasheet [1].

Table 1. Output for ICS-40300 Microphone

Output Impedance	200 Ω
Output DC Offset	0.8 V

1kHz 94 dB SPL Maximum	-43 dBV

From Table X1, the 94 dB SPL corresponds to the Vrms of speech spoken directly next to the microphone with respect to 1 Vrms. This value corresponds to a speech signal of approximately 20 mVpp at 1kHz. Given that the MCU's ADC converter uses 12 bits and assuming an amplitude of 2 Vpp for the ADC to record, the ADC's bitwise resolution is found using Equation 2.2.1.

$$\Delta V_{res} = \frac{V_{pp}}{2^n - 1} = \frac{2}{2^{12} - 1} \approx 0.5mV \quad (2.2.1)$$

Using 0.5 mV resolution, only 40 levels represent the highest possible amplitude speech signal. Out of the 12 bits for the ADC, only 6 would be used. It is clear an amplifier is required so that the speech signal can be better represented in the ADC. InverSense suggests a standard amplifier for this purpose, which is the non-inverting amplifier shown in **Figure 2.2.1** [1]. The V4 and V3 are reference voltages at 2.5 V, which is approximately the DC offset for the amplified signal. The first RC filter is a high-pass filter found using equation (2.2.2), assuming fc is the 3-dB cutoff frequency.

$$f_c = \frac{1}{2\pi RC} = \frac{1}{2\pi(47,000\Omega \pm 2350\Omega)((1 \pm 0.1)e - 6F)} = 3.4 \pm 0.5Hz \quad (2.2.2)$$

Therefore, with the high pass filter, the 0.8 V DC offset is rejected and all of the speech frequencies are passed to the OP-AMP. The selected OP AMP is the LM321, which is the single op-amp version of the LM324/NS chip. The gain for this OP-AMP is found using equation 2.2.3.

$$A_v = \frac{R_1 + R_2}{R_1} = \frac{(100 \pm 5k\Omega + 4700 \pm 235k\Omega)}{100 \pm 5k\Omega} = 48 \pm 5 \quad (2.2.3)$$

R2 in Figure 6 is the worst case approximation, where the speech signal may be clipped by the ADC. The output is then split into two signals, the Voltage reference signal going to the ADC12 and the actual output of the op-amp with a high pass filter. Vout. The Vout signal is the signal that goes into the ADC.

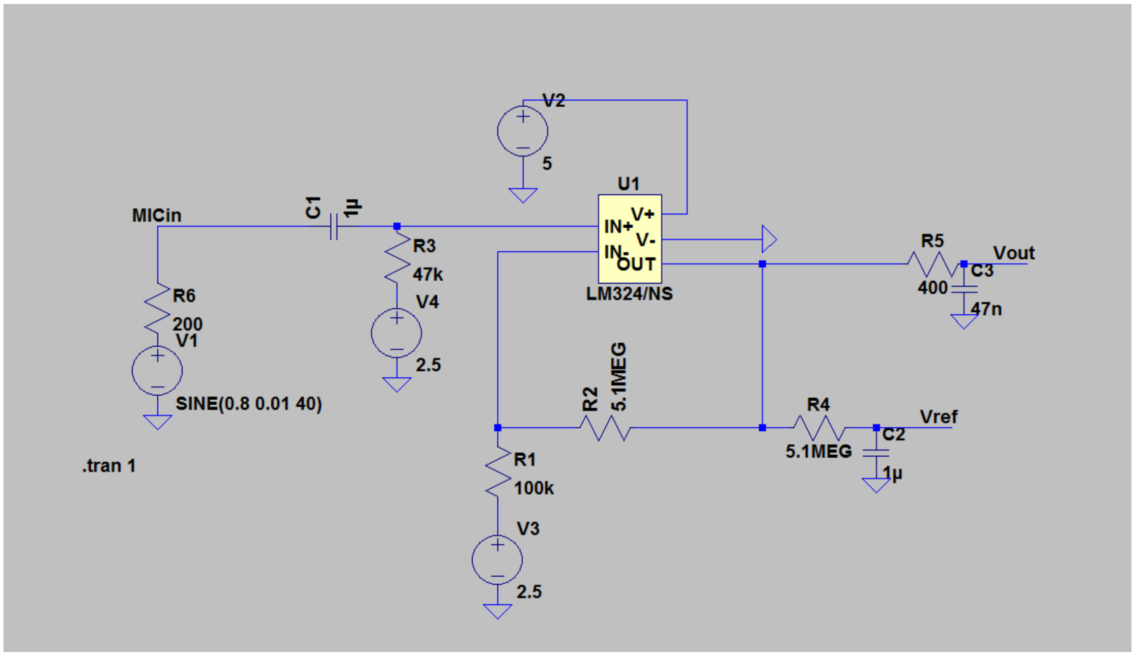
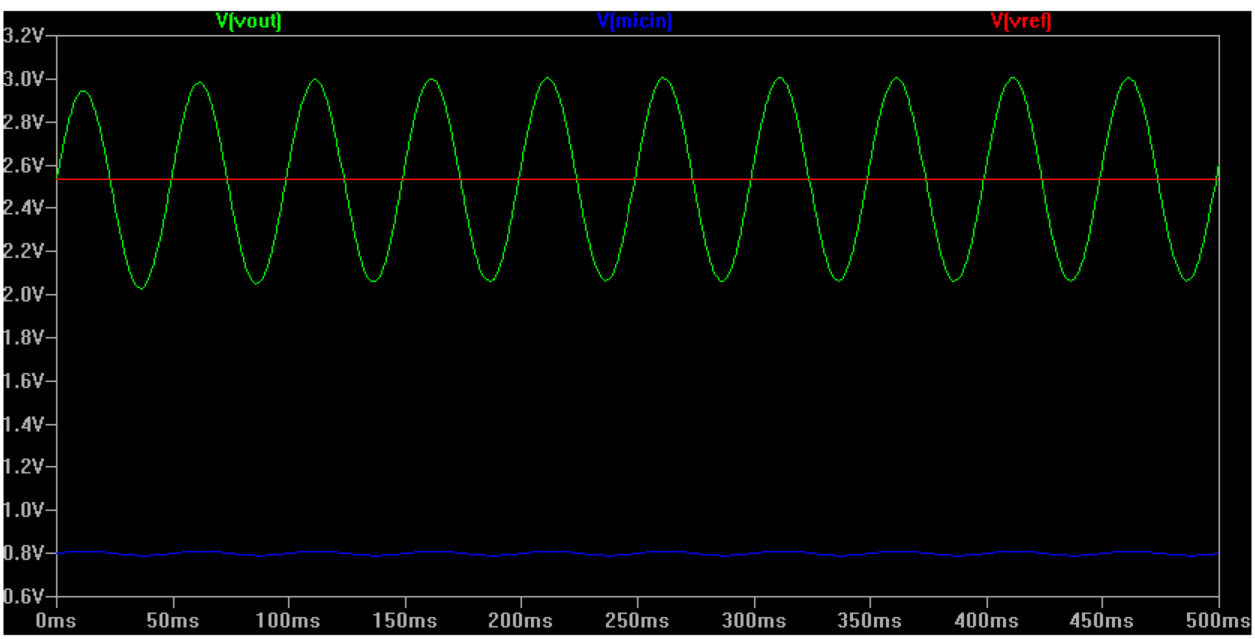
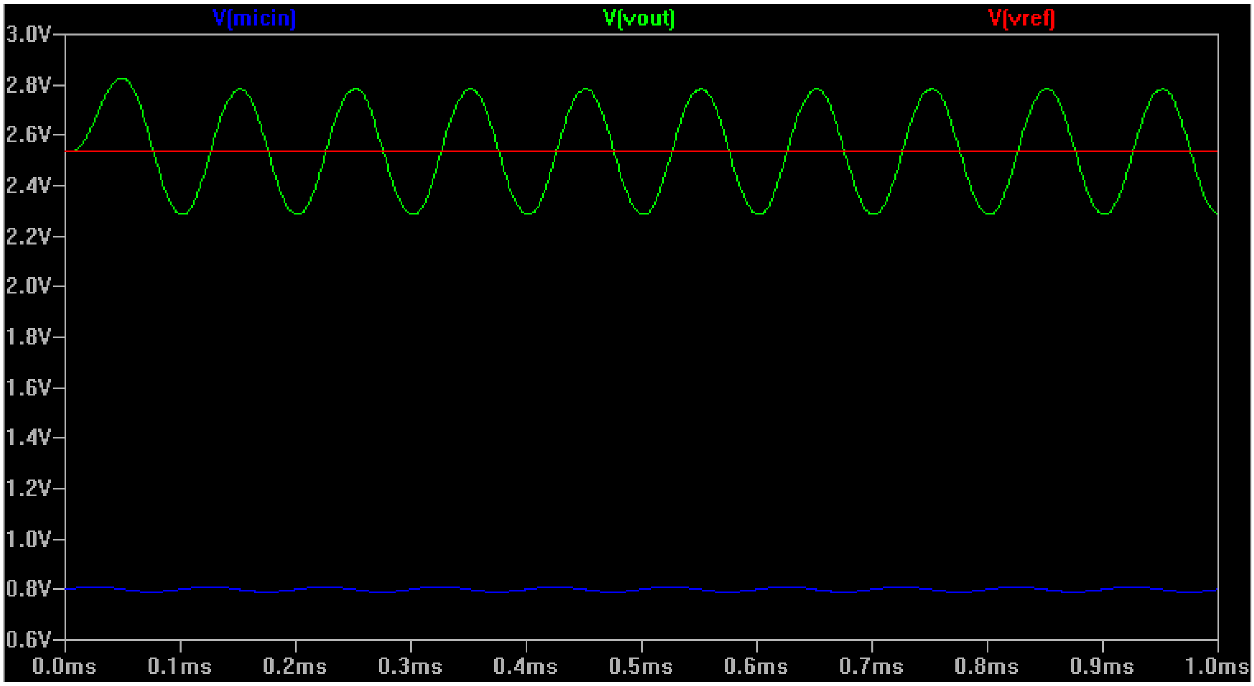


Figure 6. Non-inverting Amplifier for microphone.

The resulting simulation for 20 Hz input signal and 10kHz from the microphone with 0.8 V DC offset is shown in Figures 2.2.2(a) and 2.2.2(b), respectively.



(a)



(b)

Figure 7 Voltage signals from the microphone (blue), Audio signal to ADC12 (green), and Vref into the ADC12 (green) for (a) 20 Hz and (b) 10kHz.

From the above Figures, the approximate voltage offset is 2.5 V and the Vpp is 1 for the low frequency. The slight attenuation seen on the 10kHz frequency is due to the low pass filter with 400Ω impedance which feeds into the ADC analog input. The impedance is set low because the sampling rate is yet to be determined. We wanted to be flexible in this area because the higher resolution with quasi-static speech signals, the more accurate the speech analysis will be. The equation for minimum sampling time is given by the following equation, from TI's ADC12 datasheet [2]. The minimum sample time is given in Equation 2.2.4.

$$t_{sample} = ln(2^{n+1}) \times (R_s + R_l) \times (C_l) + 800ns \quad (2.2.4)$$

Where n is the number of bits for the ADC converter, which is 12 for the MSP430 we have selected, Rl and Cl is the equivalent resistance and capacitance of the port and Rs is the impedance of the input signal. The given values from [3], the MSP datasheet, are Rl = 1.8 kΩ and Cl = 20 pF. This gives us the following calculation shown in Equation 2.2.5 for the maximum sampling frequency.

$$f_s = \frac{1}{t_{sample}} = \frac{1}{ln(2^{12+1}) \times (400\Omega + 1800\Omega) \times (20e-15F) + 800ns} = 823kHz \quad (2.2.5)$$

A sampling frequency of 823kHz is unrealistic, but it is important to know that the design is not limited on the hardware end.

2.2.2 User I/O Block

User I/O Block allows the user to set privacy setting, view current battery power, charge the device, see the current emotional state via OLED display and/or colored LEDs, and allow the user to program preset messages to be displayed for certain emotional states. Microcontroller programming capability for the designer.

2.2.2.1 OLED Display

OLED display will display the emotional state as well as any preset user messages in the form of scrolling text for the specific emotional setting. It will also display the current power percentage of the battery pack, which is sent from the microcontroller. Ideally, the light-up signal will come from the microcontroller as a result of a button press from the user or when a new emotional state has been identified.

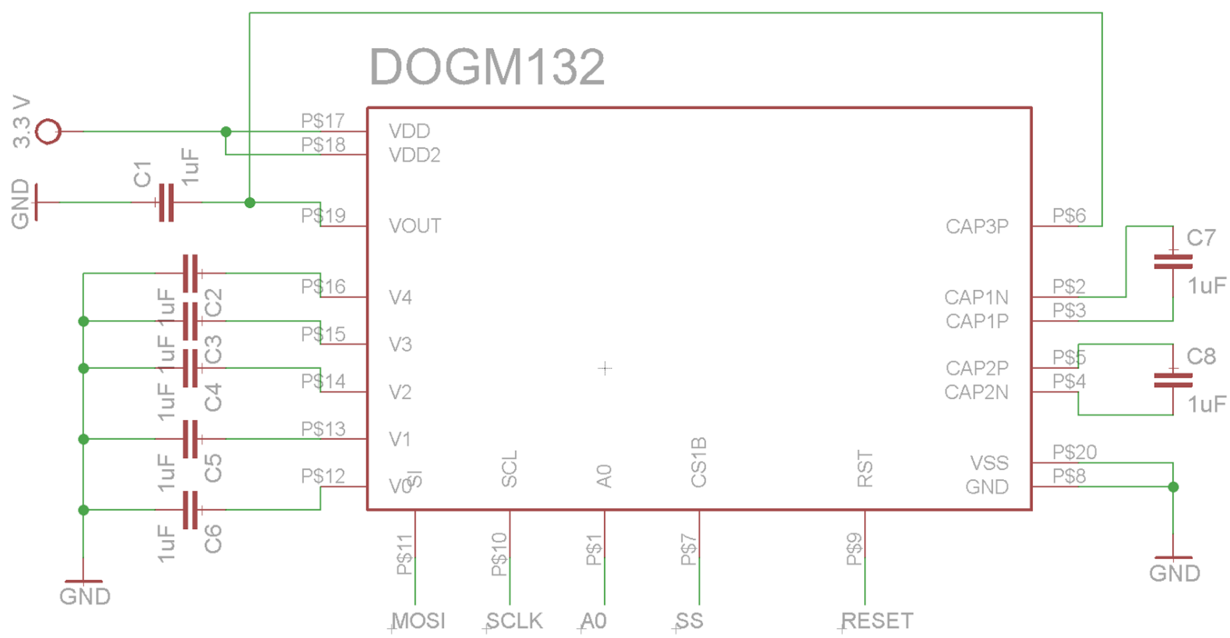


Figure 8. OLED Display Schematic

The OLED display communicates with our microcontroller through the Serial Peripheral Interface (SPI) bus located in the General Purpose I/O (GPIO) ports on our microcontroller. Since we are only writing to the display, we use the Master Out Slave In (MOSI) pin, system clock (SCLK) pin, and chip select (SS) pin to send commands to the display. To output a message on the display, we also attach an additional pin from our GPIO ports to the A0 pin on the display. This allows us to tell the display when to output a message and when to perform a command.
The list of available commands we will use is shown below:

Command	Command Code									Function
	A0	D7	D6	D5	D4	D3	D2	D1	D0	
(1) Display ON/OFF	0	1	0	1	0	1	1	1	0 1	LCD display ON/OFF 0: OFF, 1: ON
(2) Display start line set	0	0	1	Display start address						Sets the display RAM display start line address
(3) Page address set	0	1	0	1	1	Page address				Sets the display RAM page address
(4) Column address set upper bit Column address set lower bit	0	0 0	0 0	0 0	1 0	Most significant column address Least significant column address				Sets the most significant 4 bits of the display RAM column address. Sets the least significant 4 bits of the display RAM column address.
(6) Display data write	1	Write data								Writes to the display RAM
(8) ADC select	0	1	0	1	0	0	0	0	0 1	Sets the display RAM address SEG output correspondence 0: normal, 1: reverse
(9) Display normal/ reverse	0	1	0	1	0	0	1	1	0 1	Sets the LCD display normal/ reverse 0: normal, 1: reverse
(10) Display all points ON/OFF	0	1	0	1	0	0	1	0	0 1	Display all points 0: normal display 1: all points ON
(11) LCD bias set	0	1	0	1	0	0	0	1	0 1	Sets the LCD drive voltage bias ratio 0: 1/9 bias, 1: 1/7 bias (ST7565R)
(14) Reset	0	1	1	1	0	0	0	1	0	Internal reset
(15) Common output mode select	0	1	1	0	0	0 1	*	*	*	Select COM output scan direction 0: normal direction 1: reverse direction
(16) Power control set	0	0	0	1	0	1	Operating mode			Select internal power supply operating mode
(17) V_0 voltage regulator internal resistor ratio set	0	0	0	1	0	0	Resistor ratio			Select internal resistor ratio(Rb/Ra) mode
(18) Electronic volume mode set Electronic volume register set	0	1 0	0 0	0 Electronic volume value	0	0	0	0	1	Set the V_0 output voltage electronic volume register
(19) Static indicator ON/OFF Static indicator register set	0	1 0	0 0	1 0	0 0	1 0	1 0	0 0	0 1 Mode	0: OFF, 1: ON Set the flashing mode
(20) Booster ratio set	0	1 0	1 0	1 0	1 0	1 0	0 0	0 step-up value	0	select booster ratio 00: 2x,3x,4x 01: 5x 11: 6x
(21) Power save	0									Display OFF and display all points ON compound command
(22) NOP	0	1	1	1	0	0	0	1	1	Command for non-operation

Table 2. Table of Programmable Commands (DOGM Graphic Series Datasheet, p. 5)

2.2.2.2 LED Lights

The design will include red, green and blue LED lights display, which allow the user to display their emotional state to their peers. Different colors of each LED will determine the color projected onto the user's skin around the watch. This is controlled directly by the microcontroller and indirectly by the privacy setting switch which is part of the switches block.

Due to the current rating of the microcontroller, the LEDs cannot be directly connected to the I/O pins. In order to operate the LEDs under full brightness, a npn transistor circuit will be used.

Using the following equations and the specifications of the particular LEDs we chose, we can calculate the resistor rating we use in the transistor circuit.

$$Rb = \frac{(Vcc - 0.3) - Vbe}{Ib}$$

$$Ra = \frac{Vcc - Vf - Vcesat}{If},$$

whereas Vf = LED Voltage drop, If = LED current requirement

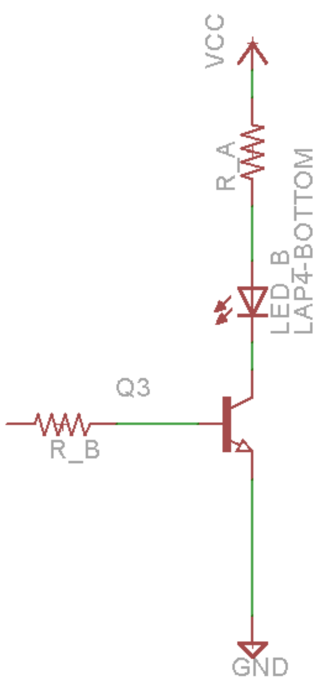


Figure 9. Circuit schematic connecting LED to Microcontroller

2.2.2.3 Switches

There are two active user inputs during normal operation of this device. The first is a slider switch that determines privacy. When this slider is turned on, the LEDs will not turn on to display their emotion to their peers; only the display will show their emotion. This signal is sent to the microcontroller.

The second user input will turn on the display during the whole duration the button is pressed and will continue to show the display for 10 seconds after the button is de-pressed. This signal is also sent to the microcontroller.

The last switch is the on/off switch. The switch will need to be held for a second or more to power off and on.

2.2.2.4 MicroUSB

The Micro USB port has two functions; power for recharging the battery and data transfer to the MCU for programming the MCU. The power line from the Micro USB is routed to the battery through the power supply circuit, which regulates the charge current and voltage. The other function allows us to program the Micro USB to perform all of the functions necessary to detect and display emotion.

MicroUSB was chosen as the port due to the small dimensions and the current prevalence of Micro-USB to USB cords for modern smart phones.

2.2.3 Power System

The power system serves the function of providing voltage and current to all components as well as regulating the charging behavior of the lithium-ion-polymer battery. The power will not be directed from the MCU to all components, but directly from the power system.

2.2.3.1 Battery

The two most important criteria for selecting a batter come down to high energy density and very small volume. The type of batteries with this characteristic are the lithium-ion polymer batteries. They have serious safety concerns, though, and will require their own voltage and charge regulator for charging. We will also consider some mechanical safety device for the user should the battery malfunction unpredictably. The power requirements for the components in the design are listed in **Table 3.**

Table 3. Power Requirements

Component	Operating Voltage Range	Maximum Current
LEDs	3.3 V	30 mA
AFE Rx	3-5.25 V	25 mA
AFE Tx	2-3.6 V	670 µA
Microphone	1.5-3.63 V	220 µA

Temperature Sensor	3.3V	650 µA
LM321MF	3.0 V - 32 V	430 µA @ 3.3 V
OLED	2.4 V or 3.3 V	5 mA with backlight, 140 µA standard
MSP430F MCU	1.8 V to 3.6 V	1.84 mA @ 8 MHz
Total mA@ 3.3 V		63.81

There are available single cell Lithium-Ion polymer batteries with approximately 700 mAhr. This would give us, assuming 90% efficiency of the buck converter, approximately 10 hours of operation operating at max power.

2.2.3.2 Power Supply

The power supply will regulate the voltage and current draw during charging as well as the current and power delivered to every component. Each LiPo cell is slightly different and the power supply will have to be designed or some off-the shelf power supply for the specific power cell. Safety is the highest concern with the power system, and this part will have to be extensively tested to ensure safe operation.

2.2.4 Microcontroller

Microcontroller accepts the information from the sensors, I/O blocks, and battery pack. It will convert the analog voice signal to a digital signal and process/interpret the other signals with a decision algorithm to determine the emotional state of the user. In order to conserve power and to avoid constant flip-flops of emotional states due to minor fluctuations, we will analyze the user's emotional state only once every minute or so. The frequency of emotional measurement will be a design decision.

Based upon the I/O block input, it will determine whether to use the OLED display and LEDs for emotional state or simply use the OLED display. It will also display the battery power whenever the user activates the OLED display. The microcontroller program and data dump will occur through the I/O block with a micro-USB port. Power to the components will not be directly provided by the microcontroller.

The microcontroller is constrained firstly by power consumption, then area and processing power. It is marginally constrained by memory, but that may change with implementation of the algorithm.

2.3 Emotion Classification

2.3.1 Speech Processing

The data recorded from the microphone is used to help classify what emotion the speaker is feeling. Features extracted from the speech data include pitch, pulses, voicing, jitter, harmonicity, and Mel-frequency cepstral coefficients. These coefficients most accurately describe the speech data in the human hearing range, and a combination of these coefficients make up the set of features used in our emotion classification algorithm.

For classification, we will use multi-class support vector machines. Mordkovich et al[3] achieved approximately 60% accuracy using support vector machines to classify 14 distinct emotions, but when they grouped the emotions into a two dimensional space, the accuracy increased up to 86.9%. The emotion grouping is shown below.

	Low Valence	Neutral Valence	High Valence
High Arousal	hot anger, panic, anxiety		elation
Neutral Arousal	disgust, sadness, contempt, cold anger, shame		pride, interest, happy
Low Arousal	despair	boredom	

Table 4. Emotion Classification by Arousal/Valence[3]

Since emotions can be split into arousal and valence levels, this grouping allows us to determine between six clusters of emotions. Arousal determines the state of excitedness, and varies between calming to agitating. Valence determines how positive the emotion is, and ranges from negative emotions such as sadness and anger to positive emotions such as interest and happiness.

Currently, only the acoustic features of the speech will be used for classification, but further research will be done into word processing too and it's effect on emotion.

2.3.2 Biosensor Emotion Classification

We use two biosensor readings to help classify emotions, the blood volume pulse sensor to detect heart rate, and skin temperature to detect autonomic nervous system activity. The features extracted from this include six parameters, mean of the raw signals, standard deviation of raw signals, mean of absolute value of the first differences of the raw signals, mean of the absolute values of the first differences of normalized signals, the mean of the absolute values of the second differences of the raw signals, and the mean of the absolute values of the second differences of the normalized signals [4].

Once the features are extracted, we will pass the feature vectors into a support vector machine, which will separate the different classes of features by hyperplane. A test feature vector is then classified by which side of the hyperplane it is on.

3. Requirements and Verification

3.1 Requirements and Verification

Module	Requirements	Verification	Points (/100)
Power Supply	a. Charge battery to 4.2 V ± 1% with maximum charge current of 500 mA b. Power the device for at least 5 hours i. Deliver a load of 65±2 mA at 3.3V for 5 minutes ii. Battery Temperature must not exceed 50 C at load of 65±2 mA at 3.3 V after 5 minutes. iii. c. Supply 3.3V with ripple of +/- 0.25V	a. Use multimeter to measure voltage difference across battery while charging. Measure charge current with separate multimeter. When fully charged, record voltage across battery. b. The voltage will be measured across the battery during discharge (i). The resulting voltage curve will be extrapolated to a voltage curve of the battery from its datasheet. From the extrapolation, we will approximate the total battery life at maximum load. i. Set 10, 510 Ohm resistors in parallel and apply the 3.3 V power to the resistors from powersupply. Measure current and voltage across batteries for 5 minutes. ii. While (i) is happening, measure and record the temperature in the battery with the thermal resistor in the power supply. c. Use multimeter oscilloscope to measure the voltage across the buck converter output as the display is turned on and microprocessor set to maximum power consumption. Compare the ripple and DC offset of the buck converter.	10
Microcontroller	a. Print Text onto OLED display b. Correctly determines user emotion with an accuracy of 70% i. Finish all computation and determine an emotion	a. Input strings of characters to microcontroller and test it's ability to correctly display character on OLED b. Test and record functionality of all individual components before and after	30

	c. Correctly choose suggestion words to display onto OLED depending on the detected emotion d. Maximum microcontroller temperature will not exceed 60℃ when operating at 8 MHz	connecting to the microcontroller c. Given clear tones of voice (for example, angry, sad, happy), send the correct emotion to the PC through the microUSB d. Program test cases into the Microcontroller with every possible emotion, then analyze the suggested words and determine relevancy e. Use an external temperature sensor to measure the temperature of the microcontroller when in use, compare that to the internal temperature	
Temperature Sensor	a. Determine temperature of skin with an accuracy error $< \pm 0.5C$ b. Determine temperature of skin with a precision error of $< \pm 0.5C$	a. Using an external temperature sensor, compare temperature readings and the difference is less than $\pm 0.5C$	5
Heart Rate Sensor	a. Determine the heart rate (Beats per minute) of user with an accuracy of 95%	a. Compare heart rate from sensor with an external heart rate monitor and calculate percentage error of our HRM	12
Microphone/ Audio	a. Able to record sound from 1 meter distance and filter out noise b. Waveform DC offset is 2.5V ± 0.2 V from a 0.8 V offset sinewave into amplifier stage. i. Microphone output to amplifier stage must be 0.8±0.05 V ii. Amplitude gain for amplifier must be 50±5 V/V for a frequency sweep from 20 Hz to 10kHz	a. Hold watch 1 m from mouth and speak in a regular tone. The microcontroller will be programmed to light up the LEDs if the amplitude recorded by the ADC is > 0.3 Vrms b. Use signal generator to create a 25 mVrms sinewave w/ 0.8 V offset and frequency sweep from 0 Hz to 10 kHz. Input that into the amplifier stage and record the output. Check the output offset. i. Record the microphone output for a 80 dB noise with frequency between 20 Hz and 22 kHz. ii. From b check the gain as the signal generator's frequency is swept to 10 kHz from 20 Hz.	25
Display	a. OLED display words that are preloaded onto the microcontroller b. LED light display will be on or off depending on a signal from the Microcontroller	a. Program the display to show characters on every possible location of the display b. Send on and off commands to the LED to check if it turns on and off	13

Switches	a. Check to make sure ON states correspond to active high and OFF states correspond to active low b. Switch should be debounced and only register one input per press	a. Connect multimeter and oscilloscope across switch and record the voltage across switch at changing states b. Connect oscilloscope across the switch and graph the voltage level during button press. There should be only one voltage spike when the button is pressed.	5

3.2 Tolerance Analysis

The most important aspect of the device is to consume the lowest amount of power possible during operation. The microprocessor's power can be minimized with a combination of low power settings and by setting the input voltage to 2.2 V DC. It's operating range is from 1.8 V to 3.6 V. Since the standard lithium-ion-polymer battery cell is between 3.7-4.1 V, a basic buck converter is needed to down convert the voltage and to illustrate the tolerance analysis, shown in Figure 10. Equations (3.2.1) and (3.2.2) are then derived from the model shown in Figure 10.

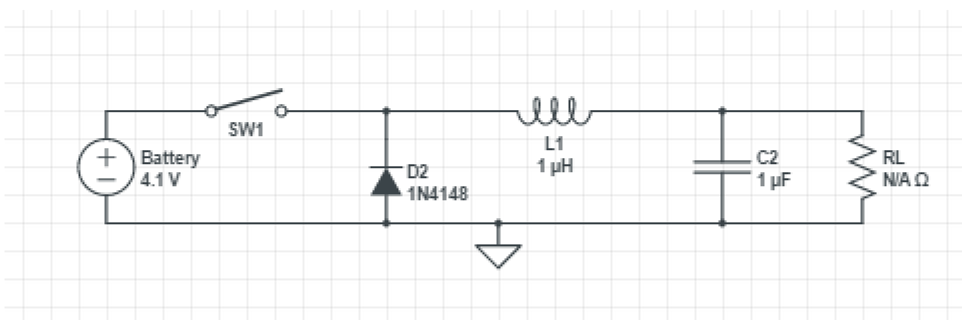


Figure 10. Basic Buck DC-DC Down Converter

$$L = (V_{IN_{MAX}} - V_{out})(\frac{V_{out}}{V_{IN_{MAX}}})(\frac{1}{f_{sw}})(\frac{1}{LIR * I_{OUT_{MAX}}}) \quad (3.2.1)$$

$$C = \frac{L(I_{OUT_{MAX}} + \frac{LIR*I_{OUT_{MAX}}}{2})^2}{(\Delta V + V_{OUT})^2 - V_{OUT}^2} \quad (3.2.2)$$

In equations 1 and 2, fsw is the minimum frequency switch which would be regulated by the user's power switch. That is approximately 1 Hz. The LIR is the current ripple to Ioutmax ratio. ΔV represents the maximum overshoot voltage. Since we are performing this analysis with a desired +/- 10% error in Vout, we will also set the overshoot voltage to 0.2 V. Note that the maximum desired error and overshoot voltage are both less than 3.6 V. Using this analysis, a 10% error in Vout will result from a 3% error in the inductor and a corresponding 20% error in the capacitor. Therefore, the device that requires the best tolerancing is the inductor.

3.3 Ethical Issues

All members in the team are aware of the IEEE Code of Ethics. Our device is designed to help people with social disability express their emotions.

1. to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;

- We will ensure that the power supply from the lithium polymer battery is connected safely and in addition we will monitor the temperature and shut down the device if the temperature of the battery is over 50 C.

3. to be honest and realistic in stating claims or estimates based on available data;

- We will calculate the battery life of the device and report the battery life in the specifications as measured
- We will test the device on different users and determine the percentage of accuracy our device is. We will not exaggerate the accuracy of the system in our final report.

5. to improve the understanding of technology; its appropriate application, and potential consequences;

- This product helps us understand how our body react and changes with our changing emotion. We see a lot of potential future development in this product and growth by adding different combinations biosensors and having more advance audio processing technology.

6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;

- We are continuously seeking more in depth knowledge in the areas of engineering covered in this project. Research notes will be taken throughout the process.

7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;

- Through design review and TA meeting sessions, we take advice from our peer and mentors to improve the design of our system, and we will credit their contributions

9. to avoid injuring others, their property, reputation, or employment by false or malicious action;

- We will design a good algorithm for determining the user emotion, and if the detected result has a high percentage of uncertainty, it will inform the user. We will also state the limitations of the product for

10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

- We peer review other project teams, and support them to follow the IEEE codes of ethics

3.4 Safety

3.4.1 Team member Safety

All members of the team will have to complete lab safety training before engaging with any lab work. For electrical safety, members will have to be aware of power ratings of all components while working them them.

3.4.2. User Safety

Since our product is a wristband, the hardware will always be very close to the user. The packaging of the products will have to be well insulated, ensuring that the user is not making any direct contact with the circuit.
The lithium polymer battery is our main safety concern. Therefore, additional protection circuit will be designed such that it cuts off the battery circuit when needed.

4. Cost and Schedule

4.1 Cost

4.1.1 Parts

Item	Part Number	Quantity	Unit Price ($)	Total Cost ($)
Temperature Sensor	TMP112	2	3.19	6.38
Heart Rate Monitor Analog Front-End	AFE4400	1	8.42	8.42
Green LED	APL3015MGC	1	0.58	0.58
Photodetector (photodiode)	QSB34CGR	1	1.05	1.05
Oscillator	CSM-7X ECS-80-18-5PX-TR	1	0.21	0.21
Diode Clamp	BAV99W-7	2	0.17	0.34
Microprocessor	MSP430G3	1	0.80	0.80
Right Angle LED (Red, Green, Blue)	HSMS-C680 (R) HSMM-C110 (G) HSMN-C110 (B)	3	0.25	0.75

NPN Transistor	DSC2A01T0L	1	0.06	0.06
Microphone	InvenSense ICS-40300	1	3.50	3.50
OPAmp	LM321	1	0.24	0.24
OLED Display	EA DOGM132	1	17.04	17.04
Resistors and Capacitors	-	20	0.10	2.00
Button/ Switch	JSX08001SAQNL	1	0.54	0.54
Lithium-Ion Polymer Battery	3.7V, some mAh	1	14.75	14.75
IC Charging Controller	MAX1555	1	1.95	1.95
Total				**55.57**

4.1.2 Labor

Name	Hourly Rate	Total Hours (hr)	Total ($) = 2.5*(Hourly Rate)*(Hours)
Jonathan Fouk	30	150	11,250
Matthew Palmer	30	150	11,250
Vivian Tseng	30	150	11,250
Total			**33,750**

4.1.3 Grand Total

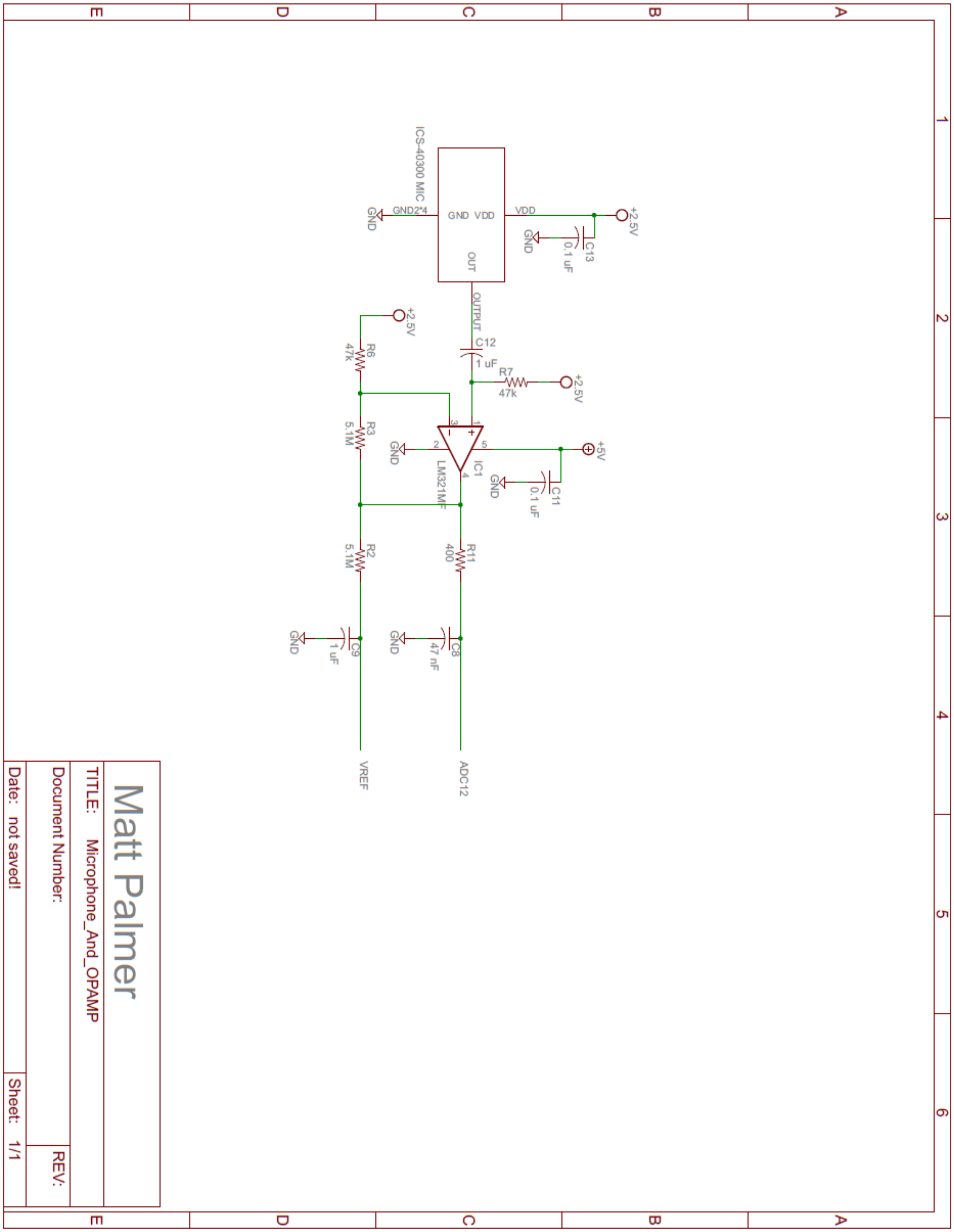
Section	Total ($)
Parts	55.57
Labor	33,750.00
Grand Total	**33805.57**

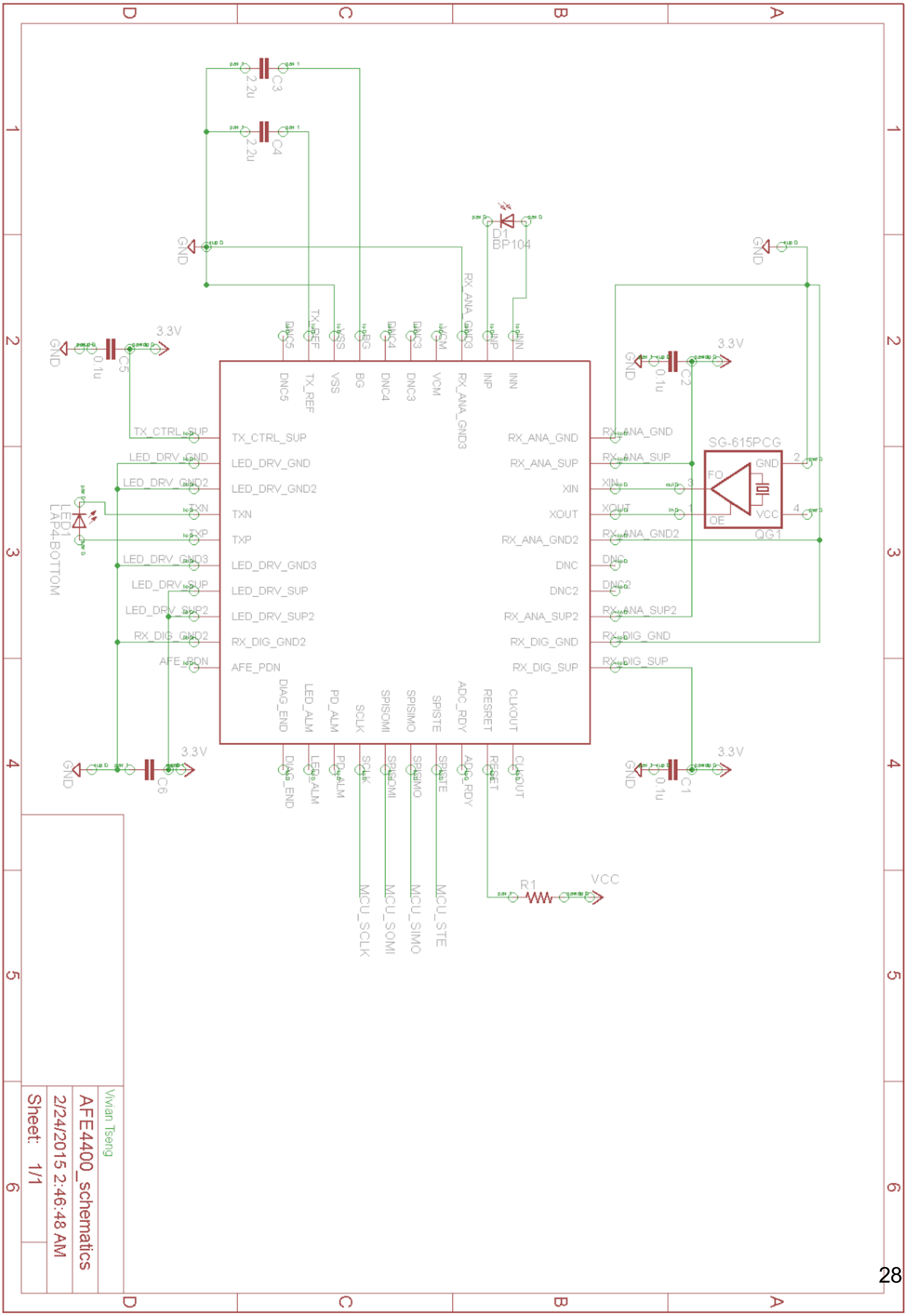
4.2 Schedule

Week	Jonathan Fouk	Matthew Palmer	Vivian Tseng
2-9	Finalize and hand in proposal	Finalize Parts list Power Requirements for all parts	Prepare and sign up for Mock Design Review
2-16	Learn Eagle Order Parts Circuit design for biosensors and microphone	Schematic Design Review Draft Circuit Design for Battery Pack, Micro-USB interface	Learn Eagle Finalize and select components Design switch circuit for user interface
2-23	Test sensors and circuit for biosensors and microphone Python/MATLab audio processing implementation	Test Microprocessor, Verify Battery Pack Design and Micro-USB interface w/ Microprocessor	Test OLED Display Test LEDs and size LED resistors, Test switch circuit for user interface
3-2	Start Microprocessor Coding, continue Python/MATLab audio processing	Design audio, verify designed circuits	Validate design layout Test Microprocessor basic functions with all devices
3-9	Continue debugging/developing audio processing algorithm	Design PCB Layout(s), thermal analysis on battery, components	Start incorporating basic features to prototype design
3-16	Continue developing audio processing algorithm	Design Physical Watch, verify PCB layout and order	Second verification on PCB layout, biosensor implementation
3-23	Spring Break Implement audio processing in microcontroller	Spring Break Continue designing physical watch, verify watch layout with machine shop and order parts	Spring Break Implement microprocessor basic functions
3-30	Add decision making algorithm to blend audio processing and biosensor readings	Construct the PCB w/ components and add to watch Attach	Test connected display and overall watch functionality

		sensors/LEDs/switches to watch/PCB	
4-6	Test and debug decision making algorithm	Test components and temperature at worst case	Test audio processing unit
4-13	Mock Presentation Preparation	Demo Sign up Mock Presentation Preparation	Mock Presentation Preparation
4-20	Test user interface for demo	Test Power supply for demo	Test biosensor functionality for demo
4-27	Presentation Preparation	Presentation Preparation	Final paper writeup
5-4	Lab Checkout	Finalize final paper	Finalize Presentation

APPENDIX A: SCHEMATICS





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SG-615PCG
QG1
D1
BP104
LED1
LAP4-BOTTOM
R1
VCC
3.3V
GND
C1
C2
C3
C4
C5
C6
2.2u
0.1u
MCU_SCLK
MCU_SOMI
MCU_SIMO
MCU_STE
TX_CTRL_SUP
LED_DRV_GND
LED_DRV_GND2
TXN
TXP
LED_DRV_GND3
LED_DRV_SUP
LED_DRV_SUP2
RX_DIG_GND2
AFE_PDN
RX_ANA_GND
RX_ANA_SUP
XIN
XOUT
RX_ANA_GND2
DNC
DNC2
RX_ANA_SUP2
RX_DIG_GND
RX_DIG_SUP
DNC5
TX_REF
VSS
BG
DNC4
DNC3
VCM
RX_ANA_GND3
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INN
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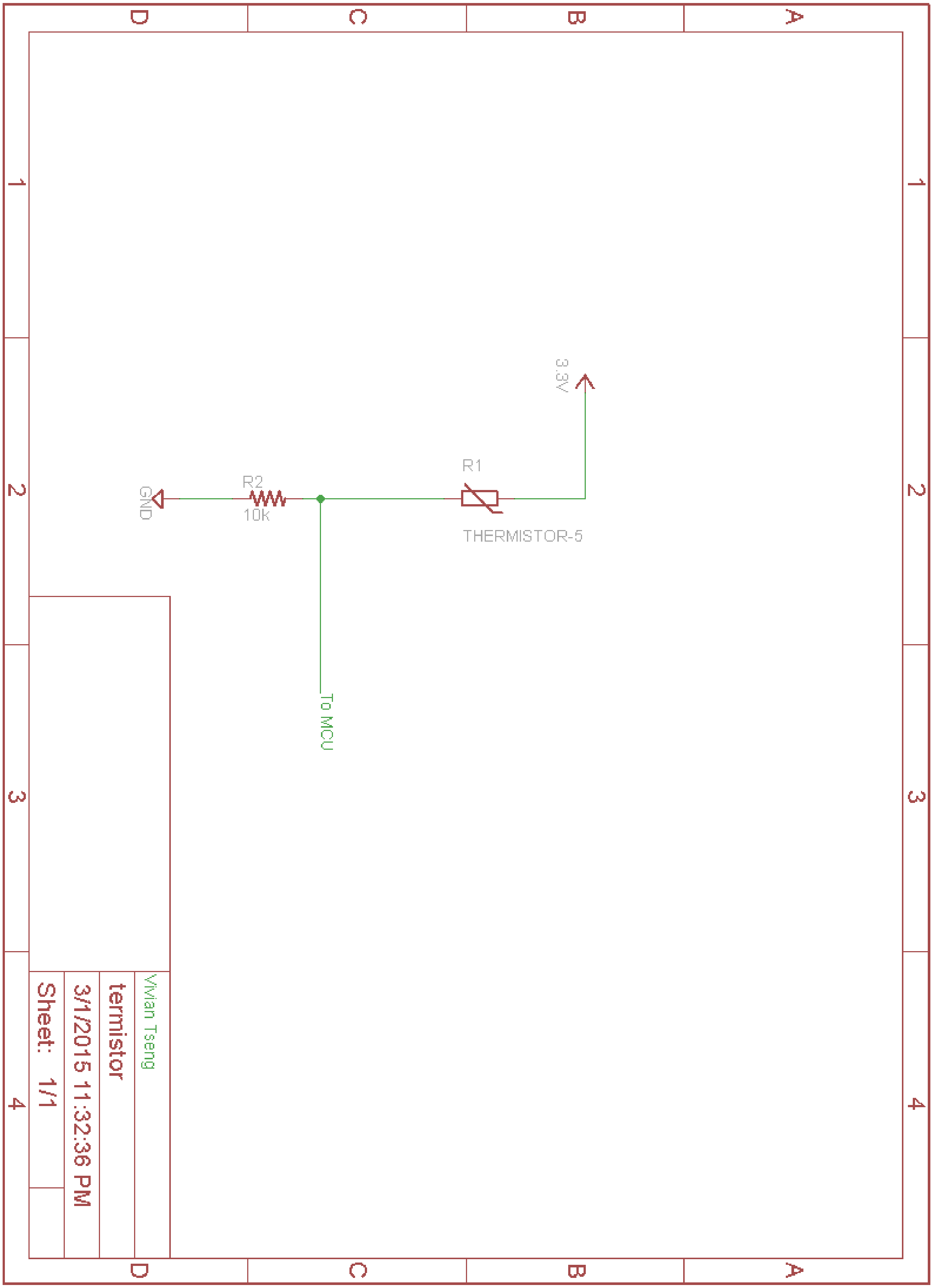
PD_ALM
SCLK
SPISOMI
SPISIMO
SPISTE
ADC_RDY
RESRET
CLKOUT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R1
THERMISTOR-5
R2
10k
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To MCU
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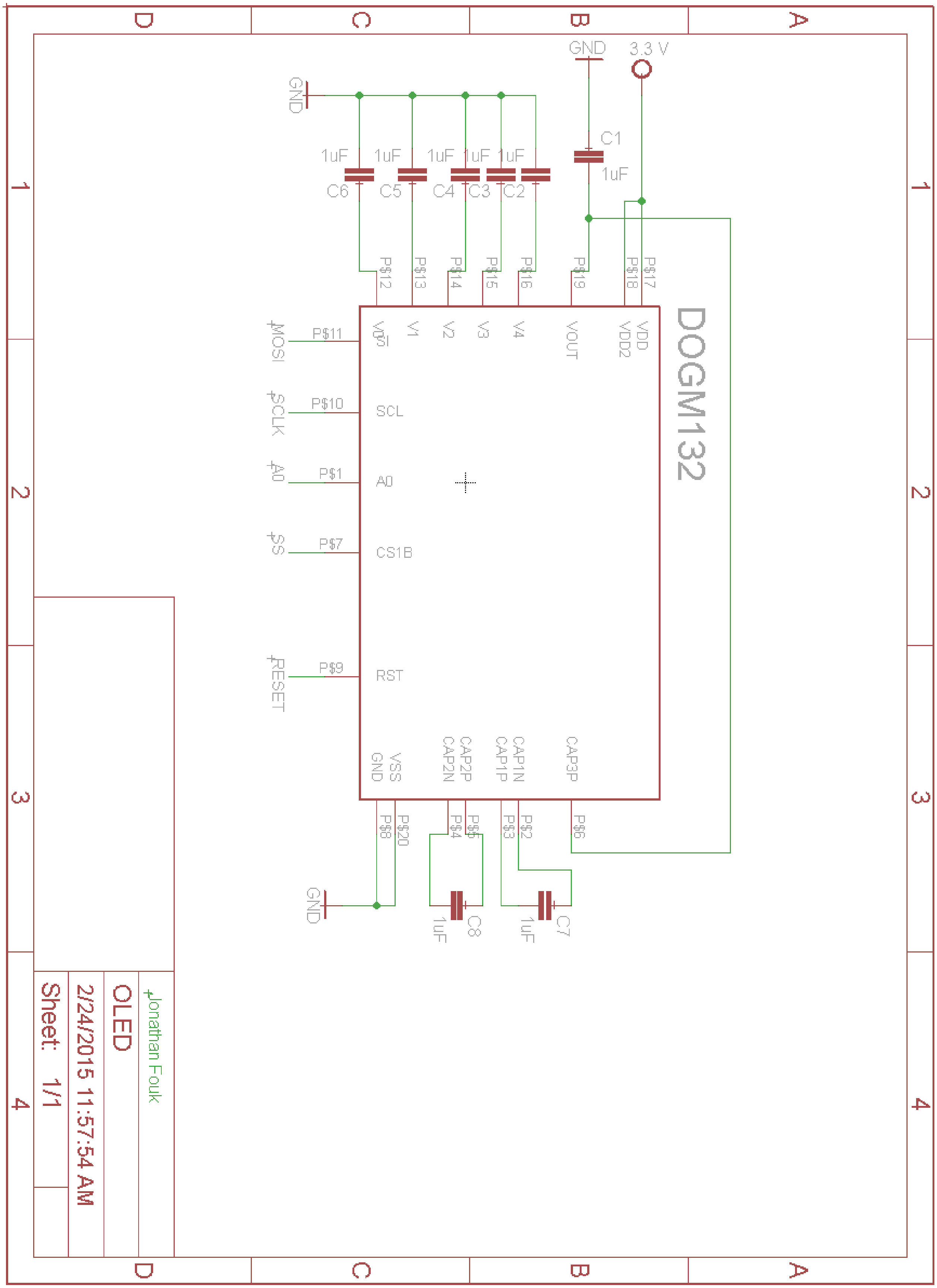

DOGM132
GND
3.3 V
C1
1uF
C2
C3
C4
C5
C6
C7
C8
P$1
P$2
P$3
P$4
P$5
P$6
P$7
P$8
P$9
P$10
P$11
P$12
P$13
P$14
P$15
P$16
P$17
P$18
P$19
P$20
MOSI
SCLK
A0
SS
RESET
SDI
SCL
A0
CS1B
RST
V1
V2
V3
V4
VOUT
VDD2
VDD
VSS
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CAP1P
CAP1N
CAP3P
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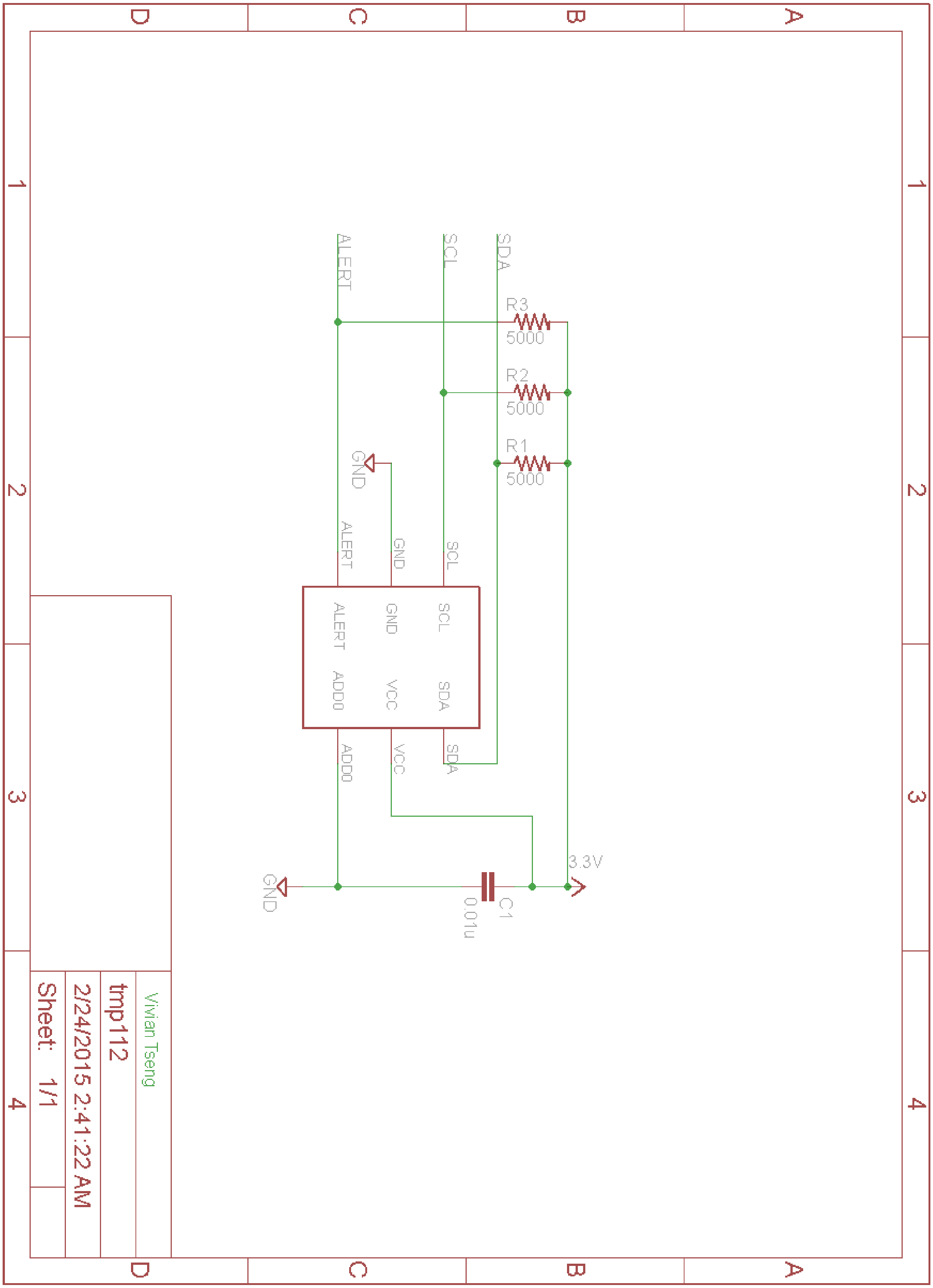
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SDA
R3
5000
R2
5000
R1
5000
GND
ALERT
GND
SCL
ALERT
GND
SCL
ADD0
VCC
SDA
ADD0
VCC
SDA
3.3V
C1
0.01u
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Vivian Tseng
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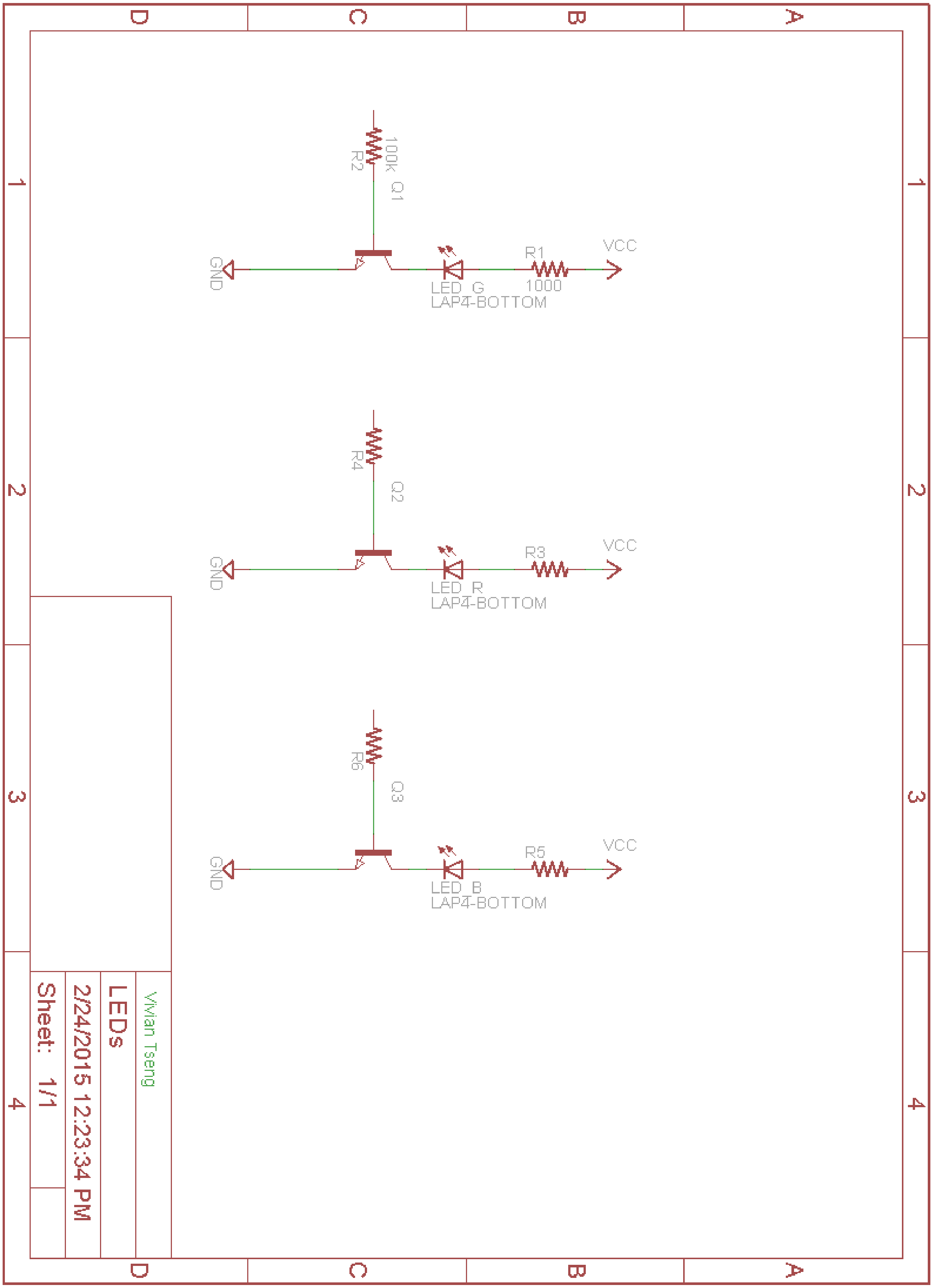
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Q1
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LED_G
LAP4-BOTTOM
R1
1000
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R4
Q2
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LAP4-BOTTOM
R3
VCC
R6
Q3
GND
LED_B
LAP4-BOTTOM
R5
VCC
Vivian Tseng
LEDs
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References

[1] InverSense, "High SPL Analog Microphone with Extended Low Frequency Response," ICS-40300 datasheet, May 2014.

[2] Texas Instruments, "Determining Minimum Acquisition Times for SAR ADCs When a DC Voltage is Applied to the Input," *Texas Instruments,* SBAA178 - March 2011, Available: http://www.ti.com/lit/an/sbaa178/sbaa178.pdf. [Accessed: Feb. 22, 2015].

[3] Mordkovich, A. Veit, K. Zilber, D. (2011). Detecting Emotion in Human Speech. *Stanford University.*

[4] Maaoui, C. Pruski, A. Emotion Recognition through Physiological Signals for Human-Machine Communication. *University of Metz.*