

A DIFFERENT KIND OF “BAR”-O-METER

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Abstract

For our Senior Design Project, we developed a system that can indirectly estimate the number of people at a bar and the atmosphere there, we call it “Bar”-O-Meter.

Our system works as follows: the pressure sensors we made gathers data from the dancing pool in a bar based on how much pressure people push to the floor, and then these data will be sent to a microcontroller, it will be generated by the microcontroller and after that, these data will be sent again from microcontroller to the PC end via Bluetooth devices. Finally the data will be displayed as different colors on computers.

All the hardware design of our system and part of the software design were completed over the course of the semester. Due to the lack of time we did not get our display online which definitely become part of our future work.

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1. Introduction

1.1 Purpose / Usefulness of Project

Most of the time, people find themselves torn between several options, especially when trying to decide on the places to have a fun night. Knowing the approximate number of people at the bars and the atmosphere there would certainly be helpful. Thus, we aim to develop a system that can indirectly estimate those information by installing weight sensors underneath the floors and making those data readily available online. We call it “A Different Kind of ‘Bar’-O-Meter.”

The “Bar”-O-Meter can facilitate the marketing effort for local bars. By participating on this online portal, bars can quickly let customers know the current scene at the bar without much effort. Additionally, customers can easily select the most desirable place to go according to their own preferences.

1.2 Project Functions

The “Bar”-O-Meter mainly consists of four major components, each of which has its designated functions. Over the course of the semester, we managed to accomplish to complete all the intended hardware functions and part of the software functions.

For hardware functions, we designed and implemented the Power Supply and the Sensor Pads. As the major component of our system, the Sensor Module senses the object placed on the sensor pad, collects all the data in a microcontroller (Arduino Uno Board), and finally transmits the processed information to the computer end via Bluetooth.

For software functions, we programmed the R/T Module and developed a Java program to parse information and display data in the form of an interactive map. The R/T Module, i.e. the Bluetooth, automatically generates a text file containing all the data on the computer end. Then, the Java program displays the information accordingly, with darker colors representing heavier weight, and vice versa.

1.3 Blocks / Subprojects

The four modules for the “Bar”-O-Meter are Power Supply, Sensor, Receiver/Transmitter (R/T), and Computer Display. The Power Supply Module converts 120V AC wall power to 5V DC power to supply both the Sensor Module and the R/T Module.

The Sensor Module collects the information from the sensing pads and consolidates everything into the Arduino Uno Board, which then transmits data to the Bluetooth chip in the R/T Module. Eventually, the Computer Display would read the information transmitted and display it in the form of an interactive map online.

The Transmitter/Receiver Module aggregates all the information from all microcontrollers without loss of information, then transmits it via Bluetooth transmitter. This block is needed to communicate between the pressure sensing pads and the display terminal. Each entry for the data transmitted will

consist of the number that determines the location of the pad and the pressure associated to it. After receiving data, it is then ready for the Computer to process and display.

A computer analyzes the data, maps the data onto the map instantaneously, and creates an interactive map. The interactive map will be displayed on an existing social website. This block will mostly be implemented through software algorithms. A map of the bar (or any measured area) will be displayed on the terminal. The map is divided into subareas; each corresponds to pressure sensing pad placed. The level of activeness will be realized through color-coding or change in patterns. The color/pattern on the map corresponds simultaneously with the intensity of the activities in the area.

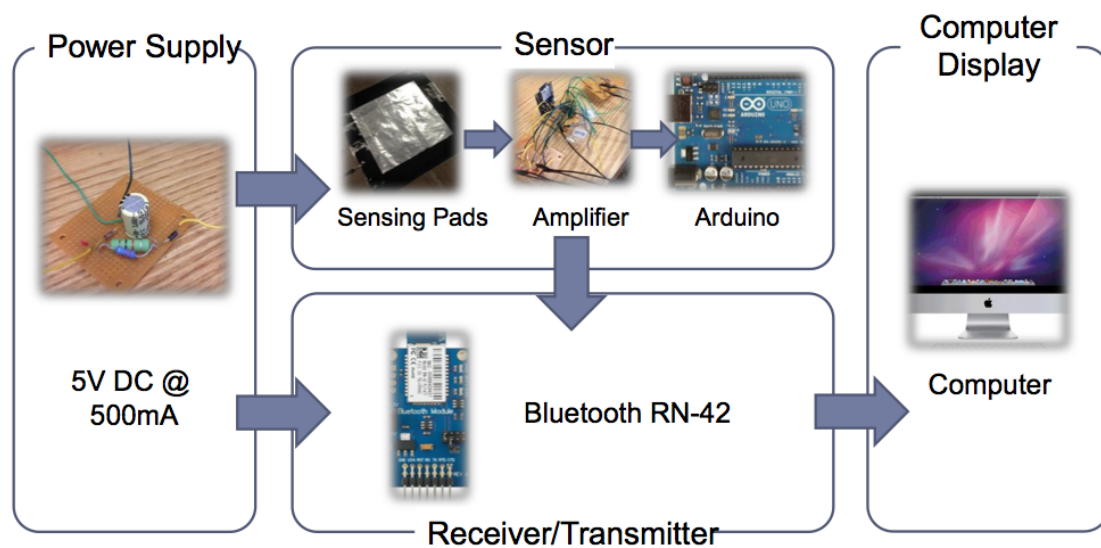


Figure 1 - Block Diagram

2 Design

2.1 General Design Alternatives

2.1.1 Power Supply Module

For our system, we wanted to build our own power supply because it was interesting to see how the current needed could affect the design of the circuit. There are several alternatives, however, to the power supply. In case the Power Supply Module fails, we can simply connect the Arduino Uno Board to a USB port, which supplies a regulated 5V DC power. Additionally, since the Arduino Uno Board has a 5V output pin, we can utilize that pin to supply power to the rest of the circuit, including the DC voltage for the DC Bridge as well as the Bluetooth chip.

2.1.2 Sensor Module

The GE NPA-700B pressure sensor was our first thought, it can measure the pressure from 1psi to 5psi and send digital output. It sounds perfect for our project, but the price issue comes. Each sensor would cost us almost 50 dollars and if we want to cover the entire area of a bar, it would be over 2000 dollars.

Then we thought why not make pressure sensors by ourselves. So after discussing with our Teaching Assistant and doing some research, we found this material called Velostat, which can change its resistance for different pressure. So we built our own pressure sensor by using it, and compare to the GE chip, it is really cheap.

After getting our pressure sensor, we needed a circuit to measure the different pressure on it. So we came up with this DC-bridge circuit. It is basically a pair of voltage dividers where the circuit output is taken as the difference in potential between the two dividers. We replaced one resistor with our pressure sensor, so that if the pressure on sensor changes, the resistance of it will change, and the difference in potential between the two dividers will change, that is what we need.

Then we needed to output this voltage difference, at the same time we also want to increase the resolution. So we added a differential amplifier circuit after our DC-bridge circuit. We spent a lot time in choosing amplifiers. LM748 amplifier, the most commonly used op-amp, was our first thought. But it cannot output the voltage close to its power supply, so it does not match our requirement. Many other amplifiers have the same problem. After discussing with Mark Smart who is from the ECE machine shop, we decided to use the LM324 amplifier which can output the voltage at the edge of its power supply, in our case, it is 0 volt.

We also need a microcontroller to generate the data from the output of the previous stage. We chose PIC16F877A at very beginning, because it is available in ECE machine shop, but then we found out that the compiler for it did not work very well. We changed to use Arduino very soon, and it turned out that using Arduino was much easier.

2.1.3 Receiver / Transmitter Module

After doing research about how to interface Bluetooth with microcontrollers, we chose the RN-42 Bluetooth Module. It can pair up with devices supporting Bluetooth SPP(Serial Port Profile)(in our case,

our microcontroller) to establish a serial interface, and it works both for 5V and 3.3V microcontroller which matched our requirement.

2.1.4 Computer Display

We were suppose to create a web page for displaying our results, but due to the shortage of time we decided to make a java application to display the results and make the online portal as our future work.

2.2 Equations / Simulations / General Circuit

2.2.1 Power Supply Module

To obtain a 5V DC @ 500mA power supply from the 120V AC wall power, we designed the Power Supply Module, including transformer, rectifier, smoothing capacitor, and regulator. The main values that we need to obtain include the capacitance C for the smoothing capacitor, resistance for R_S in series with the Zener diode. From the PSPICE simulation, we observed that I_{max} for the Zener diode is at 35.213mA. The equations to calculate these values are listed below, along with the general circuit and the simulation results.

$$R_S = \frac{V_{in,peak} - V_d - V_{out}}{I_{max}} = \frac{21 - 0.7 \times 2 - 5}{35.213\text{mA}} = 415\Omega$$

$$V_{ripple} = \max_{ripple} \frac{R_S + R_Z}{R_Z} = \frac{5 \times 1\% (17 + 415)}{17} = 1.27\text{V}$$

$$C = \frac{I}{2fV_{ripple}} = \frac{35.213\text{mA}}{2 \times 60\text{Hz} \times 1.27\text{V}} = 230\mu\text{F}$$

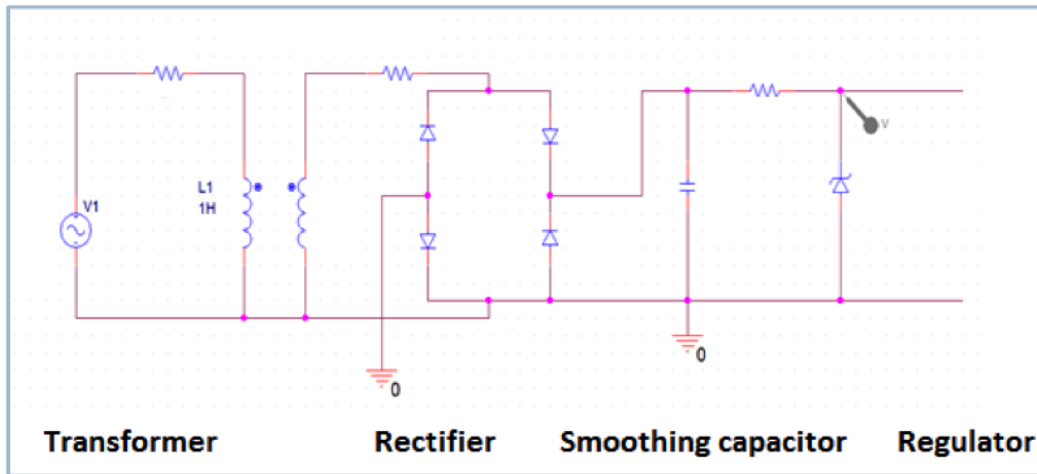


Figure 2 - General Circuit for Power Supply Module

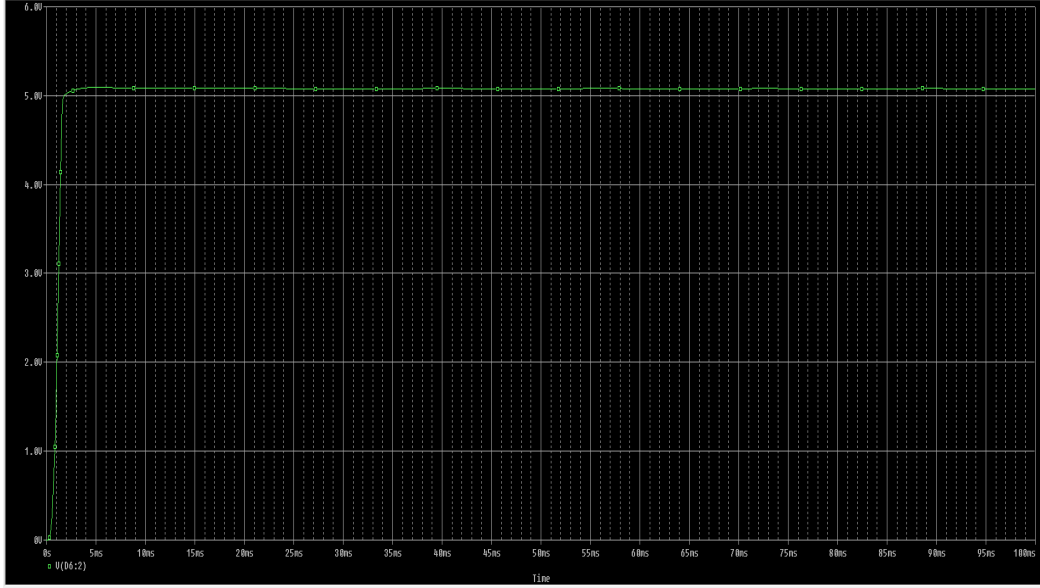


Figure 3 - Simulation Result for Power Supply Module

2.2.2 Sensor Module

The Sensor Module circuit consists of three parts - sensing pads, differential amplifiers, and microcontroller. For the initial input signal, we used the DC Bridge design. We used the following equation to calculate the voltage difference between the BD terminals of the DC Bridge:

$$V_o = \frac{R_1 R_4 - R_2 R_3}{(R_1 + R_2)(R_3 + R_4)} V_{in}$$

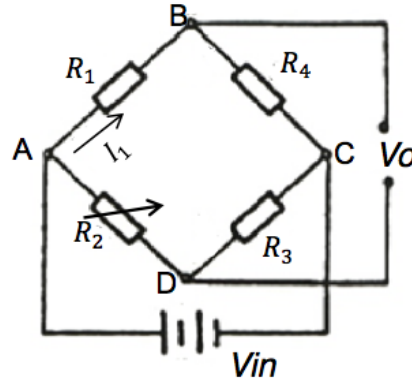


Figure 4 - DC Bridge Circuit Design

Following the DC Bridge, we employed a differential amplifier to amplify the voltage analog signal. Since we intend to amplify the signal by two times, we constructed the resistors as shown in Figure 5 to obtain the output function below. Since we need a gain of 2, we set $R_1 = R_2 = 1.5k\Omega$, and $R_f = R_g = 3k\Omega$.

$$V_{out} = \frac{(R_f + R_1)R_g}{(R_g + R_2)R_1} V_2 - \frac{R_f}{R_1} V_1$$

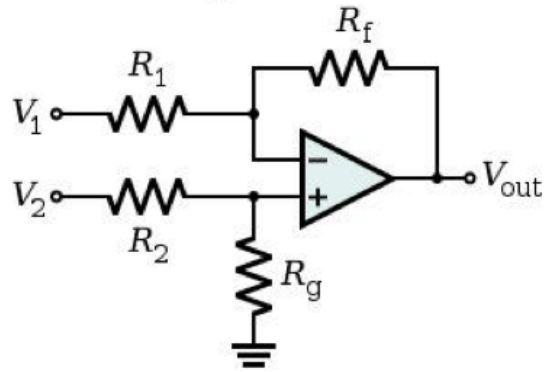


Figure 5 - Differential Amplifier Circuit Design

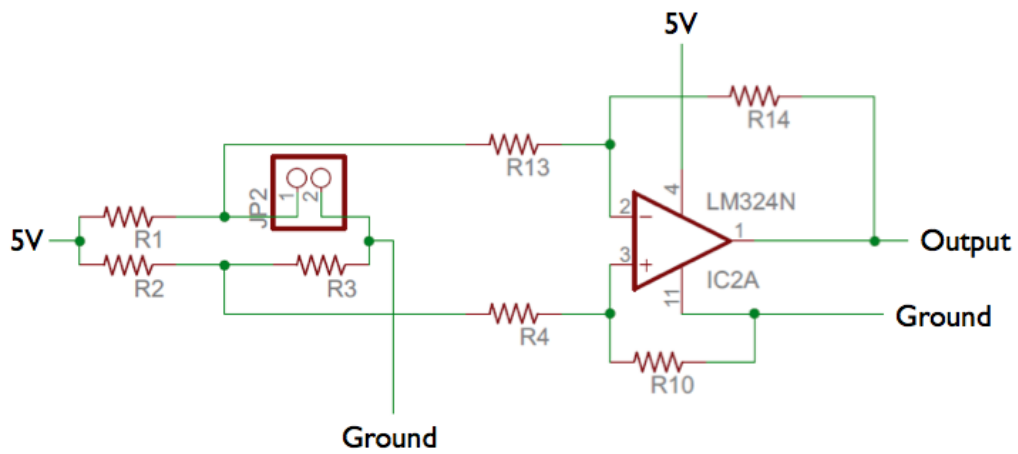


Figure 6 - General Circuit for Sensor Module

Similarly, we used PSPICE to simulate and verify the circuit that we designed. The simulation results are presented in Figure 7.

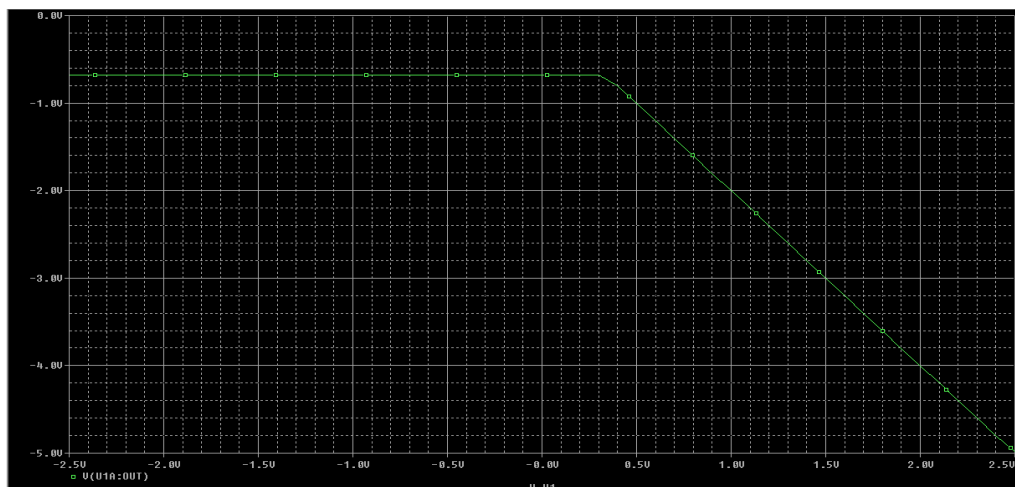


Figure 7 - Simulation Result for Sensor Module

2.3 Detailed Description of Design

2.3.1 Power Supply Module

The Power Module is designed to provide desired voltage level to supply electricity to the entire system. Since both the Sensor Module and the Transmitter/Receiver Module rely on 5V DC @ 500mA power supply, we plan to use a 120V AC to 5V DC converter, consisting of transformer, rectifier, and smoother.

The transformer intends to lower the voltage level from the wall power (120Vrms AC) to desired voltage level to 15Vrms AC. We intend to use 166G5-ND from Hammond Manufacturing, which also produces the 500mA current that we required. Since we required direct current instead of alternating current, we would then need to use a set of diodes to rectify this current. Here, we use the bridge rectifier since it is more efficient than the half-wave circuit or the center-tapped full-wave circuit. Specifically, we use four 1N4007 diodes, from Vishay Semiconductor Diodes Division, to realize that purpose. Since the current can only go under forward-biased condition, the output current will be positive as desired.

Even though we have eliminated the alternating portion of the current, we still need to maintain the current/voltage level to ensure that the system keeps running. Thus, we connect a capacitor to the circuit to smooth the current. As mentioned in the previous section, the capacitor needed is 230 μ F.

Finally, since the lowered voltage still stands at 15Vrms, and the desired voltage is 5V, we employ a regulator, in this case a Zener diode in series with a resistor. We use 1N4733 for the Zener diode, which provides us with 5.1V Zener voltage, in series with a 415 Ω resistor, as calculated before.

2.3.2 Sensor Module

We used Velostat and aluminum foil to build pressure sensors. Velostat is a brand name for a black, opaque, volume-conductive, carbon-impregnated polyolefin. Its electrical characteristics are not affected by age or humidity. Velostat is a piezoresistive material, which means that its resistance changes when it experiences a pressure. The nature of this material allows us to transfer mechanical changes into electrical signals.

We built our sensor pad by sandwiching 3 layers of Velostat between two sheets of aluminum foils, and bind them together with clear tape. A wire is attached to each aluminum foil in order to measure the change in resistance.

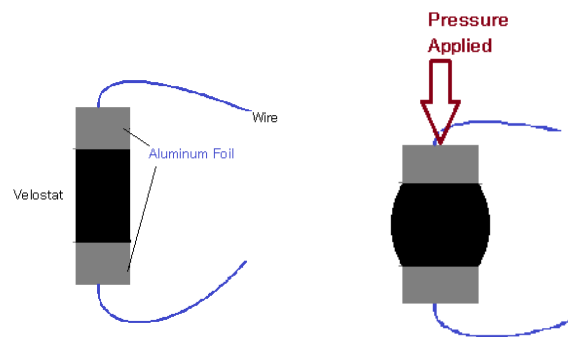


Figure 8 - Velostat

The resistance value of a resistor with the length l and the cross-sectional area A is given by

$$R = \frac{\rho l}{A}$$

When pressure is applied on the pad, the thickness of the pad decreases, which corresponds to the length of the resistor, and the cross area will become slightly bigger, therefore results in a decrease in resistance.

We chose to build the sensor pads in the size of a regular tile (25 cm x 25 cm) so that it has just enough space to fit one foot or two feet together on it, to insure it's accuracy.

For the DC bridge circuit. According to the DC Circuit Design figure above, if we look at path A-B-C we can easily get

$$I_1 = \frac{V_{AC}}{R_1 + R_2} \text{ and } V_{AB} = I_1 R_1 = \frac{R_1}{R_1 + R_2} V_{AC},$$

Same thing if we look at A-D-C path and we can get

$$V_{AD} = \frac{R_3}{R_3 + R_4} V_{AC}.$$

So we can get

$$V_0 = V_{AB} - V_{AD} = \frac{R_1 R_4 - R_2 R_3}{(R_1 + R_2)(R_3 + R_4)} V_{AC}.$$

The resistance of our pressure sensor is around 3Ω , while there is a person on it and over 2000Ω when there is nobody on it, so R_3 varies from 2000Ω to 3Ω . We want to make the voltage change as obvious as possible when people dancing on it, so we set $R_1 = R_2 = R_4 = 5\Omega$ at first so that V_0 can be largely changed while R_3 changes a little. It turned out that the resistor will become very hot after a few minutes, we realized that 5Ω is too small, and we need to increase them. But if we increase the value of R_1 , R_2 and R_4 , the change of the voltage difference will be not as obvious as before. So we tried from 5Ω to 500Ω to get a balance between these two situation. Thus, we choose 260Ω in the end. If we apply a 5V DC power supply to the circuit, and when nobody is on the sensing pad, the output voltage is about

$$V_0 = \frac{(260 \times 260 - 260 \times 2000)}{(260 + 260)(260 + 2000)} \times 5 \simeq -1.91V.$$

When some one is standing on the sensing pad, the output voltage is about

$$V_0 = \frac{(260 \times 260 - 260 \times 3)}{(260 + 260)(260 + 3)} \times 5 \simeq 2.50V$$

Additionally, if the person moves his body, then V_0 varies around 2.40V within 0.1V range, which will be shown in testing section.

For the differential amplifier circuit, we have the amplification function as follows

$$V_{\text{out}} = \frac{(R_f + R_1)R_g}{(R_g + R_2)R_1} V_2 - \frac{R_f}{R_1} V_1$$

We apply 0-5V DC power supply to this amplifier, first because our whole system works by 5V, we do not need an additional power supply for it. Another reason is that it can help us to get the rid of negative values (the output of an amplifier can not beyond or below its power supply) when there is a negative value, the output will be 0V. For our situation, when there is nobody on the pressure sensor, the output will be 0V, which makes more sense and much easier to program. In order to increase the resolution and get fully use the range, we decide to increase it by 2. So we set $R_1 = R_2 = 1.5\text{k}\Omega$, and $R_f = R_g = 3\text{k}\Omega$, the output will between 0V to 4.5V and varies around 4.2V in a range of 0.5V when people moving on the sensor, which is easier for microcontroller to detect the change compare to 0.1V.

After we have obtained our desired voltage output, it would be connected to the analog input pins of the Arduino Uno Board. The microcontroller then scales the voltage to a range of 0 to 255 so that it could be used as the alpha value for the RGB index in Java. The TX pin of microcontroller is connected to the RX pin of the Bluetooth chip to allow for serial data transmission.

2.3.3 Transmitter/Receiver Module

For the RN-42 Bluetooth chip, we used Processing to program the process that we need. There are two major functions within the program - setup and draw. The setup function sets the input port to the Bluetooth, which is RN42-5337-SPP, and sets a delay of 2 seconds to allow for establishing connection. In the draw function, it reads the data received from the Sensor Module and writes it to a text file every 100ms.

2.3.4 Computer Display

For the computer display module, we programed a java application that can read data from a txt file and output it by different color. More specifically, we saved the data from Bluetooth device in a certain form (each line represents each sensor) into a txt file, and then we read data from this file and display it on the color panel, which we built before. The larger the value is, the deeper the color appears.

2.4 Schematics with Components

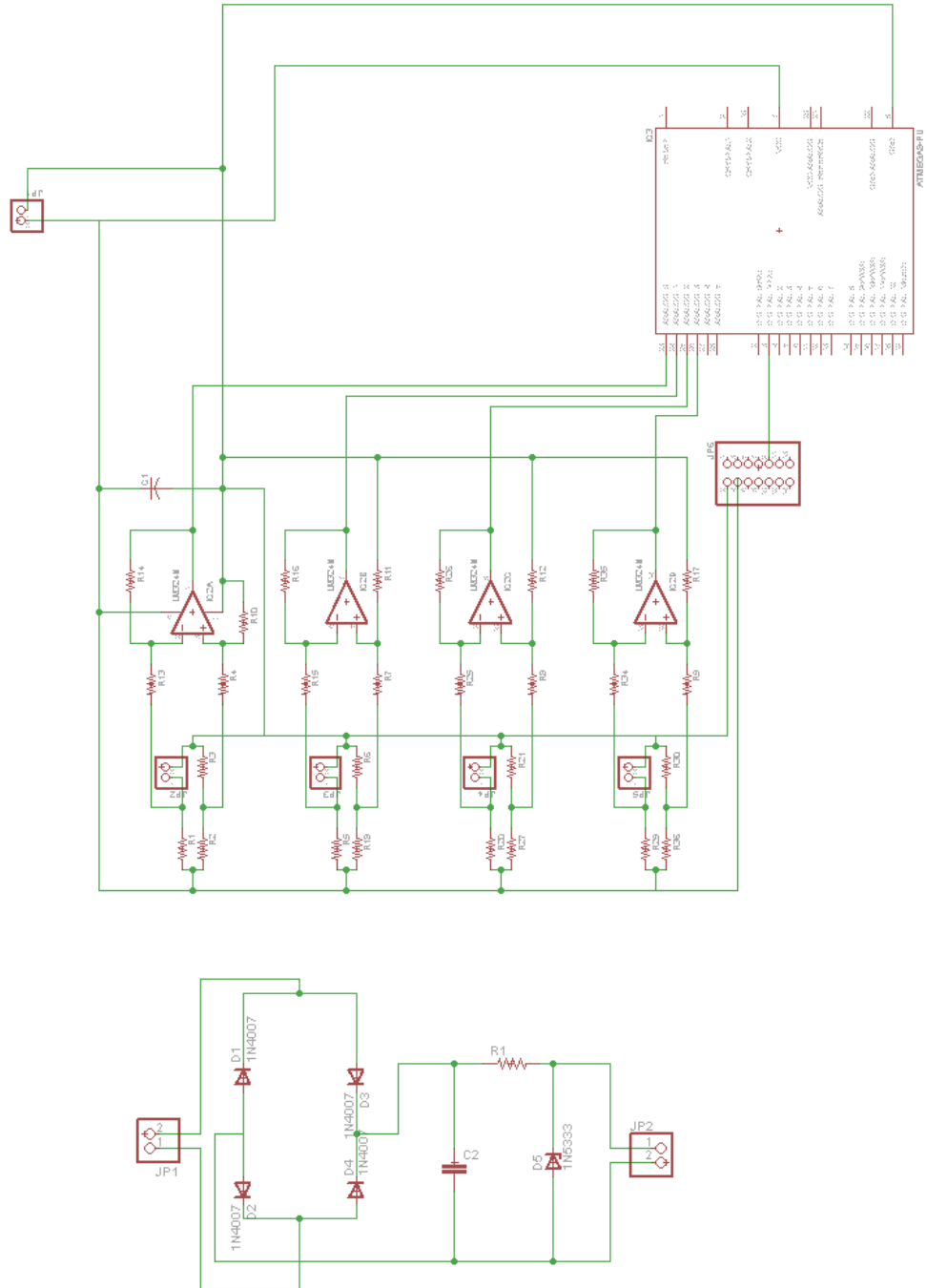


Figure 9 - Overall Schematics

3. Design Verification

We performed testing procedures for both the individual modules and the project at a whole to ensure the functionality of each module and effective connections and communications between them.

3.1 Testing Procedure & Results / Measurements

3.1.1 Power Supply Module

We tested our power module to ensure that power supply from the wall plug is sufficient, power transformer converts 120V AC to 15V AC successfully, the rectifier filters out negative voltage, the smoothing capacitor can smooth out the voltage with a less than 3% ripple.

Figure 10 shows the testing result of the output voltage on oscilloscope. As shown on the graph, the magnitude of the output voltage varies from 5.13-5.25 V, with an average of 5.2 V and a ripple voltage of 124.37 mV. Percentage regulation (%) = $1 - |(V_{SL}(V) - V_{LL}(V)) / V_{LL}(V)| = 1 - 0.12437/5.13 = 97.6\%$, sufficient for our purposes.

As we are using a 500Ω resistor in the power supply, the output current is around 30 mA, which is our desired current level.

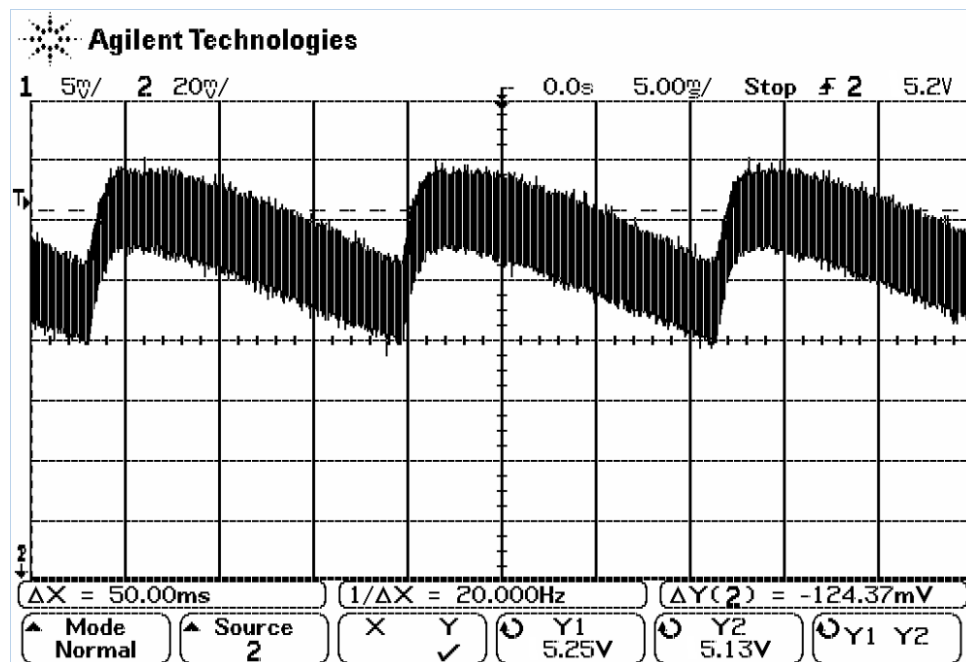


Figure 10 - Output Voltage Ripple

3.1.2 Sensor Module

We tested out sensor pad to ensure that the resistance of the sensor pad varies monotonically with input pressure.

We tested this by connecting the sensor pad to a voltmeter. When at its natural state (i.e. with no pressure applied on the pad), the resistance varies between 2.8 - 3.0 k Ω . When a small pressure is applied by putting a 30 kg weight on the sensor pad, the resistance drops immediately to around 260 Ω , when a person with a weight of 70 kg is standing on the pad, the resistance drops to around 2 Ω , the heavier the person is, the smaller the resistance gets. Therefore the requirement is verified. These changes can also be visualized from the figures of further testing.

We tested the direct current bridge circuit to ensure that it outputs negative voltage difference when no one is standing on the sensing pad, and outputs positive voltage difference of $\sim 2V$ when pressure is applied.

As shown in Figure 11, when one is standing on the sensor pad, the output is -1.85 V, when a person is stepping up and down on a sensor pad, the output voltage changes between 2.44 V to -1.85 V.

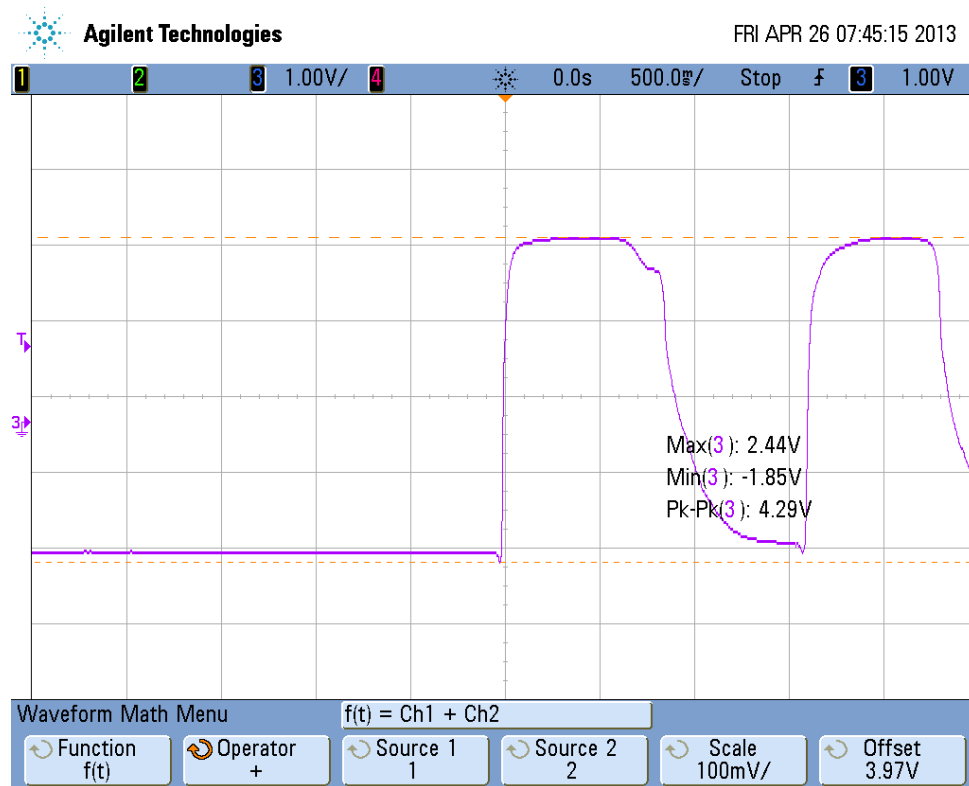


Figure 11

As shown in Figure 12, the output voltage responses accordingly if the person is wiggling slightly on the pad. In our testing case, a 76 mV peak-to-peak voltage is measured. The higher the level of movement is, the larger the peak-to-peak voltage will be.

We then tested the differential amplifier circuit to ensure that it rectifies negative value to close to 0V, and amplifies positive value by two times.

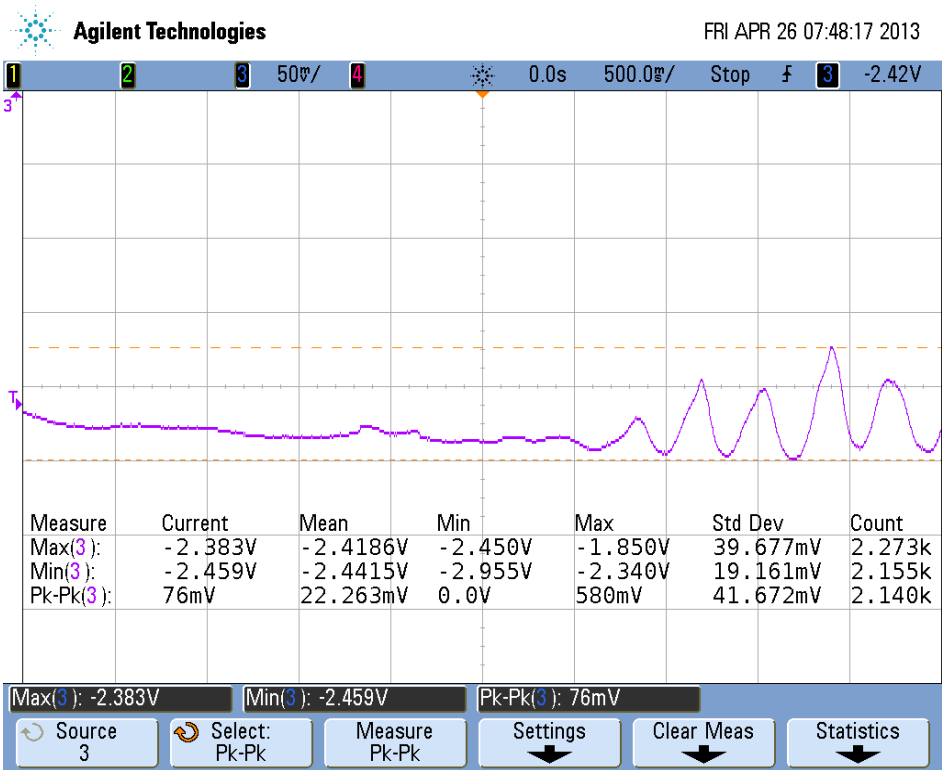


Figure 12



Figure 13

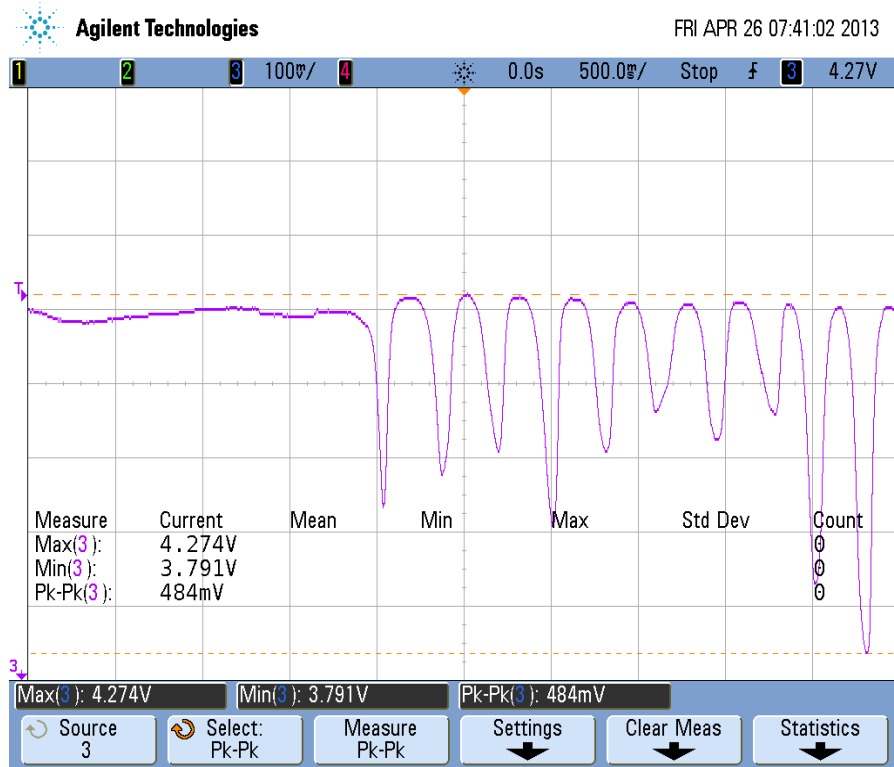


Figure 14

Figure 13 and Figure 14 are our testing graphs for the output voltage with the differential amplifier circuit.

Comparing Figure 13 to Figure 11, we can see that the -1.85 V has been regulated to 290 mV, and the maximum voltage has been increased from 2.44 V to 4.27 V.

$$4.27 \text{ V} / 2.44 \text{ V} = 1.75 \text{ times}$$

Comparing Figure 14 to Figure 12, we can see that the “wiggling” voltage range has changed from 2.38-2.46V to 3.79-4.27 V, the peak-to-peak voltage increased from 76 to 484 mV.

$$484 \text{ mV} / 76 \text{ mV} = 6.37 \text{ times}$$

The amplification rates are not exactly the same as we expected (2 times), however, it is reasonable and sufficient for our purpose. The analyses of these testing results are explained in details in section 3(c) Discussion of results and failed verifications.

We have also tested our Arduino Microcontroller to ensure that it converts analog signal (0 – 5V) from the amplifiers to digital data. We verified this by connecting the microcontroller to PC through cable, and apply voltages (ranging from 0-5V) to each input port. The value shows on the programming console are the same as the value of the voltages we applied.

3.1.3 Transmitter/Receiver Module

We tested our microcontroller to ensure that it sends digital data via Bluetooth without loss of information, the Bluetooth chip can truncate data to the digits we need, generate text file with original data and updates data automatically every 100ms.

We verified this by connecting the microcontroller to Bluetooth, pair up the Bluetooth and PC, and apply voltages (ranging from 0-5V) to each input port. The value received by the PC through Bluetooth shows on the programming console are the same as the value of the voltages we applied. The output on the computer end responds almost instantly with the change of input. By running the program we implemented, the updating rate of 100ms is verified automatically.

3.1.4 Computation and Display Module

We tested our computation and display module to ensure that it reads data from text file to obtain alpha values for each sensing pad, populates data into respective blocks, and updates constantly without changing display if input data is null

This is verified by the looking at the monitor display directly. It takes input from the text file containing data for sensor pads received by the computer, and displays data on the monitor.

Please refer to Figure 15 for a mock up display screenshot.



Figure 15 - Display Mockup

3.2 Discussion of Results and Failed Verifications

3.2.1 Power Supply Module

All of the test results for power modules match with what we expected.

3.2.2 Sensor Module

When we were testing for the differential amplifier circuit, and comparing Figure 3-4 to Figure 3-2, and Figure 3-5 to Figure 3-3, we noticed that the output voltages are not amplified by exactly 2 times. the maximum voltage with a person standing on the pad is amplified by 1.75 times and the peak-to-peak voltage when wiggling is amplified by 6.37 times. As the primary purpose of the amplifier circuit is to improve the signal resolution when under small variations to ensure the signal to be detected by the microcontroller, the 1.75-time amplification is sufficient and acceptable for our use.

The 6.37 times amplification for small signals are a lot higher than what we expected, it is reasonable to happen. As we can see from the graphs, the sensor pad is very sensitive and responsive to even small pressure changes, therefore it is difficult for the person to wiggle at an exact level of movement throughout the testing. The person on the pad wiggled slightly harder the second time of testing therefore caused the larger-than-expected amplification rate. While the testing numbers are slightly off, they are reasonable and sufficient for our purposes. We are happy with the sensitivity and the response activity of our sensor module.

3.2.3 Transmitter/Receiver Module

All of the test results for transmitter/receiver modules match with what we expected.

3.2.4 Computation and Display Module

All of the test results for power modules match with what we expected. However, based on the Requirement & Verification section of our Design Review, we were not able to the last part of the requirements which states that-- Upload information to website;

Website can store all data without loss of information, due to the lack of time. Because we have decided to focus more on the hardware aspect of this project and spend more time on improving its accuracy and stability.

4. Costs

4.1 Parts

Table 1 Parts Costs**

Part	Quantity	Per Unit Cost (\$)	Actual Cost (\$)
Power Transformer (166G5-ND)	1	20.32	\$20.32
Diode D1N4002	4	\$0.14	\$0.56
Ziner Diode: D1N5733	1	\$0.10	\$0.10
Capacitor (330 uF)	1	\$3.90	\$3.90
resistor (500 Ω)	1	\$1.80	\$1.80
resistor (260 Ω)	12	\$1.49	\$17.88
resistor (1.5 kΩ)	8	\$1.49	\$11.92
resistor (3 kΩ)	8	\$1.49	\$11.92
Op Amp (LM324N)	1	\$1.05	\$1.05
Velostat	4ft*3ft	\$1.95/ lin ft	\$7.80
Aluminum foil	1 roll	\$3.00/roll	\$3.00
Clear tape	1 roll	\$2.50/roll	\$2.50
Arduino Uno Microcontroller	1	\$25.00	\$25.00
PCB	1	10	\$10.00
Bluetooth Chip	1	\$60.00	\$60.00
Wires	30ft	\$3.00/roll	\$3.00
Grand Total			\$180.75

** Assuming the system contains 4 sensor pads

4.2 Labor

Name	Hourly Rate	Hours Invested/Week	Total Weeks	Total Labor Cost*
Chen Hu	\$30.00	10	15	\$11,250.00
Tuo Liu	\$30.00	10	15	\$11,250.00
Yiming Song	\$30.00	10	15	\$11,250.00
Grand Total				\$33,750.00

*Total Labor Cost = Hourly Rate x Hours Invested/Week x Total Weeks x 2.5

4.3 Grand Total

GRAND TOTAL = Labor + Parts = \$33,750.00 + \$180.75 = **\$33,931**

5. Conclusion

5.1 Accomplishments

Over the course of the semester, we accomplished all the hardware designs that we set out to complete and part of the software component. For the hardware, we were extremely satisfied by the Velostat that we found as the sensor pad, because it gives us little noise while discernable change in resistance when the pressure varies. Additionally, after switching from PIC microcontroller to Arduino Uno Board, we found that the programming is more straightforward and easier to modify. The program that we developed is more resilient to sudden changes in pressure and can send data to the computer at a higher frequency.

5.2 Uncertainties

Due to the nature of the Velostat material that we used, the resistance varies on a logarithmic scale as opposed to a linear scale. Thus, when one person is standing on two sensing pads, it could potentially regard this situation as two people standing on both sensing pads. However, the original intention of our system is to estimate the number of people that are present at a certain place. In this sense, a relative measure should suffice compared to an absolute measure. Thus, this type of uncertainty would be less likely to affect the usability of our system.

Additionally, since we programmed our Bluetooth chip using Processing, the program requires the computer to establish connection with Bluetooth everytime it starts, which could be sometimes unstable. To resolve this issue, we set the computer end program to automatically re-run until a successful connection is obtained, achieving minimized amount of trouble caused by this issue.

5.3 Ethical considerations

All of our group members adhered to the IEEE Code of Ethics throughout the project. The items listed below are especially relevant to our Bar-o-meter project.

#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;

This product is intended to be used in a high populated area, therefore the circuit must be packaged and protected correctly to avoid chance of electric leak or short circuit, especially when spilt by beverage or used in a damp environment.

#2 to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;

Since this product is intended for to show the activeness in a bar/club, it is possible that the bars may tamper with the “Bar-O-Meter” in order to fake the result and increase their popularity. It is important to make sure that the bars are aware of the ethical issues behind it, and agrees that they will not tamper with the product before we sell the product to them.

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

We will always be open to criticism and suggestions, and credit to those who have contributed.

5.4 Future work

5.4.1 Online Portal

To make our system more effective and useful, an online portal could be established so that various places could all upload their information, providing customers a more general idea about where to go. This online portal should be able to provide historical data tracking, so that customers can find out the general trend of that certain bar, i.e. Monday nights are more popular than other nights, or the overall population is increasing since the bar opened.

5.4.2 Mobile Application

Considering that not everyone has easy access to a computer when they want to enjoy a good night, we believe that a mobile application would provide even better experience to the users. Since all the information is displayed in the form of an interactive map, the readability would still preserve even on a mobile screen.

References

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<http://www.ti.com/lit/ds/swrs084e/swrs084e.pdf>
- [7] IEEE Code of Ethics: <http://www.ieee.org/about/corporate/governance/p7-8.html>

Appendix A Requirement and Verification Table

Table 2 Power Supply Requirements and Verifications

Requirement	Verification	Verification status
1. Power supply from wall plug reads $120 V_{rms}$ to ensure that power is sufficient	1. Connect input voltage to oscilloscope (Agilent 54642A) to ensure that wall power is 110V - 120V	Y
2. Power Transformer (166G5-ND) converts $120 V_{rms}$ from wall plug to $15 V_{rms}$ @ 30mA on secondary side.	2. Connect output to oscilloscope (same for items below) a. Output voltage should read $15V \pm 0.05V$; b. Magnitude of output current should read $30mA \pm 3mA$	Y
3. Rectifier (1N4007) filters out negative voltage and generates positive-only voltage.	3. Output voltage should read only positive values, with maximum value at $30mA \pm 3mA$.	Y
4. Smoother ($100\mu F$) gives a DC profile of 15V with $\pm 1.27V$ ripple voltage.	4. Output voltage should be smoothed to 15V with ripple voltage of $\pm 1.27V$.	Y

Table 3 Sensor Module Requirements and Verifications

Requirement	Verification	Verification status
6. Weight sensor module reads 0 when no object is placed on pad.	6. Output of the sensor module reads 0	Y
7. Weight sensor module reads weight when object is placed on pad.	7. Apply a 1 kg and a 100 kg object on plate, output both read bigger than 0.	Y
8. Weight sensor module output varies linearly with input applied to pad, ranging from 0-250 kg.	8. Apply static objects of 1 kg on the pad, with increment of 25 kg, and output reading varies accordingly, with $\pm 10\%$ error.	Y
8.1. Output of the DC Bridge circuit varies linearly with weight applied to pad, ranging from 0-250 kg	8.1. Apply static objects of 1 kg on the pad, with increment of 25 kg, and output voltage of the DC Bridge circuit should vary accordingly, with $\pm 10\%$ error.	Y
8.2. The Voltage Amplifier works correctly	8.2. Apply different voltage to the input of the Voltage amplifier (ranging from 0-2 V, with a 0.01 increment), the output of the Voltage Amplifier circuit should vary accordingly and change linearly.	Y

8.3. The Voltage Inverter works correctly	8.3. Apply different voltage to input of Voltage amplifier (ranging 0-5V, with 0.1 increment), output of Voltage Inverter circuit should read same value but opposite sign as input.	Y
9. Weight sensor module reads maximum value when applied weight is larger than allowed	9. Apply large pressure (at least > 260 kg) on sensing pad and output of the module should still read 250 kg.	Y
10. Weight sensor module responds to sudden external pressure changes.	10. Apply intermittent weight to pads with time interval of one second, then acquire data from oscilloscope using Excel Add-In. Time delay should be less than 100ms.	Y
11. Microcontroller (Arduino Uno) has preset value to determine the location of sensing pad	11. Program preset values (0, 1, 2, 3) into microcontroller and then directly connects output to oscilloscope to check output match	Y
12. Microcontroller (Arduino Uno) converts binary value to corresponding decimal values	12. Use function generator to put in a waveform to the microcontroller and determine whether the output corresponds to the binary value.	Y
13. Microcontroller (Arduino Uno) converts binary output from sensing pad to corresponding decimal values	13. Connect sensing pad to microcontroller and apply known weight to the pad, observe the output of microcontroller and check against original object weight / pressure.	Y

Table 4 Receiver/Transmitter Requirements and Verifications

Requirement	Verification	Verification status (Y or N)
14. Centralized microcontroller (Arduino Uno) stores at least 100 entries, each entry representing information from one sensing pad.	14. Program test data into the microcontroller, outlining 100 entries to represent 100 hypothetical information. Then read output from microcontroller to ensure no loss of information.	Y
15. Centralized microcontroller (Arduino Uno) can send data to computer via 2.4-GHz Bluetooth (CC2540F128)	15a. Check that the computer is connected to the Bluetooth. 15b. Ensure no loss of information from the microcontroller to PC via Bluetooth.	Y
15.1. Computer end can receive data transmitted from Bluetooth	15.1.a Send test data via Bluetooth (from Arduino) and test connectivity. 15.1.b Check data received on Terminal and see whether data matches test data.	Y
15.2. Computer end can truncate data to only the digits that represent the value on four different sensor pads.	15.2. Input different values from different sensor pads and check the data from computer end match correct input data.	Y
15.3. Computer end can generate a text file that contains original data	15.3.a Computer end can generate a text file from "Processing." 15.3.b The text file generated only contains the test data and nothing else.	Y
15.4. Generated file will be updated automatically every 100ms.	15.4.a Generate random data with 100ms interval on Arduino side 15.4.b Check that the text file is automatically updated every 100ms.	Y

Table 5 Computer Display Requirements and Verifications

Requirement	Verification	Verification status (Y or N)
16. Receives information and can be read by IAR Embedded Benchwork.	16. Import data into IAR Embedded Benchwork to ensure that the data is compatible with the software provided by TI.	Y
17. Java program is robust to handle information inflow: a. Correctly parses information from centralized microcontroller; b. Interprets pressure and activity from each sensing pad.	17. Run the Java program against test data a. Use test data for parsing information and check that output matches the desired result b. Ensure that the correct information regarding each sensing pad can be correctly displayed as output.	Y
18. Upload information to website and publicize data online.	18. a. Check that the computer is connected to the Internet b. Check if the data is being updated live.	Y
19. Website can store all data without loss of information on database.	19. Check database has enough memory to hold the designed system, including all information on sensor pads and microcontrollers for the past hour.	Y