Posture Corrector

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Introduction

According to the American Chiropractic Association, 31 million americans experience low-back pain at any given time[1]. Lower back pain is the second most common reason for visits to a doctor, outnumbered only by upper-respiratory infections. Americans spend at least $50 billion each year on back pain[1]. A study done by the Agency for Healthcare Research and Quality showed that most cases of back pain are mechanical or non-organic, meaning they are not caused by some major illness[1]. National Center for Biotechnology Information states that acute episodes of back pain are associated with muscle strain. Poor posture, as will be defined in a moment is a major player in making 50% of people in the industrialized world suffer from some form of back complaint[12]. 8 out of 10 Americans have at some point been affected by lower back pain, accounts for 93 million days of lost work annually at an estimated cost of $11 billion[13].

The 'Slouch Detector/Posture detector' was a ECE 398/445 project[2], using two accelerometers attached to the back; one near the base of the spinal curve and one near the top to measure the posture.

We will change this to a small sized wearable device which can worn comfortably for long periods of time, add a gyroscope and get rid of an accelerometer to achieve a smaller size. We will also add a wireless communication module to send posture data which the user can use in forms of graphs. With the help of the gyroscope, we will also cover an additional axis to measure a more accurate and complete picture of posture.

Our posture affects the health of our spine. The vertebrae in the lumbar region are the largest in the spine; with L4 and L5 being damaged most frequently[12]. Here is a brief picture of the same.

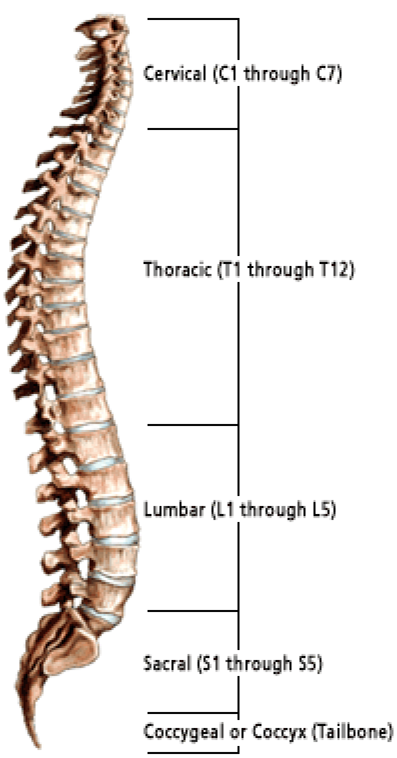


Fig. 1: The spinal cord with lower back pain in L4 and L5

The human body is not made to sit in front of computer screens for hours. The body weight while sitting gets distributed to the lower back and pelvic areas mainly.

Many studies have given some quantitative figures to maintain posture which we will describe below; but we will also go on to argue that this is not completely correct and at times not possible or efficient.

Our wearable will maintain posture within a range while accepting slouching as a way of relaxing muscles depending on the user's past data.

Research says that sitting completely upright at 90 degrees with thighs parallel to the floor is not possible and is too much strain on lumbar discs in the lower back[13]. Anything below 90 degrees for continuous periods of time is definitely not acceptable and is even more stressful to the spine.

Really the best bio-mechanical sitting position is about an angle of 135 degrees, with back support from a sturdy chair, which can essentially look like slouching. 135 degrees is the most natural posture and also what you get when you are floating in water or astronauts are in a weightless environment[13].

The last statistical information is that no matter what, assuming any position for a long period of time is a bad practise[13].

The problem with this angle is that you cannot always maintain it while working, especially while working on a computer. That is why many chairs have the option of leaning backwards.

Essentially what we are trying to achieve with our wearable is a periodic change is posture. It is difficult to lean back while using a computer, but you can lean back while talking on the phone.

In a nutshell, given a certain period of time, let's say about 3 hours; we should have some time allocated to:

- Sitting while leaning back around 110 degrees to 150 degrees.
  For 30 minutes
  Can do this while taking phone calls or reading a paper.
  This position leads to strain in the neck and is thus not advised.
- Leaning in front from 0 to 78 degrees.
  For 20 minutes.
  This creates movement in the muscles and can help relax them as well.
- Sit upright from around 79 degrees to around 105 degrees
  For 1 hour 50 minutes.
  For getting work done
- Walk around
  For 20 minutes.
  This is needed by the entire body to get some exercise and achieve complete and uniform blood circulation. This can be done while taking breaks such as walking to get food or refreshments.

By changing position, you send the forces in a different direction.
If we can maintain a certain quota of all such position in a given time, we can improve and maintain posture effectively.
These times are not fixed but all would have to be completed in the 3 hour span to move on to the next 3 hour cycle.

Design:

Block Diagram:

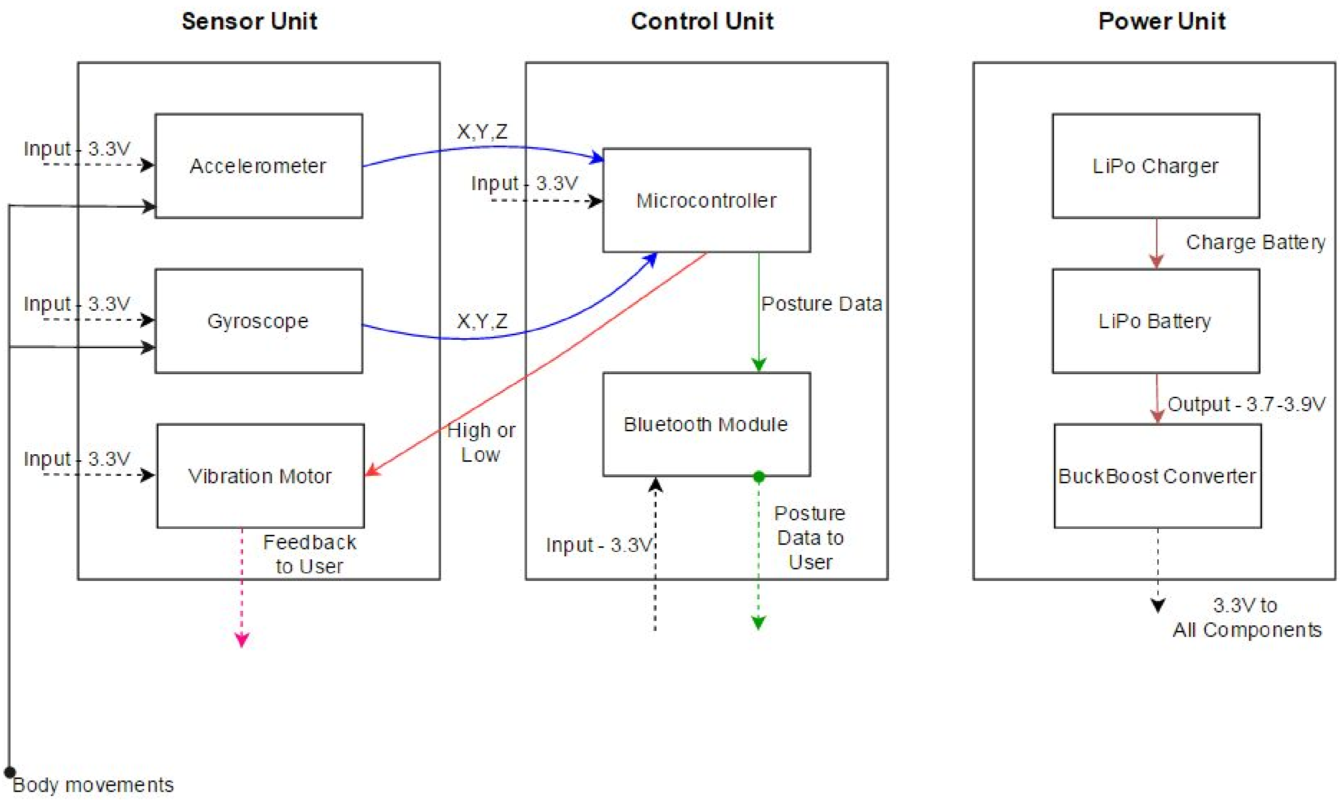


Fig. 2: Block diagram showing how the general layout of the circuit will be.

Finite State Machine:

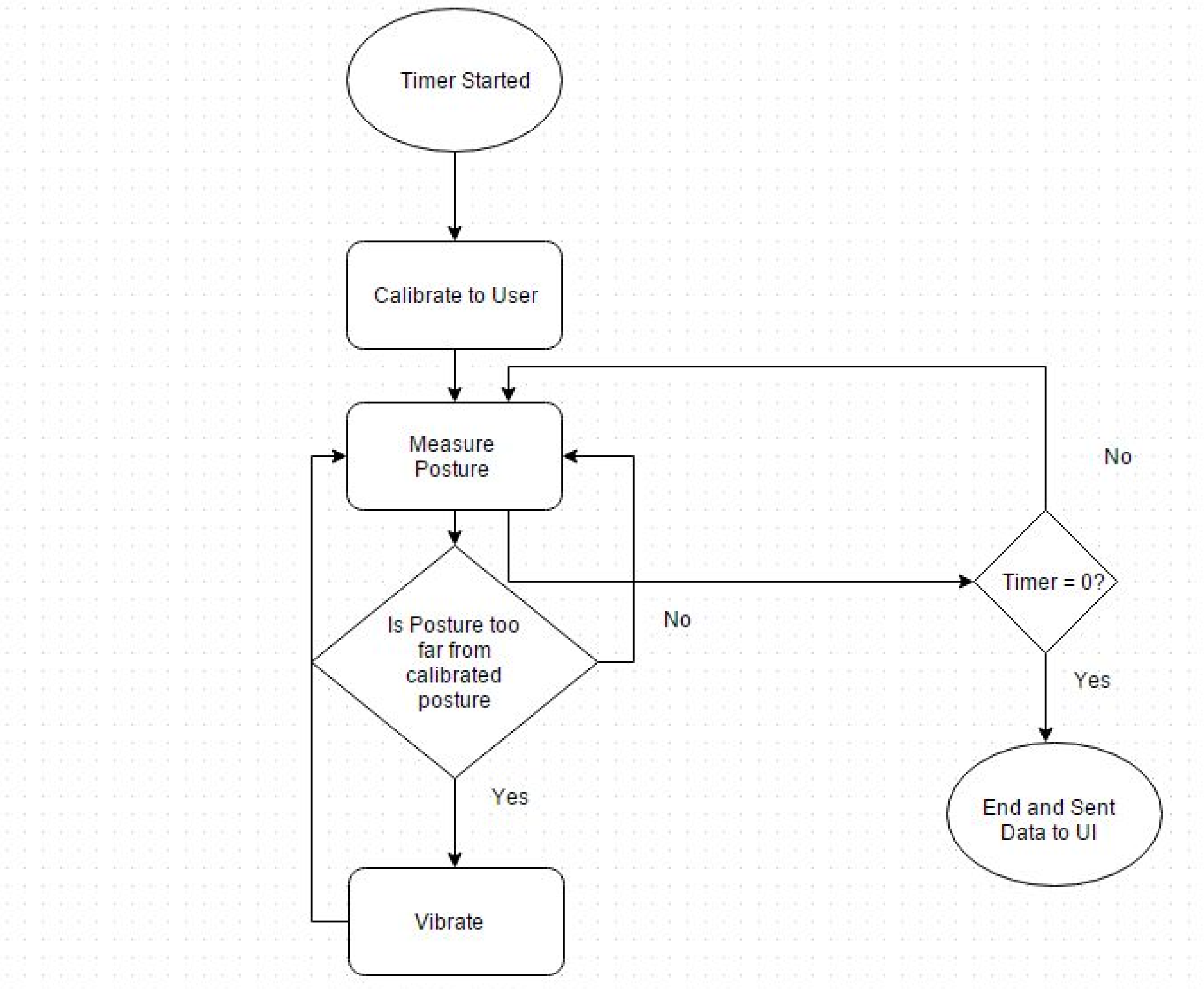


Fig. 3: State machine gives a brief description of how the product and software will work

Block Descriptions

(*All described with input, use, and output*)

Sensors

The sensor block is responsible for the input and output of the device. The accelerometer and gyroscope use body movements as input and vibration motor as output.

The intermediary function is handled by the control unit and power block for processing and voltage respectively.

Accelerometer[4]:

- Body movement and changes in posture will change angles measured by the accelerometer. Thus, body movement will act as input to accelerometers.
- Measures acceleration from a reference points which will be calibrated when wearing the device. Calculates change in position and produces x, y, z values accordingly.
- The x, y, z values are sent directly to the microcontroller which will then calculate the 3 dimensional angle.

Gyroscope[20]:

- Movement in the body, and changes in posture will produce a rate of change of the angular positions over time. Thus, body movement will act as input to gyroscope.
- Measures change in angles over time and produces x, y, z values accordingly.
- The x, y, z values are sent directly to the microcontroller which will then calculate the change in 3 dimensional angle as per requirement.

Vibration Motor[5]:

- Takes a high or low from the microcontroller
- Vibrates for a particular time if input signal from microcontroller is high and indicates to the user that they are not in a position that has acceptable posture.
- The output is a comfortable vibration.

Control Unit

The Control Unit is responsible for movement calculations, storing data, and bluetooth communication.

It will take input from the Sensor block and output to the Sensor block as well.

The power block is responsible for supplying the required voltage and current.

Microcontroller:

- Receives data from accelerometer and gyroscope.
  Receives power from battery.
- Computes the angle of the back through the accelerometer and gyroscope data. It stores this data temporarily. If any of these values cross the specified threshold values according to an algorithm; then it signals a high to the vibration motor.

- Sends a high to microcontroller if needed. Also outputs stored data via the bluetooth module when connected to a phone or computer.

Wireless Communication Module[6]:

- Takes the data (position angles and other details) from the microcontroller.
  Takes data from the computer if settings changed by user.
- It will connect to a computer and will be responsible for reliably sending data to the computer.
  It will send data to the microcontroller if there is any information sent from the computer to which it is connected.
- Will output data to the computer or microcontroller as needed.

Power:
The power block is responsible for charging the battery, and outputting battery voltage and current through the Buck-Boost converter to ensure that the circuit gets power as needed by it.

Li Po battery and recharging module:

- Input will be a micro usb to charge the battery.
- The rechargeable module will charge the battery and will have a status LED to let user know when the battery has completed charging.
- The output (of approximately 3.7 V to 3.9 V) will be to a Buck-Boost Converter.

Buck-Boost Convertor:

- Input will be voltage (of approximately 3.7 V to 3.9 V) from Li Po battery.
- This buck-boost converter, a single inductor will change the input voltage to a fixed output voltage of 3.3 V and will be capable of supplying 200mA if needed.
- Output will be a voltage of about 3.3 V which is ideal for the circuit and all the components. Also a current of 200mA is more than sufficient for all components.

Circuit Schematic

Our final product will comprise of different circuit schematics. They are:

a. Recharging module and Li PO battery pack.
b. Vibration motor to vibrate when so required by the MCU.
c. One accelerometer and one gyroscope.
d. A wireless communication module to send the stored/calculated data over low power bluetooth.
e. A buck-boost converter designed specifically for our circuit.
f. Pcb design with a microcontroller to work out the calculations by the accelerometer and gyroscope.

(a) The battery circuit schematic:

Module to recharge lithium ion battery[7].

- Charge using a micro usb.
- Status LED to show when the battery is charged.
- Voltage Regulator options: 4.20V, 4.35V, 4.40V, 4.50V
- Programmable charge current: 15mA to 500mA

All diagrams below; refer to [7]

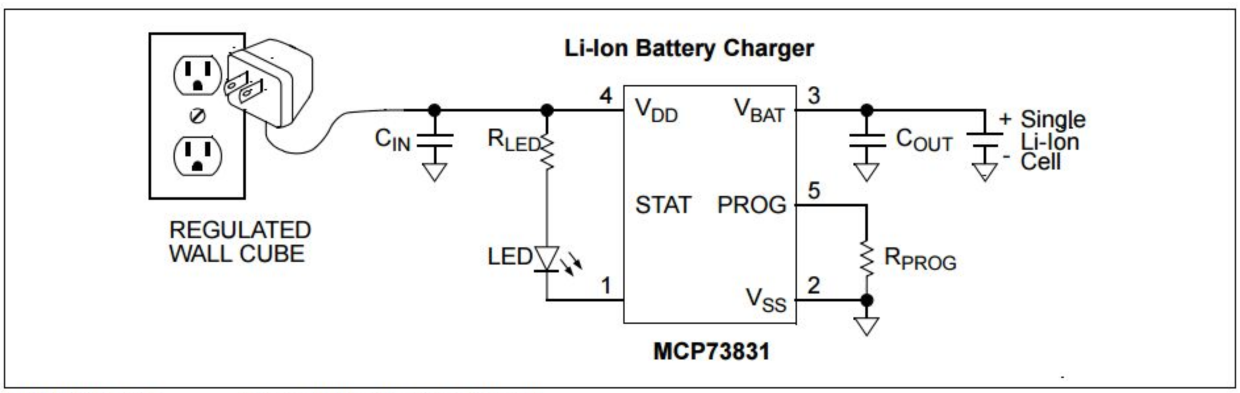


Fig. 4: Overview of circuit schematic for charger. Taken from sparkfun datasheet

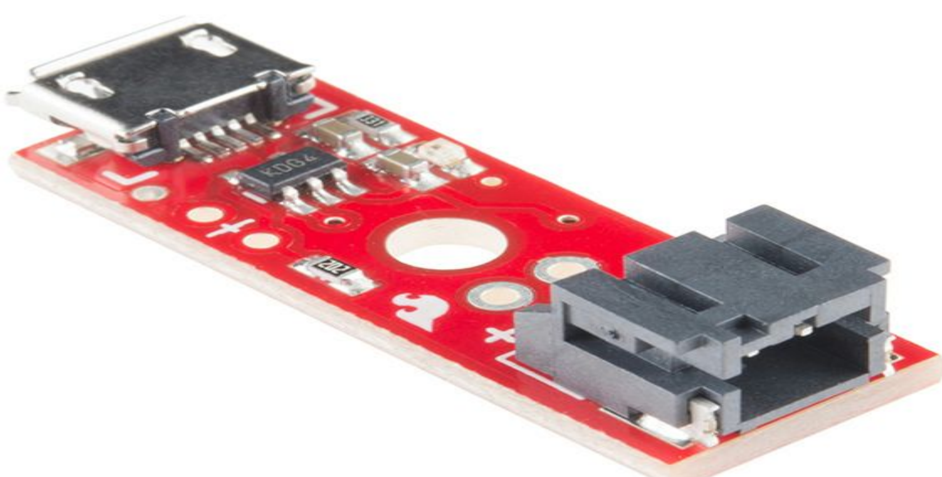


Fig. 5: How the charger will physically look.

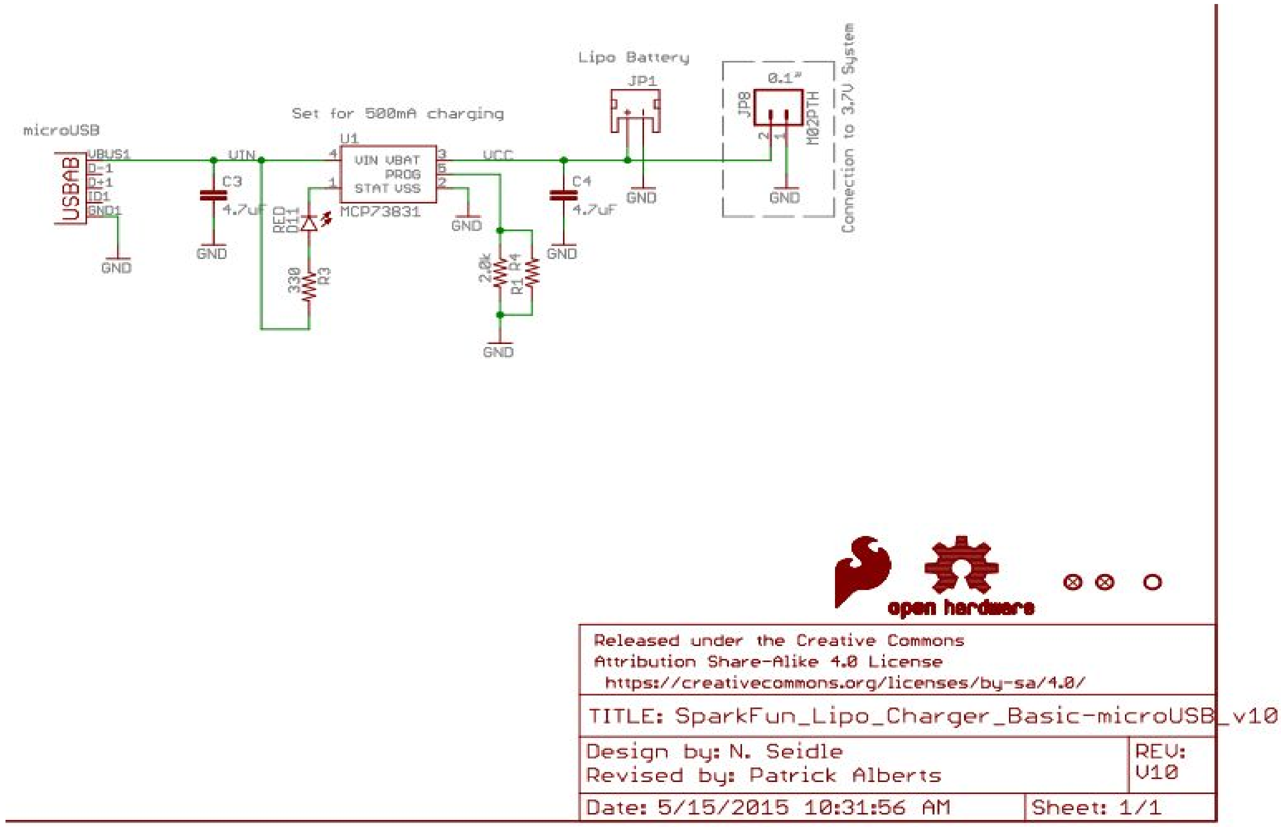


Fig. 6: Circuit schematic of charger.

(b) Vibration Motor:

Vibration motor expected to be a physical indicator without notifying anyone but the user.

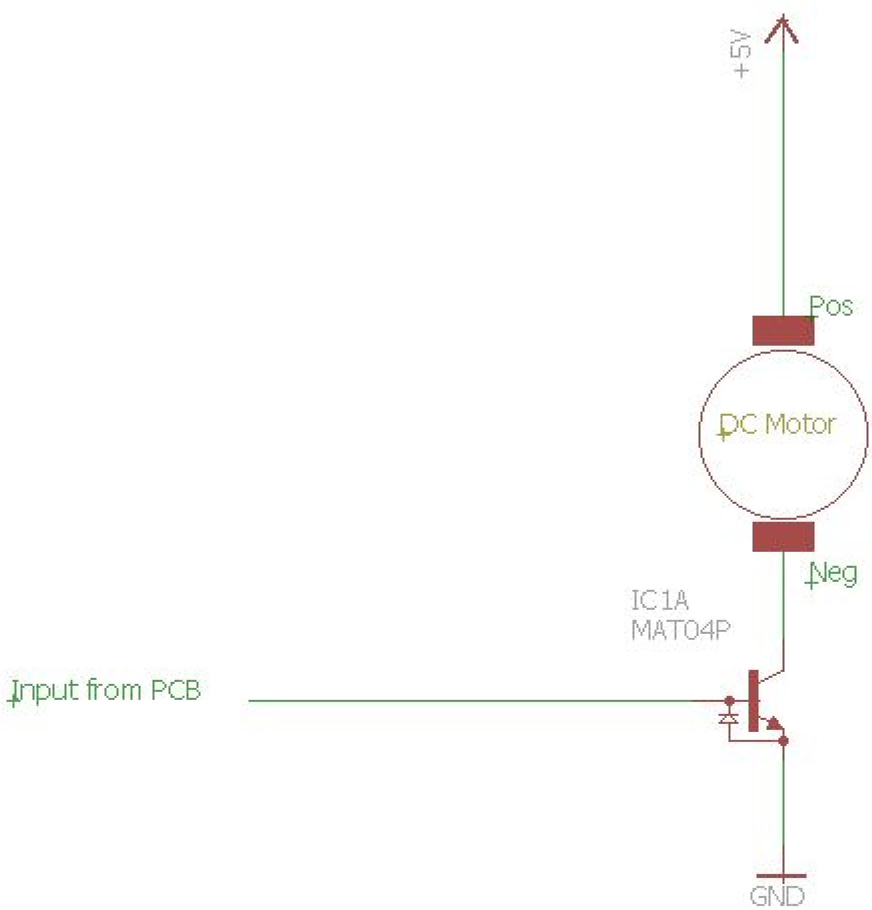
- Low powered
- Energy efficient
- As small / flat as possible to be a wearable.

Specifications of motor[5]:

- 10mm frame diameter
- 3.4 mm height
- weight 1.2grams
- 3V (2.5V to 3.8V)
- Rated current - 75 mA
- Start current - 85 mA
- Rated speed - 12000 rpm
- Terminal Resistance - 75 Ohms
- Vibration Amplitude - 0.8G

Fig. 7: How the vibration motor will look physically.
All these specific details have been taken from Sparkfun.com.

Fig. 8: Circuit diagram for vibration motor



The switch can be placed above the resistor.

Please note: We intend to reduce the size of this motor further; or rather want to make it flatter so that our final wearable device does not have to be restrained by the thickness.. As of now this is the smallest vibration motor we could find.

(c) Accelerometer and Gyroscope:

Accelerometer (MMA8452Q): [19]

- Low powered, 3-axis
- 12 bits of resolution
- Embedded interrupt functions relieves host processor from continuously polling data
- has selectable full scales of +2g/+4g/+8g
- 1.95 V to 3.6 V supply voltage
- Output Data Range from 1.56 Hz to 800 Hz
- Current consumption 6uA to 165 uA

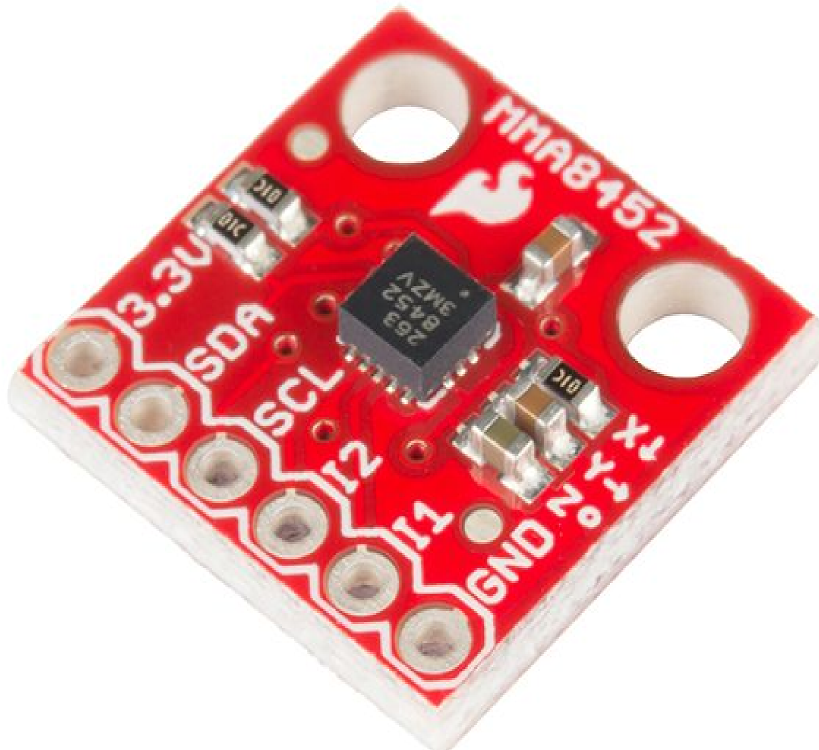
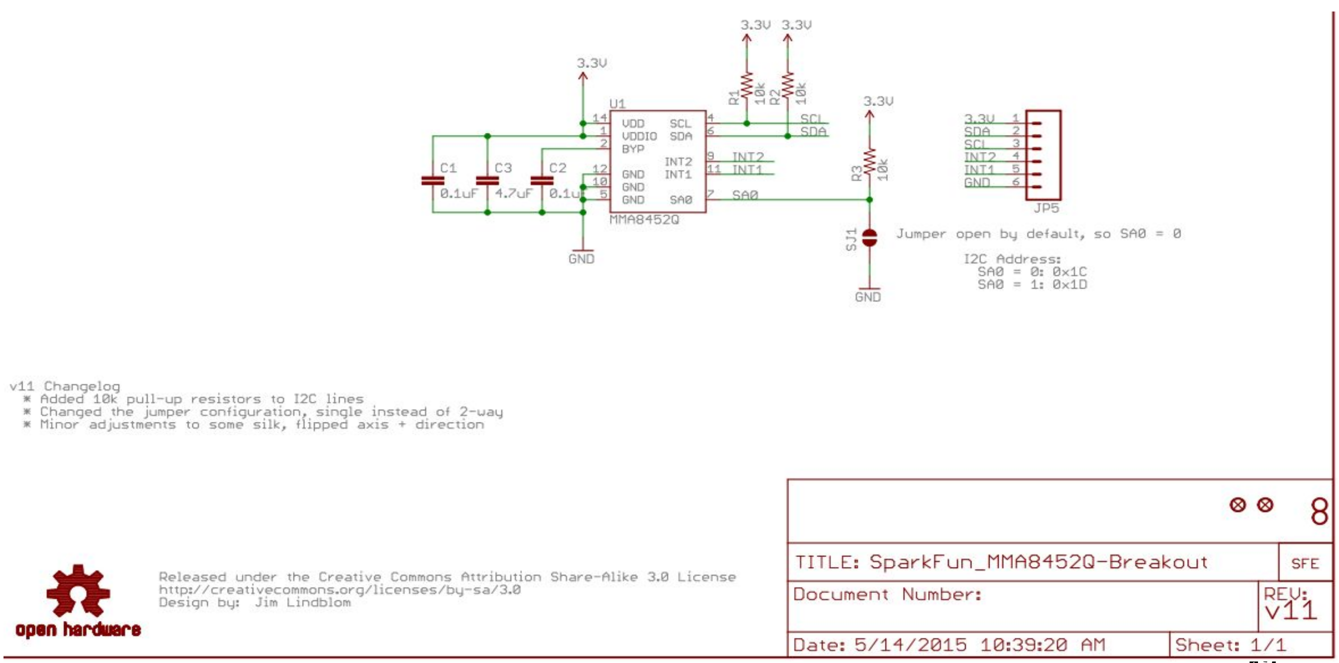


Fig. 9: How the accelerometer will look physically.

Fig. 10: Circuit schematic for accelerometer. Taken from sparkfun.



Gyroscope (ITG-3200): [20]

- 3-axis
- Embedded temperature sensor
- 2.1 V to 3.6 V supply voltage
- Current consumption 6.5mA
- Embedded interrupt functions

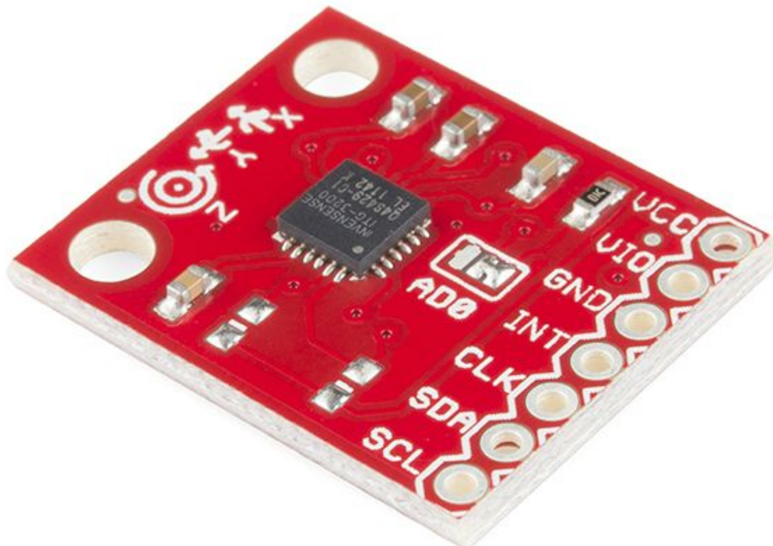


Fig. 11: How the gyroscope will look physically.

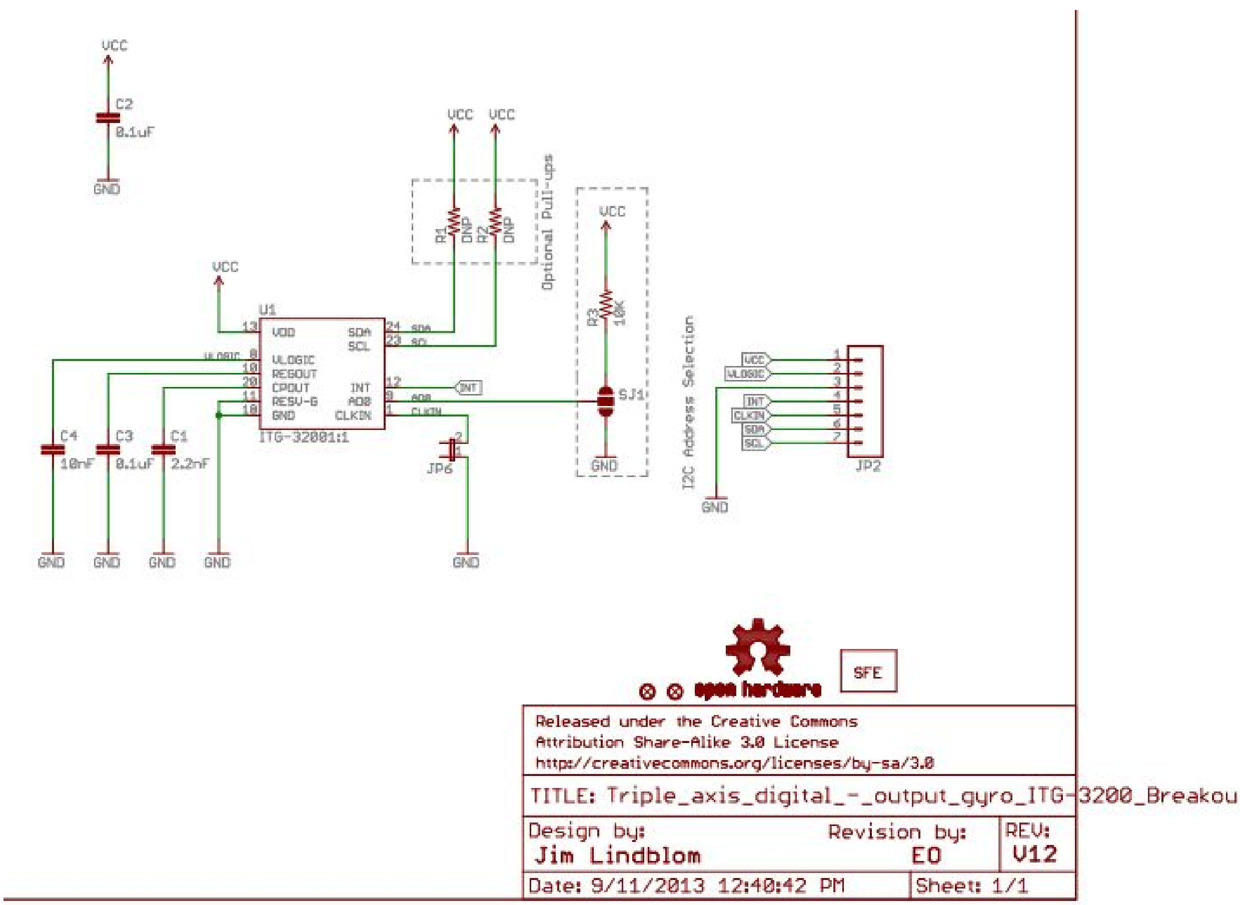


Fig. 12: Circuit schematic of the gyroscope.

(d) The communication module (RN41-XV Chip Antenna):
Bluetooth module to connect to our pcb which will be capable of sending data[6].

- Low Powered bluetooth radio module.
- Version 2.1 and backward compatible with version 2.0, 1.2, 1.1
- Has a range of up to 100m and can transfer data at a rate of 300 kbps.
- Power consumption is 30mA connected, <10mA sniff mode.
- Secure communications, 128 bit encryption.
- 3V DC supply voltage (max 3.6V and avg 3.3V).
- 3.3 V continuous supply from a buck-boost converter.
- Chip antenna on board

Fig. 13: How the bluetooth module will look physically.

Fig. 14: Radio characteristics of bluetooth module.

TABLE 2-6: RN41XV RADIO CHARACTERISTICS

Parameter	Frequency (GHz)	Min.	Typ.	Max.	Bluetooth Specification	Units
Sensitivity at 0.1% BER	2.402	-	-80	-86	≤ -70	dBm
	2.441	-	-80	-86		dBm
	2.480	-	-80	-86		dBm
RF Transmit Power	2.402	15.0	16.0		≤ 20	dBm
	2.441	15.0	16.0			dBm
	2.480	15.0	16.0			dBm
Initial Carrier Frequency Tolerance	2.402	-	5	75	75	kHz
	2.441	-	5	75		kHz
	2.480	-	5	75		kHz
20 dB Bandwidth for Modulated Carrier		-	900	1,000	≤ 1,000	kHz
Drift (Five Slots Packet)		-	15	-	40	kHz
Drift Rate		-	13	-	20	kHz
$\Delta f1_{avg}$ Maximum Modulation	2.402	140	165	175	> 140	kHz
	2.441	140	165	175		kHz
	2.480	140	165	175		kHz
$\Delta f2_{avg}$ Minimum Modulation	2.402	140	190	-	115	kHz
	2.441	140	190	-		kHz
	2.480	140	190	-		kHz

Schematic of Bluetooth Module

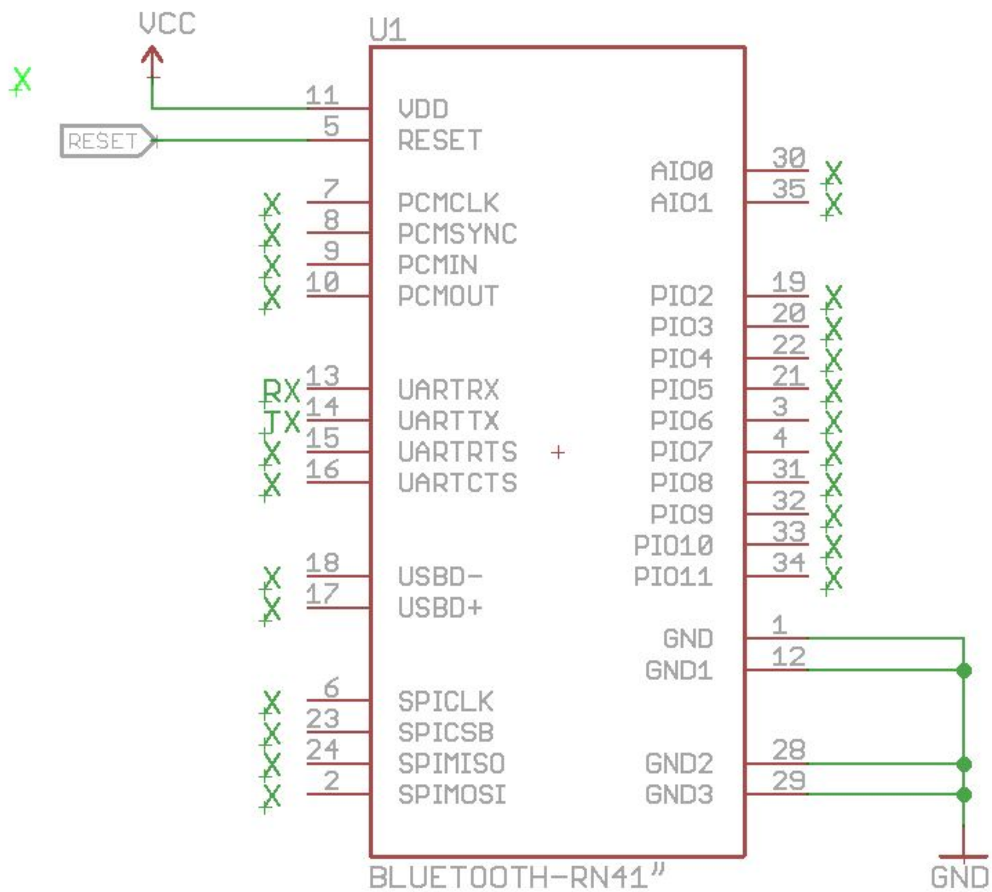


Fig. 15: Pin arrangement of the bluetooth module

(e) Buck-Boost convertor:

A buck boost converter is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude.

We will be using a buck boost circuit as shown below[21].

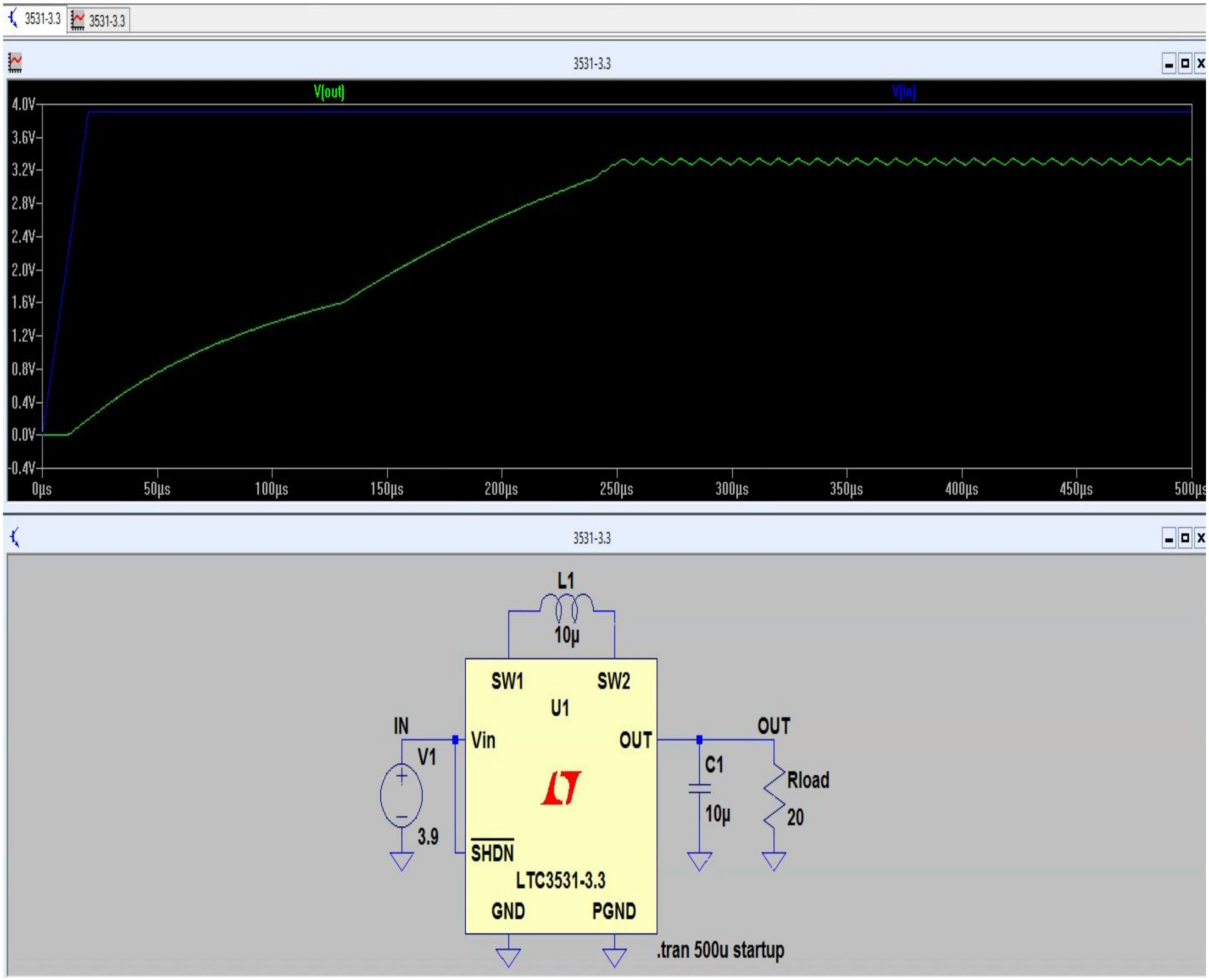


Fig. 16: Graph and circuit schematic of Buck-boost convertor

Blue line in graph	Battery input voltage
Green line in graph	Output voltage from buck-boost converter

(f) Microcontroller(AtMega328):

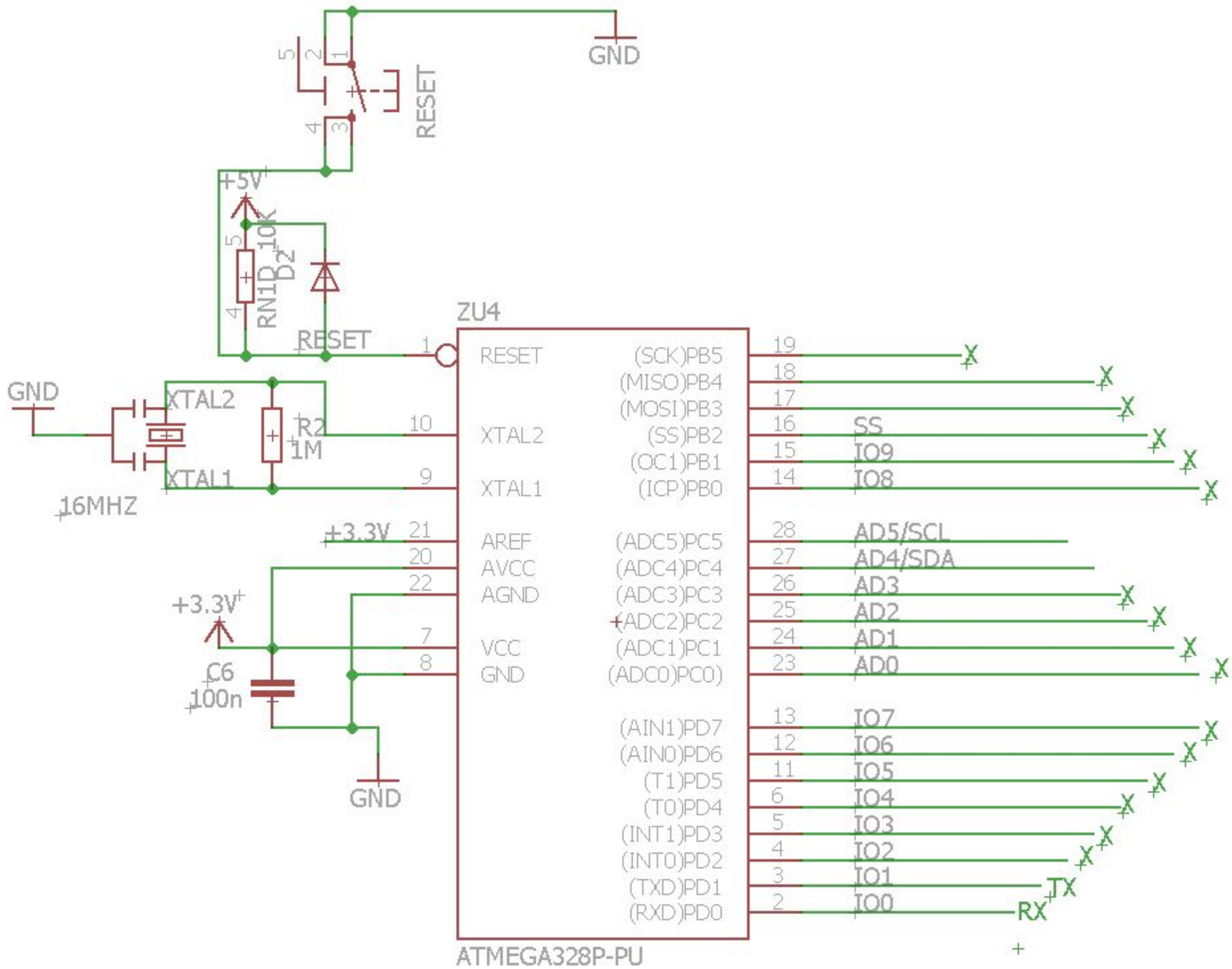


Fig. 17: Pin arrangement and basic layout of microcontroller

- 8-bit microcontroller
- 32kb flash memory
- 23 I/O pins

Calculations:

- **For vibration motor (DC shaftless motor)**

If we observe, this motor has a higher starting current than when running continuously. DC motors unlike other motors have a very high starting current that has the potential of damaging the internal circuit.

Let us further explore why we need that extra current. The basic operational voltage equation of the dc motor is given by,

$$E = E_b + I_a R_a$$

E = supply
Ia = armature current
Ra = armature resistance
Eb = back emf
The back emf is produced by the rotational motion of the current carrying armature conductor in presence of the field.

$$E_b = \frac{P.\phi.Z.N}{60A}$$

So, we can see that back emf depends on the speed of the motor (N). Since, N = 0 at the time the motor starts, $E_b = 0$.
Our final operational voltage equation becomes $E = 0 + I_a R_a$.
Thus, $I_a = \frac{E}{R_a}$.
This is why we have a very high starting current; and a result high starting torque.

This is why we use a starter to limit this current. This starter is basically a variable resistor (R_{ext}) connected in series to the 'armature winding' so as to limit the starting current of this motor to a desired optimum value.

Therefore, $I_a = \frac{E}{R_a + R_{ext}}$

Now as the motor continues to run and gather speed, the back emf successively develops and increases, countering the supply voltage, resulting in the decrease of the net working voltage. Thus now,

Therefore, $I_a = \frac{E - E_b}{R_a + R_{ext}}$

At this moment to maintain the armature current to its rated value, R_{ext} is progressively decreased unless it's made zero, when the back emf produced is at its maximum. The regulation of the external resistance in case of the starting of dc motor is facilitated by means of the starter.

- **Plot (simulation or experiment) for vibration motors**

This would be any kind of data that you acquired in the course of your design

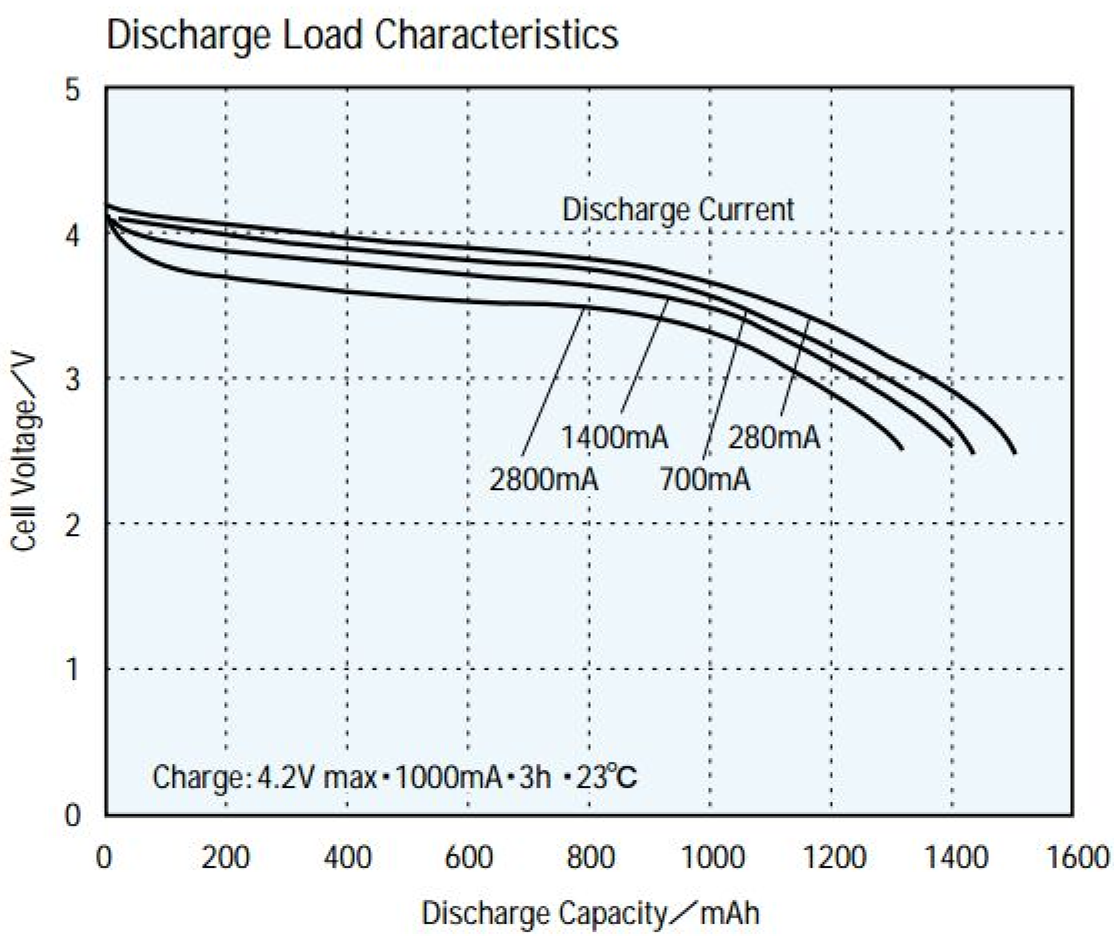


Fig. 18: Cell discharge graph. Polymer Lithium Ion DataSheet[11]

We will now calculate the approximate weight of our device. Since it is a small wearable, we would expect it to be as light as possible.

Weight of battery = 9 grams
Weight of charger = 5.5 grams
Weight of gyroscope = 17 grams
Weight of accelerometer = 15 grams
Weight of bluetooth module = 18 grams
Weight of vibration motor = 6.5 grams
Weight of microcontroller = 5 grams
Weight of other parts like board and wires = 20 grams
Weight of outer body = 4 grams

Thus, the total rough weight approximation is **100 grams**.

Now, we will calculate the dimensions of the device.

Components of size slightly greater than a quarter - gyroscope, battery, charger, bluetooth
Components of size slightly smaller than a quarter - accelerometer, vibration motor

Thus, approximating these sizes, our product should be about 6 quarters in a rectangle.
Diameter of a quarter = 0.955 inches.
Thus, our device will be about **2.865 inches x 1.91 inches x 0.5 inches.**

Now, we will calculate a rough approximation of the duration the device will run.
The components are individually connected to the battery and will only pull current when needed. Taking a value higher than the average but not the maximum value (to give us a good approximation), the circuit will continuously draw about 200mA of current.

Calculating the charge consumed in 1 hour = 60 mAh
Total charge on battery = 400 mAh
Thus, on continuous use with the bluetooth always on, it will run for about **6.6 to 7 hours**.

Now we will have a look at a daily use of 10 hours.
The vibration motor can be expected to run for about 1 hour maximum and we will keep the bluetooth always on.
Thus, we are looking at a charge of 25mAh maximum, with an efficient algorithm that wakes up the bluetooth module as per requirement.

Thus, in a day we will consume about 250 mAh. Thus, we can expect our device to run for about **20 hours (2 day usage)** continuously.

Now, we will see the charging time of the device,

The battery capacity is 400mAh.
The LiPo charger charges the battery at a rate of about slight more than 400mAh .
Thus, the total **charging time is 1 hour or less**.

Block Level Requirements and Verification

Module	Requirement	Verification	Points
Li Po Charger	● Output: 4.2 V ± 0.03 V 400mA ± 10mA	● An ammeter (DMM in the DC mA mode) and a voltmeter (DMM in DC mode) can be used to measure if the output falls in the range.	[/ 15]
Polymer Lithium Ion Battery	● Output: 3.7 V - 3.9 V 200mA - 400mA	● An ammeter (DMM in the DC mA mode) and a voltmeter (DMM in DC mode) can be used to measure if the output falls in the range.	[/ 10]
Buck-Boost converter	● Output: 3.3 V ± 0.03 V and 200mA ± 10mA	● Supply the converter with 3.7V, and go by increments of 0.1 to 3.9V to simulate the range output of the Lithium Polymer Battery. ● Output should be within the parameters specified tested through a multimeter.	[/ 15]
Accelerometer	● Output: scalar corresponding to the magnitude of the acceleration vector values in x,y,z, axis with a resolution of at least 5 degrees.	● Connect the accelerometer to an arduino which can display real time values on the computer. ● Place the accelerometer flat on surface and then rotate along all axes.	[/ 15]
Gyroscope	● Output: scalar corresponding to the magnitude of the rotational vector values around the	● Connect the gyroscope to an arduino which can display real time values on the computer.	[/ 15]

	x,y,z, axis with a resolution of at least 5 degrees.	• Place the gyroscope flat on surface and then rotate along all axes.	
Bluetooth module	• Should be able to pair with devices at least 10 feet away.	• Program microcontroller to send certain predefined values to the bluetooth device through RXD and TXD pins. • Place circuit approximately 10 feet away from a paired device and then read the data being sent and check if it matches with predefined values.	[/ 15]
Vibration motor	• Motor should not pull more than 90mA when operational.	• Connect the motor to the microcontroller and run it. • Using an oscilloscope, measure and graph the current being draw. • To pass it can't draw more than 85mA	[/ 15]
Microcontroller	• Controller will receive the data from the sensors via I2C at a minimal rate of 5Hz.	• Connect the sensors to the microcontroller. • Microcontroller will be programmed to send a high at a predefined angle and a low otherwise. • Place the sensors in predefined angles. • Microcontroller will output a high if the angle matches which will be probed and graphed on an oscilloscope.	

Tolerance Analysis:
Our buck-boost converter will be the main component responsible for keeping voltage under control in the entire circuit and we will do a tolerance analysis on it.
All our components require an average of 3.3 V and our buck-boost converter brings down the 3.7V to 3.9V battery power supply to 3.3V so that all the components can run directly. According to the information provided, the input can between 3.1V-4.2V and the output will be kept at 3.3V. With a function generator we will sweep from 0V to 4.2V at increments of 0.1.

As we have seen in the simulation of the buck-boost converter, the output voltage from the buck-boost converter increase linearly with the input voltage, but after hitting 3.3V it just stays there and oscillates about 0.15V up and down from 3.3V.

Safety Statement:
Since we are making a wearable, we will have to make sure that even if something fails, it either recovers gracefully; else stays intact and limited to the device such that the user has no physical signs of the device being broken.
Some of the things to keep in mind are:

- The battery has to be properly packed. Has to be surge protected and properly packed to prevent any leakage.
- We need to understand that a short is possible in case the device is managed roughly. We have to isolate all the components as much as possible to prevent this; and also have to incorporate a circuit breaker.
- Something to consider would be the heat of the board, if it is run for a very long time, there is a chance that the heat from the board could be harmful to the user or the surrounding parts.
- People wearing pacemakers should be careful while using this as electrical and magnetic components can interfere with its working.
- If device cause rashes or allergies, consult a doctor immediately.

Ethics
Our project follows the IEEE code of ethics as follows[22]:

[1] To accept responsibility in making decisions with the safety, health, and welfare for the public, and to disclose promptly factors that might endanger the public or the environment.

[2] To avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist.

[3] To be honest and realistic in stating claims or estimates based on available data

[5] To improve the understanding of technology; its appropriate application, and potential consequences.

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

[8] To treat fairly all persons and to not engage in acts of discrimination.

[9] To avoid injuring others, their property, reputation, or employment by false or malicious action.

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

Cost and Schedule

Cost Analysis:

Labor:

Name	Hourly Rate	Total Hours (12 weeks * 15 hours/week)	Cost per person
Vignesh	$35	180	6,300
Vishal	$35	180	6,300
Shubham	$35	180	6,300
		Overhead cost	2.5 times the overall cost (for overheads)
		Total Cost	18,900 * 2.5 = 47,250

Parts List:

Electronic components	Cost
Li Po Battery	$10
Li Po Battery Charger	$10
Wireless communication module	$35
Gyroscope	$10
Accelerometers	$10
Motors (including charger, circuit to recharge battery without removing it from original case)	$20
Wires, taping and other small things	$30
PCB	$20
Total cost	$150

Schedule:

We will all be involved in designing the pcb and the communication module as that is the crux of the course. After that is done, we will try to divide work amongst us as evenly as possible.

However, we will have to every now and then work together or at least in pairs so that everyone is on the same page and so that one single person does not become overwhelmed by the assigned workload.

A more planned schedule is described below:

Weeks	Progress	People working on it
7th-13th Feb	get proposal made and discuss with TA. Submit proposal and start with initial design and thoughts on how to start making it. Select a slot for Mock design review	Vignesh Vishal Shubham
14th-20 Feb	Order parts and get everything together Mock design review Work on the eagle assignment	Vishal Vignesh Shubham
21st-27th Feb	Finish verifying everything so we are sure we have all the parts and don't have to wait later. Design review sign up Complete Lab safety training Research and Choosing Microcontroller	Shubham Vishal all have to do Vignesh
28th Feb-5th March	finish pcb design. Design Review Block Diagrams	Shubham Vignesh Vishal
6th -12th March	Send pcb design to fabrication lab to be made Work on assembling parts needed for circuit	Vishal Shubham

	Make testing platform for all parts	Vignesh
13th-19th March	Start assembling after getting back pcb Start testing all the assembled things Design how final body will look like	Vishal Vignesh Shubham
20th-26th March	First revision of pcb Test everything and see what final parts will be needed Spring break. Finish whatever has been still left from previous weeks to stay on schedule	Shubham Vignesh Vishal
27th March-2nd April	Mock Demo Individual progress report Requirements and Verification final attempt due Check safety and other requirements of device	Vishal all have to do Vignesh Shubham
3rd-9th April	Mock Demo Finalize final design Make sure device is ready for demo	Vignesh Vishal Shubham
10th-16th April	Finish final design Make sure device is ready for demo Mock Demo	Shubham Vishal Vignesh
17th-23rd April	Demo sign up Mock presentation sign up Start working on final paper	Shubham Vishal Vignesh
24th-30th April	Demonstration Do rigorous testing on product Presentation sign up	Vignesh Vishal Shubham

1st-6th May	Turn in final papers Make sure nothing is left out in final paper and that all components are returned to lab Lab checkout	Vignesh Vishal Shubham
7th-15th May	Final exams	all

Citations:

[1] Getting facts about back pain
http://www.acatoday.org/Patients/Health-Wellness-Information/Back-Pain-Facts-and-Statistics

[2] previous projects done by students used as a reference
https://courses.engr.illinois.edu/ece445/getfile.asp?id=6910

[3] Got the idea for using an EMG from here. We might give sockets to add these to final product
http://www.instructables.com/id/Muscle-EMG-Sensor-for-a-Microcontroller/

[4] We will use this when making the circuit for accelerometers
http://www.dimensionengineering.com/info/accelerometers

[5] Vibration motor
https://www.sparkfun.com/products/8449

[6] bluetooth module
https://www.sparkfun.com/products/11601

[7] battery charger from micro usb
https://www.sparkfun.com/products/10217

[8] lithium ion battery
https://www.sparkfun.com/products/10718

[9] Check out which linear voltage regulator is needed from this page
http://www.mouser.com/Semiconductors/Power-Management-ICs/Linear-Voltage-Regulators/_/N-5cg9g

[10] Calculation for power loss to heat
https://www.dimensionengineering.com/info/switching-regulators

[11] Lithium Ion Battery- Discharge Characteristics
http://cdn.sparkfun.com/datasheets/Prototyping/Lithium%20Ion%20Battery%20MSDS.pdf

[12] CUERGO
http://ergo.human.cornell.edu/DEA3250Flipbook/DEA3250notes/sitting.html

[13] post gazette - the 135 degrees sitting requirement
http://www.post-gazette.com/news/health/2006/12/06/Study-finds-leaning-back-at-135-degree-body-thigh-angle-is-best/stories/200612060260

[14] This is extra here.
http://www.lifehacker.com.au/2013/11/the-science-behind-posture-and-how-it-affects-your-brain/

[15] This is extra here.
http://news.bbc.co.uk/2/hi/6187080.stm

[16] This is extra here.
http://theinformationage.co/2013/12/09/the-science-of-posture-why-sitting-up-straight-makes-you-happier-and-more-productive/

[17] This is extra here.
https://courses.engr.illinois.edu/ece445/getfile.asp?id=6753

[18] Li Po battery from sparkfun
https://www.sparkfun.com/products/10718

[19] Triple axis accelerometer
https://www.sparkfun.com/products/12756?_ga=1.200339947.471201849.1456630813

[20] Triple axis gyroscope
https://www.sparkfun.com/products/11977
https://www.sparkfun.com/products/9793

[21] Buck-boost circuit
http://cds.linear.com/docs/en/datasheet/3531fb.pdf
https://en.wikipedia.org/wiki/Buck%E2%80%93boost_converter
http://www.linear.com/product/LTC3531

[22] IEEE code of ethics
http://www.ieee.org/about/corporate/governance/p7-8.html

Suggested websites to see:
Below are couple of suggested motors that can be used:
https://www.sparkfun.com/products/11008
https://www.sparkfun.com/products/8449
http://www.precisionmicrodrives.com/vibrating-vibrator-vibration-motors/pancake-shaftless-coin-vibration-motors/design-considerations

The following links to get a lithium ion battery and recharge it using a micro usb.
https://www.sparkfun.com/products/10217
https://www.sparkfun.com/products/10718

Following link for a bluetooth module
https://www.sparkfun.com/products/11601

Calculations for high starting current for vibration motor
http://www.electrical4u.com/starting-methods-to-limit-starting-current-torque-of-dc-motor/

A few additional features we can add later on

- **fidgeting:** body's defense against postural stress of which discomfort is a sign. Using the rate of fidgeting, we can index the value of chair discomfort.

OVERALL PRODUCT DESCRIPTION

In general, we expect the entire product to be smaller than the size of a credit card and can be slipped into a pocket stitched to the inside of the back of a shirt.

On further development, we should be able to bring it down to the size of a thumb nail and will have the capability of being just slipped in the front pocket of a shirt. The gyroscope should be able to tell the relative position.

We do not need any form of approvals or certifications as we will market the product for recreation use and not as a medical device. To market it as a medical device will require a lot of resources and the device will have to cater to individual specific use.

The microcontroller was specifically chosen as it can handle communication between various components and can also communicate with the bluetooth module. A smaller microcontroller was incapable of bluetooth communication and any microcontroller, larger than the selected one will not be put to its full use.

A voltage of about 3.3 V and current of 200mA will be absolutely fine to run our device and will not heat or damage the circuit or the board. These boards and components that we will use can typically sustain up to about 3.6 V and 300 mA of current without any trouble. Thus we are confident of not frying up our board in the process.