Design Document

Textbook Detection System with Radio-
Frequency Identification

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1 Introduction

1.1 Objective

College Students bring textbooks with them to attend classes. Sometimes students forget to bring their books or lecture notes with them, especially for a student with a heavy schedule. Failing to bring all the required books may affect students' studying efficiency.

Our goal is to make a device that can keep tracking the information about textbooks in a student's backpack based on his/her daily schedule. In order to make a user interface, we will also develop a mobile application so that our monitor system will transmit book information remotely to the student's phone. The basic technique we will use is radio-frequency identification (RFID) and each book will be equipped with a unique identification. We will design our control unit and a power module to interact with our identification reader module and Bluetooth module. We apply multiple sensors and LEDs in order to monitor the status of our device.

1.2 Background

Most reminder applications in the market are non-physical mobile applications. These apps are similar to a calendar, but most of them do not contain a physical design to establish the connection between the schedule and hardcopy textbooks. On the other hand, there are quite a lot applications about radio-frequency identification. However, most applications use RFID as an anti-theft device, such as credit card and ATM card [1]. Our design will combine the hardware RFID reader with a mobile application with Bluetooth connection.

1.3 High-Level Requirements

- The RFID antenna should be at least 15 cm wide and 3 cm high, so that our device can easily detect the tags. The RFID reader should also be able to read at least two half-inch depth book at the same time
- The power supply of our system should be able to provide enough power on a daily basis, at least 10 hours under normal usage.
- We need to implement our protection mechanism for the battery. We need to have a protection circuit that will turn off the power supply for the rest of the circuit if the battery voltage goes below 3.3V or above 4.2V

2 Design

2.1 Block Diagram

Our system requires four sub-sections to operate: the power module, the control module, the Bluetooth module and the RFID module. The dashed line represents how power is delivered into different sections. The power module contains the battery, a protection circuit, and a voltage regulator. The protection circuit will shut down the power when the battery voltage drops below 3.3V or above 4.2V. The voltage regulator is a low dropout regulator that will regulate battery voltage to 3.3V. The control module consists of a microcontroller, two sensors, and LEDs. The temperature sensor will monitor the battery temperature. If the battery temperature exceeds the limit, the microcontroller will alert the user. Based on the force sensor, if there is no change on the total weight of the backpack for a period of time, the microcontroller will turn off the RFID antenna. In the RFID module, we will design and tune the antenna circuit to achieve 4 cm to 5 cm reading distance. Lastly, a Bluetooth module will transmit the data wirelessly to a user device such as an android phone.

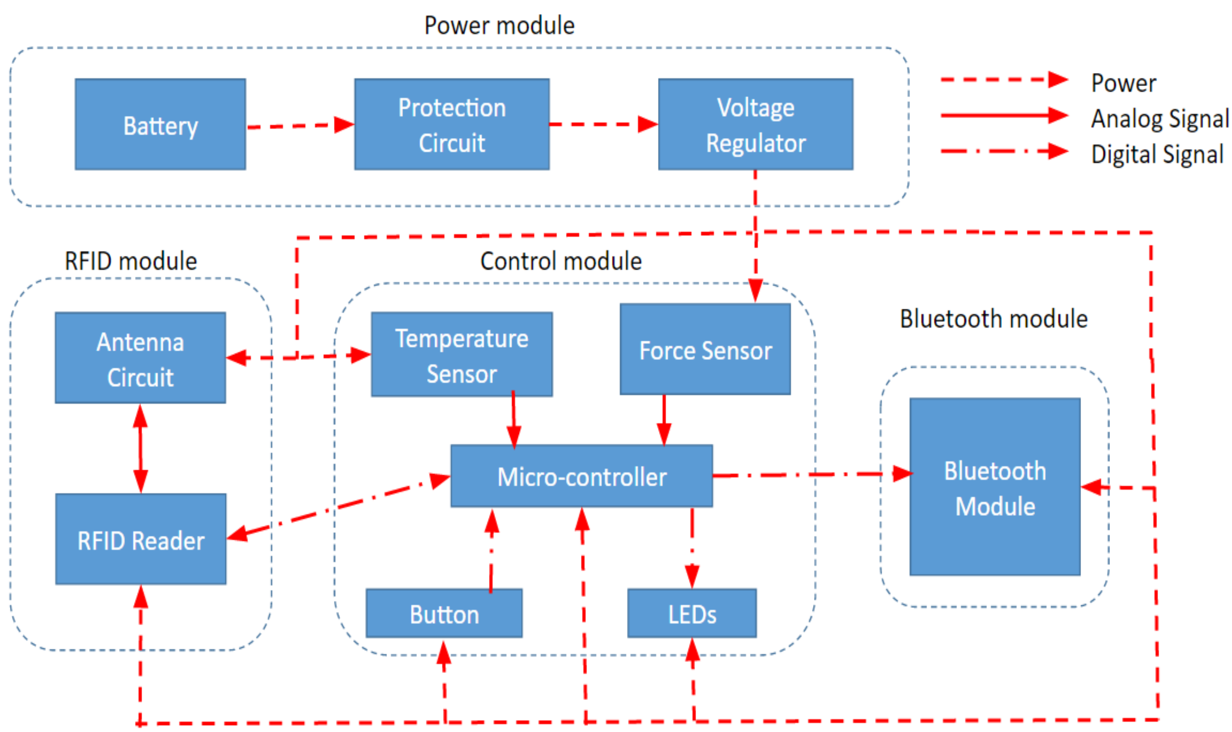


Fig.1. Block Diagram

2.2 Physical Design

We plan to place the force sensor at the bottom of the bag, everything else except the force sensor and the temperature sensor will be mounted on a single PCB near the top of the bag. This will ensure that the tag will always pass the detection field, but not staying in the field. The battery will be next to the PCB to provide enough power on a daily basis. We place the force sensor at the bottom of the bag to measure the weight change. To achieve a relatively large detection area, the RFID antenna should be at least 15 cm wide and 3 cm high. If the weight does not change for a period of time or no tag is detected for a long time, we will turn off RFID antenna to save power.

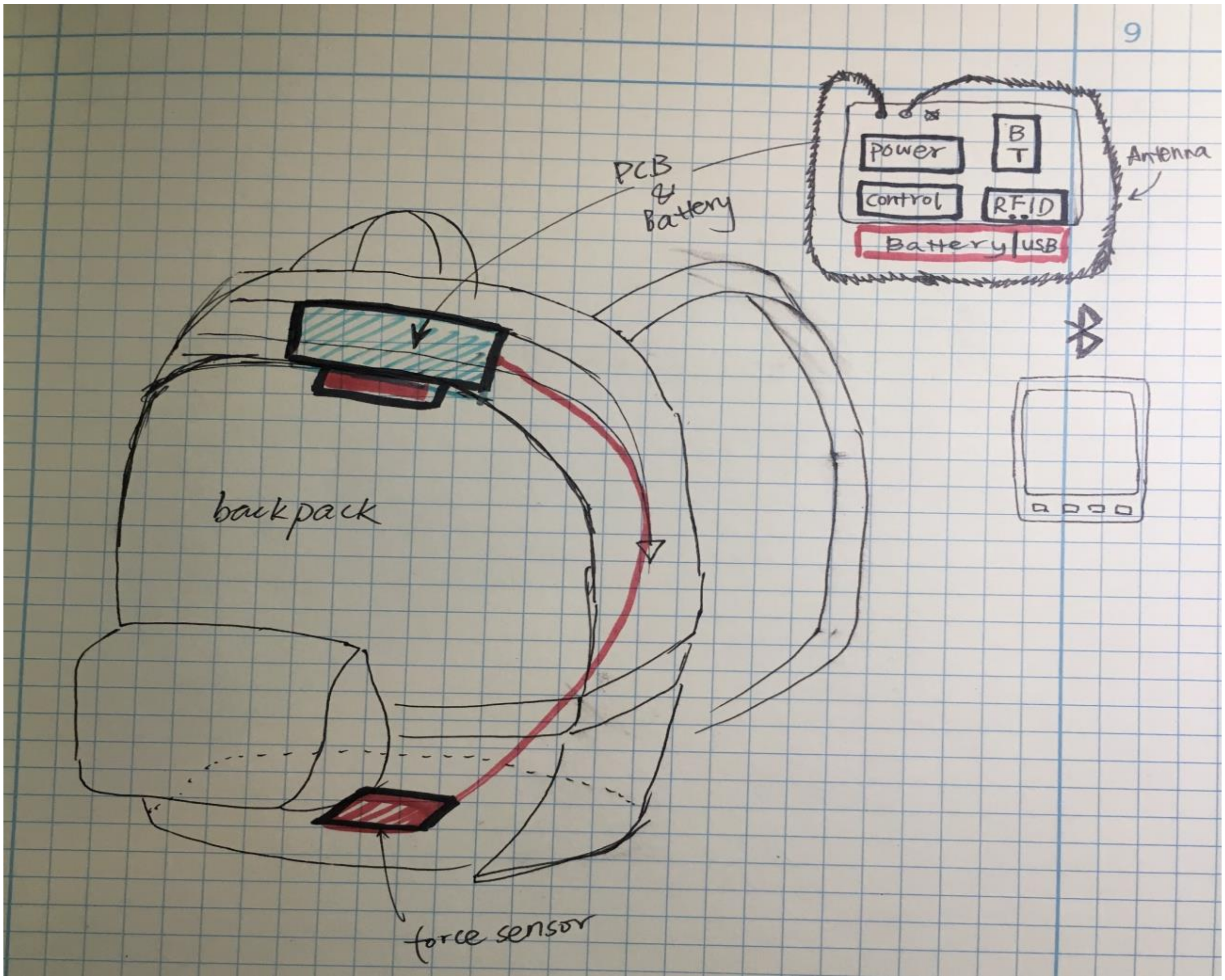


Fig.2. Physical Design Sketch

2.3 Power Module

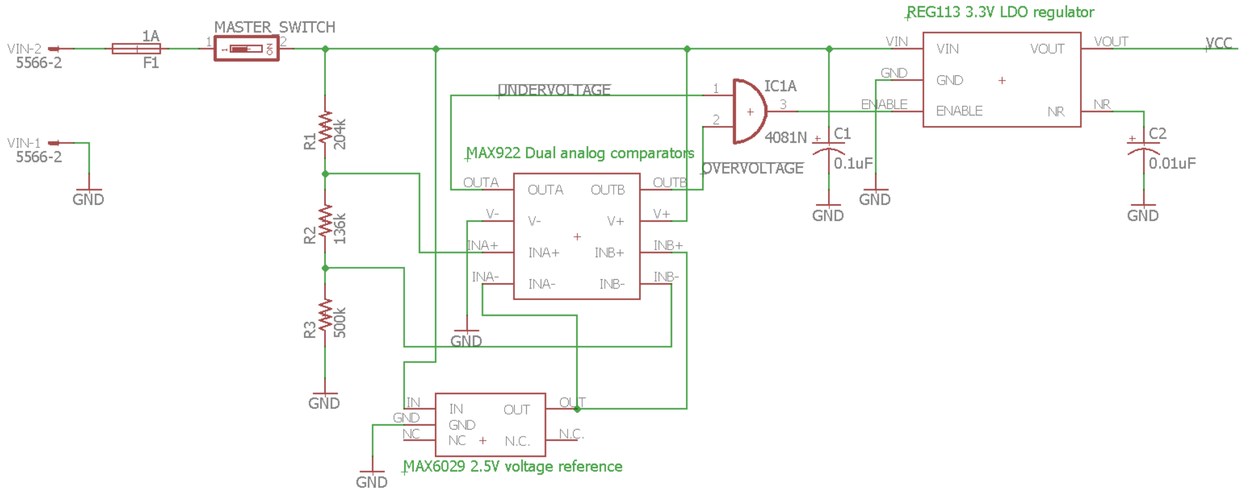


Fig.3. Power Module Schematics

The power module regulates and provides power to the rest of the circuit. It consists of a lithium ion battery, a charger for the battery, protection circuit and a voltage regulator. The power module needs to provide the rest of circuit with 3.3Volt. It also needs to monitor the voltage of battery to prevent over draining the battery.

2.3.1 Battery and charger

For this project, we decide to choose lithium ion battery. There are many reasons why we choose this battery. First, since our design will be put into a schoolbag, we want to decrease the weight as much as possible. The lithium ion battery is a good option, since it has very high energy density. Secondly, we don’t want to put toxic material or acid into the bag, so we decide not to use the standard nickel cadmium battery or lead acid battery. However, lithium ion batteries do have some safety concerns like the potential of thermal runaway. We will add additional protection circuit and sensors to ensure that the device will operate within the normal voltage and temperature range. Based on our circuit design, since the current draw is about 140 mA under the normal usage and about 270 mA at maximum, we choose to use 2500mAh battery to ensure the battery life to be at least 10 hours. Lastly, we plan to use a USB charger from the battery manufacturer for safe charging.

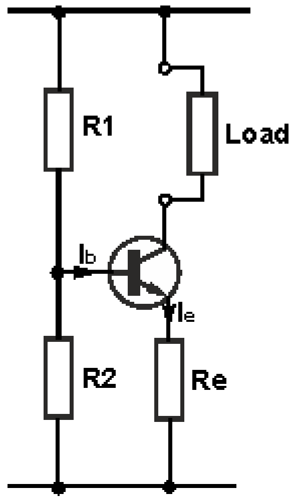


Fig.4. Constant current test circuit

Requirement	Verification
1. The battery has at least 2000mAh capacity 2. The battery voltage should be 4.1V to 4.25V when fully charged by a USB charger	1. A. Connect the battery to a 250mA constant current test circuit B. Discharge the battery for 8 hours C. Measure the battery voltage with a multimeter. The voltage should be greater than 3.0V 2. A. Connect the discharged battery to the USB charger, limit the charging current to be 500mA B. Measure the output voltage when the battery is fully charged, ensure the voltage is between 4.1V and 4.25V

2.3.2 Protection Circuit

Because improper usage of Lithium ion battery such as over draining can leads to decreased battery life or even thermal runaway, it is crucial to have a protection circuit in our design, which will ensure that the circuit will only operate within the normal range of the battery voltage. If the battery voltage is above 4.2V or below 3V, there may be potential hazard. For some additional safety, we choose 3.3V as our lower limit instead of 3V. The protection circuit will take battery voltage as input and produce the enable signal for the voltage regulator. It should prevent the rest of circuit from powering on when the battery voltage is below 3.3V or above 4.2V.

2.3.2.1 Calculation

To calculate the value of these resistors in our design, we first pick R3 to be 500kΩ to limit the current. We want the voltage between R2 and R3 to be 2.5V when Vin is 4.2V

$$V_{in} \frac{R_3}{R_1+R_2+R_3} = 2.5V \rightarrow R_1 + R_2 = 340k\Omega \; (1)$$

Next, we want the voltage between R1 and R2 to be 2.5V when Vin is 3.3V

$$V_{in} \frac{R_2+R_3}{R_1+R_2+R_3} = 2.5V \rightarrow R_2 = 136k\Omega \; (2)$$

Then we can get R1

$$R_1 = 340k\Omega - R_2 = 204k\Omega \; (3)$$

Requirement	Verification
1. The overvoltage protection output should be 0V when the battery voltage is higher than 4.2V and the undervoltage protection output should be 0V when battery voltage is lower than 3.3V 2. The circuit current should be less than 100uA when the battery voltage is not between 3.3V and 4.2V	1. A. Use the signal generator to generate a sawtooth signal from 3V to 4.4V B. Connect the signal generator to the input of the protection circuit and probe the overvoltage and undervoltage output C. The overvoltage output should match the input waveform when the input voltage is less than 4.2V and it will be 0V when the input voltage is greater than 4.2V D. Undervoltage output should be 0V when input voltage is less than 3.3V and should match the input waveform when input voltage is greater than 3.3V 2. A. Use a constant voltage of 3.2V B. Use a multimeter to measure the current drawn from battery C. The current should be less than 100uA D. Repeat the same procedure for 4.4V

2.3.2.2 Experimentation

For the experimentation, we use the signal generator to generate a 3.7V offset, 1.4V peak-to-peak amplitude sawtooth waveform to simulate the battery voltage. We then plot the input voltage and the protection circuit voltage. Note the x-axis is time and y-axis is voltage.

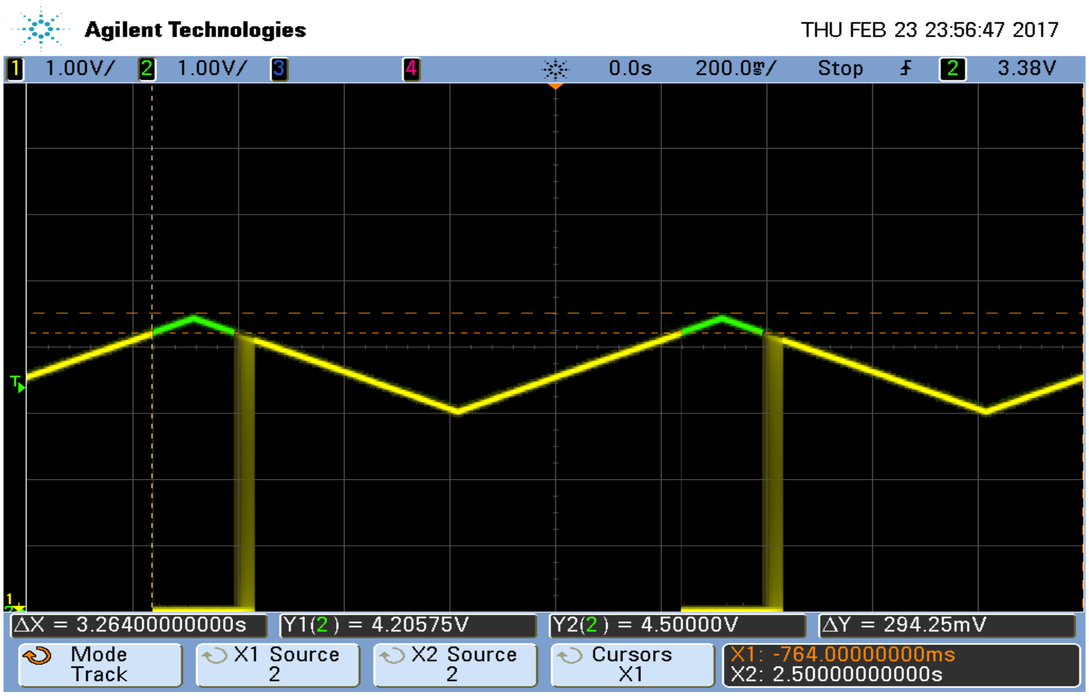


Fig.5. Overvoltage protection output

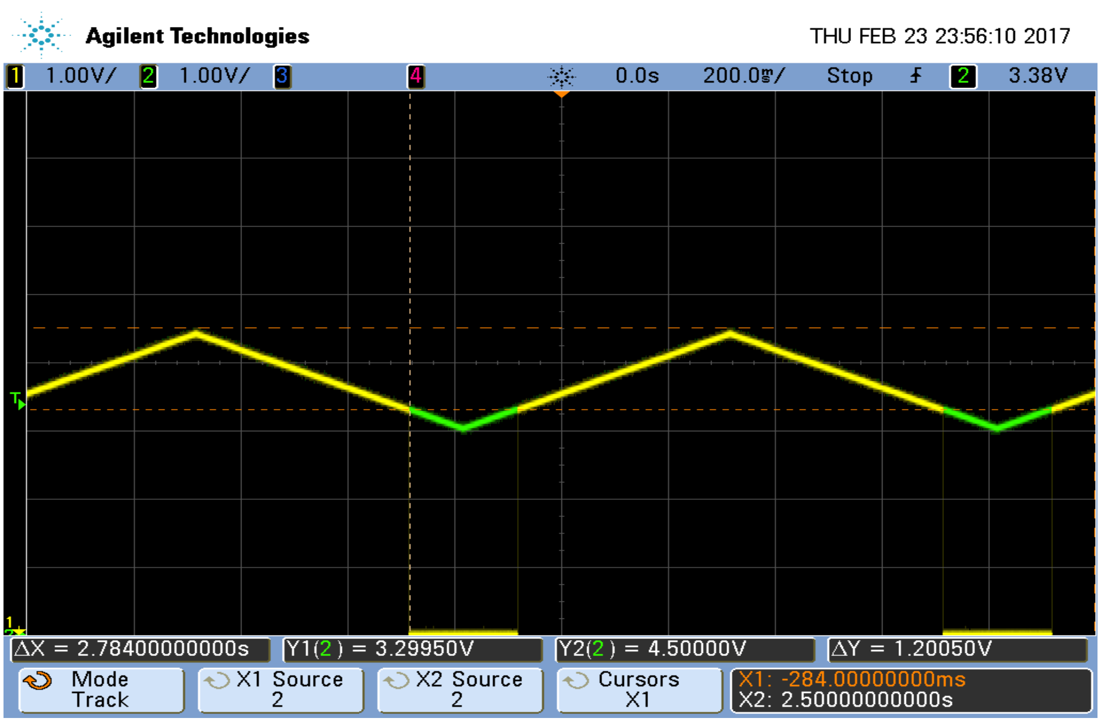


Fig.6. Undervoltage protection output

2.3.3 Voltage Regulator

The voltage regulator regulates the 3.7V - 4.2V battery voltage to a constant 3.3V. The input will be the power from the battery and the enable signal from the protection circuit. We use the output as the power supply for the rest of the circuit.

Requirement	Verification
1. Supply 3.3V +/- 5% from 3.7V to 4.2V source with ~300mA current draw 2. Output less than 0.05V when enable pin is low	1. A. Use signal generator to generate a sawtooth wave from 3.7V to 4.2V B. Connect the output of the signal generator to the input of the regulator and tie enable to high. Use a 10Ω resistor as load, and measure the output voltage with an oscilloscope C. Make sure the voltage is within 3.135V and 3.465V 2. Use the same setup, connect enable pin to ground and use an oscilloscope to measure the output voltage, the voltage should be smaller than 0.05V

2.4 Control Module

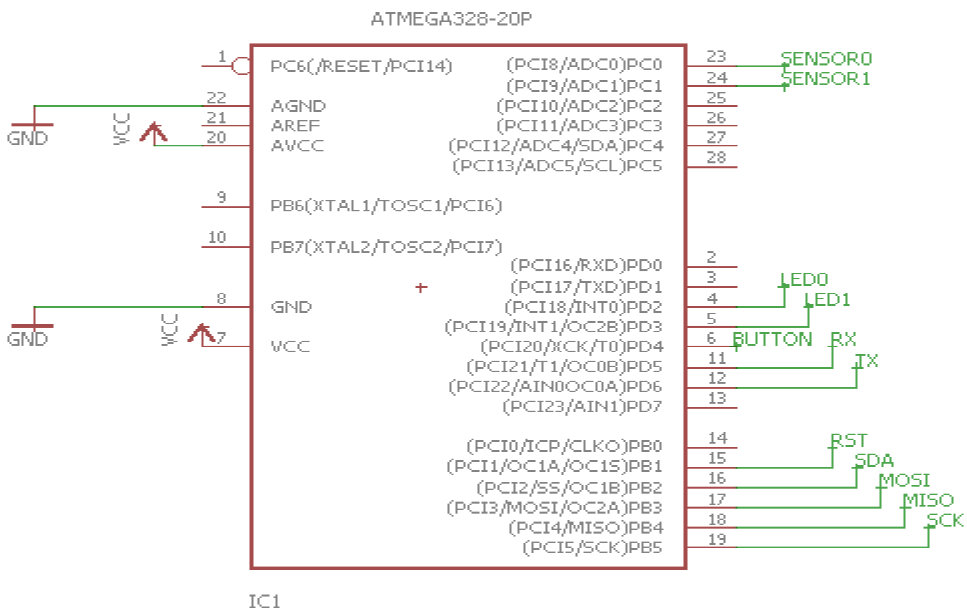


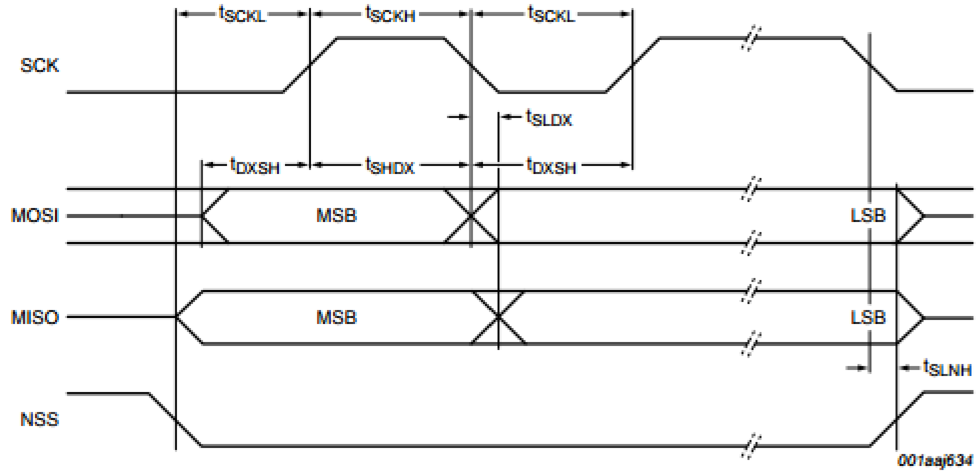
Fig.7. Control Module Schematics

The main task of the control module is to transfer the data from the RFID buffer to the Bluetooth module after the user scans textbooks in the backpack. Additionally, the control module will monitor the status of our device, which includes the battery temperature and data transmission status. The user should receive different messages on his/her phone based on different status. The control module, Fig.7, which is powered by the power module, handles both SPI and UART communication between the RFID and Bluetooth data transmission. It also has storage unit to keep the program and data from the RFID reader. The microcontroller will output signals to the LEDs to show its current status.

2.4.1 Microcontroller

During our discussion on which microcontroller we will use, it came to our attention that the timing diagram is essential for our design. We want our microcontroller to be fast, affordable, and power efficient. The microcontroller, ATmega328p, is affordable and it supports both the SPI and UART mode. The SPI interface between the reader and the microcontroller can handle data speeds up to 10Mbit/s [2]. The UART interface between the controller and the Bluetooth module has a default speed of 9.6Kbit/s and can be manually set up to 1.38 Mbit/s [3]. We provide the microcontroller a clock frequency of 10MHz, which is fast enough to handle the data transmission between the RFID module and the Bluetooth module. The controller in active mode will use 0.2mA under 3.3 Volt [4]. Lastly, the microcontroller we choose has 32KB flash and 2KB SRAM, which should be enough to store the program and data from the RFID buffer.

Requirement	Verification [5]
1. The microcontroller can receive and transmit through SPI at speed above 10Mbit/s 2. The microcontroller can receive and transmit through UART at speed about 9600 bit/s	1. A. Connect microcontroller to a terminal such as Serial Monitor B. Start timer and read 10 registers from the RFID reader C. Ensure the speed is 10Mbits/s 2. A. Connect the microcontroller to a USB port and a terminal such as the Serial Monitor B. Set up the terminal at 9600 bit/s C. Echo and send 100 characters D. Ensure the data received matches those sent



Remark: The signal NSS must be LOW to be able to send several bytes in one data stream. To send more than one data stream NSS must be set HIGH between the data streams.

Fig.8. Timing diagram for SPI [2]

One important aspect of our design is the timing and synchronization of different interfaces. Since we are using SPI for the communication between the microcontroller and the RFID reader and UART for the communication between microcontroller and Bluetooth module, it is crucial to analyze the timing so we won't lose any data between transmissions.

For the UART interface between microcontroller and Bluetooth module, we choose to use 9600 baud, so we can calculate the transfer rate for UART:

$$9600\ bits/s = 1.2KB/s\ \approx\ 1B/ms \quad (4)$$

According to the MFRC522 datasheet [b], the reader has a built-in 64-byte data FIFO and the maximum transmission rate can be 100 Mbit/s. Also, from the SPI read/write byte order, we can see that it is possible to transmit or receive multiple bytes with only 1 byte of extra overhead.

Table 6. MOSI and MISO byte order

Line	Byte 0	Byte 1	Byte 2	To	Byte n	Byte n + 1
MOSI	address 0	address 1	address 2	...	address n	00
MISO	X[1]	data 0	data 1	...	data n – 1	data n

[1] X = Do not care.

Fig.9. RFID reader SPI interface read byte order[2]

Table 7. MOSI and MISO byte order

Line	Byte 0	Byte 1	Byte 2	To	Byte n	Byte n + 1
MOSI	address 0	data 0	data 1	...	data n – 1	data n
MISO	X[1]	X[1]	X[1]	...	X[1]	X[1]

[1] X = Do not care.

Fig.10. RFID reader SPI interface write byte order[2]

Since our microcontroller is running at 10MHz, the maximum transmission rate we can get is 10Mbit/s or 1B/800ns. We can then calculate the time needed to read the entire FIFO:

$$time\ needed = \#bytes \times \frac{1}{transmission\ rate} = (64+1)B \times \frac{1}{1B/800ns} = 65 \times 800ns = 52\mu s \quad (5)$$

Since the speed of SPI communication with RFID reader is 2 order of magnitude faster than UART communication with Bluetooth, the timing requirement can be easily met.

2.4.2 Temperature Sensor

We use an analog temperature sensor to monitor the temperature around the battery. Since it is dangerous for the battery if the temperature exceeds 70 degrees Celsius [6], the device will send a warning message when the temperature exceeds 60 degrees Celsius. The sensor will shut down the power if the temperature exceeds 70 degrees Celsius.

Requirement	Verification
1. Analog temperature output of the temperature sensor should be accurate to +/- 2.5 degree Celsius	1. A. Put the sensor next to a heat source, use a IR thermometer to monitor the temperature B. Connect sensor output to one of the analog pins of the microcontroller C. Start reading temperature data from microcontroller, make sure they are accurate

2.4.3 Force Sensor

We choose a force sensitive resistor (FSR) the will allow us to detect physical pressure, squeezing and weight. This sensor is simple to use and low cost [7]. Since we want to know when the user changes the total weight of the backpack by adding/removing textbooks, we decided to place the force sensor at the bottom of the bag.

Requirement	Verification
1. The sensor should detect if the total weight of the bag has changed more than 10% in the last 2 seconds	1. A. Set up a simple circuit with one resistor and power supply. B. Apply forces on the surface of the sensor and test the voltage on the other resistor C. The voltage across the resistor should change according to the applied forces

2.4.4 LEDs & Reader Button

We use LEDs to indicate the current status of our device. We also add one button in the control module so that the user can manually turn on or turn off the RFID reader. Adding the override button gives the user more control on the device, otherwise our design will only have one power switch to control all the components.

Requirement	Verification
1. The LEDs should represent the current status of the device 2. The LEDs must be visible from 1 meter away	1. A. Connect LEDs based on Fig.5 and change the status of our device B. Ensure each LED works correctly 2. A. Turn on the LEDs and ensure all LEDs are visible in one meter

2.5 RFID Module

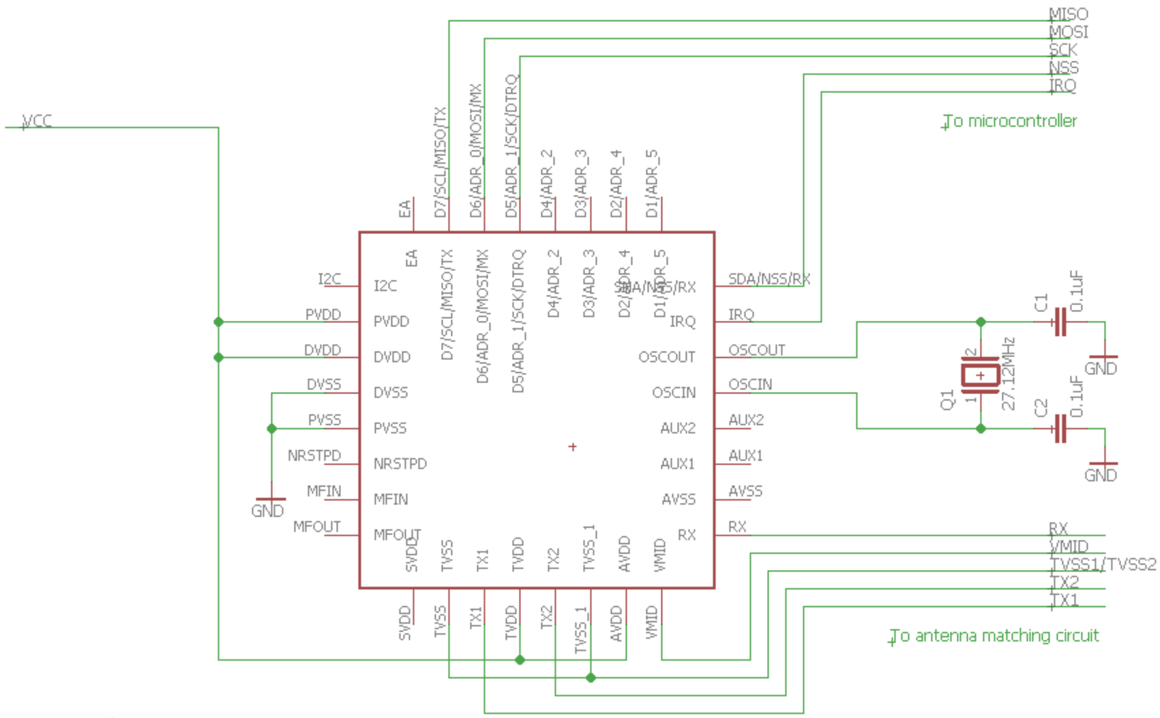


Fig.11. RFID module Schematic

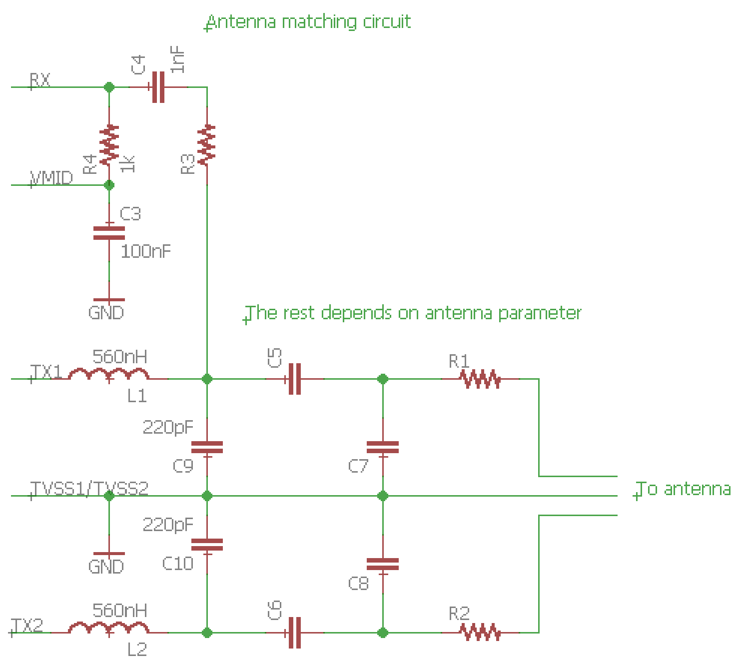


Fig.12. Antenna Schematic

We use the RFID module to read the ID of each tag and transmit the data to the microcontroller. It will be connected to the control module via the SPI bus. We choose to use high frequency (HF) chip because it provides a good read speed and is relatively cheap. Another important factor is range. We want the detection range to be around 4 cm to 5 cm for a passive tag. With proper tuning, HF chips should be able to achieve that range.

2.5.1 RFID Reader

We choose to use MFRC522 for our RFID reader. We will use the SPI interface for the communication between RFID reader and microcontroller. It will also be connected to the antenna circuit with 6 pins. It will send the tag ID of each detected tag to the microcontroller. Microcontroller should be able to put the reader into transmitter power-down mode or reactivate transmitter.

Requirement	Verification
1. Can receive and transmit tag ID when tag is placed near antenna 2. Antenna have no power when reader chip is in transmitter power-down 3. Reader chip can exit from transmitter power-down mode	1. A. Connect reader to microcontroller (Arduino) via SPI and connect reader to antenna circuit. Connect microcontroller to PC via USB B. Power on the entire circuit and place a HF tag near antenna C. User should be able to use see tag ID with serial monitor 2. A. Use microcontroller to put reader to transmitter power-down mode by setting a flag B. Use an oscilloscope to measure voltage between TX and TVSS, it should be 0V 3. A. Once the reader is in transmitter power-down mode, place a tag near antenna then tell reader to exit transmitter power-down mode B. The tag should be read and transmitted to microcontroller by reader.

2.5.2 RFID Antenna

We use the antenna circuit to generate the magnetic field needed to power and communicate with RFID tags. It will be connected to the RFID reader with 6 pins. The size of the antenna should be at least 15 cm wide and 3 cm high to achieve a reasonable reading area. The antenna circuit will be tuned so that its resonance frequency will match the operating frequency of the reader and the tag. We will follow the tuning procedure in the application note AN077925 [8]. After tuning, RFID antenna should be able to read tags from 4 cm to 5 cm away.

Requirement	Verification
1. Antenna size should be at least 15 cm wide and 3 cm high 2. Range should be 4 cm to 5 cm	1. A. Measure the size of antenna coil with a ruler 2. A. Connect the antenna circuit, RFID reader, microcontroller and PC together as in section 2.5.1 B. Power on the entire circuit, place a tag about 20 cm away from antenna C. Slowly move the tag toward the antenna, record the distance when the tag is detected D. Repeat B and C for 3 to 4 times and the average detection range should be 4 cm to 5 cm

2.6 Bluetooth Module

Considering the size of the class and the condition of the lab, we will not implement a lot of functionalities in our Bluetooth module. Because during the demo, many of the other teams may have wireless communication and the lab itself is not as good as an open field environment. We want to use a simple JY-CMU HC-06 Bluetooth module to ensure stable connection between the phone and our device.

Our Bluetooth design shouldn't be an integral part of our project. We should keep it simple and easy to use. In addition, for consideration of complexity, we shouldn't use a quite powerful Bluetooth. Before, we used Adafruit Bluetooth and there is a microcontroller in it. That microcontroller decreased our design complexity a lot. JY-MCU is simple and also add some design complexity to our project. The module can tolerate a range of around 20 Hz around 9600 Hz.

Requirement	Verification
1. The module should be able to transmit data with a rate of around 9600 baud	1. A. Create an Android application and establish the Bluetooth connection between the module and the phone. B. Send data from the module and receive the data on the phone. C. Use a terminal to record the transmission rate.

	D. Can transmit signal back to microcontroller when the phone receive data or the phone didn't receive the data.

2.8 Software

2.8.1 Microcontroller Software

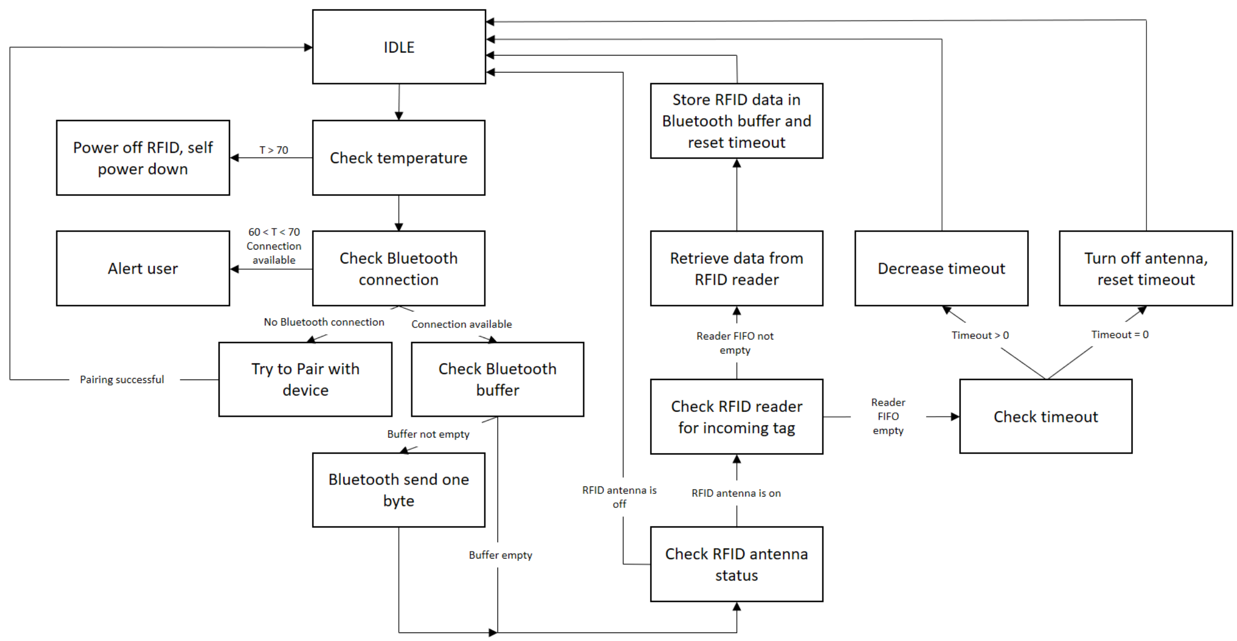


Fig.13. Microcontroller software flowchart

Explanation: At first, our program is at the idle state. Based on the circuit temperature, the circuit will choose to power off the RFID or shut down the power. If there are no connection, the program will try to pair with device. After the program is connected, it will first check if it needs to send an alert to the user. If the data buffer is not empty, the Bluetooth will send one byte to the phone. If the data buffer is empty, the program will check RFID antenna status and check RFID reader for incoming tags. If the FIFO buffer in the RFID reader is empty, the program will retrieve data from the RFID reader, store the data in the Bluetooth buffer, and reset the timeout. If the reader FIFO is empty and the timeout is above zero, the program should decrease the timeout and go to the idle state. If the timeout is equal to zero, the program will turn off the antenna and go to the idle state.

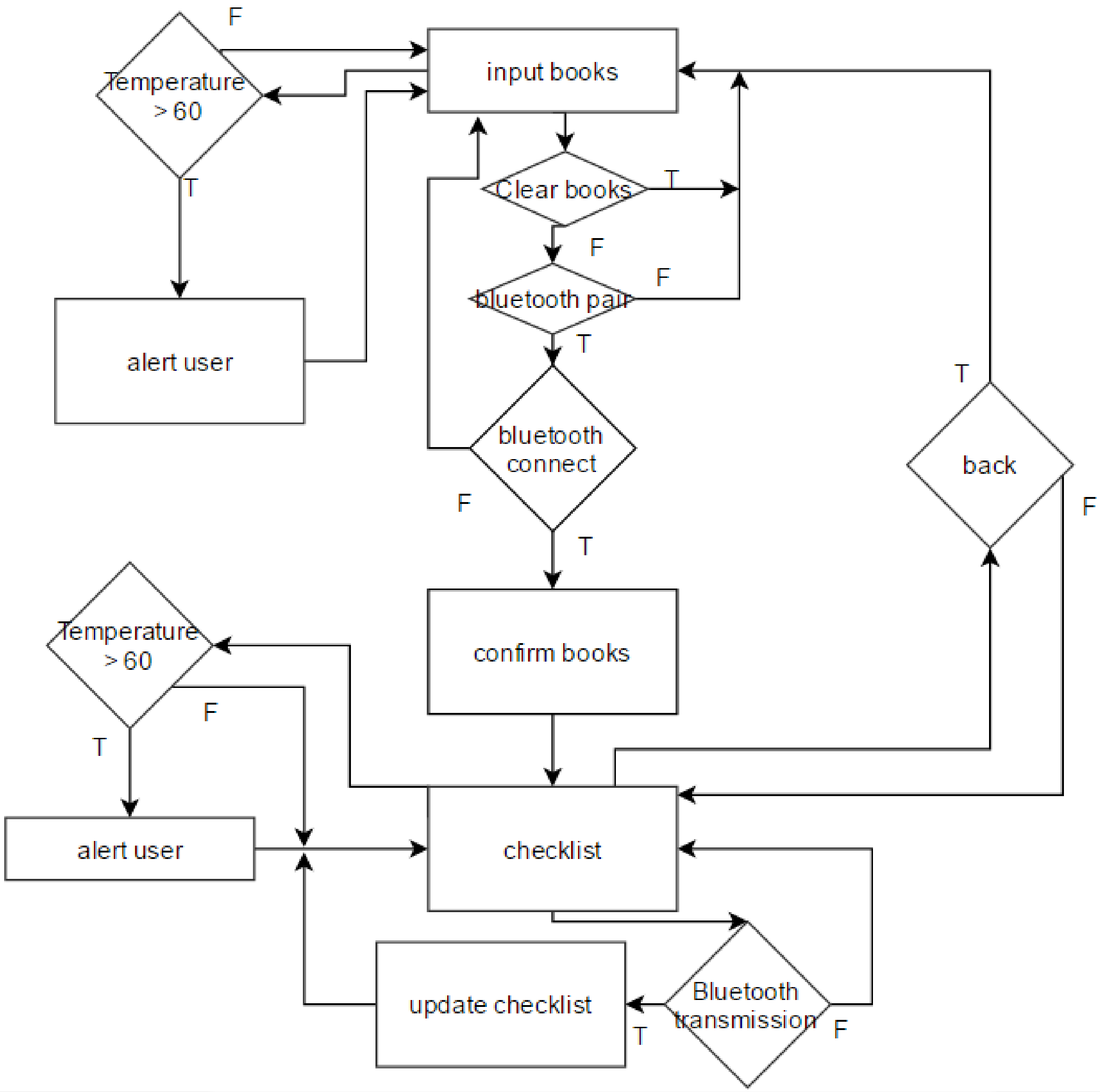


Figure.14. Android App flowchart

There are two activities in the android app. The first activity is asking the user for tag inputs. In this activity, there is an event driven mechanism to check for the temperature. If the user chooses to clear the booklist in the app, it can go back to input books. Otherwise, the user will go to the Bluetooth checking. The app will keep attempting to pair with the Bluetooth. After the app successfully connects to the Bluetooth, the user can confirm the inputs and switch to the checklist activity. In this activity, the event driven mechanism in android will check for the temperature. If there is Bluetooth transmission, the app will update the checklist. During the checklist activity, the user can push the back button to go back to the book input activity.

2.9 Tolerance Analysis

2.9.1 Power Module Tolerance Analysis

One important part of our project is the safety of battery. Improper usage of lithium ion battery can cause thermal runaway which is very dangerous and destructive. It is very important that our protection circuit and voltage regulator consume very low power when the battery voltage is too high or too low. For our project, we want the transient current to be less than $100\mu A$. According to datasheet of MAX6029 constant voltage reference [9], MAX922 comparator [10], SN74LVC1G08 Single 2-Input Positive-AND Gate [11] and REG113 LDO regulator [12], the maximum total transient current should be:

$$I_{cc,ref} + I_{cc,comp} + I_{cc,and} + I_{gnd,ldo} = 5.75\mu A + 4.8\mu A + 10\mu A + 0.2\mu A = 20.75\mu A \text{ (6)}$$

Since the total current is in the order of μA, the power consumption should be negligible. Another important problem is the input offset voltage of the comparator. The offset voltage is usually caused by manufacturing process and will cause a offset on the differential inputs of the comparator. We need the lower boundary of our protection circuit to be larger than 3V but smaller than 3.5V. From the comparator datasheet, we can see that the absolute value of input offset voltage is 10mV. We can add -10mV and +10mV separately to our circuit and calculate the cutoff voltage for undervoltage protection.

$$V_{in} \frac{R_2+R_3}{R_1+R_2+R_3} = V_{ref} + V_{offset} \text{ (7)}$$

First, we can calculate the cutoff voltage when input offset voltage is -10mV:

$$V_{cutoff} \frac{136k\Omega+500k\Omega}{340k\Omega+500k\Omega} = 2.5V - 0.01V \Rightarrow V_{curoff} = 3.289V \text{(8)}$$

Then we can calculate the cutoff voltage when input offset voltage is +10mV:

$$V_{cutoff} \frac{136k\Omega+500k\Omega}{340k\Omega+500k\Omega} = 2.5V + 0.01V \Rightarrow V_{curoff} = 3.315V \text{(9)}$$

As we can see, input offset voltage has nearly no effect on the cutoff voltage for undervoltage protection and the circuit should have a consistent behavior.

2.9.2 Control Module Tolerance Analysis

When we are tracking the total weight with the force sensor, we hope the control module will not receive a signal from the sensor that unless the sensor detects a big difference on total weight between two timestamps. For example, it is not necessary to set the weight change threshold to be 1%, which can be caused when the user is moving the backpack. Instead, we will set the weight change threshold to be 20%., so the control module will receive a signal only if the weight changes by 20%,

3 Cost & Schedule

3.1 Cost

Costs: our development costs are estimated to be $30/hour, 10 hours/week for three people. We consider we work for 12 weeks.

The approximate cost is

$$3\times \frac{\$30}{hour} \times \frac{10\,hour}{week} \times 12\ week \times 2.5 = \$27000 \quad (10)$$

Our sensors, modules's costs are estimated as 119.94$

Modules	Cost / $
Adafruit Bluefruit	17.5
Temperature sensor * 2	7.78
Proximity sensor	7.78
Atmega328 chip	2.99
SMIT BreakOut PCB for SOIC-8 * 2	5.9
SMT BreakOut PCB for 32-QFN or 32-TQFP	5.95
SMT BreakOut PCB Set For SOT-23	4.95
Max922 * 4	6.64
Max6029 * 2	12.22
Rc522 * 2	9.26
Reg113 * 3	8.88

Sn74lvc1g08dckr * 2	1.64
Tmp36 * 4	6
Lithium ion battery	9.95
charger	12.5

The total cost is 27119.94$

3.2 Schedule

Week	Xiaohao Wang	Xiaosheng Wu	Zhao Weng
2/12/2017	Start component selection	Testing microcontroller and RFID interface and select Bluetooth module	Started Bluetooth and phone connection design
2/19/2017	Finish initial component selection. Solder the SMD packages and start testing power module.	Finish testing the Bluetooth module with microcontroller Select and order temperature sensor and force sensors	Finished Bluetooth and phone connection module selection and tested the connection.
2/26/2017	Continue working on power module. Start soldering and assembly of antenna module.	Start applying the data transmit algorithm to the circuit	Make selection for the Bluetooth module
3/05/2017	Finish testing power module. Start testing antenna design.	Modify algorithm	Select and order Bluetooth module Start writing Bluetooth connection function
3/12/2017	Start working on initial PCB design Continue working on antenna tuning.	Start applying the routing algorithm to the circuit	Implement Bluetooth connection
3/19/2017	Finish antenna design. Continue working on PCB	Modify algorithm	Finished basic Android user interface design so that user can add and delete books in the app.

3/26/2017	Finish PCB design. Help others.	Add LEDs to the circuit	Finished analysis of Bluetooth and RFID timing and made sure RFID read can happen in a single Bluetooth transmission after checking datasheet
4/02/2017	Finish the Individual progress report	Finish the Individual progress report	Finish the Individual progress report
4/09/2017	Test our design in a backpack	Test our design in a backpack	Test our design in a backpack
4/16/2017	Mock Demo	Mock Demo	Mock Demo
4/23/2017	Prepare for demonstration	Prepare for demonstration	Prepare for demonstration
4/30/2017	Write final paper	Write final paper	Write final paper

4 Safety & Ethics

According to IEEE Ethics, #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.” [13], we, as future electrical engineers, are responsible for designing a safe and reliable application.

Since we will use Lithium-ion battery for this project, it is very important to keep the current and voltage within the limitation to prevent explosion [14]. In order to prevent potential hazards, we have a voltage regulator module and a protection circuit. The goal is the ensure that the overall circuit can operate with low current (below 1 A) and low voltage (about 3.3 V). On the other hand, users should not expose the power source to water or direct sunshine, which may cause safety issues on our battery. In addition, even if our final product may be able to automatically turn off the power by itself based on different conditions, it is also the user's’ responsibilities to check and turn off the power if this application is not in use.

Since the idea behind our project is to help students with their study, our application is also responsible for sending information for education purpose. According to IEEE Code of Ethics, #5:”to improve the understanding of technology; its appropriate application, and potential consequences; “[13]. We hope our project can provide students with basic knowledge in engineering design. It is also important that our design can influence other engineers in our procession. We decided to make our code open source to “to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.” [13]

However, with the help of internet, it is easy to search for our project online. We hope people who are passionate about rebuilding or improving our project can respect our property and contribution, based on IEEE Code of Ethics #7:”to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others” [13]. If other project teams are going to use the design or code from our project, the techniques used in this application should be correctly cited

Reference

[1] Technovelgy.com, “What is RFID?”, 2016. [Online]. Available: http://www.technovelgy.com/ct/technology-article.asp

[2] nxp.com, “MFRC522” [Online]. Available: https://www.nxp.com/documents/data_sheet/MFRC522.pdf

[3]www.olimex.com, “Product Data Sheet” [Online]. Available: https://www.olimex.com/Products/Components/RF/BLUETOOTH-SERIAL-HC-06/resources/hc06.pdf

[4] “Microcontroller: ATmega328P (arduino)” [Online]. Available: http://www.atmel.com/images/Atmel-8271-8-bit-AVR-Microcontroller-ATmega48A-48PA-88A-88PA-168A-168PA-328-328P_datasheet_Complete.pdf

[5] courses.engr.illinois.edu, “Wireless IntraNetwork”, 2/29/2016. [Online]. Available: https://courses.engr.illinois.edu/ece445/documents/examples/ExampleDD.pdf

[6] Elextropaedia, “Lithium Battery Failures”, 2015. [Online]. Available: http://www.mpoweruk.com/lithium_failures.htm

[7] learn.adafruit.com, “Force Sensitive Resistor”, 2015. [Online]. Available: https://www.adafruit.com/product/1075

[8] nxp.com, “Micore Reader IC Family; Directly Matched Antenna Design”, 10 May, 2006. [Online]. Available: https://www.nxp.com/documents/application_note/AN077925.pdf

[9] mouser.com, “Ultra-Low-Power Precision Series Voltage Reference”, 2009. [Online]. Available: http://www.mouser.com/ds/2/256/MAX6029-87913.pdf

[10] mouser.com, “Ultra Low-Power, Single/Dual-Supply Comparators”, 2009. [Online]. Available: http://www.mouser.com/ds/2/256/MAX921-MAX924-108730.pdf

[11] ti.com, “SN74LVC1G08 Single 2-Input Positive-AND Gate”, April, 2014. [Online]. Available: http://www.ti.com/lit/ds/symlink/sn74lvc1g08.pdf

[12] ti.com, “DMOS 400mA Low-Dropout Regulator”, September, 2015. [Online]. Available: http://www.ti.com/lit/ds/symlink/reg113.pdf
[13] Ieee.org, "IEEE IEEE Code of Ethics", 2016. [Online]. Available:

http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 29- Feb- 2016]

[14] "Design Review For: Advanced Electric Vehicle Battery Charger, ECE 445 Senior Design Project".

090521 courses.ece.illinois.edu. Archived from the original on 4 May 2013.