Anti Theft Unit

EE 175AB Final Report
Department of Electrical Engineering, UC Riverside

Project Team Member(s)	Jose Tobon Harmanpreer Chhina Isaac Lino
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Section Professor	23 Nissim Amos
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URL of Project Wiki/Webpage	http://www.AntiTheftUnit.com
Permanent Emails of all team members	tobonjose1994@yahoo.com hchhina1@gmail.com contact@isaaclino.com

Summary

This report presents the specification and features of our Anti-Theft Unit.

Revisions

Version	Description of Version	Author(s)	Date Completed	Approval
1.0	Filled first sections	JoseTobon Harmanpreet Chhina Isaac Lino	12/18/15	
1.5	Rough Draft Began filling rest of sections we had done, some left empty or erased that do not apply to our project.	JoseTobon Harmanpreet Chhina Isaac Lino	03/04/2016	
3.0	Images and more information added to final draft along with grammar / spelling corrections	JoseTobon Harmanpreet Chhina Isaac Lino	03/20/2016	

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1 Executive Summary

The final goal of this project is to show the feasibility of a discrete tracking system; something that will not alter the transportation, but it will instead be located discretely in the vehicle. The product is called anti-theft unit. What we will build is a prototype that will demonstrate the features and specifications.

The anti-theft unit will work as a secondary measure for securing one's transportation aside from bikes being lock to a post or rack, or a car's alarm system. It will be discretely hidden and will be turned on by the owner's finger via a scanner. Once activated the user will simply chose a method of charging from various inputs and the unit will take it from there. When the unit does not sense any movement of the vehicle, it will consume less energy in which case it will cause it to have a longer battery life. If the transportation is being moved while the unit is activated, the unit will immediately send a SMS to the owner with coordinates of the vehicle. It will update every 5 minutes and sense a new SMS along with it. The user may take action by calling the police providing them with the given coordinates or simply do what he pleases within the laws of his city. To deactivate the anti-theft unit the owner will simply have to scan his finger again and thus can ride his transportation with no problems.

Our design is based of a previous team's effort to make it long lasting with the focus of power consumption, as well as extra features to develop a user-friendly device.

To make our anti-theft unit to work and utilize low power consumption, we will only activate certain components when needed, while leaving the finger sensor on all the time to activate or deactivate the unit. While the unit is not active, he finger sensor will be the only one consuming power but when activated the finger sensor and accelerometer will be the ones consuming power. When the GPRS is ready to send an SMS (every five minutes) that is when most power will be consumed but only for a short period of time.

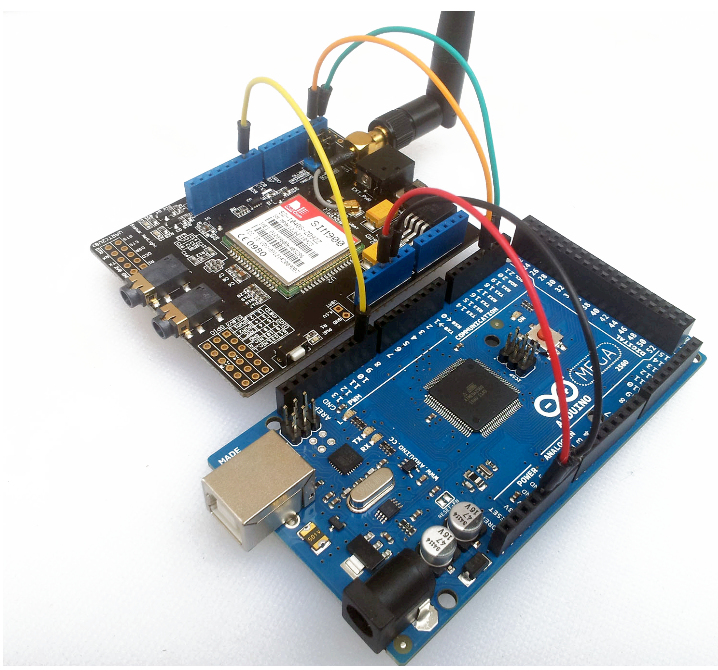

Fig. 1.1 Arduino Mega with GPRS Shield

2 Introduction

2.1 Design Objectives and System Overview

Concept and Design

We are designing a Anti-Theft system for a bicycle to prevent its stealing. The goal of our project is to invent a technologically advanced yet affordable system that could be purchased by an average middle class person. So, our system will cost less than 300 dollars. Today, there are new as well as improved inventions that are coming into the market.

However, the most important thing is the security of the new inventions. Unfortunately, most devices that are released in the market do not have any system that is built in that would prevent it from its theft. But, our, one of kind system, will allow us to ensure that our bicycle will not get stolen.

Description of System Structure

Our system allows the user to retrieve the GPS coordinates of the bicycle location at the time of being stolen. Using cellular communication, such as GPRS, owners will be informed of the theft on their phones.

Further, our system will have a fingerprint sensor that would be utilized as means of authentication, which would allow us to verify the user before letting him to gain access to our device. After multiple failed tries, the system will inform the owner that someone tried to access the bike.

The system is powered through a 4000 mAh battery that will be sufficient to power our system for an extended use. Further, there are multiple modes of power that will ensure that the system does not run out of power when needed. For example, our system will also come equipped with a solar panel that would allow us to charge our system when our bike is parked. Further, our system can be charged through hub dynamo while we are riding the bike. Further, we can use power outlet or through USB device to charge it. In emergency, we can also use AA batteries to power up the system.

There is a supply of 455 mAh from the hub dynamo. If the bike were to be ridden for 8 hours and 47 minutes, the entire battery will be charged to the max. If we use the solar panel, we can charge ¼ battery in 5 hours and 42 minutes. Further, by using the external AA batteries, the entire battery could be charged in 5 hours 38 minutes or it could be completely charged at home from the wall charger at 762 mAh in 5 hours and 14 minutes. The entire system will last 12 hours because the current consumed by the whole system when it is armed is 325 mAh and the battery capacity 4000 mAh.

 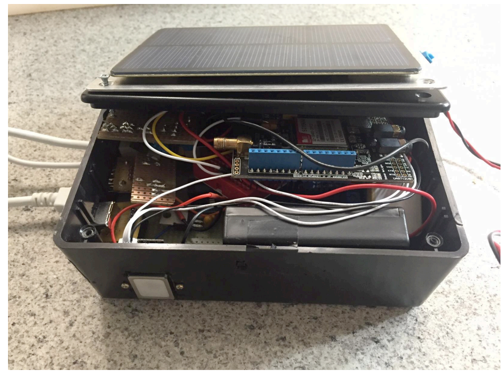

Fig. 2.1.1 Final Anti theft Unit (left) and opened inside of the unit system (right)

Responsibilities –

- Power system and power management: Harmanpreet Chhina
- Embedded systems programming: Jose Tobon, Isaac Lino
- GSM/GPRS communication: Jose Tobon
- GPS communication: Jose Tobon
- Fingerprint communication: Isaac Lino

2.2 Backgrounds and Prior Art

Bike Spike is a similar product. This particular system can allows the tracking of a system by sending coordinates of the location to the owner's phone. This particular feature was used is very similar what our system has. Our system will also allow us to use cellular communication to retrieve the GPS coordinates of the device. Similarly, their system as well as ours will have accelerometer that will allow us to measure speed and distance. However, the way our device differs is that we will be able to charge the device using hub dynamo, solar power, external AA batteries, power outlet, or any other usb device. Further, Our system is different from the fact that we are using a fingerprint sensor to authenticate.

2.3 Development Environment and Tools

Software–

Our project focuses heavily on the software side so we used the Arduino IDE on several occasions. This required us to have a PC or laptop on us, but we did not need an Internet connection to test/compile the code. We also needed a standard A-B cable from USB 1.1 to 2.0 to upload the program from the IDE to the Arduino microcontroller.

Hardware –

Our project also focused on power consumption and output, so it would not damage the unit. To test this out we used datasheets for each component and tested each power output with the multimeter. Most components we bought came with pins not soldered to the component. It gave us a choice from 90 degrees' pins to straight pins. Some components needed a AC/DC converter, but instead of building one, we decided to use a premade one.

2.4 Related Documents and Supporting Materials

GSM communication standards are set by ETSI
UART and SPI communication protocols according to IEEE standards

2.5 Definitions and Acronyms

- USB – Universal Serial Bus
- IDE – Integrated Development Environment (Arduino Software)
- AC – Alternating Current
- DC – Direct Current
- GSM – Global System for Mobile communications
- GPRS – General Packet Radio Receiver
- GPS – Global Positioning Unit
- SPI – Serial Peripheral Interface
- UART – Universal Asynchronous Receiver/Transmitter
- API – Application Programming Interface

3 Design Considerations

3.1 Assumptions

Describe any assumption, background, or dependencies of the end product, its use, the operational environment, or significant project issues. These are things you are assuming to be true, that directly affect the design.

The fingerprint module sensor GT-511C3 comes with one chip CPU Cortex M3. It was assumed that the algorithm is embedded directly to this chip on its firmware and a optical sensor, with a high readability definition, but in real situation the delay takes more time since we have to take in consideration climatic factors as humidity and temperature. If the unit is left in a high temperature, the module works erratically.

We had assumed that since the battery accepts 1 Amp maximum input, it might draw 1 Amp if the source is capable of providing it. However, this was not true for our internal battery. Our battery was charging at rates close to 700 mAh, and never approached near 1 A.

3.2 Realistic Constraints

As we designed and build our project, we knew that we had to think before we built on how we wanted the project to be. As well, when we designed the project, many constraints began to show up which we also had to take into consideration. First of all, we had a certain threshold for the amount we wanted to spend on the overall project. Our project was within our budget with good technology.

Another constraint was the time we had, if we had more time, the project would have been neater, and cleaner. Which also correlates to the size of our unit, in this case, our unit was size of (6" x 4" x 2"). If we had the time, we would have conducted our circuitry design with PCB with the help of Pavle which would make our project smaller and more portable than what it is.

With the amount of power each module needed to function correctly, and we wanted our device to last long when active, we had to figure out which internal battery would at least last up to 10 hours. With that in mind, we ended up getting the Avido 4000 mAh battery.

A fingerprint enrollment Fingerprint enrollment was sometimes an issue since the 3rd party software was designed with different coding tecniques. Basically the flowchart bellow will allow us to manage better the enrollment, however the result was not as predicted

EnrollStart with a (not used) ID

1 - CaptureFinger

2 - Enroll1 (1 is the 1st image taken)

3 - Wait to take off the finger using IsPressFinger

1 - CaptureFinger

2 - Enroll2 (2 is the 2nd image taken)

3 - Wait to take off the finger using IsPressFinger

1 - CaptureFinger

2 – Enroll3 (3 is the 3rd image taken)

3 - Wait to take off the finger using IsPressFinger

Realistically the software will prompt you to place your finger 3 times to analyze and encode the proper image but if the finger is moved in the wrong place or a force was applied excessively, the code will reject it and more than three takes must be done.

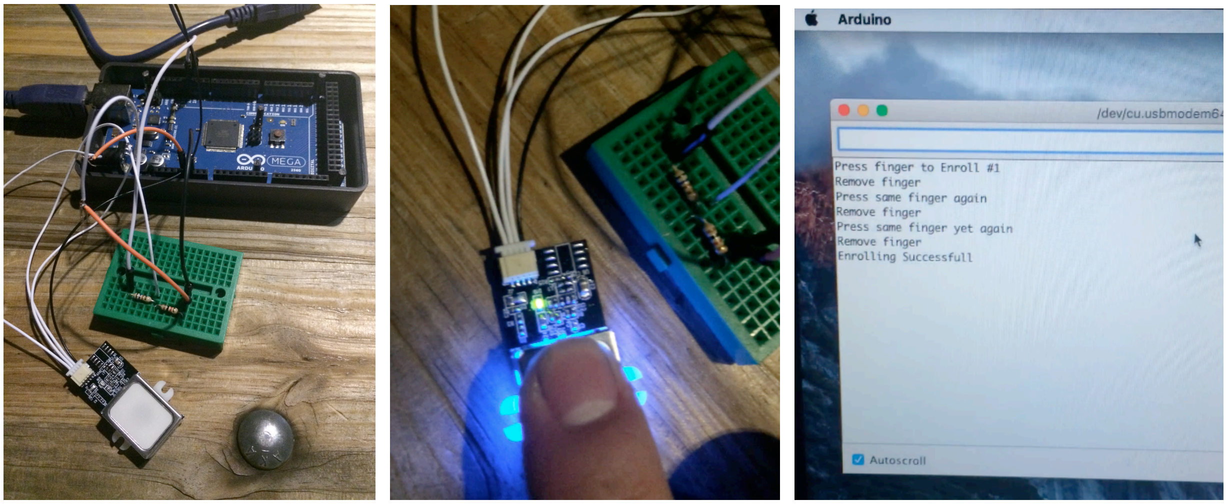

Fig 3.2 Fingerprint scanner with arduino mega with software on screen

3.3 System Environment and External Interfaces

Google Maps API allow for the embedding of Google Maps onto web pages of outside developers, this code it will use a simple JavaScript language program to arrange the proper frames. It is designed to work on both mobile devices as well as traditional desktop browser applications. The API includes language localization for over 50 languages, region localization and geocoding, and has mechanisms for enterprise developers who want to utilize the Google Maps API within an intranet. The API it is simple and secure to ask for in order to manipulate the Map interface on the application characteristics. These are the steps to get the API code:

The type of key you need is a Key for Android applications. The key is free. You can use it with any of your applications that call the Google Maps Android API, and it supports an unlimited number of users:

- The fast, easy way: Use the link provided in the google_maps_api.xml file created:

1- Copy the link provided in the google_maps_api.xml file and paste it into your browser. The link takes you to the Google Developers Console and supplies information via URL parameters, thus reducing the manual input required from you.

2- Follow the instructions to create a new project on the console or select an existing project.

3- Create an Android API key for your console project.

- A slightly less fast way: Use the credentials provided in the google_maps_api.xml file that Android Studio created for you:

1- Copy the credentials provided in the google_maps_api.xml file.

2- Go to the Google Developers Console in your browser.

3- Use the copied credentials to add your app to an existing API key or to create a new API key. For more details, see the complete process.

3.4 Industry Standards

Type A Female USB port was used to connect the internal battery to the AC/DC converter, Solar Panel, or the external AA batteries. This would allow the user to make an easier connection between the battery and the power sources.

3.5 Knowledge and Skills

Here are the list of classes, knowledge and skills by name:

Jose Tobon – New skills learned: Knowledge on GPS/GPRS coding and Arduino software.
CS 10 and CS 13 (C++ courses)
EE 120B and EE 128 (embedded systems courses)
EE 115 (communication systems)
EE 001B (circuit analysis II)
EE 100A/B (electronic circuits I/II)
Engineering 180W (technical communications)

Isaac Lino –
CS 10 and CS 13 (C++ courses)
EE 120A / EE 120B (Embedded Systems Courses)
EE 110A (Systems and Signals)
EE 001A / EE 001B (Circuit Analysis I/II)
EE 100A (Electronic Circuits I)
CS 122A (Interm. Embedded Systems)

Harmanpreet Chhina –
CS 10 and CS 13 (C++ courses)
EE 120B and EE 128 (Embedded Systems)
EE 1A, EE 1B (Circuit Analysis)
EE 100A, EE 100B (Electronic Circuits)
EE 116 (Electromagnetics)
EE 115 (Intro to Communication Systems)
EE 123 (Power Electronics)

3.6 Budget and Cost Analysis

Unit / Module / Accessory	Model	Price
* Arduino Microcontroller	Atmega 2560	$40.00
* GPS	GPS6MV1	$11.00
* Fingerprint Scanner	GT-511C3	$35.00
* GPRS	GPRS Shield V1.4	$45.00
* Accelerometer	MPU-5060	$ 6.00
* Hub Dynamo	DH-3D72	$70.00
* AC DC Converter	(Handmade)	$8.00
* External Battery Holder	(Aftermarket)	$5.00
* Step-Up DC-DC	Pololu	$ 6.00

* USB AC Adapter	(Aftermarket)	$10.00
* Solar Panel	Radioshack	$15.00
*USB ports female	aftermarket	$2.00

________***Total:*** **$283.00**

3.7 Safety

As we designed our project within the enclosure, we knew we had to take into consideration if something were to short circuit within the enclosure. We knew that if the system were to short circuit none of the components will be damaged severely. On the exception of the hub dynamo which would provide around 500 mA or 7-15 V AC which may cause serious damage if wires were to be short circuited. As well for the external triple AA batteries, the step up converter would heat to an extent so to counteract its heat, we placed it as far as possible to any circuitry that may be damaged with the heat.

It can be configurable to send the information to a website to be able to track all the time users position, this can be a security measure for parents where they can track their movements at any time.

The accelerometer sensor can also monitor speed and acceleration as well. Parents can have access to the tool at any time or make it private to use it as anti-theft unit.

For the methods of charging, such as the Hub dynamo and solar panel, there is a risk that the output of both devices may cause the user some damage if it were to make contact with them. So we reduced the output of each using a voltage regulator which would limit its output to at most 5 volts. as well for users of a young age, he components will not easy to reach, since the box is closed with 4 screws on each corner, so only mature ages will be able to conduct their research or fix issues if needed.

Users have the option of making the location data public, along with their bike position to make it easy to spot. Access to this information can also be granted to local law enforcement to increase the chances of recovery. Besides security, this unit can also act as a safety device. GPS tracking is a double edge sword. It can be a valuable asset when it is used to maximize the general welfare of society. However, many people choose to use it for their own selfish means. It is acceptable to use GPS tracking, but only for emergency cases.

3.8 Performance, Security, Quality, Reliability, Aesthetics etc.

A fingerprint sensor was used to arm the device. This is better than utilizing cards to authenticate or memorizing long passwords. This integrated device in our system facilitates an easier authentication for the user. Regarding the actual security, the system has an accelerometer that would help detect any movement of the bike. So, if some person tries to steal it, then our system will send GPS coordinates using GPRS communication.

The system is compact and practical. It is not very large in size. We had to choose the right size of the solar panel so that the solar panel is large enough but yet small enough to be embedded and part of the entire design itself. Further, to ensure a smaller size, instead of using large breadboards, we chose to use only parallel stripboard and directly soldering various components to the board. We cut the board so that we are only using the portion of the board that we actual needed. This ensured that the final design of our system was small and compact. We used a project enclosure from Radio Shack in which we enclosed all the components. On enclosure box, we cut out all the places for USB ports and to turn the external batteries ON/OFF that contributed to the final aesthetics of the device.

The quality of or device is to what can be similar to a normal phone with moderate use. The internal battery being 4000 mAh and our units max current consumption was what would make our unit last approximately 12 hours charged. If a smart phone has service, then our device would also have service due to the antenna it uses, which means reliability everywhere as long as the GPS can receive an accurate longitude and latitude location.

Since we used female USB's to connect our circuits to the internal battery, the enclosure of the unit is nice and neat with only the female outputs and battery connections can be send to choose method of charging. As well, the other thing coming out of the box would only be the fingerprint scanner and the wire going in from the Hub Dynamo and solar panel.

3.9 Documentation

Notes where taken whenever tests were conducted for the power management part. We also created circuits on notebook that were finally implemented. We experimented with different circuits and took notes on how the different components of the circuits actually work with the overall design. The most important aspect of power engineering was voltage regulation; therefore, we had to experiment with different types of voltage regulators like linear regulators and switch mode DC-DC converters. We took notes on the values being recorded. Later, we chose only the components that provided a balance between low power consumption and high efficiency.

About the fingerprint sensor, The module itself does all of the heavy lifting behind reading and identifying the fingerprints with an on-board optical sensor and 32-bit CPU. All you need to do is send it simple commands. To get started, just register each fingerprint that you want to store by sending the corresponding command and pressing your finger against the reader three times. The fingerprint scanner can store different fingerprints and the database of prints can even be downloaded from the unit and distributed to other modules. As well as the fingerprint "template," the analyzed version of the print, you can also retrieve the image of a fingerprint and even pull raw images from the optical sensor!

3.10 Design Methodology

Compilers software such as Arduino's sketch software will ensure the proper code compile since our project was based on Arduino's shield prototypes. Once the layout ideal diagram was set, building testing and debugging was optimal to ensure the proper communication for each component.

3.11 Risks and Volatile Areas

At one point, there was a suspicion of the voltage regulator that was in use could potentially be damaged because it recommended using a capacitor in order to reduce voltage spikes. Since, this capacitor was not available, lower voltage to the regulator was provided instead, because it would still work the same way but would reduce risk of damaging the voltage regulator.

With all the components fitted into the small enclosure, we knew that if a component where to heat up and it where to close to the other components, it may damage the unit. What we did, was evenly space out each circuit and even placed some under the lid of the enclosure.

Another unsafe situation was that the whole system was mounted in the bike frame which is very noticeable that it is not what comes in any type of bike. Chances are the thief may simply kick it off, but what in order to avoid this issue, the device was mounted where the thief could not reach it unless he would be able to reach where the arm bars are at without making it look suspicious.

4 Experiment Design and Feasibility Study

Trying to make all components work in unity, there was a suspicion that the codes being used at the moment for each component individually some of the pins where used for two or more components. Such as the GPS and the finger print scanner both used pins 10 and 11 for Rx and Tx. So an online search for other pins that can be used as Tx and RX pins was conducted. What was found was that the fingerprint scanner would only function with the 10 and 11 pins, so the other pins that may be used are (10 11 12 13 50 51 52 53 62-69) so I ended up using pins 12 and 13 respectively for Tx and Rx.

4.1 Experiment Design

The modules, we wanted to use for the Anti Theft Unit such as the GPS, the GPRS, the fingerprint scanner and what enclosure was used, we all decided that those were the ones we wanted to use. Arming and disarming, was made by Isaac Lino, but implemented by Jose Tobon. The results we got from it where to an extent accurate, but required the finger o be placed with as much of how much was enrolled in the first place to detect it as similar.

The results from the modes of operations where made by Harman which were either at least 10% of what he wanted give or take; placing the components neatly and where it will not cause damage inside the enclosure was accomplished by Jose Tobon. The final result, our prototype, came out to be 98% of the cosmetic we needed.

Fingerprint scanner experimentation was perform by Isaac Lino.
Unfortunately, scanners are usually unreliable or difficult to implement. But we've found this great fingerprint module that communicates over TTL Serial to Arduino so you can easily embed it into project This is the updated version of the GT-511C3 which has an increased memory capacity. The module canstore up to 200 different fingerprints (that's 10x more than the first old version GT-511R1) and is now capable of 360 degrees recognition.

The module is small and easy to mount using two mounting tabs on the side of the sensor. The on-board JST-SH connector has four signals:Vcc, GND, Tx, Rx. A compatible JST-SH pigtail can be found in the related items below. Demo software for PC is available in the documents below, simply connect the module to your computer using an SDK software or Arduino's Serial Monitor to encode/store into its data base!For testing purposes and acquaracy, the implementation in hardware and software was made with Arduino Mega 2560 and Arduino Uno.

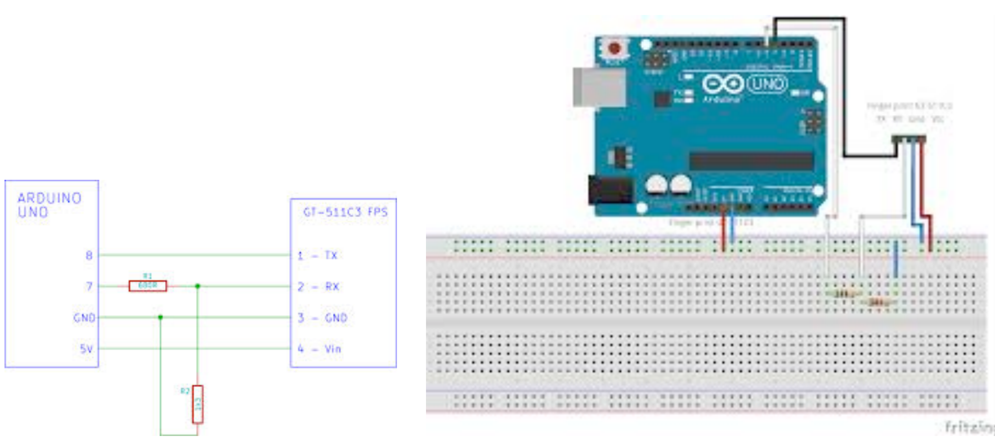

Fig 4.1.1 Fingerprint scanner diagram schematic pinout

5 Architecture

5.1 System Architecture

Our system consists of Arduino Mega. GPRS shield allowed us to communicate with our phone. GPS module helped us get the GPS coordinates for the device. The fingerprint sensor allowed us to authenticate or authenticate the device.

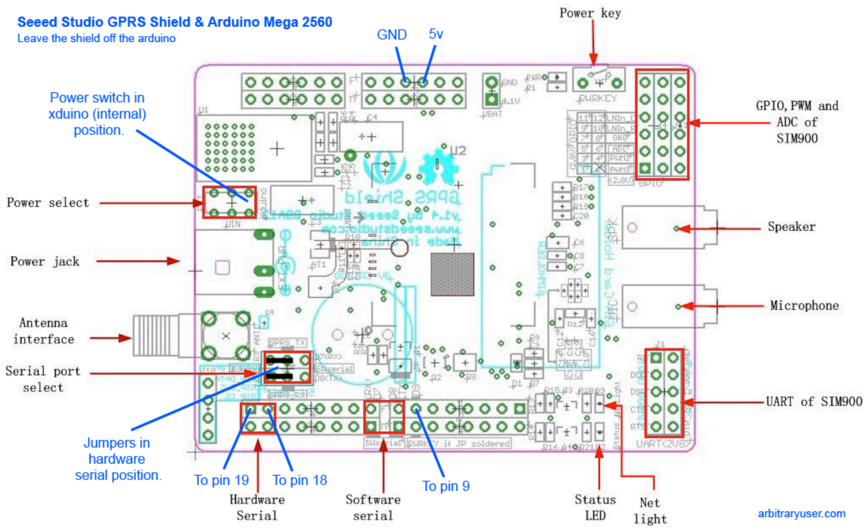

Fig 5.1.1 GPRS Arduino Shield pinouts

Further, the device had about 4 ways to charge. Harmanpreet Chhina, was in charge of selecting the correct components and making them work with the internal battery. We could charge the internal battery using the Shimano Hub Dynamo 3D72. Further, we could charge the device using a RadioShack 1.5 W Solar Panel. We could also charge the internal battery using AA batteries. Lastly, it is also possible to charge the device using wall charger or USB when it is connected to our computer.

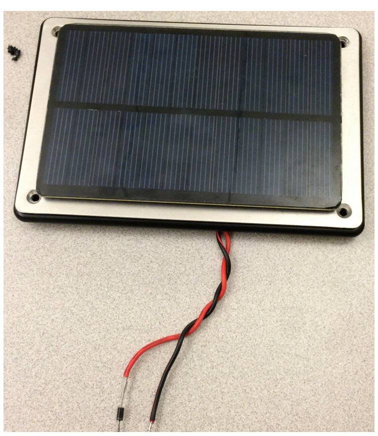

Fig 5.1.2 Solar Panel

Fig 5.1.3 Shinamo Hub Dynamo

The fingerprint algorithm uses 240x216 image for its input. This command captures raw image from the sensor and converts it to 240x216 image for the fingerprint algorithm. If the finger is not pressed, this command returns with non-acknowledge. Using the best image for enrollment to get best enrollment.

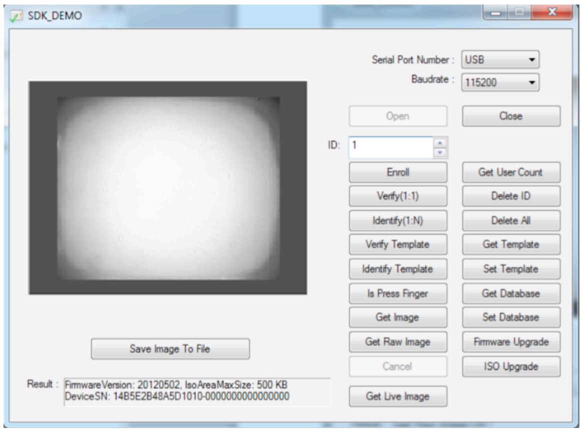

Fig 5.1.4 Fingerprint scanner SDK software screenshot

Fig 5.1.5 Fingerprint scanner module

5.2 Rationale and Alternatives

Capture of the fingerprint image alternative on C code. Identification and verification implementation performed by Isaac Lino and Jose Tobon:

IsPressFinger() function checks whether a finger placed on the sensor. This function is used especially while enrollment.

CaptureFinger() captures a fingerprint image (240x216), if a finger isn't placed on the sensor, it returns with error. If this function returns with success, the device's internal RAM keeps valid fingerprint image for the subsequent commands. If the host issues other command, the fingerprint image will be used and destroyed.

GetRawImage() captures a raw live image (240x216), it doesn't check whether a finger placed on the sensor, this function is used for debug or calibration.

To Identify and IdentifyTemplate the C code software performs 1: N matching operation.
Verify and VerifyTemplate fuction perform 1: 1 matching operation.

Just before calling of image-related matching functions (Identify, Verify), the host must call CaptureFinger. This is just suftware implementation alternative we used to verify and control the hosting fingerpirnt information

6 High Level Design

High-level designs are most effective if they attempt to model groups of system elements from a number of different views. Typical viewpoints are:

a. Conceptual or Logical: The concept is simple, to track a veihcle by GPS.

b. Harmanpreet was in charge of power related hardware. We used USB ports that would allow us to directly connect the output of the power source to the internal battery input for charging. We have 3 USB ports to choose which of the power source to choose. For example, one of the USB port was for solar panel output, another for the external batteries as the source, and third for the hub dynamo output. We could plug in the cable to other side of the cable to the input of the internal battery.

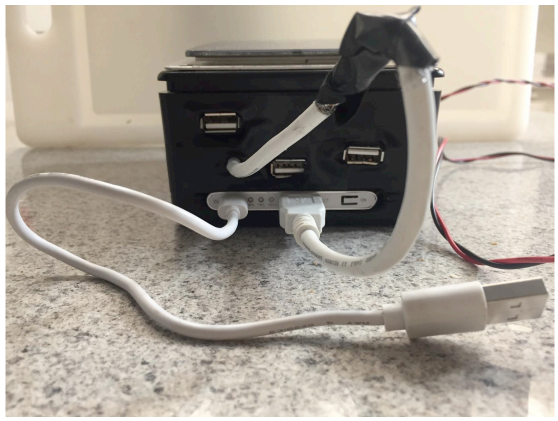

Fig 6.0.1 Showing 3 USB ports for 3 different power sources: solar panel, hub dynamo, and external rechargables AA batteries

c. We are able to receive the coordinates of the GPS through GPRS communication. We were able to receive a link to our phone which once clicked would open the Google Maps service and would allow us to see the location of our bike.

d. Security: Isaac was in charge of handling the fingerprint sensor. The fingerprint sensor allowed us to arm the device. The user can use it to authenticate himself. Further, Jose Tobon was in charge of handling the sending of GPS coordinates to the phone using GPRS communication. We were able to get the GPS coordinates and browse them using the Google Maps link that we received on our phone.

Fig 6.0.2 Sideview showing fingerprint sensor

6.1 Conceptual View

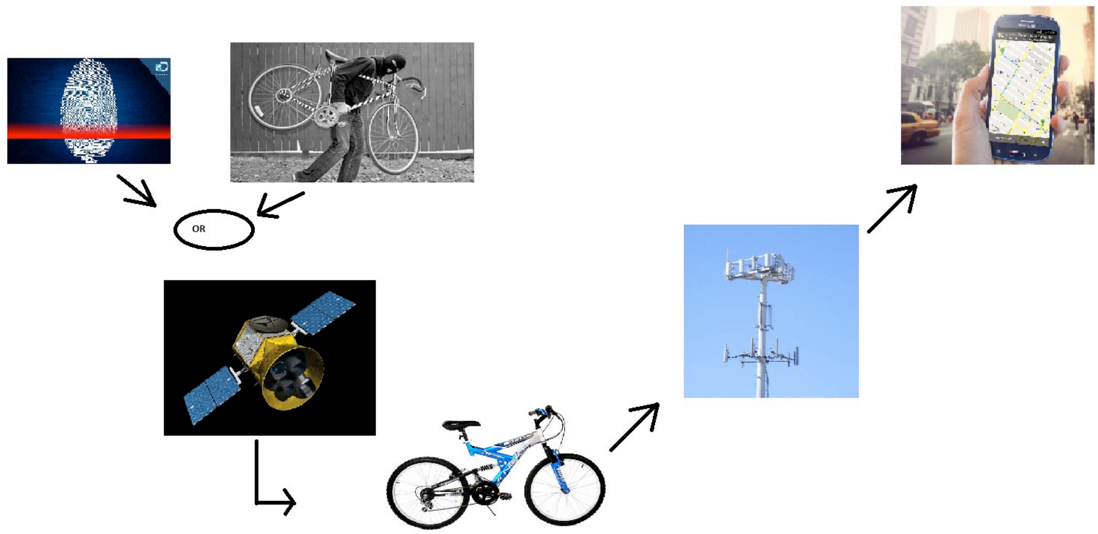

Fig 6.1.1 Anti Theft Unit conceptual image

As you can see in the above figure, it shows how the Anti Theft Unit's components would function with one another. If the system is armed already and a non user scans his finger print while armed, it will trigger the GPS to grab coordinates and send those coordinates modified via a GPRS to your phone thus receiving a link with the location f the bike (approximately every five minutes).

As well, there is another form of security which is if the bike was moved, the accelerometer will be triggered and thus triggering the GPS as mentioned above.

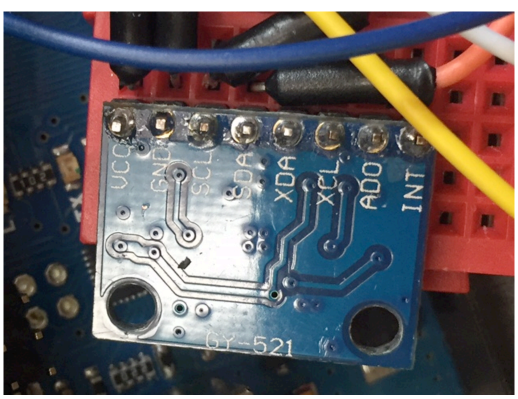

Fig 6.1.2 Accelerometer used in our system

Responsabilities by Jose Tobon were GSM and GPS implementation as well as accelerometer and Isaac Lino with detection of correct or incorrect finger scanned

Harmanpreet Chhina was responsible for creating circuits and regulating the voltage. Following is the schematic of the AC to DC converter that I built.

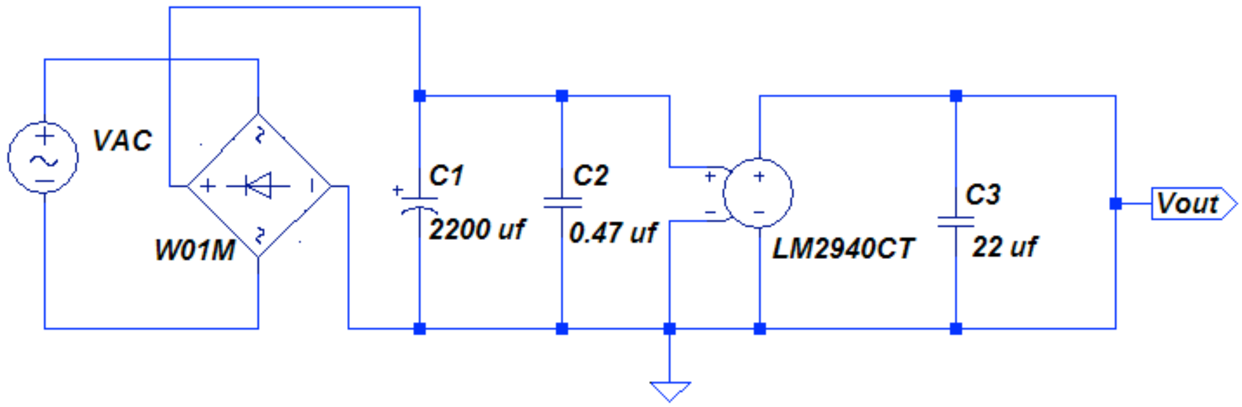

Figure 6.1.4: Schematic for AC to DC converter for the hub dynamo

Harmanpreet, In charge of using AA batteries to charge the internal battery. Following is the schematic of the switch mode DC-DC converter that we used for the external AA batteries. The input voltage of 0.5 V - 5 V is accepted and 5 V is the output of the converter.

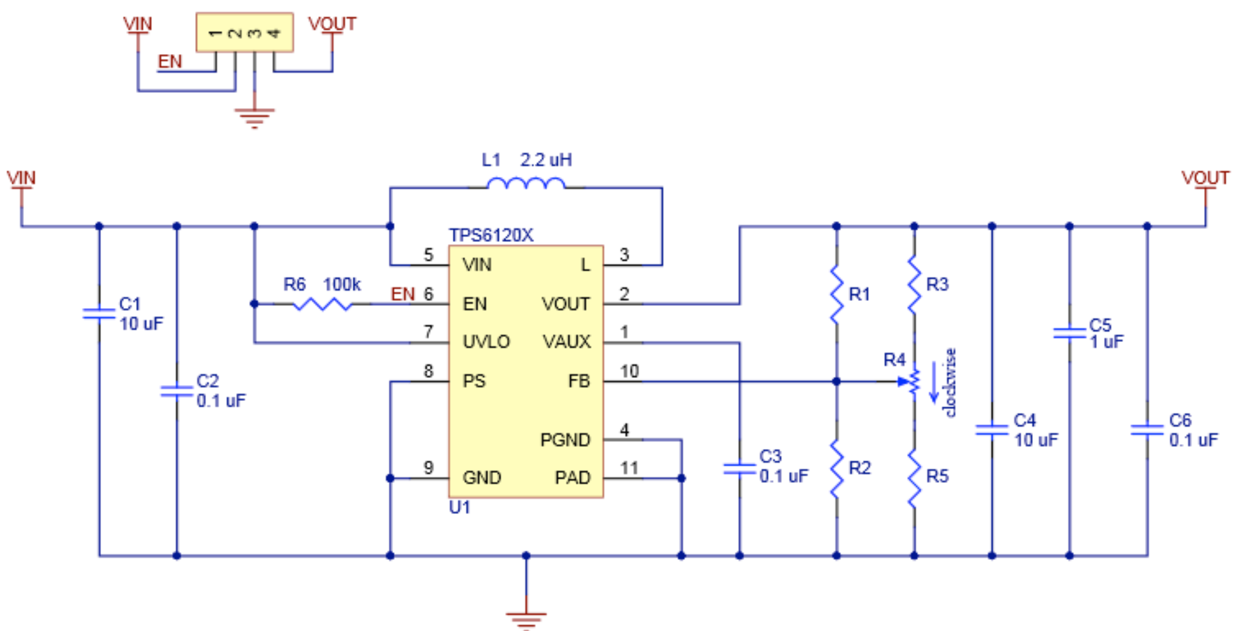

Figure 6.1.5 : Here is the schematic of the step up converter that we used. Schematic is obtained from Pololu.com.

Solar panel to work with the internal battery by Harmanpreet. In order to make the solar panel work with the internal battery a circuit using diode was created, to make current flow in only one direction, and using a low dropout voltage regulator to step down the voltage to 5 V.

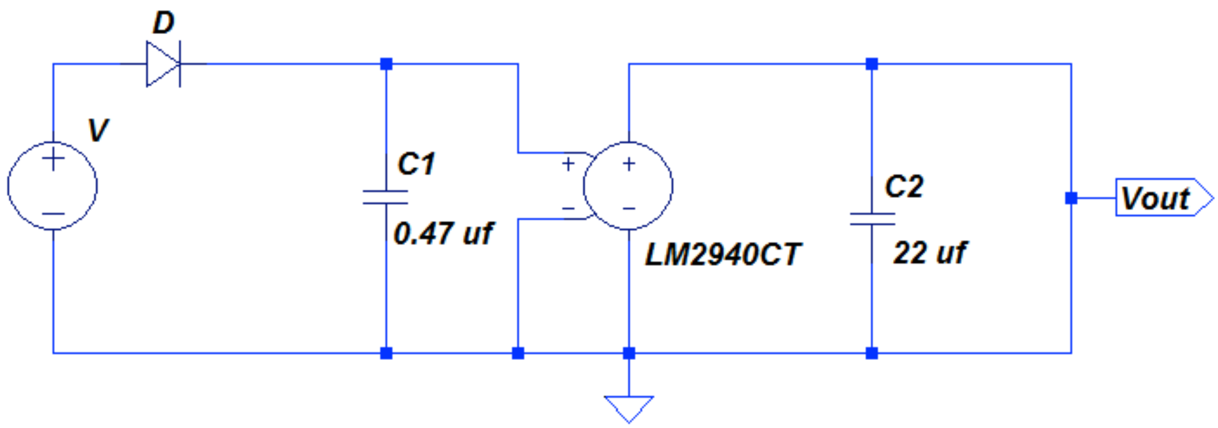

Figure: Circuit Schematic of voltage regulation circuit for the solar panel

6.2 Hardware

- Arduino MEGA 2560 - Jose Tobon, Isaac Lino
- GPRS Shield V 1.0 - Jose Tobon, Isaac Lino
- GPS GY-521
  - Grabbing just latitude and logitude - Jose Tobon
- Accelerometer
  - Detecting above threshold movement - Jose Tobon
- Fingerprint Sensor
  - Identifying and authorizing a person to arm/disarm the unit - Isaac Lino,Jose Tobon
- Shimano Hub Dynamo 3D72
  - Circuit Designing, Converting AC to DC and regulating voltage - Harmanpreet Chhina
- Solar Panel
  - Solar Panel Selection, voltage regulation, circuit designing - Harmanpreet Chhina
  - Solar Panel Testing - Harmanpreet Chhina, Jose Tobon
- External AA Rechargeable Batteries
  - Circuit Designing, Regulating the voltage, and testing - Harmanpreet Chhina
- Wall Charger
  - Implementation/Testing - Harmanpreet Chhina

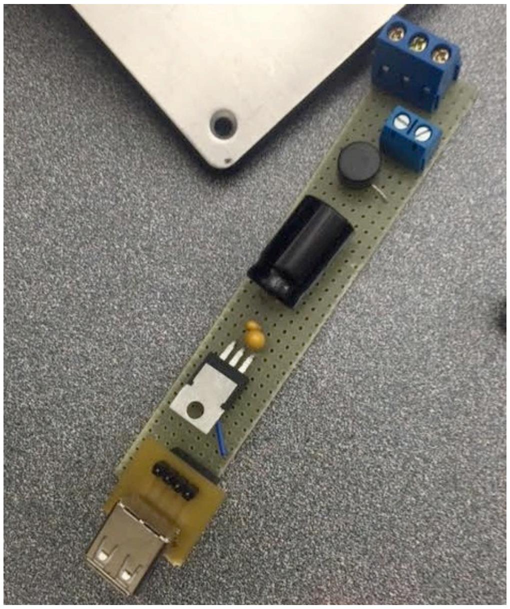

Figure 6.2.1: AC-DC converter for Hub Dynamo

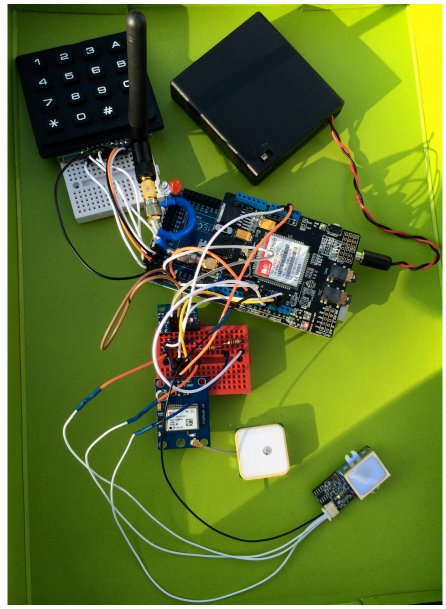

Figure 6.2.2: Unit beta-testing (Demo keypad)

6.3 Software

Jose Tobon was responsible for embedding all components together as well as building finite state machines for each components. Isaac Lino was responsible to configure the finger print scanner data base, setting up the finger print scanner on Arduino's IDK software, small contribution and implementation to GPS module and GPRS shield coding.

- Coding the GPS to get real time location – Jose Tobon
- Coding GPRS to send message every 4-5 mins- Jose Tobon
- Coding accelerometer to detect actual movements not false alarms- Jose Tobon
- Enroll finger print to the scanner- Isaac Lino
- Embedding all above modules to work as one, and arm disarm Unit-Jose Tobon

7 Data Structures

****** This chapter is not aplicable to the Anti Theft Unit project *****

7.1 Internal software data structure

****** Not aplicable to the Anti Theft Unit project ******

7.2 Global data structure

****** Not aplicable to the Anti Theft Unit project ******

7.3 Temporary data structure

****** Not aplicable to the Anti Theft Unit project ******

7.4 Database descriptions

****** Not aplicable to the Anti Theft Unit project ******

8 Low Level Design

8.1 GPS Module

Model used was Ublox NEO-6M GPS by Jose Tobon:

Datasheet:
https://www.u-blox.com/sites/default/files/products/documents/NEO-6_DataSheet_(GPS.G6-HW-09005).pdf

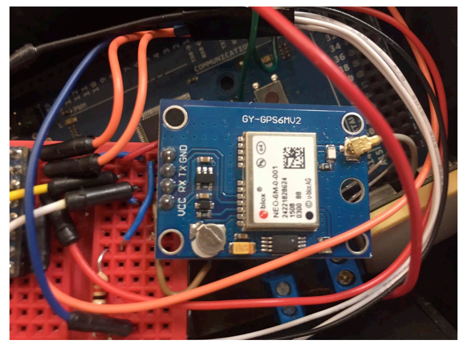

Figure8.1.1: Shows the GPS module as part of the entire system

8.1.1 GPS Module narrative description.

The GPS module uses UART communication to communicate with the microcontroller. UART communication is when a byte of data from the GPS is broken into individual bits (8) and then sent over wire to the receiving pin of the microcontroller. In the hardware of the microcontroller, the bits are combined again to form a byte and you now have your data to manipulate to your liking.

8.1.2 GPS Module interface details

UART communication requires 2 pins for TX/RX communication from both the microcontroller and the GPS module. From the TX pin of the GPS, the microcontroller's RX pin is connected. From the RX pin of the GPS, the microcontroller's TX pin is connected.

8.1.3 GPS Module processing details

The constraints for the GPS module where that, it required four satellites to receive an accurate location of the unit, but they would work to an extent, as well as the GPS unit, would no receive data inside building structures, where the signal could not reach.

8.2 Fingerprint Scanner Module

Fngerprint scanner GT-511C1R by Isaac Lino.

datasheet:
https://cdn.sparkfun.com/datasheets/Sensors/Biometric/GT511C1R_datasheet_V1%205_20140312.pdf

Figure8.2.1: Fingerprint Scanner

8.2.1 Fingerprint Module Processing Narrative

Fingerprint scanner similar to the GPS used UART communication between itself and the Arduino mega microcontroller. Isaac Lino was responsible for this module

8.2.2 Fingerprint Module Interface description.

Since both the GPS and the scanner needed to work with Rx and Tx, there was a need to find different pins and modify our codes until they both were working. Its input was a finger image translated into binary string match with the stored binary strings. If identical, would send an output to check if the accelerometer was going off or if the scanner detected same finger would disarm.

8.2.3 Fingerprint Module processing details

1 Select the COM port that the Arduino is connected to.
2 Select 9600 for the baud rate, which is the default for the GT-511C3.
3 Click the Open button to connect to the scanner.
4 Check for Existing Fingerprints
Click the Get User Count button so see if the FPS is storing any existing fingerprints. The number of fingerprints stored will be displayed in the Result box at the bottom of the window.
Clicking the Delete All button will remove all existing fingerprints from memory.
5 To enroll a new user, first select an unused ID in the ID box. If there are no stored fingerprints, the ID can be left at 0. Click the Enroll button. The user will now be prompted to place a finger on the fingerprint scanner.
The user will be prompted to take the finger off and then place it back two more times so that the finger is scanned three times in total. If all the scans are successful, a message will appear in the result box and the ID number will be incremented so that a new user can be added to the fingerprint scanner.

8.3 GPRS Module

The GPRS module we used is from seed studio V1.0 by Jose Tobon

Datasheet: http://www.seeedstudio.com/wiki/GPRS_Shield_V1.0

For testing purposes we used other teams GPRS since it worked identical to ours but it was a newer version which connected faster.

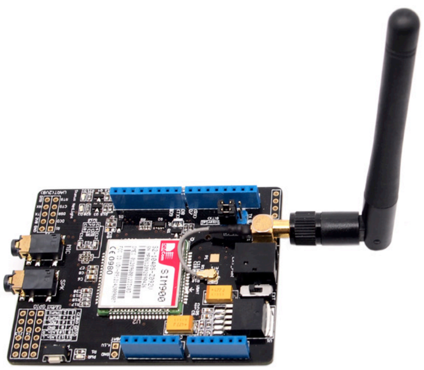

Figure8.3.1: GPRS Shield

8.3.1 Processing narrative for GPRS module

The GPRS shield works through GSM network to receive. It also uses UART like the above modules, but unlike the others, it uses AT commands to provide its functions.

8.3.2 GPRS Module interface description.

The module can sit on top of the Arduino Mega with D7(Rx) pin from the GPRS connected to pin 19 of the Mega 2560 as well as D8 (Tx) connected to pin 18. Its function for our project, was simply basic where we simply sent a message every 5 minutes with the location of the unit.

8.3.3 GPRS Module processing details

Constraints with the module where that, as we said above, our version had trouble connecting to the service provider but connected after a while. On the other hand, the one we use fro a different team would connect as soon as it received signal. Limitations also included its maximum word count sent via SMS which was around 160.

8.4 Accelerometer Module

Accelerometer used was he MPU-6050 with built in gyroscope by Jose Tobon.

Datasheet: http://playground.arduino.cc/Main/MPU-605

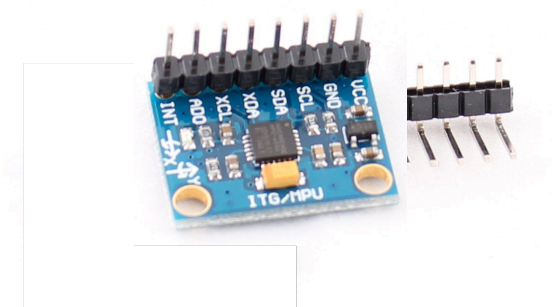

Figure8.3.1: Accelerometer Shield

8.4.1 Processing narrative for Accelerometer module

Accelerometers sensor works using I2C, since it is also a gyroscope. In our case, the accelerometer knows when it is triggered by the piezoelectric effect. Where to crystals if thy where bump to each other they would create a voltage thus sending an output.

8.4.2 Accelerometer Module interface description.

The module has multiple pins, but the for our case, we only used the SDA and SCL pins connected to the Arduino pins 20 and 21 respectively as well as he GND and VCC pins.

8.4.3 Accelerometer Module processing details

To detect if the accelerometer or gyroscope had a significant change in movement or placement, we would compare the first reading with the second reading, if the difference was above a certain threshold, then it will signify that the bike was being stolen or if it was below, it will simply ignore the action.

9 User Interface Design

Isaac was responsible for handling the fingerprint sensor. The user communicates with the device through the fingerprint sensor. The user first enrolls using his fingerprint utilizing the computer. Later, the user can take advantage of the fingerprint sensor to authenticate itself.

9.1 Application Control

****** Not Applicable *******

9.2 Screen

****** Not Applicable *******

9.3 Development system and components available

For the user interface such as the finger print scanner that was used, required a third party software to enroll the users finger into the database if first use. The software is called SDK_Demo, which basically tells you a step by step instruction on how to enroll your finger and store it within its memory. The max fingerprints it can hold is 20.

In our project, the finger print when the unit is turned on, will light on and off periodically until the user presses a finger on it. Once the finger print is being scanned, it will act according to it being in the system or not. If the print is in the system, the scanners LED will blink on and off six times quickly, and if its not in the system, it will blink three times on and off slowly, letting the user know what action the unit is going to take.

10 Experiment Design and Test Plan

10.1 Design of Experiments

Test Experiment Case 1: (Jose Tobon)

1. What is the objective of the experiment? What function does it test? Which technical design objective does this measure?
    a. Objective of this experiment was to see if the GPS was outputting the correct coordinates.
2. Experiment setup
    a. We simply connected the GPS to the Arduino with no other component
3. Experiment procedure and how to collect data
    a. We ran the sample code we had and saw the output through the Serial Monitor. We then grabbed the coordinates and
4. Expected results
    a. We expected the positions to be perfect, but with the coordinates we received were at least 20 feet away from our exact position.

Test Experiment Case 2: (Jose Tobon)

1. What is the objective of the experiment? What function does it test? Which technical design objective does this measure?
    a. Objective of this experiment was to see what values where the position of a stationary Accelerometer/Gyroscope.
2. Experiment setup
    a. We simply connected the Accelerometer and left it in a stationary place.
3. Experiment procedure and how to collect data
    a. We ran the sample code we had and saw the output through the Serial Monitor as the module was stationary. We also moved the module a little to see how much the numbers changed, as well as high movement.
4. Expected results
    a. Based on the position we got when we moved the module very fast, we subtracted from the first stationary position and based our threshold off that.

10.2 Bug Tracking

1. While working on the AC to DC converter after replicating on the parallel stripboard. It was noticed that instead of getting 5 VDC, the reading was about 5 VAC. After testing and debugging, It showed one of the legs of the rectifier was connected to the output of the voltage regulator and hence it was reading a wrong output. A new AC to DC converter had to be built and by correcting previous errors, correct results were the outcome. Harmanpreet Chinna contribution
2. During the process of getting the solar panel to work with internal battery there was an observation that in the dark, the battery was actually discharging. Therefore, a diode was added so that it would allow current flow only towards the internal battery. Harmanpreet Chinna contribution
3. When measuring the current output of the wall charger. There was a very high value that was about 1 A. But, later, I understood the optimal way was to break into the circuit while load was connected. I corrected my mistake and connected the internal battery to the wall charger to measure how much current was being drawn by the battery and recorded a value lower than 1 A. Harmanpreet Chinna contribution.

10.3 Quality Control

We tested the components multiple times. Whenever we could optimize it, we tried our best to optimize our system. For example, when we were working with the hub dynamo. We created multiple circuits to work with the hub dynamo. First, we experimented with different types of switch mode DC-DC converter. However, these types of converters were using a lot of power. The final current that we could get from the hub dynamo was very less. Then, we used a linear regulator. This was a low dropout voltage regulator and therefore it was using way less current.

Further, we checked the output of the AC/DC converter. Then, we saw that the output was not purely DC. So, we used a filtering capacitor to ensure that the output of the AC/DC converter is purely DC. We used a 2200 μF capacitor to accomplish the job.

Similarly, we experimented with the circuits and voltage regulation for other components and made sure that our circuits were not using much. For example, even for the solar panel, we chose linear regulators so that we don't use much power. However, I chose to use the switch mode DC-DC converter for the external batteries because of its efficiency and the voltage step up requirement.

10.4 Performance bounds

****** Not Aplicable ******

10.5 Identification of critical components

The modules in our unit that needed to function precise were quite a few. Such as the GPRS shield which needed to connect to the service provider to send SMS when the bike or mean of transportation was stolen.

10.6 Items Not Tested by the Experiments

Modules not tested during design of system was the input voltage and current of the Arduino Mega 2560 due to being main head component for the unit.

11 Experimental Results and Test Report

Carry out the experiments designed in the section above to test your modules and prototype and present the results. Present the results of the experiments and provide an analysis of the experimental test data.

State clearly who is responsible for which test case

11.1 Rechargeable External Batteries

11.1.1 Experiment 1

1. I, Harmanpreet Chhina, connected 4 batteries AAA batteries to the a multimeter and recorded the voltage.
2. The voltage was 4.8 V and we regulated the voltages using a step up converter and achieved a voltage of about 5.279 V. We achieved close to 5 V which we had expected.
3. However, I realized that the AAA batteries were rates only 800 mAh. Our internal battery might need about 1 Amp of input.

4. Therefore, I bought new rechargeable AA batteries that had a higher capacity.

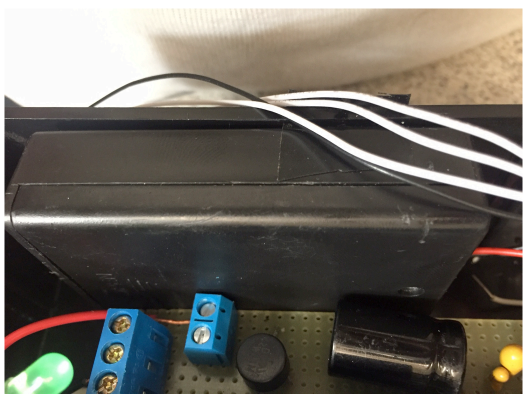

Fig 11.1.1 Shows external battery holder as part of the entire system

11.1.2 Experiment 2

1. Another set of batteries were bought that were AAA and were rated at 1000 mAh and were made by Tenergy.
2. The voltage of the 4 AAA batteries was tested and it was 4.8 V as well. This was expected voltage since we were using the batteries in series.
3. However, then It was noticed there was going to use a step up voltage converter, U1V11F5 made by Pololu, to regulate the voltage to about 5 V. However, now It was noticed that the voltage regulator could be damaged due to high voltage we are being provided, there could have been voltage spikes way above 5 V, damaging the regulator.
4. Therefore, now a new set of rechargeable batteries were bought because there were 3 AA battery holders with ON/OFF button. Harmanpreet Chinna contribution

11.1.3 Experiment 3

1. There was a utilization of 3 AA batteries and connected Fluke 87 and recorded the voltage to be 3.865 V.
2. As expected, this voltage under 4.5 V
3. This voltage was safe to use with the switch mode DC to DC converter that we were using.
4. No corrective measures were taken.
5. Harmanpreet Chinna contribution

11.2 Voltage Regulation using Rechargeable Batteries

11.2.1 Experiment 1

6. I, Harmanpreet, built voltage regulation circuit using Pololu's step up/step down converter while using rechargeable batteries.
7. I got about 5.279 V using multimeter. This value was expected since the regulator regulates the voltage to 5 V.
8. However, I realized that this converter accepts about 2.7 V - 11.8 V and outputs close to 5 V. However, I realized that it would have been better if we used a step up converter because as the battery dies down then we would still be able to step up the voltage to 5 V even though we will be be receiving lower current from the external batteries.
9. So, I decided to use Pololu's U1V11F5.

11.2.2 Experiment 2

1. I, Harmanpreet, now used the new Pololu's U1V11F5. It allowed us to provide the voltage between 0.5 V - 5 V and steps up to 5 V. I created a circuit using 3 AA batteries and the DC to DC converter. I connected the Fluke 87 multimeter observed the voltage to be 5.07 V.
2. I had expected the voltage to be close to 5 V and that is what I got, 5.07 V.
3. Since we we providing voltage lower than 5 V at all times, it was more optimal to use this voltage regulator over the previous which accepted voltage between 2.7 V - 11.8 V.
4. No corrective actions were necessary

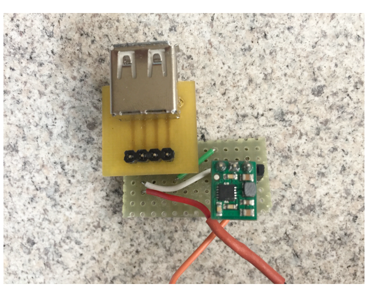

Figure 11.2.2 Shows components used for voltage regulation circuit for the rechargeable AA batteries

11.3 External Batteries with Voltage Regulation

11.3.1 Experiment 1

1. I, Harmanpreet, checked if the battery was being charged after connecting a Female USB Type-A Female port to the circuit. When I connected the circuit to the internal battery through the USB cable. I could see the battery was being charging.
2. This was expected that battery would charge since I was using a voltage regulator circuit.
3. However, I was not sure what amount of current was going into the battery.
4. So, I had to use a Fluke 87 to break into the circuit to check how much current was going into the battery.

11.3.2 Experiment 2

1. I, Harmanpreet, broke into the circuit using a USB cable while charging the battery. So, I connected a Fluke 87 multimeter and saw that the current was about 708 mAh at 5.07 V.
2. I expected the current to be close to 1 Amp.
3. However, I realized that the battery has its own rate at which it draws the current that it needs.
4. No corrective measures were taken.

11.4 Solar Panel

11.4.1 Experiment 1

1. I, Harmanpreet, with the help of Jose measured the current that was being output by a solar panel that I bought. It was giving only 112 mA maximum.
2. I assumed that the current was somewhere close to 120 mA because the solar panel was rated at 120 mA. Therefore, our results were correct.
3. We measured this current using a Fluke 87. However, we realized that since this amount of current was not optimal for our battery because our battery capacity was quite large.
4. Therefore, I looked around and bought a new solar panel that was rated 1.5 W at 6 V.

11.4.2 Experiment 2

1. I, Harmanpreet, with help of Jose Tobon, tested the new solar panel several times. Once, we got 224 mA at about 6.43 V from it in direct sunlight.
2. This amount of power was expected since we using 1.5 W 6 V solar panel.
3. However, we directly had connected the solar panel to the battery which not recommended.
4. I corrected this later by connecting it to battery and breaking into the circuit to see how much current was going into the internal battery.

11.4.3 Experiment 3

1. Now, I, Harmanpreet, created a voltage regulating circuit and saw recorded the voltage to be 4.95 V.
2. The voltage was expected since it was close to 5 V.
3. Our voltage regulating circuit was correct since we were getting close to 5 V.

4. No corrective actions were necessary.

11.4.4 Experiment 4

1. I, Harmanpreet, tested the current going into the battery after connecting the solar panel to the internal battery. I broke into the circuit and saw about 175 mA was going into the internal battery and I saw that the battery's LEDs showed that it was charging as well.
2. I expected a higher number than 175 mA.
3. I could attribute the lower number to not getting enough sunlight. We might not have had enough sun that day even though I waited hours that day to get higher number.

4. No corrective actions were taken.

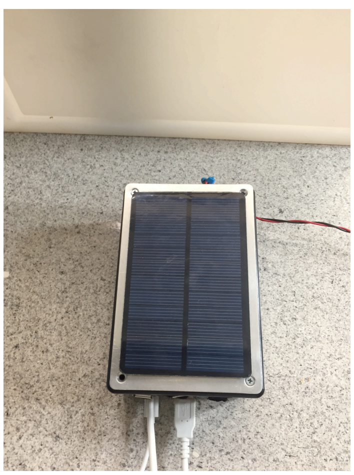

Figure 11.4.4 Top view solar panel

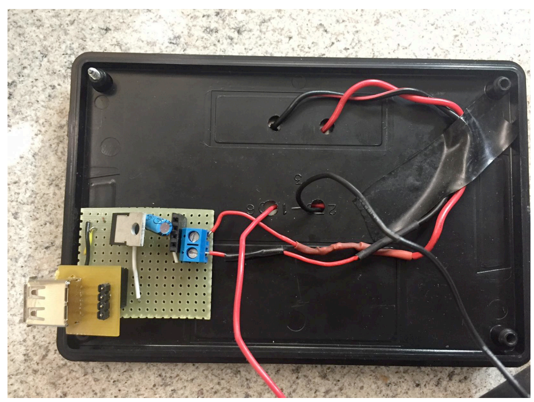

Figure 11.4.5 Back view of solar panel converter

11.5 Hub Dynamo and Ac to DC converter

11.5.1 Experiment 1

1. I, Harmanpreet Chhina, connected the output of the hub dynamo to the multimeter. I checked that the voltage that was output was 15 VAC maximum at 22 Hz. Then I checked that the current was 504 mA maximum that came from the hub dynamo.
2. These numbers were expected since the hub dynamo was rated 6 V, 3 W.
3. As we span the wheel faster, the hub dynamo produced higher voltage.

4. No corrective actions were taken.

11.5.2 Experiment 2

1. I, Harmanpreet, also built an AC to DC converter and checked how much current I could get from it and the voltage. I checked that I was able to get about 4.95 V. I checked the how much current I could get, it was about 463 mAh.
2. These numbers were expected because I was regulating the voltage to 5 V and that the AC to DC converter uses current as well.
3. However, I realized that it is better to check the current while I was charging the internal battery.

4. So, I tried to measure the current going into the battery while charging it.

11.5.3 Experiment 3

1. I, Harmanpreet, checked the current again and the voltage output after connecting the internal battery to the output of the AC to DC converter. I broke into the circuit using a multimeter to check how much current was going into the internal battery. I recorded the voltage to be about 4.95 V. I recorded the current to be 455 mAh.
2. These results were expected because AC to DC converter uses some power as well.
3. However, I got a lower number for current. It might attribute to LEDs of the battery using some power as well.

4. No corrective actions were taken.

11.6 USB wall charger

11.6.1 Experiment 1

1. I, Harmanpreet, checked how much maximum voltage and current was I getting from the wall charger. The voltage was about 5.09 V.
2. I was getting more than about 1200 mA. This was not expected since I this would be detrimental to the battery. I was expecting a number lower than 1 A.
3. However, I just shorted it without any resistance.

4. I realized my mistake and then checked the current drawn from the wall charger while charging the internal battery.

11.6.2 Experiment 2

1. I, Harmanpreet, checked the current and voltage after connecting the internal battery to the wall charger. I broke into the circuit and measured power going into the internal battery. I measured that 762 mAh was going into the internal battery at 5.09 V.
2. This number was expected since it was lower than 1 A.
3. Since we now had connected a load, we were getting a value that load required.

4. No corrective actions were needed.

Figure 11.6.2 Hub Dynamo Converter

11.7 Current Consumption

11.7.1 Experiment 1

1. I, Harmanpreet, measured the current consumed by the system. I measured the current being used by the system to be 325 mAh when it is armed and working under normal conditions.
2. We expected the current consumption to be between 300-400 mAh and our estimation was correct.
3. Our system was not using much power in relation to our battery life. Our battery can capacity is 4000 mA.

4. No correct actions were necessary.

11.7.2 Experiment 2

1. We tested current consumption while sending a message to our phone and our system used 351 mA.
2. We expected a small change in current consumption.
3. GPRS shield uses 26 mA.

4. No corrections were necessary.

11.7.3 Experiment 3

1. We measured the operating current of the fingerprint sensor. We measured the current used by the entire system with and without fingerprint sensor. We measured the difference to be 35 mA.
2. This current is low compared to what was being reported by datasheet but still is correct.
3. Fingerprint sensor does not use much current; only uses high amounts of current while enrolling.

4. No corrective measure was taken.

12 Conclusion and Future Work

12.1 Conclusion

Harmanpreet was responsible for the power management; we were successful in powering our device in multiple ways as we planned. We had planned that we will be able to power our device using external rechargeable AA batteries, hub dynamo, solar power, USB, and wall charging. We were able to meet our objective by employing a total a 5 ways to charge the device so that the user never runs out of power.

Further, our objective was to achieve at least 400 mAh from the hub dynamo because we knew that the AC/DC converter will use some power. We met our objective after experimenting with different components and making sure that we using components efficiently with low power consumption. We were able to get about 455 mAh from the hub dynamo, the AC/DC converter used 45 mA of current. Further, our objective was to get at least 150 mAh from the solar panel in the direct sunlight, due to the size of the internal battery. I was able to meet this objective by getting about 175 mAh because we also had to strike a balance between size and power; since, we needed small solar panel because overall size of the system had to be compact and small. Further, I was able to use rechargeable external batteries using the Pololu's step up converter and were able to achieve decent amount of power. Lastly, we could use USB port to charge the battery through a computer.

Also, our objective was to make our system last at least 12 hours without recharging. Our system was using 325 mAh and we could make the system last over 12 hours. Further, since we have multiple ways to charge; therefore, it will be hard to run out of battery. Lets say we ride our bike bike for about 2 hours, we can get 22.75 percent of the internal battery charged. Next, if we have park our bike for about 5 hours and 42 minutes and use solar energy, we can get another 25 percent of the battery charged. Next, in an emergency, we can use external rechargeable AA battery to charge our internal battery in 5 hours and 38 minutes. Also, it also possible to charge the battery through the USB port with a laptop or USB wall charger. We can use the entire battery through wall charger in about 5 hours and 14 minutes.
I, Jose Tobon realized from this project, that our whole design met our goals. Only issues we had were the cosmetic issues where sometimes the female USBs would push back into the enclosure as well as the battery. That was due to making the holes a little bigger than expected.

I also noticed that in some cases the GPRS would simply not connect to our service provider, maybe due to lack of not being the newest version, so for future, we would like to change the module for the newest version. As well, I would have loved for the GPS to work in doors,but the case with our module, it was not capable. Overall our project met our goal on the aesthetic where it was small and compact. with few wires coming in and out of the bx which reduces messiness. As well, the overall function pleased us to near what we expected.

12.2 Future Work

As you can see, many of the great ideas that we had in mind did not show up in our final design. It was due to the time constraint we had, but if we had more time, We would have implemented a LCD display to track your speed and show when the system was armed. As well for future work, we would like to implement a sort of alarm system where you push a button to arm or disarm the unit, sort of like a car alarm.

Not only would we add extra features if time permits, we would have tried to make it as small and compact as possible, where it can easily be hidden from human sight. As well, the life span of our Anti Theft Unit would be made longer than what it is now. So the user can worry less about the system running out of battery life when the unit is stolen.

From power perspective, we already have multiple ways to power our device so that we do not run out of power. For future work, we can also add power multiplexing. This would allow us to have solar panel and hub dynamo connected to the internal battery while we are outdoors. Whenever we are riding, the internal battery will be charging; as soon as we stop riding, battery will start charging through solar panel without having to make necessary connection readjustments. Such power multiplexers are available that are made by Pololu.

12.3 Acknowledgement

Professor Nissim Amos- Let us in the right direction with our unit, and how to make it different from others. As well keeping us on the right schedule to finish on time.

Pavle Kirilov- Who was there to help until the end. Not just with soldering components, but as well to lend a helping hand and how to go about certain builds.

Fernando Gonzalez, Dillon Ronson, Faran Ghias- For letting us used code to get google link for the SMS to phone. As well, for letting us use their project as a reference to ours.

Niraj Patel, Hayden Baker, Adrian Flores- Who were there to lend their components to see if ours were defected, and as well help build brace for unit on bike.

John Chi- Example code for the Accelerometer/Gyroscope in the Arduino playground site.

Mikal Hart- Providing reference for GPS code.

13 References

List the references used in the design, including books, data sheets, technical documents, industry standard documents. References can be printed documents or online.

Use the IEEE Citation procedures and list in alphabetic order all your references based on their first, second, etc., authors, in a chronological order. You may include these references depending on each chapter or as a whole.

14 Appendices

Presents information that supplements the design specification, including:

Appendix A: Parts List

- Accelerometer: Kootek GY-521 MPU-6050 MPU6050 Module 3 Axis analog gyro sensors 3 Axis Accelerometer Module
- FingerPrint Scanner: GT-511C3
- GPRS module: GPRS shield V1.0(laer used V2.1
- GPS module: Ublox NEO-6M GPS Module Aircraft Flight Controller For Arduino MWC IMU APM2 US
- Hub Dynamo: Shimano DH-3D72 Dynamo Rim Brake 36h
- Microcontroller: Arduino Mega 2560
- AC/DC converter by Harmanpreet Chhina
- Avido 4000 mAh battery

Appendix B: Equipment List

- DC power supply: used in the testing of the power management system we implemented.
- Laptop: software written and uploaded to microcontroller from here.
- Multimeter: to check current and voltage at different points of various circuits.
- USB cable: Standard A-B cable; 1.0 USB to 2.0 USB, connect the laptop and Arduino Mega.

Appendix C: Software List (URL to online drive or SVN server, with sharing set to Public. Can omit this appendix if your project didn't involving writing a program)

Appendix D: Citations

- For AC to DC converter:

http://www.14degrees.org/diy-bicycle-dynamo-usb-charger-for-smartphones-and-battery-packs/

Appendix E: Link to code if you would like to modify or use it as a template

https://drive.google.com/drive/u/1/folders/0B2n9f-LeMu_AcjY4ZklUSWNXcG8