Cell Phone Pocket Tool

ECE 398 Fall 2016

Design Review

Group #7

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1 Introduction
1.1 Statement of Purpose
In today’s world, Phones have become a basic necessity of every individual’s life. People tend to carry them everywhere and anywhere they go due to its purpose be it for communication, web browsing, or just playing games on them etc. However, despite their requirements, it is not very convenient to carry these devices everywhere and all the time. This may be due to their battery life, chances of being stolen or forgotten or for the very fact that they are an electronic device and thus damageable. Our goal is to design a case which attaches to the cell phone and turns it into conveniently portable pocket tool thus minimizing the above mentioned constraints.

1.2 Objectives
1.2.1 Goals & Benefits
- Able to track lost phone, even if the phone is out of battery
- Extra support to protect phone from falls
- Added battery life
- Phone can be slowly charged in areas where electricity is not available
- Extra to eliminate the need of a wallet
- Case is not too big, and can still fit in the user’s pocket
- Easy to install

1.2.2 Functions & Features
- GPS tracking device that can send signals to an external website
- Carbon Fibre case that strengthens the rigidity of the user’s phone
- Case also protects the internal electrical components
- Internal lithium polymer battery can be used as a backup battery to charge the user’s phone
- Solar panel on the exterior of the case can be used to charge the extra battery in places without outlets or electricity
- Sleeves in the case allow for storage of cards and cash
- Carbon Fibre case encloses all the components and is not too large
- Adhesive pad allows most cell phone users to stick the case to the back of their phone
- Raised carbonate fibre edges for further protection on the exterior.
- Various different colors to choose from
- Temperate glass, which is the outside top layer, allows sunlight to pass into the solar panel

1.2.3 Alternatives & Competition
There currently are no other products like this in the market. There may be a wide variety of strong cases for different cell phones, but none of these cases have the features that the Cell phone pocket tool has. There were some different alternative designs while coming up with the final design. At first there was going to be usb cords inside the case that would be able to attach the rechargeable battery to the phone’s USB port. Another design that was scratched was to make the case carry certain small tools. This could not work because there would not be enough room in the case for these tools. We wanted to make sure that the case was not too large that it would not fit in pockets or purses.

2 Design

2.1 Block Diagrams
2.1.1 System Overview

Figure 1. System Overview Block Diagram
2.1.2 Concept Sketch

- Space for camera
- Detachable card holder and also acts as a stand
- Solar panel under tempered glass
- Charging Port
2.2 Block Descriptions

2.2.1 Carbon Fibre Back Cover Case
Comes in various sizes and shapes and attaches to the cell phone. It consists of a charging pin with same dimension as the charging port of the cell phone and the pin goes into the charging port. The case is light, thin, durable and strong. It adds to the thickness of phone by 6mm and to its weight by about 100~110 grams (most of this weight is contributed by the lithium polymer battery and the carbon fibre other weights can be ignored being negligible.)

The case is the backbone of the design. Besides providing extra strength to the phone, it encloses all of the other components in our design. It makes sure that no water or debris can enter the case. Lastly, it protects all of the electronics in case the user were to drop the phone.

The carbon fibre case is made from a carbon fibre layup mold. The carbon fibre is a 3K Twill weave. This weave is inexpensive and extremely strong. The case can have an exposed carbon fibre look, or the user may pick a solid color that is colored over the carbon fiber.

The bottom edge of the case by the phone’s charging port, has a removable sliding edge. This sliding edge will connect the external battery to the phone's charging port. This is the only feature that will change from phone to phone. Also, the user can still use the case on other phones if they decide to change their type of phone whether it is android or apple.

2.2.2 Exterior Sleeves
There is a detachable card case for customer to keep their credit cards and it also acts as a stand to watch movies etc. However if the customer wishes for their phone to look slim then towards the bottom of the case there is a sleeve that can be used for credit cards, IDs, and cash. This sleeve is under all of the electronic components and is the closest component to the adhesive pad. The sleeves are designed to fit the size of the common cards at 3.37 X 2.125 inches. These sleeves can make the wallet obsolete if the user wants to travel lightly.

2.2.3 Solar Panel
The solar panel is used to charge the extra battery in cases of emergency. If the user is in an area where there are no outlets or electricity, the solar panel can be left in the sunlight to charge the extra battery. The solar panel has a peak voltage of 3.0 Volts and a peak current of 200mA. The open circuit voltage is 3.6 Volts. The panel should not be used to always charge the battery, but instead of emergencies. The panel will lie right below the tempered glass. This is so that the panel is not exposed to the elements. The glass will help protect the panel and also prevent the panel from scratches or other damage in the case the phone is dropped. The
output of the solar panel will be connected to the main PCB module that will then send the charge safely to the external battery.

2.2.4 Tempered Glass
Transparent 1mm thick glass with a slight curvature to absorb the sunlight and concentrate it on the solar panels. It also ensures that the panels are safe in case of a drop as it is strong and does not shatter like glass.
This is the top layer of the case. It sits directly over the solar panel, and allows sunlight to pass through. The glass is held in place with a strong glue adhesive and attaches to the edges of the carbon fibre base.

2.2.5 Lithium Polymer Battery
Rechargeable battery that powers the GPS tracker, and can charge the phone’s internal factory battery when needed. This battery can be charged in two different ways. First, it can be charged by the solar panels when they are exposed to the sun’s energy or it can be charged by plugging the usb cord into a charger port of the phone, just as the phone is usually charged. The lithium polymer battery that will be used has a nominal voltage of 3.7V and a charge rate of 2500mAh.

2.2.6 Lithium Polymer Battery Charger and Low Voltage Lockout PCB Module
This block is the main PCB for the case. This PCB will have 3 main functions. The first function of this PCB module is to take the charge and current generated by the solar panel and send it to the external lithium polymer battery. The output of the solar panel is 3 Volts so a boost-converter will be needed to step-up the voltage to 3.7 Volts.

The GPS module will also need a boost-converter. Since the GPS module may require 5 Volts, a boost-converter will be used to increase the output voltage of the battery to the desired input voltage of the GPS device.

The next and most important function will be to charge the lithium polymer battery. This is very important because these batteries are extremely fragile and dangerous. The design will be make sure that a constant current and voltage are used to charge the battery. During the charging process there are three main phases. The first phase is a preconditioning charge. The second is a constant-current fast charge. The last phase will have a constant-voltage charge to make sure the battery is at its max voltage. The circuit will be supplied charge from an external source such as an outlet. This will occur when the external cover is slid into place. The external battery and internal battery will be connected in parallel. This allows both batteries to charge at the same time.

The last function is to have the external battery charge the phone’s main internal battery. This also occurs when the external cover is slid into place, connecting both batteries.

2.2.7 GPS Tracking Device
The GPS device should get its GPS location and then broadcast its location over the internet, as well as an ID that will be assigned to it when installing it on the board. The GPS have to be able to be powered by a Li-Ion battery and operate around 3-5V, with some sort of broadcast system. Its dimensions will need to be less than 2.8” in width and less than 4” in the length to fit in the case. Thickness should be minimal to keep the case compact, and the device should not be heavy enough to weigh down the case. The device will send a signal GPS coordinates to the website if the user has registered the device.

2.2.8 Adhesive Pad

Another key important part of the cell phone pocket tool is the adhesive pad. This is needed to attach the whole case to an existing phone. The pad comes in a size of 6 X 3 Inches. This is large so that the user may cut the adhesive to match the size of their cell phone. The double sided adhesive is very strong and should keep the cell phone pocket tool attached to the phone at all times. If needed the adhesive could be slowly pried off and removed with general purpose adhesive cleaner.

2.3 Lithium Polymer Standalone Charger Schematic

![Figure 3. Li-Po Standalone Charger from Linear Technologies PN: LTC4065](image)

![Figure 4. Pin locations of PN; LTC4065](image)

2.4 Software Flowchart
Figure 5. Website Flowchart

Above is the primitive website flowchart. The user will first enter the website in the create account stage. After the user creates an account, the user will be asked to enter the GPS ID associated with the device they purchased. A cookie will allow the user to remain logged in, with CSRF defense to stop others from logging into the account by taking the cookie. The username and password will be hashed and inputted into the website database for security. The user may be asked to input other information as well, including security questions for password resets. When the user logs in, the database will check for the updated GPS coordinates, which will also be periodically updated since the device can move. There will be an embedded Google Map interface with the most recent GPS coordinates with a refresh button so the user can see where the device moved.
2.5 Simulations and Calculations

2.5.1 Lithium Polymer Standalone Charger

The schematic that was listed in Figure 3, has various different simulations. One of the most important features of the circuit is to make sure that output voltage of the charger does not exceed the max output voltage of 4.2 Volts. This can be seen in Figure 7. In this case, the supply voltage has gone over the limit of 4.2 Volts, but the output voltage still does not exceed this cutoff voltage.

Another simulation that is important, is to have a constant charge current if the supply voltage goes over the threshold. This can be seen in Figure 8. The charger continuously sends the same charge current even though the supply voltage is increasing over the threshold. This is also very important because the lithium polymer battery requires a constant charge current in order to efficiently and safely charge the battery. Simulations gathered from data sheet in reference [1].
2.5.2 Power Consumption Calculation

The battery that has been chosen has a nominal voltage of 3.75V. In order to find the power capacity and capability of the battery the following equations were used.

Capacity [Wh] = Nominal voltage * Current provided = 3.75 * 2.5Ah = 9.375Watt hours (1)

Capability [C] = Ahr / hr = 2.5Ah / 1hr = 2.5Amps (2)
2.5.3 IV-Characteristics of Solar Cell

Figure 9. I-V Curve of a Solar Cell

As from the photo, to get the maximum power output from our solar cell, we need to compare the open circuit voltage and short circuit current, and find the maximum power output. This photo is from reference [2].

3 Requirements and Verifications

3.1 Requirements & Verifications
3.1.1 Carbon Fibre Back Cover Case [5 Points]

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verifications</th>
</tr>
</thead>
</table>
| 1. Needs to be shock resistant.  
2. Case also needs to be waterproof  
3. Case needs to withstand extreme cold and heat. -20°F - 150°F | 1. Cover will be attached to a working cell phone. Case and phone will undergo a drop test from 5 Feet, and will also undergo a vibration test for two hours. 
2. Case will be submerged in a water tank for one hour. Internal electronics all must still function properly. (Functionality Test)  
3. Case with internal electronics will be placed in a thermal chamber for 8 Hours. Basic functionality test conducted after. |
### 3.1.2 Exterior Sleeves [2 Points]

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Has to hold the standard credit card dimensions of 3.37 X 2.125 inches.</td>
<td>1. Various different cards will be inserted into the sleeves for 50 cycles. Sleeves must still hold cards if turned upside down.</td>
</tr>
<tr>
<td>2. Sleeves cannot be more than 5% bigger than this standard sized. If so, cards may slide out.</td>
<td>2. Measurements of dimensions will be taken with an accurate caliper. Measurements must be within 5% of required dimensions.</td>
</tr>
</tbody>
</table>

### 3.1.3 Solar Panel [10 Points]

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cannot output a voltage higher than 3.7 Volts with a current load of no more than 200mA ± 5%.</td>
<td>1. Multimeter will be used to measure output voltages and currents of the solar panel when the panel is under sunlight. Charge sent from panel must not exceed requirements.</td>
</tr>
<tr>
<td>2. Panel must absorb energy when sun’s visibility is at least 50%</td>
<td>2. Multimeter is used to see if solar panel is absorbing some energy at different points of the day, and during cloud coverage.</td>
</tr>
</tbody>
</table>

### 3.1.4 Tempered Glass [4 Points]

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Needs to not crack after falling from at least 5 Feet</td>
<td>1. Drop test from 5 Feet for 100 cycles. Screen should have no signs of cracks after test.</td>
</tr>
<tr>
<td>2. Glass should be scratch resistance</td>
<td>2. Glass should be scratch free after being exposed to a mineral with a Mohs hardness of 7.</td>
</tr>
</tbody>
</table>

### 3.1.5 Lithium Polymer Battery [10 Points]

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lithium battery must have a <strong>nominal</strong> cell voltage of 3.7 ± 5%, and a charge output range of 2000mAh - 3000mAh</td>
<td>1. Multimeter used to measure input and output voltages to make sure they are in the required range.</td>
</tr>
<tr>
<td>2. Battery must have a lifetime of at least 5000 full charges.</td>
<td>2. Battery must be charged then discharged by a 2 Ohm load for 5000 full charges.</td>
</tr>
<tr>
<td>3. Battery should charge a dead phone to at least 50% of full charge.</td>
<td>3. Rechargeable battery must charge a dead phone to at least 50% Multimeter will be used to monitor voltages and currents.</td>
</tr>
<tr>
<td>4. Battery must be able to work in parallel</td>
<td></td>
</tr>
</tbody>
</table>
with the factory battery in the cell phone.

4. Multimeter and oscilloscope used to make sure both batteries can work and charge in parallel.

### 3.1.6 Lithium Polymer Battery Charger and Low Voltage Lockout Module [10 Points]

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Must be able to charge Polymer Battery in the three phases listed in the block diagram.</td>
<td>1. Battery will be monitored with a multimeter during each phase of charging process. Voltages must be within batteries allowed values of 2.5 V to 4.2 Volts.</td>
</tr>
<tr>
<td>2. Internal Boost converter must convert the output voltage from the external battery to the needed input voltage of 5 V for the GPS module.</td>
<td>2. Boost converter must take an input voltage of around 3.7 Volts and boost the voltage to 5 Volts for the GPS module. Converter will be monitored with an oscilloscope.</td>
</tr>
<tr>
<td>3. Needs to take output of solar panel and send charge to the external battery.</td>
<td>3. Charge must be coming from the solar panel (multimeter reading) and sent to the external battery.</td>
</tr>
<tr>
<td>4. Low voltage lockout module must disconnect battery from circuit if voltage drops below minimum battery voltage of 2.5 Volts</td>
<td>4. Lockout circuit will be tested. This needs to be done in a safe laboratory area, because lithium polymer battery may explode when operating below its threshold. Circuit should disconnect the battery from the rest of the circuit in this case to make sure no other components are harmed.</td>
</tr>
<tr>
<td>5. Module must connect external battery to phone's internal battery for general charging.</td>
<td>5. Multimeter readings on both external and internal batteries during charging from a wall charger.</td>
</tr>
</tbody>
</table>

### 3.1.7 GPS Tracking Device [10 Points]

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Needs to take a voltage of 3 - 5 V</td>
<td>1. Voltage functionality test. Voltages from the allowed range are tested on the device while the device is running.</td>
</tr>
<tr>
<td>2. Must be able to send an accurate signal that can track the phone to within 8 meters.</td>
<td>2. Signals are sent from phone in a known location. Once the phone is tracked, it must be accurate to within in 8 meters. This test will be carried out 100 times in different locations.</td>
</tr>
<tr>
<td>3. Must be powered by the lithium polymer battery.</td>
<td>3. At least a half-fully charger lithium polymer battery.</td>
</tr>
</tbody>
</table>
battery must power the GPS device. GPS device must be powered for at least 1 hour in order to ensure a signal has been sent to the website.

3.1.8 Adhesive Pad [4 Points]

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Verifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Needs to fit to at least 70% of today’s Smart Phones</td>
<td>1. Measurements of today’s top cell phones will be taken to find an average value.</td>
</tr>
<tr>
<td>2. Should remained attached to phone if a force of 200N is applied to pull the case apart.</td>
<td>2. Phone with case attached by adhesive will undergo a force-pull test of run through an Instron testing machine.</td>
</tr>
</tbody>
</table>

3.2 Tolerance Analysis

The most important functionality of this case will be the GPS tracking device and website functionality. Phones can be expensive to replace, and this case will help the user or the police track their phone in case of emergency or they lost it. The website should be up and operational at least 95% of the time, and the GPS tracker must be accurate to 8 meters. This is usually the typical accuracy of a cell phone GPS unit. In order to make sure the GPS works at most time, the phone will not be able to be recharged after a certain battery threshold is reached, and only the GPS tracker will work after that. The GPS tracker should work for at least 24 hours after the battery of the phone is empty, and the rechargeable battery no longer charges the phone.

This function will need to be tested to insure its accuracy. The plan is to test a couple of different small GPS devices that can fit into the phone’s case. Each tested device will send a signal to a designated website that will then tell us the location of the phone. One of the members will then make sure the gps and the phone are in this location and measure how far off the phone was from the center dot on the website. The GPS with the best average will be chosen.

3.3 Safety

The cell phone case was designed taking safety into consideration:

- The case has a rugged design made of carbon fibre which is a very strong and light polymer protecting the phone from damage in case of drops from about 5 ft. In addition, the edges of the case both in the front and back are high enough to keep it off a flat surface. This additionally helps to not have body contact with the phone, minimising the radiation though in a very small amount.
- A cell phone’s radiation increases when the battery level is lower, thence, addition of an extra battery significantly contributes toward minimising the radiation.
● All electrical components are inside the carbon case covered with an added layer of insulation to prevent any electrical shocks. Therefore making the case shock resistant.
● The solar panels are covered with an electrically insulating tempered glass and moreover a detachable back case is provided to reduce the radiation effects.
● In the case the phone is lost it can be tracked with the inbuilt GPS system of the case.
● The main PCB module contains an undervoltage and over voltage protection circuit. This is to ensure that the battery will not explode under non tolerable voltages and currents.
● The phone case, due to its material, does not capture the radiated heat from the phone and nor blocks it. This causes no internal damage to the phone or affecting its operating capacity.

3.4 Ethical Issues
One issue with this product is the possible inaccuracy of the GPS system. If the system failed, the GPS signal may claim it’s in a home when it’s not actually there. This could cause the owner of the pocket device to assume that someone in the home stole the device, possibly causing legal issues.

If the website is unsecure, this can lead to a data breach. This could give away user’s personal information. If the hacker was able to gain access to the GPS location updates, they would be able to track people down who are using the device. In order to avoid this, the database will need to be as secure as possible to avoid this kind of data breach.

The Cell Phone Pocket Tool also follows IEEE codes of ethics. These are listed below and are found in reference [3].

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;
2. to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;
3. to be honest and realistic in stating claims or estimates based on available data;
4. to reject bribery in all its forms;
5. to improve the understanding of technology; its appropriate application, and potential consequences;
6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
8. to treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression;
9. to avoid injuring others, their property, reputation, or employment by false or malicious action;
10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

4 Cost and Schedule

4.1 Cost Analysis

4.1.1 Labor

<table>
<thead>
<tr>
<th>Name</th>
<th>Rate</th>
<th>Overhead</th>
<th>Hours</th>
<th>Total</th>
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</thead>
<tbody>
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<td>Jonathan Rakushin</td>
<td>$25</td>
<td>x2.5</td>
<td>250</td>
<td>$15625</td>
</tr>
<tr>
<td>Casey Labuda</td>
<td>$25</td>
<td>x2.5</td>
<td>250</td>
<td>$15625</td>
</tr>
<tr>
<td>Shruti Chanumolu</td>
<td>$25</td>
<td>x2.5</td>
<td>250</td>
<td>$15625</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>$46875</strong></td>
</tr>
</tbody>
</table>

4.1.2 Parts

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Manufacturer</th>
<th>Vendor</th>
<th>Cost/Unit</th>
<th>Total Cost</th>
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<td>Hunan Sounddon</td>
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<td>Robot Shop</td>
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<td>$43.95</td>
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<tr>
<td>Solar Panel</td>
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<td>Sundance Solar</td>
<td>Sundance Solar</td>
<td>$5.79</td>
<td>$5.79</td>
</tr>
<tr>
<td>12&quot; by 12&quot; 3/16” thick tempered glass</td>
<td>1</td>
<td>Store Supply Warehouse</td>
<td>Store Supply Warehouse</td>
<td>$2.26</td>
<td>$2.26</td>
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<tr>
<td>Custom Carbon Fibre Case</td>
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<td>Unknown</td>
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<td>Battery PCB Module</td>
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<td>Tenergy</td>
<td>Battery Junction</td>
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<td>Parts</td>
<td>$105.09</td>
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<td><strong>Grand Total</strong></td>
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<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Task</th>
<th>Responsibility</th>
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<tr>
<td>09/29/16</td>
<td>Finalize Project Proposal</td>
<td>All</td>
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<tr>
<td>10/10/16</td>
<td>Look into parts</td>
<td>Casey</td>
</tr>
<tr>
<td>10/13/16</td>
<td>Finalize Parts and Design Review</td>
<td>All</td>
</tr>
<tr>
<td>10/15/16</td>
<td>Order Parts</td>
<td>Shruti</td>
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### 5 References

