Multiple Input Battery Charger
Competitive Value Analysis

Group 3
Homework 2
November 11, 2003
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1 Introduction

1.1 Product Specifications

Our product should be lightweight and small enough to provide easy portability. It must also have a simple to understand user interface that will be implemented using an LED array and buzzer. For the power source, a transformer will be used to convert a variety of AC sources (90-260 V) to DC power and a fuse will be placed in series to prevent damage to the device in the event of a power spike. The power source must also format the various DC inputs from the Solar Panel and Pedal Generator into a usable DC signal. In addition to regulating the power output to the battery the charge monitor must also monitor the charge status to ensure that the battery is not overcharged. Our product must be very affordable with a development cost of U.S. $50 and a production cost of less than U.S. $25.

1.2 Purpose

There are two major purposes of this report. The first purpose is to compare and perform value analysis on several design concepts and determine the most feasible implementation. The second purpose is to compare our chosen design approach against existing products and decide if and where our product will fit into the market. We will use value analysis matrices to aid us in deciding which options will make our product the most marketable.
2 Design Options

2.1 General Design Approach

Given the set of product specifications described in the introduction, we found that the most effective way to design the device was as a set of several interconnecting subsystems. The block diagram shown below highlights the three main subsystems identified during the design process: a power supply, a battery charge monitor and a charge status display. The power supply in our product is used to format any applied voltage from the three types of potential inputs (wall outlet AC, solar panel or pedal generated voltage) and to apply a voltage on the battery in order to charge it. The charge monitor is needed to regulate the current flow into the battery so that the battery does not become overcharged or otherwise damaged during the process of charging. Additionally, the charge status display is necessary to indicate the level of charge on the battery and, in particular, to alert when the battery has been fully charged.

Additionally, there are several methods of charging the battery that depend on a variety of factors including the internal chemistry and ambient temperature of the battery. Different chargers utilize a variety of charging algorithms to provide optimal charge to the battery. Among these are the Wet Standard, the Wet Low Standard, the AGM Standard and the VRLA Gel-Cell Standard. The algorithms make use of different applied voltages and currents at different times in the charging process; the Wet Low Standard is shown in Figure 21. We have elected to use a two step charging algorithm whereby the power supply will apply a constant current until the charger reaches a certain voltage threshold at which point the current will be tapered off.

---

1 Car Battery FAQ (Online: http://uuhome.de/william.darden/carfaq9.htm#algorithms)
2.2 Value Criteria of Design Options

The power supply could be designed in several different ways. The value criteria we chose to use are cost, efficiency, voltage tolerance, accommodation for brownouts and voltage spikes, and simplicity of design.

The charge monitor is another subsystem that has a variety of implementation methods. We chose cost, power consumption, durability, and simplicity of design as our most important criteria.

Another subsystem that we feel is important to our design is having a display/interface to allow the user to know when the battery is charged. Ease of understanding, cost, simplicity, and power consumption are among the decisive factors.
The charging algorithm used is a parameter that differs between competing devices. To choose our algorithm, we will use simplicity and cost of implementation as our driving criteria.

2.3 Metrics for Value Analysis

After researching several available products and considering both our design specifications and the needs of our customer we were able to determine a key set of design criteria that would help us choose the most effective implementation strategy. The following list presents the weighting of our module design criteria:

- Affordability (3)
- Operating Conditions (2)
- Efficiency of Operation (2)
- Durability (1.5)
- Availability of Components (1)
- Simplicity of Design (0.5)

2.4 Summary of Design Approaches from Brainstorming

Power Supply

The power supply subsystem of our design is responsible for converting an AC source into DC and accepting two additional DC sources. In brainstorming this subsystem we determined two ways of handling the AC/DC conversion process. Converting the 110/220 AC voltage into a DC voltage could either be done internally through the use of a transformer, bridge rectifier and zener diode or the conversion could be done externally through the use of an AC adapter rated for the appropriate voltage range.
Charge Monitor

While brainstorming the charge monitor we identified several design strategies for this subsystem. Because the charge monitor must tell the charge status display what to indicate, we considered using an A/D converter in a sample-and-hold configuration to quantify the battery’s voltage. The digital output could then be passed through several combinational logic circuits in order to generate both the appropriate input for the charge status display and the control signals for the power supply. Another digital approach would be to utilize a PIC microcontroller with an internal A/D converter. The PIC could then read the battery voltage and internally generate the output for the charge status display and control signals for the power supply. This particular design strategy would eliminate the need for additional combinational logic circuitry.

Having considered digital solutions we next considered an analog strategy for implementing the charge monitor. One possible analog design consists of generating a reference voltage (possibly the voltage at which the charger stops charging) and comparing it to the battery’s voltage using a comparator. The output signal from the comparator would then be sent back to the power supply in order to control the charge placed on the battery by means of a negative feedback loop. Another analog design would be to use the LED array in the charge status display to measure a specific voltage on the battery and then feed that voltage back to the power supply in a negative feedback loop. This design approach has the advantage of merging the charge monitor and charge status display into a single functional subsystem.
Charge Status Display

Several design options exist for the charge status display. An analog display with an arrow that either ranges between 0 and 100% charge or indicates the battery voltage (a voltmeter) could be used. A single LED or group of LEDs could also be used for this task. The single LED design would have the LED lit when the battery reached full charge, while the LED array design would feature a progressive update of the charge status. Another option would be to use a 7-segment LED display to output a numeric charge percentage. Additionally, in terms of non-visual display systems, a buzzer could be used to generate an audible signal that the battery has finished charging. The buzzer also need not be standalone as it could be used in conjunction with one of the other design strategies.
3 Specific Module Design Options

3.1 Power Supply:

Product Requirements

Handles 110/220V AC as input
Supports solar panels and pedal generator as input
Produces a DC voltage suitable for charging a 12V lead acid car battery

Options Available and Advantages/Disadvantages

External AC/DC conversion using an AC adaptor:
Easy to implement, more expensive.
Internal AC/DC conversion:
Hard to implement, less expensive.

Value Analysis

Cost: Price of subsystem.

- Inexpensive: 3
- Reasonably Priced: 2
- Expensive: 1

Simplicity: Ease of construction.

- Easy: 3
- Moderate: 2
- Hard: 1

Availability: Widely available components

- Good: 3
- Average: 2
- Poor: 1

Weight Assignments

A completed value analysis for the power supply is shown in Table 1 below.
### 3.2 Charge Monitor:

**Product Requirements**

- Does not overcharge the battery
- Outputs to the display
- Controls the power supply

**Options Available and Advantages/Disadvantages**

- Digital with combinational logic:
  - Hard to implement, easily expandable/robust, high power consumption.
- PIC microcontroller:
  - Software expandable (handles logic internally), replacement parts unavailable in developing countries.
- Analog with comparator:
  - Hard to implement, readily available replacement parts.
- Integrated with charge status display:
  - Efficient design, low power consumption.

**Value Analysis**

<table>
<thead>
<tr>
<th>Cost</th>
<th>Value point</th>
<th>Total</th>
<th>Value point</th>
<th>Total</th>
<th>Value point</th>
<th>Total</th>
<th>Value point</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inexpensive</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reasonably Priced</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expensive</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Power supply value analysis
Efficiency: Power consumption of the subsystem

Good 3
Average 2
Poor 1

Simplicity: Ease of construction.

Easy 3
Moderate 2
Hard 1

Weight Assignments

A completed value analysis for the charge monitor is shown in Table 2 below.

<table>
<thead>
<tr>
<th>Quality</th>
<th>Value Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency of Operation</td>
<td>Charge Monitor</td>
</tr>
<tr>
<td>Value point</td>
<td>Total Value point</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Convenience</th>
<th>Value Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplicity of design</td>
<td>Charge Monitor</td>
</tr>
<tr>
<td>Value point</td>
<td>Total Value point</td>
</tr>
<tr>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Total</td>
<td>0.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost</th>
<th>Value Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components</td>
<td>Charge Monitor</td>
</tr>
<tr>
<td>Value point</td>
<td>Total Value point</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>13.5</td>
</tr>
</tbody>
</table>

| Customer Value: (Quality/Convenience/Cost) | 8 | 1 |
| Total | 0.5 | 0.7 | 1.2 | 0 |

Table 2: Charge monitor value analysis

3.3 Charge Status Display:

Product Requirements

Easy to understand
Inexpensive
Low power consumption

Options Available and Advantages/Disadvantages

Analog display:
Hard to interpret, more expensive.

Buzzer:
Easy to implement, does not indicate charge status.

Seven segment display:
Hard to implement, more expensive, requires literacy.

Single LED:
Inexpensive, low power consumption, easy to implement, does not indicate charge progress.

LED array:
Inexpensive, low power consumption, harder to implement than single LED, indicates charge progress.

**Value Analysis**

Cost: Price of subsystem.

- Inexpensive: 3
- Reasonably Priced: 2
- Expensive: 1

Simplicity: Ease of construction.

- Easy: 3
- Moderate: 2
- Hard: 1

Understandability: The clarity of the display.

- Good: 3
- Average: 2
- Poor: 1

**Weight Assignments**

For the display subsystem, we considered understandability to be the most important criteria and, as a result, it was assigned a weight of 3. Of the remaining two criteria, cost was assigned a weighting of 2 and simplicity a weighting of 1.
### Charge Status Display Value Analysis

<table>
<thead>
<tr>
<th>Quality</th>
<th>Market</th>
<th>Analog Display</th>
<th>Buzzer</th>
<th>Seven Segment Display</th>
<th>Single LED</th>
<th>LED Array</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value point</td>
<td>Value point</td>
<td>Total</td>
<td>Value point</td>
<td>Total</td>
<td>Value point</td>
</tr>
<tr>
<td>1: Simplicity of design</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2: Understandability</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost</th>
<th>Market</th>
<th>Analog Display</th>
<th>Buzzer</th>
<th>Seven Segment Display</th>
<th>Single LED</th>
<th>LED Array</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value point</td>
<td>Value point</td>
<td>Total</td>
<td>Value point</td>
<td>Total</td>
<td>Value point</td>
</tr>
<tr>
<td>1: Components</td>
<td>2</td>
<td>7.5</td>
<td>15</td>
<td>1.5</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>15</td>
<td>15</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

**Customer Value (Quality x Convenience x Cost):**

<table>
<thead>
<tr>
<th></th>
<th>Value point</th>
<th>Value point</th>
<th>Total</th>
<th>Value point</th>
<th>Total</th>
<th>Value point</th>
<th>Total</th>
<th>Value point</th>
<th>Total</th>
<th>Value point</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>0.3</td>
<td>4</td>
<td>1.3</td>
<td>18</td>
<td>3.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Charge status display value analysis
4 Preferred Design Approach

Our value analysis shows that the most value effective approach will be to use an internal AC to DC converter for the AC input of the power supply. The device will be required to accept an input range of 90–260 V AC and 6-16 V DC.

As for the charge monitor, we found that integrating this system with the display unit would be the most cost-effective way of implementation. Using an array of LEDs for the display in conjunction with an audible buzzer will prove the most inexpensive means of providing an intuitive user interface.

![Figure 2: Functional System Block Diagram](image)
5 Competitive Value Analysis

5.1 Quality

Operating Conditions: How well will the product operate under extreme conditions (heat, humidity).

- Very Well: 5
- Well: 4
- Moderately: 3
- Poorly: 2
- Very Poorly: 1
- Not at all: 0

Display: The quality of the charge status display.

- LCD, Full: 4
- LCD, Segmented: 3
- LED Array: 2
- Analog Display: 1
- No Display: 0

Extra Features: Are there a variety of distinguishing features?

- Several: 2
- A Few: 1
- None: 0

Range: The range of input voltages that the charger will be able to operate with.

- Wide: 2
- Moderate: 1
- Small: 0

5.2 Convenience

Ease of use: User interface difficulty.

- Very Simple: 4
- Simple: 3
- Moderate: 2
- Difficult: 1
- Nearly Impossible: 0
Charge Time: How long does it take the charger to charge the battery?

<table>
<thead>
<tr>
<th>Speed</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td>3</td>
</tr>
<tr>
<td>Moderate</td>
<td>2</td>
</tr>
<tr>
<td>Slow</td>
<td>1</td>
</tr>
<tr>
<td>Very Slow</td>
<td>0</td>
</tr>
</tbody>
</table>

Modular Design: Easy to replace individual subsystems?

<table>
<thead>
<tr>
<th>Modular Design</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
</tr>
</tbody>
</table>

Components: Availability of Components.

<table>
<thead>
<tr>
<th>Availability</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Widely Available</td>
<td>3</td>
</tr>
<tr>
<td>Common</td>
<td>2</td>
</tr>
<tr>
<td>Uncommon</td>
<td>1</td>
</tr>
<tr>
<td>Rare</td>
<td>0</td>
</tr>
</tbody>
</table>

Versatility: Can operate with multiple power inputs.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 inputs</td>
<td>3</td>
</tr>
<tr>
<td>2 inputs</td>
<td>2</td>
</tr>
<tr>
<td>1 input</td>
<td>1</td>
</tr>
<tr>
<td>0 inputs</td>
<td>0</td>
</tr>
</tbody>
</table>

Weight: Weight of Charger.

<table>
<thead>
<tr>
<th>Weight</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5lbs</td>
<td>4</td>
</tr>
<tr>
<td>5lbs&lt; W &lt;10lbs</td>
<td>3</td>
</tr>
<tr>
<td>10lbs&lt; W &lt;15lbs</td>
<td>2</td>
</tr>
<tr>
<td>15lbs&lt; W &lt;20lbs</td>
<td>1</td>
</tr>
<tr>
<td>20lbs+</td>
<td>0</td>
</tr>
</tbody>
</table>

5.3 Cost

Price: Consumer cost for product.

<table>
<thead>
<tr>
<th>Price</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;$20</td>
<td>3</td>
</tr>
<tr>
<td>$20&lt; $ &lt;$35</td>
<td>2</td>
</tr>
<tr>
<td>$35&lt; $ &lt;$50</td>
<td>1</td>
</tr>
<tr>
<td>$50+</td>
<td>0</td>
</tr>
</tbody>
</table>
5.4 Metrics for Value Analysis

For our value analysis, we weighed each criterion depending on its importance to the customer. The price of the charger was our most important criterion. The device will need to be affordable to appeal to the largest market possible. The second highest item on our criteria list was the product’s ability to operate under extreme conditions. We chose a value rating of 2. The charger will be of no use to our market if it cannot operate under the high heat that exists in Mali and other developing countries. Durability was next on our list and rated at 1.5. The product needs to have a long lifespan and be able to withstand everyday bumps and drops. Furthermore, the people we are marketing this device toward will not be able to afford buying such a device often, so it needs to last. We weighed the power efficiency at 2. It is also important that the internal components be widely available to the people of Mali; to justify this we assigned availability of components a weight of 1. Finally, simplicity of design was rated 0.5. This will also be important to the people of Mali and other developing countries who are most likely not technically educated.
6 Competitors

After searching widely, we were able to find many competitors in the market of recharging batteries. Typical applications for battery charging included Marine, camping/outdoor, and automotive uses. It was determined after thorough research that our product would be unique to the marketplace due to the fact that currently no charging device available is designed to accept multiple power sources. Despite this, we will evaluate similar products for each type of input source; AC, Solar, and Pedal Generated. Table 4 shows the competitive value analysis of our product vs. the four competitors described below.

6.1 Solar Chargers

When solar panels are used to charge storage batteries, their limited output under low sunlight conditions leads to seriously shortened battery life and performance. Trying to protect against this creates higher costs, as the typical solution seems to be increasing the size / number of both the panels and batteries. In addition, typical solar controllers, although able to protect batteries from under/over charge, fail to optimize the charge rate capabilities of the solar panels. They also do not remove sulphate* build-up on the battery’s storage plates, causing longer recharge time, boil out and significantly shortened life.

There are a variety of solar devices that will fully charge a battery with prices ranging from U.S. $64 - $900 depending on the extra features. Output wattage and solar panel size of these chargers seemed to be the biggest price differentiator. After looking at several models, we what seemed to be two of the better commercially available solar chargers out there.
PRO-KIT 15-WATT SOLAR BATTERY CHARGER – ICP Global Technologies

The Pro-Kit Charger was similar to many other solar products available. At U.S. $189 the device is far more expensive than our product, but the photovoltaic cell is what drives the cost of the charger up and because our charger relies on an external solar cell, it is reasonable to assume that our product would be a competitor².

Specifications:

- Wattage: 15 watts
- Approx. Watt-Hrs / Day *: 60 – 75
- Dimensions: 38” x 13” x 1” / 965 mm x 330 mm x 25 mm
- Temperature Range: -40°F to 176°F / -40°C to 80°C

Ratings:

- Operating Conditions: 5, Diverse Temperature Range and Weatherproof Design
- Display: 2, Very Limited User Display
- Extra Features: 1, Has a few added features like overcharge protection
- Range: 4, Can operate on many input voltages- dependent upon sunlight
- Ease of use: 4, Intuitive to Use
- Charge Time: 2, Depends on available sunlight, 15 W Max Output
- Modular Design: Unknown- Don’t know internal design
- Components: Unknown- Don’t know internal components
- Versatility: 1, Operates on 1 Input
- Weight: 3, Light-weight
- Price: 0, $189

BATTERYMINDER 12 VOLT 5 WATT SOLAR CHARGER– VDC ELECTRONICS

The BatteryMINDER, produced by VDC Electronics is another typical product that beats most other competitor’s price significantly for its output specs. The device distinguishes itself in particular because it “optimizes the solar panel’s charge rate, ensuring batteries are charged in the shortest

² Solar Chargers at JC Whitney- (Online: http://jcwhitney.com)
possible time, keeping them at full-charge indefinitely, without ever overcharging."³

**Specifications:**

- **Wattage:** 5 watts  
- **Peak Output:** 333 mAmps@15 volts  
- **Approx. Watt-Hrs / Day:** 20 - 25  
- **Approx. Amps / Day:** 1.4 - 1.75  
- **Dimensions:** 19 5/8" x 13 5/8" x 5/8"  
- **Weight:** 7 lbs  
- **Temperature Range:** 0°F to 130°F  
- **Warranty:** 5 years

**Ratings:**

- **Operating Conditions:** 4, Diverse Temperature Range and Weatherproof Design  
- **Display:** 0, No User Display  
- **Extra Features:** 2, Battery Minder Component Optimizes Charge  
- **Range:** 4, Can operate on many input voltages- dependent upon sunlight  
- **Ease of use:** 2, Moderate Difficulty  
- **Charge Time:** 1, Depends on available sunlight, 5 W Max Output  
- **Modular Design:** Unknown- Don’t know internal design  
- **Components:** Unknown- Don’t know internal components  
- **Versatility:** 1, Operates on 1 Input  
- **Weight:** 3, Light-weight  
- **Price:** 0, $99.95

### 6.2 AC Chargers

There were an extensive number of portable, commercially available battery chargers, with prices ranging from about U.S. $30 - $500. The price was largely a variable of extra features, number of batteries that could be charged at one time and the output amperage, which determines the rate at which a battery is charged. The Competitors also had different ways of implementing what seemed to be different charging algorithms to achieve optimal charge. There are two options examined in this section, a typical, fully-finished consumer model and an exposed AC charger circuit made for industrial/customized applications. Because most consumer models were essentially the same, we chose the two models that best represent the needs and specs of our market.

³ BatteryMart, Solar Battery Chargers (Online: http://www.batterymart.com/battery.mv?c=solarchargers)
The Mobil Line Deep Cycle Battery charger is typical of most portable chargers in that it can recover deeply discharged batteries as well as prevent overcharging. The charger also has overload and reverse polarity protection as well as an intuitive, simple to understand LED display\(^4\). At U. S. $49.95, the device is competitively priced for the variety of features that it offers in comparison to other models.

**Specifications:**

- **Output:** 12 Volt Nominal; 10 Amp DC
- **Set Voltage:** 14.7 +/- 0.1 Volt
- **Float Voltage:** 14.0 +/- 0.1 Volt
- **Input:** 105 VAC - 120 VAC ; 60 Hz
- **Dimensions:** 3-1/2" x 2-1/4" x 4-1/2"
- **Weight:** 3 lbs.; 1.36kg

**Ratings:**

- **Operating Conditions:** Unknown
- **Display:** 2, LED Array
- **Extra Features:** 2, Several Extra features like polarity indicator and surge protection
- **Range:** 0, Only Rated for American Power Standard
- **Ease of use:** 4, Very Easy to Use
- **Charge Time:** 3, 10 Amp Output, uses charging algorithm for optimal time
- **Modular Design:** Unknown- Don’t know internal design
- **Components:** Unknown- Don’t know internal components
- **Versatility:** 1, Operates on 1 Input – American AC Standard
- **Weight:** 4, Light-weight
- **Price:** 1, $49.95

**L12-0.5/115AC LEAD ACID CHARGER– IBEX INC.**

Ibex Inc. offers a wide variety of industrial application battery chargers that can handle both American and European AC power sources as well as being manufactured to operate in harsh and extreme in

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\(^4\) Battery Mart, 12 Volt AC Chargers (Online: [http://www.batterymart.com/battery.mv?c=12voltchargers](http://www.batterymart.com/battery.mv?c=12voltchargers))
environments. Their line of devices are rugged and made to last for many years without failure or need for repair. The Ibex chargers range in cost from U.S. $45-$80⁵.

**Specifications:**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output:</td>
<td>14.8 V 10 Amps</td>
</tr>
<tr>
<td>Input:</td>
<td>103 – 252 V AC</td>
</tr>
<tr>
<td>Dimensions:</td>
<td>5” x 4” x 3”</td>
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<tr>
<td>Weight:</td>
<td>4 lbs</td>
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<tr>
<td>Temperature Range:</td>
<td>0°F to 130°F</td>
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**Ratings:**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Conditions:</td>
<td>4, Designed to Handle Extreme and Harsh Environments</td>
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<tr>
<td>Display:</td>
<td>0, No User Display</td>
</tr>
<tr>
<td>Extra Features:</td>
<td>1, Has some internal extra features</td>
</tr>
<tr>
<td>Range:</td>
<td>2, Accommodates American and European Power Standards</td>
</tr>
<tr>
<td>Ease of use:</td>
<td>0, Not housed, controls don’t come with circuit</td>
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<tr>
<td>Charge Time:</td>
<td>2, Uses 3-Stage Temperature Dependent Charging Algorithm</td>
</tr>
<tr>
<td>Modular Design:</td>
<td>1, Circuit is modular</td>
</tr>
<tr>
<td>Components:</td>
<td>2, Uses common parts like transformers, diodes and capacitors</td>
</tr>
<tr>
<td>Versatility:</td>
<td>2, Operates on 2 Inputs – US and European Standards</td>
</tr>
<tr>
<td>Weight:</td>
<td>4, Light-weight</td>
</tr>
<tr>
<td>Price:</td>
<td>1, $45</td>
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6.3 Pedal Chargers

From our market research, we determined there is not a wide variety of a commercially available pedal charger. Most of our inquires led us to believe that nearly all pedal chargers are homemade devices pieced together from various parts, typically bicycles and car alternators. There does not appear to be a standard consensus on how pedal chargers are built; a pedal generator will have various outputs depending on the RPM being produced, the gear-ratio of the chain drive, and the actual device being used as the generator to convert mechanical to electrical energy. Due to the lack of competing products available in the market place, our company will need to determine our own set of requirements for the pedal charging feature.

⁵ Ibex AC Battery Chargers (Online: http://www.ibexmfg.com)
# Battery Charger Value Analysis

<table>
<thead>
<tr>
<th>Quality</th>
<th>Market</th>
<th>ICP Pro-K</th>
<th>VDC Batteryminder</th>
<th>Mobil line</th>
<th>Cliplight</th>
<th>Ibx L12</th>
<th>WPI</th>
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<tbody>
<tr>
<td></td>
<td>Value point</td>
<td>Total</td>
<td>Value point</td>
<td>Total</td>
<td>Value point</td>
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<tr>
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<td>10</td>
<td>4</td>
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<td>4</td>
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<td>0</td>
<td>0</td>
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<td>2</td>
<td>1</td>
<td>4</td>
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<td>3</td>
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<td>0.5</td>
<td>1.8</td>
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<td>6.4</td>
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</table>

Table 6: Competitive Value Analysis
7 Capabilities

Our design was largely an effort to minimize price while maximizing the design and customer requirements. Because cost is the biggest issue, we are not on a level playing field with most competitors who charge a great deal more for a product that offers significantly less versatility. Our product offers many of the features that other competitors have like reverse charge and surge protection, easy-to-use display, and over/undercharge suppression. The key distinguishing features of our product is that it will be very portable and will accommodate 4 different forms of source power.

There are also several disadvantages associated with our product. Because we have a very small amount of time to develop this device, it will be hard to guarantee the long-term functionality/safety of the product. Our development options are also very limited because of our extremely small budget. Before asserting whether our product will be better than our competitors, we must first employ a rating of our proposed design:

- Operating Conditions: 5, Diverse Temperature Range and Weatherproof Design
- Display: 2, LED Array to indicate percentage charged
- Extra Features: 2, Has a several added features
- Range: 4, Can operate on many input voltages- 6-260 V AC
- Ease of use: 4, Intuitive to Use
- Charge Time: 3, 2-stage Algorithm
- Modular Design: 1, Modular Component Design
- Components: 2, Uses common components
- Versatility: 3, Operates on 3 Inputs – Solar, AC, and a Pedal Generator
- Weight: 3, Light-weight
- Price: 2, <$25 mass-production
8 Conclusion

During the course of conducting extensive market research and competitor analysis we concluded that our product will be highly viable in the market of battery chargers. In particular, we were able to determine that the feature set offered by our product far outstrips any of the competing commercially available products.

In addition to fully understanding our customers and the specifications that would appeal most to them, we were able to develop a better overall perspective on how we will implement the device. The value analysis also helped us to consider additional design possibilities that would have otherwise been overlooked.
9 References

1. Car Battery FAQ
   (Online: http://uuhome.de/william.darden/carfaq9.htm#algorithms)
2. Solar Chargers at JC Whitney
   (Online: http://jcwhitney.com)
3. Battery Mart, Solar Battery Chargers
   (Online: http://www.batterymart.com/battery.mv?c=solarchargers)
4. Battery Mart, 12 Volt AC Chargers
   (Online: http://www.batterymart.com/battery.mv?c=12voltchargers)
5. Ibex AC Battery Chargers
   (Online: http://www.ibexmfg.com)