Integrating a Rechargeable Lithium Battery with the PandaBoard Development Platform

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Abstract

The purpose of this application note is to provide guidance to PandaBoard and PandaBoard ES users who wish to integrate a rechargeable battery into their systems. This note includes PandaBoard design specifications, a comparison of two suggested battery solutions and a discussion of trade-offs to consider when designing your own system.

Keywords: PandaBoard, Li-Ion, Regulator, PowerPack
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1 Introduction

The PandaBoard is a single-board development platform which features an impressive array of ports and built-in features. Its fast processor makes it suitable for CPU intensive applications including 1080p video streaming. Unlike the Arduino, PandaBoard does not officially support the use of battery power. However, it’s versatility in other areas makes it appealing for a wide variety of projects, and, if properly assembled, powering the PandaBoard from a battery can be useful in applications where portability is desired.

2 Determining Power Needs

2.1 PandaBoard Inputs

The PandaBoard draws power from either USB or a dedicated 5V DC connector. Power over Ethernet (POE) is not supported. The DC connector has the following dimensions:

*Barrel Connector: 2.1mm ID, 5.5mm OD - Tip Positive*

The DC connector should be used in most cases. **USB is highly recommended against** if you anticipate any significant current draw from your application, as each USB port can only supply around 500mA current. If you need to power your system from a USB port, you can buy a cheap USB-DC connector. One example is the *Barrel Jack Adapter - USB to 5.5mm* which can be found at SparkFun for $2.95. Keep in mind that whichever option you choose, the input must be 5V regulated. The PandaBoard does not feature any internal regulators and supplying the wrong voltage could result in the board not powering on and/or permanent damage.

2.2 Calculating Current Draw

PandaBoard recommends using a 5V 4A regulator to power their board. However, currents much lower than this will probably suffice, depending on your application. You may consult the following tables to figure out the expected current that you will require. Add all USB devices and other attachments on top of the power draw from the PandaBoard itself. Always be conservative when estimating current, as insufficient PSUs are known to cause random software crashes on the PandaBoard.
Table 1: Current draw of PandaBoard in various modes of operation.

<table>
<thead>
<tr>
<th>Operating Mode</th>
<th>Current Draw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power On</td>
<td>163 mA</td>
</tr>
<tr>
<td>Running Ubuntu 10.10, WLAN disabled</td>
<td>400-570 mA</td>
</tr>
<tr>
<td>Running Ubuntu 10.10, WLAN enabled</td>
<td>450-710 mA</td>
</tr>
<tr>
<td>CPU Running at 100%</td>
<td>700-800 mA</td>
</tr>
</tbody>
</table>

Table 2: Current draw of common devices

<table>
<thead>
<tr>
<th>Device</th>
<th>Current Draw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyboard</td>
<td>15 mA</td>
</tr>
<tr>
<td>Mouse</td>
<td>30 mA</td>
</tr>
<tr>
<td>HDMI</td>
<td>50 mA</td>
</tr>
<tr>
<td>single USB max load</td>
<td>500 mA</td>
</tr>
<tr>
<td>Lights/Motors</td>
<td>May Vary</td>
</tr>
</tbody>
</table>

3 Single-Cell Chargers

If you already own a Li-Ion battery, or you wish to pick out your own battery and build the system in a more DIY fashion, single-cell chargers are an attractive solution. They incorporate charging circuitry, power path management, and boost regulators in an all-in-one package. When the circuit is plugged in they can power both the load and the battery charger, and when unplugged they automatically switch to powering the load from the battery.

Figure 1: Diagram of the flow of power using a single-cell charger. The charger automatically selects which paths are active.

The main reason not to use a single-cell charger is if you expect your application to draw more than 1000mA. At this range, 5v boost converters
become expensive and hard to find. If you have a medium to high power application, skip to the next section.

### 3.1 Selecting a Battery

3.7V Li-Ion/Polymer Battery Packs are increasingly common and can be purchased from a variety of vendors including:

- Powerizer [www.batteryspace.com](http://www.batteryspace.com)
- AllBattery [www.all-battery.com](http://www.all-battery.com)

Before selecting a pack, you should make sure that it is professionally balanced and comes with a built-in protection circuit. The PCB should protect against over-charging, under-charging, over-drain, short circuit, and wrong polarity. In addition, the battery’s maximum discharge rate should sit comfortably above your highest anticipated current draw.

### 3.2 Selecting a Charger

Two of the most popular hobbyist chargers are produced by Adafruit and Sparkfun. Sparkfun’s charger has a built-in Boost Regulator, while Adafruit’s does not. In order to use Adafruit’s charger with the PandaBoard you will have to add your own boost regulator. For this reason, the Sparkfun charger is suggested.

To use the Sparkfun charger, connect the PandaBoard to the pins labeled ‘out’, your battery to the JST connector, and your 5V power source to either the micro-USB connector or the pins labeled ‘charger’. Detailed instructions can be found on the charger’s product page.
3.3 Comparison of Chargers

<table>
<thead>
<tr>
<th></th>
<th>Sparkfun Power Cell - LiPo Charger/Booster</th>
<th>Adafruit USB LiPoly Charger - v1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>$19.99 USD</td>
<td>$12.50 USD</td>
</tr>
<tr>
<td>Input Type</td>
<td>USB mini-B/solder holes</td>
<td>micro-USB/solder holes</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>5V</td>
<td>up to 12V</td>
</tr>
<tr>
<td>Boost Regulator</td>
<td>600 mA max</td>
<td>NA</td>
</tr>
<tr>
<td>Charge current</td>
<td>1000 mA max</td>
<td>1000 mA max</td>
</tr>
</tbody>
</table>

Table 3: Attribute comparison of two popular single-cell chargers.

4 External Power Packs

Using an external power pack to power your PandaBoard provides reliable performance with minimal design and assembly. External power packs are also able to deliver much higher currents than single-cell systems. For these reasons, this method is recommended first unless the user has a good reason not to use it.

The power flow of this system requires the user to manually switch between the battery and the wall adapter.

![Diagram of power flow using an external power pack](image)

Figure 2: Diagram of the flow of power using an external power pack. The user needs to manually select which path will lead into the PandaBoard.
4.1 Selecting a Pack

A wide selection of external power packs can be found online. They go by several names (power banks, backup batteries, external battery packs, etc.) and are often marketed as cellphone/tablet chargers. These packs will usually have a high capacity/price ratios and preconfigured outputs of 5 and 12 volts. Some important specifications to consider when picking out your power pack include:

- **Capacity** - This value will be listed in either Ah or mAh. Most packs fall inside of the 5,000 mAh - 10,000 mAh range. Keep in mind that these values are often over exaggerated for marketing purposes and do not include the efficiency of the pack’s output regulator. For example, if you have a 10,000 mAh battery being boosted by an 80% efficient regulator, your battery pack will have an effective capacity of

\[
10000 \text{ mAh} \times 0.80 = 8000 \text{ mAh}
\]

- **Output Current** - The output defines the maximum current draw that the battery pack can support. Look for a pack that supports 2A or 3A. These are usually advertised as Apple iPad Chargers (iPad batteries require a large charging current).

- **Connectors** - Most packs come equipped one or more 5V output via USB. In order to use these with the PandaBoard, you will need to connect the battery pack to a USB-to-DC adapter. Plugging directly into the PandaBoard’s USB port will limit the input to 500 mA regardless of the capabilities of the battery pack.

4.2 Connecting to the PandaBoard

For portable systems that will only ever be powered by a battery, simply plug in your power pack and turn it on. Your board should power on and begin working.

If you would like to implement a more elegant solution, a toggle and power switch can be added if you posses basic soldering skills. Refer to the schematic below to connect a toggle/power switch.
Figure 3: Power schematic featuring power DPST switch (SW1) and input selector SPDT switch (SW2).

**Parts List**

1. DPST rocker switch [link](#)
2. SPDT toggle switch [link](#)
3. Power barrel connector [link](#)
4. USB-to-DC barrel connector adapter [link](#)

**Assembly Instructions**

1. Slice the USB adapter in half.
   
   • Take the USB side. This will be what you plug into your power pack. Solder the positive voltage wire to the power switch input and the negative voltage wire to a common ground.

   • Take the male barrel side. This will be what you plug into your PandaBoard. Solder the positive voltage wire to the output of the toggle switch and the negative wire to a common ground.

2. Take the female barrel connector. This is where you will plug in your 5 V adapter. Wire the positive pin to the power input switch and the negative pin to a common ground.
3. Wire the outputs of the power input switch to the inputs of the selector switch.

5 Further Reading

Much of the information in this application note regarding the PandaBoard was found at the product website [www.http://pandaboard.org](http://pandaboard.org) and the OMAP community wiki [http://www.omappedia.com/wiki/PandaBoard](http://www.omappedia.com/wiki/PandaBoard). These are both excellent sources for tutorials and demos.

Further information regarding Li-Ion batteries and battery safety can be found at [www.batteryuniversity.com](http://www.batteryuniversity.com)