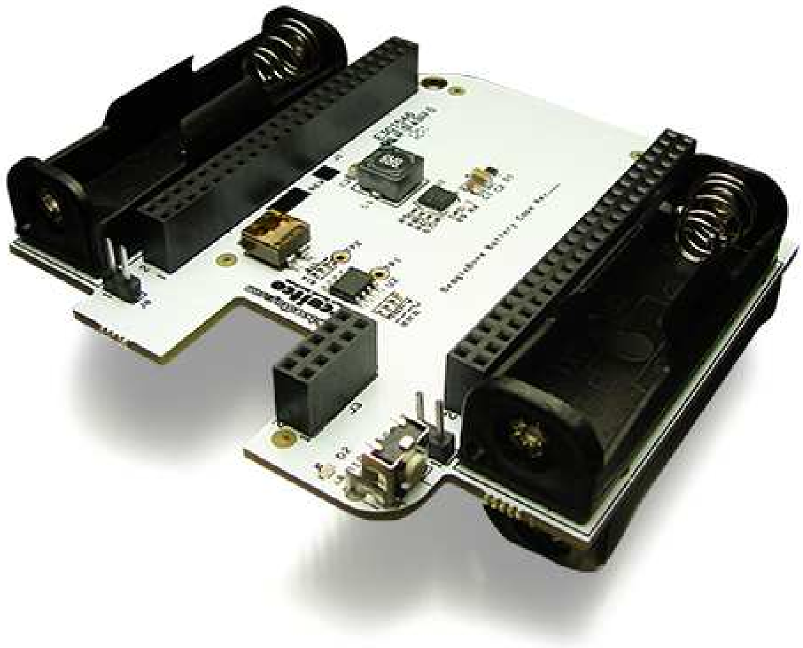

BeagleBone Battery Cape Rev A System Reference Manual

Revision A
June 20th, 2012

For any questions, concerns, or issues submit them to support@beagleboardtoys.com

BEAGLEBONE BATTERY CAPE DESIGN

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NOTES

1.0 Introduction

This document is the System Reference Manual for the BeagleBone Battery Cape, an add-on board for the BeagleBone.

This document is intended as a guide to assist anyone purchasing or who are considering purchasing the board to understand the overall design and usage of the BeagleBone Battery Cape from the system level perspective.

The design is subject to change without notice as we will work to keep improving the design as the product matures.

The key sections in this document are:

Section 2.0 – Change History
Provides tracking for the changes made to the System Reference Manual.

Section 3.0 – Overview
This is a high level overview of the BeagleBone Battery Cape.

Section 4.0 – Features and Specification
Provided here are the features and electrical specifications of the board.

Section 5.0 – System Architecture and Design
This section provides information on the overall architecture and design of the BeagleBone Battery Cape. This is a very detailed section that goes into the design of each circuit on the board.

Section 6.0 – Mechanical
Information is provided here on the dimensions of the BeagleBone Battery Cape.

Section 7.0 – Design Materials
This section provides information on where to get the design files.

2.0 Change History

2.1 Change History

Table 1 tracks the changes made for each revision of this document.

Table 1. Change History

Rev	Changes	Date	By
A	Initial release.	06/20/2012	BBT

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3.0 BeagleBone Battery Cape Overview

3.1 Descriptions

The BeagleBone Battery Cape provides a portable power solution for BeagleBone boards and its Capes. This Cape provides 5V power supply to the BeagleBone using 4 Lithium AA battery cells. Power will be provided to BeagleBone's VDD_5V power rail as soon as battery cells are installed. The BeagleBone Battery cape is also equipped with a power switch, a power indicator LED, and an EEPROM for muxing configuration.

Figure 1 below is a picture of the board.

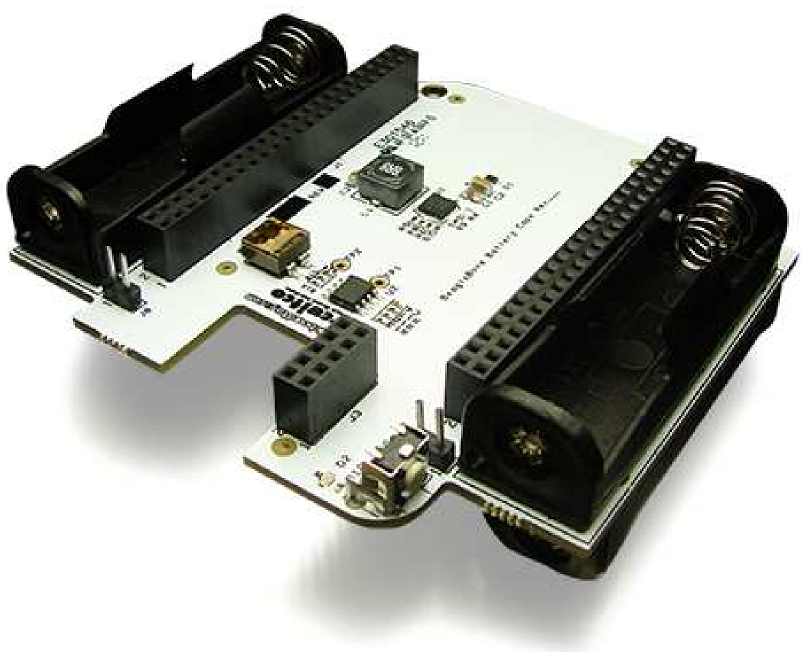

Figure 1. The BeagleBone Battery Cape

3.2 In The Box

The final packaged BeagleBone Battery Cape Rev A product will contain the following items:

- 1 BeagleBone Battery Cape
- 1 Wiki information card

3.3 Getting Started

Following the instructions below to start using your BeagleBone Battery Cape:

1. Mount the Battery Cape on the BeagleBone.
2. Install 4 AA Lithium battery cells to the battery holders. Each holder should only hold one cell.
3. As soon as battery cells are installed, the BeagleBone will power on.
   - *Note: Due to holder configuration, BeagleBone will power on as soon as two battery cells on one wing are installed. This is normal. You can keep installing battery cells on the other wing*
4. The Power LED on the Battery Cape and BeagleBone should be lit.

You can start using your BeagleBone.

3.4 Repairs

If you feel the board is in need of repair, follow the RMA Request process found at http://www.beagleboardtoys.com/support/rma

Do not send the board in for repair until an RMA authorization has been provided.

Do not return the board to the distributor unless you want to get a refund. You must get authorization from the distributor before returning the board.

4.0 Features and Specifications

This section covers the specifications of the BeagleBone Battery Cape and provides a high level description of the major components and interfaces that make up the board.

Table 2 provides a list of the BeagleBone Battery Cape's features.

Table 2. BeagleBone Battery Cape Features

	Feature	
Power Supply	3.0V via Lithium battery cells	
Holder s	4 AA battery holders	
PCB	3.55" x 3.40"	2 layers
Indicators	Power LED	
EEPROM	Cape Address EEPROM	
Expansion Connector	Two 46-position connectors	
	10-position connector	

4.1 Key Component Locations

Figure 2 below shows the top side locations of key components on the PCB layout of the BeagleBone Battery Cape:

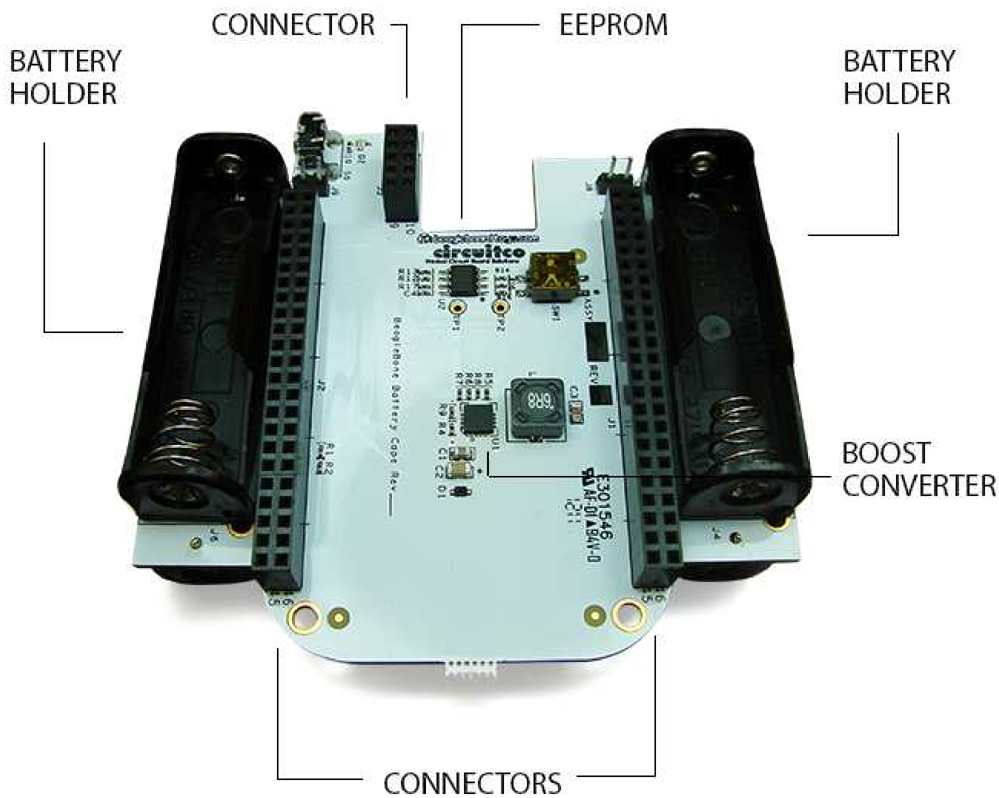

Figure 2. Battery Cape key components

4.2 Battery Holders

The BeagleBone Battery Cape features 4 battery holders distributed equally on each side of PCB. Holders on each wing are mounted on the opposite sides of the PCB. These holders are the 2460 model and provided by Keystone. Each holder can hold a single AA battery cell.

Four Battery holders are configured as 2 parallel sets on both wings of the Battery Cape. Each set consists of 2 holders populated on opposite sides of the PCB. The holders in each set are connected in series. Thus, if both holders in one set are installed with battery cells, 5V will be provided to power rail VDD_5V right away. Installing the other set will provide more current to the boost converter.

4.3 Indicators

There is one indicator on the board and this indicator is the Power LED D2. The Power LED indicates that power from battery cells is applied to the VDD_5V power rail, which is used to power the BeagleBone. The Power LED is located between the Power switch and the 10-position connector.

4.4 Expansion Connectors

The BeagleBone Battery Cape uses a standard stackable connector set for BeagleBone capes. This set is composed of two 46-position connectors and one 10-position connector. These connectors can be used to stack on a BeagleBone or be stacked by another cape.

4.5 Switch

There is a Power switch on the board next to the 10-position expansion connector. This button is a standard tactile switch and mounted at right angle. The PWR_BUT signal, which can also be accessed at expansion connector J2, is connected to the Power button. When pressed and held for 10 seconds, the Power button will turn off the mounted BeagleBone.

4.6 Mechanical Specifications

Size:	3.55” x 3.40”
Layers:	2
PCB thickness:	.062”
RoHS Compliant:	Yes

4.7 Electrical Specifications

Table 3 is the electrical specification of the external interfaces to the BeagleBone Battery panel.

Table 3. BeagleBone Battery Electrical Specifications

Specification	Min	Typ	Max	Unit
Power				
Input Voltage VBAT	1.8	3	5.5	V
Output Voltage		5.0		V
Environmental				
Temperature range	0		+85	C

5.0 System Architecture and Design

This section provides a high level description of the design of the BeagleBone Battery Cape and its overall architecture.

5.1 System Block Diagram

Figure 3 is the high level block diagram of the BeagleBone Battery Cape.

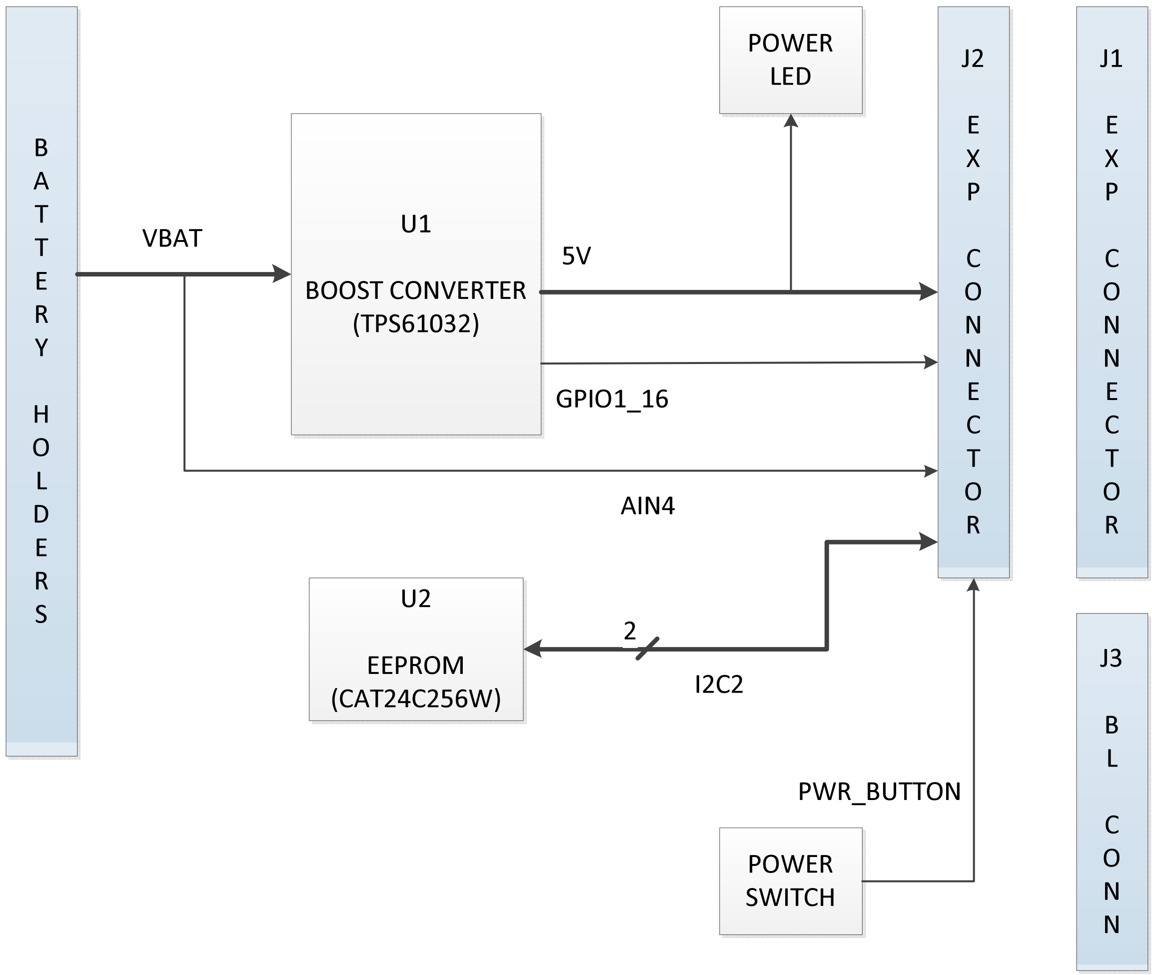

Figure 3. BeagleBone Battery Cape High Level Block Diagram

5.2 VBAT

The BeagleBone Battery Cape is powered from 4 single Lithium AA battery cells. These cells will provide power to the VBAT power rail, which is the input to the boost converter. When installed, 4 battery cells are connected as two sets in parallel; each sets consists of two cells in series. Since the nominal voltage of each AA cell is 1.5V, two cells in series will provide a maximum voltage of 3.0V to VBAT. By having two series groups of battery cells in parallel, more current can be supplied to the boost converter. **Figure 4** shows the battery holder configuration.

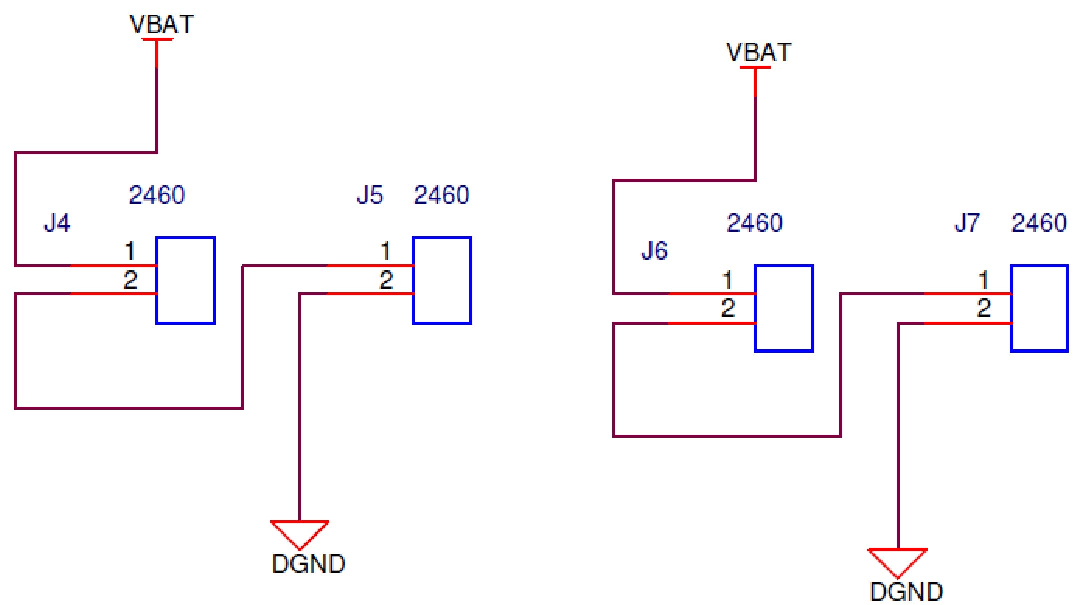

Figure 4. Battery Holder Configuration

The voltage level of VBAT can be monitored by an analog input AIN4 on expansion connector J2. Since the analog inputs on BeagleBone are at 1.8V level, a voltage divider is required to bring VBAT to a third of its voltage level. Therefore, AIN4 will read 1V when VBAT is at its maximum voltage level (3V). **Figure 5** display the voltage divider for battery voltage level input.

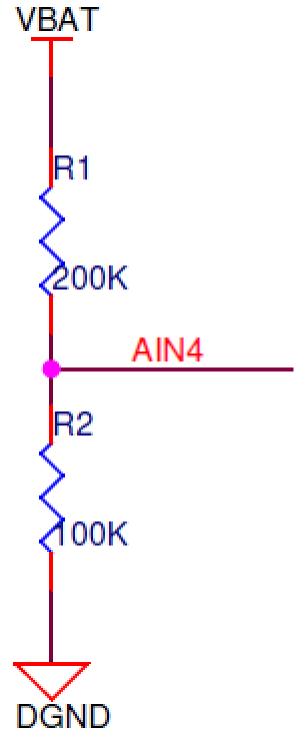

Figure 5. Battery voltage level divider

5.3 Boost Converter

The Battery Cape uses TPS61032 to generate a stable output voltage to power rail VDD_5V of BeagleBone. TPS61032 provides high efficient power conversion and is capable of delivering output current up to 1A at 5V at a supply voltage down to 1.8V. The converter can be disabled to minimize battery drain. During shutdown, the load is completely disconnected from the battery. A low-EMI mode is implemented to reduce ringing and, in effect, lower radiated electromagnetic energy when the converter enters the discontinuous conduction mode.

The device is put into operation when the EN pin is pulled high. This pin on the Battery Cape is connected to VBAT; therefore, the boost converter will start operation as soon as VBAT reaches 3.0V. The internal start-up cycle will start with the pre-charge phase. During this phase, the output capacitor is charged to a value close to the input voltage. Until the output voltage is reached, the boost switch current limit is set to 40% of its nominal value to avoid high peak currents at battery during startup. Output voltage of the boost converter is determined by voltage divider resistors R4 and R9. The maximum output voltage is 5.5V. In this case, R4 and R9 are chosen to be 180K and 1.74M respectively to set the output voltage to be 5.35V. 350mV will be dropped across Schottky diode D1 to provide 5V to power rail VDD_5V.

The SYNC pin is connected to Ground to enable the power save mode. The LBI input is pulled low to disable the low battery detector circuit. The LBO output, which is mapped to GPIO1_16, will stay at high impedance. **Figure 6** is the boost converter circuit.

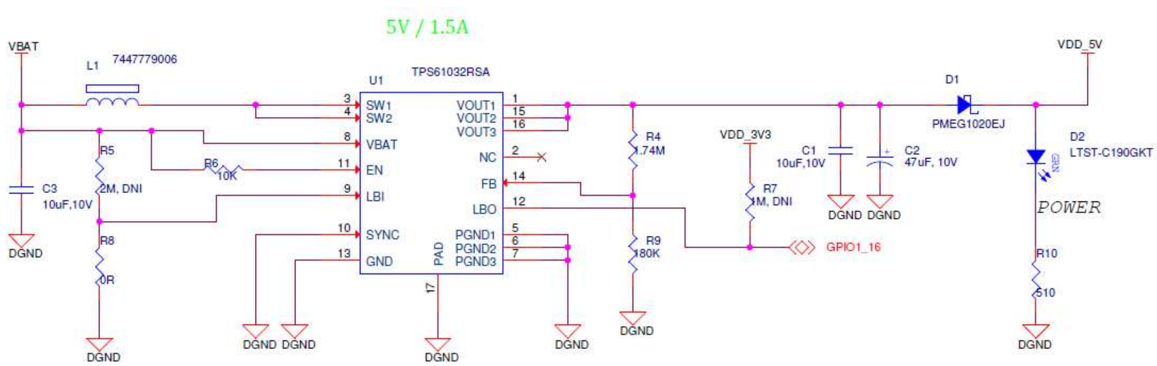

Figure 6. Boost converter circuit

5.4 EEPROM

The BeagleBone Battery Cape has an EEPROM containing information that will allow the SW to identify the board and to configure the expansion headers pins as needed. EEPROMs are required for all Capes sold in order for them to operate correctly when plugged in the BeagleBone.

The EEPROM used on this cape is the same one as is used on the BeagleBone, a CAT24C256. The CAT24C256 is a 256 kb Serial CMOS EEPROM, internally organized as 32,768 words of 8 bits each. It features a 64-byte page write buffer and supports the Standard (100 kHz), Fast (400 kHz) and Fast-Plus (1 MHz) I2C protocol. **Figure 7** is the design of the EEPROM circuit.

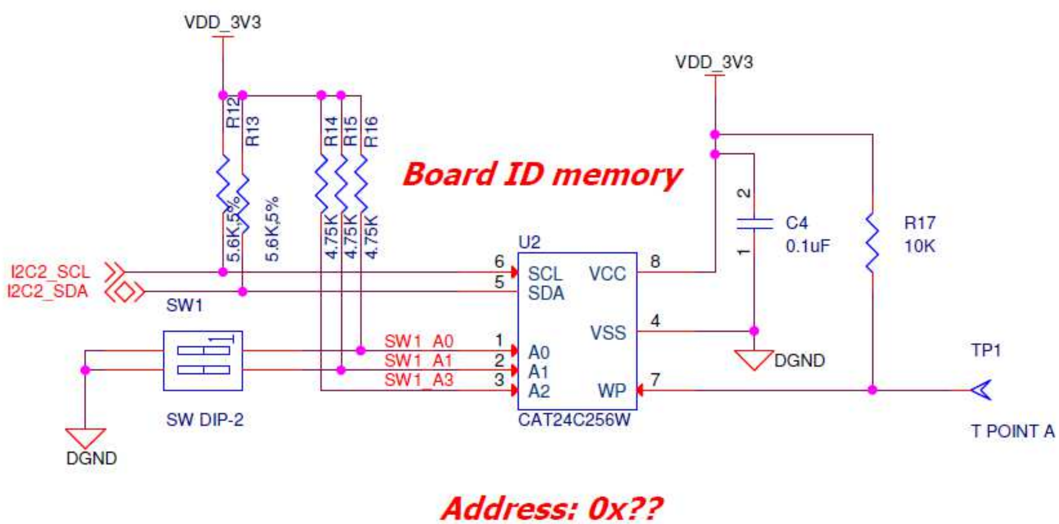

Figure 7. BeagleBone Battery Cape EEPROM

5.4.1 EEPROM Address

In order for each Cape to have a unique address, a board ID scheme is used that sets the address to be different depending on the order in which it is stacked onto the main board. A two position dipswitch or jumpers is used to set the address pins of the EEPROM. It is the responsibility of user to set the proper address for each board. Address line A2 is always tied high. This sets the allowable address range for the expansion cards to 0x54 to 0x57.All other I2C addresses can be used by the user in the design of their Capes. But, these addresses must not be used other than for the board EEPROM information.

5.4.2 I2C Bus

The EEPROMs on each expansion board is connected to I2C2. For this reason I2C2 must always be left connected and should not be changed by SW to remove it from the expansion header pin mux. The I2C signals require pull-up resistors. Each board must have a 5.6K resistor on these signals. With four resistors this will be an affective resistance of 1.4K if all Capes were installed.

6.0 Mechanical Information

This section provides information on the mechanical aspect of the BeagleBone Battery Cape. **Figure 8** is the dimensions of the BeagleBone Battery Cape.

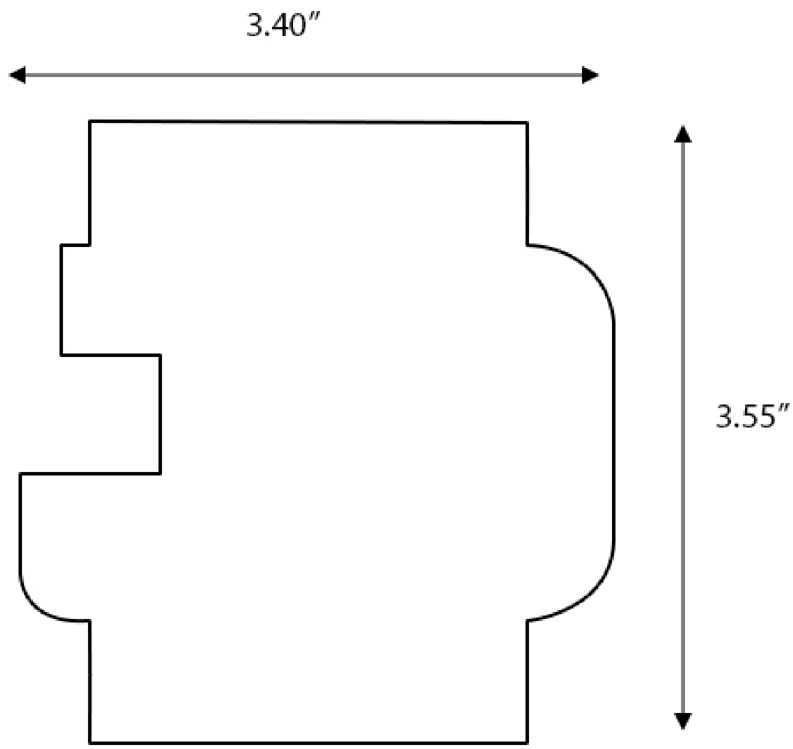

Figure 8. BeagleBone LCD3 Cape Dimensions Drawing

7.0 Design Materials

Design information can be found at BeagleBoardToys wiki:
http://beagleboardtoys.com/wiki/index.php?title=BeagleBone_Battery

Provided there is:

- Schematic in PDF
- Schematic in OrCAD
- Manufacturing files
  - PCB Gerber
  - PCB Layout (Allegro)
- Bill of Materials
- System Reference Manual (This document)

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