# BeagleBone Green
# System
# Reference Manual

**Revision v1**
**July 22, 2015**
**Reference to the BBB_SRM**

**THIS DOCUMENT**

**This document is derived from work by Gerald Coley (gerald@beagleboard.org), for hardware questions, please send your email to XiangNan Qu (xiangnan.qu@seeed.cc), for software and ecosystem questions, please direct to Jason Kridner (jkridner@beagleboard.org) and http://beagleboard.org/discuss.**

**Send all comments and errors concerning this document to the author at xiangnan.qu@seeed.cc**

**All information in this document is subject to change without notice.**

**For an up to date version of this document refer to:**

**http://www.seeedstudio.com/wiki/beaglebone_green**

## BEAGLEBONE DESIGN

These design materials referred to in this document are **\*NOT SUPPORTED\*** and **DO NOT** constitute a reference design. Only "community" support is allowed via resources at BeagleBoard.org/discuss.

THERE IS NO WARRANTY FOR THE DESIGN MATERIALS, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE DESIGN MATERIALS "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE DESIGN MATERIALS IS WITH YOU. SHOULD THE DESIGN MATERIALS PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

This board was designed as an evaluation and development tool. It was not designed with any other application in mind. As such, the design materials that are provided which include schematic, BOM, and PCB files, may or may not be suitable for any other purposes. If used, the design material becomes your responsibility as to whether or not it meets your specific needs or your specific applications and may require changes to meet your requirements.

# Table of Contents

**Tables**

**Figures**

## 1.0 Introduction

This document is the **System Reference Manual** for the BeagleBone Green and covers its use and design. The board will primarily be referred to in the remainder of this document simply as the board, although it may also be referred to as the BeagleBone Green as a reminder. There are also references to the original BeagleBone as well, and will be referenced as simply BeagleBone.

This design is subject to change without notice as we will work to keep improving the design as the product matures based on feedback and experience. Software updates will be frequent and will be independent of the hardware revisions and as such not result in a change in the revision number.

Make sure you check the support Wiki frequently for the most up to date information.

http://www.seeedstudio.com/wiki/beaglebone_green


## 2.0 Change History

This section describes the change history of this document and board. Document changes are not always a result of a board change. A board change will always result in a document change.

### 2.1 Document Change History

Table 1. Change History

| REV | Description | Date | By |
|---|---|---|---|
| V1 | *Production release* | *June 3, 2015* | *QXN* |

## 3.0  Connecting Up Your BeagleBone Green

This section provides instructions on how to hook up your board. Two scenarios will be discussed:

    1) Tethered to a PC and
    2) As a standalone development platform in a desktop PC configuration.

## 3.1      What's In the Box

In the box you will find three main items as shown in **Figure 1**.

- BeagleBone Green
- Micro USB to USB Type A Cable
- Instruction card with link to the support WIKI address.

This is sufficient for the tethered scenario and creates an out of box experience where the board can be used immediately with no other equipment needed.



**Figure 1.     In The Box**

## 3.2    Main Connection Scenarios

This section will describe how to connect the board for use. This section is basically a slightly more detailed description of the Quick Start Guide that came in the box. There is also a Quick Start Guide document on the board that should also be referred to. The intent here is that someone looking t purchase the board will be able to read this section and get a good idea as to what the initial set up will be like.

The board can be configured in several different ways, but we will discuss the most common scenarios as described in the Quick Start Guide card that comes in the box.

## 3.3    Tethered To A PC

In this configuration, the board is powered by the PC via the provided USB cable--no other cables are required. The board is accessed either as a USB storage drive or via the browser on the PC. You need to use either Firefox or Chrome on the PC, IEx will not work properly. **Figure 2** shows this configuration.



**Figure 2.    Tethered Configuration**

All the power for the board is provided by the PC via the USB cable. In some instances, the PC may not be able to supply sufficient power for the board. In that case, an external 5VDC power supply can be used to power the board through VDD_5V pin in P9 connector, but this should rarely be necessary.

### 3.3.1   Connect the Cable to the Board

1.   Connect the small connector on the USB cable to the board as shown in **Figure 4**. The connector is on the bottom side of the board.
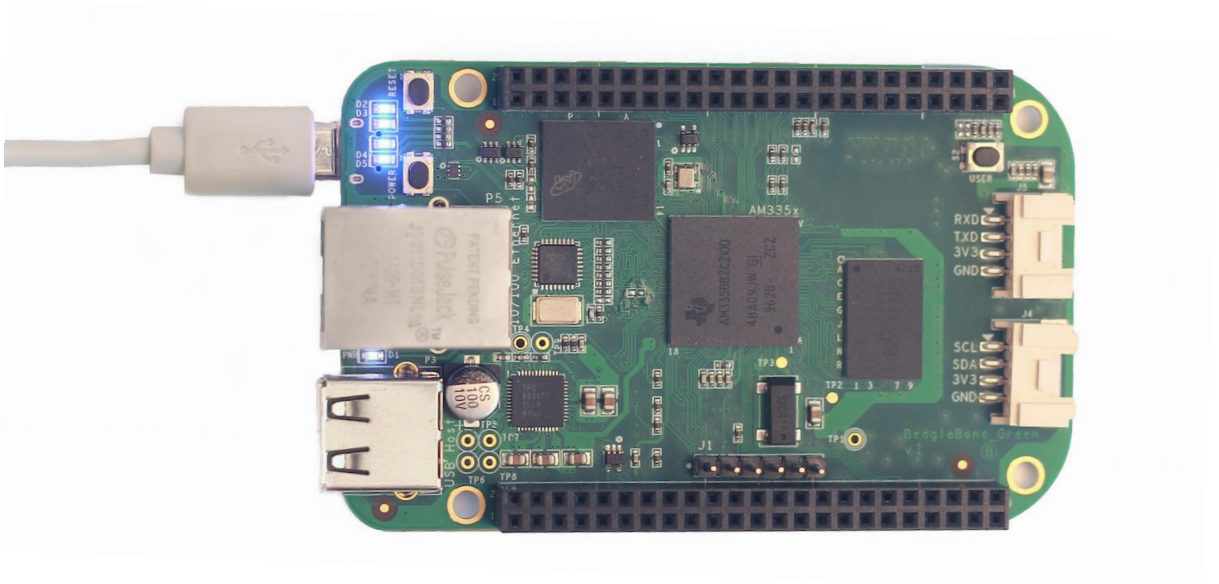


**Figure 3.     USB Connection to the Board**

2.     Connect the large connector of the USB cable to your PC or laptop USB port.

3.   The board will power on and the power LED will be on as shown in **Figure 4** below.

**Figure 4.    Board Power LED**

4.  When the board starts to the booting process started by the process of applying power, the LEDs will come on in sequence as shown in **Figure 5** below. It will take a few seconds for the status LEDs to come on, so be patient. The LEDs will be flashing in an erratic manner as it begins to boot the Linux kernel.
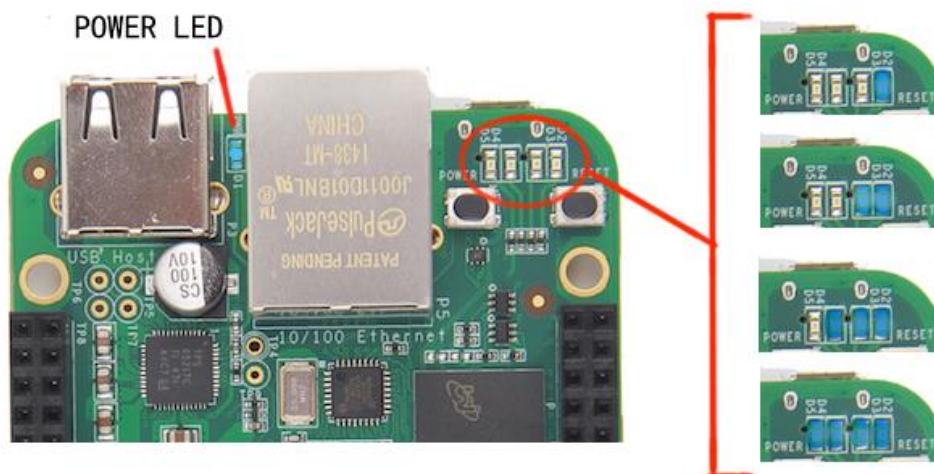


**Figure 5.    Board Boot Status**

### 3.3.2   Accessing the Board as a Storage Drive

The board will appear around a USB Storage drive on your PC after the kernel has booted, which will take a round 10 seconds. The kernel on the board needs to boot before the port gets enumerated. Once the board appears as a storage drive, do the following:


1)  Open the USB Drive folder.
2)  Click on the file named **start.html**
3)  The file will be opened by your browser on the PC and you should get a display showing the Quick Start Guide.
4)  Your board is now operational! Follow the instructions on your PC screen.

## 4.0  BeagleBone Green Overview

BeagleBone Green (BBG) is based on the classical open-source hardware design of BeagleBone Black (BBB) and added two Grove connectors. It has removed the HDMI port on the BBB and also updated the 5V barrel to Micro USB host.

The main improvement about BeagleBone Green is that adding two Grove connector for supporting Grove system. For more information about Grove system please visit: http://www.seeedstudio.com/wiki/Grove_System


## 4.1      BeagleBone Black Compatibility

The board is intended to be compatible with the BeagleBone Black as much as possible. There are several areas where there are differences between the two designs. These differences are listed below, along with the reasons for the differences.

- Removed the 5VDC Power Jack
  - Cost down
  - Rarely used
  - Normally you can power the board through the Micro USB port
- Removed HDMI framer IC and connector
  - Cost down
  - If you still need to display with HDMI interface, you can add a HDMI cape
- Replace Mini USB port with Micro USB
  - More commonly used
- Grove interface onboard
  - There are more than 100 Grove Sensors and Actuators can be easily used
  - Focus on the IoT applications

## 4.2     BeagleBone Green Features and Specification

**Table 2.   BeagleBone Green Features**

| | Feature |
|---|---|
| Processor | Sitara AM3358BZCZ100 1GHz, 2000 MIPS |
| Graphics Engine | SGX530 3D, 20M Polygons/S |
| SDRAM Memory | 512MB DDR3L 800MHZ |
| PMIC | 4GB, 8bit Embedded MMC |
| Debug Support | Micro USB Jack,5VDC External Via Expansion Header |
| PCB | 3.4" x 2.1" , 6 layers |
| Indicators | 1-Power, 2-Ethernet, 4-User Controllable LEDs |
| HS USB 2.0 Client Port | Access to USB0, Client mode via Micro USB |
| HS USB 2.0 Host Port | Access to USB1, Type A Socket, 500mA LS/FS/HS |
| Serial Port | UART0 access via 6 pin 3.3V TTL Header. Header is populated |
| Ethernet | 10/100, RJ45 |
| SD/MMC Connector | microSD , 3.3V |
| Grove Connectors | 1-Uart2, 1-I2C2 |
| User Input | Reset Button<br>Boot Button<br>Power Button |
| Video Out | Not support |
| Audio Out | Not support |
| Expansion Connectors | Power 5V, 3.3V , VDD_ADC(1.8V)<br>3.3V I/O on all signals<br>McASP0, SPI1, I2C, GPIO(69 max), LCD, GPMC, MMC1, MMC2, 7 AIN(1.8V MAX), 4 Timers, 4 Serial Ports, CAN0, EHRPWM(0,2),XDMA Interrupt, Power button, Expansion Board ID (Up to 4 can be stacked) |
| Weight | 1.4 oz (39.68 grams) |
| Power | Refer to Section 6.1.7 |

## 4.3      Board Component Locations

This section describes the key components on the board. It provides information on their location and function. Familiarize yourself with the various components on the board.

### 4.3.1   Connectors, LEDs, and Switches

**Figure 6** below shows the locations of the connectors, LEDs, and switches on the PCB layout of the board.
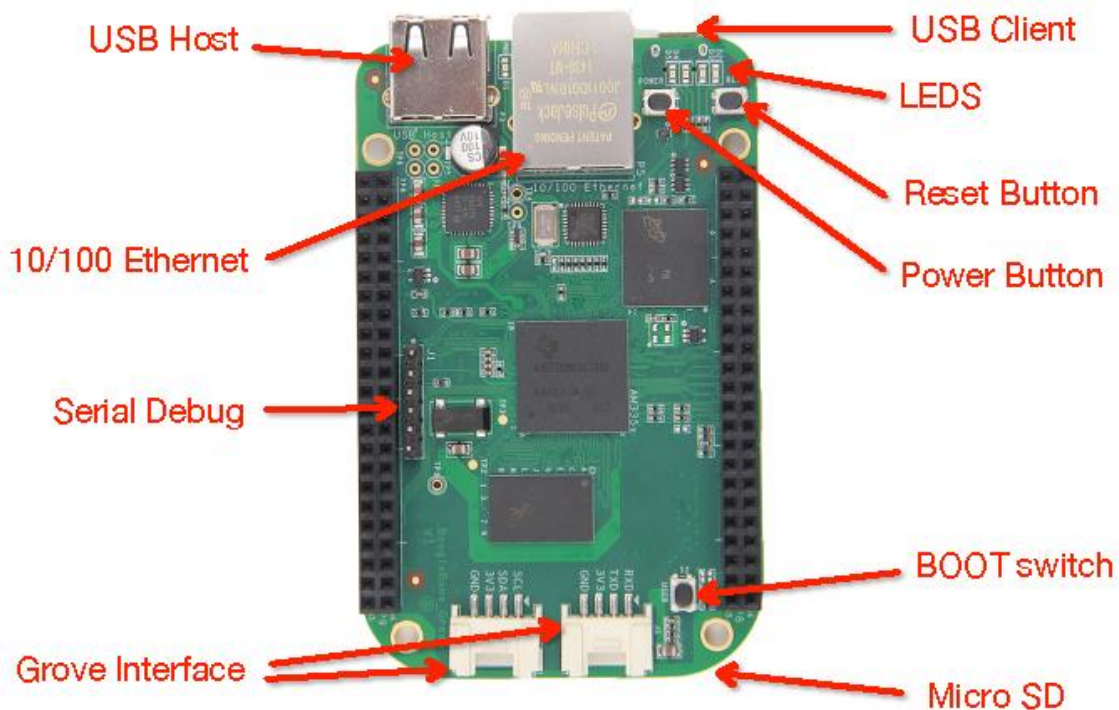


**Figure 6.     Connectors, LEDs and Switches**

- **Power Button** alerts the processor to initiate the power down sequence and is   used to power down the board.
- **10/100 Ethernet** is the connection to the LAN.
- **Serial Debug** is the serial debug port.
- **USB Client** is a Micro USB connection to a PC that can also power the board.
- **BOOT switch** can be used to force a boot from the micro SD card if the power is   cycled on the board, removing power and reapplying the power to the board.
- There are four blue **LEDS** that can be used by the user.
- **Reset Button** allows the user to reset the processor.
- **Micro SD** slot is where a micro SD card can be installed.

- **Grove Interface** is where the Grove sensor is connected to.
- **USB Host** can be connected different USB interfaces such as Wi-Fi, BT, Keyboard, etc.

### 4.3.2    Key Components

**Figure 7** below shows the locations of the key components on the PCB layout of the board.
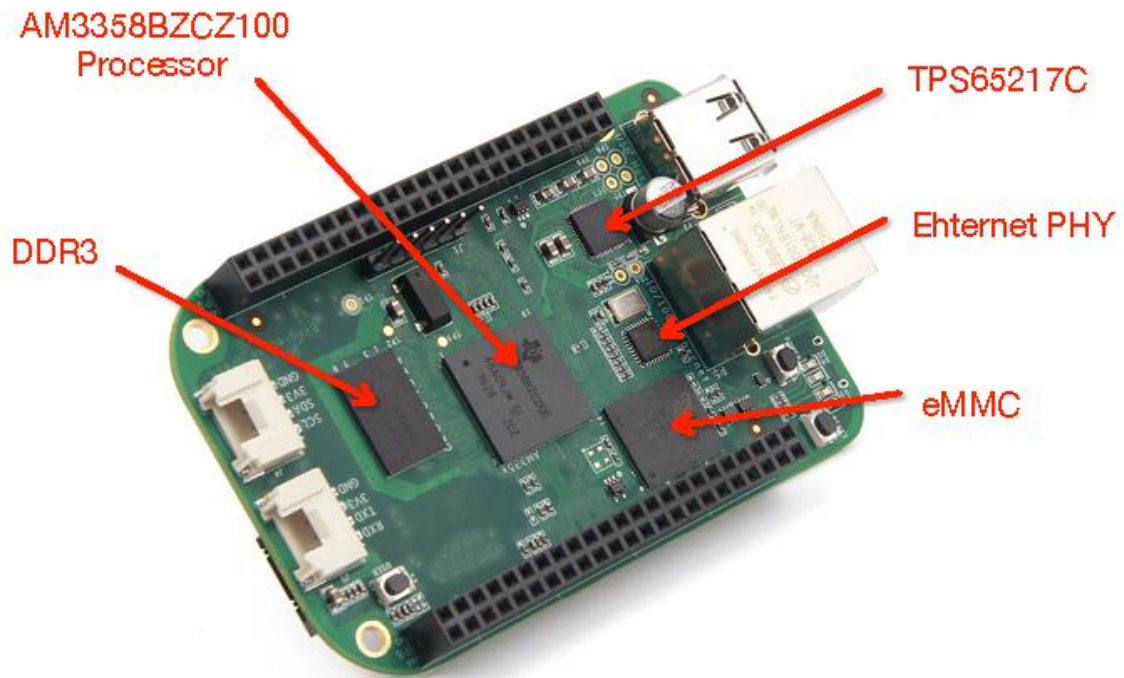


**Figure 7.    Key Components**

- **Sitara AM3358BZCZ100** is the processor for the board.
- **Micron 512MB DDR3L** or Kingston 512mB DDR3 is the Dual Data Rate   RAM memory.
- **TPS65217C PMIC** provides the power rails to the various components on the   board.
- **SMSC Ethernet PHY** is the physical interface to the network.
- **Micron eMMC** is an onboard MMC chip that holds up to 4GB of data.

## 5.0  BeagleBone Green High Level Specification

This section provides the high level specification of the BeagleBone Green.

### 5.1  Block Diagram

**Figure 8** below is the high level block diagram of the BeagleBone Green.
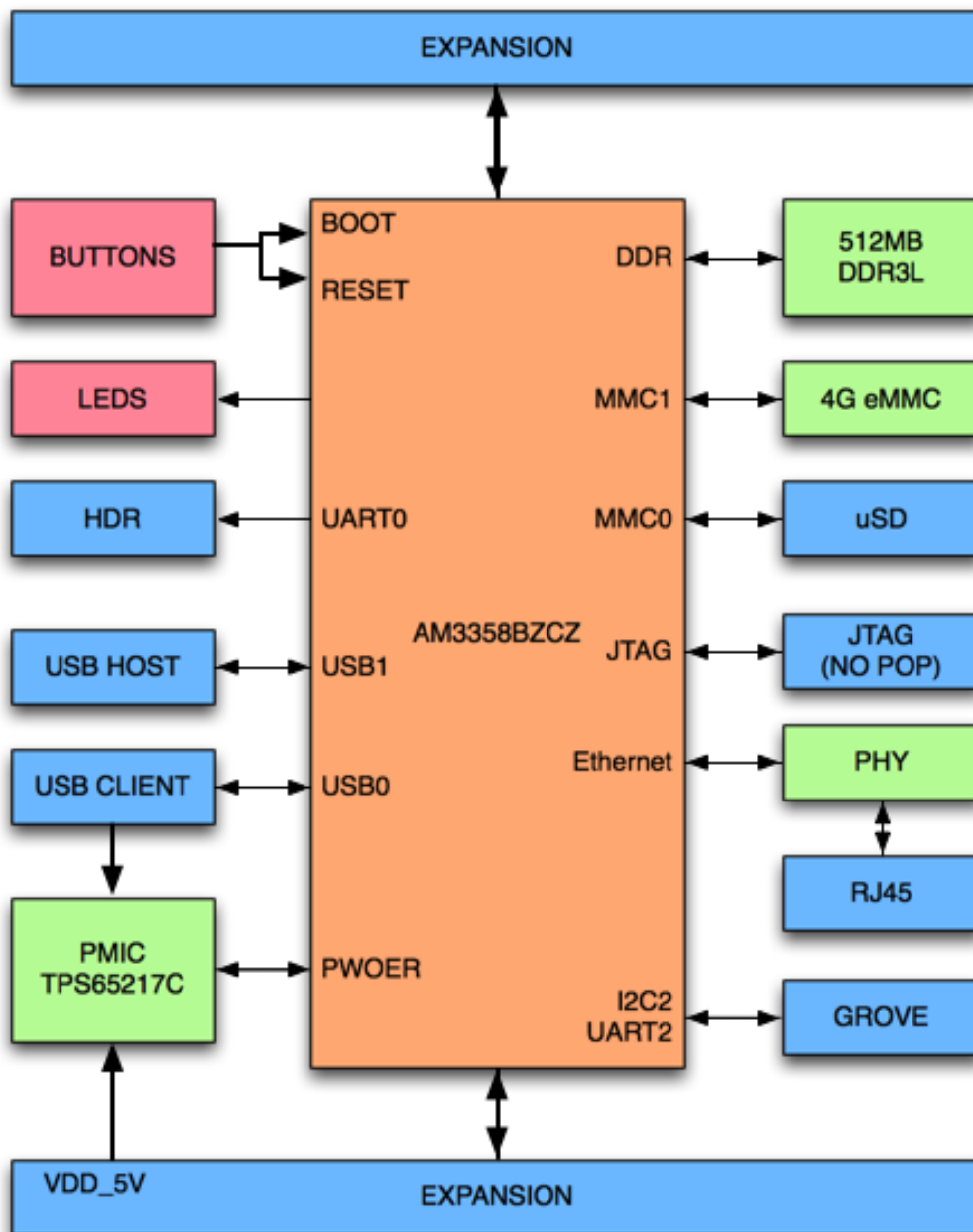


**Figure 8.    BeagleBone Green Block diagram**

## 5.2      Processor

Sitara AM3358BZCZ100

## 5.3      Memory

Described in the following sections are the three memory devices found on the board.

### 5.3.1   512MB DDR3L

A single 256Mb x16 DDR3L 4Gb (512MB) memory device is used. The memory used is is one of two devices:

    - MT41K256M16HA-125 from Micron
    - D2516EC4BXGGB from Kingston

It will operate at a clock frequency of 400MHz yielding an effective rate of 800MHZ on the DDR3L bus allowing for 1.6GB/S of DDR3L memory bandwidth.

### 5.3.2   4KB EEPROM

A single 4KB EEPROM is provided on I2C0 that holds the board information. This information includes board name, serial number, and revision information. This is the not the same as the one used on the original BeagleBone. The device was changed for cost reduction reasons. It has a test point to allow the device to be programmed and otherwise to provide write protection when not grounded.

### 5.3.3   4GB Embedded MMC

A single 4GB embedded MMC (eMMC) device is on the board. The device connects to the MMC1 port of the processor, allowing for 8bit wide access. Default boot mode for the board will be MMC1 with an option to change it to MMC0, the SD card slot, for booting from the SD card as a result of removing and reapplying the power to the board. Simply pressing the reset button will not change the boot mode. MMC0 cannot be used in 8Bit mode because the lower data pins are located on the pins used by the Ethernet port. This does not interfere with SD card operation but it does make it unsuitable for use as an eMMC port if the 8 bit feature is needed.

### 5.3.4   MicroSD Connector

The board is equipped with a single micro SD connector to act as the secondary boot source for the board and, if selected as such, can be the primary boot source. The connector will support larger capacity micro SD cards. The micro SD card is not provided

with the board. Booting from MMC0 will be used to flash the eMMC in the production environment or can be used by the user to update the SW as needed.

### 5.3.5   Boot Modes

As mentioned earlier, there are four boot modes:

- **eMMC Boot...**This is the default boot mode and will allow for the fastest boot time and will enable the board to boot out of the box using the pre-flashed OS image without having to purchase an microSD card or an microSD card writer.
- **SD Boot...**This mode will boot from the microSD slot. This mode can be used to override what is on the eMMC device and can be used to program the eMMC when used in the manufacturing process or for field updates.
- **Serial Boot...**This mode will use the serial port to allow downloading of the software direct. A separate USB to serial cable is required to use this port.
- **USB Boot...**This mode supports booting over the USB port.

*Software to support USB and serial boot modes is not provided by beagleboard.org. Please contact TI for support of this feature.*

A switch is provided to allow switching between the modes.

- Holding the boot switch down during a removal and reapplication of power without a microSD card inserted will force the boot source to be the USB port and if nothing is detected on the USB client port, it will go to the serial port for download.
- Without holding the switch, the board will boot try to boot from the eMMC. If it is empty, then it will try booting from the microSD slot, followed by the serial port, and then the USB port.
- If you hold the boot switch down during the removal and reapplication of power to the board, and you have a microSD card inserted with a bootable image, the board will boot from the microSD card.

*NOTE: Pressing the RESET button on the board will NOT result in a change of the boot mode. You MUST remove power and reapply power to change the boot mode. The boot pins are sampled during power on reset from the PMIC to the processor. The reset button on the board is a warm reset only and will not force a boot mode change.*

## 5.4     Power Management

The **TPS65217C** power management device is used along with a separate LDO to provide power to the system. The **TPS65217C** version provides for the proper voltages required for the DDR3L. This is the same device as used on the original BeagleBone with the exception of the power rail configuration settings which will be changed in the internal EEPROM to the **TPS65217C** to support the new voltages.

DDR3L requires 1.5V instead of 1.8V on the DDR2 as is the case on the original BeagleBone. The 1.8V regulator setting has been changed to 1.5V for the DDR3L. The LDO3 3.3V rail has been changed to 1.8V to support those rails on the processor. LDO4 is still 3.3V for the 3.3V rails on the processor. An external **LDOTLV70233** provides the 3.3V rail for the rest of the board.

## 5.5     PC USB Interface

The board has a Micro USB connector that connects the USB0 port to the processor. This is the most commonly used connector.

## 5.6     Serial Debug Port

Serial debug is provided via UART0 on the processor via a single 1x6 pin header. In order to use the interface a USB to TTL adapter will be required. The header is compatible with the one provided by FTDI and can be purchased for about $12 to $20 from various sources. Signals supported are TX and RX. None of the handshake signals are supported.

## 5.7     USB1 Host Port

On the board is a single USB Type A female connector with full LS/FS/HS Host support that connects to USB1 on the processor. The port can provide power on/off control and up to 500mA of current at 5V. Under USB power, the board will not be able to supply the full 500mA, but should be sufficient to supply enough current for a lower power USB device supplying power between 50 to 100mA.

You can use a wireless keyboard/mouse configuration or you can add a HUB for standard keyboard and mouse interfacing.

## 5.8     Power Sources

The board can be powered from three different sources:

- USB port on a PC
- A power supply with a USB connector.
- Expansion connectors

The USB cable is shipped with each board. This port is limited to 500mA by the Power Management IC. It is possible to change the settings in the TPS65217C to increase this current, but only after the initial boot. And, at that point the PC most likely will complain, but you can also use a dual connector USB cable to the PC to get to 1A.

The power supply is not provided with the board but can be easily obtained from

numerous sources. A 1A supply is sufficient to power the board, but if there is a cape plugged into the board or you have a power hungry device or hub plugged into the host port, then more current may needed from the P9 Expansion connector VDD_5V pin.

Power routed to the board via the expansion header could be provided from power derived on a cape.

## 5.9     Reset Button

When pressed and released, causes a reset of the board. The reset button used on the BeagleBone Black is a little larger than the one used on the original BeagleBone. It has also been moved out to the edge of the board so that it is more accessible.

## 5.10    Power Button

A power button is provided near the reset button close to the Ethernet connector. This button takes advantage of the input to the PMIC for power down features. While a lot of capes have a button, it was decided to add this feature to the board to ensure everyone had access to some new features. These features include:

• Interrupt is sent to the processor to facilitate an orderly shutdown to save files and to un-mount drives.
• Provides ability to let processor put board into a sleep mode to save power.
• Can alert processor to wake up from sleep mode and restore state before sleep was entered.

If you hold the button down longer than 8 seconds, the board will power off if you release the button when the power LED turns off. If you continue to hold it, the board will power back up completing a power cycle.

*We recommend that you use this method to power down the board. It will also help prevent contamination of the SD card or the eMMC.*

If you do not remove the power jack, you can press the button again and the board will power up.

## 5.11    Indicators

There are a total of five blue LEDs on the board.

• One blue power LED indicates that power is applied and the power management IC is up. If this LED flashes when applying power, it means that an excess current flow was detected and the PMIC has shut down.

- Four blue LEDs that can be controlled via the SW by setting GPIO pins.

In addition, there are two LEDs on the RJ45 to provide Ethernet status indication. One is yellow (100M Link up if on) and the other is green (Indicating traffic when flashing).

## 5.12    CTI JTAG Header

A place for an optional 20 pin CTI JTAG header is provided on the board to facilitate the SW development and debugging of the board by using various JTAG emulators. This header is not supplied standard on the board. To use this, a connector will need to be soldered onto the board.

If you need the JTAG connector you can solder it on yourself. No other components are needed. The connector is made by Samtec and the part number is FTR-110-03-G-D-06. You can purchase it from http://www.digikey.com/.

## 5.13    Grove Interfaces

There are two Grove connectors on the board:

- **I2C…**The J4 connector is I2C interface. It accesses to the processor's I2C2 interface and also connect with the P9 expansion header's I2C2 pins. The Grove I2C connector is for the connection of Grove sensors with I2C interface.

- **Uart…**The J5 connector is UART interface. It accesses to the processor's UART2 interface and also connect with the P9 expansion header's UART2 pins. The Grove UART connector is for the connection of Grove sensors with UART interface.

Because of I2C and UART Interface can be setup to GPIO , the Groves with Digital interface are supported for both Connectors.

If you want to connect more Grove modules , see **Grove Cape for BeagleBone Series** innovated by Seeedstudio:

http://www.seeedstudio.com/depot/Grove-Cape-for-BeagleBone-Series-p-1718.html

For more information about Grove system, please visit:
http://www.seeedstudio.com/wiki/Grove_System

## 5.14    Cape Board Support

The BeagleBone Green has the ability to accept up to four expansion boards or capes that can be stacked onto the expansion headers. The word cape comes from the shape of the board as it is fitted around the Ethernet connector on the main board. This notch acts as a key to ensure proper orientation of the cape.

The majority of capes designed for the original BeagleBone or BeagleBone Black will work on the BeagleBone Green. The two main expansion headers will be populated on the board. There are a few exceptions where certain capabilities may not be present or are limited to the BeagleBone Green. These include:

- GPMC bus may NOT be available due to the use of those signals by the eMMC. If the eMMC is used for booting only and the file system is on the microSD card, then these signals could be used.
- Another option is to use the microSD or serial boot modes and not use the eMMC.
- The power expansion header is not on the BeagleBone Green so those functions   are not supported.

## 5.15    Expansion Board External Power

A cape can have a jack or terminals to bring in whatever voltages may be needed by that board. Care should be taken not to let this voltage be fed back into any of the expansion header pins.

It is possible to provide 5V to the main board from an expansion board. By supplying a 5V signal into the $VDD\_5V$ rail, the main board can be supplied. This voltage must not exceed 5V. You should not supply any voltage into any other pin of the expansion connectors. Based on the board design, this rail is limited to 1A per pin to the BeagleBone Green.

*There are several precautions that need to be taken when working with the expansion headers to prevent damage to the board.*

*1) Do not apply any voltages to any I/O pins when the board is not powered on.*
*2) Do not drive any external signals into the I/O pins until after the VDD_3V3B rail is up.*
*3) Do not apply any voltages that are generated from external sources.*
*4) If voltages are generated from the VDD_5V signal, those supplies must not become active until after the VDD_3V3B rail is up.*
*5) If you are applying signals from other boards into the expansion headers, make sure you power the board up after you power up the BeagleBone Green or make the connections after power is applied on both boards.*

*Powering the processor via its I/O pins can cause damage to the processor.*

## 6.0  BeagleBone Green Mechanical

### 6.1      Dimensions and Weight

Size:                    3.5" x 2.15" (86.36mm x 53.34mm)
Max height:              .187" (4.76mm)
PCB Layers:              6 .062"
PCB thickness:           Yes
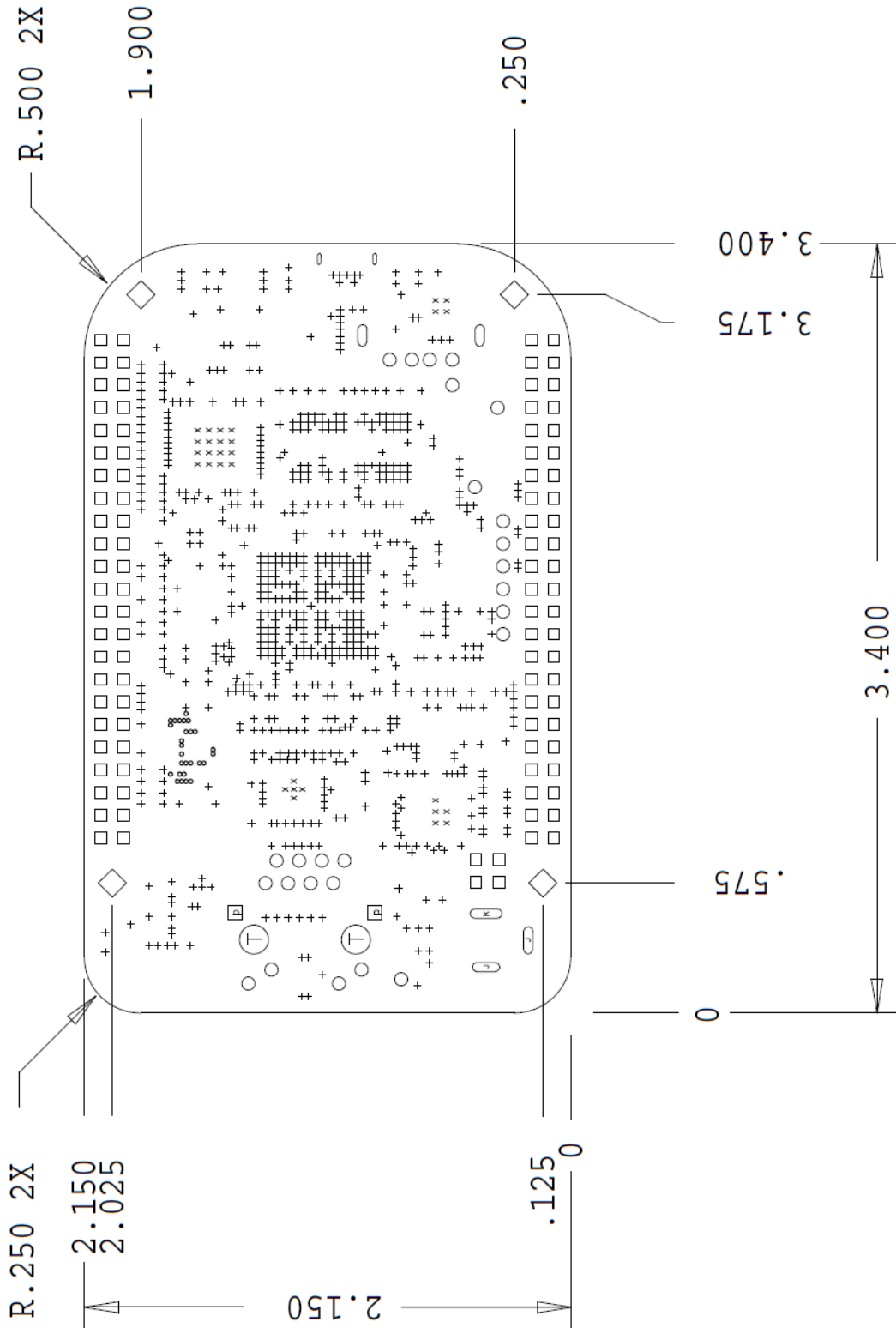RoHS Compliant:          1.4 oz

## 6.2     Board Dimensions
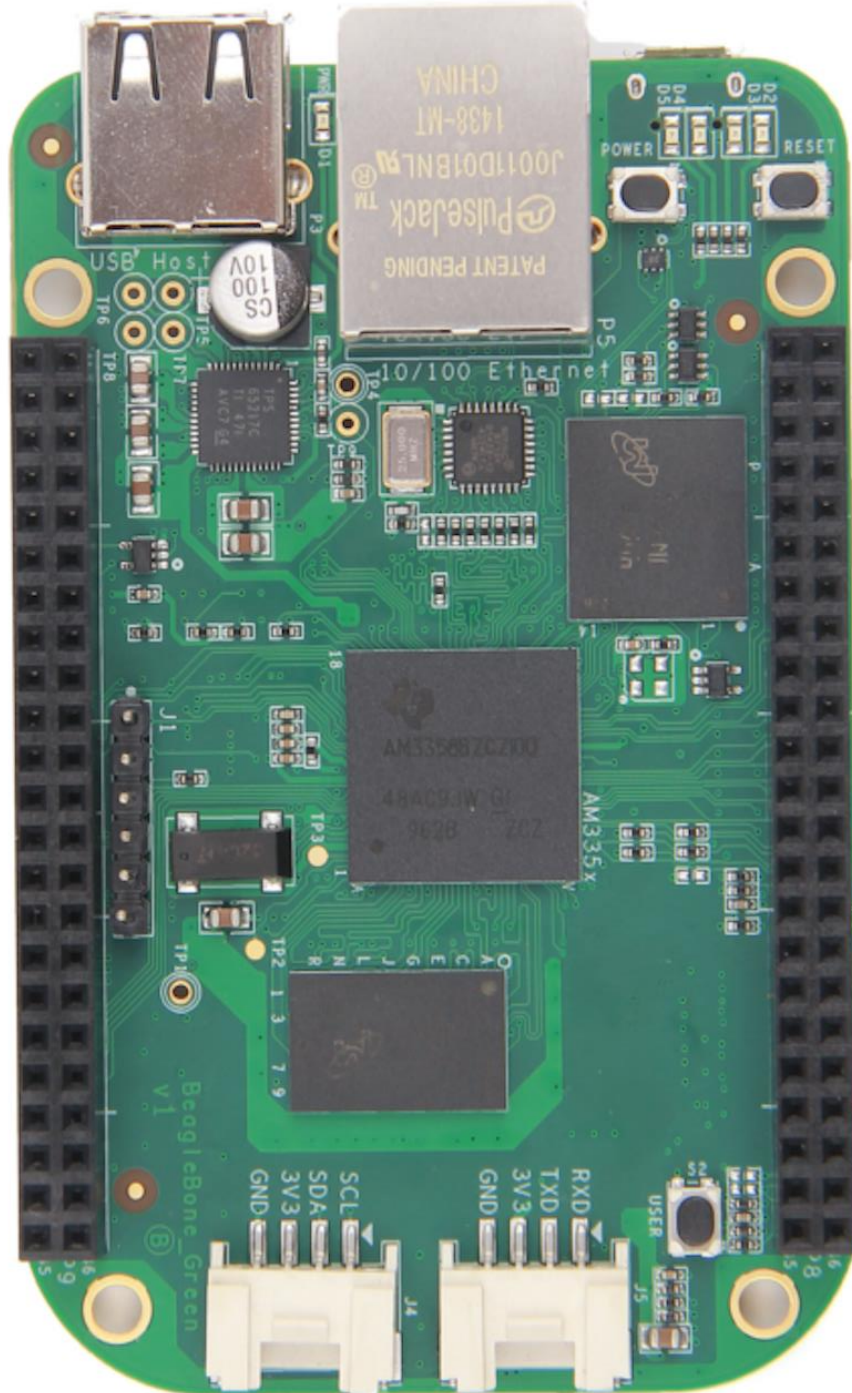


**Figure 9.     Board Dimensions**

## 7.0  Pictures



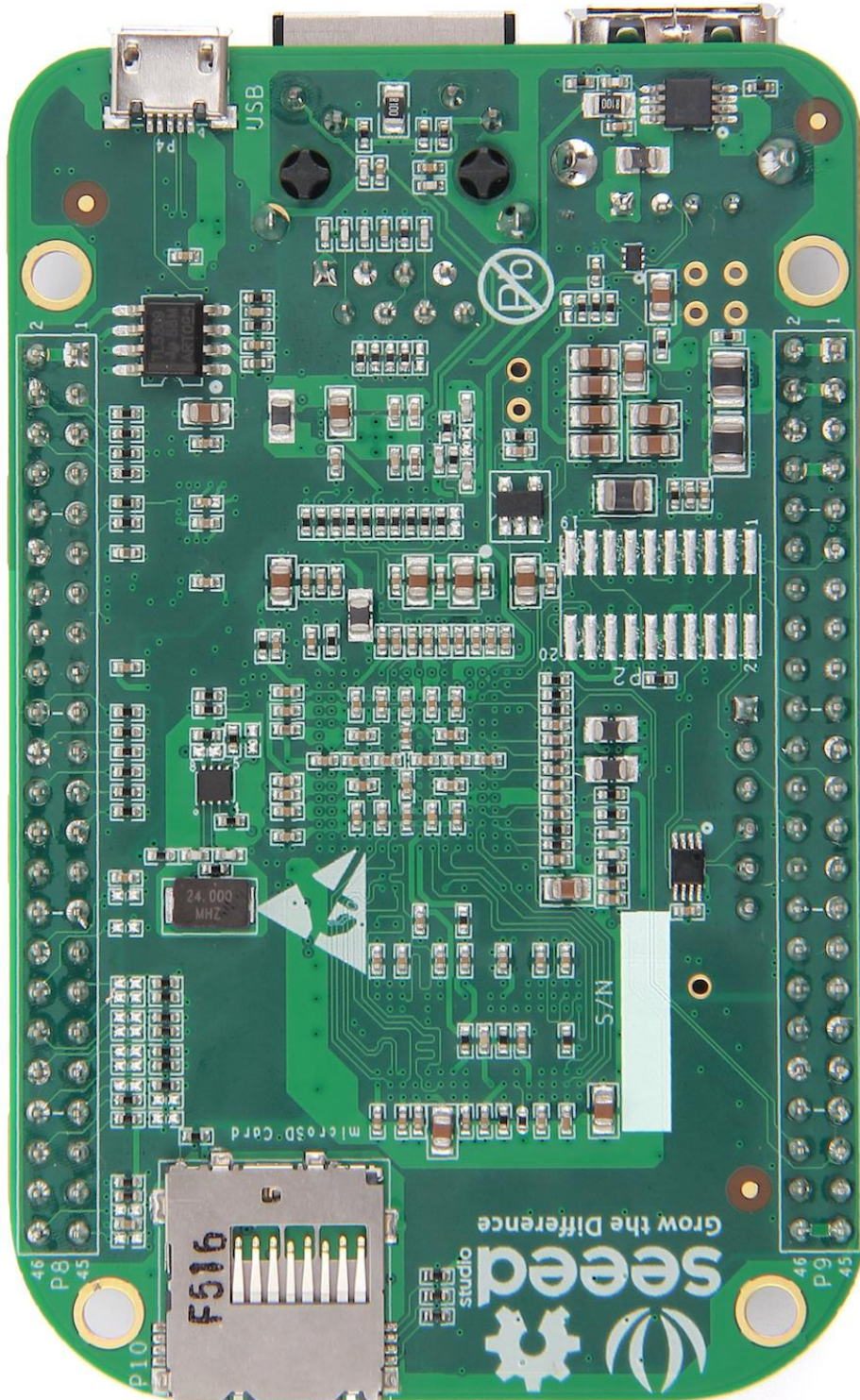**Figure 10.   Top Side**

**Figure 11.   Bottom Side**

## 8.0  Support Information

All support for this design is through the BeagleBoard.org community at:

beagleboard@googlegroups.com
or
http://beagleboard.org/discuss.

## 8.1     Hardware Design

Design documentation can be found on the eMMC of the board under the documents/hardware directory when connected using the USB cable. Provided there is:

- Schematic in PDF
- Schematic in OrCAD (Cadence Design Entry CIS 16.3)
- PCB Gerber
- PCB Layout File (Allegro)
- Bill of Material
- System Reference Manual (This document).

This directory is not always kept up to date in every SW release due to the frequency of changes of the SW. The best solution is to download the files from the Circuitco WIKI at http://www.seeedstudio.com/wiki/beaglebone_green

## 8.2     Software Updates

It is a good idea to always use the latest software. Instructions for how to update your software to the latest version can be found at:
http://www.seeedstudio.com/wiki/beaglebone_green