



# **BeagleBone LCD7 Cape Rev A3 System Reference Manual**

Revision A3  
September 1st, 2012



## THIS DOCUMENT

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## BEAGLEBONE LCD7 CAPE DESIGN

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## 1.0 Introduction

This document is the System Reference Manual for the BeagleBone LCD7 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 LCD7 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 LCD7 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 LCD7 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 LCD7 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
A1	Initial release.	04/25/2012	BBT
A2	1. LCD_AVDD_EN Signal is moved from J2-42 (GPIO0_7) to J1-20 (GPIO1_31) 2. PCB revision changed from -01 to -02	06/21/2012	BBT
A3	Add A2 vs. A3 section (2.2)	09/01/2012	BBT

### 2.2 A2 vs. A3

In revision A3 the Enter button has been moved from GPIO3\_19 to GPIO0\_3 and LCD\_DVDD\_EN has moved from GPIO1\_31 to GPIO0\_2. These changes in GPIOs are to support awake interrupt in sleeping mode.

The PCB revision is also changed from BB-Bone-LCD7-PCB-03 to BB-Bone-LCD7-PCB-04.

### 2.3 A1 vs. A2

The only design change in A2 is that the LCD\_AVDD\_EN signal is moved from pin 42 of connector J2 to pin 20 of connector J1. In revision A1, LCD\_AVDD\_EN signal is mapped to GPIO0\_7 which is also a DMA interrupt. By moving LCD\_AVDD\_EN signal, this DMA interrupt is now available when BeagleBone is used with LCD7 Cape. Both revisions should not have any functional difference.

The PCB revision is also changed from -02 to -03.

## 3.0 BeagleBone LCD7 Cape Overview

### 3.1 Descriptions

The BeagleBone LCD7 cape provides an LCD solution with touchscreen capability for BeagleBone boards. The 7" TFT LCD screen, attached to the topside of the board, can display up to a resolution of 800x480 and is a 4-wire resistive touchscreen. The board is equipped with seven buttons located at finger-friendly positions. These buttons include five user buttons that are connected to GPIO signals as well as power and reset. The backside of the cape is where the BeagleBone and additional cape can be mounted.

**Figure 1** below is a picture of the board.



**Figure 1.** The BeagleBone LCD7 Cape

### 3.2 In The Box

The final packaged BeagleBone LCD7 Cape Rev A2 product will contain the following items:

- 1 BeagleBone LCD7 Cape with standoffs



**Figure 2. BeagleBone LCD7 Cape Box Contents**



### 3.3 Getting Started

Following the instructions below to start using your BeagleBone LCD7 Cape:

1. Mount the BeagleBone to the BeagleBone Connectors on the LCD7 Cape.
  - *Note: The BeagleBone Connectors are the set of male connectors on the backside of the LCD7 Cape.*
2. Make sure the SD card using with BeagleBone has Angstrom image 06\_18\_12 or later.
3. Plug in a 5V DC power supply to the DC connector on the LCD7 Cape.
4. Following screens will be displayed on the LCD screen:
  - BeagleBone logo
  - Angstrom log-in prompt
  - Auto Calibration utility
5. Follow the instructions given by the Auto Calibration utility to calibrate the LCD7 touchscreen.
  - *Note: The Auto Calibration utility is automatically displayed when the card is used for the first time. This utility can be run again under menu System > Administration > Calibrate Touchscreen*
6. After calibrated, the Angstrom desktop will be displayed on the LCD screen.

You can start using the board.

### 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 LCD7 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 LCD7 Cape's features.

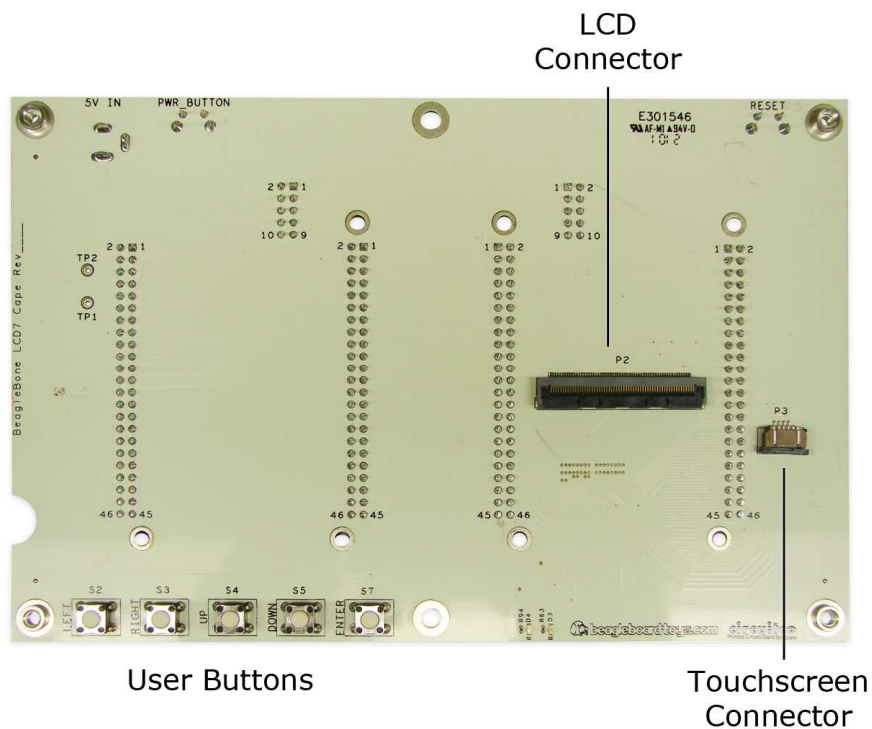
**Table 2. BeagleBone LCD7 Cape Features**

	Feature	
<b>Display</b>	ThreeFive TFC-S9700RTWV35TR-01	
<b>LCD Size</b>	7"	
<b>Panel Type</b>	a-Si TFT active matrix	
<b>Resolution</b>	800 x 480	
<b>Colors</b>	16.7M	
<b>Interface</b>	RGB 16-bit	
<b>Touch Panel</b>	Resistive	
<b>Color Depth</b>	RGB 16-bit	
<b>Power Supply</b>	5V DC on board	5V via expansion
		3.3V via expansion
<b>PCB</b>	4.50" x 6.90"	6 layers
<b>Indicators</b>	Power LED	
	User LED	
<b>EEPROM</b>	Board ID EEPROM	
<b>Connectors</b>	Two 46-position male headers	
	10-position male header	
	Two 46-position female headers	
	10-position female header	



## 4.1 Key Component Locations

**Figure 3** below shows the top side locations of key components on the PCB layout of the BeagleBone LCD7 Cape:



**Figure 3. Key Components on top side**

Figure 4 below shows key components on the back side of the board:

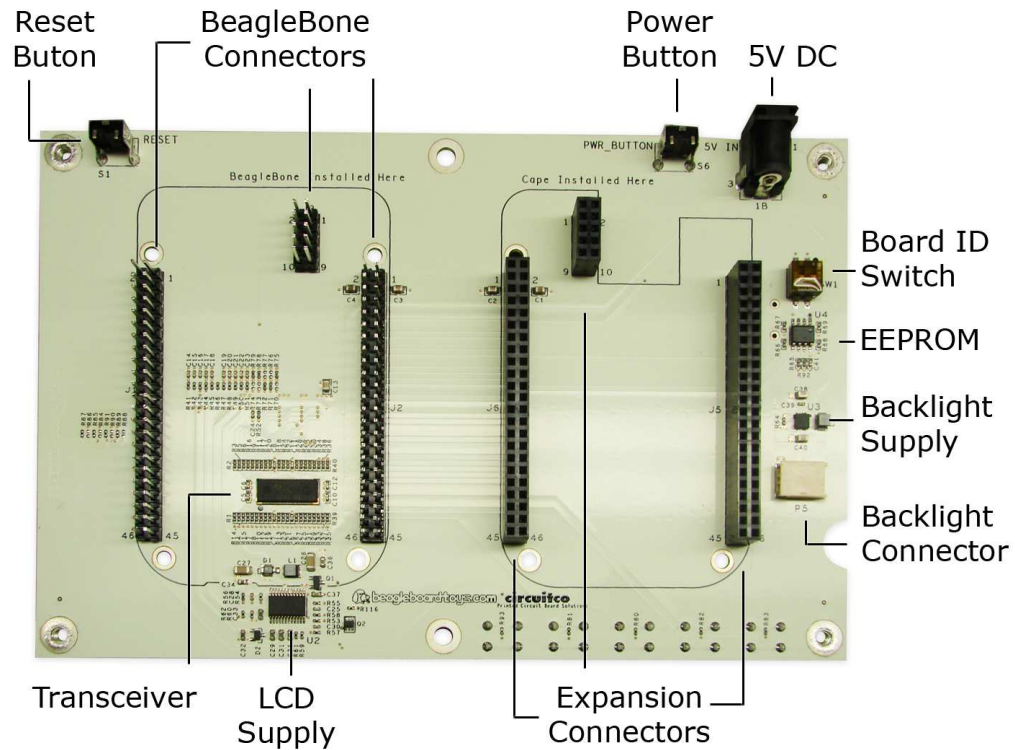


Figure 4. Key Components on bottom side

## 4.2 LCD Panel

The LCD Panel is supplied by ThreeFive. The Model number is TFC-S9700RTWV35TR-01. This display uses amorphous silicon (a-Si) as a switching device. This model is composed of a single 7.0 (16:9) inches transmissive type main TFT LCD panel. The resolution is 800x480 and it can display up to 16.7M colors.

### 4.3 Indicators

There is one Power LED and one User LED located on board. The Power LED indicates that power is applied to the board. The User LED is controlled by GPIO1\_28. These two LEDs are green when lit and located on the top side of the board and to the right of the user buttons.

### 4.4 Expansion Header

There are two sets of connectors located on the bottom side of the board. One set is male and is used for BeagleBone, whereas the other, which is female, is used to mount an additional cape. Each set is composed of two 46-position connectors and one 10-position connector.

### 4.5 Buttons

The power button and reset button are located underneath the LCD display. These are standard tactile switches and mounted at right angle. The reset button, when pressed, will reset the board. The power button, when pressed and held for 10 seconds, will turn off the board. In addition to those two buttons, the BeagleBone LCD7 also features five different buttons located next to each other on the top side of the board. These buttons are labeled as Left, Right, Up, Down, and Enter. They are mapped to different GPIO signals that can be accessed via expansion header. The reset button and power button, on the other hand, are connected to the RESET and PWR\_BUT respectively which can also be accessed at expansion connector J2.

### 4.6 DC Power Connector

A 5V DC power connector P1 is provided onboard. The board can be powered using this power connector or via the mounted BeagleBone. The connector used is a 2.1mm center positive x 5.5mm outer barrel. Once plugged in, 5V will be provided to the VDD\_5V power rail, which is also used by the BeagleBone. The 5V DC power connectors on the BeagleBone LCD7 Cape and the BeagleBone should not be used at the same time.

#### 4.7 Mechanical Specifications

Size:	4.50" x 6.90"
Layers:	6
PCB thickness:	.062"
RoHS Compliant:	Yes
Weight:	TBW

#### 4.8 Electrical Specifications

**Table 3** is the electrical specification of the external interfaces to the BeagleBone LCD7 panel.

**Table 3. BeagleBone LCD7 Electrical Specifications**

Specification	Min	Typ	Max	Unit
<b>Power</b>				
Input Voltage DC	4.8	5	5.2	V
Current DC		1.0		A
<b>Environmental</b>				
Temperature range	0		+85	C

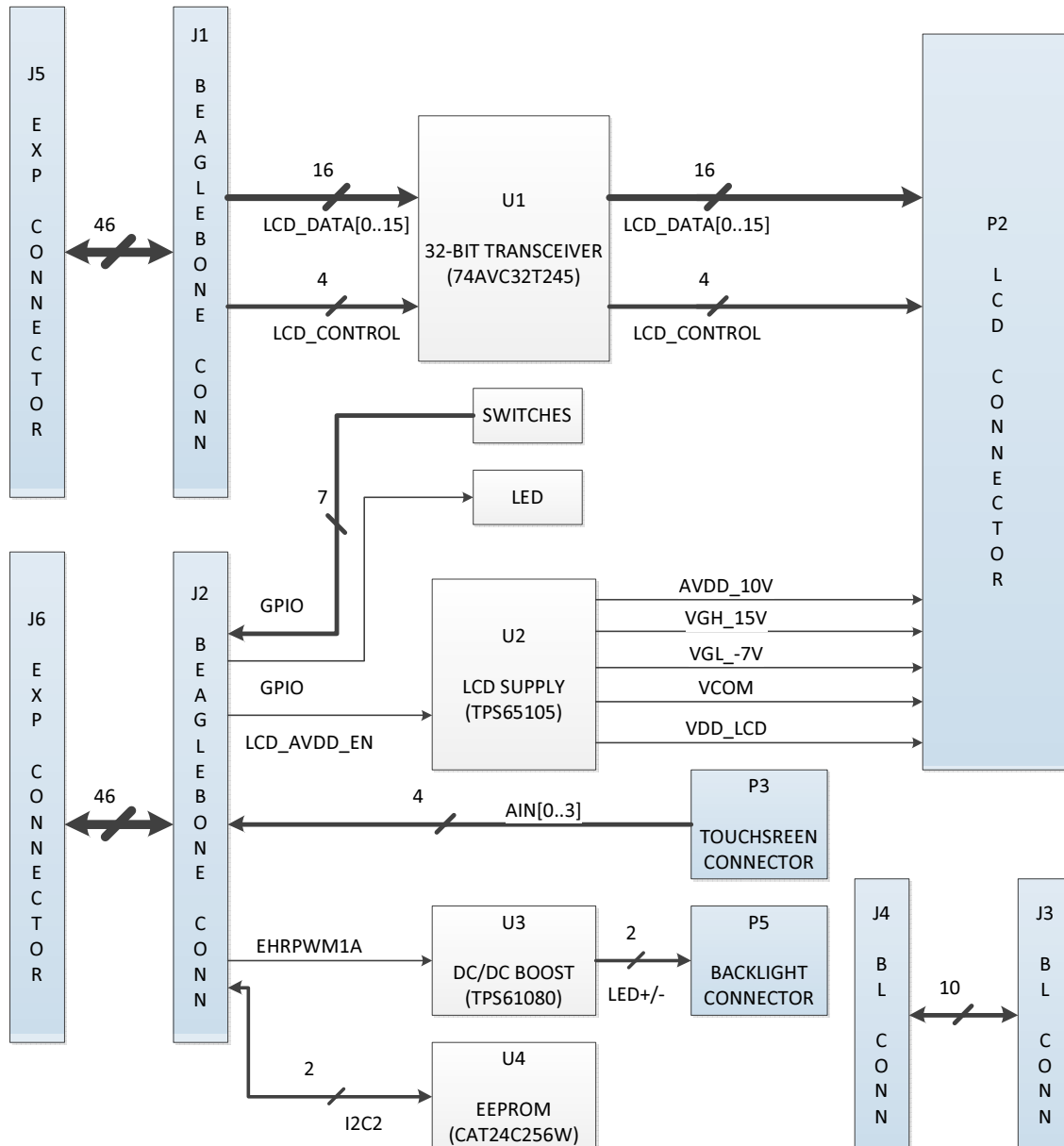


## 5.0 System Architecture and Design

This section provides a high level description of the design of the BeagleBone LCD7 Cape and its overall architecture.

### 5.1 System Block Diagram

**Figure 7** is the high level block diagram of the BeagleBone LCD7 Cape.

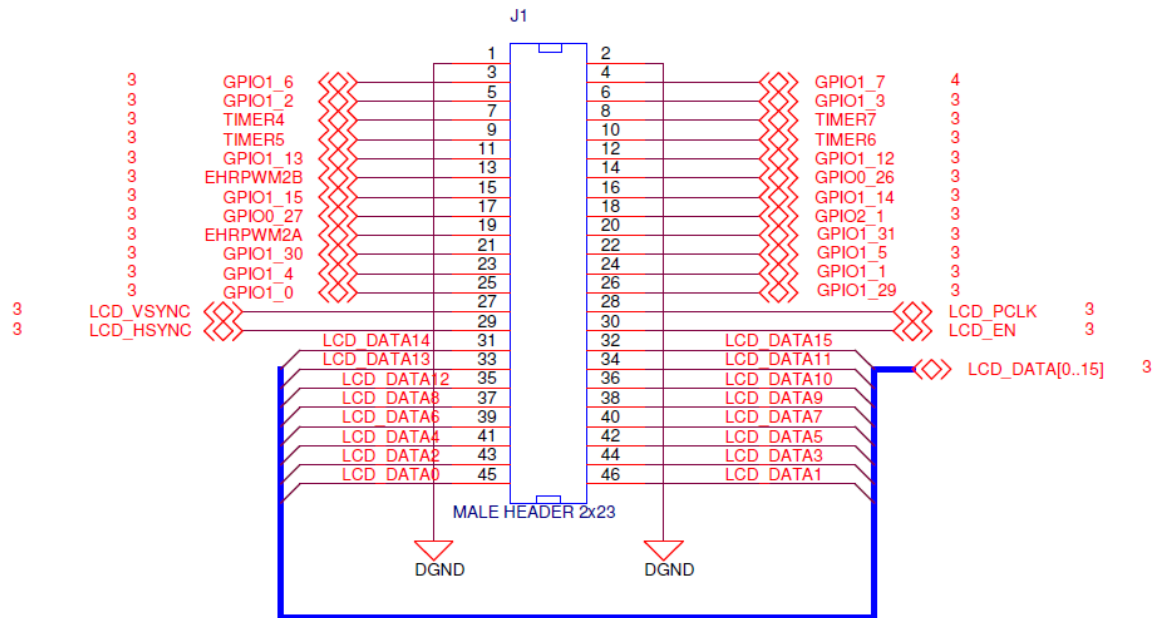


**Figure 5. BeagleBone LCD7 Cape High Level Block Diagram**

## 5.2 LCD Interface

### 5.2.1 Expansion connectors

The LCD interface of the BeagleBone LCD7 Cape uses 16 data and 4 control signals from the BeagleBone's expansion connectors. By using only 16 signals for LCD\_DATA, more pins can be available at the expansion header for other capes. The quality of 16-bit LCD output, nonetheless, is very similar to 24-bit. The 4 control signals are horizontal sync (LCD\_HSYNC), vertical sync (LCD\_VSYNC), enable input (LCD\_EN), and the pixel clock (LCD\_PCLK). **Figure 5** shows these LCD signals at expansion connector J1.

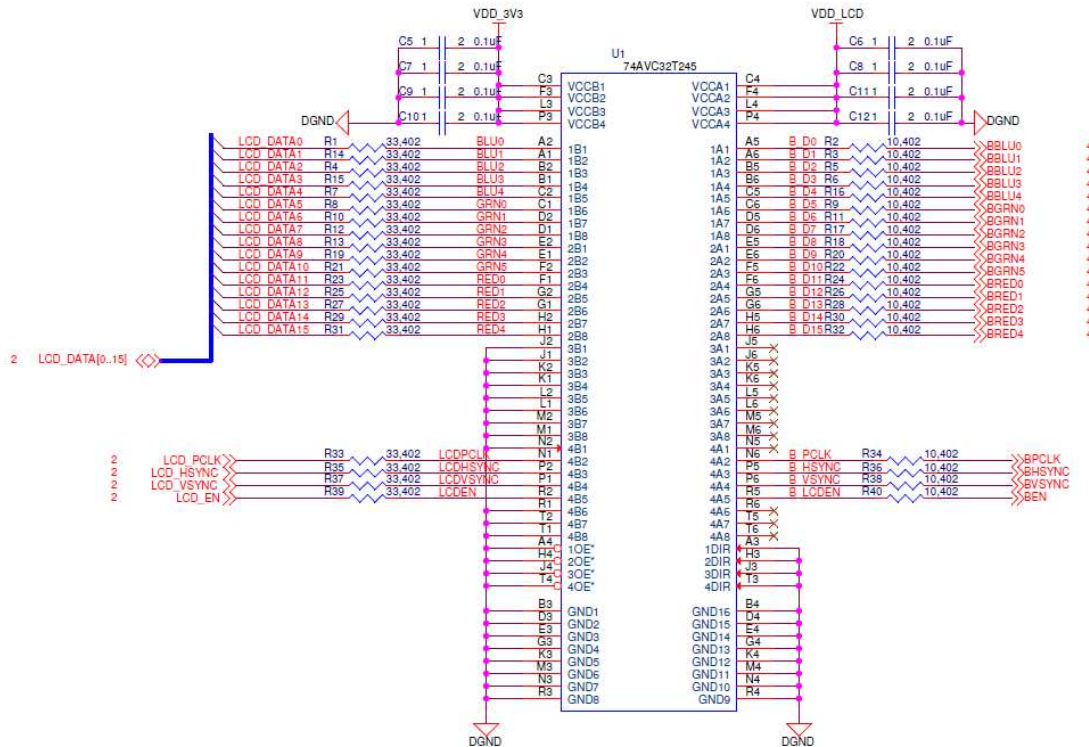


**Figure 5.** LCD Signals at expansion connector J1

### 5.2.2 Non-Inverting Bus Transceiver

The LCD signals are buffered through U1 (74AVC32T245), which is a 32-bit dual-supply bus transceiver. 74AVC32T245 features two ports, A and B. Each port tracks a separate power-supply rail. This allows for universal low-voltage translation. The output-enable (OE) input specifies whether the buses are isolated. The direction-control input, on the other hand, determines the data transmission direction. On the BeagleBone LCD7 Cape, no voltage translation required since its two power rails are both 3.3V. Both the direction-control and output-enable inputs are set low, so the data are transmitted from B

to A before going to LCD connector P2. **Figure 6** shows the LCD signals are buffered through U1.



**Figure 6.** LCD Signals buffered through U1

### 5.2.3 Touchscreen Interface

The TFC-S9700RTWV35TR-01 touchscreen is resistive and composed of 4 different X or Y signals. These signals are connected to the analog inputs AIN0 to AIN4, which can be accessed via expansion connector J2.

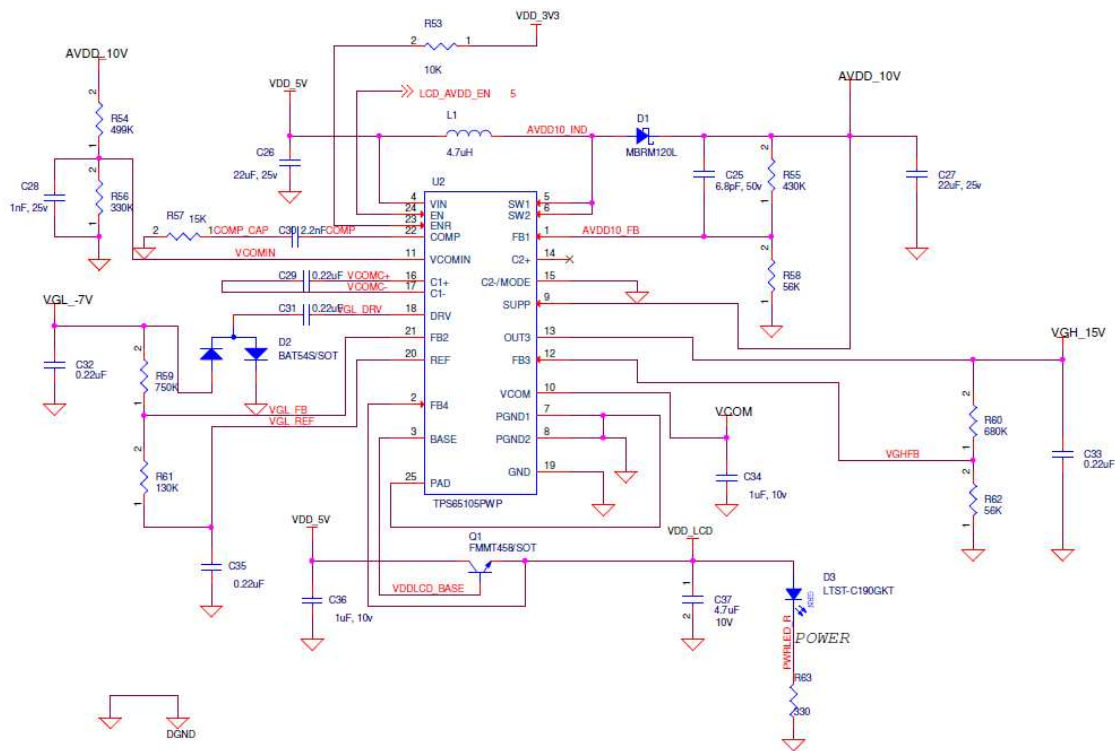
## 5.3 Power Management

### 5.3.1 LCD Power Supply

The main Power Management IC (PMIC) in the system is the TPS65105. This PMIC offers a compact and small power supply solution that provides all three voltages required by TFT LCD displays. TPS65105 also has an integrated VCOM buffer to power the LCD backplane as well as a linear regulator controller to provide a 3.3V output for system powered by 5V only. The enable (EN) input of the device is controlled by signal LCD\_AVDD\_EN, which is exposed at expansion connector J1.

For more information about TPS65105, refer to <http://www.ti.com/product/tps65105>

**Figure 7** shows TPS65105 in the system.



**Figure 7. BeagleBone LCD7 Power Management IC**

The main boost converter of TPS65105 operates with a fixed frequency of 1.6MHz and provides the AVDD\_10V power rail for the LCD interface. This output is also fed to SUP

pin as an input voltage for positive and negative charge pumps and bias supply for VCOM buffer. The input of the VCOM buffer is VCOMIN pin. If VCOM is not used in a circuit, the buffer can be shut down and the quiescent current can be reduced by grounding the VCOMIN pin. In this case, VCOMIN is connected to a 4V resistive divider of AVDD\_10V, which results in VCOM output to be 4V. TPS65105 is also integrated with adjustable positive and negative charge pumps. The input voltage to these charge pumps is the aforementioned AVDD\_10V output that is fed to SUP input. These positive and negative outputs are 15V and -7V, which provide the positive and negative gate drive voltages VGH and VGL of the LCD panel.

TPS65105 also provides a linear regulator controller to generate a 3.3V output from a 5V source. This linear regulator controller is independent from the system since it has its own enable input. In the BeagleBone LCD7 Cape, this enable pin is connected to the VDD\_3V3 power rail to make sure the controller is always active. An external npn transistor is used, and its base is driven by the Base output from the PMIC. A feedback signal is fed back to TPS65105 to ensure the transistor's output is fixed at 3.3V. This voltage is connected to power rail VDD\_LCD and also powers the Power LED.

The main boost converter of TPS65105 as well as positive and negative charge pumps, linear regulator, and VCOM buffer have an internal soft start. The purpose of soft start is to avoid heavy voltage drop at the input or output of the boost converter due to high inrush current at start-up. The output voltages have a power on sequence as follow:

AVDD\_10V -> VGL\_-7V -> VGH\_15V -> VCOM

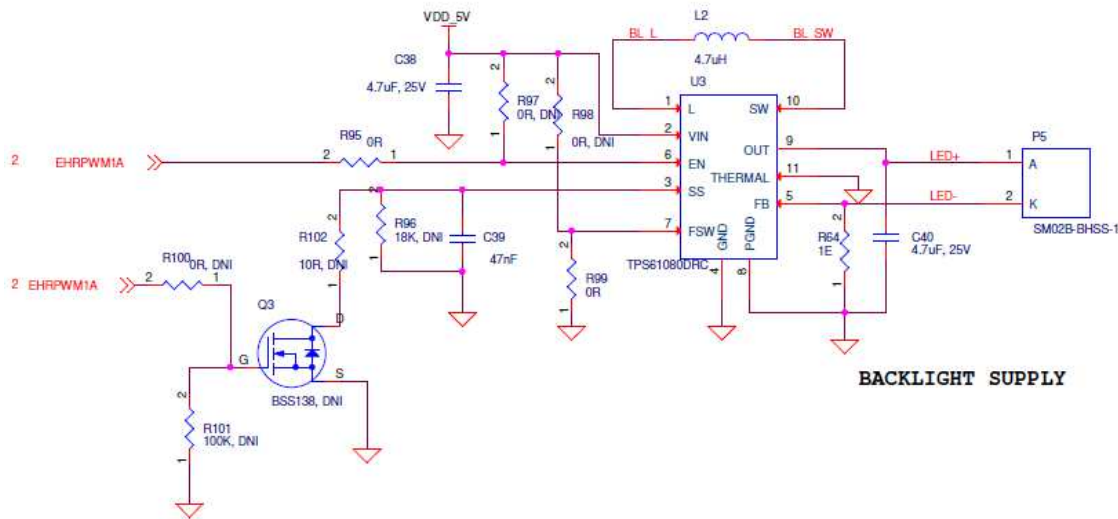
This sequence matches the power on sequence of the LCD panel.

### 5.3.2 Backlight Power Supply

The backlight of TFC-S9700RTWV35TR-01 LCD panel is composed of 27 LEDs divided into 9 parallel series. Each LED has a maximum current rating of 20mA; therefore, a maximum current of 180mA is required to power the LCD backlight.

The backlight of the LCD panel is powered by a High Voltage DC/DC Boost Converter TPS61080. This boost converter can operate from input supply of 5V and provide output voltage up to 27V. This IC features an input/output isolation which prevents any output leakage under shutdown, avoid inrush current during start up or unlimited short current. The enable (EN) pin is controlled by signal EHRPWM1A which is exposed at pin 14 of expansion connector J2. When the EN pin is pulled high, the device is active. TPS61080 uses a current mode control with constant PWM. The switching frequency can be configured to be 600kHz or 1.2MHz by connecting FSW pin to a logic low or high

respectively. TPS61080 utilizes an external inductor to store and transfer energy to the output capacitor which is connected to the Anode terminal of the LCD backlight. The Cathode terminal is connected to the feedback (FB) pin of the device. A current sense resistor is connected to the FB pin for a constant current output. **Figure 8** shows the backlight circuit of the BeagleBone LCD7 Cape:



**Figure 8. BeagleBone LCD7 Backlight Circuit**

## 5.4 EEPROM

The BeagleBone LCD7 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 8** is the design of the EEPROM circuit.

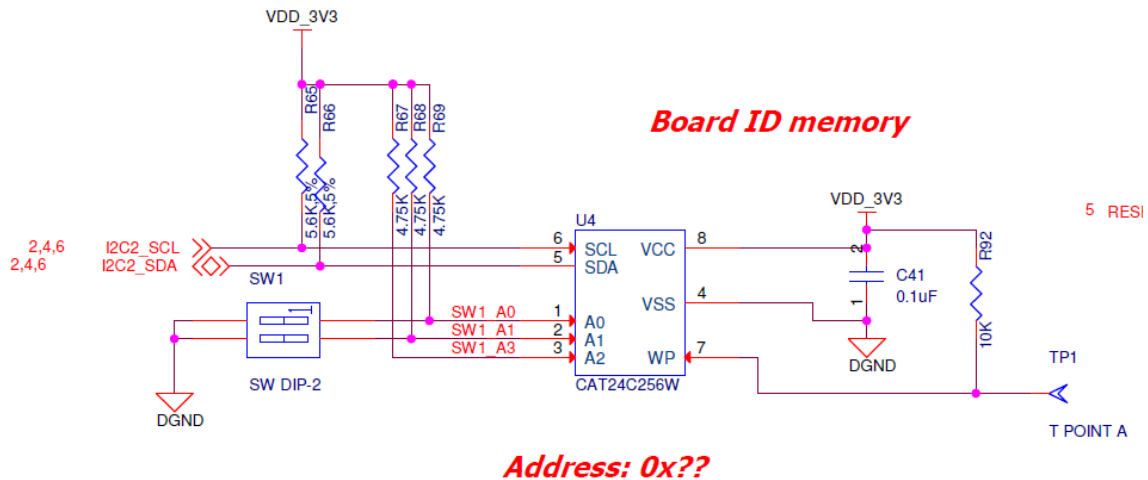


Figure 9. BeagleBone LCD7 Cape EEPROM

#### 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 effective resistance of 1.4K if all Capes were installed.

## 6.0 Mechanical Information

This section provides information on the mechanical aspect of the BeagleBone LCD7 Cape. **Figure 14** is the dimensions of the BeagleBone LCD7 Cape.

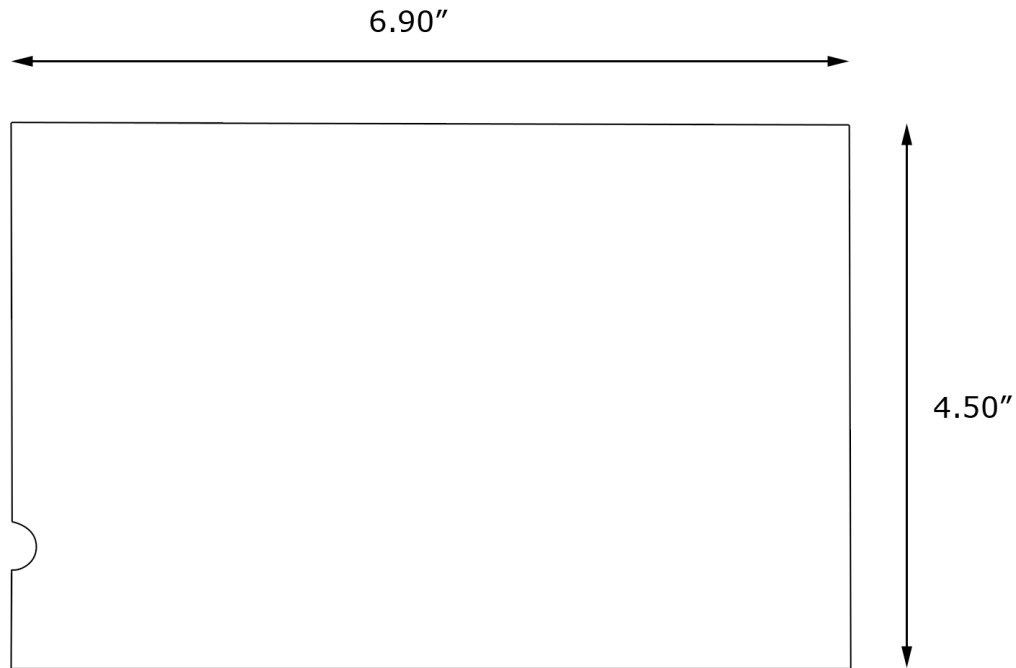


Figure 10. BeagleBone LCD7 Cape Dimensions Drawing



## 7.0 Design Materials

Design information can be found at BeagleBoardToys wiki:

[http://beagleboardtoys.com/wiki/index.php?title=BeagleBone\\_LCD7](http://beagleboardtoys.com/wiki/index.php?title=BeagleBone_LCD7)

Provided there is:

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

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