



BeagleBone LCD7 Cape Rev A2 System Reference Manual

Revision A2
June 21st, 2012

THIS DOCUMENT

This work is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-sa/3.0/> or send a letter to Creative Commons, 171 Second Street, Suite 300, San Francisco, California, 94105, USA.

All derivative works are to be attributed to BeagleBoardtoys.com.

For more information, see <http://creativecommons.org/licenses/by-sa/3.0/>

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

BEAGLEBONE LCD7 CAPE 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 Beagleboardtoys.com/support

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.

We mean it; these design materials may be totally unsuitable for any purposes.

BeagleBoardToys provides the enclosed product(s) under the following conditions:

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by BeagleBoardtoys.com to be a finished end-product fit for general consumer use. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within **30 days** from the date of delivery for a full refund. **THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.**

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies BeagleBoardtoys.com from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

BeagleBoardtoys.com currently deals with a variety of customers for products, and therefore our arrangement with the user **is not exclusive**. BeagleBoardtoys.com assumes **no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein**.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on BeagleBoardtoys.com environmental and/or safety programs, please contact visit BeagleBoardtoys.com.

No license is granted under any patent right or other intellectual property right of BeagleBoard.org covering or relating to any machine, process, or combination in which such BeagleBoardtoys.com products or services might be or are used.

Mailing Address:

Beagleboardtoys.com
1380 Presidential Dr. #100
Richardson, TX 75081
U.S.A.



WARRANTY: *The BeagleBone LCD7 Cape is warranted against defects in materials and workmanship for a period of 90 days from purchase. This warranty does not cover any problems occurring as a result of improper use, modifications, exposure to water, excessive voltages, abuse, or accidents. All boards will be returned via standard mail if an issue is found. If no issue is found or express return is needed, the customer will pay all shipping costs.*

Before returning the board, please visit Beagleboardtoys.com/support

To return a defective board, please request an RMA at <http://www.beagleboardtoys.com/support/rma>



Table of Contents

FIGURES	7
TABLES	7
1.0 INTRODUCTION	9
2.0 CHANGE HISTORY	10
2.1 CHANGE HISTORY.....	10
2.2 A1 VS. A2	10
3.0 BEAGLEBONE LCD7 CAPE OVERVIEW	11
3.1 DESCRIPTIONS.....	11
3.2 IN THE BOX	12
3.3 GETTING STARTED.....	13
3.4 REPAIRS	13
4.0 FEATURES AND SPECIFICATIONS	14
4.1 KEY COMPONENT LOCATIONS	15
4.2 LCD PANEL	16
4.3 INDICATORS	17
4.4 EXPANSION HEADER.....	17
4.5 BUTTONS	17
4.6 DC POWER CONNECTOR	17
4.7 MECHANICAL SPECIFICATIONS	18
4.8 ELECTRICAL SPECIFICATIONS	18
5.0 SYSTEM ARCHITECTURE AND DESIGN	19
5.1 SYSTEM BLOCK DIAGRAM.....	19
5.2 LCD INTERFACE	20
5.2.1 <i>Expansion connectors</i>	20
5.2.2 <i>Non-Inverting Bus Transceiver</i>	20
5.2.3 <i>Touchscreen Interface</i>	21
5.3 POWER MANAGEMENT.....	22
5.3.1 <i>LCD Power Supply</i>	22
5.3.2 <i>Backlight Power Supply</i>	23
5.4 EEPROM	24
5.4.1 <i>EEPROM Address</i>	25
5.4.2 <i>I2C Bus</i>	25
6.0 MECHANICAL INFORMATION	26
7.0 DESIGN MATERIALS	27

Figures

Figure 1.	The BeagleBone LCD7 Cape.....	11
Figure 2.	BeagleBone LCD7 Cape Box Contents.....	12
Figure 3.	Key Components on top side.....	15
Figure 4.	Key Components on bottom side.....	16
Figure 5.	BeagleBone LCD7 Cape High Level Block Diagram.....	19
Figure 5.	LCD Signals at expansion connector J1.....	20
Figure 6.	LCD Signals buffered through U1.....	21
Figure 7.	BeagleBone LCD7 Power Management IC.....	22
Figure 8.	BeagleBone LCD7 Backlight Circuit.....	24
Figure 9.	BeagleBone LCD7 Cape EEPROM.....	25
Figure 10.	BeagleBone LCD7 Cape Dimensions Drawing.....	26

Tables

Table 1.	Change History.....	10
Table 2.	BeagleBone LCD7 Cape Features.....	14



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

2.2 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 -01 to -02.



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	
Display	ThreeFive TFC-S9700RTWV35TR-01	
LCD Size	7"	
Panel Type	a-Si TFT active matrix	
Resolution	800 x 480	
Colors	16.7M	
Interface	RGB 16-bit	
Touch Panel	Resistive	
Color Depth	RGB 16-bit	
Power Supply	5V DC on board	5V via expansion
		3.3V via expansion
PCB	4.50" x 6.90"	6 layers
Indicators	Power LED	
	User LED	
EEPROM	Board ID EEPROM	
Connectors	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:

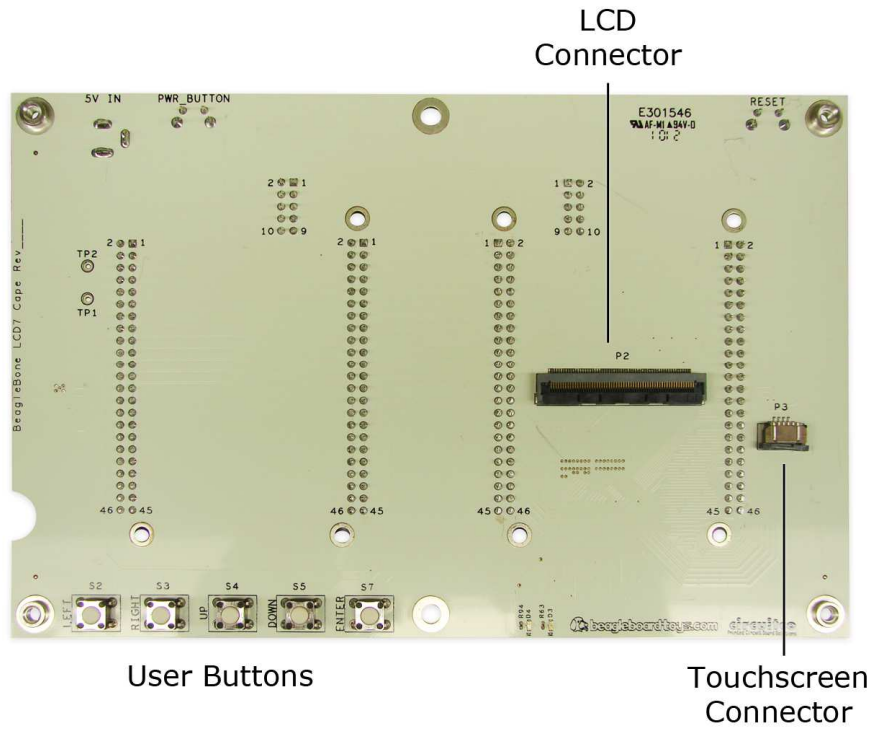


Figure 3. Key Components on top side

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

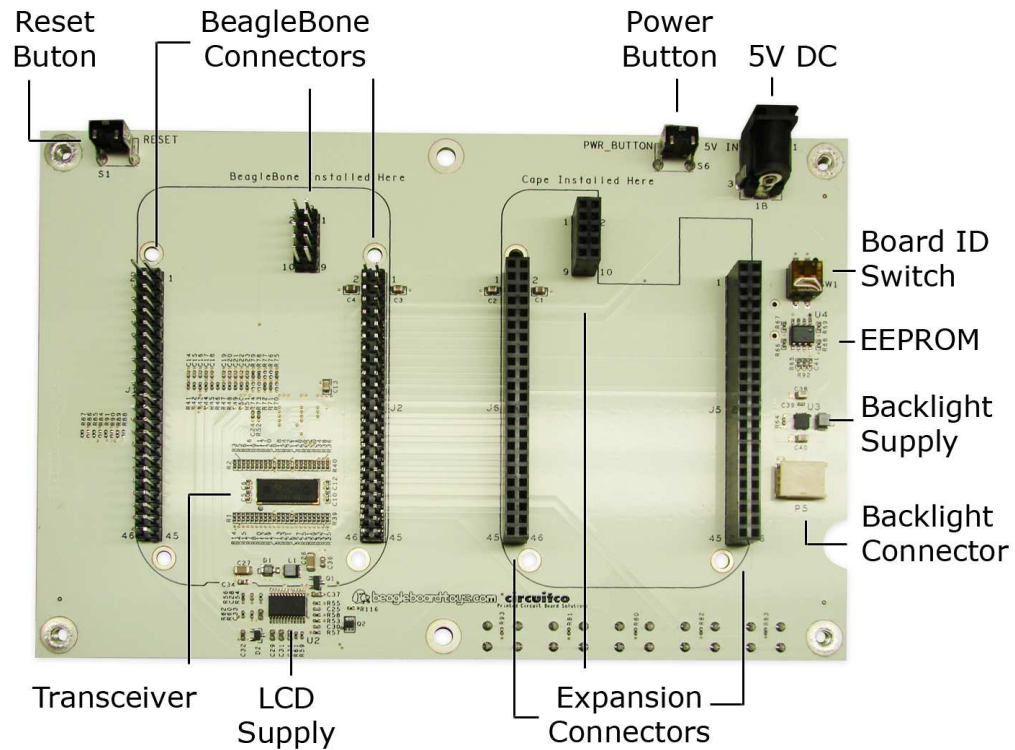


Figure 4. Key Components on bottom side

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
Power				
Input Voltage DC	4.8	5	5.2	V
Current DC		1.0		A
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 LCD7 Cape and its overall architecture.

5.1 System Block Diagram

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

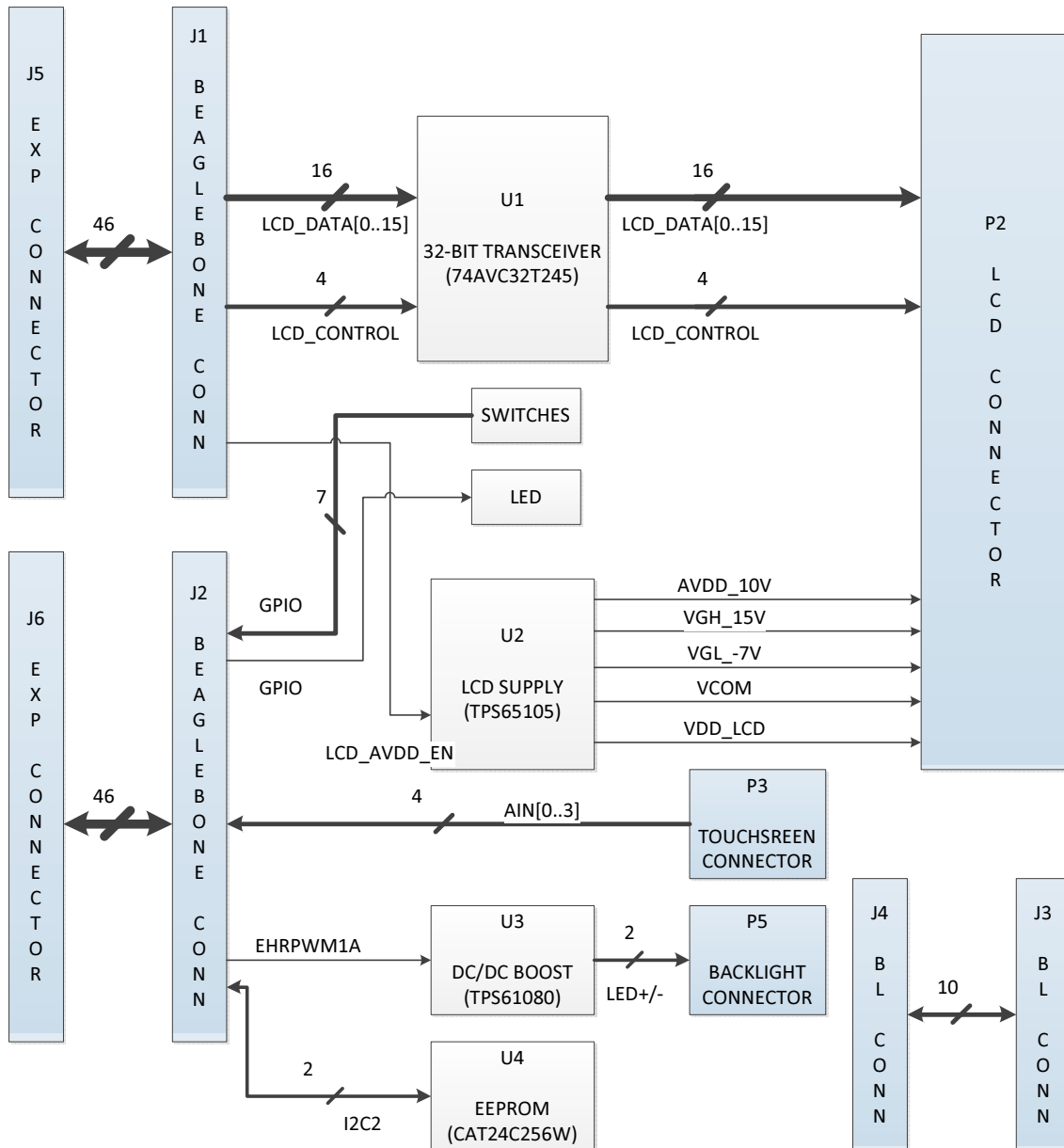


Figure 5. BeagleBone LCD7 Cape High Level Block Diagram

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.

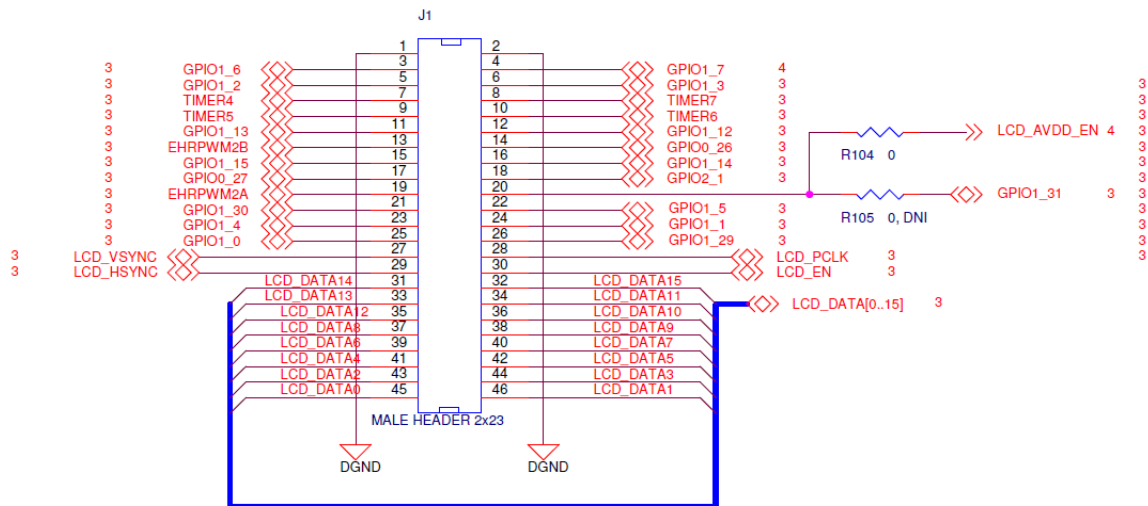


Figure 5. LCD Signals at expansion connector J1

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.

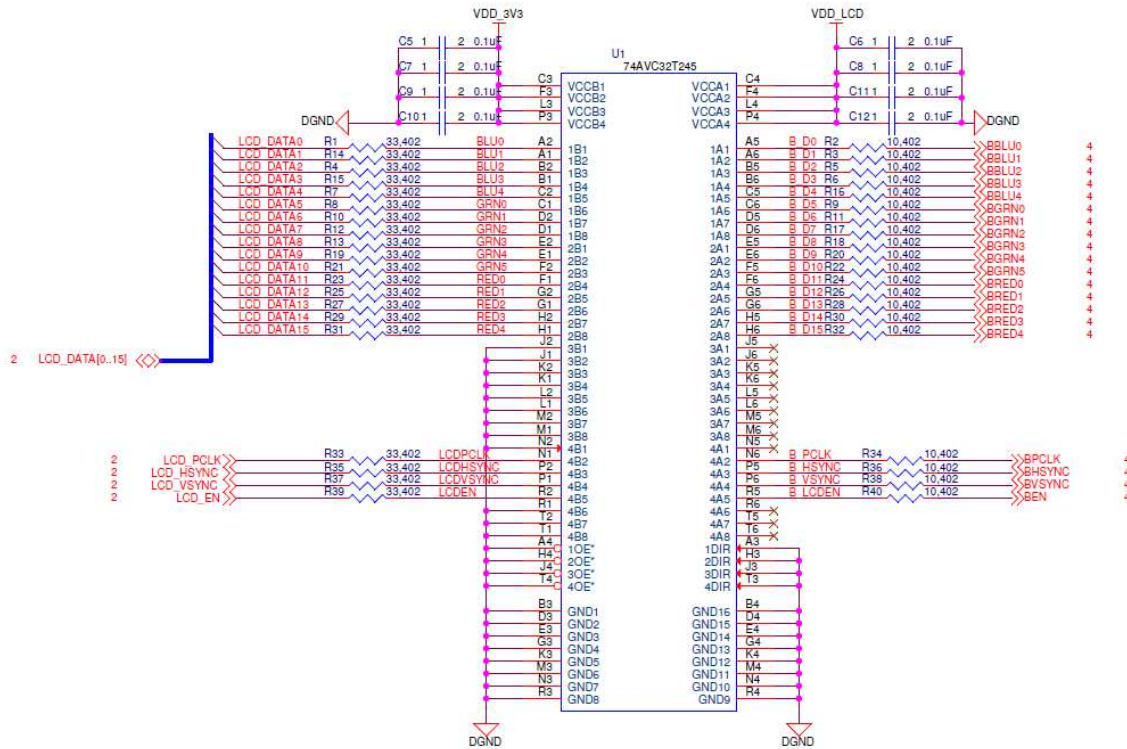


Figure 6. LCD Signals buffered through U1

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.

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

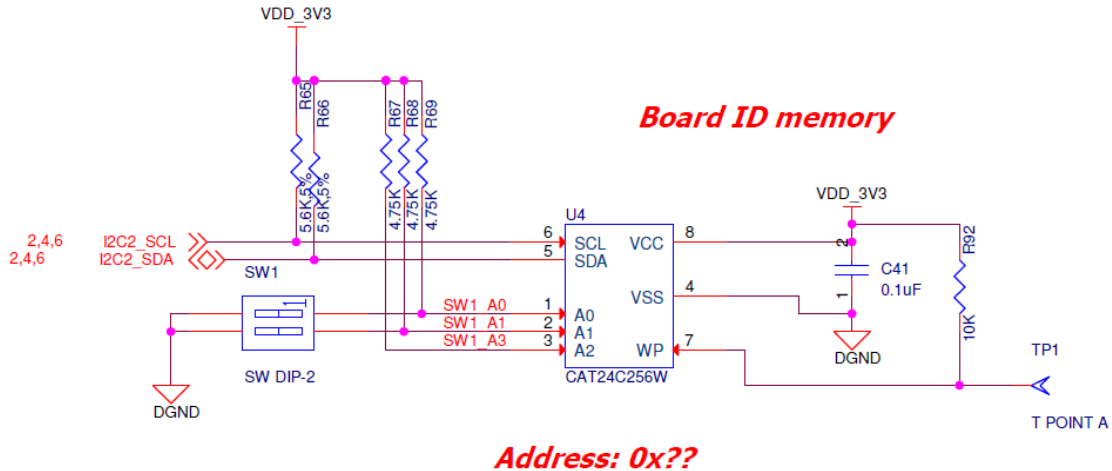


Figure 9. BeagleBone LCD7 Cape EEPROM

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.

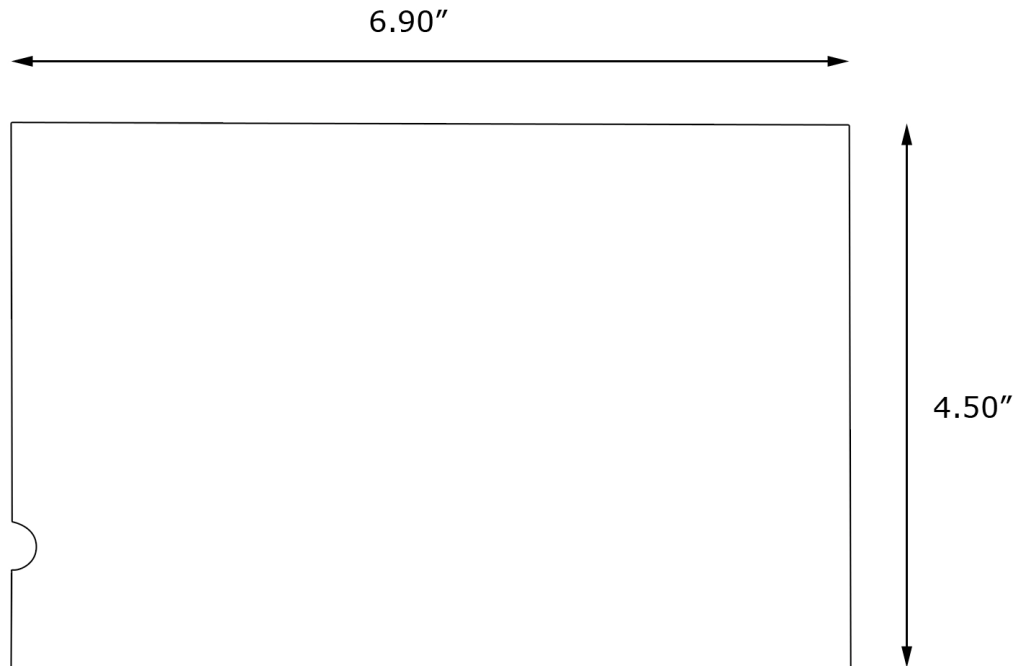


Figure 10. BeagleBone LCD7 Cape Dimensions Drawing

7.0 Design Materials

Design information can be found at BeagleBoardToys wiki:

http://beagleboardtoys.com/wiki/index.php?title=BeagleBone_LCD7

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)

*These design materials 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.*

We mean it, these design materials may be totally unsuitable for any purposes.