

# BeagleBoard-xM LCD7 Rev B System Reference Manual

November 1st, 2012



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## BEAGLEBOARD-XM LCD7 DESIGN

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## 1.0 Introduction

This document is the System Reference Manual for the BeagleBoard-xM LCD7, an add-on board for the BeagleBoard-xM.

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 BeagleBoard-xM LCD7 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 BeagleBoard-xM LCD7.

### [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 BeagleBoard-xM LCD7. 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 BeagleBoard-xM LCD7.

### [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.	10/14/2011	BBT
B	<ol style="list-style-type: none"><li>1. Backlight circuit modified.</li><li>2. LCD EDID EEPROM removed</li><li>3. GND testpoint TP3 added</li><li>4. PCB is now 4-layered</li></ol>	11/01/2012	BBT

### 2.2 A vs. B

In revision B, the backlight circuit being modified to provide better current control for the LCD backlight. The LCD EDID EEPROM and support for other platforms have been removed; the board is now called BeagleBoard-xM LCD7 and supports only BeagleBoard-xM.

There are also some changes on the PCB; however, these changes are not populated; therefore, they will not affect the performance of the board.

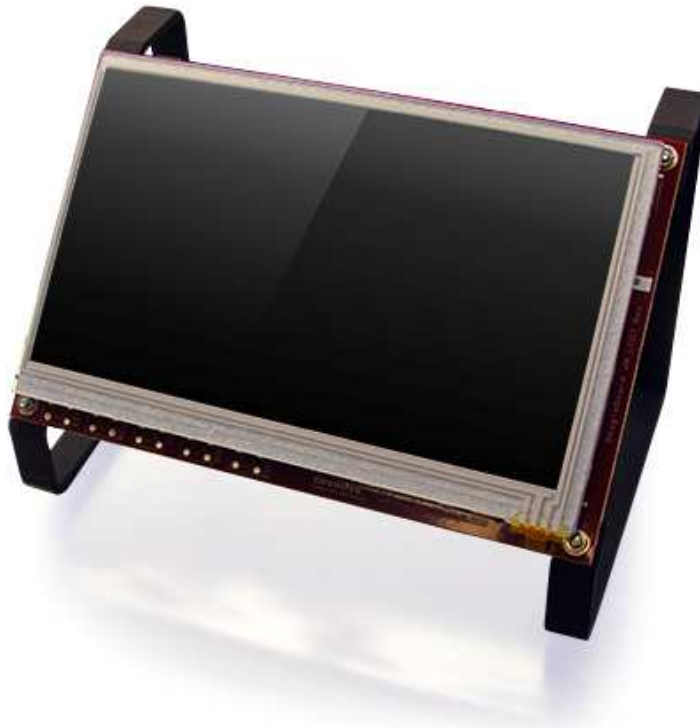
The number of PCB layers has been reduced to 4. The PCB revision is changed to BB-XM-LCD7-PCB-01.

## 3.0 BeagleBoard-xM LCD7 Cape Overview

### 3.1 Descriptions

The BeagleBoard-xM LCD7 provides an LCD solution with touchscreen capability for BeagleBoard-xM 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 backside of the board is where the BeagleBoard-xM and additional expansion boards can be mounted. The BeagleBoard-xM LCD7 Cape is also equipped with a reset button and a connector footprint for a WiFi expansion connector.

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



**Figure 1.** The BeagleBoard-xM LCD7 board

### 3.2 In The Box

The final packaged BeagleBoard-xM LCD7 product will contain the following items:

- 1 BeagleBoard-xM LCD7 with standoffs
- 1 wiki information card
- 1 bracket information card

### 3.3 Getting Started

Following the instructions below to start using your BeagleBoard-xM LCD7 :

1. Mount the BeagleBoard-xM to the Beagle Expansion connector and LCD dual connectors on the back of the LCD7 board.
  - *Note: The Beagle Expansion connector is the 28 pin male header on the back of LCD7 board. The LCD dual connectors are two 20 pin male headers also on the back of LCD7 board.*
2. Go to the wiki page for the BeagleBoard-xM LCD7 and download the latest Angstrom image <http://beagleboardtoys.com/wiki/>
3. Follow the instructions on the wiki to write the image file to your SD card.
4. Plug in 5V supply to the 5V connector P1 on the LCD7 board.
5. The BeagleBoard-xM is now booting up. This process may take 1-2 minutes
6. After finishing booting up, 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 BeagleBoard-xM 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 BeagleBoard-xM LCD7 Cape's features.

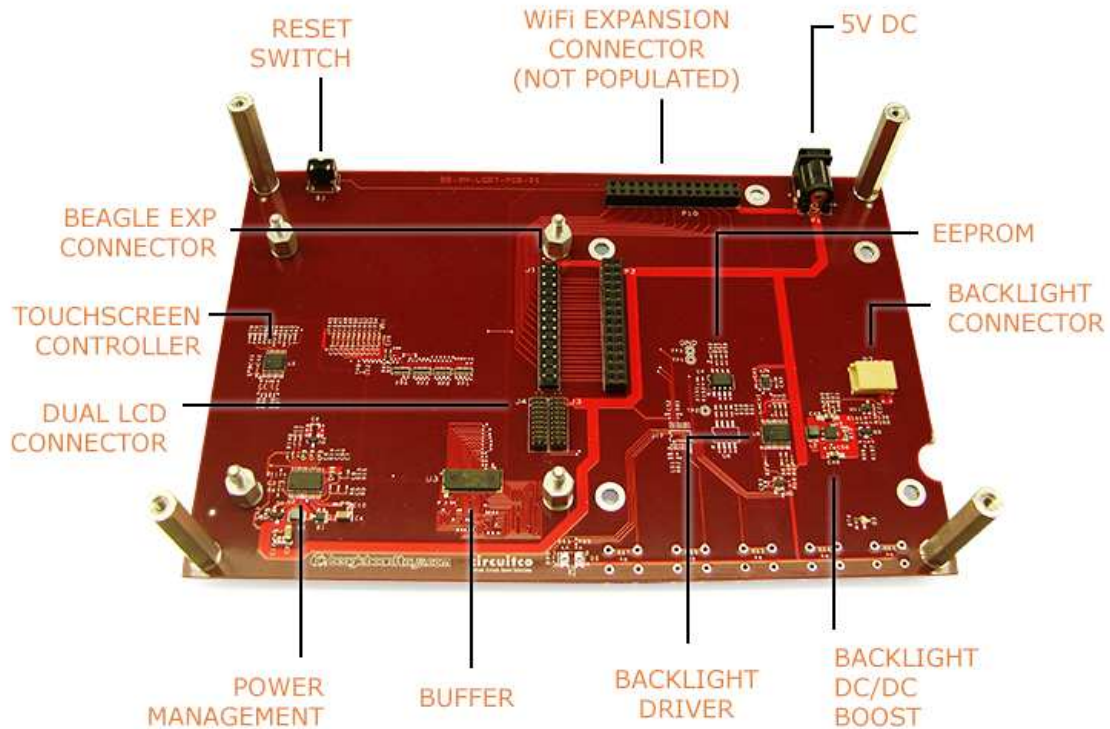
**Table 2. BeagleBoard-xM LCD7 Cape Features**

	<b>Feature</b>	
<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>Touch Panel</b>	Resistive	
<b>Color Depth</b>	RGB 16-bit	
<b>Power Supply</b>	5V DC on board	
<b>PCB</b>	4.50" x 6.90"	4 layers
<b>Indicators</b>	Power LED	
<b>EEPROM</b>	Board ID EEPROM	
<b>Connectors</b>	28 pin Beagle connector	
	Dual 20-pin LCD connector	
	28 pin Expansion connector	
	28 pin WLAN expansion connector (footprint)	



## 4.1 Key Component Locations

**Figure 2** below shows the locations of key components on the PCB of the BeagleBoard-xM LCD7 Cape:



**Figure 2.** Key Components on BeagleBoard-xM LCD7

## 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 indicator (D3) on board. This LED indicates power has been applied to the LCD panel.

## 4.4 Expansion Connectors

J1 is the Beagle Expansion connector to be used with BeagleBoard-xM. This connector is a 28-pin male header that can be mated with the female expansion headers on BeagleBoard-xM.

P2 is an expansion connector to be used for an additional cape. This connector is female and has 28 pins. The signals brought out to this connector are the same as the Beagle Expansion connector J1.

P10 is a WLAN Expansion connector. Though not populated, this provides an option for customer to install a WLAN daughter card to the BeagleBoard-xM LCD7.

## 4.5 Switches

There is a reset switch (S1) that is populated at 90 degree to the PCB. This button is located on the top right corner when looking down at the LCD screen and is used to reset the main board.

## 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 BeagleBoard-xM. The connector used is a 2.1mm center positive x 5.5mm outer barrel. Once plugged in, 5V will be provided to the DC\_5V power rail, which is also used by the BeagleBoard-xM.

**Note: The 5V DC power connectors on the BeagleBoard-xM LCD7 and the BeagleBoard-xM should not be used at the same time.**

#### 4.7 Mechanical Specifications

Size:	4.50" x 6.90"
Layers:	4
PCB thickness:	.062"
RoHS Compliant:	Yes

#### 4.8 Electrical Specifications

**Table 3** is the electrical specification of the external interfaces to the BeagleBoard-xM LCD7 panel.

**Table 3. BeagleBoard-xM LCD7 Electrical Specifications**

Specification	Min	Typ	Max	Unit
<b>Power</b>				
Input Voltage DC	4.8	5	5.2	V
Current DC		2.0		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 BeagleBoard-xM LCD7 and its overall architecture.

### 5.1 System Block Diagram

Figure 3 is the high level block diagram of the BeagleBoard-xM LCD7.

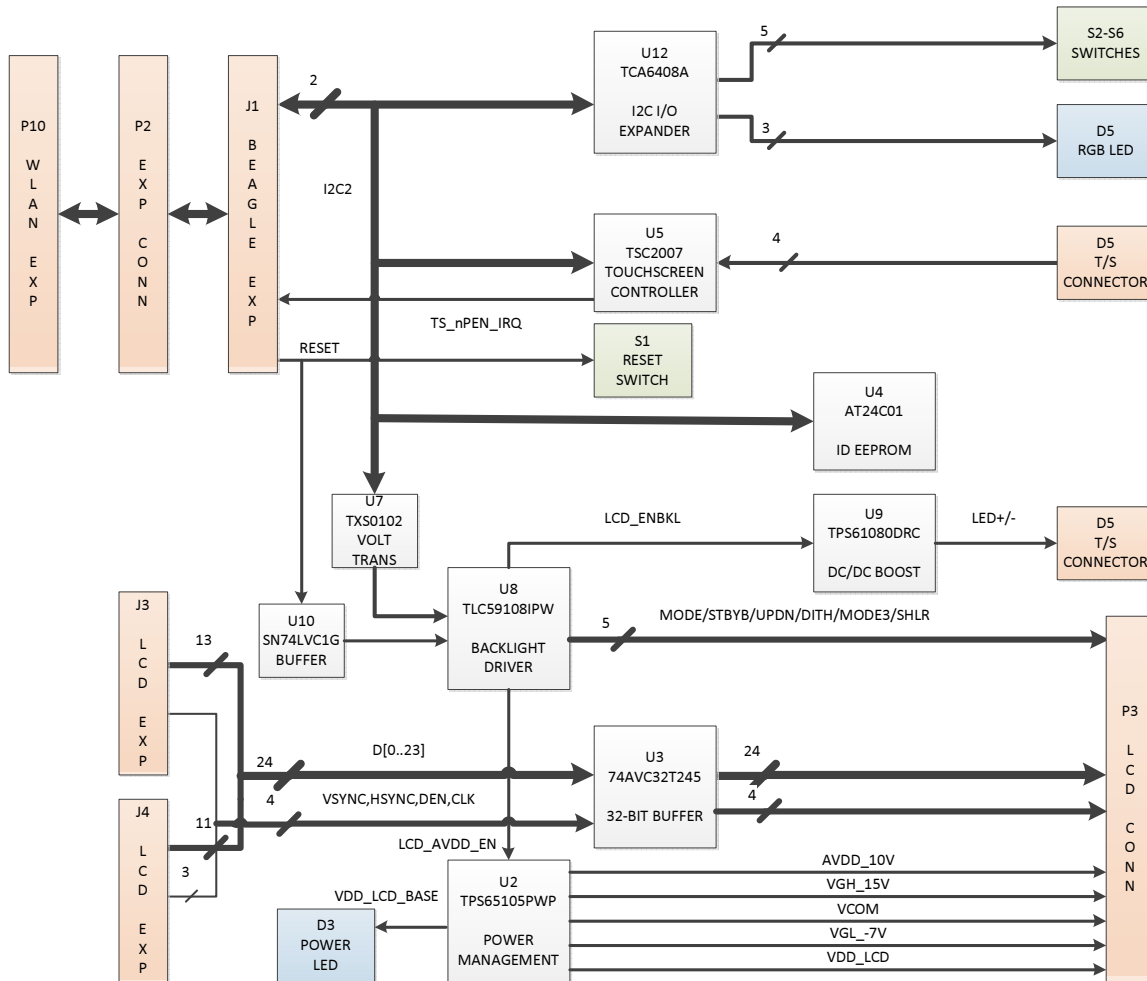


Figure 3. BeagleBoard-xM LCD7 High Level Block Diagram

## 5.2 LCD Interface

### 5.2.1 Expansion connectors

The LCD interface of the BeagleBoard-xM LCD7 uses 24 data and 4 control signals from the BeagleBoard-xM's Dual LCD connectors J3 and J4. The 4 control signals are horizontal sync (HSYNC), vertical sync (VSYNC), enable input (DEN), and the pixel clock (CLK). **Figure 4** shows these LCD signals at the dual LCD connectors.

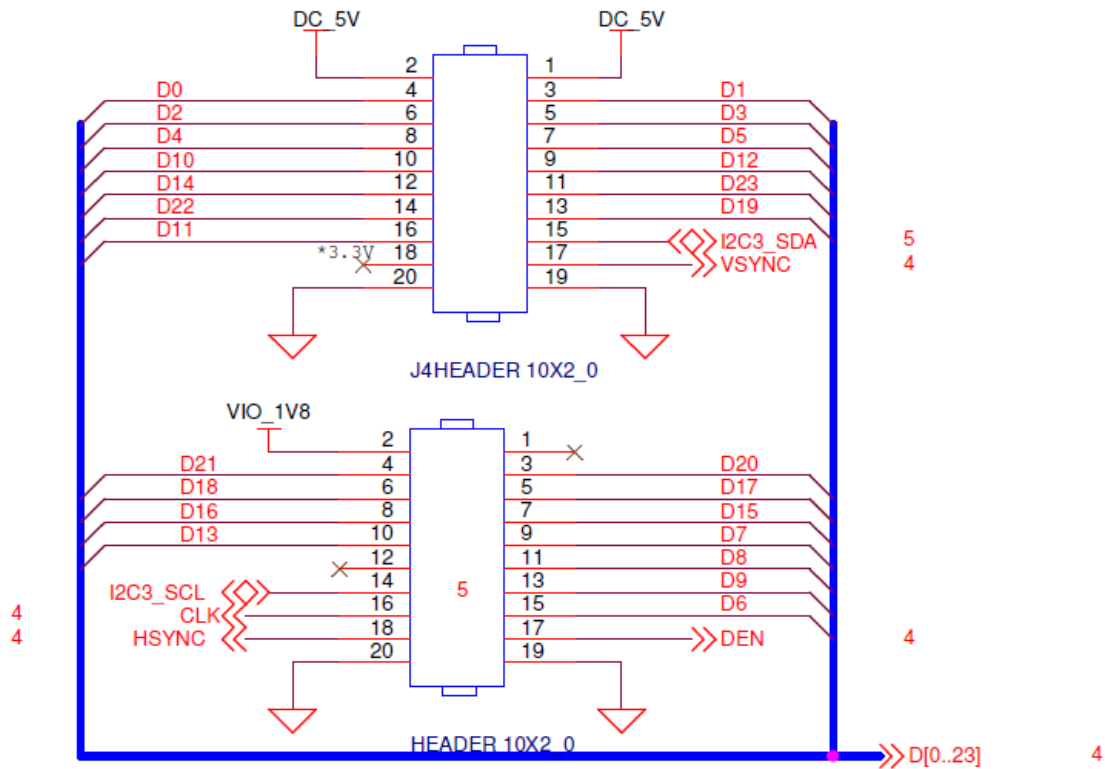


Figure 4. LCD interface at dual LCD connectors

5.2.2 Non-Inverting Bus Transceiver

The LCD signals are buffered through U3 (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 BeagleBoard-xM, since the signals coming out of the expansion header are at 1.8V, power supply of B port is also tracked 1.8V. Signals at A port, on the other hands are supplied by the power rail VDD\_LCD (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 5** shows the LCD signals are buffered through U3.

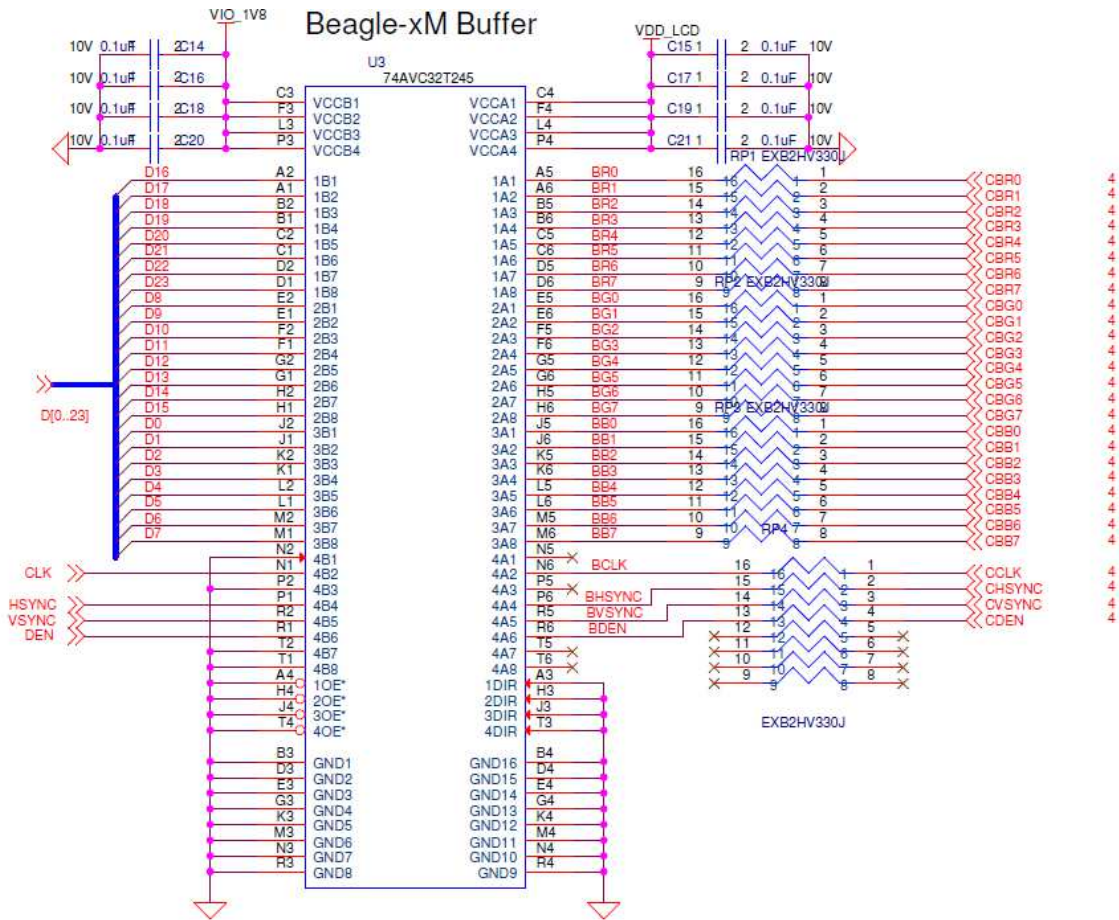


Figure 5. LCD Signals buffered through U3

### 5.2.3 Touchscreen Interface

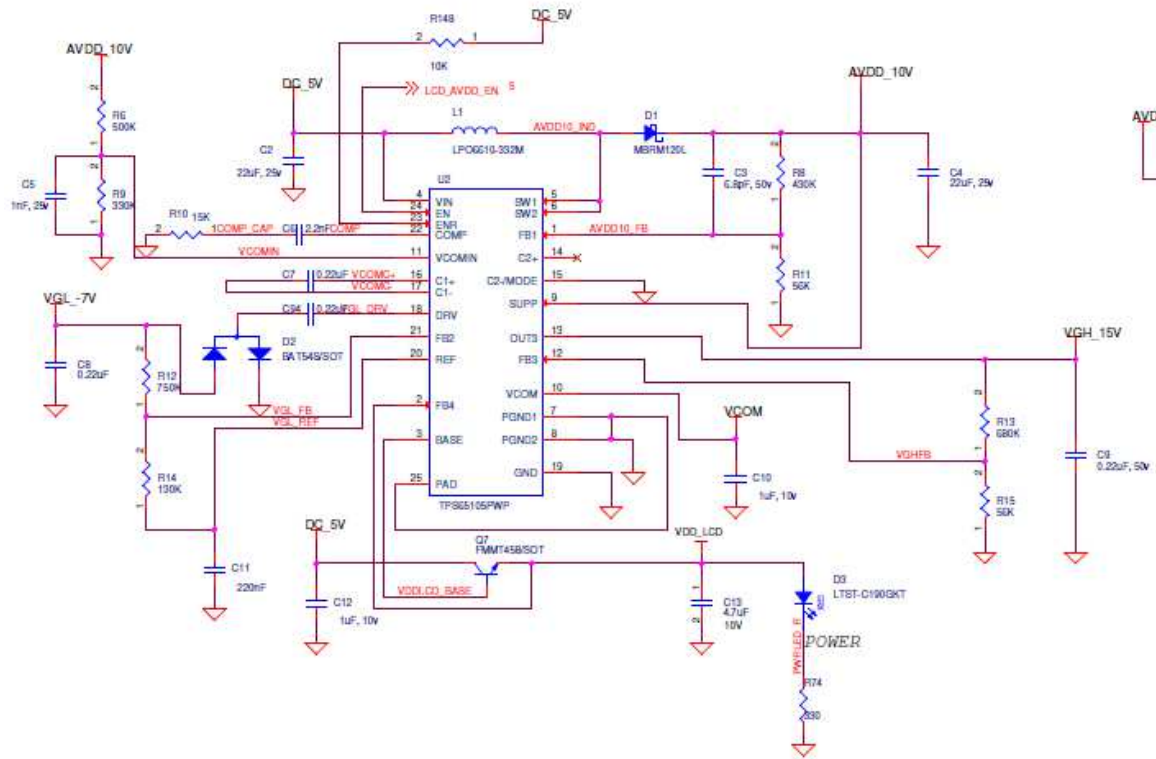
The TFC-S9700RTWV35TR-01 touchscreen is resistive is connected to touchscreen connector P6, which is composed of 4 different X or Y signals. These signals are received by the onboard touchscreen controller TSC2007 (U4). When the screen is touched, interrupt output TS\_nPEN\_IRQ is asserted to detect the touch. TSC2007 is a low-power touchscreen controller that can operate with supply voltage of 1.8V. TSC2007 supports I2C serial bus and data transmission protocol. Touchscreen data can be transmitted over I2C2 bus to the BeagleBoard-xM.

## 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 6** shows TPS65105 in the system.



**Figure 6. BeagleBoard-xM 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 BeagleBoard-xM LCD7, this enable pin is connected to the DC\_5V 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 the LCD\_ENBKL signal passing through a PWM circuit. 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 600 kHz or 1.2 MHz 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 7** shows the backlight circuit of the BeagleBoard-xM LCD7 Cape:

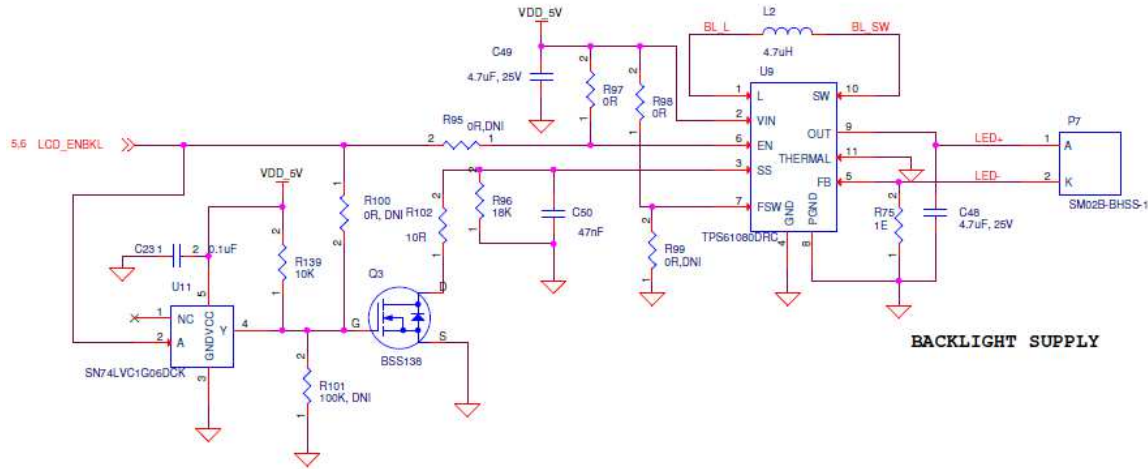
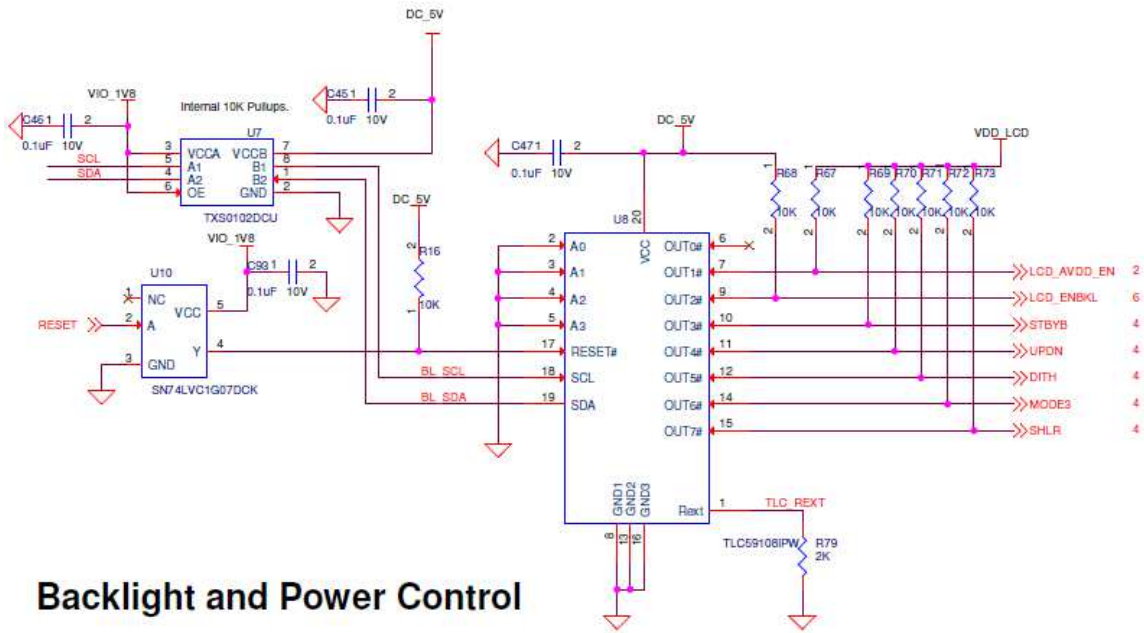


Figure 7. BeagleBoard-xM LCD7 Backlight Circuit

### 5.3.3 LCD Control Signals

The power, backlight, LCD panel interface on the BeagleBoard-xM LCD are controlled by an I<sup>2</sup>C-based 8-bit PWM controller TLC59108. TLC59108 communicates with the processor of BeagleBoard-xM via I<sup>2</sup>C2 bus. Voltage translation is required since TLC59108 is operating with 5V power supply while the I<sup>2</sup>C2 signals are at 1.8V. The TLC59108 is capable of providing 8 different PWM outputs. These outputs are used to provide control over the LCD power management (LCD\_AVDD\_EN), LCD backlight (LCD\_ENBKL), as well as LCD interface (STBYB, UPDN, DITH, MODE3, SHLR). The output current can be set by choosing different values for external resistor  $R_{EXT}$ . **Figure 8** shows the PWM controller in the schematic:



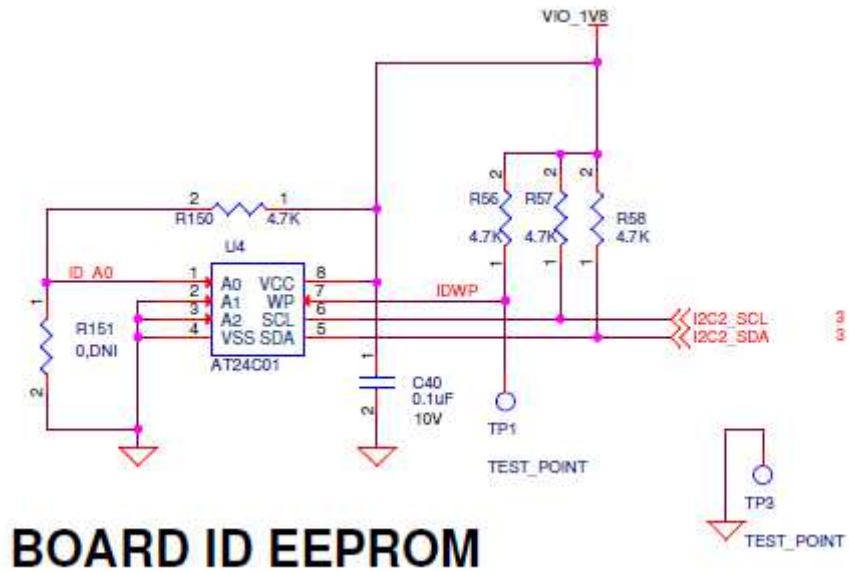
**Backlight and Power Control**

**Figure 8. BeagleBoard-xM LCD7 Backlight Circuit**

**5.4 EEPROM**

The BeagleBoard-xM LCD7 Cape has an EEPROM containing information that will allow the SW to identify the board. EEPROMs are required for all expansion boards in order for them to operate correctly when plugged in the BeagleBoard-xM. The EEPROM used on this board is a 1024-bit electrically erasable and programmable read only memory AT24C01B. AT24C01B is internally organized as 128 words of 8 bits each. **Figure 9** is the design of the EEPROM circuit.



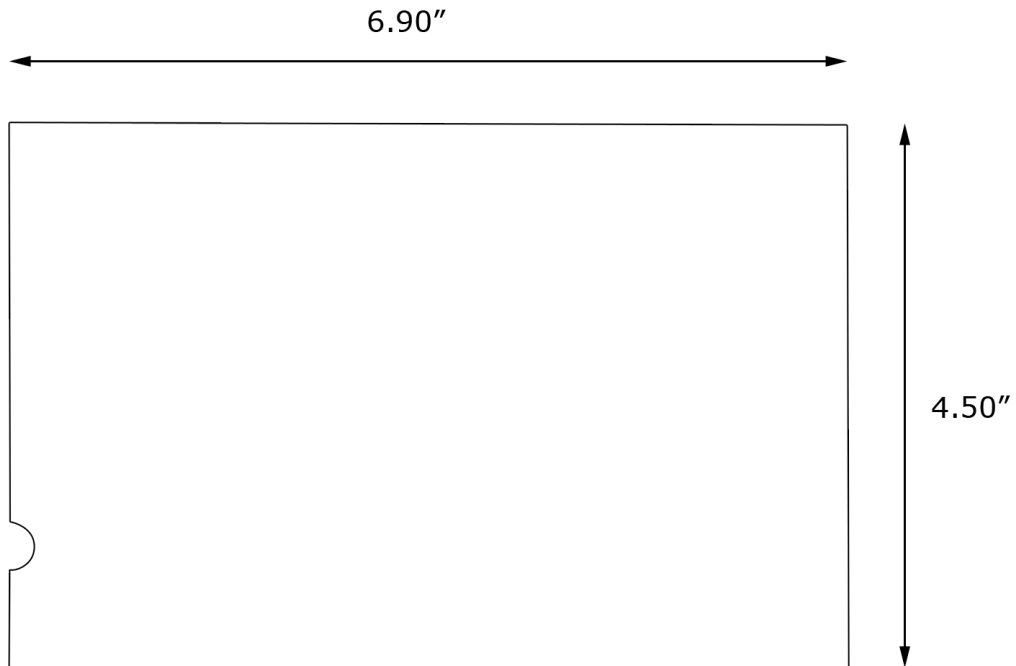


# BOARD ID EEPROM

Figure 9. BeagleBoard-xM LCD7 Cape EEPROM

## 6.0 Mechanical Information

This section provides information on the mechanical aspect of the BeagleBoard-xM LCD7 Cape. **Figure 10** is the dimensions of the BeagleBoard-xM LCD7 Cape.



**Figure 10. BeagleBoard-xM LCD7 Dimensions Drawing**

## 7.0 Design Materials

Design information can be found at BeagleBoardToys wiki:

[http://beagleboardtoys.com/wiki/index.php?title=BeagleBoard-xM\\_LCD7](http://beagleboardtoys.com/wiki/index.php?title=BeagleBoard-xM_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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