



BeagleBone DVI-D Cape Rev A2 System Reference Manual

**Revision A2
June 28th, 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 DVI-D 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 DVI-D 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 REV A1 VS. A2.....	10
2.3 REV A VS. A1	10
2.3.1 PCB Changes.....	10
2.3.2 Design Changes.....	10
2.3.3 Production Changes.....	11
3.0 BEAGLEBONE DVI-D CAPE OVERVIEW	12
3.1 DESCRIPTIONS.....	12
3.2 BOX CONTENT	13
3.3 GETTING STARTED.....	13
3.4 REPAIRS	16
4.0 FEATURES AND SPECIFICATIONS	17
4.1 KEY COMPONENT LOCATIONS	17
4.2 DVI-D INTERFACE.....	18
4.3 HDMI CONNECTOR	18
4.4 MAIN EXPANSION HEADER.....	19
4.5 PMIC EXPANSION HEADER	19
4.6 MECHANICAL SPECIFICATIONS	20
5.0 BEAGLEBONE DVI-D CAPE SYSTEM ARCHITECTURE AND DESIGN	21
5.1 SYSTEM BLOCK DIAGRAM.....	21
5.2 DVI-D INTERFACE.....	22
5.2.1 Main Expansion Headers	22
5.2.2 Bus Transceiver.....	23
5.2.3 Digital Transmitter.....	23
5.3 EEPROM	24
5.3.1 EEPROM Address	25
5.3.2 I2C Bus.....	26
5.4 USER LED'S	26
6.0 MECHANICAL INFORMATION	28
6.1 BEAGLEBONE DVI-D CAPE DIMENSIONS	28
6.2 DVI_PDn JUMPER.....	28
7.0 DESIGN MATERIALS	29



Figures

Figure 1.	The BeagleBone DVI-D Cape	12
Figure 2.	DVI-D Cape and BeagleBone.....	13
Figure 3.	The Angstrom log-in prompt	15
Figure 4.	Major Components.....	17
Figure 5.	HDMI Connector	18
Figure 6.	Stackable Main Expansion Connector	19
Figure 7.	Stackable Battery Expansion Connector.....	19
Figure 8.	BeagleBone DVI-D Cape High Level Block Diagram.....	21
Figure 9.	BeagleBone DVI-D Cape Pin Usage	22
Figure 10.	Bus Transceiver	23
Figure 11.	Digital Transmitter and 2-Bit Voltage Translator.....	24
Figure 12.	BeagleBone DVI-D Cape EEPROM	25
Figure 13.	User LED's	26
Figure 14.	BeagleBone DVI-D Cape Dimensions Drawing	28

Tables

Table 1.	Change History	10
Table 2.	BeagleBone DVI-D Cape Features	17
Table 3.	User LED Control.....	27

1.0 Introduction

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

This document provides detailed information on the overall design and usage of the BeagleBone DVI-D Cape from the system level perspective. It is not intended to provide detailed documentation of any other component used on the board. It is expected that the user will refer to the appropriate documents for these devices to access detailed information. It will provide information on how to interact with these components from an interface perspective. The perspective will be general in nature and not specific to any one board.

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 DVI-D Cape.

[Section 4.0 – Features and Specification](#)

Provided here are the features and specifications of the board.

[Section 5.0 – System Architecture and Design](#)

This section provides information on the overall architecture and design of the BeagleBone DVI-D 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 DVI-D 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
0.1	Initial release.	12/14/2011	BBT
0.2	1. Updated photos 2. DVI_PDn jumper	2/2/2012	BBT
A1	1. Add Rev A vs. A1 section (2.2) 2. Add Getting Started section (5.2)	3/30/2012	BBT
A2	1. Add Rev A1 vs. A2 section (2.2) 2. Modified block diagram due to pin change of signal DVI_PDn	6/27/2012	BBT

2.2 Rev A1 vs. A2

The DVI_PDn signal in revision A2 is moved from pin 42 of connector P2 to pin 20 of connector P1. In revision A1, DVI_PDn signal is mapped to GPIO0_7 which is also a DMA interrupt. By moving DVI_PDn signal, this DMA interrupt is now available for other Capes when BeagleBone is used with DVI-D Cape.

In addition, 4 zero ohm resistors are added to the audio circuitry; however, this addition does not have any effect since the audio circuitry is not populated on DVI-D Cape. Both revisions should not have any functional difference.

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

2.3 Rev A vs. A1

2.3.1 PCB Changes

- 1) Remove trace from P1.4 to R90
- 2) Add DVI-PDn trace from P2.42 to R91

2.3.2 Design Changes

- 1) Add 10k pull-up resistor R123 to pin WP of U8
- 2) Add Testpoint 2

2.3.3 Production Changes

- 1) Red jumper from pin 42 of P2 to R91 is no longer required

BeagleBone DVI-D Rev A and A1 should functional identically. Pull-up resistor and testpoint are added solely for production purposes.



3.0 BeagleBone DVI-D Cape Overview

3.1 Descriptions

The BeagleBone DVI-D Cape is designed to provide DVI-D interface for BeagleBone boards. This board features a standard HDMI connector, which can be connected to a DVI-D monitor using a HDMI-to-DVI-D cable. The video output of the BeagleBone DVI-D Cape is limited to 16-bit so more pins at the expansion headers of BeagleBone can be available for other Capes. The output resolution is hardcoded to 1024x768.

Note: The BeagleBone DVI-D Capes are not shipped with audio circuitry. This circuitry is marked as “DNI” on the schematic and the corresponding parts are not populated on the board. The BeagleBone DVI-D Cape only provides DVI-D interface to the BeagleBone.

Figure 1 below is a picture of the board.



Figure 1. The BeagleBone DVI-D Cape

3.2 Box Content

The final packaged BeagleBone DVI-D Cape Rev A2 product will contain the following items:

- 1 BeagleBone DVI-D Cape in an ESD bag

3.3 Getting Started

The BeagleBone DVI-D Cape should work right out of the box with latest Angstrom image for BeagleBone. Following the instructions below to verify the board is working:

- 1) Mount the BeagleBone DVI-D on top of BeagleBone.

*Note: The Ethernet connector on BeagleBone should fit right into the cutback on BeagleBone DVI-D. **Figure 2** shows the proper way to stack the BeagleBone DVI-D Cape*



Figure 2. DVI-D Cape and BeagleBone

- 2) Make sure the micro SD card using with BeagleBone has latest Angstrom image.
- 3) Connect the BeagleBone DVI-D Cape to a DVI-D supported monitor using a HDMI-to-DVI-D cable.
Note: The HDMI end should be plugged into the HDMI connector on the BeagleBone DVI-D Cape.
- 4) Power up the BeagleBone by using a 5V DC power supply.
- 5) Make sure the monitor is powered on. You should see a beaglebone logo, Angstrom log-in prompt, and eventually Angstrom desktop. **Figure 3** shows the Angstrom log-in prompt is successfully displayed on a DVI-D supported monitor.



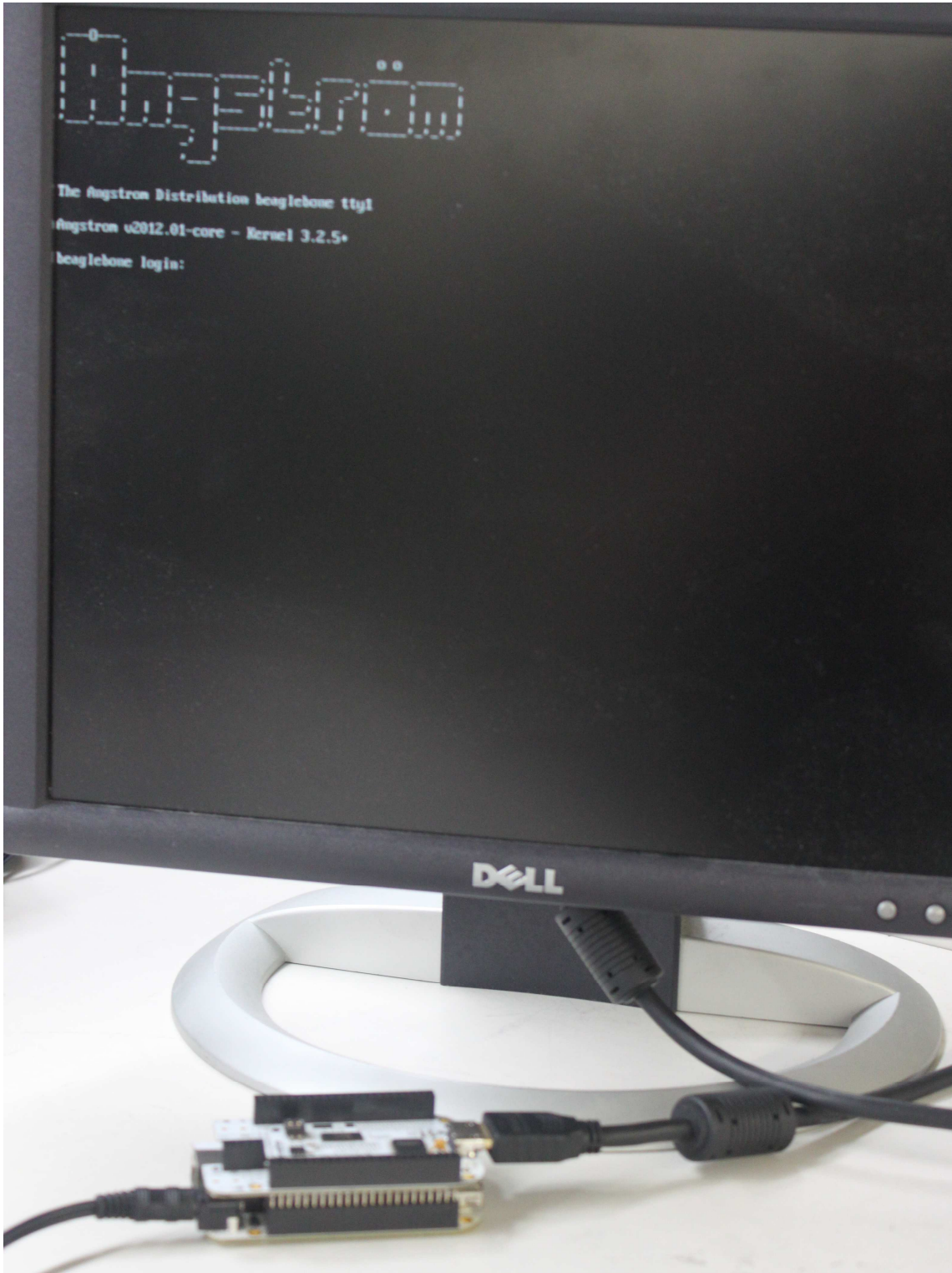


Figure 3. The Angstrom log-in prompt



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 a 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 DVI-D 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 DVI-D Cape's features.

Table 2. BeagleBone DVI-D Cape Features

	Feature	
Interface	DVI-D	
Connector Type	HDMI	
Color Depth	RGB 16-bit	
Power Supply	3.3V (via expansion)	
	5V (via expansion)	
PCB	2.15" x 3.40" (54.6mm x 86.4mm)	6 layers
Indicators	Two user LEDs	
EEPROM	Board ID EEPROM	
Expansion Connector	46-pin main expansion headers	
	10-pin battery expansion header	

4.1 Key Component Locations

Figure 4 shows the location of the key components on the board.

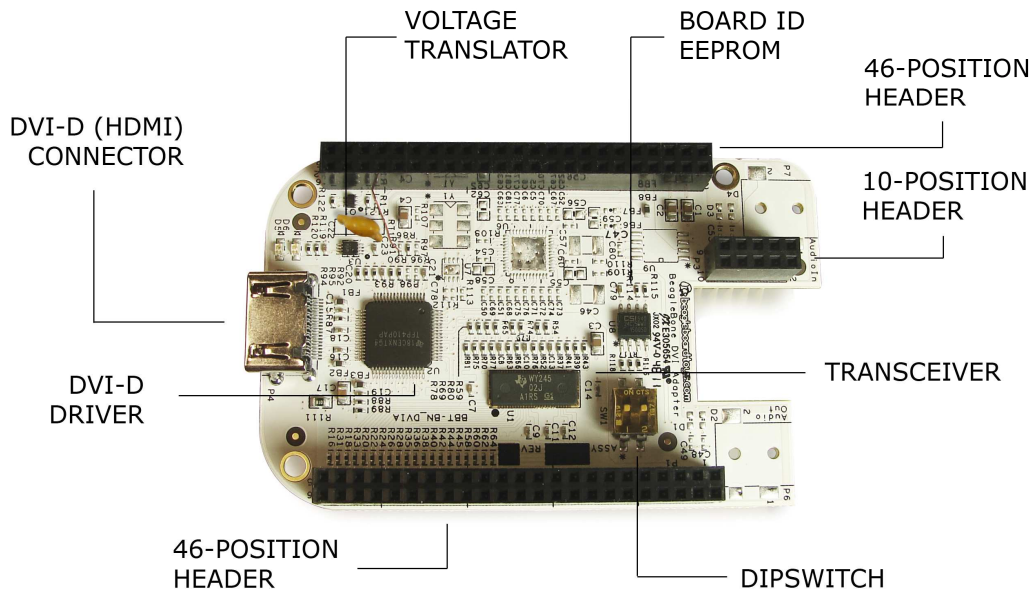


Figure 4. Major Components

4.2 DVI-D Interface

The BeagleBone DVI-D Cape can drive an LCD panel equipped with a DVI-D digital input. This is the standard LCD panel interface of the processor and will support 16-bit color output. DDC2B (Display Data Channel) or EDID (Enhanced Display ID) support over I2C is provided in order to allow for the identification of the LCD monitor type and the required settings.

4.3 HDMI Connector

The BeagleBone DVI-D Cape uses an HDMI connector that was selected for smaller size. **It does not support the full HDMI interface and is used to provide the DVI-D interface portion only.** Users must use an HDMI to DVI-D cable or adapter to connect to an LCD monitor. This cable or adapter is not provided with the BeagleBone DVI-D Cape. A standard HDMI cable can be used when connecting to a monitor with an HDMI connector. **Figure 5** is a picture of the HDMI connector.

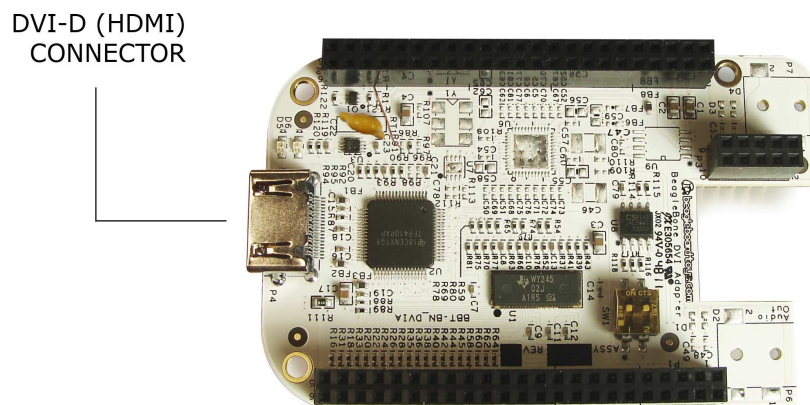


Figure 5. HDMI Connector

4.4 Main Expansion Header

The BeagleBone DVI-D Cape uses two dual row 46 position connectors. These connectors are from MLE and stackable. The part number of these connectors is SSHQ-123-D-08-F-LF. **Figure 6** is a picture of the connector.

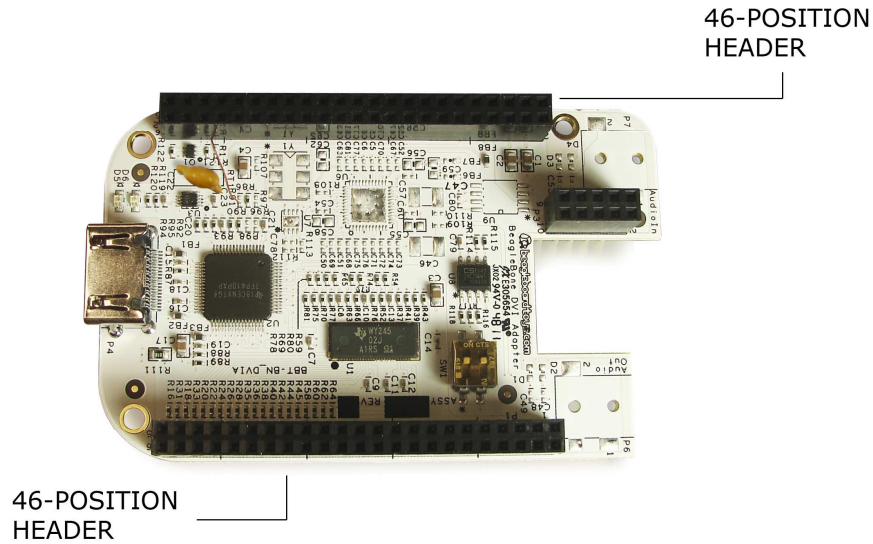


Figure 6. Stackable Main Expansion Connector

4.5 PMIC Expansion Header

This connector is a single two 10-pin expansion header. This is a dual row 10 position 2.54mm x 2.54mm connector and is the same as the main connector except with less position. **Figure 7** is a picture of the connector.

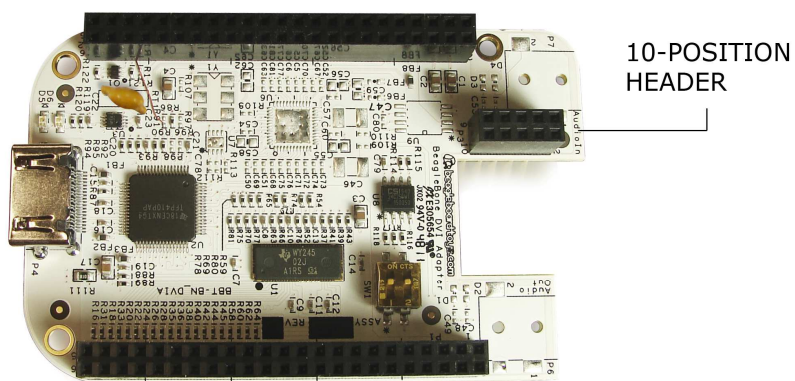


Figure 7. Stackable Battery Expansion Connector

4.6 Mechanical Specifications

Size:	2.15" x 3.40"
Layers:	4
PCB thickness:	.062"
RoHS Compliant:	Yes
Weight:	TBW



5.0 BeagleBone DVI-D Cape System Architecture and Design

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

5.1 System Block Diagram

Figure 8 is the high level block diagram of the BeagleBone DVI-D Cape.

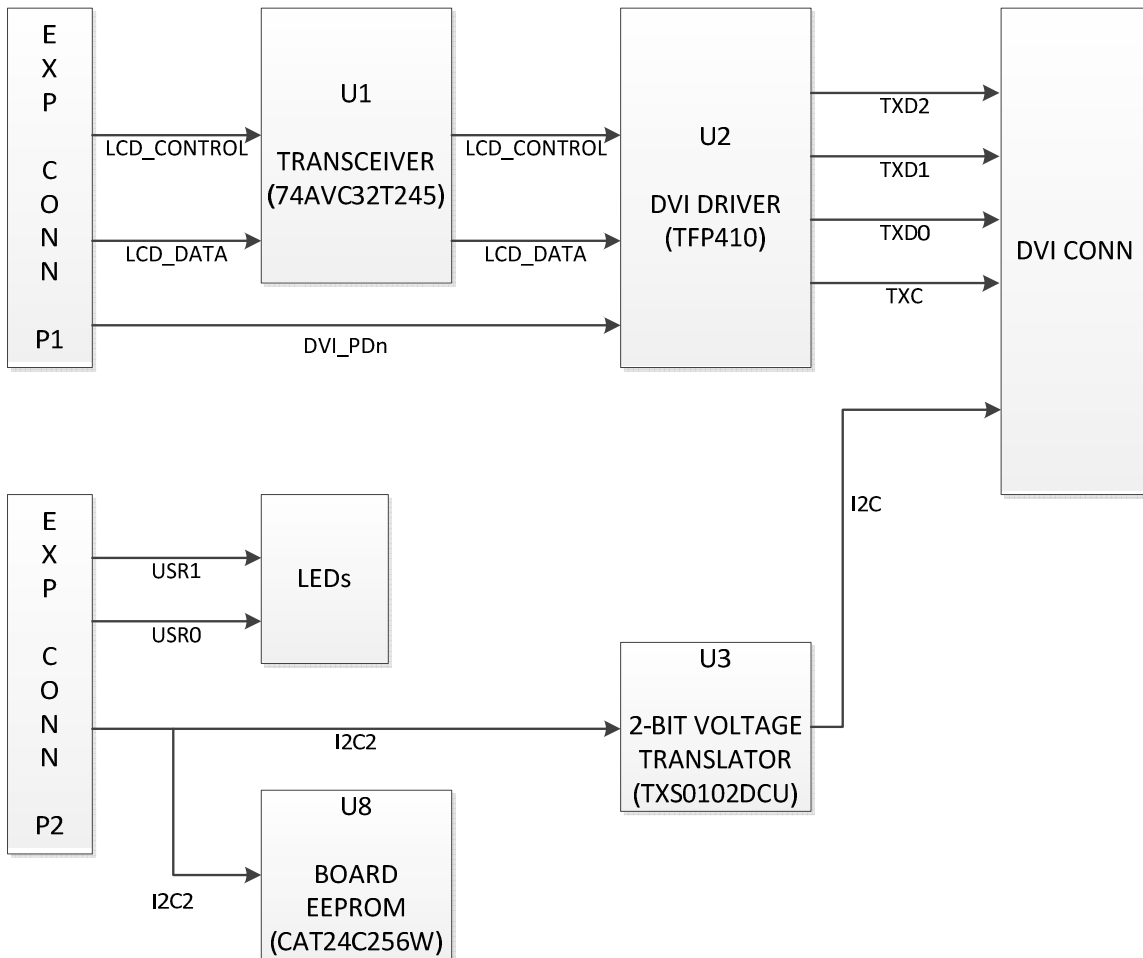


Figure 8. BeagleBone DVI-D Cape High Level Block Diagram

5.2 DVI-D Interface

5.2.1 Main Expansion Headers

The BeagleBone DVI-D Cape reserves 21 pins from the expansion headers including 16 LCD data signals, 4 LCD control signals, and a DVI power down signal. The DVI-D Cape reduces the number of LCD data signals from 24 to 16. The output quality of 16-bit color is very similar to a 24-bit; however, more signals on the expansion header can be available for other capes.

This cape uses the power rail SYS_5V to power the User LED's, EDID I2C signals to the DVI-D (HDMI) connector and the connector itself. The remaining components are powered by power rail VDD_3V3. In addition to the monitor EDID, the Board ID EEPROM on the DVI-D cape can also be accessed via I2C2 signals.

Figure 9 displays the DVI-D signals at connector P1

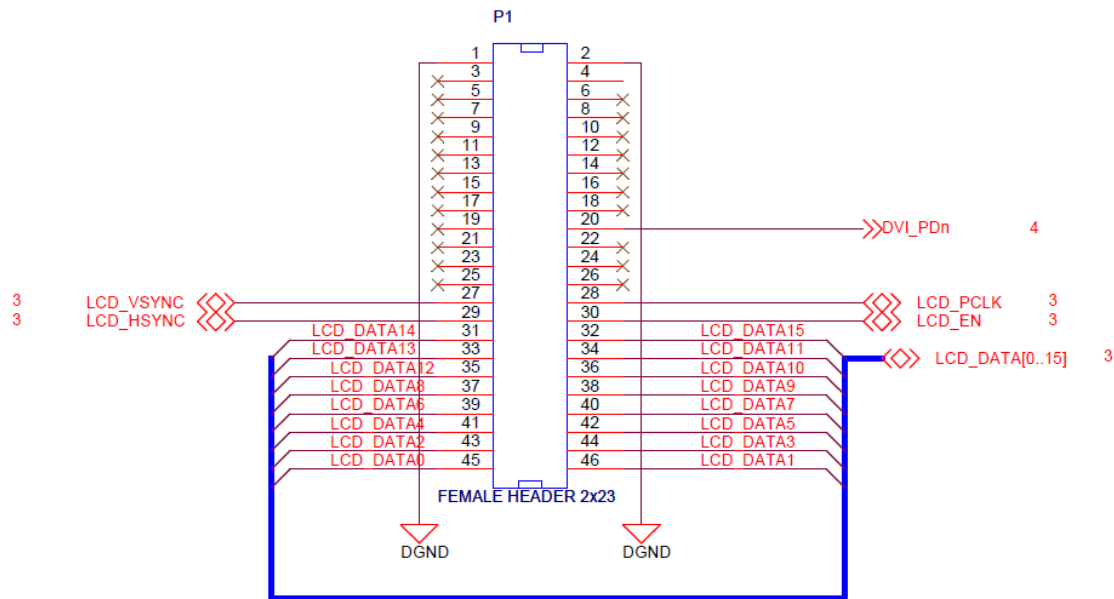


Figure 9. BeagleBone DVI-D Cape Pin Usage

5.2.2 Bus Transceiver

LCD data and control signals are buffered through 74AVC32T245 which is a 32-bit dual supply bus transceiver. The 74AVC32T245 also features configurable voltage translation and can operate within voltage range of 1.4V-3.6V. Direction-control (DIR) and output-enable (OE) inputs determine which direction the device transmits data. LCD signals from the main expansion headers are at 3.3V level and the buffered output from the 74AVC32T245 are also at 3.3V; thus, no voltage stepping up or down is needed. **Figure 10** shows the LCD signals buffered through 74AVC32T245.

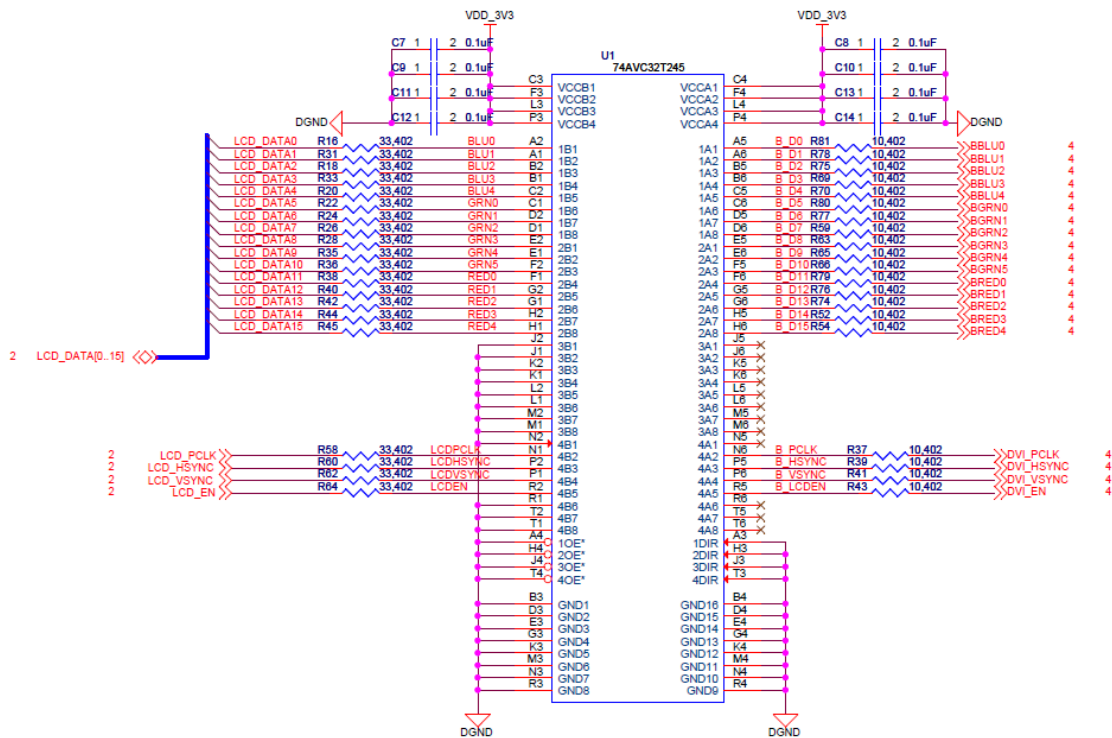


Figure 10. Bus Transceiver

5.2.3 Digital Transmitter

TFP410 is a digital transmitter which transmits LCD signals to the HDMI port. The DVI power down signal is connected to the active-low power down pin (PD) of the transmitter. The TFP410 transmits three pairs of differential signal outputs and one pair of differential output clock to the HDMI connector. The EDID I2C signals that goes to the HDMI connector is at 5V; thus, a 2-bit bi-directional voltage translator TXS0102DCU is required to step up the EDID I2C signals from main expansion header P2 to 5V. **Figure 11** shows the TFP410 and TXS0102DCU in the schematic.

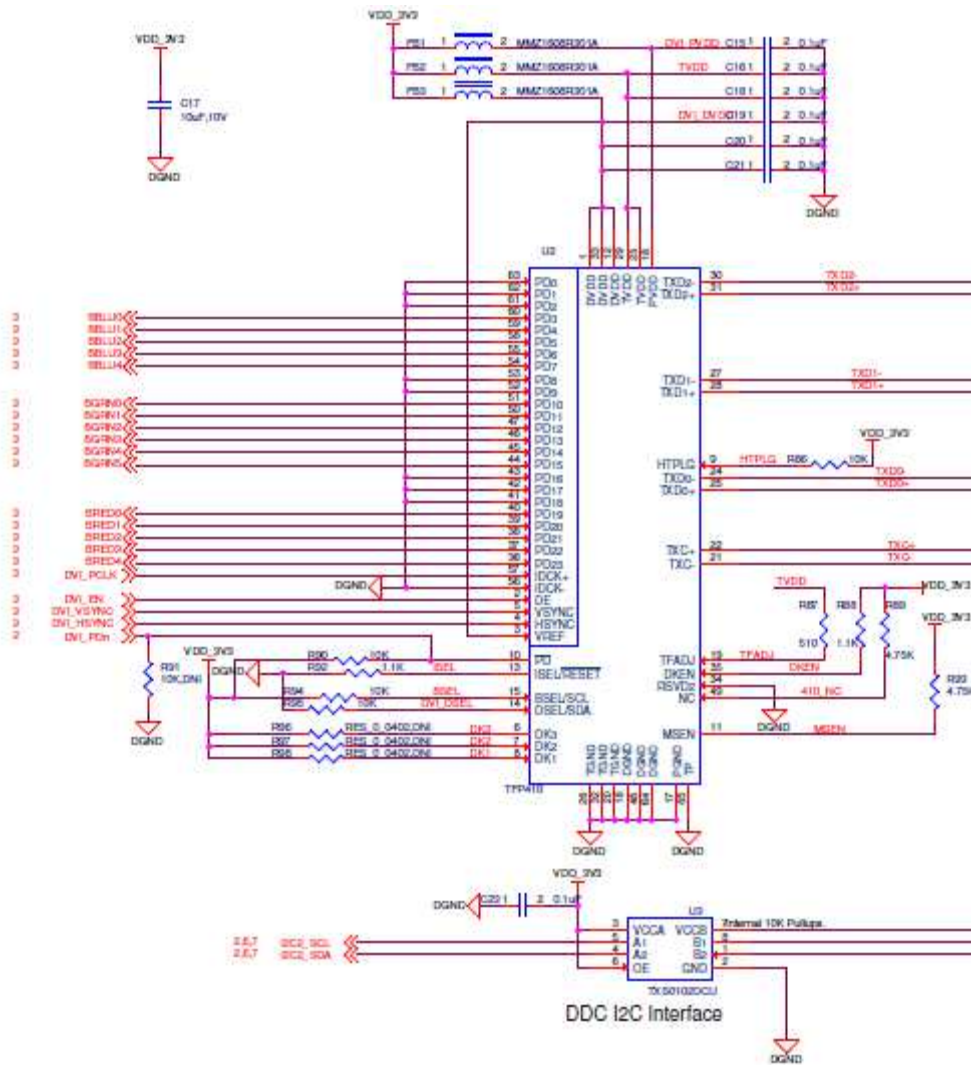


Figure 11. Digital Transmitter and 2-Bit Voltage Translator

5.3 EEPROM

The BeagleBone DVI-D 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 14** is the design of the EEPROM circuit.

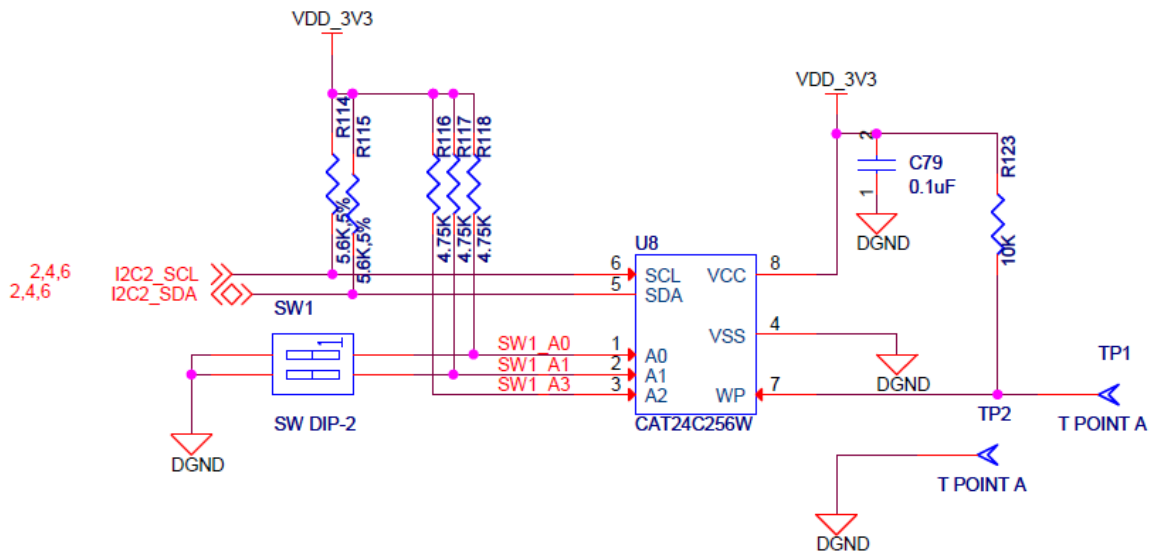


Figure 12. BeagleBone DVI-D Cape EEPROM

5.3.1 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.

5.3.2 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.

5.4 User LED's

The BeagleBone DVI-D Cape features two user LED's which are same as D2 and D3 on the BeagleBone boards. These two LED's can be access via GPIO pins on the processor. **Figure 13** shows the LED circuitry.

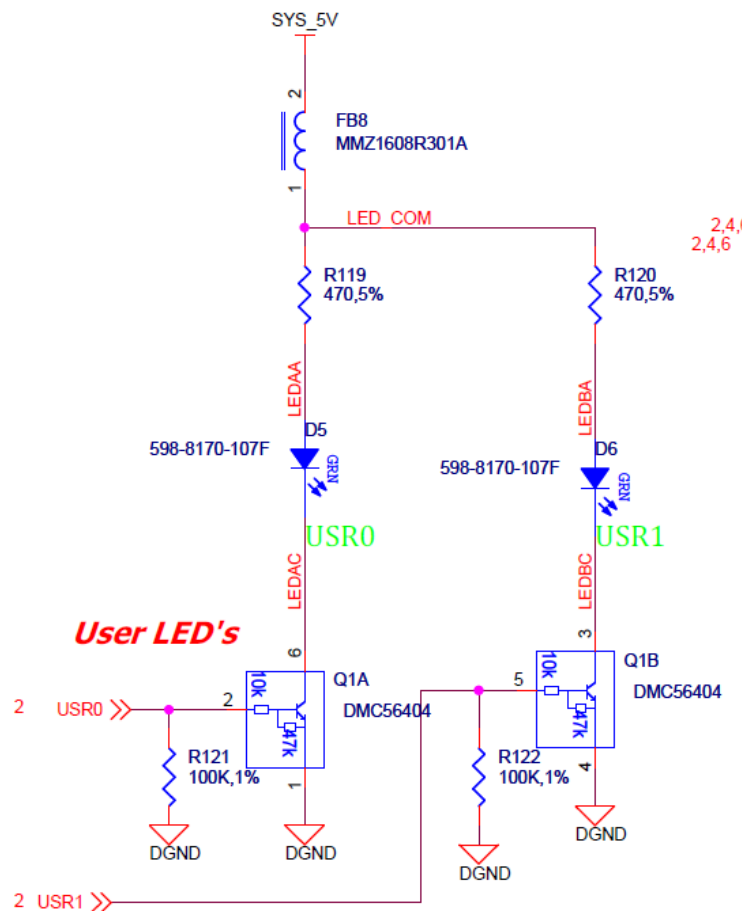


Figure 13. User LED's

Q1 provides level shifting from the processor to drive the LED's that are connected to SYS_5V rail. FB8 provides noise immunity to the system by the LED's which can be a source of noise back into the system rail. Each LED is controlled by settings the appropriate GPIO bit HI. At power up all LED's are off. **Table 3** is the GPIO User LED assignments.

Table 3. User LED Control

LED	GPIO
User 0	GPIO1_21
User 1	GPIO1_22



6.0 Mechanical Information

6.1 BeagleBone DVI-D Cape Dimensions

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

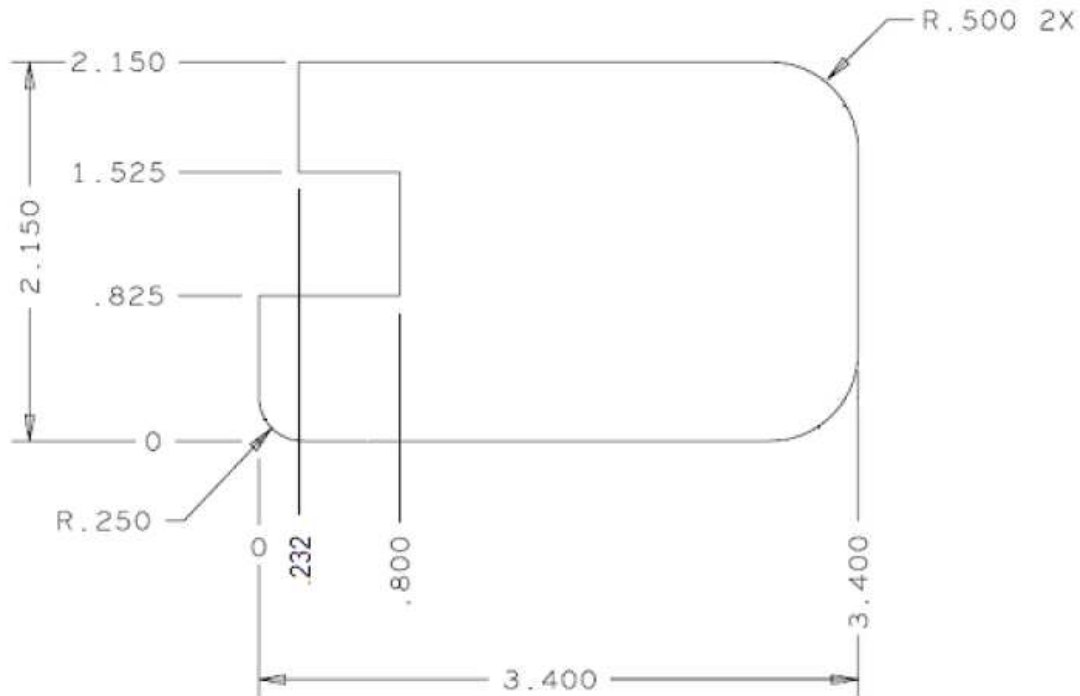


Figure 14. BeagleBone DVI-D Cape Dimensions Drawing

6.2 DVI_PDn Jumper

On BeagleBone DVI-D Cape Rev A there is a jumper connecting from pin 42 of connector P2 to R91 (which is DNI). This is the DVI_PDn signal that goes from the main connector to the DVI-D driver unit on the board. The PCBs of these boards are labeled “PCB Rev A” in the back. Future releases (A1 and later) of BeagleBone DVI-D Cape had their PCB modified so no more jumpers are required.

7.0 Design Materials

Design information can be found at BeagleBoardToys wiki:

http://beagleboardtoys.com/wiki/index.php?title=BeagleBone_DVI-D

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.