TI DLP® LightCrafter™ Display 2000 EVM User's Guide

The DLP LightCrafter Display 2000 EVM is a low-cost platform enabling the use of DLP technology with embedded host processors (such as the BeagleBone Black). This small, compact design enables quick implementation and demonstration in ultra-mobile applications.

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1 DLP LightCrafter Display 2000 EVM Overview

This user's guide presents an overview of the DLP LightCrafter Display 2000 Evaluation Module (EVM) and a general description of the main features and functions. It will explain the first steps to get started, as well as provide a detailed description of the system functions, the on board LEDs, and the main connectors. The available configurations with which the system can be evaluated will also be presented. This will help give the user a successful start with their DLP LightCrafter Display 2000 evaluation module.

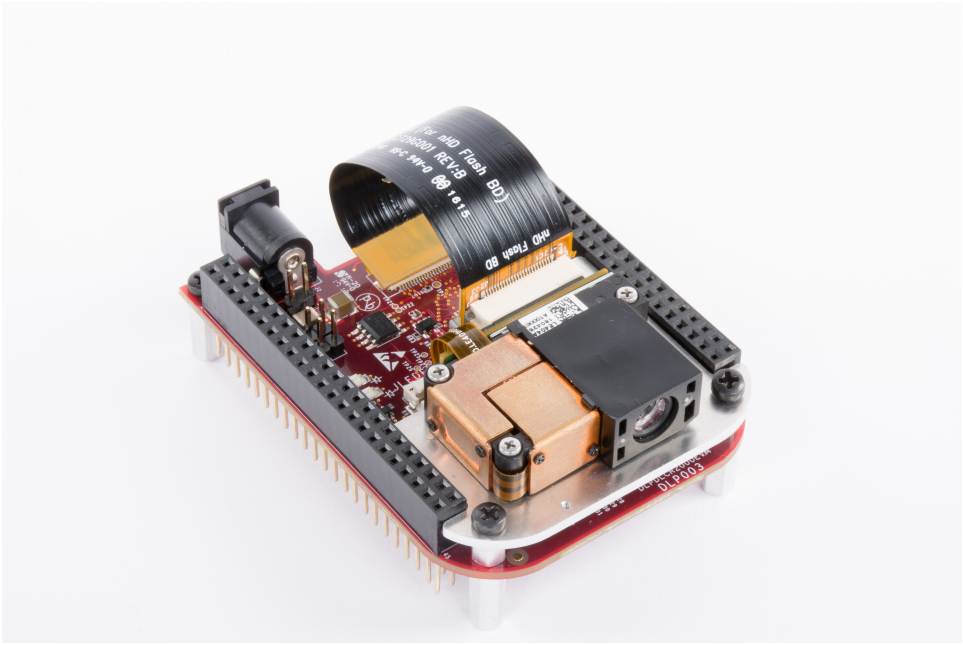


Figure 1. DLP LightCrafter Display 2000 EVM

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2 Quick-Start Guide

This quick-start assumes default conditions as shipped.

1. Confirm that the optical engine is properly connected to the DLP LightCrafter Display 2000 EVM.
   - Align "pin 1" of the optical engine connector with "pin 1" of the digital micromirror device (DMD) data flex cable (female side). Similarly, align "pin 1" of the DMD data flex cable (male side) to the DLP LightCrafter Display 2000 EVM (at connector J1). The following images are provided to assist in proper assembly of the EVM with the optical engine.

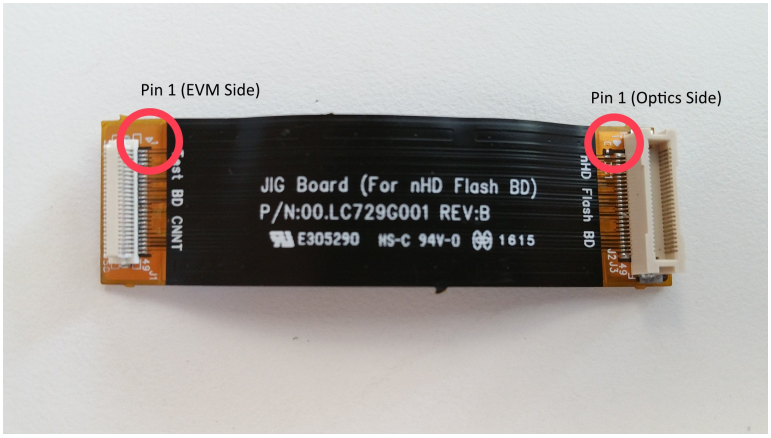


Figure 2. 0.2 nHD Optical Engine Flex Cable Connector Overview

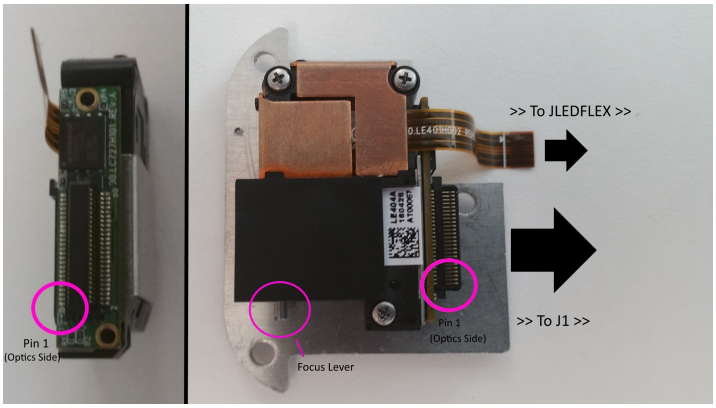


Figure 3. 0.2 nHD Optical Engine Connection Overview

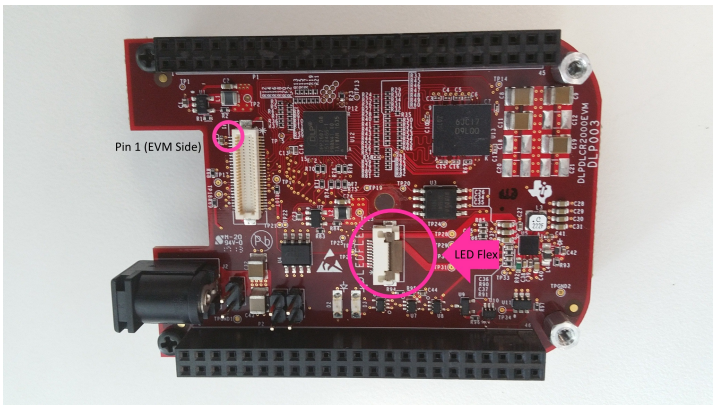


Figure 4. EVM Connector Overview

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2. Power up the DLP LightCrafter Display 2000 EVM by applying an external DC ITE power supply (5-V DC, 3.0 A) to the J2 connector.
   - Use an AC-DC switching power supply which accepts 50-60 Hz 100-240 V AC inputs, and outputs a nominal 5-V DC at maximum 3-A output current. For this purpose we recommend the TE20A0503F01 Desktop Wall Adapter (or equivalent). The DC power supply jack has a 2.5 mm inner diameter and 5.5 mm outer diameter.
   - If the host processor used supports it, the system can be made to receive power through the attached host. Power and ground will need to be supplied via header J3 on the board. Please refer to the user's guide for your respective host processor to determine if enough current can be supplied to drive the DLP LightCrafter Display 2000 EVM. A minimum of 320 mA is recommended for the EVM to run at typical brightness settings.
3. After the DLP LightCrafter Display 2000 EVM is turned on, the projector will display a DLP LightCrafter Display splash screen. See Figure 5 for an example:



Figure 5. EVM Splash Screen

4. The focus of the image can be adjusted with the focus switch on the optical engine.

From this point, the system will need to be supplied with a video source (via a host processor such as the BeagleBone Black) and given instructions via the included I^2C bus. Methods for doing this are provided in the following sections.

2.1 Use With Host Processor

In the case where the system will be controlled via a host processor, the selected host must possess the necessary GPIO pinouts to drive the inputs to the EVM. This can be accomplished using a customized video and I^2C output driver. In the case of the BeagleBone Black, a software driver for use with the DLP LightCrafter Display 2000 EVM has been provided such that the pinouts of the BeagleBone Black match the footprint of the EVM I/O ports. This driver also works with the BeagleBone Green. This guide will assume the user is interfacing with a BeagleBone Black as an example.

To begin, an appropriate operating system image must be installed onto the board. The latest Debian image designed for the BeagleBone should be installed to access the most up-to-date EVM drivers designed for the BeagleBone Black. For help with this step, consult the getting started page located at http://beagleboard.org/getting-started. TI recommends using Debian Jessie (version 8.9) to ensure there are no compatibility issues with the EVM.

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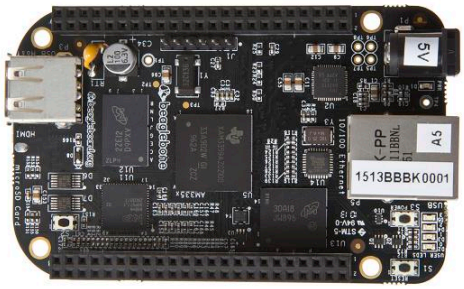


Figure 6. BeagleBone Black Host Processor

After installing the BeagleBone-compatible Debian image, an interface between the host processor and the user must be established. There are two ways of going about this:

- Onboard mini-HDMI video output with USB keyboard and mouse connection
- Remote connection via SSH terminal application (such as PuTTY for Windows users)

Using a remote SSH connection is recommended for its flexibility and ease of use. Before continuing, download PuTTY (or refer to your preferred SSH terminal application) from the creator's website located at http://www.putty.org/. Included on the website are documentation links to provide more detailed information on how to use PuTTY. (1)

Once the system is set up properly, the BeagleBone Black will communicate with the EEPROM on the DLP LightCrafter Display 2000 EVM on boot-up. This will tell the BeagleBone Black to load the appropriate daughter card (or cape) overlay to configure the GPIO ports on the host processor. Once the cape overlay is loaded, the host processor can interface with the EVM through:

- Parallel I/F video data (via RGB888)
- Issuing I^2C commands (via I^2C commands)
- Enabling/disabling the EVM (via PROJ_ON_EXT)

Support for use of these features with the DLP LightCrafter Display 2000 EVM is included in the BeagleBone Black support scripts, which can be found in the "opt/scripts" directory and executed from the terminal command line. More information on this can be found in the "Example Application" section (Section 4). To access the BeagleBone Black terminal, please follow the networking access guide at http://elinux.org/Beagleboard:Terminal_Shells.

I^2C commands can be issued by using the aforementioned shell scripts but can also be issued manually using the I^2C terminal commands "i2cdetect", "i2cget", "i2cset". These commands use the onboard I^2C bus to communicate with peripheral devices attached to the host processor. Use of these commands is documented at http://elinux.org/Interfacing_with_I2C_Devices. For further information, the "man" command in Linux can also be used to access internal manuals for "i2cdetect", "i2cget", and "i2cset". Please refer to Figure 7 and Figure 8 for example usages of these commands within a Linux ssh terminal interfacing with the BeagleBone Black. Typically, the DLPC2607 is located at address 0x1b and the EEPROM is located at address 0x54, 0x55, 0x56, or 0x57 depending on the configuration of jumpers J4 (Bit 1 of address) and J5 (Bit 0 of address) on the EVM. By default, the EEPROM device address is 0x54.

(1) PuTTY is third party content ("Third Party Content"). Third Party Content is not under TI's control and TI is not responsible for such content, or any changes or updates to such content. TI provides links and access to Third Party Content to you only as a convenience and TI does not endorse such content. Use of third party websites, features, and tools is governed by the applicable terms of use and privacy practices of such websites and services. You agree to review and accept applicable terms in respect of Third Party Content.

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```
debian@beaglebone:~$ i2cdetect -r -y 2
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:          -- -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- 1b -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- UU UU UU UU -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
debian@beaglebone:~$
```

Figure 7. "i2cdetect" Example Use (In Bash)

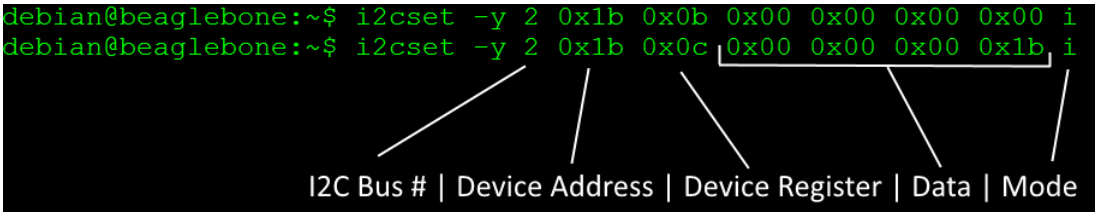


Figure 8. "i2cset" Example Use (In Bash)

2.2 Use Without Host Processor

If the system is to be controlled without the use of a host processor, an external I^2C driver will be necessary to issue commands to control the system. In this case, a USB-I^2C compatible dongle may be employed to enable communication between the PC and the DLP LightCrafter Display 2000 EVM. When choosing to use this method to interact with the system, please refer to the documentation of your specific dongle for help in setting up your system. Once it is connected and set up, follow the DLPC2607 Software Programmer's Guide (DLPU013) for help in issuing commands to the system.

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3 What is in the DLP LightCrafter Display 2000 EVM?

The DLP LightCrafter Display 2000 EVM consists of two subsystems:

- **Light engine**: Includes the optics, red, green, and blue LEDs, and the 640 × 360 (nHD) DLP2000 DMD. Features a factory-default LED current drive of 320 mA (approximately 20 lumens) out of the box.
- **Driver board**: Includes the DLP chipset comprising of DLPC2607 display controller and DLPA1000 PMIC/LED driver. Four standoffs are provided separately to fasten this board to a BeagleBone Black.

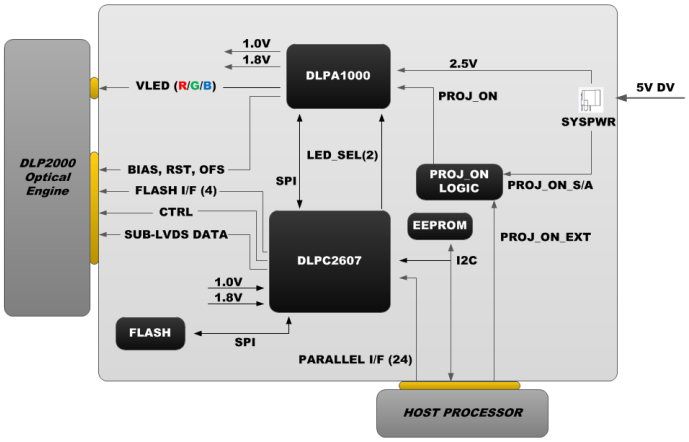


Figure 9. DLP LightCrafter Display 2000 EVM Block Diagram

The light engine is held atop the driver board on a mechanical plate. The standoffs that fasten the mechanical plate to the system can be disassembled with room to attach a host processor. The system can be operated with a host processor or on its own using any I^2C driver attached to the header ports P1 and P2.

Status LEDs D2 and D3 indicate the status of HOST_IRQ and PROJ_ON respectively. HOST_IRQ will go low when the system has completed boot sequence, while PROJ_ON indicates the operational state of the EVM projector. For more information consult the DLPC2607 Data Sheet (DLPS030).

The system possesses an onboard rewritable flash memory unit which can be loaded with new firmware, as well as an onboard EEPROM. The EEPROM can be utilized with a host processor as a boot ID chip. This allows the host processor to treat the DLP LightCrafter Display 2000 EVM as a cape and automatically load appropriate device drivers on boot. The addressing configuration of this EEPROM can be managed using provided jumpers J4 (Bit 1 of address) and J5 (Bit 0 of address) located on the EVM.

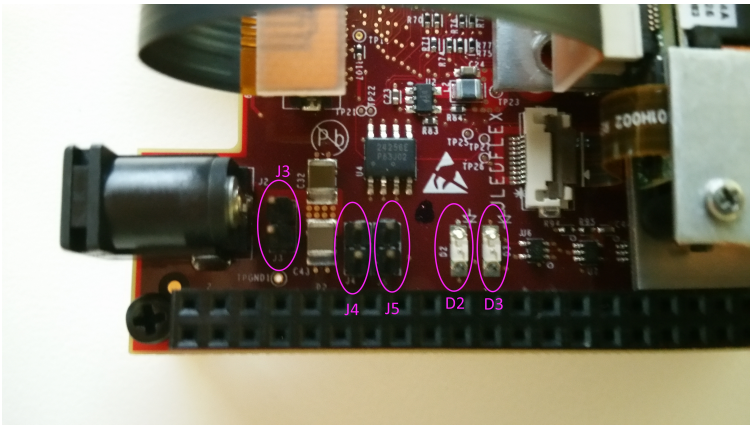


Figure 10. EVM Headers and LEDs

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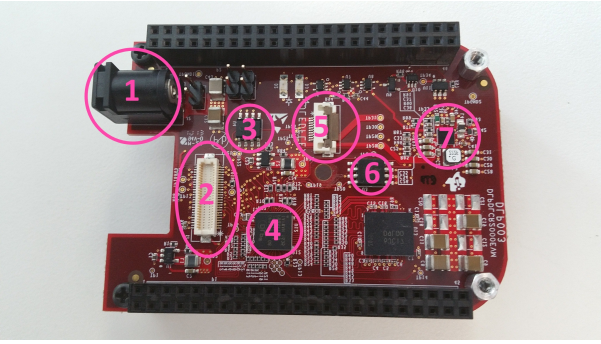


Figure 11. DLP LightCrafter Display 2000 EVM Component Diagram

Table 1. DLP LightCrafter Display 2000 EVM Component Chart

ITEM NUMBER	COMPONENT
1	5 V, 3 A DC Power Jack Connector
2	DMD Data Connector
3	Device ID EEPROM
4	DLPC2607 Controller
5	DMD LED Connector
6	DLPC2607 Flash Memory
7	DLPA1000 PMIC/LED Driver

3.1 Optical Light Engine Overview

The optical engine in the EVM is developed and manufactured by Young Optics Incorporated.

The light engine consists of the following components:

- 0.2-inch nHD DMD (DLP2000)
- OSRAM red, green, and blue LED – LE BA Q6WM and LCG H9RM
- DMD flex cable to interface between light engine and DLPC2607
- LED flex cable to interface between LEDs and DLPA1000

Table 2. Optical Engine Specifications

PARAMETER	MIN	TYP	MAX	UNIT
Brightness		20	30 (1)	lm
LED Current	100	320	500	mA
Brightness Uniformity	75%			
Throw Ratio		1.6		
Offset		100%		
Focus Range	10		60	inch
Image Diagonal Size	10		60	inch

(1) The DLPDLCR2000EVM optical engine can be driven to 30 lumens at maximum current settings, but will also run at high temperatures. It is recommended that the user add a heatsink to the system when running beyond typical operating conditions to maintain the same unit temperature.

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The dimensions of the optical engine are shown in Figure 12:

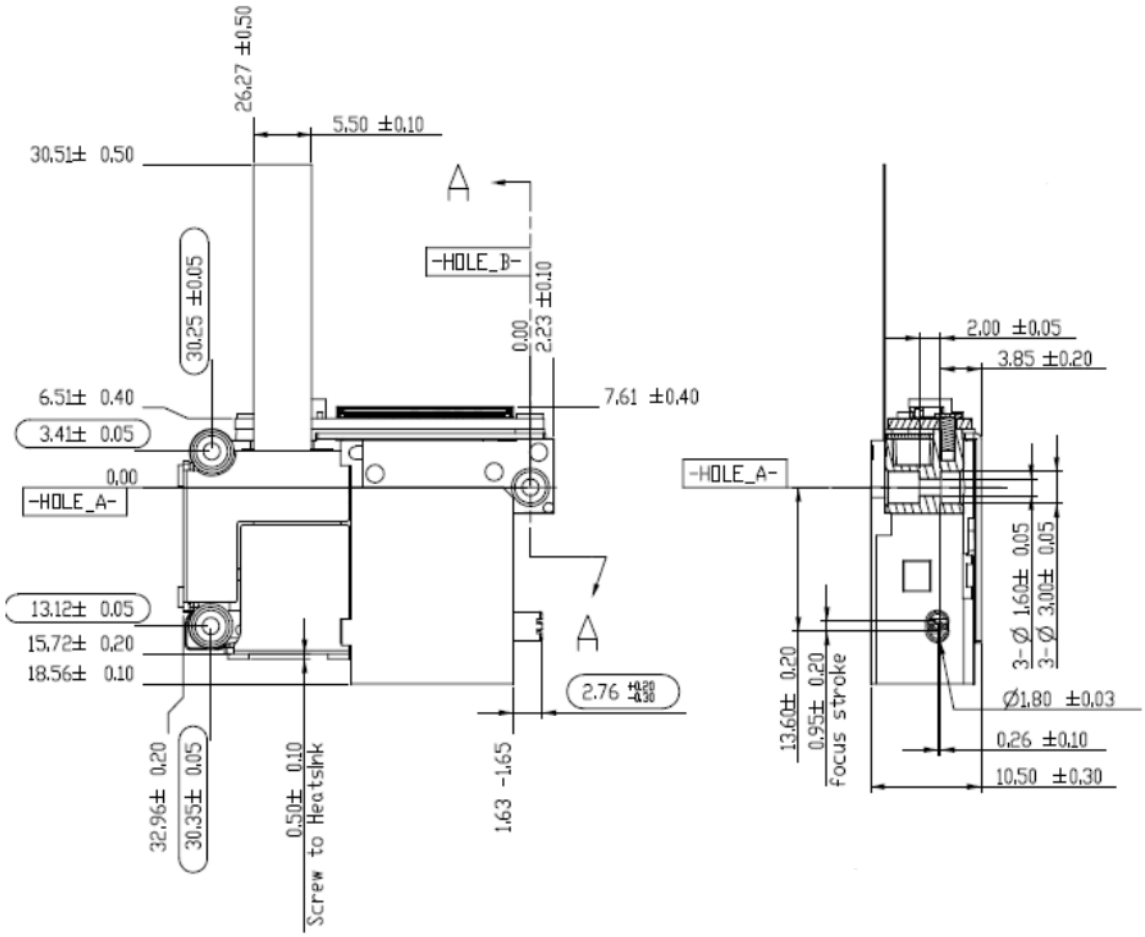


Figure 12. Dimensions of Optical Engine

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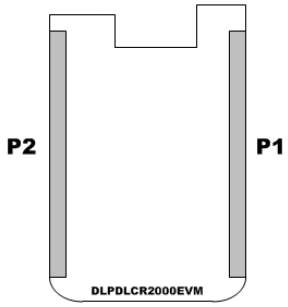
3.2 External Interface Overview

This EVM communicates with the outside world using a pair of GPIO connectors designated P1 and P2. These connectors can be interfaced with the following sources:

- Parallel video driver (using adapter board)
- Host processor (via direct GPIO)

Some examples of host processors that can be used with this device include the BeagleBone Black and Raspberry Pi. A breakdown of the pinouts on these two connector ports can be found in Figure 13.

P2	
1: GND	2: GND
3: VINTF	4: N/A
5: N/A	6: N/A
7: N/A	8: N/A
9: N/A	10: N/A
11: N/A	12: N/A
13: N/A	14: N/A
15: PROJ_ON_EXT	16: N/A
17: N/A	18: N/A
19: EXT_SCL	20: EXT_SDA
21: N/A	22: N/A
23: N/A	24: N/A
25: N/A	26: N/A
27: N/A	28: N/A
29: N/A	30: N/A
31: N/A	32: N/A
33: N/A	34: N/A
35: N/A	36: N/A
37: N/A	38: N/A
39: N/A	40: N/A
41: N/A	42: N/A
43: HOST_PRESENTZ	44: GND
45: GND	46: GND



Legend:
Not Used
Parallel I/F Video Data
Parallel I/F Video Control
I2C Bus
System Supply Lines
System Control Lines

P1	
1: N/A	2: N/A
3: N/A	4: N/A
5: N/A	6: N/A
7: N/A	8: N/A
9: N/A	10: N/A
11: Data18	12: Data19
13: Data22	14: Data21
15: Data16	16: Data17
17: Data20	18: GPIO5
19: Data23	20: N/A
21: N/A	22: N/A
23: N/A	24: N/A
25: N/A	26: GPIO_INIT_DONE
27: VSYNC	28: PCLK
29: HSYNC	30: DATAEN
31: Data14	32: Data15
33: Data13	34: Data11
35: Data12	36: Data10
37: Data8	38: Data9
39: Data6	40: Data7
41: Data4	42: Data5
43: Data2	44: Data3
45: Data0	46: Data1

Figure 13. EVM Pinout Diagram

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4 Example Application

A quick and simple method for evaluating the DLP LightCrafter Display 2000 EVM is to use available video players on Debian to playback a sample video. After completing the quick-start setup, one should use FileZilla (https://filezilla-project.org/) or a similar FTP application to access the BeagleBone Black and upload a compatible .mp4 video. If the system fails to load the DLP LightCrafter Display 2000 EVM as an output monitor, the following commands can be issued to configure the system to external video mode at the appropriate nHD resolution:

```
i2cset -y 2 0x1b 0x0b 0x00 0x00 0x00 0x00 i
i2cset -y 2 0x1b 0x0c 0x00 0x00 0x00 0x1b i
```

To play the video, software such as mplayer or vlc is necessary and can be acquired using "apt-get" in the terminal (use "man apt-get" to see how to use the apt-get package manager). In the terminal, the user should execute the following:

1. The existing desktop is “0”
   a. "export DISPLAY=:0"
   b. "mplayer <file>" OR "vlc :0 <file>"
2. Generate a new x as “2” if there is no fb being created
   a. "xinit -- :2"
   b. "mplayer –vo x11 <file>" OR "vlc –x11-display :2 <file>"

To automate this process, we can employ sample scripts provided on the BeagleBone Black operating system. To find them, navigate to the directory "/opt/scripts/device/bone/capes/DLPDLCR2000/" and follow the README.txt file there to install the dlp_lightcrafter-1.0.19.tar package. Once installed, navigate back to the "DLPDLCR2000" directory and invoke python to run a script on the system. For example:

1. "cd /opt/scripts/device/bone/capes/DLPDLCR2000/"
2. "export DISPLAY=:0"
3. "python MplayerTest.py"

5 Troubleshooting

If you encounter any issues when using the DLP LightCrafter Display 2000 EVM, the following tips below may assist you in resolving common or known problems:

- When reading the "System Temperature" register using compound command 0xC5, the system may return an incorrect value on the initial read. If this occurs, send a second read command to the DLPC2607 to receive the correct temperature value in return.
- When attempting to send an *invalid* command to the DLPC2607, the command error flag may read as 0 even though an error flag should have been raised. This is a known issue.
- If the DLP LightCrafter Display 2000 EVM is connected to the BeagleBone Black, ensure that both devices are powered up for proper operation. If the BeagleBone Black is not receiving power, the DLP LightCrafter Display 2000 EVM may fail to boot even though it is receiving power.

6 Additional Documentation

The following documents are applicable to the DLP LightCrafter Display 2000 EVM and are available at www.ti.com.

- DLP2000 (0.2 nHD) DMD Data Sheet (DLPS078)
- DLPC2607 DLP PICO Processor 2607 ASIC Data Sheet (DLPS030)
- DLPC2607 Software Programmer's Guide (DLPU013)

For assistance, refer to the DLP and MEMS TI E2E™ community support forums.

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Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from B Revision (September 2017) to C Revision	Page
• In Section 2.1, added comment recommending specific Debian distro for DLPDLCR2000EVM	4
• In Section 4 (Example Application), fixed a typo in directory structure listing	11

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Changes from A Revision (August 2017) to B Revision	Page
• Removed links to specific retailers in the text	4

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Changes from Original (July 2017) to A Revision **Page**

- Updated Figure 3 (0.2 nHD Optical Engine Connection Overview) to clarify location of focus lever 3
- Added reference to Section 4 (Example Application) in Section 2.1 (Use With Host Processor) 5
- Added Figure 10 (EVM Headers and LEDs)..... 7
- In Section 4 (Example Application), added description on automating the sample playback process 11

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