

Keynote nHD Pattern Expansion Module (PEM)

User's Guide

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1. Overview

Much of this guide is based on the Texas Instruments (TI) LightCrafter User's Guide, but it also highlights important differences in operation and function from the TI design. The Pattern Expansion Module (PEM) application is a software application that executes on a BeagleBone (BB) single board computer module that the TI LCR2000EVM can plug into. The PEM can execute on the BeagleBone Black or BeagleBone Green version. Other solutions may work but have not been tested.

This guide assumes that you have a fundamental understanding of Linux and programming. Keynote is unable to provide answers to Linux or networking questions related to the BeagleBone. We strongly recommend that you use the resources at www.beaglebone.org for more information.

1.1. Installing PEM Application on BeagleBone

The current PEM application has been built for the "Wheezy" version of Debian. Later versions are not tested and may not work. We urge you to flash your Beaglebone with the version of "Wheezy" that is described here.

First, create an SD card that will be used to flash the operating system.

- Use Windows Win32DiskImager to create the flasher uSD Card to be used to initialize BB with the following image files:

bone-debian-7.11-lxde-4gb-armhf-2016-06-15-4gb.img

You can find these image file at <http://beagleboard.org/latest-images>. Also, further information can be found at http://elinux.org/Beagleboard:BeagleBoneBlack_Debian.

- Insert uSD Card into BB and boot the card while holding config switch during startup to begin NAND flash reprogramming. Please do this with the Beaglebone board disconnected from the DLPCR2000 EVM projector. For further instructions, please see www.beaglebone.org

- After running the flasher uSDcard to install the default Debian build, boot the board without the uSDcard and verify the version:

```
cat /etc/dogtag
```

```
or cat /ID.txt
```

Ensure the Beaglebone is connected by Ethernet and can access the web. After logging in, clone the PEM application repository to the Beaglebone:

git clone <https://github.com/keynotep/LCR2000-nHD-PEM-App>

Then execute the PEM installer script:

```
cd DebianMods  
./pem_install.sh
```

The script will ask you to reboot the board if the installation steps complete successfully. Shut down the OS (shutdown –Ph now) or use the power button on the Beaglebone board. After plugging the projector into the Beagleboard and powering up both units, you will see the projector show the default splash screen, then change to a dark image with red, green and blue vertical bars.

This indicates the software has been installed on the BeagleBone and can communicate via the Qt GUI.

1.2. Building the nHD-PEM GUI

The nHD-PEM GUI provides control of the module either through Ethernet or by using Ethernet over USB through the USB port on the BeagleBone itself. The GUI is based on Qt, allowing it to be built in Windows, OS X, or Linux.

To build the GUI, follow these steps.

1. Download the latest version of QT Creator at <http://qt.io.com/developers>
2. Download the most recent version of the PEM source located on GitHub (<https://github.com/keynotep/LC2000-nHD-PEM-GUI>).
3. Open the project in Qt Creator, build it and then execute.

1.3. Initial GUI Setup

When the user interface opens, Select the “Connect” button to start control of the nHD (see Figure 1). This will initialize communication and display the unit’s revision information.

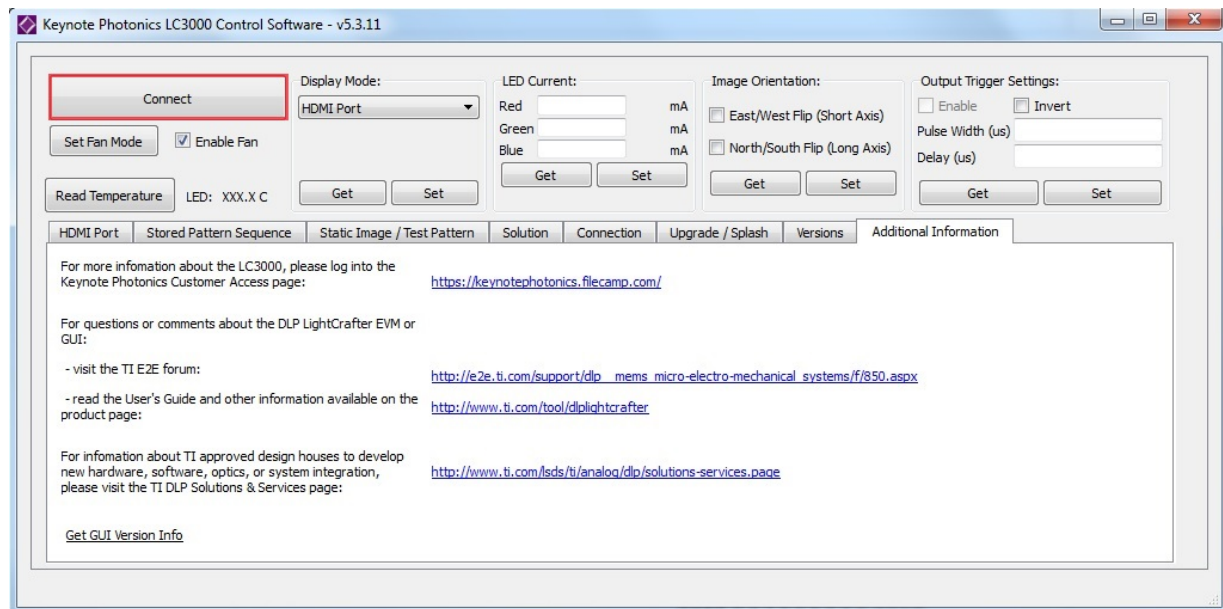


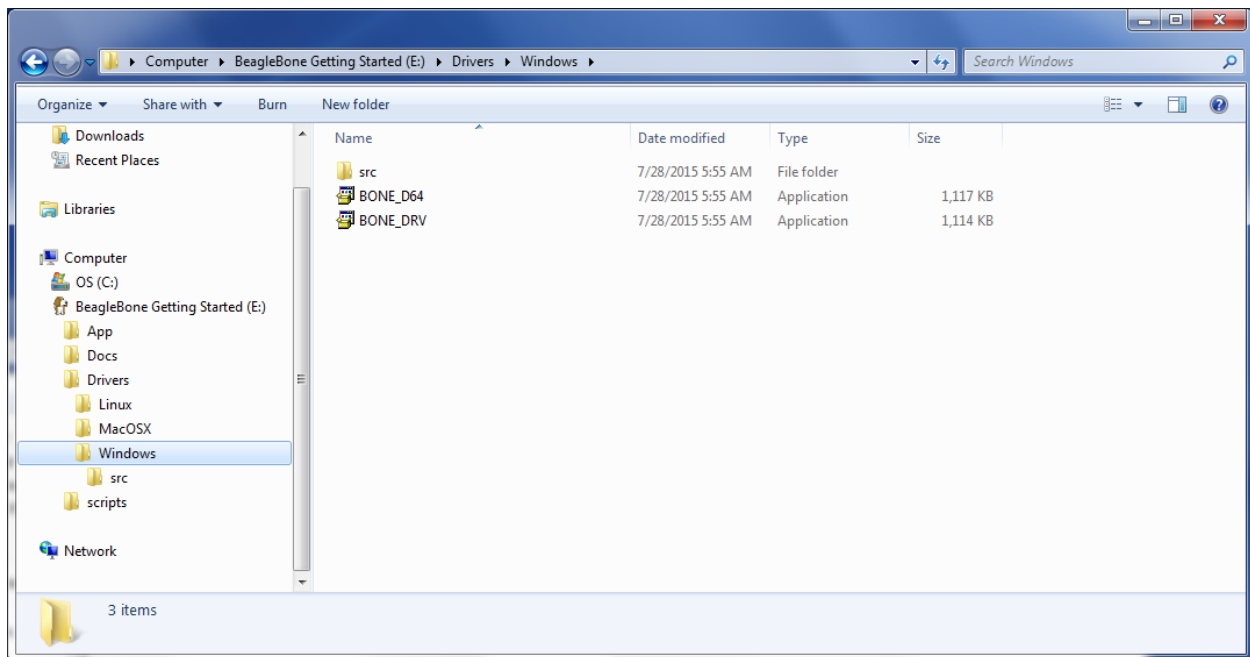
Figure 1 nHD GUI

1.4. Connecting by USB (RNDIS or Ethernet-over-USB)

Instead of using a network IP address, the BeagleBone can define the IP address for a USB connection. If this is the first time you connect the USB to a particular port in your PC, you will likely need to install the appropriate RNDIS driver.

1.4.1. Windows 7

After powering up the Lightcrafter2000 with the BeagleBone and connecting your PC to the BeagleBone USB port, you will see the BeagleBone file system on Explorer. Click the folder Drivers, Windows and select the BONE_D64 if you have the 64-bit version of Windows7. Otherwise, select BONE_DRV.EXE.



You will be asked permission to execute the program dpinst.exe. Please select yes. After that, you will see the following window. Select and follow the instructions.



This process will take around 5 minutes to install on your system depending on the its speed. When completed, click Finish on the last window.



1.4.2. Windows 8.1 and 10

Instead of using the driver located on the BeagleBone, you must download the latest driver at <http://beagleboard.org/static/beaglebone/latest/README.htm> or click on the following link.

https://beagleboard.org/static/Drivers/Windows/BONE_D64.exe

The next section describes how to connect the GUI to the PEM application.

1.4.3. RNDIS IP Address

After powering up the nHD and ensuring that you have connected the BeagleBone USB connector to your PC USB port, perform the following steps to connect the GUI with the PEM Application on the module:

4. In the Connection Tab, change the IP address to **192.168.7.2**.
5. Press the Connect button as before.

1.4.4. Connecting by Ethernet

After the startup sequence is complete, the projector will display a test pattern. Please wait approximately 15 seconds after the test pattern is displayed before trying to connect with the projector.

1. Confirm that the PC is connected to your network server.
2. Connect the BeagleBone to the same network server using an Ethernet cable.
3. Open the nHD-PEM GUI in Qt:
4. Open the "Connection" tab and set the IP address in the "Current IP Address" textbox.

Keynote Photonics sets the default hostname for the nHD-PEM to "nHD-pem" before shipping. Change the Current IP Address to "nHD-pem.local" or "nHD-pem.<domainname>.com". Either of these names should work in most cases. See your network administrator in case of difficulty.

5. Select the Connect button. The Connect button changes to a Disconnect button after the GUI establishes a connection. If the connection is unsuccessful, please repeat the connection attempt a few times. If that does not solve the issue, you may need to restart the GUI or the nHD projector and BeagleBone.

1.5. Support

For questions regarding the PEM application or installation, please contact us through e-mail at support@keynotephotonics.com.

For questions regarding the TI DLPC2607 or the LCR2000EVM projector board, please refer to the TI E2E forum at https://e2e.ti.com/support/dlp_mems_micro-electro-mechanical_systems/video_and_data_display/f/947

For questions about the Beaglebone board or the related Debian operating system, please go to <https://beagleboard.org> or other forums and information available on the web.

2. Operating Modes

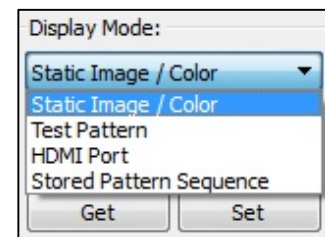
The nHD-PEM application allows the user to display images using four different modes: static image/color, test pattern, and stored pattern sequences. Each mode is described in detail below.

2.1. Static Image/Color

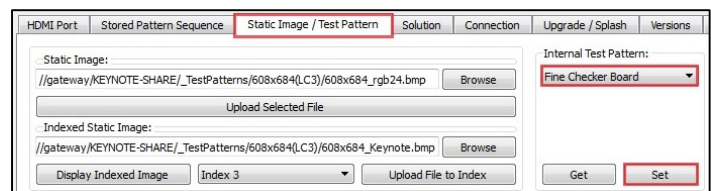
nHD projectors display 640x360 bitmap image files that are mapped to the DMD mirrors.

To display a static image:

- From the Display Mode dropdown box, select Static Image and then select the “Set” button.



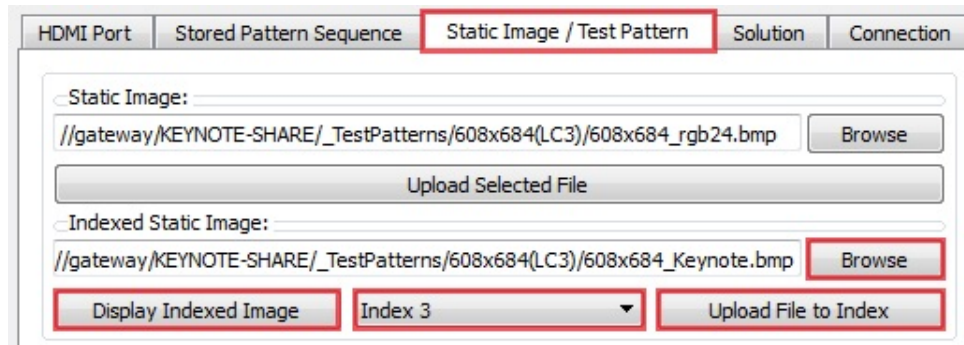
- To show a static image, from the “Test Pattern/Image” tab, select the “Browse” button in the Static Image panel and locate your desired 640x360 image. Then select the “Upload Selected File” button to display the image.



Static images can also be uploaded and stored in 16 indexes ranging from 0 to 15. These images can be displayed at any time. To upload an image to an index and then recall it:

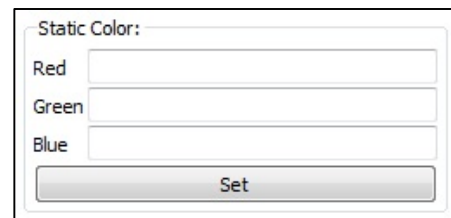
- Set the Display Mode to Static Image.
- Under the “Indexed Static Image” section, select the “Browse” button to choose an image.
- Use the dropdown menu to select an index number location, then select “Upload File to Index.”

- To display an indexed image, select an index number from the dropdown menu, then select “Display Indexed Image” to show the corresponding image.



The GUI can also be used to display a static color as a custom combination of red, green, and blue.

- To show a static color, from the “Test Pattern/Image” tab, set the desired color in the Static Color panel. Then select the “Set” button to display the image.

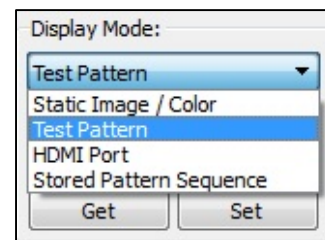


2.2. Internal Test Patterns

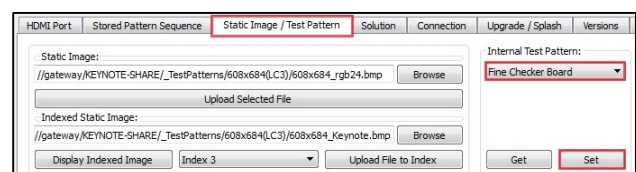
Fourteen basic test patterns have been preloaded onto your projector, ranging from solid colors to simple lines and scales. These patterns can be used to test focus, LED functionality, brightness, and more.

To display an internal test pattern:

- From the Display Mode dropdown box, select Internal Test Pattern and then select the “Set” button.



- From the “Test Pattern/Image” tab, select any of the test patterns in the dropdown box in the Internal Test



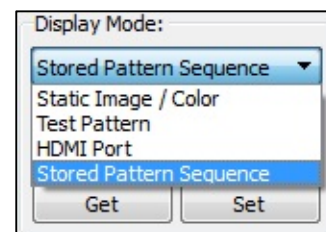
Pattern panel. Then, select the “Set” button.

2.3. RGB Pattern Sequences

Pattern sequences issue a set of defined images with a selected LED color. Only 8-bit sequences are supported. Also note that unlike the pattern sequence capability in other chipsets such as the DLPC300, images always use an RGB color sequential sequence. Linear gamma is enabled and all other video processing functions in the DLPC2607 are disabled.

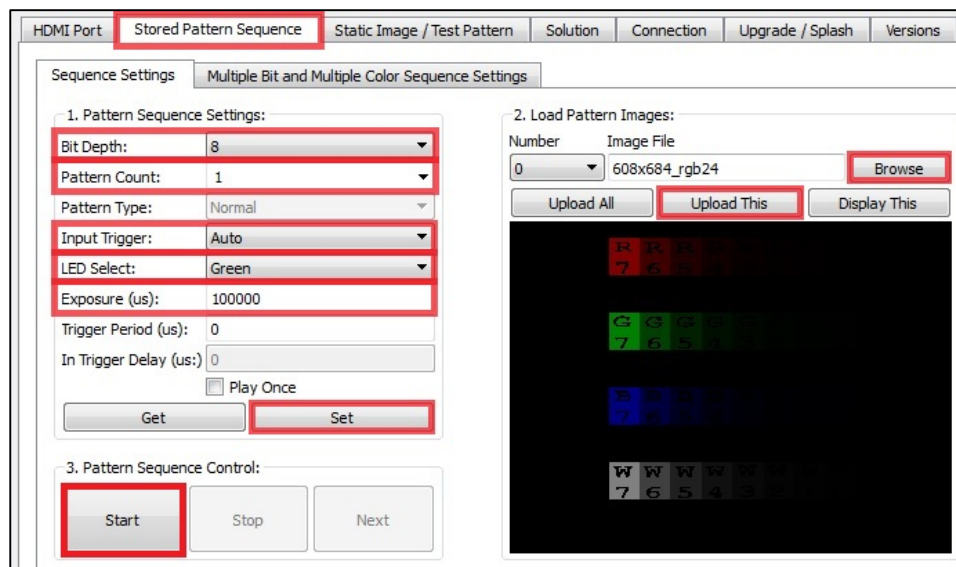
To display pattern light sequence:

- From the Display Mode dropdown box, select “Stored Pattern Sequence” and then select the “Set” button.



- From the “Sequence Settings” tab and the “Pattern Sequence Settings” panel,
 - From the “Bit Depth” dropdown box, select your preferred bit depth (range of 1-8)
NOTE: ONLY 8-bits is currently supported
 - From the “Pattern Count” dropdown box, select the number of patterns.
 - From the “LED Select” dropdown box, select any one color
 - Set the Input Trigger to the desired setting
 - Command: Next image is shown when the user selects the “Next” button
 - Auto: Next image is shown automatically
 - External: Next image is triggered by an externally connected trigger input.
 - **NOTE: NOT CURRENTLY SUPPORTED. FUTURE GPIO pin will be defined to enable this feature.**
 - Type your desired exposure level into the appropriate box. This time (in microseconds) determines how long each image is displayed.
 - **NOTE: Exposure time will be rounded to the nearest frame time, which currently is fixed at 16.6 ms.**
 - Enable Play Once mode, if desired, to play through a pattern sequence one time only.
 - **NOTE: PLAY ONCE NOT CURRENTLY SUPPORTED**

- Select the “Set” button
- From the “Load Pattern Images” panel,
 - If uploading one image at a time, use the Number dropdown to select the position in which to insert an image (starting at 0)
 - If uploading multiple images at once, set the Number to the position of the first image in the series being uploaded
 - Browse and select a 640x360 .bmp image(s); in this example we use “640x360_rgb24”
 - Select the “Upload This” button (one image) or “Upload All” (multiple images).
- From the “Pattern Sequence Control” panel, select “Start” and use the “Next” button as necessary



To change settings: Under Pattern Sequence Settings, make any changes, then select the “Set” button. If you are changing the number of images, you will need to re-upload the image files.

2.4. Camera Triggering

At this time, external camera triggers are not supported. Future versions of the PEM application will drive one of the GPIO pins on the Beaglebone that can be used to initialize a camera capture. The camera exposure will need to extend over the entire frame time to integrate the full 8-bit image.

3. Saving Solutions

The nHD-PEM application can store custom solutions which can be loaded at any time. A solution saves the current display into memory to be recalled at any time. This solution can later be recalled or set to run as the default solution which starts after booting.

To store and recall a solution:

- Ensure that the GUI has been set to the proper settings and that the projector is displaying the image that you would like to save as a solution.
- Set the appropriate settings such as LED Current, Pattern Sequence bit depth, number of patterns, input trigger, trigger period, exposure, time, display mode, and so forth.
- Go to the "Solution" tab and in the "Create New Solution" panel, type a name for your solution, then select "Save."
- The new solution will be added to the list of stored solutions. Any solution can be recalled by selecting its name, then selecting "Load."
- To save a solution as default, select its name, then select "Default." The default solution is shown when the projector powers on. The current default solution is shown in blue text.

4. Firmware Upgrades

To upgrade the PEM application, perform the following steps:

1. Select the "Solution / Splash" and "Firmware Upgrades" tabs.
2. Select which firmware to upgrade and then click the Browse button.
3. After the file is selected, click the Install button.
4. Power down the Beaglebone or reboot the system using the linux command line interface via ssh.

NOTE: Only PEM application updates are supported at this time.

5. Revision History

Rev	Release Date	Brief Description of changes:
Draft	8/31/2017	Preliminary Release
-	09/05/2017	Clarifications and updates