Application Report
DLPA035A–May 2013–Revised October 2013

Creating Multiple Bit Depth and Multiple Color Pattern Sequences for DLP® LightCrafter™ Kit

ABSTRACT

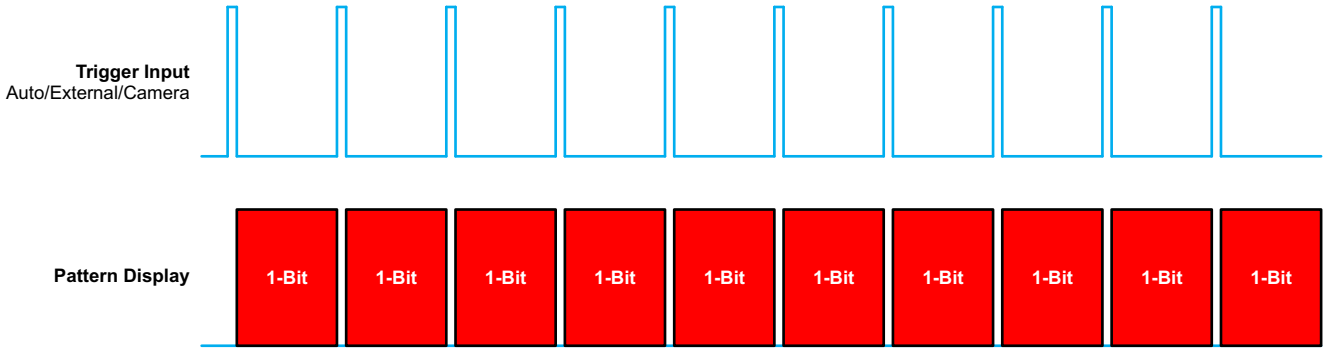
The current software in the DLP LightCrafter supports a pattern sequence where all the patterns in the sequence must use the same bit depth and LED light color. Figure 1, Example 1 shows ten 1-bit patterns illuminated by the red LED and triggered by an external trigger. Figure 1, Example 2 shows another pattern sequence with five 8-bit patterns illuminated by the green LED.

This application report describes new software capabilities that support a pattern sequence with multiple bit-depth or LED light colors (MBMC), or both, for developers that need to go beyond the single bit depth and LED color pattern sequence. Figure 2, Example 1 shows a multiple bit-depth and color pattern sequence with the following seven patterns: 1-bit red pattern, 2-bit green pattern, 5-bit blue pattern, 6-bit red pattern, 7-bit red pattern, 3-bit blue pattern, and 8-bit red pattern. Figure 2, Example 2 shows a pattern sequence with the following five patterns: 8-bit blue pattern, 1-bit red pattern, 7-bit green pattern, 2-bit green pattern, and 8-bit red pattern. The new software capabilities support this multiple bit-depth or colors, or both, with the limitation that the total number of bit planes do not exceed 96 bit planes.

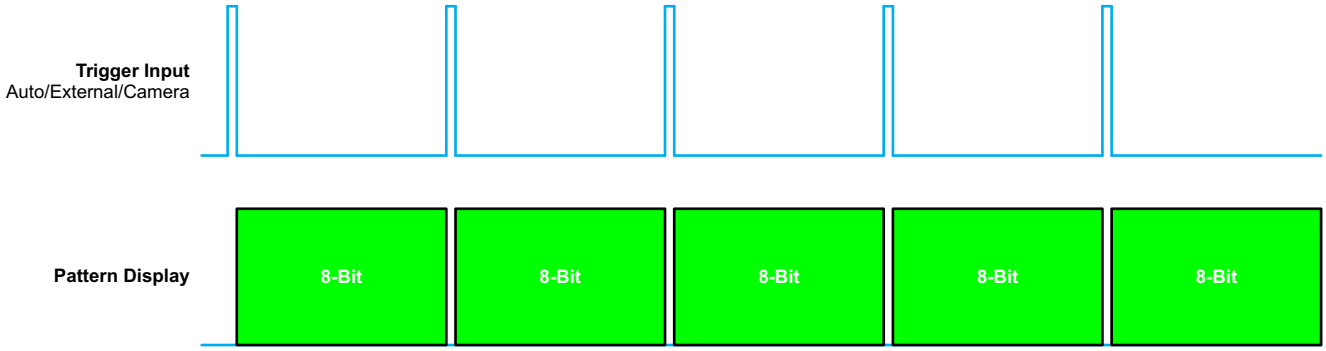
A bit plane refers to the number of bits used to describe a pattern. For example, an 8-bit pattern is considered to consume eight bit planes; a 7-bit pattern consumes seven bit planes, and so on. This document uses bit-per-pixel (bpp) to describe the bit depth of a pattern; that is, an 8-bit pattern would be written as 8bpp.

For a limited time, TI will make available DLPC300 configuration files that support MBMC and can be loaded to the DLP LightCrafter.

NOTE: The instructions in this application report are specific to DLP LightCrafter GUI v4.0 and v4.0.1. Versions 5.0 and above can import the readme file information, prepare the images, and setup the GUI settings automatically. Please read the most recent DLP LightCrafter User's Guide DLPU006 for the proper instructions to use these features.

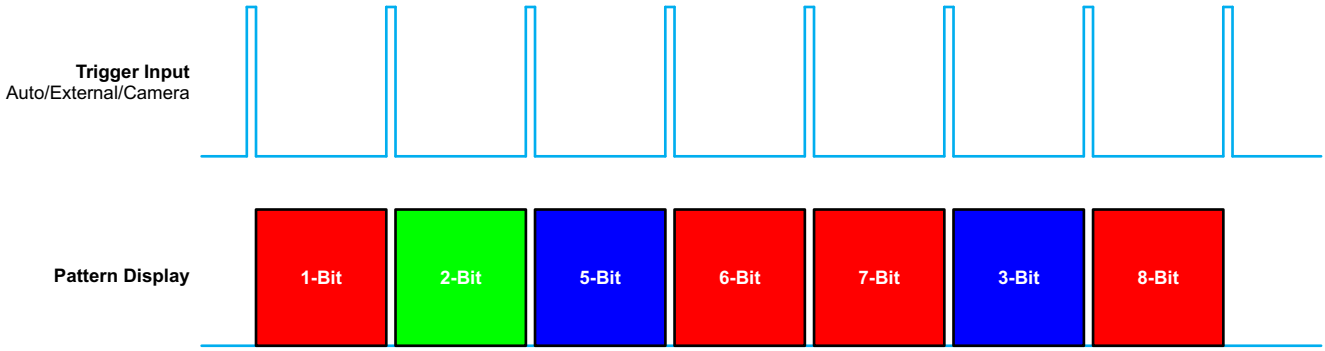


Example 1: 1bpp Red Color Pattern Sequence

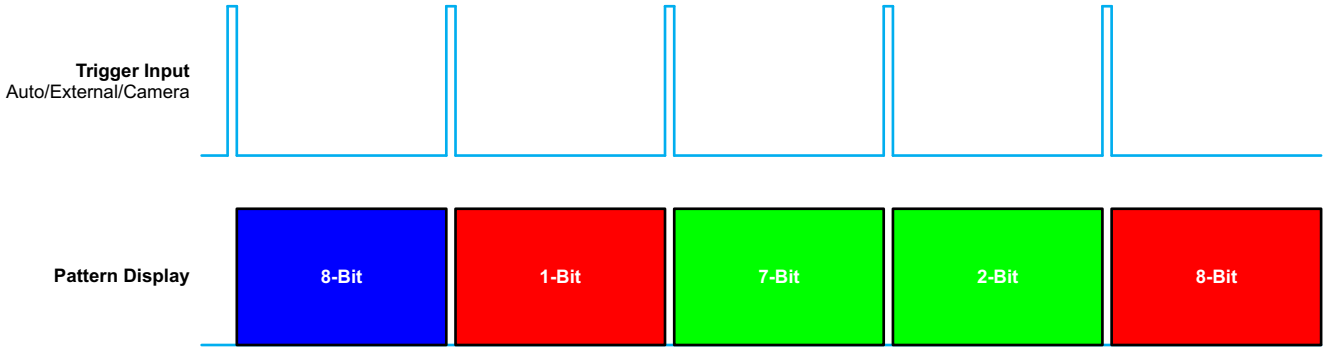


Example 2: 8bpp Green Color Pattern Sequence

Figure 1. Fixed Bit-Depth Pattern Sequence (With Color Set to Red/Green/Blue)



Example 1: Variable Bit-Depth Pattern Sequence



Example 2: Variable Bit-Depth Pattern Sequence

Figure 2. Variable Bit-Depth Pattern Sequence (With Color Selection for Each of the Patterns)

The following steps are defined to use the MBMC pattern sequence feature:

1. Update the DLP LightCrafter Software, see Section 1.
2. Submit MBMC pattern sequence request to TI, see Section 2.
3. Prepare patterns to upload on to DLP Lightcrafter, see Section 3.
4. Load MBMC pattern sequence and image files on to DLP Lightcrafter, see Section 4.
5. Save Solution for reuse.

NOTE: For implementing the MBMC feature without the GUI, use DLP LightCrafter API Sample Code v2.0. TCP command level implementation of downloading patterns and MBMC sequences is available in the Sample Code. The *Demo_8_VariableBitDepthPatSeqDemo()* function illustrates this feature.

1 Update DLP LightCrafter Software

The multibit and multicolor features are available with the following software versions for the DLP LightCrafter Kit:

1. DLP LightCrafter GUI v4.0 or above [1] [2]
2. DM365 Software v4.0 or above
3. DLPR300 (DLPC300 Configuration and Support Firmware) v2.6.43 or above
4. MSP430 Firmware v2.6 or above

The DM365 software v4.0 and DLP LightCrafter GUI v4.0 are part of the DLP LightCrafter Firmware and Software Package v2.0 available on the TI website (http://www.ti.com/tool/dlplightcrafter)

1.1 Additional Software

LightCrafter_MBMCSeq_PatternParser utility

The pattern parser utility separates all input patterns into individual 1bpp and arranges them in order so that the sequence on to the DLP Lightcrafter is correct. The parser utility uses the readme file, supplied by TI, and a .txt file which lists the pattern image file names. The pattern parser utility is also available on the TI website (http://www.ti.com/tool/dlplightcrafter)

1.2 Documentation

The DM365 software v4.0 refers to DLP LightCrafter DM365 Command Interface Guide (DLPU007).

2 Submit MBMC Pattern Sequence to TI

Submit MBMC pattern sequence requests on TI's E2E forum in the DLP LightCrafter Development Platform subsection (http://e2e.ti.com/) by providing the following information; ‘d’ and ‘e’ are optional.

(a) Create a post in the DLP LightCrafter forum titled, "MBMC Request."

(b) Pattern Exposure time[1] (250 µs < PExT ≤ 20000 µs).

(c) Patterns Sequence Information shown in Table 1.

(d) The development time frame of the project.

(e) A description of the application and the need for this capability.

NOTE: (1) The Pattern Exposure time parameter influences the maximum bit-depth possible in the sequence for each pattern. For example, if the exposure time is 1000 µs, then it is only possible to have 1-bit or 2-bit depth patterns. On the other hand, an exposure time ≥ 8333 µs supports patterns of all bit-depths from 1 to 8. See the DLP LightCrafter Evaluation Module User’s Guide (DLPU006) Table 3-2 to find the minimum exposure time for each pattern’s bit-depth.

(1) The instructions in this application note are specific to DLP LightCrafter GUI v4.0 and v4.0.1.

(2) DLP LightCrafter GUI v5.0 and above can import the readme file information, prepare the images, and setup the GUI settings automatically. Please read the most recent DLP LightCrafter User's Guide DLPU006 for the proper instructions to use these features.

Table 1. MBMC Pattern Sequence Information Input

Pattern Bit-Depth	Number of Patterns	Pattern Color (Red/Green/Blue)
5	5	Blue
1	6	Red
..	..	…
..	..	…
7	2	Green
1	3	Blue

Notes on filling in the table:

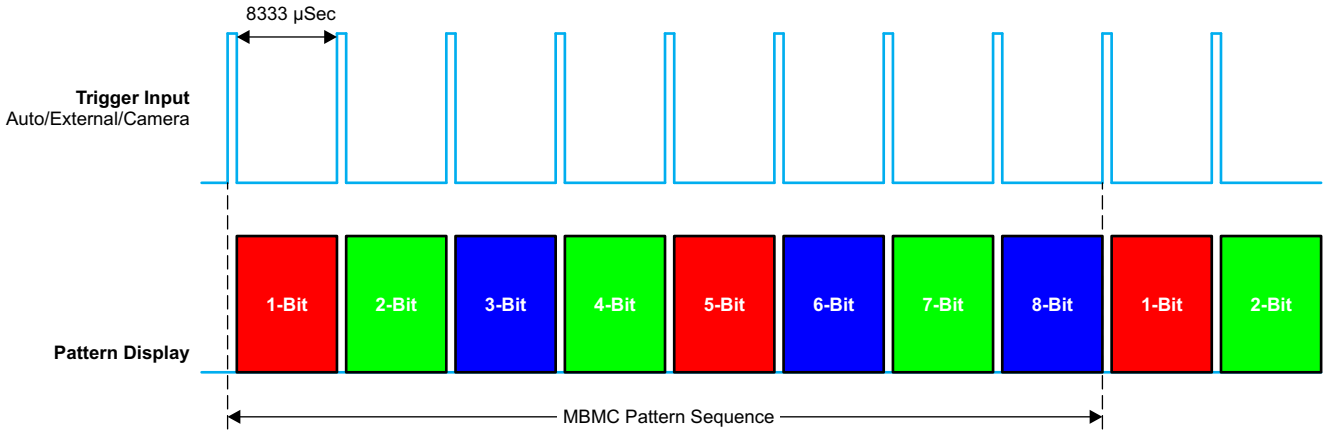
- Patterns must be listed in the order to be displayed.
- Depending on the order of patterns with different bit-depths, it is possible that there will be unused bit-planes that still count towards the maximum 96 bit-planes. The system does not allow split multiple bit-depth patterns across the 24-bit frame buffer boundaries. For example, in the first row of Table 1, there are five, 5bpp patterns. This would translate to 5 × 5 = 25 individual bit planes, but each frame buffer can only accommodate 24 individual binary frames. Therefore, in a pattern sequence of five, 5-bit patterns, 20 reside in the first frame buffer, while the last 5-bit planes reside in the next frame buffer. The 5bpp × 5 pattern set actually consumes 29 individual bit planes of the frame buffer:
  - 5bpp × 4 patterns + 4 unused patterns = 24 patterns (from the first frame buffer)
  - 5bpp × 1 pattern = 5 patterns (from the second frame buffer)
  - Results in 24 + 5 = 29 individual binary patterns

The next step is to create a final sequence in the following form:

<pattern_bit-depth>X<num_of_patterns><color (R)ed or (G)reen or (B)lue>_<pattern_bit-depth>X<num_of_patterns><color (R)ed or (G)reen or (B)lue>_.....<pattern_bit-depth>X<num_of_patterns><color (R)ed or (G)reen or (B)lue>_<exposure_time>µs

Example:
1bppX1G_2bppX1G_3bppX1G_4bppX1G_5bppX1G_6bppX1G_7bppX1G_8bppX1G_8333µs

This generates the sequence as shown in Figure 3.



MBMC Pattern Sequence:
1bppX1R_2bppX1G_3bppX1B_4bppX1R_5bppX1G_6bppX1B_7bppX1R_8bppX1G_83333 µSec

Figure 3. MBMC Pattern Sequence Output

3 Prepare Images to Upload onto DLP Lightcrafter

After TI has processed the MBMC pattern sequence request, a download link will be available on the E2E DLP LightCrafter Development Platform forum http://e2e.ti.com/ where the user can download the MBMC sequence configuration file. **The time taken to process your request depends on the number of requests for the MBMC pattern sequences**.

The downloaded file will be in the zip file format and formatted as follows:

Syntax:

<dd><mmm><yyyy>_<hh>_<mm>_<am/pm>.zip

Example: 22March2013_12_17_PM.zip

Download the file and unzip it to a local folder. The following three file extensions should be present with file names of similar syntax:

1. 22Mar2013_12_17_PM.bin
2. 22Mar2013_12_17_PM.lua
3. 22Mar2013_12_17_PM_Readme.txt

NOTE: The files are auto generated. Do not edit them or the MBMC sequence configuration will not work.

3.1 MBMC Color Sequence Binary (<dd><mmm><yyyy>_<hh>_<mm>_<am/pm>.bin)

This binary file (.bin) contains information about the pattern sequence.

3.2 MBMC Sequence Register Level Instructions (<dd><mmm><yyyy>_<hh>_<mm>_<am/pm>.lua)

This readable text file (.lua) contains all of the register settings to configure the DLPC300 to load the MBMC pattern sequence. This is useful when DM365 is not used in the intended application. In such cases, the MBMC pattern sequence can be configured by sending I2C commands to the DLPC300 and FPGA in the same sequence and values described in this test file.

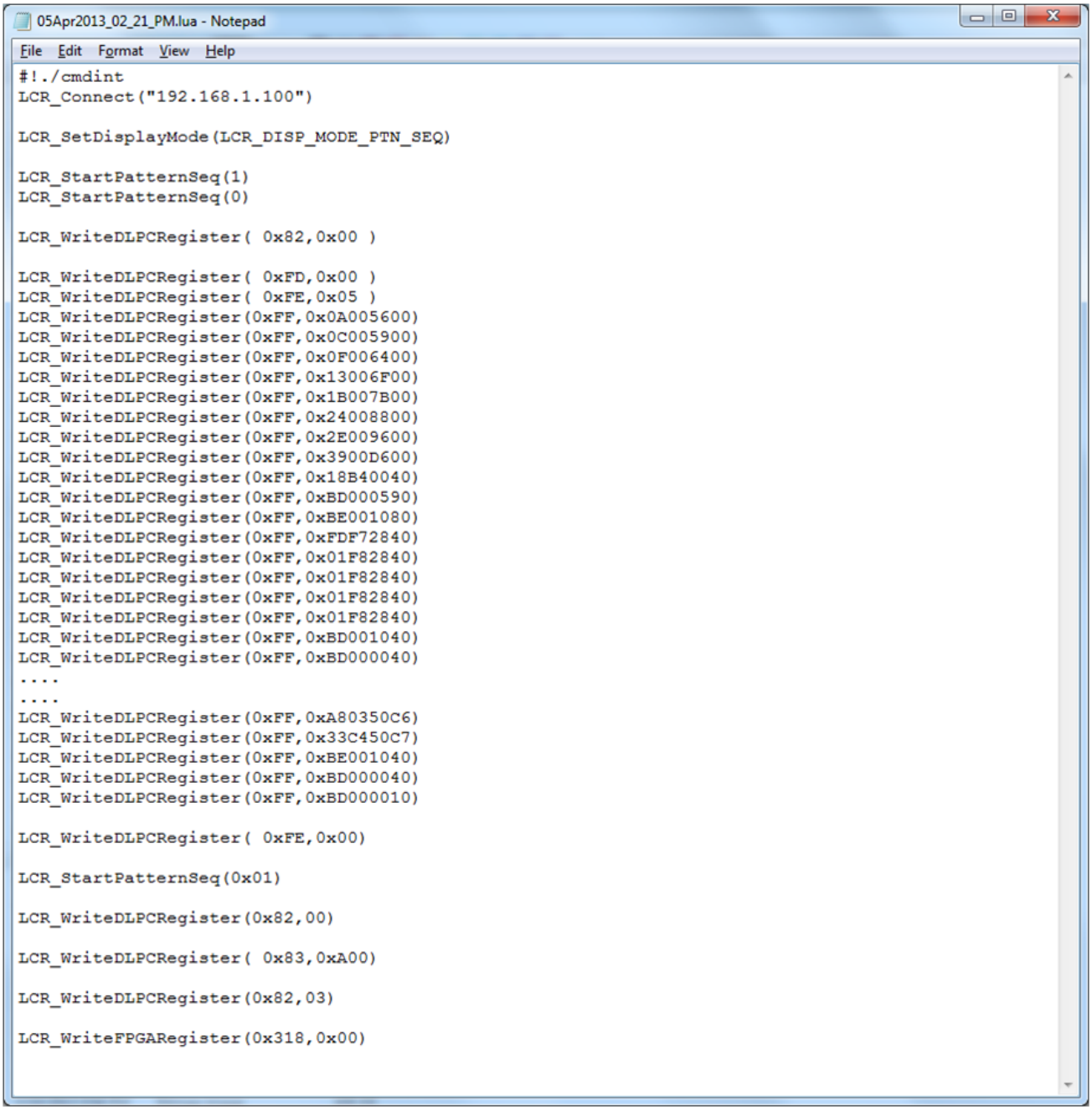


Figure 4. Register Level MBMC Pattern Sequence Definition

NOTE: Contact TI support for additional help from TI to use the I2C register level configuration.

3.3 MBMC Sequence Readme File(<dd><mmm><yyyy>_<hh>_<mm>_<am/pm>_Readme.txt)

The Readme file contains important information that is needed to configure the DLP LightCrafter hardware in Section 4. File Name represented as:
<ddmmmyyyy_hh_mm_AM/PM>_Readme.txt as shown in Figure 5.

This file contains information about the MBMC patterns sequence such as:

1. Minimum Trigger Period
2. Multiple bit depth or multiple color sequence vector setup information
   (a) Start vector
   (b) Number of vectors in the sequence
3. A list of the individual 1bpp patterns parsed from the image files. Note that the list is already properly arranging for the images to appear in order on the DLP LightCrafter hardware.

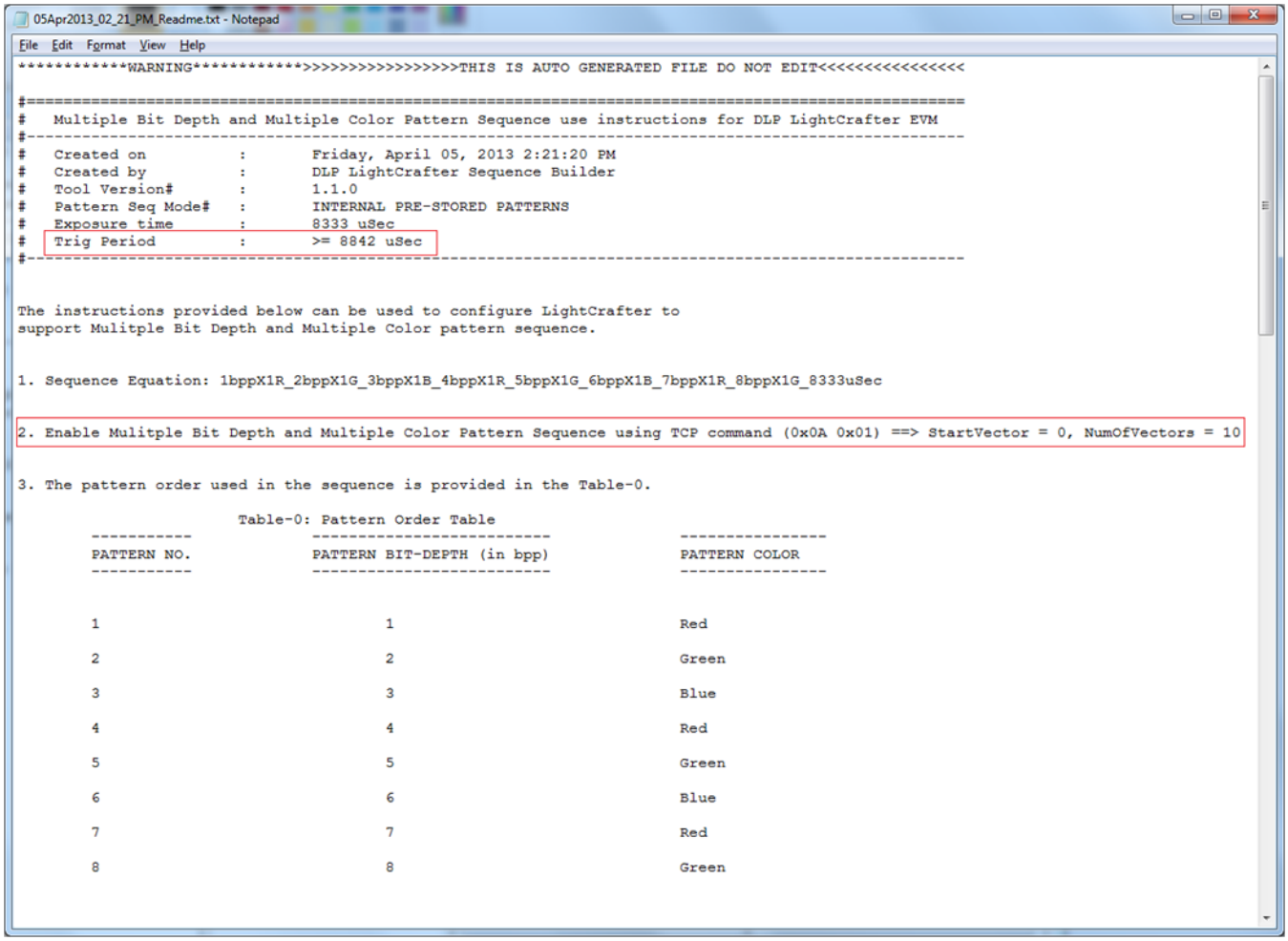


Figure 5. Sample Readme File

3.3.1 Minimum Trigger Period

The minimum trigger period (in µs) can be found in the Readme document header. For the MBMC Pattern Sequence to work, the trigger period setting must be greater than or equal to the value mentioned in the Readme document.

Values as shown in Figure 5 Sample Readme file:

- Trigger Period ≥ 8842µs

3.3.2 MBMC Sequence Vector Setup Information

This information is the second instruction shown in the red box in Figure 5. Note the StartVector and Number of Vectors information accordingly.

Values as shown in Figure 5 Sample Readme file:

- StartVector = 0
- Number of Vectors = 10

3.3.3 Parsing Patterns Into Individual 1bpp Patterns

The patterns must be split into individual 1bpp patterns and arranged in order before uploading to the DLP LightCrafter Kit. Use the LightCrafter_MBMCSeq_PatternParser utility discussed in Section 1 to split and arrange the patterns.

Follow these steps:

1. Copy the LightCrafter_MBMCSeq_PatternParser.exe utility into local folder.
2. Copy the Readme file into the *same folder*.
3. Copy all patterns that need to be parsed into the *same folder*.
4. Create a file with " .txt" extension, containing each pattern name. Ensure the pattern names are put in the same order as submitted in the MBMC Pattern Sequence Information Table, that is, the first pattern name should appear at top and last pattern name should appear at the bottom. **Include a blank line at the bottom of the file after the last pattern name.**
5. Run the command to parse and automatically arrange the patterns in order.

   <drive>:\> <folder_path>\LightCrafter_MBMCSeq_PatternParder.exe -r

   <readme_file_name> -I <pattern_name_list>

   Example:

   C:\LightCrafter_MBMCSeq_PatternParser>LightCrafter_MBMCSeq_PatternParser.exe -r 05Apr2013_02_21_PM_Readme.txt -I imgList.txt

   Figure 6 shows a screen shot of the execution.

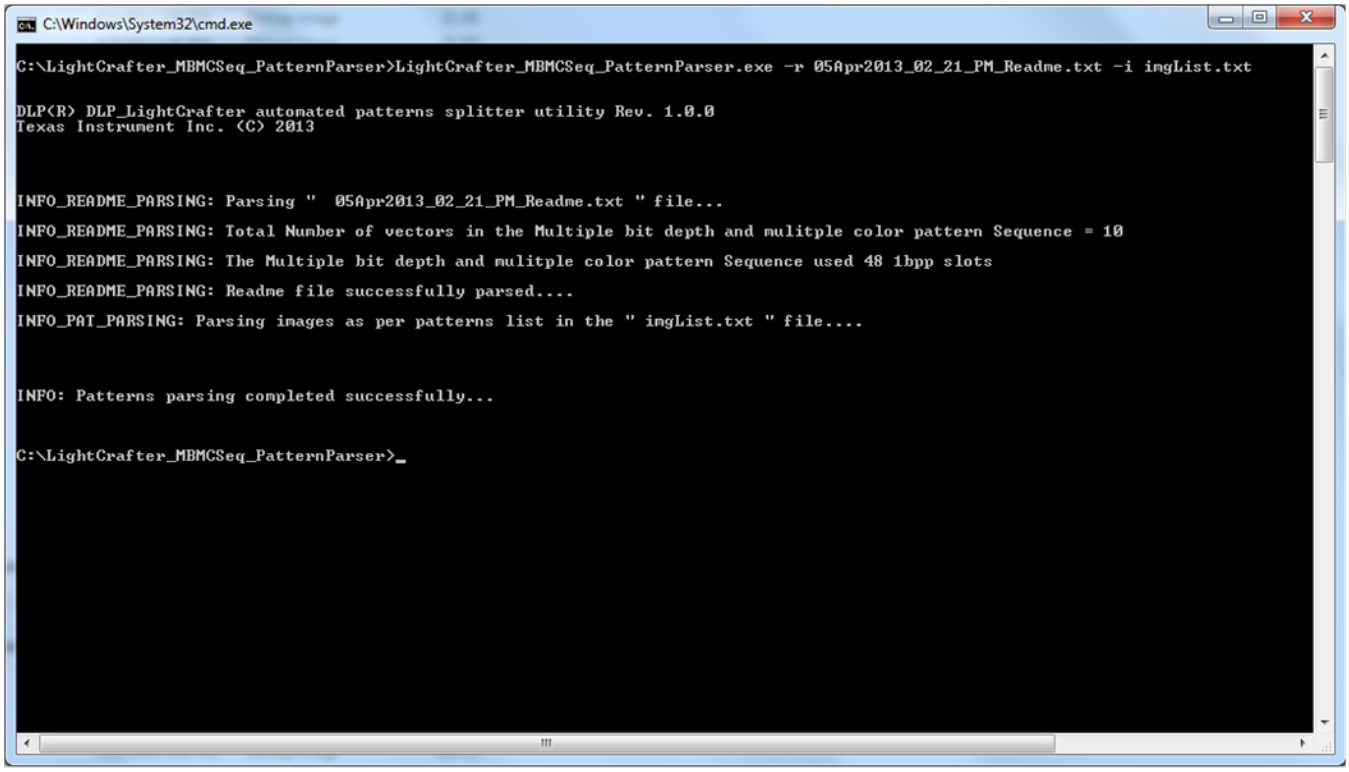


Figure 6. Screen Shot of Pattern Parsing Utility Execution

6. After the patterns are parsed there are 'N' number of 1bpp patterns. The patterns names are formatted <nn>_PAT.bmp
7. Typically the total number of patterns generated is 24, 48, or 96. As described in Section 2, the parser may insert blank 1bpp patterns. These blank patterns are placeholders, which the sequence will not display, but the patterns still need to be inserted as fillers at the proper location in the frame buffer.

4 Load MBMC Pattern Sequence and Image Files on to DLP Lightcrafter

Follow the GUI screen shots for instructions on uploading the MBMC pattern sequence.

1. Connect GUI to the DLP LightCrafter Kit and select the Pattern Sequence Display Mode.

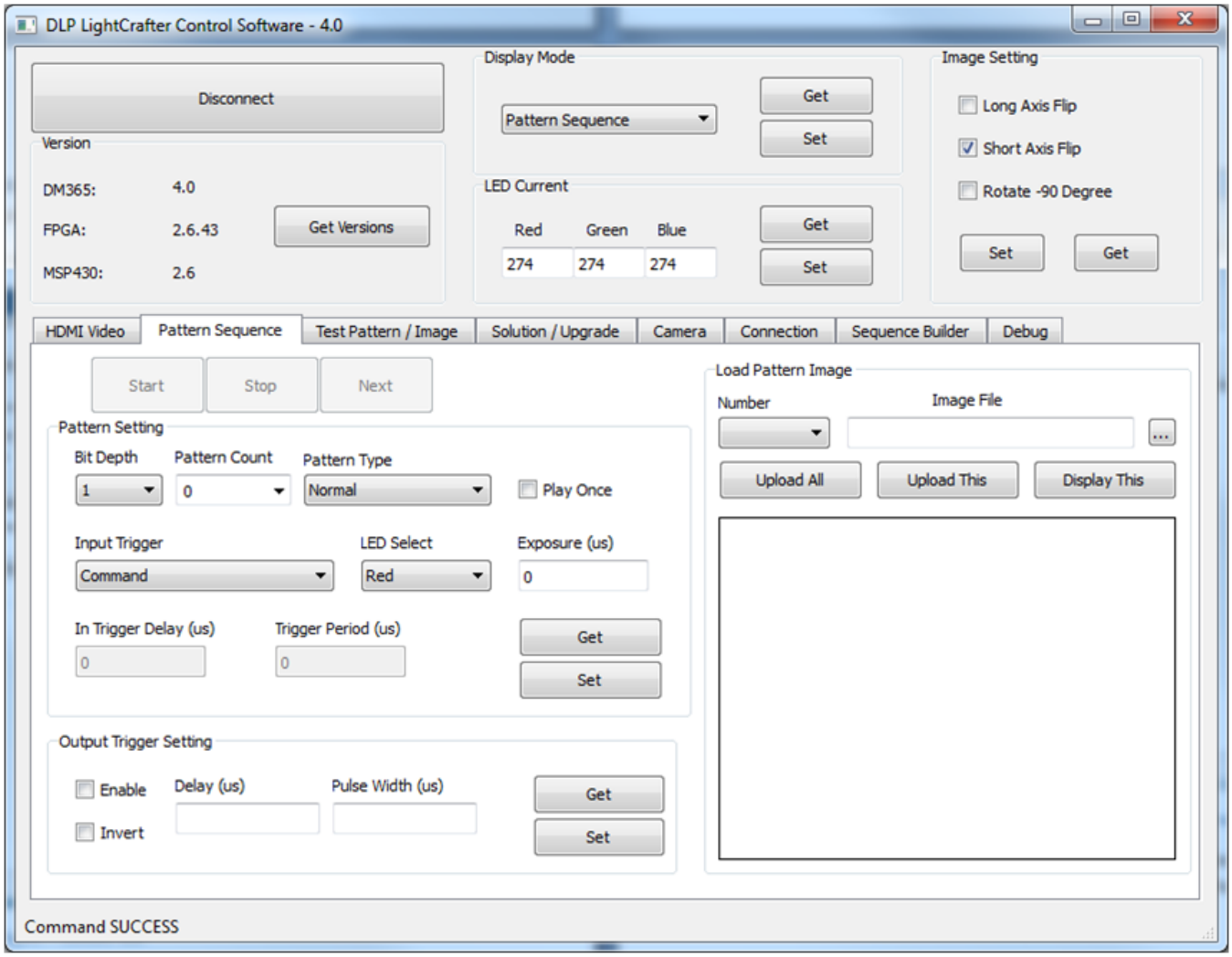


Figure 7. Connect GUI

2. See the Readme txt file to set the following Pattern Settings: Pattern Count, LED Select, Exposure, and Trigger Period. The number of 1bpp patterns is equal to number of patterns generated. This value is one of three values, 24, 48, or 96.

NOTE: LED Select must be set to DEFAULT.

Trigger Period must be greater than or equal to the value specified in the Readme file.

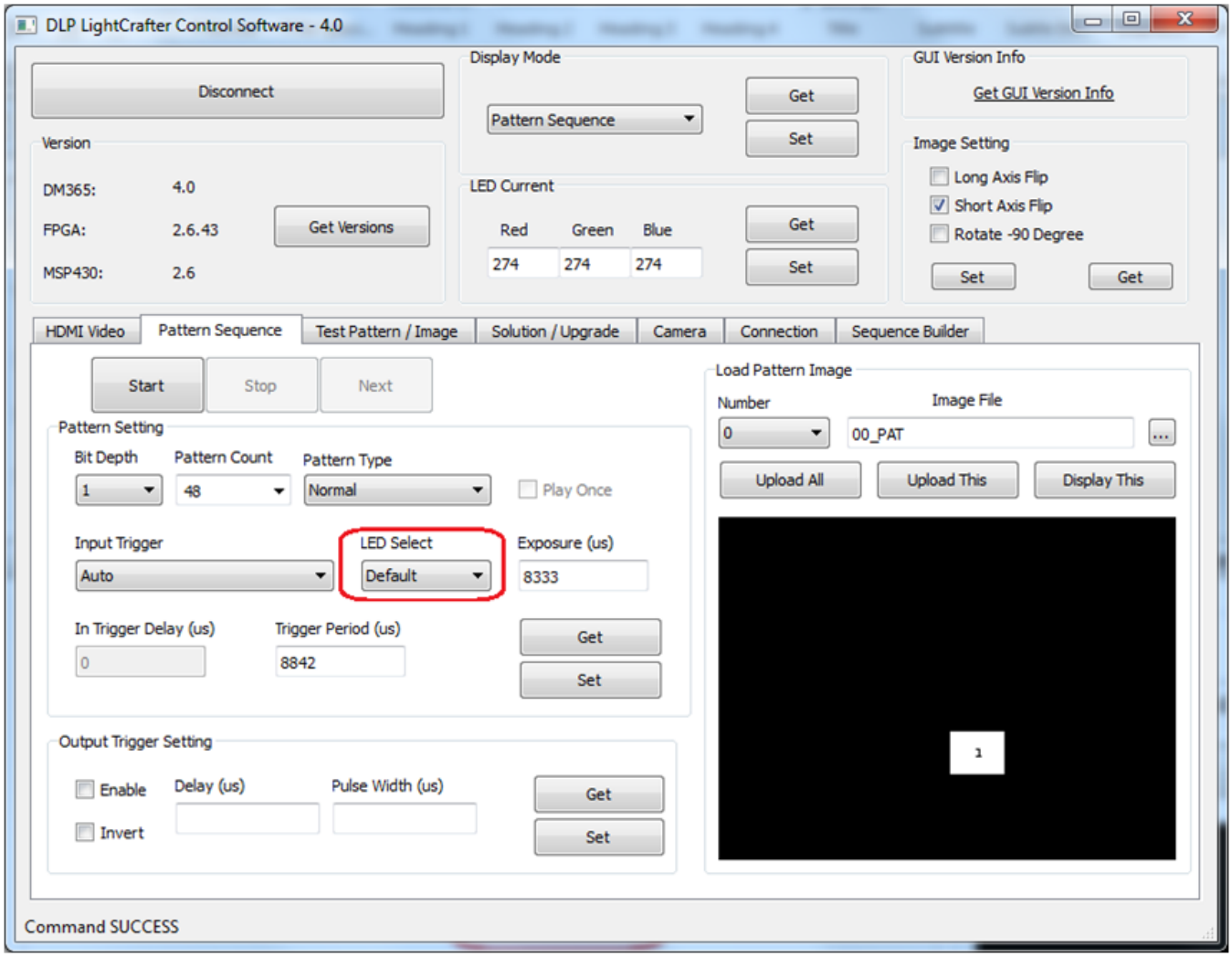


Figure 8. Screen Shot of Pattern Sequence Tab

3. Navigate to the Sequence Builder tab and load the MBMC pattern sequence binary file. First, load the sequence followed by setting the “Start Vector” and the “Num of Vectors” per the Readme file.

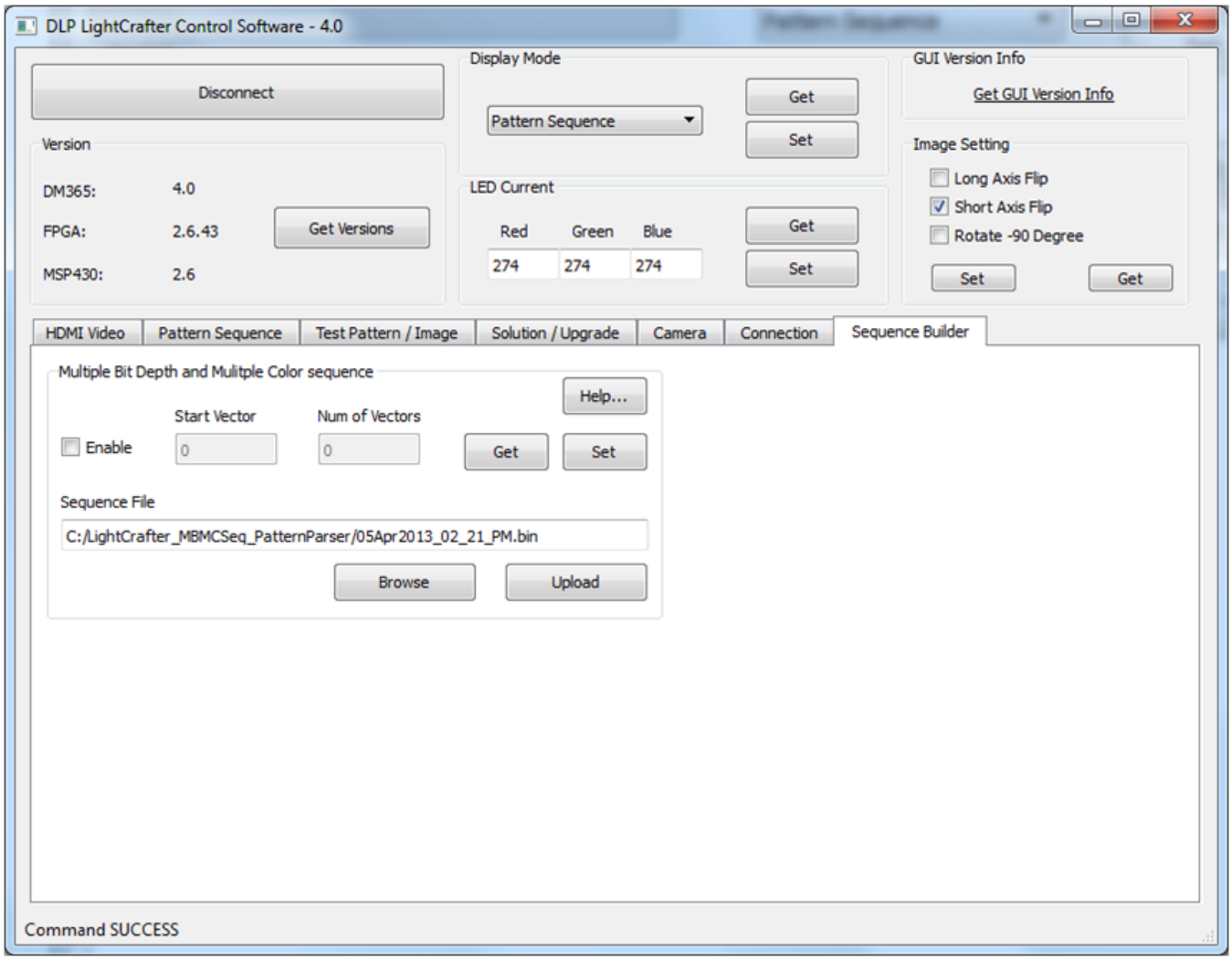


Figure 9. Screen Shot of MBMC Sequence Binary File Loading

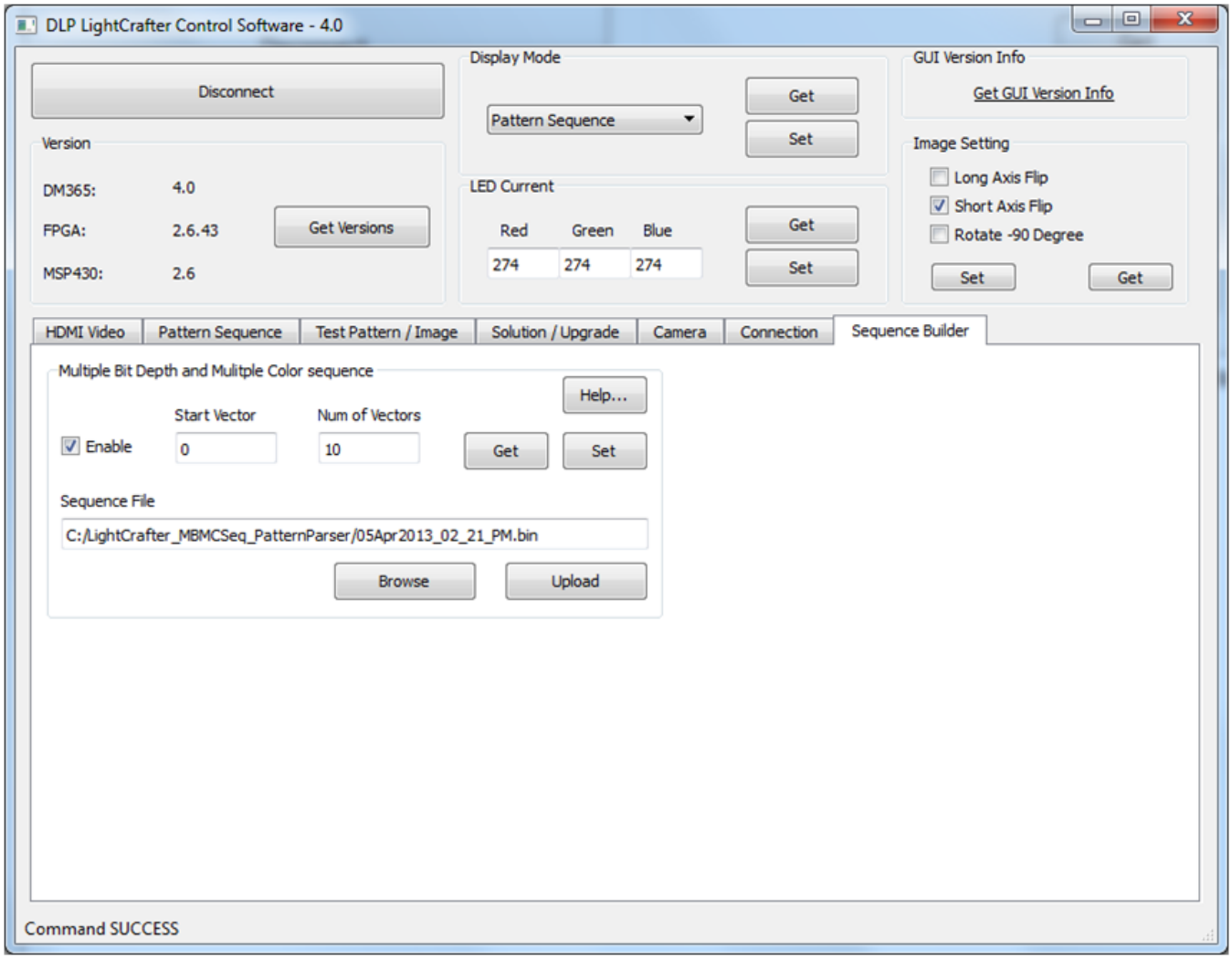


Figure 10. Screen Shot of MBMC Sequence Vector Information

4. Switch to the 'Pattern Sequence' tab.
5. Start the Sequence.

5 Save Solution for Reuse

Because of the lengthy process involved in configuring the kit to run MBMC pattern sequences, TI recommends saving the Solution for easy reuse.

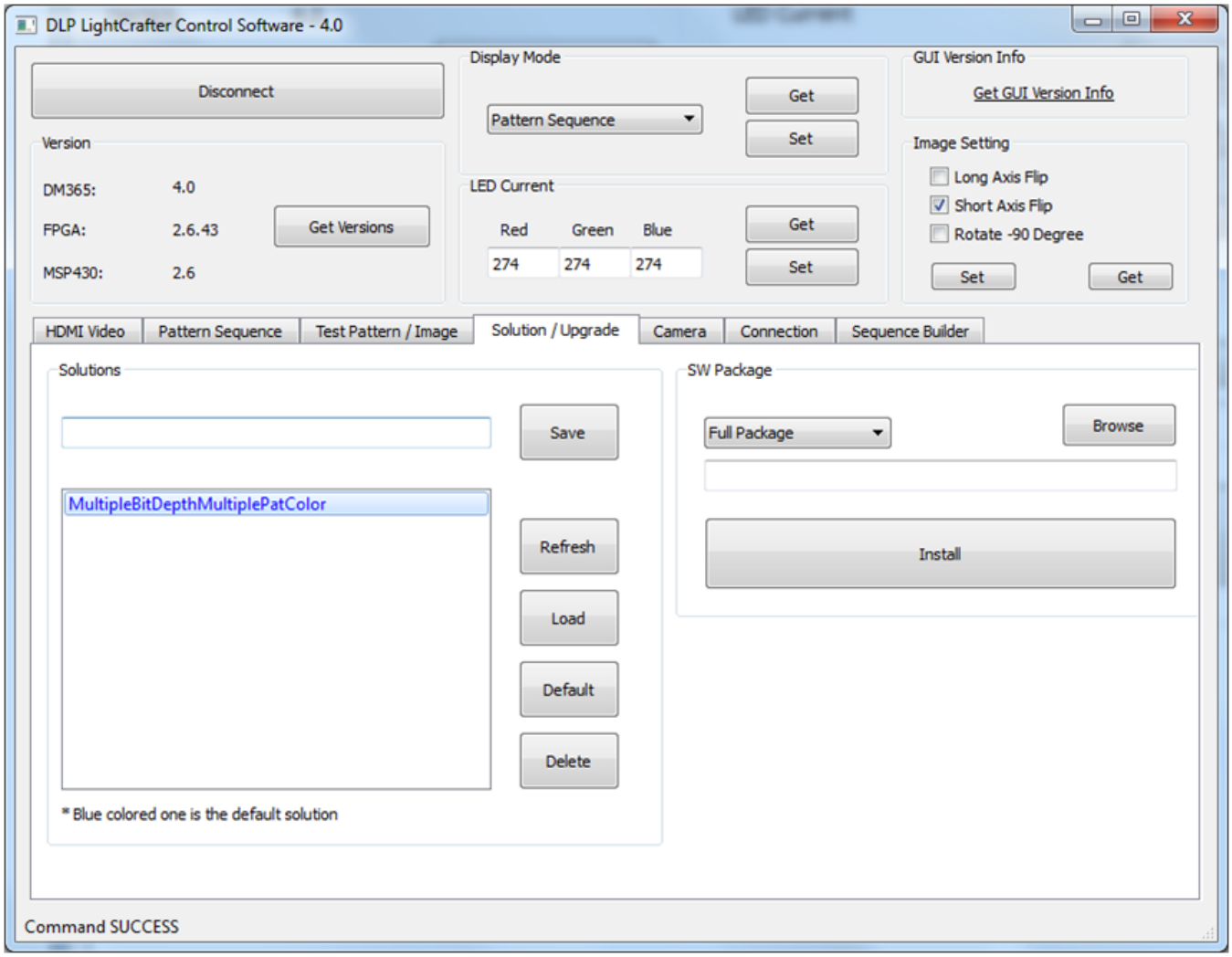


Figure 11. Screen Shot of Saved MBMC Sequence Solution

Appendix A Sample Code for Development

TCP command level implementation of downloading patterns and MBMC sequences is available in the DLP LightCrafter API Sample Code (v2.0). In the sample code, the Demo_8_VariableBitDepthPatSeqDemo() function describes how to download and configure the DLP Lightcrafter by programming instead of using the GUI.

Revision History

Changes from Original (May 2013) to A Revision	Page
• Added details about the required GUI versions specific to this application report	1

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

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