**TEXAS INSTRUMENTS**

# DLP® LightCrafter™ DM365 Command Interface Guide

## 1    About This Guide

The DLP® LightCrafter™ is a third party implementation of a next generation DLP Pico reference design to enable faster development cycles for applications requiring small form factor, and intelligent pattern display. This technology brings together a set of components providing an efficient and compelling system solution for:

- Small display projector: Embedded display, Interactive display, Information overlay
- Structured light applications: 3-D modeling/design, Biometric: fingerprint identification and face recognition, Machine vision and inspection
- Medical and life sciences: vascular imaging, dental impression scanner, intraoral dental scanners, orthopaedics, prosthesis, CT/MRI/X-Ray marking, retail cosmetics

This guide is an introductory document for the DLP® LightCrafter™ that provides an overview of host commands to control DLP® LightCrafter™'s operation. Other documents provide more in-depth information of the hardware and software features of DLP® LightCrafter™'s components.

## 1.1    Overview

The DLP® LightCrafter™ module consists of three subsystems:

- Light Engine – includes the optics, red, green, and blue LEDs, and the 608 x 684 diamond pixel 0.3" WVGA DMD. Capable of 20 lumens out-of-the-box with support to 50 lumens with user's addition of active cooling.
- Driver Board – includes the LED driver circuits, DLPC300 Controller, Power Management circuits, and MSP430.
- System Board – includes TMS320DM365, FPGA, and several connectors for external inputs.

Figure 1 shows the major hardware components.

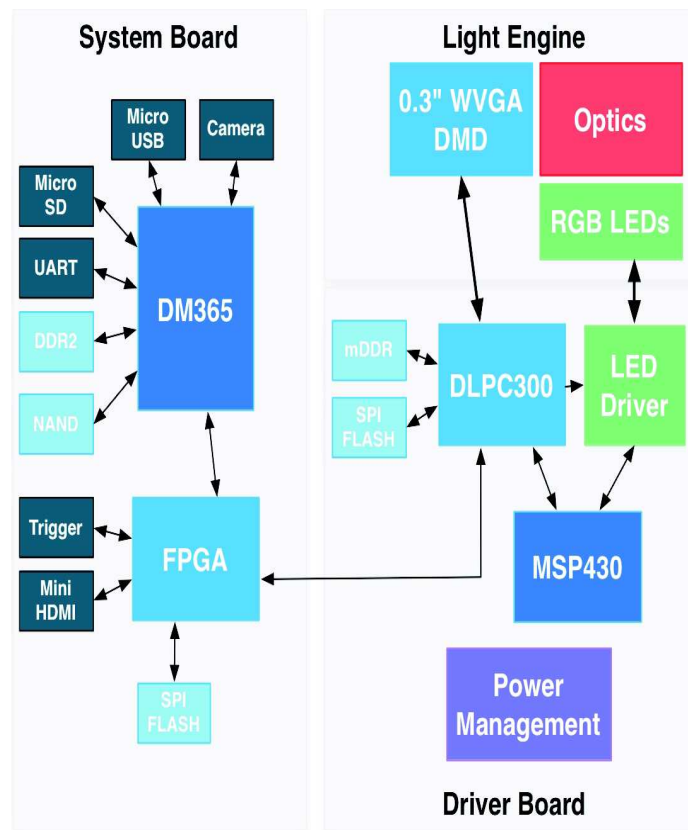DLP is a registered trademark of Texas Instruments.

**Figure 1. DLP® LightCrafter™ Block Diagram**

The DLP® LightCrafter™ module runs and embedded Linux kernel. A PC host communicates with DLP® LightCrafter™ through USB. When the LightCrafter module is connected to the PC through USB, the LightCrafter enumerates as a virtual ethernet device over USB. The virtual network on the PC is assigned IP address 192.168.1.99 while the LightCrafter module is assigned the IP address 192.168.1.100. LightCrafter uses the Remote Netword Driver Interface Specification (RNDIS) protocol to exchange TCP packets (Ethernet over USB emulation). The command packets are received on TCP port number 0x5555. Each command packet may either be sent on a single TCP packet or split accross multiple TCP packets. The TCP packets received by LightCrafter are interpreted by an application running on the DM365.

The following sections describe the packet and command structure to control the DLP® LightCrafter™ functions.

## 2    Packet Structure

All the commands are packetized. Each command packet is acknowledged by a response packet. The host must wait for the packet response before sending another command packet. Only the host can initiate the packet transaction.

A command packet consists of 6 byte header, a variable size data payload and a checksum byte.

| HEADER | | | | | | DATA | CHECKSUM |
|---|---|---|---|---|---|---|---|
| Byte 0 | Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 .. Byte N | Byte (N+1) |
| Packet Type | CMD1 | CMD2 | Flags | Payload Length | | Data Payload | Checksum |

## 2.1 Packet Type

The first byte defines the type of the packet:

    0x00 – LightCrafter System Busy Packet
    0x01 – LightCrafter Error Packet
    0x02 – Host Write Command Packet
    0x03 – LightCrafter Write Response Packet
    0x04 – Host Read Command Packet
    0x05 – LightCrafter Read Response Packet

### 2.1.1 LightCrafter System Busy Packet [Packet Type 0x00]

LightCrafter may send a System Busy Packet as a response to a Host's Write/Read command. It indicates that the LightCrafter system has not completed the previous command or is busy performing some other operation. This response has no data, so the data length of this packet is zero. All the bytes in the packet, except the first one, are ignored.

### 2.1.2 LightCrafter Error Packet [Packet Type 0x01]

LightCrafter may send an Error Packet as a response to a Host's Write/Read command. It indicates that there is an error in interpreting/executing the command. The error is passed in the data payload as one byte error code. There can be more than one error code in a single packet.

    The error packets are:

    0x01 – Command execution failed with unknown error
    0x02 – Invalid command
    0x03 – Invalid Parameter
    0x04 – Out of memory resource
    0x04 – Hardware device failure
    0x05 – Hardware busy
    0x06 – Not Initialized (any of the preconditions for the command is not met)
    0x07 – Some object referred by the command is not found. For example, a solution name was not found.
    0x08 – Checksum Error
    0x09 – Packet format error due to insufficient or larger than expected payload size
    0x0A – Command continuation error due to incorrect continuation flag

### 2.1.3 Host Write Command Packet [Packet Type 0x02]

A host Write Command sends configuration information to the LightCrafter module. The data payload contains the parameters of the command.

### 2.1.4 LightCrafter Write Response Packet [Packet Type 0x03]

The LightCrafter sends a write response packet to the host to indicate successful execution. The CMD1 and CMD2 are same as the corresponding Write Command. This packet has no data payload.

### 2.1.5 Host Read Command Packet [Packet Type 0x04]

A host Read Command requests information from the LightCrafter module. The information requested is identified using the CMD2 and CMD3. Any additional parameter is passed in the data payload.

### 2.1.6 LightCrafter Read Response Packet [Packet Type 0x05]

The LightCrafter sends a Read Response packet to the host as a response to a host Read Command. The CMD1 and CMD2 are same as the corresponding read command. The data payload has non-zero length and contains the requested information.

## 2.2 Command ID (CMD1 & CMD2)

CMD1 and CMD2 together form a unique ID for the command. The list of commands supported by the LightCrafter module is explained in Section 3

The CMD1 identifies the main command number and CMD2 describes the sub command number.

## 2.3 Payload Length (L1 & L2)

The bytes L1 and L2 represent the data length excluding checksum. L1 corresponds to the LSB while L2 corresponds to the MSB.

## 2.4 Data Payload

The data related to the current command. The data length and content will vary depending on the command. The maximum data payload size is 65535 bytes.

## 2.5 Checksum

This byte is used for verifying the integrity of the command packet. It is the sum of all the bytes in the current packet, not including the checksum byte.

Checksum = (Byte 0 + Byte 1 + … Byte N) MODULO[ 0x100 ]

## 2.6 Command Flags

The command interpreter utilizes the flags to understand and follow the transfer of data through multiple command and response packets. The flags are:

   0x00 – The packet payload contains the complete data
   0x01 – The packet payload contains the beginning of the data
   0x02 – The packet payload contains the intermediate data
   0x03 – The packet payload contains the last data

# 3 Command Specification

The following sections define the list of commands and their corresponding data payloads as supported by the LightCrafter module. The command number is the hex representation of CMD1 and CMD2 bytes. All the multi-byte data are sent in Little-endian order.

## 3.1 Version String (0x01 0x00)

This command reads the LightCrafter software and firmware versions.

**Table 1. Host Read Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | 0x00 – DM365 SW Revision<br>0x10 – FPGA Firmware Revision<br>0x20 – MSP430 SW Revision |

**Table 2. LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 – Byte 31 | Revision String (Null terminated ASCII string) |

## 3.2   Current Display Mode (0x01 0x01)

This command sets/reads the current display mode.

**Table 3. Host Write Command / LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|-----------|---------------------|
| Byte 0 | 0x00 – Static Image<br>0x01 – Internal Test Pattern<br>0x02 – HDMI Video Input<br>0x03 - Reserved<br>0x04 - Pattern Sequence Display |

## 3.3   Current Test Pattern (0x01 0x03)

This command sets/reads the currently selected Internal Test Pattern.

**Table 4. Host Write Command / LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|-----------|---------------------|
| Byte 0 | 0x00 - 14x8 Checkerboard (default)<br>0x01 - Solid black<br>0x02 - Solid white<br>0x03 - Solid green<br>0x04 - Solid blue<br>0x05 - Solid red<br>0x06 - Vertical lines (1-white, 7-black)<br>0x07 - Horizontal lines (1-white, 7-black)<br>0x08 - Vertical lines (1-white, 1-black)<br>0x09 - Horizontal lines (1-white, 1-black)<br>0x0A - Diagonal lines<br>0x0B - Vertical Gray Ramps<br>0x0C - Horizontal Gray Ramps<br>0x0D - ANSI 4x4 Checkerboard |

## 3.4   LED Current Setting (0x01 0x04)

This command sets/reads the red, green, and blue LED current values.

**Table 5. Host Write Command / LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|-----------|---------------------|
| Byte 0 - Byte 1 | Red LED current. Range 0 – 1024. Default 274 |
| Byte 2 - Byte 3 | Green LED current. Range 0 – 1024. Default 274 |
| Byte 4 - Byte 5 | Blue LED current. Range 0 – 1024. Default 274 |

If 0 is set, then that particular LED is disabled. 0x400 means full current (2A) and should only be used in short bursts. A value of 0x112 corresponds to 633mA. 633mA is the maximum amount for continuous operation with no active thermal cooling.

## 3.5   Static Image (0x01 0x05)

This command loads a static bitmapped image into the LightCrafter's DLPC300 memory buffer.

**Table 6. Host Write Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte N | BMP image file contents. When no image is loaded a 24-bit red, green, and blue vertical color bar is displayed. |

## 3.6 Static Color (0x01 0x06)

This command fills the screen with given color (24 bit) when set to "Static Image mode".

**Table 7. Host Write Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte 3 | 24 bit Color in 00RRGGBB format |

## 3.7 Display Setting (0x01 0x07)

This command sets/reads the current display setting.

**Table 8. Host Write Command / LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | Flip image on long axis |
| | 0 - No flip (default) |
| | 1 - Flip on long axis |
| Byte 1 | Flip image on short axis |
| | 0 - No flip |
| | 1 - Flip on short axis (default) |
| Byte 2 | Rotate image by -90 degrees |
| | 0 - No rotation (default) |
| | 1 - Rotate image by -90 degrees |

## 3.8 Video Input Setting (0x02 0x00)

This command sets/reads the current video input setting.

**Table 9. Host Write Command / LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte 1 | Input Resolution X |
| Byte 2 - Byte 3 | Input Resolution Y |
| Byte 4 - Byte 5 | First Active Pixel (Input cropping) |
| Byte 6 - Byte 7 | First Active Line (Input cropping) |
| Byte 8 - Byte 9 | Active Width (Input cropping) |
| Byte 10 - Byte 11 | Active Height (Input cropping) |

Table 10 shows the supported resolutions. Note that the EDID is set to 608 x 684 mode. To report a different resolution through the HDMI input, a different resolution must be programmed on the EDID.

**Table 10. Supported Resolutions for Video Input**

| | | | |
|---|---|---|---|
| 240x320 | 640x480 | 480x852 | 864x480 |
| 320x240 | 480x720 | 852x480 | 720x240 |
| 240x427 | 720x480 | 480x853 | 720x288 |
| 427x240 | 480x752 | 853x480 | 360x640 |

**Table 10. Supported Resolutions for Video
Input (continued)**

| 430x640 | 752x480 | 480x853 | 640x360 |
|---------|---------|---------|---------|
| 640x430 | 480x800 | 854x480 | 854x480 |
| 480x640 | 800x480 | 480x854 | 608x684 |

## 3.9 Video Mode Setting (0x02 0x01)

This command sets/reads the current video mode setting.

**Table 11. Host Write Command / LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|-----------|---------------------|
| Byte 0 | Frame Rate 15, 30, 40, 50, or 60 Hz. Default is 60 Hz |
| Byte 1 | Bit Depth. Range 1 – 8. (default is 8) |
| Byte 2 | 1 - RGB: Uses Red, Green, and Blue LEDs for full color (default)<br>2 - Monochrome Red LED<br>3 - Monochrome Green LED<br>4 - Monochrome Blue LED |

## 3.10 Pattern Sequence Setting (0x04 0x00)

This command defines/reads a pattern sequence setting.

**Table 12. Host Write Command / LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|-----------|---------------------|
| Byte 0 | Pattern bit depth (1 – 8) |
| Byte 1 | Number of patterns in the sequence ( 1 – 96) |
| Byte 2 | Include inverted patterns (only applicable for 1 bit patterns)<br>0 – Every pattern is displayed<br>1 – Each pattern is displayed and followed by its inverted pattern before the next pattern is displayed |
| Byte 3 | Input trigger type<br>00 – Command Trigger (Through Current Pattern Command)<br>01 – Auto Trigger<br>02 – External Trigger (Positive Polarity)<br>03 – External Trigger (Negative Polarity)<br>04 – Camera Trigger (Positive Polarity)<br>05 – Camera Trigger (Negative Polarity)<br>06 – External Trigger + Exposure (only for 1-bit depth mode) |
| Byte 4 - Byte 7 | Input Trigger Delay in micro seconds |
| Byte 8 - Byte 11 | Trigger Period in micro second (only for Auto Trigger mode) |
| Byte 12 - Byte 15 | Exposure Time in micro seconds |
| Byte 16 | LED Select<br>0 – Red<br>1 – Green<br>2 – Blue |

### 3.11 Pattern Definition (0x04 0x01)

This command defines/reads the pattern used in the pattern sequence.

**Table 13. Host Write Command / LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | Pattern Number (0 – 95/BitsPerPattern) |
| Byte 1 - Byte N | The Pattern bitmap in Windows BMP format. Supported bit-depths are 1, 2, 4 and 8. Only the least bits of size defined by the current bit depth will be used. |

**Table 14. Host Read Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | Pattern Number (0 – 95/BitsPerPattern) |

**Table 15. LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte N | The pattern bitmap in Windows BMP format. Supported bit-depths are 1, 2, 4, and 8. If the image bit-depth is more than the current bit-depth setting, then only the least significant bits of the image bit-depth are used. |

### 3.12 Start Pattern Sequence (0x04 0x02)

This command starts or stops the display of currently defined pattern sequence

**Table 16. Host Write Command / LigthCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | 0 – Stop Pattern Sequence<br>1 – Start Pattern Sequence |

### 3.13 Advance Pattern Sequence (0x04 0x03)

This command advances the pattern to the next stored pattern. This is only valid in SW Trigger mode. No data payload is used.

**Table 17. Host Write Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| none | |

### 3.14 Trigger Output Setting (0x04 0x04)

This command sets/reads the trigger output setting (used for camera trigger).

**Table 18. Host Write Command / LigthCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | TRUE – Enable Trigger output<br>FALSE – Disable Trigger output |
| Byte 1 | Trigger source selection |

**Table 18. Host Write Command / LigthCrafter Read Response Data
Payload (continued)**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 2 | Trigger Polarity<br>0 – Positive<br>1 – Negative |
| Byte 3 - Byte 6 | Trigger Delay in micro seconds |
| Byte 7 - Byte 10 | Trigger Pulse Width |

## 3.15  Display Pattern (0x04 0x05)

This command (supported in DM365 firmware version 3.0 or greater) continuously displays the selected pattern sequence with the inidcates exposure and trigger period settings.

**Table 19. Host Write Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte 1 | Pattern number. Range of values 1-1500 |

## 3.16  Extended Pattern Sequence Setting (0x04 0x08)

This command (supported in DM365 firmware version 3.0 or greater) defines/reads an extended pattern sequence setting.

**Table 20. Host Write Command / LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | Pattern bit depth (1 – 8) |
| Byte 1 - Byte 2 | Number of patterns in the sequence ( 1 – 1000) |
| Byte 3 | Include inverted patterns (only applicable for 1 bit patterns)<br>0 – Every pattern is displayed<br>1 – Each pattern is displayed and followed by its inverted pattern before the next pattern is displayed |
| Byte 4 | Input trigger type<br>00 – Command Trigger (Through Current Pattern Command)<br>01 – Auto Trigger<br>02 – External Trigger (Positive Polarity)<br>03 – External Trigger (Negative Polarity)<br>04 – Camera Trigger (Positive Polarity)<br>05 – Camera Trigger (Negative Polarity)<br>06 – External Trigger + Exposure (only for 1-bit depth mode) |
| Byte 5 - Byte 8 | Input Trigger Delay in micro seconds |
| Byte 9 - Byte 12 | Trigger Period in micro second (only for Auto Trigger mode) |
| Byte 13 - Byte 16 | Exposure Time in micro seconds |
| Byte 17 | LED Select<br>0 – Red<br>1 – Green<br>2 – Blue |
| Byte 18 | Play mode (not applicable in Auto Trigger setting)<br>0 - Display pattern sequence once, with each pattern displayed after a trigger<br>1 - Continuously display pattern sequence, with each pattern displayed after a trigger |

### 3.17 *Extended Pattern Definition (0x04 0x81)*

This command (supported in DM365 firmware version 3,0 or greater) defines/reads one pattern of a pattern sequence.

#### Table 21. Host Write Command Data Payload

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte 1 | Pattern Number (0 – 1500) |
| Byte 2 - Byte 3 | Column position to display this pattern within the DMD |
| Byte 4 - Byte 5 | Row position to display this pattern within the DMD |
| Byte 6 - Byte N | The pattern bitmap in Windows BMP format. Supported bit-depths are 1, 2, 4, 8, and 24-bits. If the image bit-depth is more than the current bit-depth setting, then only the least significant bits of the image bit-depth are used. |

#### Table 22. Host Read Command Data Payload

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte 1 | Pattern Number (0 – 1500) |

#### Table 23. LightCrafter Read Response Data Payload

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte N | The pattern bitmap in Windows BMP format. Supported bit-depths are 1, 2, 4, 8, and 24-bits. If the image bit-depth is more than the current bit-depth setting, then only the least significant bits of the image bit-depth are used. |

### 3.18 *Camera Capture (0x05 0x00)*

This command captures one frame of the image from the integrated camera port and returns the raw bytes.

#### Table 24. Read Command Data Payload

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | Capture Mode<br>0 – Stop capture<br>1 - Single frame capture<br>2 - Continuous capture |

#### Table 25. Read Response Data Payload

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Bytes 0 - Byte 1 | Width of the image |
| Bytes 2 - Byte 3 | Height of the image |
| Byte 4 | Image format<br>0 - RGB888 (3 bytes per pixel)<br>1 - 8-bit Gray Scale (1 byte per pixel)<br>2 - 10-bit Gray Scale (2 bytes per pixel)<br>3 - UYVY16 (2 bytes per pixel)<br>4 - RGB565 (2 bytes per pixel)<br>5 - SBGGR888 (1 byte per pixel - Bayer format) |
| Bytes 5 - Byte 6 | Trigger delay in microseconds |
| Bytes 7 - Byte 10 | Trigger pulse width |

### 3.19 Save Solution/Read Solution (0x06 0x00)

This command saves the current settings of the displayed mode in persistent memory storage with the given solution name. This setting can be restored using the "Manage Solution" command.

**Table 26. Host Write Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte 31 | 32 byte Solution name (0 padded string) |

**Table 27. LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | Number of solutions stored (0 – 254) |
| Byte 1 | Default solution index (0 – 254)<br>255 – No default solution |
| Byte 2 - Byte 33 | First solution name (0 padded string) |
| Byte 34 - Byte 65 | Second solution name (0 padded string) |
| … | … |

### 3.20 Manage Solution (0x06 0x01)

Loads, deletes, or set as default the previously saved solution of the given solution name.

**Table 28. Host Write Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | 0 – Delete Solution<br>1 – Load Solution<br>2 – Set as Default Solution |
| Byte 1 - Byte 32 | Solution Name (0 padded string) |

### 3.21 Installation File (0x07 0x00)

This command downloads and install the firmware file.

**Table 29. Host Write Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte 3 | "IPKG" (File identifier) |
| Byte 4 - Byte 35 | Version string for this install package |
| Bytes 36 | Number of files in this package |
| Byte 37 - Byte 39 | Reserved |
| Byte 40 - Byte 43 | ID of the First Installation File |
| Byte 44 - Byte 75 | Version string of the First Installation File |
| Byte 76 - Byte 79 | Length of the First Installation File |
| Byte 80 - Byte 83 | 32 bit Checksum of the First Installation File |
| Byte 84 - Byte (84 + N) | First Installation File contents (N = file length) |
| Byte N - Byte (N + 3) | ID of the Second Installation File |
| Byte (N + 4) - Byte (N + 35) | Version string of the Second Installation File |
| Byte (N + 36) - Byte (N + 39) | Length of the Second Installation File |
| Byte (N + 40) - Byte (N + 40 + M) | Second Installation File contents (M = file length) |
| Byte (N + 40 + M) - Byte (N + 43 + M) | ID of the Third Installation File |

**Table 29. Host Write Command Data Payload (continued)**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| ... | |

Install File ID:
    "MSPS" – MSP430 Firmware in tagged hex format
    "FPGA" – FPGA Configuration file in "rbf" format
    "DLPC" – DLPC300 Firmware in binary format
    "EDID: - EDID Content in binary format

## 3.22 Set IP Address (0x08 0x00)

This command changes the IP address of the LightCrafter module.

**Table 30. Host Write Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte 3 | IP address in 4 byte format. Default 192.168.1.100 |

## 3.23 DLPC300 Register (0xFF 0x00)

This command writes/reads the DLPC300 register.

**Table 31. Host Write Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | DLPC300 Register Address |
| Byte 1 - Byte 4 | Data to be written to the register |

**Table 32. Host Read Command Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 | DLPC300 Register Address |

**Table 33. LightCrafter Read Response Data Payload**

| DATA BYTE | VALUE - DESCRIPTION |
|---|---|
| Byte 0 - Byte 3 | Data read from the register |

# IMPORTANT NOTICE