![Texas Instruments logo]

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.
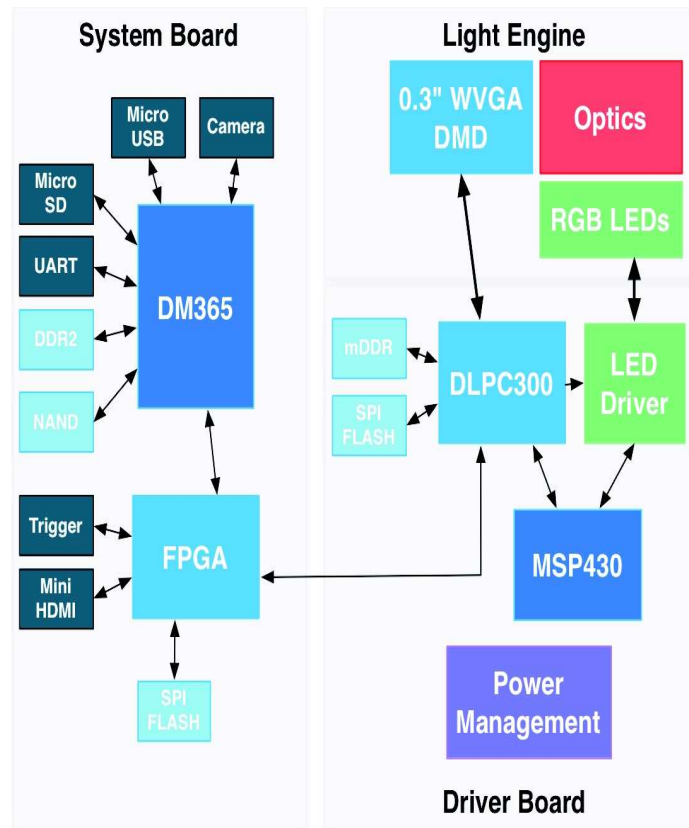
Figure 1 shows the major hardware components.

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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 Network 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 across 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
0x05 – Hardware device failure
0x06 – Hardware busy
0x07 – Not Initialized (any of the preconditions for the command is not met)
0x08 – Some object referred by the command is not found. For example, a solution name was not found.
0x09 – Checksum Error
0x0A – Packet format error due to insufficient or larger than expected payload size
0x0B – 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 CMD1 and CMD2. 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 the 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:

0×00 – The packet payload contains the complete data

0×01 – The packet payload contains the beginning of the data

0×02 – The packet payload contains the intermediate data

0×03 – 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 (0×01 0×00)

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 0x10 – FPGA Firmware Revision 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 (0×01 0×01)

This command sets/reads the current display mode.

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

DATA BYTE	VALUE - DESCRIPTION
Byte 0	0×00 – Static Image 0×01 – Internal Test Pattern 0×02 – HDMI Video Input 0×03 - Reserved 0×04 - 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 - 14×8 Checkerboard (default) 0x01 - Solid black 0x02 - Solid white 0x03 - Solid green 0x04 - Solid blue 0x05 - Solid red 0x06 - Vertical lines (1-white, 7-black) 0x07 - Horizontal lines (1-white, 7-black) 0x08 - Vertical lines (1-white, 1-black) 0x09 - Horizontal lines (1-white, 1-black) 0x0A - Diagonal lines 0x0B - Vertical Gray Ramps 0x0C - Horizontal Gray Ramps 0x0D - ANSI 4×4 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. 0×400 means full current (2 A) and should only be used in short bursts. A value of 0×112 corresponds to 633 mA. 633 mA is the maximum amount for continuous operation with no active thermal cooling.

3.5 Static Image (0×01 0×05)

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.

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

3.6 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

3.7 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 × 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

240×320	640×480	480×852	864×480
320×240	480×720	852×480	720×240
240×427	720×480	480×853	720×288
427×240	480×752	853×480	360×640

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

430×640	752×480	480×853	640×360
640×430	480×800	854×480	854×480
480×640	800×480	480×854	608×684

3.8 Video Mode Setting (0×02 0×01)

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) 2 - Monochrome Red LED 3 - Monochrome Green LED 4 - Monochrome Blue LED

3.9 Pattern Sequence Setting (0×04 0×00)

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) 0 – Every pattern is displayed 1 – Each pattern is displayed and followed by its inverted pattern before the next pattern is displayed 2 - Use Internally Generated 1 bpp Patterns. Refer to command (0×04 0×06) for more details
Byte 3	Input trigger type 00 – Command Trigger (Through Current Pattern Command) 01 – Auto Trigger 02 – External Trigger (Positive Polarity) 03 – External Trigger (Negative Polarity) 04 – Camera Trigger (Positive Polarity) 05 – Camera Trigger (Negative Polarity) 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 0 – Red 1 – Green 2 – Blue

3.10 Pattern Definition (0×04 0×01)

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.

3.11 Start Pattern Sequence (0×04 0×02)

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 1 – Start Pattern Sequence

3.12 Advance Pattern Sequence (0×04 0×03)

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	

3.13 Trigger Output Setting (0×04 0×04)

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 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 0 – Positive 1 – Negative
Byte 3 - Byte 6	Trigger Delay in micro seconds
Byte 7 - Byte 10	Trigger Pulse Width

3.14 Display Pattern (0×04 0×05)

This command (supported in DM365 firmware version 3.0 or greater) continuously displays the selected pattern sequence with the indicates 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

3.15 Define Internally Generated Pattern (0x04 0x06)

This command (supported in DM365 firmware version 4.0 or greater)

Define the Internally Generated Pattern sequence. There are 16 internally generated patterns pre-defined in the DLPC300 and each one can be inverted. Up to 32 patterns can be displayed in a sequence. PatternType = 2 should be selected in Pattern sequence setting(cmd id = 0×04 0×0 or cmd id = 0×04 0×80) for this to work.
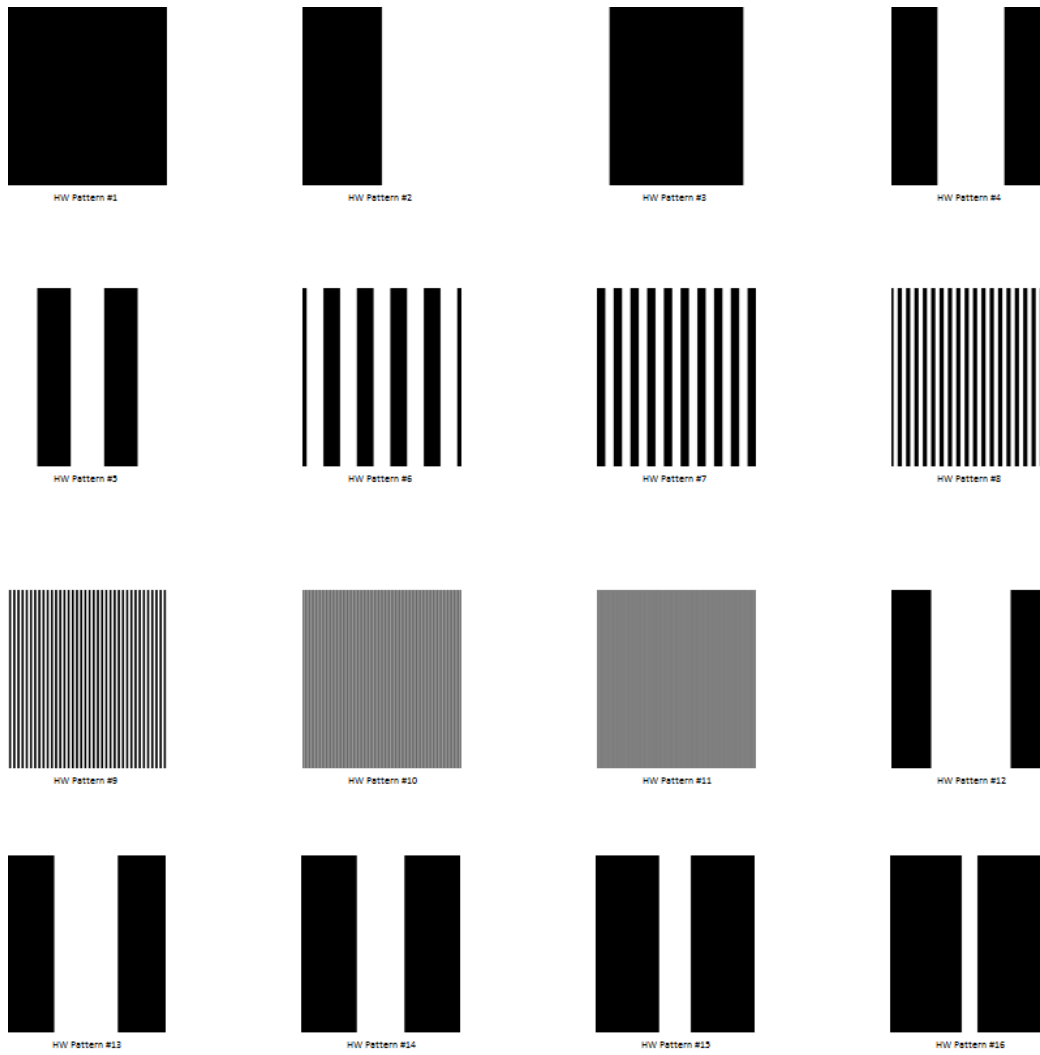
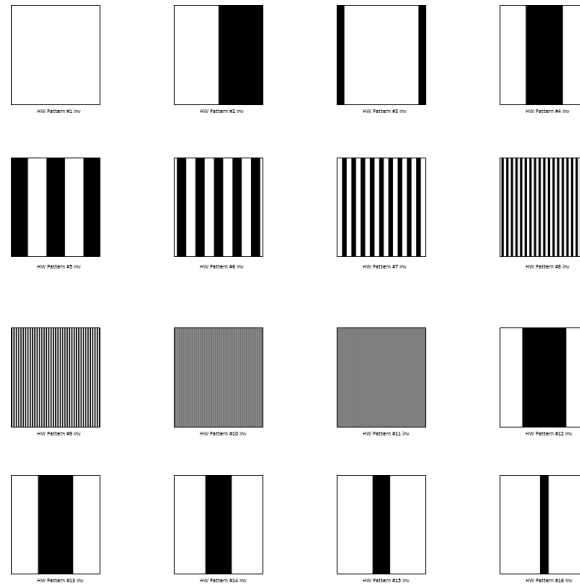**Figure 2. Internally Generated Patterns**

Figure 3. Internally Generated Patterns Inverted

Table 20. Host Write Command Data Payload

DATA BYTE	VALUE - DESCRIPTION
Byte 0	Start Index of the internally generated pattern to be defined
Byte 1	Number of patterns to be defined
Byte 2	Internally generated Pattern Number (0 – 15 Predefined patterns)
Byte 3	Invert internally generated 1bpp Pattern 0 - Do not invert 1 - Invert Pattern
Byte 4	Repeat Byte 2 - Byte 3 for each pattern

Extended Pattern Sequence Setting (0×04 0×80)

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

Table 21. 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) 0 – Every pattern is displayed 1 – Each pattern is displayed and followed by its inverted pattern before the next pattern is displayed 2 – Use Internally Generated Patterns. Refer to command 0x04 0x06

Table 21. Host Write Command / LightCrafter Read Response Data Payload (continued)

DATA BYTE	VALUE - DESCRIPTION
Byte 4	Input trigger type 00 – Command Trigger (Through Current Pattern Command) 01 – Auto Trigger 02 – External Trigger (Positive Polarity) 03 – External Trigger (Negative Polarity) 04 – Camera Trigger (Positive Polarity) 05 – Camera Trigger (Negative Polarity) 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 0 – Red 1 – Green 2 – Blue
Byte 18	Play mode (not applicable in Auto Trigger setting) 0 - Display pattern sequence once, with each pattern displayed after a trigger 1 - Continuously display pattern sequence, with each pattern displayed after a trigger

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 22. 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 23. Host Read Command Data Payload

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

Table 24. 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.

3.16 Camera Capture (0×05 0×00)

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

Table 25. Read Command Data Payload

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

Table 26. 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 0 - RGB888 (3 bytes per pixel) 1 - 8-bit Gray Scale (1 byte per pixel) 2 - 10-bit Gray Scale (2 bytes per pixel) 3 - UYVY16 (2 bytes per pixel) 4 - RGB565 (2 bytes per pixel) 5 - SBGGR888 (1 byte per pixel - Bayer format)
Bytes 5 - Byte 6	Trigger delay in microseconds
Bytes 7 - Byte 10	Trigger pulse width

3.17 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 27. Host Write Command Data Payload

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

Table 28. LightCrafter Read Response Data Payload

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

3.18 Manage Solution (0×06 0×01)

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

Table 29. Host Write Command Data Payload

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

Installation File (0×07 0×00)

This command downloads and install the firmware file.

Table 30. 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
…	

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

Set IP Address (0×08 0×00)

This command changes the IP address of the LightCrafter module.

Table 31. Host Write Command Data Payload

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

3.19 Load Custom Sequence Image (0×0A 0×00)

This command loads the Custom Sequence into the DLPC300 controller

Table 32. Host Write Command Data Payload

DATA BYTE	VALUE - DESCRIPTION
Byte 0 - Byte N	Custom Sequence binary data

3.20 Enable Custom Sequence (0×0A 0×01)

This command (supported in DM365 firmware version 4.0 or greater)

This command configures the Custom sequence Vector information.

Table 33. Host Write Command / LightCrafter Read Response Data Payload

DATA BYTE	VALUE - DESCRIPTION
Byte 0	Custom sequence Start Vector information [1] [2] [3]
Byte 1	Number of Vectors in the Custom sequence

[1] Sending this command without loading custom sequence returns command failed.
[2] By sending this command with Byte 0 = 0×00 and Byte 1 = 0×00 will basically disable the custom sequence.
[3] Similarly, upon reading the Custom Sequence enable state if the returned value shows that Byte 0/Start Vector = 0 and Byte 1/Number of Vectors = 0 means the custom sequence is not running or enabled.

3.21 DLPC300 Register (0xFF 0x00)

This command writes/reads the DLPC300 register.

Table 34. 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 35. Host Read Command Data Payload

DATA BYTE	VALUE - DESCRIPTION
Byte 0	DLPC300 Register Address

Table 36. LightCrafter Read Response Data Payload

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

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