DDP3021 Solid State Software Programmer's Guide

DLP® Products

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TEXAS INSTRUMENTS

Revision History

Rev	Section	Revisions
A	All	Initial Release
B	All	Revised commands 0x06, 0x07, 0x28, 0x29, 0x2A, 0x2B, 0x2C, 0x43, 0x80, 0xA0, 0xAB, 0xAC, 0xAD, 0xAE, 0xB3, and 0xB4
C	10.2, 13.5, 14.1.12, 14.2.5, 14.1.4	Inserted note in section 10.2 stating that Display Color Segment does not require calibration to be unlocked. Updated section 13.5 per $1999 CQ5219 (PWM duty cycle min/max). Added note to Color Point Processing Control stating CCP_enable and select_desaturation_mode cannot be used in LED OFF mode. Revised Request Internal Color Sensor Measurements (Command 0xA2). Added Set Internal Sensor Averaging command.
D	7.9, 7.19, 7.25, 8, 9.2.3, 12.3,12.5, 12.6, 11.1, 11.2, 13.3, 14 Multiple	Added LED Off control bit to DB Configuration Added HSG commands, Added Projection mode notes, Inserted 3D interface commands Section Changed range from 0-511 to 1-1024 Changed DB Min/Max limits, Added EEPROM read capability, Added Slave Status command for Dual ASIC systems Added Extended status command, Fixed DB borders range, Updated several Color Point Processing (DSP) commands; Removed legacy DSP commands 0x20-26, 0xAA Organized sections for more logical grouping.
E	7.10	Inserted Run-Time Calibration Disable command
F	2.9 6.2 7.19, 7.20 7.25 All 14.2.19 Appendix A Appendix C	Revised minimum delay time Removed Bookmark error Revised notes section Fixed Bookmark error Deleted commands 0x53, 0x55, 0x56, 0x61, 0xc0, 0xc4,0xc6, 0xc7, and 0xc8 Inserted Request De-saturation Mode command (0xCD) Updated quick reference table Deleted DDP1011 references
G	14.2.16 11	Added Request DSP Sensor Timing Configuration (0xB9 command) Corrected definition of ssfail field for System status
H	8.2	Field "Glasses shutter transition time" of command 0x39 is now read only, writes to this field will be ignored

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1 Introduction

A brief summary of this paper, trademark information, and documents associated to this work can be found in this introductory section.

1.1 Abstract

This document specifies the ARM software control interface to the DDP3021 Solid State Component Set.

This document also defines all applicable communication protocols, initialization, timing and control bit definitions.

1.2 Trademarks

The Texas Instruments logo and Texas Instruments are registered trademarks of Texas Instruments.

Trademarks of Texas Instruments include:

- TI™
- DLP®
- Digital Light Processing®
- BrilliantColor™
- DynamicBlack™
- DynamicColor™
- SmoothPicture™
- SharpPicture™
- DLP Composer™
- DarkChip™

1.3 Applicable Documents

The following documents are for reference only:

- DLP® Products DDP3021 Solid State Component Set User's Guide, TI PN 2507783
- DDP3021 Datasheet, TI PN 2506502
- PMD1000 Motor Controller Data Sheet, TI PN 2506224
- Solid State Driver Interface Specification, TI PN 2507926
- I^2C Bus Specification - Philips Semiconductor 1994 Desktop Video Data Handbook

2 Initialization

Information on application initialization is found in this section.

After assertion of the PWR_GOOD signal, the DDP3021 ASIC will begin executing the application initialization. A memory test is run, followed by the setting of all default I^2C parameters based on the user input values from FLASH.

The Master ASIC then, in the following order, writes the sequence table duty cycles to the DSP, enables the sequencer and Solid State driver, and after receiving SS_LIT status, sends the calibration mode command to the DSP.

The Projection Mode is set to Blank at this time and is not changed to the default Projection Mode (or user-selected Projection Mode) until after the I^2C service delay expires. During the I^2C service delay, the DSP will run a built-in calibration, which is separate from the calibration procedure described in *Section 4 System Calibration Procedure* on page 14. No user input is required for this calibration.

Projection Mode commands sent during the I^2C service delay will be acknowledged but not applied. After the I^2C service delay has expired, the last Projection Mode command received will be applied to the hardware.

Information on the initialization sequence of an LED-based solid state illumination system is provided below in this section.

2.1 Power-up Timeline

Figure 1: LED System Power-Up Timeline on page 10 shows the timeline of activity during system power-up process for an LED system.

When the power is applied to the ASIC, the ARM CPU performs Power-up Reset Processing. The LED_ENABLE command occurs, and the LEDs are illuminated.. Upon receiving LED_LIT from the driver, the ARM will initialize the DSP and command calibration to occur.

The OEM host must then send the following calibration data to the ARM through the DSP Color Manager Control I^2C Command. (See *Section 4* on page 14.)

- External Measured Red x,y,L color Point (DSP Color Manager Control I^2C Command: 0x00) acquired during initial calibration.
- External Measured Green x,y,L color Point (DSP Color Manager Control I^2C Command: 0x01) acquired during initial calibration.
- External Measured Blue x,y,L color Point (DSP Color Manager Control I^2C Command: 0x02) acquired during initial calibration.
- Measured Internal Color Points (DSP Color Manager Control I^2C Command: 0x17) measured continually by the DLP® Chipset and obtained by request when necessary.
- Disable Calibration Mode and then Enable Color Processing Mode. (DSP Color Manager Control I^2C Command: 0x87. OEM should enable as described in *Figure 1: LED System Power-Up Timeline*.) The same command can be used to disable calibration and enable color processing.

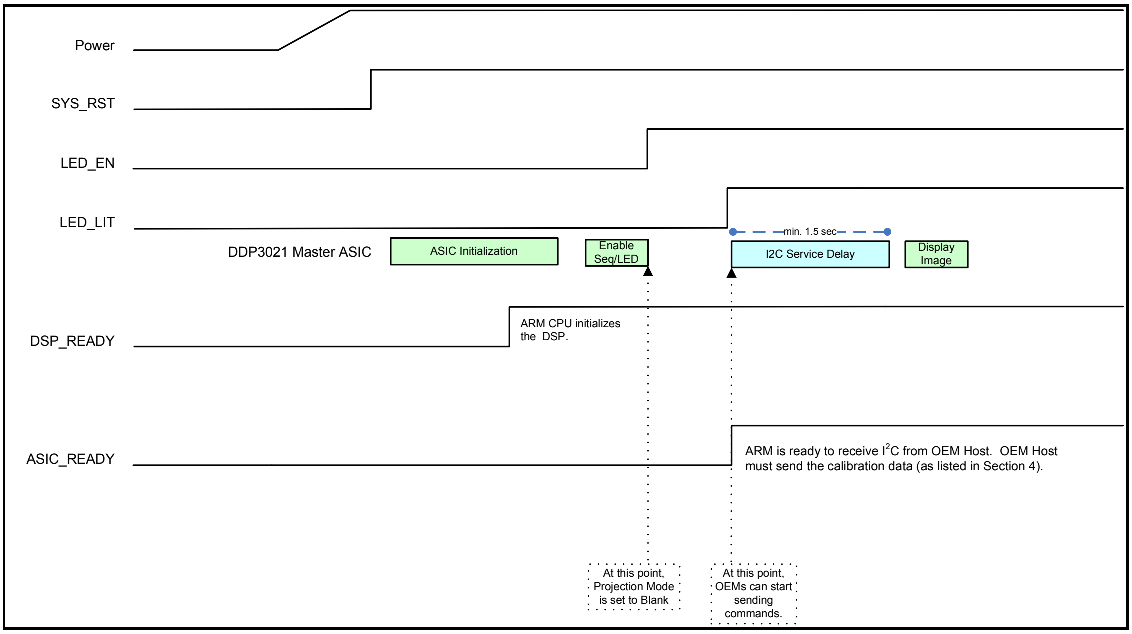

Figure 1: LED System Power-Up Timeline

2.2 Initialize the Formatter Electronics

The ARM Software initializes the formatter hardware in small increments. This allows the reset processing to take the least amount of time possible.

2.3 PMD 1000 Fans

After the formatter electronics are initialized, the PMD1000 fan outputs are initialized to values found in the flash memory.

2.4 RLDRAM Memory Test

After the LED_LIT is asserted, a simple test of the RLDRAM memory system is performed. The result of this test (pass/fail) is recorded for later use in the system status and initialization processing (See *Section 2.8 Memory Test Failure Retry* on page 11.

2.5 LED Enable

The LED module will be enabled during initialization and prior to the I^2C service delay. The LED strobe outputs will also be active (Sequence running) before the LED Enable signal is asserted. The DSP will start sending SPI transfers specifying an appropriate current. The LED driver will respond to the LED_EN signal by enabling current to the LEDs. Once current is enabled, the driver will activate the LED_LIT signal. Once the LED_LIT signal is activated, the DSP can start controlling the current to the LEDs.

2.6 Default Processing

After the LED is enabled, the default values saved in the Flash memory shall be applied to corresponding I^2C command registers.

2.7 EEPROM Processing

If an optional EEPROM is installed and contains commands, this command stream will be played back into the I^2C command registers. Adding this optional EEPROM to the system will increase the initialization time by measurable amount. The amount of increase depends on the number and type of I^2C commands saved in the EEPROM command stream.

2.8 Memory Test Failure Retry

During initialization of the system, a software reset may be required if the RLDRAM Memory Test fails. This reset will occur before assertion of the LED_EN signal. This Memory Test Failure retry will only occur once per system reset.

2.9 I2C Service Delays

The I^2C service delay period begins on the transition of the hardware ASICREADY signal. Refer to the DDP3021 Solid State Component Set User's Guide for a detailed specification of this signal.

I^2C commands sent during the I^2C service delay period will be acknowledged and processed. The delay period is provided as a window of opportunity to modify default settings. Changes to default settings made during this delay period shall be applied prior to the display of the initial screen image. The I^2C service delay time is programmable through the DLP Composer™ tool set. The minimum delay time is 4 seconds to avoid displaying the internal calibration LED current ramp.

2.10 Display an Image

The display of the video image, or a default display mode, activates after the formatter electronics initialize, the LED module enables, the LED_LIT signal asserts, initial sensor data is collected, and the I^2C Service Delay expires.

3 Steady State Processing

Information on the steady state operation of an LED-based solid state illumination system is provided below in this section.

3.1 Steady State Timeline

To support DynamicBlack™ processing, the DSP transfers SPI data once per video frame.

A SmoothPicture™ subframe is shown in *Figure 2: Example of "Red" Driver*. The data sent during an SPI transfer is applicable to the next subframe. The subframe signal is used by the OEM's driver to switch the current setting from those used during the last frame to the updated values received during the last frame. Figure 2 also shows that sensor data, indicated by the sensor strobe being active, will also be sampled during the subframe. This data will be sampled when all the mirrors are in the off state. The current value during this time may differ from the values used during the rest of the frame. The width of the strobe pulses will be determined by the sequences. They could range from ~2µs to ~1000µs depending on those sequences.

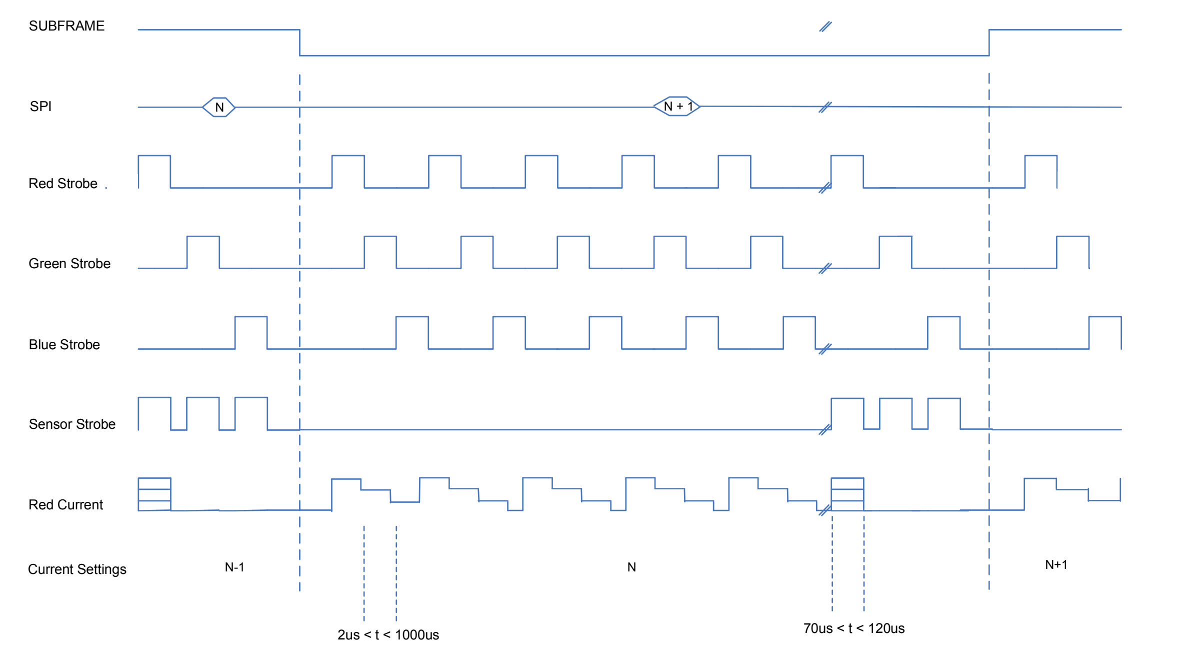

Figure 2: Example of "Red" Driver

NOTE:

Non SmoothPicture™ systems will still use the subframe signal as described above.

3.2 Suggested Access Methodologies

If the OEM Micro Controller Unit (MCU) needs to do processing which includes sending I^2C commands to the DDP3021 based on receiving a VSync signal, then please consider the following timeline in *Figure 3: Recommended Order of Execution for OEM* on page 13.

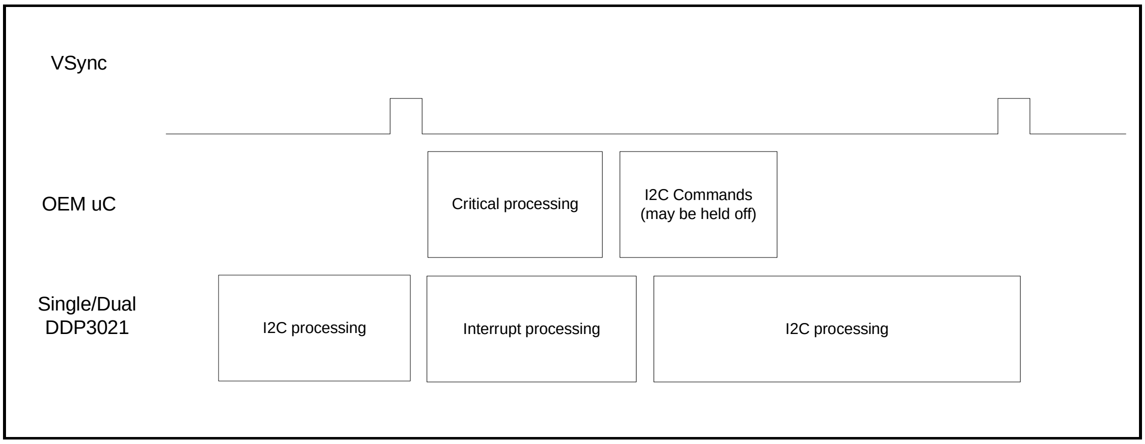

Figure 3: Recommended Order of Execution for OEM MCU

This timeline shows the recommended order of execution for the OEM MCU. The reason for this ordering is that the I^2C commands will be held off by the DDP3021 while it processes the VSync interrupt. The shown ordering allows the most overlap of processing between the two devices and allows the critical processing in the OEM MCU to occur in a timely predictable manner.

While processing the DSP Color Manager requests, the OEM I^2C command will be received and queued but not processed.

3.3 Steady State Process Flow

NOTE:

The following process assumes that calibration has been performed and the calibration data has been stored by the System Micro Controller Unit (MCU) EEPROM or optional EEPROM

The flowchart in Figure 4: LED System "Steady-State" Process Flow on page 14 describes the closed loop operation after power is applied. Once power is applied, the System MCU sends the calibration data and the initial BrilliantColor™ Look to the DLP® Chipset. The MCU enables the color compensation algorithm and the DLP® Chipset begins to analyze the data from the feedback sensor for every frame. The DLP® chipset uses the feedback sensor data to calculate new duty cycles and current parameters required to maintain the desired BrilliantColor™ Look as set by the MCU. The DLP® chipset adjusts the duty cycle and sends the appropriate LED drive current information to the LED driver. This process continues until a user makes a new BrilliantColor™Look selection through the System MCU.

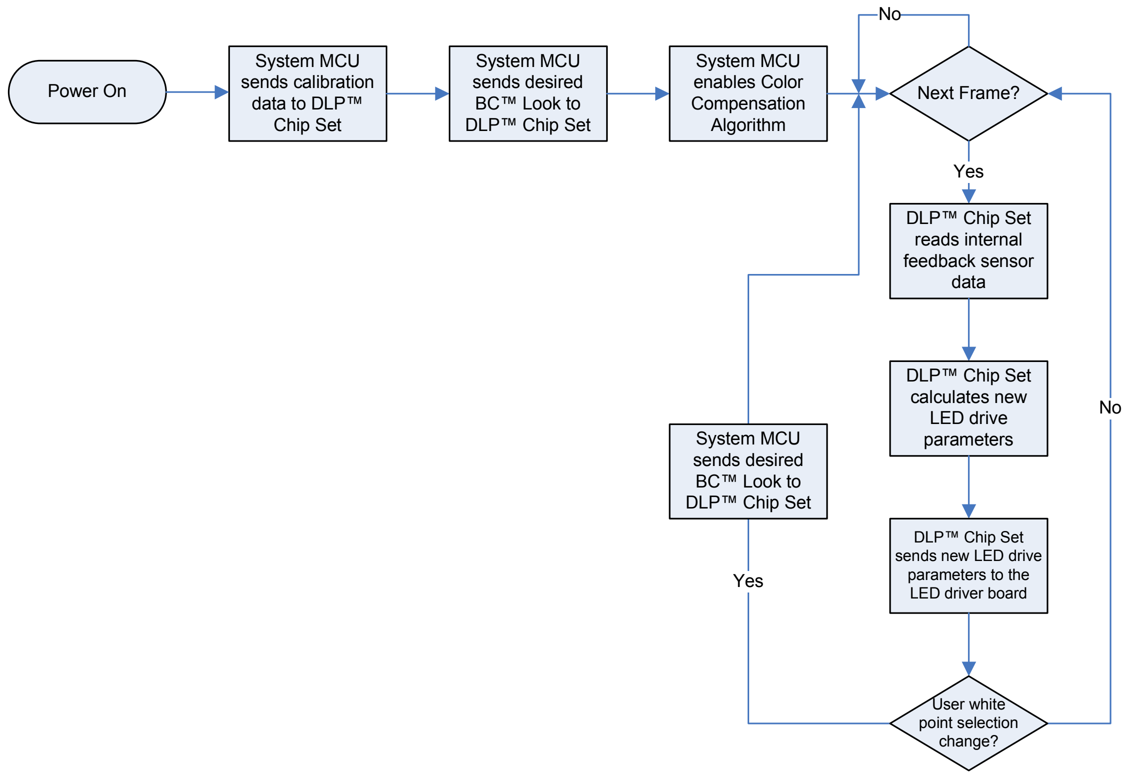

Figure 4: LED System "Steady-State" Process Flow

4 System Calibration Procedure

LED light emissions vary over time in brightness and color as a function of temperature. During operation, a color feedback sensor in the LED illumination module takes brightness measurements (A, B, C) of each LED. For the LED color compensation algorithm to work correctly, the sensor color points need to be calibrated to a known reference and stored in the OEM Flash (EEPROM) memory or optional EEPROM.

To calibrate the LED Feedback Sensor System:

1. Power up the system and allow it to achieve steady state operating conditions.
2. Use the DSP Color Manager Control I^2C Command **0x87** to enable calibration.
3. While in Curtain Mode, display a red flat field (Code 255) test pattern.
4. Set up an external color sensor (colorimeter) to be used to take external color measurements.
5. Take external measurements x, y, Y for red and record in the OEM flash.
6. Simultaneously trigger the colorimeter and feedback sensors to each take a measurement. (The feedback sensor is triggered using DSP Color Manager Control I^2C Command **0xA2**). Store these measurements in OEM Flash (or EEPROM) memory (System I^2C MCU).

7. While in Curtain Mode, display a green flat field (Code 255) test pattern.
8. Take external measurements x, y, Y for green and record in the OEM flash.
9. Simultaneously trigger the colorimeter and feedback sensors to each take a measurement. (The feedback sensor is triggered using DSP Color Manager Control I^2C Command **0xA2**). Store these measurements in OEM Flash (or EEPROM) memory (System I^2C MCU).
10. While in Curtain Mode, display a blue flat field (Code 255) test pattern.
11. Take external measurements x, y, Y for blue and record in the OEM flash.
12. Simultaneously trigger the colorimeter and feedback sensors to each take a measurement. (The feedback sensor is triggered using DSP Color Manager Control I^2C Command **0xA2**). Store these measurements in OEM Flash (or EEPROM) memory (System I^2C MCU).
13. Calibration is complete. Repeat start up procedure (see *Section 2.1Power-up Timeline* on page 9) to re-enable color processing.

NOTE

See *Section 14.1.1 Measured Red x, y and Lumens Color Point (Command 0x00)* for more detail on calibration commands.

5 Interface Protocol

5.1 Interface Standards

The protocol used in communicating information to the DDP3021 consists of a serial data bus conforming to the Philips I^2C specification, up to 100KHz.

5.2 Slave Receive Mode

With the DDP3021 operating in the slave-receiver configuration, the first byte following the start condition is the DDP3021 devices write address (34h).

The interface consists of a number of sub-address registers each capable of accepting multiple bytes of data. Each command/sub-address accepts a certain number of data bytes. The number of data bytes for each command/sub-address is described in *Section 6* on page 17.

Sending the wrong number of bytes to a sub-address is not an error. If too few bytes are sent, then the entire transaction is ignored. If too many bytes are sent, then the correct number of bytes is used and the extra bytes are ignored.

5.3 Slave Transmit Mode

With the Single DDP3021 operating in the slave-transmitter configuration, the first byte following the start condition is DDP3021 device read address (35h). One word of system status will be returned followed by additional bytes containing system hardware values or firmware information Table 1: DDP3021 I2C Address Map Summary summarizes the I^2C memory map.

	Example Device Address	Sub-Address	Group Command
Write	34h	Below e0h	Register Control
Write	34h	Above e0h	Mailbox Control
Read	35h	N/A	System Hardware & Firmware Information

Table 1: DDP3021 I^2C Address Map Summary

5.4 Reserved Areas

When writing to valid registers, all unused/reserved bits should be set to zero. Reserved registers should never be written.

When reading valid registers, all unused/reserved bits should be ignored.

6 Command Description

ARM Control commands, register sub-addresses and corresponding control bits are specified in the next Section. Control commands shall be accepted in any order. Each control command will be validated for sub-address and parameter errors as they are received. Commands failing validation shall be ignored. Each control command validation failure shall set the command/parameter error bit in the System Status (See Section 11 System Status on page 47). Reserved bits in control commands should be set to zero, but will not set the command/parameter error bit if they are not. The OEM is not guaranteed correct operation if reserved bits are set to non-zero.

Validated control commands are stored in a command queue. The command queue is serviced in a first-in-first-out (FIFO) manner. When the command queue is empty, all commands have been serviced and the System Ready bit in the System Status (See *Section 11 System Status*) is set to 1.

When the command queue starts in the empty state, execution of most single control commands will require a minimal time to complete. Degamma commands will require more time to complete. When the command queue starts in the non-empty state, execution times may double. In the event the DDP3021 is busy or the command queue is full and unable to accept a command, it shall hold the I^2C bus for, at most, the duration of the maximum command execution time as allowed by the I^2C specification.

While the Color Point Control algorithm is in operation, communication between the DSP and the Master ASIC will take place as necessary to change sequences. When this occurs, the normal I^2C status will return an indication of System not Ready (System Ready Bit is not set). Normal command processing will be suspended while this communication takes place. I^2C commands will be received but not processed until the DSP/Master ASIC communication is complete.

Most commands initialize to default values as specified using the ASIC Options Manager within the DLP Composer™ tool set when building system firmware. These default values may be superseded by OEM supplied values during optional EEPROM processing and/or at I^2C Service Delay time by the system MCU.

Most commands can cause visual artifacts. Those commands that will not cause visual artifacts have a note stating this.

Most command data values can be read. Those that cannot be read are marked as write only. Some command values (for example, Hardware and Software Versions) are read only.

6.1 ARM Commands

The flowchart below shows an example of a read command toward the ARM.

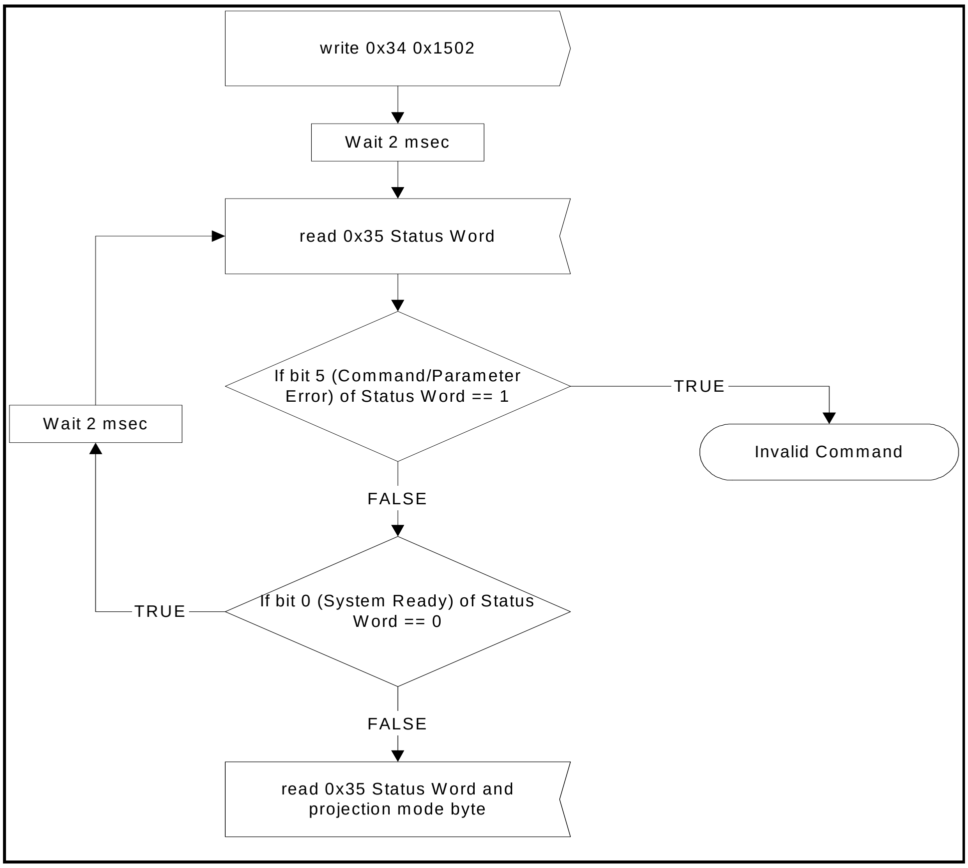

Figure 5: Example of Flow Chart for Reading Projection Mode Data

Reading data is a two-step process. The first step is to tell the chipset which command data value you wish to read. This is accomplished by sending the read command (0x15) followed by the command byte you wish to read.

The second step is to read the status word followed by the command value in a single read transaction.

NOTE:

When sending the I²C address (typically 0x34 or 0x35), a negative acknowledgement (NAK) means the DDP3021 is busy. Try the request again.

6.2 DSP Commands

For reading from and writing data to the DSP, a slightly different format is used and is described below.

All write commands to the DSP are 9 bytes in length. The first byte is 0x5Eh, followed by 8 bytes specific to the DSP command defined in Section 14. Read commands require first a 9-byte write command, where the first byte is 0xDE, followed by 8 bytes describing the information requested. After waiting for the System Ready bit in the System Status to be set to 1 to indicate the data is ready to be read, a read from the 0x35h slave address then returns the normal 2 bytes of system status, followed by a variable number of bytes depending on the requested information.

For DSP Read commands, 0xDE is used instead of 0x15+ write ADDR like other I2C control commands. Each DSP I2C command consists of the DSP command followed by 8 bytes, the first being the DSP command number. The two examples below show how to read from and write commands to the DSP.

1. Request DSP Status (See *Section 14.2.1 Read of DSP Status Register (0x43)* on page 74):

   1. Write to slave address 0x34 the following hex data: 0xDE 43 00 00 00 00 00 00 00

      - Read the following 4 bytes from slave address 0x35**: *ss ss pp pp pp***
      - Where ***ss ss*** is the normal 2-byte system status and ***pp pp pp*** is the 3-byte DSP status.

2. Set Max Current for Blue channel to 255.

   - Write to slave address 0x34 the following hex data: 0x5E 80 02 00 00 00 00 00 FF

NOTE:

The first two data bytes returned from the read command are the normal I2C status bytes.

7 Control Commands

The following sections describe the control commands for the ARM.

7.1 Brightness Control (Write – 0ah)

Byte 0: CA MSB

r	r	r	r	r	b10	b9	b8

Byte 1: CA LSB

b7	b6	b5	b4	b3	b2	b1	b0

Byte 2: CB MSB

r	r	r	r	r	b10	b9	b8

Byte 3: CB LSB

b7	b6	b5	b4	b3	b2	b1	b0

Byte 4: CC MSB

r	r	r	r	r	b10	b9	b8

Byte 5: CC LSB

b7	b6	b5	b4	b3	b2	b1	b0

b 10:0 – Brightness coefficient data
r : Reserved, set to zero

The Brightness Control provides the ability to change the minimum black level for each of the input channels (A/G/Y, B/R/Cr and C/B/Cb) independent of the maximum white level and offset for that channel. The brightness coefficients (CA, CB & CC) are signed, 11-bit (s8.2), 2's complement values between –256.00 and 255.75, inclusive.

See the Brightness, Contrast and Offset appendix for more information on how the Brightness, Contrast and Offset commands interact.

All programmable coefficient values represent numbers less than 256.00 but greater than or equal to negative 256.00. The binary point is between bits 2 and 1. The following table shows the bit values for the coefficients.

Coefficient MSBYTE Bit Values

					B10	B9	B8
					SIGN	2**7	2**6

Coefficient LSBYTE Bit Values

B7	B6	B5	B4	B3	B2	B1	B0
2**5	2**4	2**3	2**2	2**1	2**0	2**-1	2**-2

Binary Point

7.2 BrilliantColor™ Control (Write – 0dh)

en	r	bc5	bc4	bc3	bc2	bc1	bc0

en (7) – Enable Brilliant Color Processing

bc(2:0)– BrilliantColor™ mode selection
- 0: BC look 1
- 1: BC look 2
- 2: BC look 3
- 3: BC look 4
- .
- .
- .
- .
- 63: BC look 64

r – Reserved, set to zero

7.3 Chroma Interpolation (Write - 14h)

cie	r	r	R	r	r	r	cim

cie(7) – Chroma Interpolation Enable
- 0: Chroma Interpolation is disabled
- 1: Chroma Interpolation is enabled

cim(1) – Chroma Interpolation Mode
- 0: Interpolation
- 1: Chroma copy

r – Reserved, set to zero

Chroma Interpolation provides 2 methods of 4:2:2 to 4:4:4 conversions. The primary interpolates between sub-sampled values to produce the missing values. The secondary method is a Chroma Copy method that simply uses the chroma signal for 2 consecutive pixels. The Chroma Interpolation function can be disabled to support 4:4:4 data pass-thru for non-sub sampled (4:4:4) video and RGB applications.

7.4 Chroma Transient Improvement (Write - 18h)

ctie	r	r	R	gs3	gs2	ft	freq

ctie (7) – Chroma Transient Improvement (CTI) Enable
0: CTI function is disabled
1: CTI fFunction is enabled

gs (3:2) – Gain Select
00: 1
01: 2
10: 4
11: 8

ft (1) – Filter Type
0: for low bandwidth source
1: for high bandwidth source

freq (0) – Horizontal bandpass filter Frequency
0: for low bandwidth source
1: for high bandwidth source

r – Reserved, set to zero

Chroma Transient Improvement reduces color smear and produces crisp edges with no ringing artifacts by filtering input data.

7.5 Color Selection (Write - 12h)

Byte 0: Foreground Green MSB

R	r	r	r	r	r	r	grn8

Byte 1: Foreground Green LSB

grn7	grn6	grn5	grn4	grn3	grn2	grn1	grn0

Byte 2: Foreground Red

red7	red6	red5	red4	red3	red2	red1	red0

Byte 3: Foreground Blue

blu7	blu6	blu5	blu4	blu3	blu2	blu1	blu0

grn (8:0) – Green color range 0 – 511
red (7:0) – Red color range 0 – 255
blu (7:0) – Blue color range 0 – 255

r – Reserved, set to zero

Four bytes are sent to describe the foreground color. Foreground color is used when projection mode (See *Section 7.25 Projection Mode (Write - 02h)* on page 36) is set to "Video Curtain," and for the fill space if an image smaller than max (1920x1080 for 1080p) is specified in the "Lines/Frame" (See *Section 7.22 Lines/Frame (Write - 07h)* on page 33) and/or "Pixels/Line" (See *Section 7.24 Pixels/Line (Write - 06h)* on page 35).

Foreground color is used for the solid field test pattern (See *Section* ***Error! Reference source not found. Error! Reference source not found.*** on page **Error! Bookmark not defined.**).

NOTE

The foreground color is sometimes referred to as "Pleasing color".

7.6 Color Space Converter (Write - 0Bh)

csce	r	dfm1	dfm0	dtm0	r	r	r

csce (7) – Color Space Converter Enable (Deafult: 0)
- 0: Disable
- 1: Enable

dfm(5:4) – Input Data Format
- 00: CSC 0
- 01: CSC 1
- 10: CSC 2
- 11: CSC 3

dtm(3) – Data Type
- 0: RGB data type
- 1: YCrCb data type

r – Reserved, set to zero

A Color Space Converter is used to specify the color matrix that should be used to translate input data to RGB data or to color correct RGB input data.

The CSC accepts only 4:4:4 sample data format. The design contains one color space matrix with nine elements. As the interface shows, there are four matrixes to choose from. The values for each of the four available matrixes are adjustable via the DLP Composer™ tool set. The defaults are:

CSC 0 = ITU-R.BT.601(NTSC/PAL/SECAM)
CSC 1 = ITU-R.BT.709(HD)
CSC 2 = SMPTE 240M(HD)
CSC 3 = RGB

7.7 Contrast (Write - 01h)

Byte 0: CA Percentage

c7	c6	c5	c4	c3	c2	c1	c0

Byte 1: CB Percentage

c7	c6	c5	c4	c3	c2	c1	c0

Byte 2: CC Percentage

c7	c6	c5	c4	c3	c2	c1	c0

c(7:0) – Contrast percentage gain for a data channel
Range: 32h – 96h

Each contrast byte controls the gain applied to the maximum white level for a given data channel independent from the minimum black level and offset for that channel. The contrast gain has a range from 0.5 to 1.5 (50% to 150%) with 1.0 (100%) being nominal. The desired gain is achieved by sending the percentage gain for each data channel as a number between 32h and 96h (50 and 150 decimal) in these bytes.

See the Brightness, Contrast, and Offset Appendix on page 107 for more information on how Brightness, Contrast, and Offset commands interact.

7.8 Data Channel Swap (Write – 1dh)

r	r	r	r	r	dc	dc	dc

dc – ABC channel swap
000: ABC
001: CAB
010: BCA
011: ACB
100: BAC
101: CBA
r - Reserved, set to zero.

Enabling this function will swap ABC data channels in the DDP3021 ASIC.

7.9 DynamicBlack™ Configuration (Write – 55h)

Byte 0: DynamicBlack™ control

ena15	enb14	pix13	pix12	r	r	r	LEDOFF_DIS

Byte 1: DynamicBlack™ strength

str7	str6	str5	str4	str3	str2	str1	str0

ena(15) DynamicBlack™ Enable
0: Disable DynamicBlack™ processing
1: Enable DynamicBlack™ processing

ena(14) DynamicBlack™ Border Control Enable
0: Disable DynamicBlack™ Border Exclusion
1: Enable DynamicBlack™ Border Exclusion

ena(13:12) DynamicBlack™ Border Pixel Weight
00: 0%
01: 25%
10: 50%
11: 75%

LEDOFF_DIS (8) DB™ LED Off function control
0: DB™ LED off function is enabled (default)
1: Disable DB™ LED off function

str(0:7) DynamicBlack™ Strength
0-3 DynamicBlack™ processing strength
4-255 reserved

r - Reserved, set to zero.

This command is only valid if the user has enabled DynamicBlack™ processing through the DLP Composer™ tool set.

Border Pixel Weight value sets the weighting of pixels within the border region relative to the interior of the image. The border region is setup via DynamicBlack™ Border Configuration mailbox command (See *Section 13.3 DynamicBlack™ Border Configuration Mailbox (Write only – ECh)* on page 57).

When DynamicBlack™ is enabled , the DB™ LED Off disable functionality controls whether the LED driver levels are set to zero, turning off the LED light output, for very dark scenes. This function requires that the DLP Composer™ project have the DB™ LED Off functionality enabled. If the DB™ LED Off function is disabled, normal DB™ functionality will continue to operate.

7.10 Run-Time Calibration Disable (Write – 5Dh)

Byte 0: Run-Time Calibration Control

r	r	r	r	r	r	**Ena_Limit**	**Disable**

Byte 1: DB™ Aperture Resume Limit

ar7	ar6	ar5	ar4	ar3	ar2	ar1	ar0

Byte 2: DB™ Aperture Disable Limit

ad7	ad6	ad5	ad4	ad3	ad2	ad1	ad0

Disable(0) Disable Run-Time Calibration
0: Run-Time calibration enabled (default)
1: Run-Time calibration disabled

Ena_Limit(1) Enable Limits for Run-Time Calibration
0: Disable Limits (default)
1: Enable Limits (only valid if **Disable** = 0)

ar[7:0] *DB™ Aperture Resume Limit*
Defines the aperture setting for resuming run-time calibration. Only valid if **Ena_Limit** = 1 and **Disable** = 0. Range = 1-254. Must be less than Disable Limit or command error will be returned.

Ad[7:0] *DB™ Aperture Disable Limit*
Defines the aperture setting for disabling run-time calibration. Only valid if **Ena_Limit** = 1 and **Disable** = 0. Range = 1-254. Must be greater than Resume Limit or command error will be returned.

r - Reserved, set to zero.

This command allows disabling of the Run-Time Calibration LED sampling performed by the DSP. Two options are available, to either disable the calibration completely or disable the calibration based on programmed DB™ aperture limits.

The *DB™ Aperture Disable Limit* setting specifies the aperture value that will disable calibration. Any aperture setting of this value or greater will cause the Run-Time calibration to be disabled and the calibration sense current to be set to zero.

The *DB™ Aperture Resume Limit* setting specifies the aperture value for which the Run-Time Calibration will resume. Any aperture setting of this value or less will cause the Run-Time Calibration to be re-enabled and the calibration sense current to be non-zero.

When the calibration ramp is turned off, the DAC current sent to the driver for the ramp sensor time will be set to zero. If the calibration ramp was disabled while ramping up, then when it is re-enabled it starts at 255 and ramps down first. The ramping functionality will then continue as before. If the calibration ramp was disabled while ramping down, then when it is re-enabled it starts at 0 and ramps up first. The ramping functionality will then continue as before.

NOTE:

Calibration ramping is important to the color control of the system over varying lumens and temperature ranges. Ramping should be left enabled whenever possible, and should only be disabled for short times in modes which are known to have minimal brightness and color variation.

7.11 DynamicColor™ Contrast Control (Write - 73h)

Byte 0: DynamicColor™ Control

dcgl15	dcll14	dsk13	r	r	r	dcs9	dcs8

Byte 1: DynamicColor™ Black Level

dcbl7	dcbl6	dcbl5	dcbl4	dcbl3	dcbl2	dcbl1	dcbl0

dcgl(15) – DynamicColor™ Contrast Global Adjustment Enable.
0: Disable
1: Enable
dcgl(14) – DynamicColor™ Contrast Local Adjustment Enable.
0: Disable
1: Enable

dcsk(13) – DynamicColor™ Skin Inhibit Enable.
 0: Disable
 1: Enable
dcs(9:8) – DynamicColor ™ Strength
 00: Low
 01: Medium
 10: Maximum
dcbl(7:0) DynamicColor™ Black Level Adjustment.
 Range 0%-100%.
 This parameter is expressed as percentage of pixels.
 Min percentage is 0% (0x00). Max percentage is 100% (0x64).

r - Reserved, set to zero.

The DynamicColor™ Contrast Inhibit Enable/Disable function allows the user to inhibit skin tone detection. When enabled, contrast enhancement is limited for hues that have a high probability of being a skin tone.

The DynamicColor™ Strength settings allow the user to adjust how much compression at the extremes of the dynamic range, and how much expansion in the middle of the dynamic range is allowed.

The DynamicColor™ Black Level adjustment is used to improve the perceived contrast of the image while minimizing clipping. The contrast improvement is achieved through the application of a transfer function that is adjusted based off the overall luminance of a scene.

7.12 DynamicColor™ Saturation Control (Write – 74h)

Byte 0: Saturation Adjustment Enable

sen15	r	r	r	r	r	r	r

Byte 1: Saturation Gain

sg7	sg6	sg5	sg4	sg3	sg2	sg1	sg0

sen(15) - DynamicColor™ Saturation Adjustment Enable.
 0: Disabled
 1: Enabled

sg(7:0) - DynamicColor™ Saturation Strength.
 Writing to this register 0x80 sets the gain value to 1.0.

r – Reserved, set to zero

The DynamicColor™ Saturation Adjustment improves skin tone colors by applying gain value to the saturation channel. The saturation strength is derived from the gain value with range from 0.0 to 1.9921875The format of the gain value is u1.7:

Bit Values for the Saturation Gain Byte

B7	B6	B5	B4	B3	B2	B1	B0
2**0	2**-1	2**-2	2**-3	2**-4	2**-5	2**-6	2**-7

Binary Point

7.13 Internal VSync for TPG (Write – 1Ah)

evs7	evs6	evs5	evs4	evs3	evs2	evs1	evs0

evs (7:0) – TPG VSync
Valid VSync ranges are 44.0Hz to 65.0Hz with a resolution of 0.5Hz (default 60.0Hz.)

The Internal VSync command is used to set the internal VSync rate for the Test Pattern Generator (TPG) Mode.

The following table shows the bit values for TPG VSync Rates. Note the decimal point is between bits 1and 0.

TPG VSync Bit Values

B7	B6	B5	B4	B3	B2	B1	B0
2**6	2**5	2**4	2**3	2**2	2**1	2**0	2**-1

Binary Point

NOTE:

For WUXGA based systems, the maximum Vsync is 60Hz for cropped images or 50Hz for non-cropped images.

7.14 Fan PWM Output Settings (Write – 10h)

Byte 0: Fan1 PWM Output Settings

F1os7	F1os6	F1os5	F1os4	F1os3	F1os2	F1os1	F1os0

Byte 1: Fan2 PWM Output Settings

F2os7	F2os6	F2os5	F2os4	F2os3	F2os2	F2os1	F2os0

Byte 2: Fan3 PWM Output Settings

F3os7	F3os6	F3os5	F3os4	F3os3	F3os2	F3os1	F3os0

F1os (7:0) – Fan1 PWM Output Setting
Range: 0 = off
30%-100% in 5% increments (0x1e – 0x64)

F2os (7:0) – Fan2 PWM Output Setting
Range: 0 = off
30%-100% in 5% increments (0x1e – 0x64)

F3os (7:0) – Fan3 PWM Output Setting
Range: 0 = off
30%-100% in 5% increments (0x1e – 0x64)

r - Reserved, set to zero.

This function controls the PWM fan(s) attached to the PMD1000 fan output(s).

NOTE

PWM duty cycle values will be rounded down to the nearest 5%. PWM duty cycle values that are less than 30% will be treated as 0 (off).

This interface is only valid in a system that includes a PMD1000. It will NOT generate an error if used on any other system.

This command will not cause visual artifacts.

7.15 Gamma Correction (Write – 09h)

Byte 0: Degamma control MSB

dgm15	dgm14	r	r	r	r	r	r

Byte 1: Degamma control LSB

r	r	r	degs4	degs3	degs2	degs1	degs0

dgm(15:14) – Degamma mode
01: Degamma enabled
11: Degamma disabled

degs(4:0) – Degamma Table Selection.
00h: TI Film
01h: TI Graphics Enhanced
02h: TI Video Enhanced (NTSC, PAL, SECAM)
03h: Linear
04h-13h: OEM defined tables
14h-FFh: reserved

r – Reserved, set to zero

The Digital Micro-Mirror Device is inherently linear in response. Degamma processing is used to remove the gamma curve which was applied to video and graphics data at the source.

7.16 General Purpose Filter Control (Write - 75h)

Byte0: GPF Control

fen15	r	r	r	vl11	vl10	fs9	fs8

Byte 1: GPF Master Gain

mg7	mg6	mg5	mg4	mg3	mg2	mg1	mg0

fen(15) –General Purpose Filter (GPF) Enable
- 0: GPF Disable
- 1: GPF Enable

fs(9:8) – SharpPicture™ Filter Select
- 00: HD High Sharpness
- 01: HD Low Sharpness
- 10: SD Image Enhancer
- 11: Use current filter selection

vl(11:10) – Variance LUT Select
- 00: Variance LUT for HD High Sharpness
- 01: Variance LUT for HD Low Sharpness
- 10: Variance LUT for SD Image Enhancer
- 11: Unity gain LUT

mg(7:0) – Master Gain value. Range (0-255)

r – Reserved, set to zero

SharpPicture™ Filter selection is used to apply TI supplied spatial sharpening or softening coefficients to the input video stream. If you choose to use the General Purpose Filter (GPF) Mailbox command (0xF2) to load custom coefficients, use a selection value of 11(binary) while changing the Master Gain value or Enable status.

The GPF function also computes a variance for the span of the filter. This variance signal is an indicator of the spatial frequency content of the portion of the image spanned by the filter. This signal can be used to selectively decrease the sharpness gain for noisy portions of the image. The Variance LUT is designed to work with the filter to reduce the noise in an image.

Variance LUT selection is used to apply one of four TI supplied variance LUT values. To maintain backward compatibility with previous designs, use the same binary value here as the SharpPicture™ Filter selection above.

GPF Master Gain determines how much of the filtered signal is added to the output signal. Setting this value to 0 indicates that the output signal is not filtered at all. Setting this value to 255 indicates that the output signal is 100% filtered.

7.17 Hardware Versions (Read Only – 9Bh)

Byte 0: DMD Device Version

Dmd7	Dmd6	Dmd5	Dmd4	Dmd3	Dmd2	Dmd1	Dmd0

Byte 1: DAD Device Version

Dad7	Dad6	Dad5	Dad4	Dad3	Dad2	Dad1	Dad0

Byte 2: ASIC Device Version

Asic7	Asic6	Asic5	Asic4	Asic3	Asic2	Asic1	Asic0

Byte 3: Reserved

R	R	R	R	R	R	R	R

Byte 4: PMD Device Version

PMD7	PMD6	PMD5	PMD4	PMD3	PMD2	PMD1	PMD0

Byte 5: BML Revision

BML7	BML6	BML5	BML4	BML3	BML2	BML1	BML0

Dmd(7:0)	– DMD Revision
Dad(7:0)	– DAD Revision, if present
Asic(7:0)	– ASIC Revision
R(7:0)	– Reserved
PMD(7:0)	– PMD Revision, if present
BML(7:0)	– Merge Logic FPGA, if present

NOTE:

Not all chipsets contain a DAD, PMD or BML device. In these cases, the return value for the respective Revision byte is undefined but 6 bytes can still be returned.

*e.g. BML - Used **only** for dual DDP3021 65" 1080p and 0.67" WUXGA DMD systems so other component sets could read only 5 bytes*

This command will not cause visual artifacts.

7.18 Horizontal Image Position (Write – 04h)

Byte 0: Horizontal Direction & Position MSB

Dir	r	r	r	r	r	r	hpos8

Byte 1: Horizontal Position LSB

hpos7	hpos6	hpos5	hpos4	hpos3	hpos2	hpos1	hpos0

dir – Direction of the horizontal offset
 0: shift image left
 1: shift image right

hpos (8:0) – Horizontal Position
 Number of pixels horizontally offset from centered position, in 1 pixel increments. hpos = 0 means image is centered horizontally on the device. hpos = 1 means image is offset by 1 pixel in the horizontal direction indicated by the dir bit.
 Range: 0 – 384

r – Reserved, set to zero.

The image, as defined by pixels per line (See *Section 7.24 Pixels/Line (Write - 06h)* on page 35) and lines per frame (See *Section 7.22 Lines/Frame (Write - 07h)* on page 33), can be moved partially off the active area of the DMD.

7.19 Hue, Saturation, and Gain (HSG) Control (Write – 13h)

This command is used to adjust gain, saturation, and hue for red, green, blue, cyan, magenta, and yellow colors, and the red, green, and blue gains for the white color.

Byte 0: Red Gain (MSB)

red_gain15	Red_gain14	red_gain13	red_gain12	red_gain11	red_gain10	red_gain9	red_gain8

Byte 1: Red Gain (LSB)

red_gain7	Red_gain6	red_gain5	red_gain4	red_gain3	red_gain2	red_gain1	red_gain0

Byte 2: Red Saturation (MSB)

red_sat15	Red_sat14	red_sat13	red_sat12	red_sat11	red_sat10	red_sat9	red_sat8

Byte 3: Red Saturation (LSB)

red_ sat7	Red_ sat6	red_ sat5	red_ sat4	red_ sat3	red_ sat2	red_ sat1	red_sat0

Byte 4: Red Hue (MSB)

red_hue15	Red_hue14	red_hue13	red_hue12	red_hue11	red_hue10	red_hue9	red_hue8

Byte 5: Red Hue (LSB)

red_ hue7	Red_ hue6	red_ hue5	red_ hue4	red_ hue3	red_ hue2	red_ hue1	red_hue0

…

HSG Byte 36 (MSB)

w_rg15	w_rg14	w_rg13	w_rg12	w_rg11	w_rg10	w_rg9	w_rg8

HSG Byte 37 (LSB)

w_rg7	w_rg6	w_rg5	w_rg4	w_rg3	w_rg2	w_rg1	w_rg0

HSG Byte 38 (MSB)

w_gg15	w_gg14	W_gg13	w_gg12	w_gg11	w_gg10	w_gg9	w_gg8

HSG Byte 39 (LSB)

w_gg7	w_gg6	w_gg5	w_gg4	w_gg3	w_gg2	w_gg1	w_gg0

HSG Byte 40 (MSB)

w_bg15	w_bg14	W_bg13	w_bg12	w_bg11	w_bg10	w_bg9	w_bg8

HSG Byte 41 (LSB)

w_bg7	W_bg6	w_bg5	w_bg4	w_bg3	w_bg2	w_bg1	w_bg0

Bytes 0-5: Red Gain, Saturation, Hue
Bytes 6-11: Green Gain, Saturation, Hue
Bytes 12-17: Blue Gain, Saturation, Hue
Bytes 18-23: Cyan Gain, Saturation, Hue
Bytes 24-29: Magenta Gain, Saturation, Hue
Bytes 30-35: Yellow Gain, Saturation, Hue

_Gain(0-15) – Gain in signed 1.14 format. Range: >= 0, < 2. Max= 1.99993896484375
_Sat(0-15) – Saturation in signed 1.14 format. Range: >= 0, < 2. Max= 1.99993896484375
_Hue(0-15) – Hue in signed 1.14 format. Range: >= -1, <= 1.

Bytes 36-41: White color Red Gain, Green Gain, Blue Gain:

w_rg(0-15) – Red gain for white color. Signed 1.14 format; Range: >=0< 2; Max= 1.99993896484375
w_gg(0-15) – Green gain for white color. Signed 1.14 format; Range: >= 0, < 2; Max= 1.99993896484375
w_bg(0-15) – Blue gain for white color. Signed 1.14 format; Range: >= 0, < 2; Max= 1.99993896484375

All 21 words (42 bytes) must be sent as one contiguous block to ensure the values are updated. Sending tables with bad data values will likely result in unacceptable screen images.

NOTE:

These commands will work for systems with a DSP; however they must be used carefully. Any change of a Look or desired Color Point will cause CCA to be overwritten by the DSP/ARM. It will require the user to re-send the desired HSG settings whenever a major change is made to the desired system Look.

This command overrides the Color Coordinate Adjustment (CCA) settings. It also sets the projector Color Coordinate Adjustment Matrix mode to 7 primaries (P7).

The previous CCA matrix mode setting is restored when using the commands Color Coordinate Adjustment Fixed Size Matrix Mailbox (EEh) and Color Coordinate Adjustment Mailbox (EBh).

7.20 Hue, Saturation, and Gain (HSG) from CCA (Read-only – 16h)

This command is used to read the hue, saturation and gain values for red, green, blue, cyan, magenta, and yellow colors, along with the red, green, and blue component of the white color. Use this command to obtain the equivalent HSG values after setting the CCA registers.

Byte 0: Red Gain (MSB)

red_gain15	Red_gain14	red_gain13	red_gain12	red_gain11	red_gain10	red_gain9	red_gain8

Byte 1: Red Gain (LSB)

red_gain7	Red_gain6	red_gain5	red_gain4	red_gain3	red_gain2	red_gain1	red_gain0

Byte 2: Red Saturation (MSB)

red_sat15	Red_sat14	red_sat13	red_sat12	red_sat11	red_sat10	red_sat9	red_sat8

Byte 3: Red Saturation (LSB)

red_ sat7	Red_ sat6	red_ sat5	red_ sat4	red_ sat3	red_ sat2	red_ sat1	red_sat0

Byte 4: Red Hue (MSB)

red_hue15	Red_hue14	red_hue13	red_hue12	red_hue11	red_hue10	red_hue9	red_hue8

Byte 5: Red Hue (LSB)

red_ hue7	Red_ hue6	red_ hue5	red_ hue4	red_ hue3	red_ hue2	red_ hue1	red_hue0

...

HSG Byte 36 (MSB)

w_rg15	w_rg14	w_rg13	w_rg12	w_rg11	w_rg10	w_rg9	w_rg8

HSG Byte 37 (LSB)

w_rg7	w_rg6	w_rg5	w_rg4	w_rg3	w_rg2	w_rg1	w_rg0

HSG Byte 38 (MSB)

w_gg15	w_gg14	W_gg13	w_gg12	w_gg11	w_gg10	w_gg9	w_gg8

HSG Byte 39 (LSB)

w_gg7	w_gg6	w_gg5	w_gg4	w_gg3	w_gg2	w_gg1	w_gg0

HSG Byte 40 (MSB)

w_bg15	w_bg14	W_bg13	w_bg12	w_bg11	w_bg10	w_bg9	w_bg8

HSG Byte 41 (LSB)

w_bg7	W_bg6	w_bg5	w_bg4	w_bg3	w_bg2	w_bg1	w_bg0

Bytes 0-5: Red Gain, Saturation, Hue
Bytes 6-11: Green Gain, Saturation, Hue
Bytes 12-17: Blue Gain, Saturation, Hue
Bytes 18-23: Cyan Gain, Saturation, Hue
Bytes 24-29: Magenta Gain, Saturation, Hue
Bytes 30-35: Yellow Gain, Saturation, Hue

_Gain(0-15) – Gain in signed 1.14 format. Range: >= 0, < 2. Max= 1.99993896484375

_Sat(0-15) – Saturation in signed 1.14 format. Range: >= 0, < 2. Max= 1.99993896484375

_Hue(0-15) – Hue in signed 1.14 format. Range: >= -1, <= 1.

Bytes 36-41: White color Red Gain, Green Gain, Blue Gain:

w_rg(0-15) – Red gain for white color. Signed 1.14 format; Range: >=0< 2; Max= 1.99993896484375
w_gg(0-15) – Green gain for white color. Signed 1.14 format; Range: >= 0, < 2; Max= 1.99993896484375
w_bg(0-15) – Blue gain for white color. Signed 1.14 format; Range: >= 0, < 2; Max= 1.99993896484375

NOTE:

These commands will work for systems with a DSP; however they must be used carefully. Any change of a Look or desired Color Point will cause CCA to be overwritten by the DSP/ARM. It will require the user to re-send the desired HSG settings whenever a major change is made to the desired system Look.

7.21 Image Orientation (Write - 03h)

r	r	r	r	r	r	ew	ns

ew - east/west flip.
- 0: normal (front projection and projector right-side up **OR** rear projection and projector upside-down)
- 1: flip (rear projection and projector right-side up **OR** front projection and projector upside-down)

ns - north/south flip.
- 0: normal (projector right-side up)
- 1: flip (projector upside down)

r - Reserved, set to zero.

East/West flip is used to permit the design to operate in both rear-projection and front-projection applications. North/South Flip is used to permit the design to operate in both normal and mechanically inverted applications. East/West flip function flips the image horizontally. North/South flip function flips the image vertically. North/South/West/East flip functions change the position of "horizontal starting column" and "vertical starting line", flipping it along a major axis, but not the meaning of those terms.

7.22 Lines/Frame (Write - 07h)

Byte 0: Lines/Frame MSB

r	r	r	r	r	olin10	olin9	olin8

Byte 1: Lines/Frame LSB

olin7	olin6	olin5	olin4	olin3	olin2	olin1	olin0

olin(10:0) - Number of active lines per frame on the DMD. The valid range is DMD dependant.
1080p range: 768 to 1080

r – Reserved, set to zero.

If an output value smaller than max is used, the unused space will be filled with the foreground color specified in Color Selection command (See *Section 7.5 Color Selection (Write - 12h)* on page 20).

7.23 Offset (Write – 00h)

Byte 0: CA MSB							
r	r	r	r	r	b10	b9	b8
Byte 1: CA LSB							
b7	b6	b5	b4	b3	b2	b1	b0
Byte 2: CB MSB							
r	r	R	r	r	b10	b9	b8
Byte 3: CB LSB							
b7	b6	b5	b4	b3	b2	b1	b0
Byte 4: CC MSB							
r	r	R	r	r	b10	b9	b8
Byte 5: CC LSB							
b7	b6	b5	b4	b3	b2	b1	b0

b 10:0 – Offset coefficient data

r : Reserved, set to zero

The Offset Control provides the ability to add or subtract a fixed bias from each of the input channels (A/G/Y, B/R/Cr and C/B/Cb) independent from the minimum black level and maximum white level. This may be used to remove any inherent DC or pedestal offsets in the main channel data signals. The offset coefficients (CA, CB & CC) are signed, 11-bit (s8.2), 2's complement values between –256.00 and 255.75, inclusive.

NOTE

A set of fixed offsets are automatically applied to incoming YCrCb data to normalize the values into the 0-255 range. The fixed offsets are 16(Y), 128(Cr) and 128(Cb). The offsets defined in this interface are additive to any fixed offset the system applies. The total offset value (system applied and this interface) cannot exceed 255.75.

See the Brightness, Contrast, and Offset appendix for more information on how the Brightness, Contrast and Offset commands interact.

All programmable coefficient values represent numbers less than 256.00 but greater than or equal to negative 256.00. The binary point is between bits 2 and 1. The following table shows the bit values for the coefficients.

Coefficient MSBYTE Bit Values

					B10	B9	B8
					SIGN	2**7	2**6

Coefficient LSBYTE Bit Values

B7	B6	B5	B4	B3	B2	B1	B0
2**5	2**4	2**3	2**2	2**1	2**0	2**-1	2**-2

Binary Point

7.24 Pixels/Line (Write - 06h)

Byte 0: Pixels/Line MSB

r	r	r	r	opix11	opix10	opix9	opix8

Byte 1: Pixels/Line LSB

opix7	opix6	opix5	opix4	opix3	opix2	opix1	opix0

opix(11:0) - Number of active pixels per line on the DMD. The valid range is DMD dependant.
1080p range: 1024 to 1920

r - Reserved, set to zero.

If an output value smaller than max is used, the unused space will be filled with the foreground color specified in Color Selection command (See Section 7.5 Color Selection (Write - 12h) on page 20).

The definition of horizontal image position is "hpos" from Section 7.18 Horizontal Image Position (Write – 04h) on page 30.

7.25 Projection Mode (Write - 02h)

pm2	pm1	pm0	r	r	r	r	r

pm (7:5) - Projection Mode.

000: Video Curtain - A solid color Video Curtain, defined by the foreground color of the Color Select command (see Section 7.5), will be displayed in place of the source image.

001: Test Patterns –The test pattern selected with the Test Pattern command (see Section 12.7) will be displayed in place of the source image.

010: Blank - The lamp is enabled, however the display will be blanked to black and no image of any kind can be displayed. Blank mode should be used during any source or channel change.

100: Freeze –The last Normal source image will be kept on the screen and will not update until Projection Mode is returned to "Normal".

011: Illumination Off – Optionally (selectable through DLP Composer ™ tool) the DMD device can go into a 50/50 duty cycle mode. It is recommended that the power will be supplied for at least 3 minutes after issuing this command. The illumination source will be turned off. The DMD will still be powered down normally when power is removed.

110: Normal - The selected source will be displayed.

101: Custom Test Patterns – Due to the slow load time of custom test patterns this mode is for calibration use only. Pre-compressed test pattern images stored in flash and selected with the Custom Test Pattern command will be displayed in place of the source image. See Section 12.1 for the selection of Custom Test Patterns.

r - Reserved, set to zero.

In addition to the Normal Display mode, two (2) standby Projection modes are supported for use when no input source is available or desired for display as well as a freeze-frame mode, a Test Patterns mode and a Illumination Off mode.

NOTE:

Using Freeze Mode after the Test Pattern or Custom Test Pattern Mode will produce unpredictable results. Freeze Mode usage order should be Normal/Freeze/Normal.

The Illumination Off mode can be used to cool the projection system prior to power off.

NOTE:

The electronics must be reset to exit the Illumination Off mode.

The Test Pattern and Custom Test Pattern modes use internally generated HSync and VSync signals. (See Section 7.13 Internal VSync for TPG (Write – 1Ah) on page 26 for setup details.) All other modes use the HSync and VSync values from the incoming video source.

Blank and Curtain mode will use internal syncs if no valid external sync is detected.

NOTE:

All Image processing algorithms and image size and positioning are applicable ONLY in Normal Mode.

7.26 PWM Enable (Write - 11h)

pwm0	pwm1	pwm2	r	r	r	r	r

pwm0 – PWM Channel 0 enable
0: Disabled
1: Enabled

pwm1 – PWM Channel 1 enable
0: Disabled
1: Enabled

pwm2 – PWM Channel 2 enable
0: Disabled
1: Enabled

r - Reserved, set to zero.

Three generated Pulse-Width-Modulated (PWM) signals are provided. An OEM can use these signals for a variety of purposes.

Refer to DLP® Products DDP3021 Solid State Component Set Specification User's Guide for a detailed specification of these signals.

NOTE:

This command will not cause visual artifacts.

7.27 Read (Write only – 15h)

rd7	rd6	rd5	rd4	rd3	rd2	rd1	rd0

rd(7:0) – Command to read

This command tells the chipset what data it must make available to be read on the next I^2C read transaction.

- Example: To read the Offset settings, use an I^2C write transaction to send a read command(0x15) with the Offset command value (0x0) as the lone data byte. Wait for the Ready status bit to be set and read back the status and the Offset data.
- In Pseudo code:

```
Write(0x34,0x1500) // 0x15 is the "read" command
                   // 0x0 is the Offset command
Do {
   Status = Read(0x35, 2)
  }
Until (Status & Ready)
Data = Read(0x35, 8)  // Data[2] through Data[7] are the Offset command values
```

Most command data values can be read. Those that cannot be read are marked as write only.

NOTE

This command will not cause visual artifacts.

7.28 Reset Factory Defaults (Write only – 1Bh)

fd7	fd6	fd5	fd4	fd3	fd2	fd1	fd0

fd(7:0) – Factory Defaults Reset Control

Writing the value 0xFD to this register causes the microcontroller to read the factory default settings for all registers from the flash memory and reset all registers to these factory default settings. The factory default settings are OEM specific and set using the DLP Composer™ tool set.

NOTE:

This command will not reload factory defaults for DSP or from the optional EEPROM.

7.29 Software Versions (Read Only – 9Ch)

Byte 0: Version

Rd_M7	Rd_M6	Rd_M5	Rd_M4	Rd_M3	Rd_M2	Rd_M1	Rd_M0

Byte 1: Version

Rd_N7	Rd_N6	Rd_N5	Rd_N4	Rd_N3	Rd_N2	Rd_N1	Rd_N0

Byte 2: Version

Rd_P15	Rd_P14	Rd_P13	Rd_P12	Rd_P11	Rd_P10	Rd_P9	Rd_P8

Byte 3: Version

Rd_P7	Rd_P6	Rd_P5	Rd_P4	Rd_P3	Rd_P2	Rd_P1	Rd_P0

Byte 4: Version

Arm_M7	Arm_M6	Arm_M5	Arm_M4	Arm_M3	Arm_M2	Arm_M1	Arm_M0

Byte 5: Version

Arm_N7	Arm_N6	Arm_N5	Arm_N4	Arm_N3	Arm_N2	Arm_N1	Arm_N0

Byte 6: Version

ArmP15	ArmP14	ArmP13	ArmP12	ArmP11	ArmP10	ArmP9	ArmP8

Byte 7: Version

ArmP7	ArmP6	ArmP5	ArmP4	ArmP3	ArmP2	ArmP1	ArmP0

Byte 8: Version

Fls7	Fls6	Fls5	Fls4	Fls3	Fls2	Fls1	Fls0

Byte 9: Version

Fls7	Fls6	Fls5	Fls4	Fls3	Fls2	Fls1	Fls0

Byte 10: Version

Fls7	Fls6	Fls5	Fls4	Fls3	Fls2	Fls1	Fls0

Byte 11: Version

Fls7	Fls6	Fls5	Fls4	Fls3	Fls2	Fls1	Fls0

RdM(7:0) – ARM Major Software Revision
RdN(7:0) – ARM Minor Software Revision
RdP(15:0) – ARM Patch Software Revision

ArmM(7:0) – ARM API Major Software Revision
ArmN(7:0) – ARM API Minor Software Revision
ArmP(15:0) – ARM API Patch Software Revision

Fls(7:0) – OEM Flash build Revision
Fls(7:0) – OEM Flash build Revision
Fls(7:0) – OEM Flash build Revision
Fls(7:0) – OEM Flash build Revision

NOTE:

This command will not cause visual artifacts.

7.30 Vertical Image Position (Write – 05h)

Byte 0: Vertical Direction

dir	r	r	r	r	R	r	r

Byte 1: Vertical Position

vpos7	vpos6	vpos5	vpos4	vpos3	Vpos2	vpos1	vpos0

dir (15) – Direction of the vertical offset
0: shift image up
1: shift image down

vpos (7:0) – Vertical Position

Number of vertical pixels offset from centered position in single pixel increments. vpos = 0 means image is centered vertically on the device. vpos = 1 means image is offset by 1 pixel in the vertical direction indicated by the dir bit.

Range: 0 – 255

r – Reserved, set to zero.

The image, as defined by pixels per line (See Section 7.24 Pixels/Line (Write - 06h) on page 35) and lines per frame (See Section 7.22 above), can be moved partially off the active area of the DMD.

NOTE:

For SmoothPicture™ DMDs, the image moves in 2 pixel increments.

Up adjustment with *DynamicColor™ Local Contrast enabled* is restricted to *12* + <*vertical front porch of original input source*> lines. For sub-images, vertical front porch is gained for every line cropped from the bottom of the image.

8 3D Control Commands

The following sections describe the 3D control commands for the ARM.

NOTE: The behavior of the following commands is altered with respect to normal 2D operation.

Horizontal Image Position (Write – 04h)

Lines/Frame (Write – 07h)

When in 3D mode horizontal image size and position are restricted to even pixel positions only.

If the system is set up for odd pixels, the image will be automatically shifted when switching into 3D.

8.1 3D_Mode_Enable (Write – 38h)

Byte 0:

3D_EN	R	R	R	R	R	R	R

3D_EN (7): Stereo Mode Enable

1: Stereo Mode Enabled

0: Stereo Mode Disabled

R - Reserved, set to zero.

8.2 3D_Mode_Parameters (Write – 39h)

Byte 0:

R	R	R	R	R	R	R	GT

Byte 1:

GT	GT	GT	GT	GT	GT	GT	GT

Byte 2:

LP	R	R	R	R	R	R	R

GT (16:8): Glasses shutter transition time (read only, writes to this field will be ignored). The transition time range is 0 – 3 ms in 10 us increments.

NOTE:

Typical transition time is 2ms although faster time is possible with glasses that support a faster shutter speed.

LP (7): Default Left/Right Lens Polarity as defined in the VESA standard.

1: Inverted Polarity

0: Standard Polarity

NOTE:

Inverted Polarity will cause dual view left/right images to swap.

R - Reserved, set to zero.

9 SmoothPicture™ Interface

Some DMD devices (HD5, xHD5) support SmoothPicture™ processing which require synchronization with an external actuator. There are two methods to generate the control signals necessary for the actuator used with these component sets; Waveform Generator and Voice Coil. The following sections describe commands used for these functions.

9.1 Waveform Generator Control Commands

The commands in this section control the data output from the SmoothPicture™ waveform generator.

9.1.1 *Set Frame Delay (Write – 56h)*

Byte 0:

r	r	r	r	r	R	r	r

Byte MSB 1:

r	r	r	r	sfd19	sfd18	sfd17	sfd16

Byte MSB 2:

sfd15	sfd14	sfd13	sfd12	sfd11	sfd10	sfd9	sfd8

Byte LSB 3:

sfd7	sfd6	sfd5	sfd4	sfd3	sfd2	sfd1	sfd0

NOTE

This command can also be applied to set frame delay in the Voice Coil systems.

sfd(19:0) – 20-bit value indicating amount of delay to apply before waveform edge output begins in a SmoothPicture™ enabled system.

Range : 0 <= n <= 1048575
LSB = 30 ns
r – reserved (set to zero)

9.1.2 *Set Number of Edge Segments (Write – 57h)*

Byte 0:

ed7	ed6	ed5	ed4	ed3	ed2	ed1	ed0

ed(7:0) – the number of edge shape words, from the edge shape table, to use for waveform generation.
Min. value = 2
Max. value = 255

9.1.3 *Set Edge Segment Length (Write – 58h)*

Byte 0 MSB:

esl15	esl14	esl13	esl12	esl11	esl110	esl9	esl8

Byte 1 LSB:

esl7	esl6	esl5	esl4	esl3	esl2	esl1	esl0

esl(15:0) – duration of each edge segment, LSB = 200 ns

Min. value = 2
Max. value = 65535

9.1.4 *Set Gain (Write – 59h)*

Byte 0:

dg7	dg6	dg5	dg4	dg3	dg2	dg1	dg0

dg(7:0) – this gain value is applied to the waveform edge shape data before output from the SmoothPicture™ on DAT_OUT(7:0).

Range is from 0 to 1.9921875. 80 hex equals gain of 1.

Min. value = 0
Max. value = 255 (ffh)

Bit Values

B7	B6	B5	B4	B3	B2	B1	B0
2**0	2**-1	2**-2	2**-3	2**-4	2**-5	2**-6	2**-7

Binary Point

9.1.5 *Set Fixed Output (Write – 5ah)*

Byte 0:

fxout7	fxout6	fxout5	fxout4	fxout3	fxout2	fxout1	fxout0

fxout(7:0) – defines fixed output code from SmoothPicture™, on signals DAT_OUT(7:0)

9.1.6 *Fixed Output Enable (Write – 5bh)*

Byte 0:

r	r	r	r	r	r	r	fxen0

fxen(0) – enable fixed output mode.
0: disable fixed output mode
1: enable fixed output mode

r – reserved (set to zero)

9.1.7 *Set DC Offset (Write – 5ch)*

Byte 0:

r	r	r	dco	dco	dco	dco	dco

dco (4:0) – DC offset value, a 5 bit unsigned number
Min. value = 0
Max. value = 31 (1fh)

r – reserved (set to zero)

NOTE:

See *Section 13.6 Waveform Edge Shape Table Mailbox (Write only – F1h)* for the Waveform Edge Shape Table Mailbox command to load the Waveform Generation table if the change of default values is required.

9.2 Voice Coil Control Commands

The commands in this section control the Voice Coil Module in the SmoothPicture™.

9.2.1 *Quench Pulse Width (Write – 45h)*

Byte 0 MSB:

qpw15	qpw14	qpw13	qpw12	qpw11	qpw10	qpw9	qpw8

Byte 1 LSB:

qpw7	qpw6	qpw5	qpw4	qpw3	qpw2	qpw1	qpw0

qpw(15:0) – Quench pulse width value, LSB=30nS. Range= 0-65535.

9.2.2 *Delay Pulse Width (Write – 46h)*

Byte 0 MSB:

dpw15	dpw14	dpw13	dpw12	dpw11	dpw10	dpw9	dpw8

Byte 1 LSB:

dpw7	dpw6	dpw5	dpw4	dpw3	dpw2	dpw1	dpw0

dpw(15:0) – Delay pulse width value, LSB=30nS. Range= 0-65535.

9.2.3 *PWM HiTime (Write – 47h)*

Byte 0 MSB:

r	r	r	r	r	r	r	pht8

Byte 1 LSB:

pht7	pht6	pht5	pht4	pht3	pht2	pht1	pht0

pht(8:0) – High time for the Voice Coil PWM. Range = 1-1024 r – reserved (set to zero)

9.2.4 *Delta Max (Write – 48h)*

Byte 0 MSB:

dm15	dm14	dm13	dm12	dm11	dm10	dm9	dm8

Byte 1 LSB:

dm7	dm6	dm5	dm4	dm3	dm2	dm1	dm0

dm(15:0) – The limit of the change to the Delay pulse and Quench pulse widths when in Auto-Update mode. Range= 0-65535

9.2.5 *Fixed Sample Frequency (Write – 52h)*

Byte 0 MSB:

fsf15	fsf14	fsf13	fsf12	fsf11	fsf10	fsf9	fsf8

Byte 1 LSB:

fsf7	fsf6	fsf5	fsf4	fsf3	fsf2	fsf1	fsf0

fsf(15:0) – Fixed Sample Period value for the Voice Coil Control Algorithm, LSB = 40 nS.
Range = 2-65535

10 Calibration Commands

The following sections describe the calibration commands for the ARM.

10.1 Calibration Unlock (Write only – 20h)

unlock 7	unlock 6	unlock 5	unlock 4	unlock 3	unlock 2	unlock 1	unlock 0

unlock 7:0 – Calibration register access keyword.

This register provides an interlock to prevent inadvertent writing of calibration registers. Access to this calibration registers (registers 21h – 2Fh), with the exception of Display Segment Color command (0x22), is denied until the correct sequence of keywords is written to this register. The correct sequence of keywords is A5h followed by 5Ah. Once the calibration registers have been unlocked, any of them can be accessed. Unlocking is not required for each register individually. Unlocking will cause the unlocked bit to be set in the status register. Writing to calibration registers, without unlocking via this register first, will cause the command error bit to be set in the status register. Writing any other value to this register will turn off access to (lock) the calibration registers and clear the Unlocked bit in the status register.

NOTE:

This command will not cause visual artifacts.

10.2 Display Segment Color (Write – 22h)

en	r	r	r	r	Ds2	Ds1	Ds0

r – Reserved, set to zero
en 7 - enable/disable segment color display
- 0: disabled
- 1: enabled

ds 2:0 - select segment color
- 000: display color1
- 001: display color2
- 010: display color3
- 011: display color4
- 100: display color5
- 101: display color6

110-111: Reserved

This command can be used to display and measure primary colors during CCA calibration procedures.

Display Segment Color command needs to be preceded by the following sequence of commands:

- Projection Mode
- Test Pattern
- Solid Field (with Color Selection of white =0xff,0x1ff,0xff for GRB respectively)

Complete these commands in order too switch the system to "Full-on White Test Pattern Mode" prior to enabling Display Segment Color.

The display colors can be selected by setting bits (2:0).

NOTE:

The Display Color Segment does not require calibration to be unlocked.

10.3 OEM Data (Write – 29h)

Byte 0: OEM Data

OEM7	OEM6	OEM5	OEM4	OEM3	OEM2	OEM1	OEM0

Byte 1: OEM Data

OEM7	OEM6	OEM5	OEM4	OEM3	OEM2	OEM1	OEM0

Byte 2: OEM Data

OEM7	OEM6	OEM5	OEM4	OEM3	OEM2	OEM1	OEM0

Byte 3: OEM Data

OEM7	OEM6	OEM5	OEM4	OEM3	OEM2	OEM1	OEM0

Byte 4: OEM Data

OEM7	OEM6	OEM5	OEM4	OEM3	OEM2	OEM1	OEM0

Byte 5: OEM Data

OEM7	OEM6	OEM5	OEM4	OEM3	OEM2	OEM1	OEM0

Byte 6: OEM Data

OEM7	OEM6	OEM5	OEM4	OEM3	OEM2	OEM1	OEM0

Byte 7: OEM Data

OEM7	OEM6	OEM5	OEM4	OEM3	OEM2	OEM1	OEM0

OEM(7:0) – OEM data

NOTE:

This command is valid only on the systems that have an optional EEPROM included.

This command allows an engine manufacturer to save 8 bytes of engine specific information to EEPROM, which can then be retrieved by the OEM front-end. The information will be preserved even after the system is powered down and can be read back at power up. This command can't be used between EEPROM Start and Stop Recording. A command error will be issued if this is attempted. If the OEM data command is issued on the system with previously stored OEM data, the new command will automatically erase old OEM data.

Other commands stored using the EEPROM Start and Stop Recording function will not be affected by the use of the OEM Data Command.

NOTE:

This command will not cause visual artifacts.

11 System Status

The system status register consists of two bytes of data. This register is returned as the first two bytes of every read cycle issued to the DDP3021device address. The command error and mailbox download complete bits are cleared to zero each time the system status is read. Steady state signals report the latest status and are not cleared each time read.

Byte 0: System Status MSB

Pgm	r	r	r	ug	ee	r	ssfail

Byte 1: System Status LSB

Rmbs	sslit	cmderr	mbcmp	ac	unlk	sg	rdy

pgm – Programming mode (bootloader active)
0: Not in programming mode
1: In programming mode
ug – User GPIO Status (For instance fan status)
0: HW functional
1: HW failure
ee – EEPROM recording status
0: not recording
1: recording
ssfail – Solid State Failure or ARM to DSP communication issue
0: No failure
1: Failure

For LED architectures: one or more LED modules have experienced a failure. Specific LED module can be determined through a DSP status command (0x43) described later.

rmbs – RLDRAM Memory test OK
0: false
1: true
sslit – Solid State Lit – For LED architecture: LED Module is on (this is a reflection of the "lamp lit" signal from the OEM)
0: false
1: true
cmderr - Command/parameter Error
0: false
1: true
mbcmp - Mailbox download complete
0: incomplete - incorrect number of mailbox words received
1: complete - expected number of mailbox words received
ac – Smooth Picture ™ actuator status
0: hardware is functional
1: hardware failure
unlk - Calibration unlock
0: calibration registers are locked
1: calibration registers are unlocked
sg - System good status
0: something is wrong
1: all hardware is functional
rdy - System Ready
0: the system is currently busy (initializing, executing a command, etc.)
1: the system is ready to execute a command
r – Reserved; MAY NOT BE 0

11.1 Get Slave System Status (Read – CEh)

This command returns the two bytes system status of the Slave ASIC. The format is described in section 11 with the exception of the ee (EEPROM recording) status bit which is not applicable and noted as reserved.

11.2 Extended Status (Read only – 3ch)

Byte 0:

r	r	r	r	r	r	DSPPGE	DSPPN

Byte1:

r	r	r	r	r	r	PF	DEVID

This command can be read if the System Status 'SystemGood' flag is cleared during initialization indicating an issue occurred during power up.

The following might be reasons for an incomplete system initialization:

DEVID: 0: Initialization completed OK
1: DMD Device ID SW version mismatch
PF: 0: Initialization completed OK
1: Premium features found in a value DMD part image

If any of these bits are set to 1 a mismatch between DMD type and the flash image file has been detected. The system will be able to communicate via i2c and an image will be shown but no change to the default Look will be allowed and DynamicBlack™ will be unavailable.

DSPPN: 0: DSP Part Number matches System Configuration.
1: DSP Part Number does not match System Configuration. No image will be displayed, however user can read system status and extended status.
DSPPGE: 0: DSP was programmed correctly (or did not need programming).
1: In-Circuit programming of the DSP could not be performed.

12 Test and Debug Commands

The following sections describe the test and debug commands for the ARM.

12.1 Custom Test Patterns (Write – 36h)

r	r	r	r	r	tp2	tp1	tp0

tp(2:0) – Custom Test Pattern
000: TI Custom Test Pattern 1 – SmoothPicture™ Calibration Test Pattern
001: Custom Test Pattern 2
010: Custom Test Pattern 3
011: Custom Test Pattern 4

r – Reserved, set to zero

This command lets the user select from the Custom Test Patterns created with DLP Composer™ tool set, compressed and stored in flash in the appropriate format.

Custom Test Patterns are enabled using the Projection Mode command (See *Section 7.25 Projection Mode (Write - 02h)* on page 36).

The number of custom test patterns stored in flash depends on the flash size selected via the DLP Composer™ tool set, image complexity and the compression algorithm used.

Customers can choose not to store any Custom Test Patterns if flash size is a concern.

NOTE:

In Custom Test Patterns mode all video processing functionality is bypassed, therefore, commands like Brightness, Offset or Image Size and Positioning won't take any effect. Custom Test Patterns command is not suitable for bezel adjustment.

12.2 Degamma Mailbox Select (Write only - 35h)

r	r	r	r	r	r	color1	color0

color(1:0) - Determines the color(s) to which the gamma mailbox data applies.
- 00: data written to Red, Green, and Blue tables.
- 01: data written to Red table only.
- 10: data written to Green table only.
- 11: data written to Blue table only.

r – Reserved, set to zero

This command is used to tell the DDP3021, which colors the gamma mailbox data should be applied to. (See *Section 13.2 Degamma Mailbox (Write only – E4h)* on page 55.)

NOTE:

This command will not cause visual artifacts.

12.3 DynamicBlack™ Level (Write – 4Ah)

Byte 0:

dmin	dmin	dmin	dmin	Dmin	dmin	dmin	dmin

Byte1:

dmin	dmin	dmin	dmin	Dmin	dmin	dmin	dmin

dmin(15:0) – DynamicBalck ™ min aperture setting (Range 1- 254)

This command directly sets the PWM value for DynamicBlack™.

NOTE:

The DynamicBlack™ algorithm must be disabled before using this command.

The AOM configuration for DynamicBlack™ must be set to use PWM to use this command (instead of the DSP command 0x35 which only controls the LED current values to adjust the dimming levels).

12.4 DynamicBlack™ Min (Write – 4Ch)

Byte 0:

dmin	dmin	dmin	dmin	dmin	dmin	dmin	dmin

Byte1:

dmin	dmin	dmin	dmin	dmin	dmin	dmin	dmin

dmin(15:0) – DynamicBalck ™ min aperture setting (Range 1- 254)

This command sets the minimum aperture value.

12.5 DynamicBlack™ Max (Write – 4Dh)

Byte 0:

dmax	dmax	dmax	dmax	dmax	dmax	dmax	dmax

Byte1:

dmax	dmax	dmax	dmax	dmax	dmax	dmax	dmax

dmax(15:0) – DynamicBalck ™ max aperture setting (Range 1-254)

This command sets the maximum aperture value.

NOTE:

The minimum command value typically corresponds to the fully closed position, while the maximum command typically corresponds to the fully open position.

12.6 EEPROM Recording (Write – 37h)

R	r	r	r	r	r	r	st

st(0) – EEPROM Recording
  0: EEPROM Stop Recording
  1: EEPROM Start Recording
r – Reserved, set to zero

NOTE:

This command works as described only on systems that include the optional EEPROM. On systems that do not include the optional EEPROM, using this command will cause the command/parameter error bit to be set in the system status register. (See *Section 11 System Status* on page 47.)

This command lets the user start/stop recording the optimal settings for a light engine. These settings should be determined during the engine optimization session. When the user issues the command to "start recording", the EEPROM recording bit in the System Status register will be set to indicate that all commands are being recorded. As more commands are sent to the chipset, they will be executed and recorded in the EEPROM. When the last command is complete, the user will issue the command to "stop recording" and the EEPROM recording bit in the System Status register will be cleared to indicate that commands are no longer being recorded.

After recording, when the engine is brought out of reset, the ARM software applies the default values set through the AOM composer interface, replays the command stream that was recorded during the tune-up session and then raises the ASICREADY line and accept I^2C commands during the I^2C user delay period. (See *Section 2 Initialization* on page 8.)

Suggested commands to record in the EEPROM are: DSP Color, SmoothPicture™ parameters, and electronic bezel adjustments.

If the user issues the start recording command followed immediately by the stop recording command, the EEPROM will be emptied.

NOTE:

Recording commands into the EEPROM can cause a measurable lengthening of the chipset reset process. The duration of this time is dependant on the number and type of the commands recorded.

This command will not cause visual artifacts

EEPROM Read-Back functionality:

- command format and usage
  w 0x34 0x15 0x37 0x01
  r 0x34 0x04 the command always returns 4 bytes of data.

- The first read-back command issued returns the "**number of commands"** (2 bytes) & the "**number of bytes**" (2 bytes) stored in EEPROM and set the pointer/address to the first EEPROM command stored.

- The second time the read-back command is issued it returns four bytes of data in EEPROM, starting with the first command saved and the next three bytes (which could be data and another command/parameter).
  - example returned data: "0x03 0x20 0x00 0x00" for only one Projection Mode (set to TPG) command saved in EEPROM
  - example returned data: "0x03 0xC0 0x73 0xE2" for Projection Mode and part of the Dynamic Color Contrast command
  -

- Continuous read-back command issued will return the next 4 bytes saved in EEPROM until,
  - end of EEPROM - after last (0x00 padded) 4 bytes of data returned, returns "command error" if another playback command is issued.
  - or any other I2C command is issued - which will reset the EEPROM pointer back to the first command stored; another playback command issued will start as the "first" playback command above.

NOTE:

Issuing the Read-back command while in the recording mode will return "command error".

12.7 Test Patterns (Write – 33h)

Byte 0:

r	r	r	r	tp3	tp2	tp1	tp0

Byte1:

tpp7	tpp6	tpp5	tpp4	tpw3	tpw2	tpw1	tpw0

tp(3:0) – Test Pattern
- 0000: Solid Field
- 0001: Horizontal Ramp
- 0010: Vertical Ramp
- 0011: Horizontal Lines
- 0100: Diagonal Lines
- 0101: Vertical Lines
- 0110: Grid
- 0111: Checkerboard
- 1000: ANSI Checkerboard

tpp(7:4) - Test Pattern Period
- How often the pattern repeats

tpw(3:0) – Test Pattern Width
- The width of each line in the pattern

r – Reserved, set to zero

The color used for the Solid Field test pattern is determined by the foreground color chosen through the Color Selection command (See *Section 7.5 Color Selection (Write - 12h)* on page 20). All other patterns use Black and White. Test patterns are enabled using the Projection Mode command (See *Section 7.25 Projection Mode (Write - 02h)* on page 36).

The Horizontal and Vertical ramp patterns are made up of multiple ramps.

The Test Pattern Period is the number of pixels in the pattern before it repeats. For best results, this value should be a power of 2 and larger than Test Pattern Width. Does not apply to solid or ramp patterns (0,1,2).

Test Pattern Width is the width of the line (in pixels). For best results, this value should be a power of 2 and less than or equal to half of the Test Pattern Period. Does not apply to solid or ramp patterns (0,1,2).

For checkerboard, byte 1 (normally, the period and width) is treated as a single, 8-bit value that indicates the width and height (in pixels) of each square.

The Test Pattern Generator VSync command should be used to set the internal VSync rate for the Test Pattern Generator mode.

12.8 Voice Coil Smooth Picture™ Actuator Control (Write – 53h)

Byte0: SPC

en	r	r	r	r	r	r	r

en – Enable SmoothPicture™ Voice Coil Actuator
0: Disabled
1: Enabled

r - Reserved, set to zero.

This command turns on/off the Voice Coil Smooth Picture ™ actuator.

13 Mailbox Control

Mailbox Control permits the user to download data tables directly to DDP3021. All data is written to the same I^2C address to enable large amounts of data to be transferred easily.

13.1 CSC Mailbox (Write only – E5h)

Byte 0: CSC MSB

r	r	r	csc12	csc11	csc10	csc9	csc8

Byte 1: CSC LSB

csc7	csc6	csc5	csc4	csc3	csc2	csc1	csc0

r – Reserved, set to zero

NOTE:

Sending incomplete tables or tables with bad data values will likely result in unacceptable screen images. TI recommends downloading a complete table as a contiguous block to ensure the mailbox is closed and values are updated.

$$\begin{bmatrix} G \\ R \\ B \end{bmatrix} = \begin{bmatrix} C1 & C2 & C3 \\ C4 & C5 & C6 \\ C7 & C8 & C9 \end{bmatrix} \begin{bmatrix} A \\ B \\ C \end{bmatrix}$$

All programmable CSC coefficient values represent numbers less than 4 but greater than or equal to negative 4. They are 13-bit signed 2's complement numbers with the binary point between bits 9 and 10.

Coefficient MSBYTE Bit Values

			B12	B11	B10	B09	B08
			SIGN	2**1	2**0	2**-1	2**-2

Binary Point

Coefficient LSBYTE Bit Values

B7	B6	B5	B4	B3	B2	B1	B0
2**-3	2**-4	2**-5	2**-6	2**-7	2**-8	2**-9	2**-10

CSC Mailbox Sub-Address Map

WORD	Coefficient
0	C1
1	C2
2	C3
3	C4
4	C5
5	C6
6	C7
7	C8
8	C9

Writing to the CSC mailbox register will overwrite the CSC values established by the Color Space Converter command (See Section 0

Color Space Converter (Write - 0Bh) on page 21). The contrast command data will be applied to any data downloaded through this interface.

13.2 Degamma Mailbox (Write only – E4h)

Byte 0: Degamma MSB

r	r	r	r	degam11	degam10	degam9	degam8

Byte 1: Degamma LSB

degam7	degam6	degam5	degam4	degam3	degam2	degam1	degam0

NOTE:

Degamma words sent to DDP3021 are immediately applied to the hardware. Sending incomplete Degamma tables, or tables with bad data values, will likely result in unacceptable screen images.

TI recommends downloading Degamma Color tables only at mode changes or at a time when blanking or freezing the screen image is acceptable. Table data is applied immediately to the hardware and may result in unacceptable image artifacts as it is being downloaded.

TI recommends downloading a complete table as a contiguous block of 1024 words.

1024 12-bit values are required to define a complete degamma table (2048 bytes total.)

A Degamma Mailbox download completes when byte 2048 of the Degamma Color table is successfully received. The mailbox download complete flag (See *Section 11 System Status* on page 47) in the System Status Word is set at that time. Any Degamma values received after the 1024 word will wrap around to the beginning of the Degamma table and begin overwriting low address data values.

The mailbox download complete flag will not be set under the following conditions:

- More than 1024 words of Degamma data are received .
- Less than 1024 words of Degamma data are received .

Immediate termination of Degamma download (not recommended per NOTE above) can be initiated by sending any non-Degamma Mailbox command after the 1st and before the 1024 word of Degamma table data.

To restart a Degamma table download in progress or after a failed attempt:

1. Send any non-Degamma Mailbox command to end the current download in progress.
2. Select the Degamma Color Table to be downloaded via the Mailbox Color Command.
3. Send 1024 words of the selected Degamma Color table via the Degamma Mailbox Command.

Degamma Mailbox Sub-Address Map for 12-bit Degamma Mode

WORD	DESCRIPTION
0	DLUT(11:0) Word 0
1	DLUT(11:0) Word 1
2	DLUT(11:0) Word 2
…	
1021	DLUT(11:0) Word 1021
1022	DLUT(11:0) Word 1022
1023	DLUT(11:0) Word 1023

Degamma LUT word bit definitions

BYTE-1

				B11	B10	B9	B8
				GAM(11)	GAM(10)	GAM(9)	GAM(8)

BYTE-0

B7	B6	B5	B4	B3	B2	B1	B0
GAM(7)	GAM(6)	GAM(5)	GAM(4)	GAM(3)	GAM(2)	GAM(1)	GAM(0)

For reference, the degamma function GRB input values are formatted as floating point FP_7e5_20. The FP_7e5_20 designation represents a floating point notation specifying a 7-bit mantissa and a 5-bit exponent. An MSB 8th bit mantissa is implied and always set to "1". The exponent is offset 20 bits. The valid range for the degamma mailbox in floating point is 0 to 256, which corresponds to 0 to 0xE00 in the Exponent/Mantissa format shown below.

B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
5-bit exponent					7-bit mantissa						

In the following: F = Floating point number, E = 5-bit exponent, M = 7-bit mantissa

To convert from Exponent/Mantissa format to Floating point:

F = 0 (for E = 0)
$F = (128 + M)*2^{E-27}$ (for E > 0)

To convert from Floating point to Exponent/Mantissa format:

<u>For F = 0:</u>
E = 0
M = 0

<u>For F > 0:</u>
$E = int(20 + log_2 F)$
If $((log_2 F > -20 \text{ and } log_2 F < -19) \text{ or } (F*2^{(7-int(log2F))} > 255.5))$ then E = E +1
If E < 0 then E = 0
If E > 31then E = 31

$M = round(F*2^{27-E} – 128)$
If M < 0 then M = 0
If M > 127 then M = 127

13.3 DynamicBlack™ Border Configuration Mailbox (Write only – ECh)

DynamicBlack™ Border Configuration Setup Mailbox Sub-Address Map

Word	Description	Range	Default
0	Left Pixel (left edge of border region)	0 – 0x7ff	0 (no left edge border)
1	Right Pixel (right edge of border region)	0 – 0x7ff	0x7ff (no right edge)
2	Top Line (top line of border region)	0 – 0x7ff	0 (no top border)
3	Bottom Line (bottom line of border region)	0 – 0x7ff	0x7ff (no bottom border)

This command is used to configure the DynamicBlack™ border exclusion region.

A value greater than or equal to the number of display pixels means no right edge border.

A value greater than or equal to the number of display lines means no bottom border.

(See *Section 7.9 DynamicBlack™ Configuration (Write – 55h)* on page 22 on how to assign a lesser weight to pixels within the region so that they do not contribute as much to overall scene brightness.)

NOTE:

Sending incomplete tables or tables with bad data values will likely result in unacceptable screen images. TI recommends downloading a complete table as a contiguous block to ensure the mailbox is closed and values are updated.

13.4 General Purpose Filter (GPF) Mailbox (Write only – F2h)

Byte 0: GPF MSB

r	r	r	r	r	r	csc9	csc8

Byte 1: GPF LSB

csc7	csc6	csc5	csc4	csc3	csc2	csc1	csc0

r – Reserved, set to zero

NOTE:

Sending incomplete tables or tables with bad data values will likely result in unacceptable screen images. TI recommends downloading a complete table as a contiguous block to ensure the mailbox is closed and values are updated.

All 25 coefficients are used on 1080p systems.

All programmable General Purpose Filter coefficient values represent numbers between –4.0 and 3.99609375. They are 10-bit signed numbers with the binary point between bits 7 and 8 (format s2.8).

Coefficient MSBYTE Bit Values

					B10	B09	B08
					SIGN	2**1	2**0

Binary Point

Coefficient LSBYTE Bit Values

B7	B6	B5	B4	B3	B2	B1	B0
2**-1	2**-2	2**-3	2**-4	2**-5	2**-6	2**-7	2**-8

GPFMailbox Sub-Address Map

WORD	Coefficient
0	C1
1	C2
2	C3
3	C4
4	C5
5	C6
6	C7
7	C8
8	C9
…	…
24	C25

13.5 PWM Setup Mailbox (Write only – EAh)

Byte 0: PWM MSB

r	r	r	r	r	r	r	r

Byte 1: PWM

r	r	r	r	pwm19	pwm18	pwm17	pwm16

Byte 2: PWM

pwm15	pwm14	pwm13	pwm12	pwm11	pwm10	pwm9	pwm8

Byte 0: PWM LSB

pwm7	pwm6	pwm5	pwm4	pwm3	pwm2	pwm1	pwm0

pwm(19:0) – PWM Setup data

r – Reserved, set to zero

The PWM control function provides three Pulse Width Modulated signals to devices outside the component set. The provided mailbox allows changing parameters of these PWM signals.

Refer to DLP® Products DDP3021 Solid State Component Set Specification User's Guide for a detailed specification of these signals.

Values are increments of 60ns.

NOTE:

The high pulse width should be between 1% and 99% of the clock period. For example, if the period is 8191, the high pulse width can range from 82 to 8109.

This command will not cause visual artifacts.

PWM Setup Mailbox Sub-Address Map

DWord	Description	Range	Default
0	Channel 0 Clock Period	1 to 0xffff	8191 (0x1fff)
1	Channel 0 High Pulse Width	1 to (Period -1)	4096 (0x1000)
2	Channel 1 Clock Period	1 to 0xffff	8191 (0x1fff)
3	Channel 1 High Pulse Width	1 to (Period -1)	4096 (0x1000)
4	Channel 2 Clock Period	1 to 0xffff	8191 (0x1fff)
5	Channel 2 High Pulse Width	1 to (Period -1)	4096 (0x1000)

13.6 Waveform Edge Shape Table Mailbox (Write only – F1h)

Byte 0: Edge Shape Value

Esv7	Esv6	Esv5	Esv4	Esv3	Esv2	Esv1	Esv0

NOTE:

Sending incomplete tables or tables with bad data values will likely result in unacceptable screen images. TI recommends downloading a complete table as a contiguous block to ensure the mailbox is closed and values are updated.

Edge Shape Table Mailbox Sub-Address Map for 8-bit values

Byte	DESCRIPTION
0	Edge shape value
1	Edge shape value
2	Edge shape value
3	Edge shape value
4	Edge shape value
5	Edge shape value
6	Edge shape value
….	….
254	Edge shape value
255	Edge shape value

This data defines the value of the waveform output rising and falling edges. This data is output from SmoothPicture™, signals DAT_OUT(7:0), after gain is applied. Data output is triggered by both edges of the internal SmoothPicture™ sub-frame signal. Once triggered, data is output from the edge shape table until the end value is reached (determined by Number of Edge Segments). The end value is held until the next internal sub-frame edge trigger.

14 Color Point Processing – DSP Commands (Write – 5Eh; Read – DEh)

The DSP Color Point Processing commands allow for I2C communications to the LED Illumination module and the LED DSP Controller. Various actions may be requested through selection of the appropriate DSP CMD.

Byte 0: DSP CMD

b7	b6	b5	b4	b3	b2	b1	b0

Byte 1: PARAMETER

b7	b6	b5	b4	b3	b2	b1	b0

Byte 2: PARAMETER

b7	b6	b5	b4	b3	b2	b1	b0

…

Byte 7: PARAMETER

b7	b6	b5	b4	b3	b2	b1	b0

Valid DSP CMD values are listed below. Parameters for each command are detailed in the following sections.

0x00 Set Measured Red x, y, Lumens color point
0x01 Set Measured Green x, y, Lumens color point

0x02	Set Measured Blue x, y, Lumens color point
0x03 – 0x16	**Reserved**
0x17	Set Internal Measured Color Point Data
0x18-0x1D	**Reserved**
0x1E	Set Desired x, y and Gain
0x1F	Set Desired x, y and Gain Offset
0x20-0x26	**Reserved**
0x27	Select Desaturation Mode
0x28-0x34	**Reserved**
0x35	Set DB Level
0x36-0x42	**Reserved**
0x43	Request read of DSP LED Status Register
0x44	Request DSP Part number
0x45-0x50	**Reserved**
0x51	Set Measurement Intervals
0x52-0x5F	**Reserved**
0x60	Set Sensor Samples to Average
0x61-0x7F	**Reserved**
0x80	Override LED max current setting
0x81-0x86	**Reserved**
0x87	Color Point Processing Control
0x88-0x90	**Reserved**
0x91	Override Color Channel DAC Settings
0x92-0x9F	**Reserved**
0xA0	Request max current setting
0xA1	Request measured x, y Lumens Setting
0xA2	Request internal color sensor measurements
0xA3-0xA5	**Reserved**
0xA6	Request DynamicBlack™ Level
0xA7	Reserved
0xA8	Request Version Information
0xA9	Request temperature sensor readings
0xAA-0xAE	**Reserved**
0xAF	Request x, y and Gain Offset Values
0xB0	**Reserved**
0xB1	Request Color Channel DAC settings
0xB2	**Reserved**
0xB3	Request Driver Information
0xB4	**Reserved**
0xB5	Request Internal Sensor Averaging Setting
0xB6	Request Driver Status
0xB7	Request Driver ADC Value
0xB8	Request Driver Capability
0xB9-0xC0	**Reserved**
0XC1	Request Average Temperature Values
0xC2-0xCA	**Reserved**
0xCB	Request Desired x, y and Gain
0xCC	Request Desired x, y and Gain Compensation
0xCD	Request De-saturation Mode

0xCE-0xFF **Reserved**
* Requires an updated driver that supports these commands

14.1 LED Calibration and Initialization Commands

The following sections describe the details for each command related to DSP Color Management.

14.1.1 *Measured Red x, y and Lumens Color Point (Command 0x00)*

The Red x, y and Lumens measurement is taken by an external sensor (colorimeter) during system calibration. The results are programmed into the system using the 0x00 command.

Byte 0: DSP CMD

0	0	0	0	0	0	0	0

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: x (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^ Binary Point

Byte 3: x (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 4: y (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^ Binary Point

Byte 5: y (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 6: Lumens (MSB)

L15	L14	L13	L12	L11	L10	L9	L8

Byte 7: Lumens (LSB)

L7	L6	L5	L4	L3	L2	L1	L0

Where:

x	u[1.15] x color point for Red (range 0.0 < x <= 1.0)
y	u[1.15] y color point for Red (range 0.0 < x <= 1.0)
L	[15:0] Red Lumens (range 0 – 65535)

NOTE:

Sending a value of zero for either x or y will result in a command error and the values will not be applied.

14.1.2 *Measured Green x, y and Lumens Color Point (Command 0x01)*

The Green x, y and Lumens measurement is taken by an external sensor (colorimeter) during system calibration. The results are programmed into the system using the 0x01 command.

Byte 0: DSP CMD

0	0	0	0	0	0	0	1

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: x (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^ Binary Point

Byte 3: x (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 4: y (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^ Binary Point

Byte 5: y (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 6: Lumens (MSB)

L15	L14	L13	L12	L11	L10	L9	L8

Byte 7: Lumens (LSB)

L7	L6	L5	L4	L3	L2	L1	L0

Where:

x	u[1.15] x color point for Green (range 0.0 < x <= 1.0)
y	u[1.15] y color point for Green (range 0.0 < x <= 1.0)
L	[15:0] Green Lumens (range 0 – 65535)

NOTE:

Sending a value of zero for either x or y will result in a command error and the values will not be applied.

14.1.3 *Measured Blue x, y and Lumens Color Point (Command 0x02)*

The Blue x, y and Lumens measurement is taken by an external sensor (colorimeter) during system calibration. The results are programmed into the system using the 0x02 command.

Byte 0: DSP CMD

0	0	0	0	0	0	1	0

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: x (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^ Binary Point

Byte 3: x (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 4: y (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^ Binary Point

Byte 5: y (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 6: Lumens (MSB)

L15	L14	L13	L12	L11	L10	L9	L8

Byte 7: Lumens (LSB)

L7	L6	L5	L4	L3	L2	L1	L0

Where:

x	u[1.15] x color point for Blue (range 0.0 < x <= 1.0)
y	u[1.15] y color point for Blue (range 0.0 < x <= 1.0)
L	[15:0] Blue Lumens (range 0 – 65535)

NOTE:

Sending a value of zero for either x or y will result in a command error and the values will not be applied.

14.1.4 *Write Internal Color Sensor Measurements (Command 0x17)*

During the initial calibration of the system, the color point of each of the primary colors is measured using the internal sensor (reference DSP CMD 0xA2). This data, combined with the external color point data, is used by the DSP to maintain a desired color point. This command must be sent to the DSP set upon a power-up or reset condition.

Byte 0: DSP CMD

0	0	0	1	0	1	1	1

Byte 1: CCA Column

0	0	0	0	0	c2	c1	c0

Byte 2: A (MSB)

A15	A14	A13	A12	A11	A10	A9	A8

Byte 3: A (LSB)

A7	A6	A5	A4	A3	A2	A1	A0

Byte 4: B (MSB)

B15	B14	B13	B12	B11	B10	B9	B8

Byte 5: B (LSB)

B7	B6	B5	B4	B3	B2	B1	B0

Byte 6: C (MSB)

C15	C14	C13	C12	C11	C10	C9	C8

Byte 7: C (LSB)

C7	C6	C5	C4	C3	C2	C1	C0

Where:

c[2,0] = Requested Color, 0=red, 1=green, 2=blue, 3-7=reserved

A[15:0] A component of sensor measurement (0 – 65535)

B[15:0] B component of sensor measurement (0 – 65535)

C[15:0] C component of sensor measurement (0 – 65535)

14.1.5 *Set Desired x, y and Gain (Command 0x1E)*

The Set Desired x, y and Gain command sets the desired target color point for operation.

Byte 0: DSP CMD

0	0	0	1	1	1	1	0

Byte 1: Reserved

0	0	0	0	CLR3	CLR2	CLR1	CLR0

Byte 2: gain (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

Byte 3: gain (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 4: x (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

Byte 5: x (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 6: y (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

Byte 7: y (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Where:

CLR[3:0] Specifies which color the settings apply to.

0 = Red
1 = Green
2 = Blue
3 = Yellow
4 = Cyan
5 = Magenta
6 = White
7-14 = Reserved

gain u[1.15] gain for color point (range 0.0 < x < 2.0)
x u[1.15] x for color point (range 0.0 < x <= 1.0)
y u[1.15] y for color point (range 0.0 < x <= 1.0)

NOTE:

Sending a value of zero for either x, y or y gain will disable correction for that color. If the white point is being controlled by current (see command 0x27) then the white point will still be controlled even if the white gain is set to 0. There will just be no additional adjustment for white.

14.1.6 *Set Desired x, y and Gain Offset (Command 0x1F)*

The Desired x, y and gain for White and all primary and secondary colors is chosen with the BrilliantColor™ Look selection command. To allow for small variations in these color points due to manufacturing deviations, this command allows entering a positive or negative offset to the desired color.

Byte 0: DSP CMD							
0	0	0	1	1	1	1	1
Byte 1: Reserved							
0	0	0	0	CLR3	CLR2	CLR1	CLR0
Byte 2: gain (MSB)							
2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}
Byte 3: gain (LSB)							
2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}
Byte 4: x (MSB)							
Sign	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}
	^Binary point		Byte 5: x (LSB)				
2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}
Byte 6: y (MSB)							
Sign	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}
	^Binary point		Byte 7: y (LSB)				
2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Where:

CLR[3:0] Specifies which color the settings apply to.

0 = Red
1 = Green
2 = Blue
3 = Yellow
4 = Cyan
5 = Magenta
6 = White
7-14 = Reserved
15 = Apply to all color channels

gain u[1.15] gain for color point (range 0.0 < x < 2.0)

x = s[0.15] x color point for offset (range -1.0< x < 1.0) , signed two's complement

y = s[0.15] y color point for White (range -1.0 < x < 1.0) , signed two's complement

NOTE:

Sending a value of zero for either x, y or y gain will disable correction for that color.

14.1.7 *De-saturation Mode Select (Command 0x27)*

The default mode for de-saturation is disabled, or off. This command allows selecting between turning off de-saturation, or enabling de-saturation via CCA.

Byte 0: DSP CMD

0	0	1	0	0	1	1	1

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Mode (LSB)

0	0	0	0	0	0	M_1	M_0

Where:

M[1:0] 0 = Off - No Desaturation. [Default]
1 = De-saturation via CCA
2 = De-saturation via current.

NOTE:

De-saturation should never be enabled during Illumination Off projection mode.

14.1.8 *Set DB Level (Command 0x35)*

This command sets the percentage DynamicBlack™ attenuation level that the DSP will use to scale the LED driver current values.

Byte 0: Command

0	0	1	1	0	1	0	1

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: DB Value MSByte

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

Byte 7: DB Value LSByte

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

DynamicBlack™ Value[15:0]. Format is u1.15 expressed as a percentage, where 1.0 is 100 % current level, or no attenuation.

NOTE:

The DynamicBlack™ algorithm must be disabled before using this command (I2C command 0x55).

The AOM configuration for DynamicBlack™ must be set to use Current control in order to use this command (instead of the I2C command 0x4A which uses the PWM signal to the DSP to adjust the dimming levels).

14.1.9 *Set Measurement Intervals (0x51)*

The DSP will continually measure the output power of the LED Driver Power Supply based on the initial Measured Values and update a running average of the power in three time windows; seconds, minutes and hours. Similarly, averages of Temperature will be tabulated. This command allows setting the size of each of these intervals.

When this command is received the DSP will zero out the running averages and Peak values calculated before this command was sent and will "re-start" the calculations.

Byte 0: Command

0	1	0	1	0	0	0	1

Byte 1: Number of Seconds

S7	S6	S5	S4	S3	S2	S1	S0

Byte 2: Number of Minutes

M7	M6	M5	M4	M3	M2	M1	M0

Byte 3: Number of Hours

H7	H6	H5	H4	H3	H2	H1	H0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:
S[7:0] Specifies the number of seconds in the seconds running average window.

M[7:0] Specifies the number of minutes in the minutes running average window.

H[7:0] Specifies the number of hours in the hours running average window.

14.1.10 *Set sensor samples to average (0x60)*

The Set Internal Sensor Averaging command is used to set the number of samples of the internal light sensor that will be averaged when the Color Management Algorithm is executing.

Byte 0: DSP CMD

0	1	1	0	0	0	0	0

Byte 1: Type

0	0	0	0	0	0	0	Type

Byte 2: Number of Averages

A7	A6	A5	A4	A3	A2	A1	A0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:

Type: What measurement to apply the number of samples to
- 0 = Apply number of samples parameter to calibration table
- 1 = Apply number of samples parameter to operating current sensor measurements.

A[7:0] = Number of samples to averages (range = minimum of 3, typically 1 – 10)

14.1.11 *Override Max Current Setting (0x80)*

The Override Max Current Setting command allows overriding the default maximum current used by the DSP for each color.

Byte 0: Command

1	0	0	0	0	0	0	0

Byte 1: SSI Module Selection

0	0	0	0	CLR3	CLR2	CLR1	CLR0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: MSByte

0	0	0	0	B11	B10	B9	B8

Byte 7: LSByte

B7	B6	B5	B4	B3	B2	B1	B0

Where:

CLR[3:0] Specifies which SSI module the current settings apply to.

0 = Red channel

1 = Green channel

2 = Blue channel

3-15 = Reserved

B[11:0] Current setting. Range = 0 – 4095; Driver Dependant (8, 10 or 12 bit).

14.1.12 *Color Point Processing Control (Command 0x87)*

The Color Point Processing Control command enables or disables Calibration mode and enables or disables the Color Point Processing function.

Byte 0: DSP CMD

1	0	0	0	0	1	1	1

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Color Point Processing Control

0	0	0	0	0	CURCCA	CAL_EN	WP_EN

Where:

WP_EN	0:	Disable	Controls if White Point Correction Algorithm is Enabled.
	1:	Enable	
CAL_EN	0:	Disable	Controls if Calibration mode is Enabled.

Byte 0: DSP CMD

1	0	0	0	0	1	1	1

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Color Point Processing Control

0	0	0	0	0	CURCCA	CAL_EN	WP_EN

Where:

	1:	Enable	
CURCCA	0:	User Current	When WP_EN=1, this field determines which method the DSP uses to control the white point.
	1:	Use CCA	

NOTE:

1. Calibration and White Point Correction Algorithm cannot be enabled together. This state is undefined and will cause the command error bit to be set in the System Status Word.

2. WP_EN should never be enabled during Illumination Off projection mode.

14.1.13 *Override Color Channel DAC Settings (Command 0x91)*

The SSI driver contains several Digital to Analog Converters (DACs) to control the current level for each color channel. This command overrides the DSP control of the DAC value to be used and is only valid when the color manager algorithm is disabled. The capability is provided to set all of the DAC values for each color channel.

Byte 0: Command

1	0	0	1	0	0	0	1

Byte 1: SSI Module Selection

0	0	0	0	CLR3	CLR2	CLR1	CLR0

Byte 2: DAC Selection

0	0	0	0	DAC3	DAC2	DAC1	DAC0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: DAC Value MSByte

0	0	0	0	B11	B10	B9	B8

Byte 7: DAC Value LSByte

B7	B6	B5	B4	B3	B2	B1	B0

CLR[3:0] Specifies which SSI module the DAC settings apply to.
- 0 = Red channel
- 1 = Green channel
- 2 = Blue channel
- 3-15 = Reserved

DAC[3:0] Specifies the DAC setting to be used for the specified color.
- 0 = DAC setting during Red strobe
- 1 = DAC setting during Green strobe
- 2 = DAC setting during Blue strobe
- 3 = DAC setting during Sensor Sample 1 strobe (Subframe 1)
- 4 = DAC setting during Sensor Sample 2 strobe (Subframe 2)
- 5 = DAC setting during Yellow strobe
- 6 = DAC setting during Cyan strobe
- 7 = DAC setting during Magenta strobe
- 8 = DAC setting during White
- 9 = DAC setting during Black (i.e. when CLR strobe is off)
- 10-15 = Reserved

B[11:0] DAC current level setting.

14.2 Read Back Commands

The following commands are either used during normal operations to request operating information from the LED DSP controller or to verify the operation of the illumination module hardware. Most of the time, this information is used by algorithms internal to the ASIC.

14.2.1 *Read of DSP Status Register (0x43)*

The Request Read of DSP Status Register command requests the current status of the DSP Color Manager.

Byte 0: Command

0	1	0	0	0	0	1	1

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: MSByte

0	0	0	0	0	0	0	0

Byte 7: LSByte

0	0	0	0	0	0	0	0

Returned data is 3 bytes in the following format:

Byte 0: SPI Communication Status

0	0	0	0	0	SER B	SER G	SER R

Byte 1: Temperature Status

0	0	0	0	0	TEMP_B	TEMP_G	TEMP_R

Byte 2: Color Management System Status

ERR	Res	Res	Res	CAL_EN	WP_EN	Res	Res

SER_x: SPI Error Flag per color. (**B**lue, **G**reen, **R**ed)

1 = SPI Data packet echoed from Driver does not match data packet sent.
0 = No failure

TEMP_x: Illuminator Over Temperature Flag per color. (**B**lue, **G**reen, **R**ed)

1 = Illuminator temperature is above the desired operating temperature.
0 = No failure

ERR: SPI transmission error to LED Driver. Set until status read

1 = Error occurred while sending and SPI command to the driver (i.e. echoed data does not match sent data). Refer to byte 0 for specific driver failure.
0 = No errors.

CAL_EN: Calibration Mode Enable.

1 = Calibration mode is enabled.
0 = Calibration mode is disabled.

WP_EN: White Processing (Color Management System) Enable.

1 = Color Management System is enabled.
0 = Color Management System is disabled.

14.2.2 *Request DSP Part Number (0x44)*

This command retrieves the DSP Part Number from Flash.

Byte 0: DSP CMD

0	1	0	0	0	1	0	0

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Upon receipt of this command, the LED DSP Controller places the 12 byte ASCII DSP Part Number into the I^2C Output FIFO. This value is then read using I^2C.

The format of the returned data is shown below:

Byte 0: Byte 1 of Part Number (i.e. ASCII character 1)

PN0_7	PN0_6	PN0_5	PN0_4	PN0_3	PN0_2	PN0_1	PN0_0

:
Byte 1 – 10;
:

Byte 11: Byte 12 of Part Number (i.e. ASCII character 12)

PN11_7	PN11_6	PN11_5	PN11_4	PN11_3	PN11_2	PN11_1	PN1_10

For example, if the part number is 2509809-1101, then Byte 0 of the data is the ASCII code for 2, Byte 1 is the ASCII code for 5, and so on. The dash is included in the data. The entire returned data (in hexadecimal format) would be in this case:

<32 35 30 39 38 30 39 2D 31 31 30 31>

14.2.3 *Request HW Current Setting (0xA0)*

The Request Max Current Setting command allows reading the maximum current used by the DSP for each color.

Byte 0: Command

1	0	1	0	0	0	0	0

Byte 1: SSI Module Selection

0	0	0	0	CLR3	CLR2	CLR1	CLR0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:

CLR[3:0] Specifies which SSI module the current settings apply to.

0 = Red channel

1 = Green channel

2 = Blue channel

3-14 = Reserved

B[11:0] Current setting. Range = 0 – 4095; Driver Dependant (8, 10 or 12 bit).

Returned data is 2 bytes:

Byte 0: MSByte

1	0	1	0	B11	B10	B9	B8

Byte 1: LSByte

B7	B6	B5	B4	B3	B2	B1	B0

Where:

B[11:0] Current setting. Range = 0 – 4095; Driver Dependant (8, 10 or 12 bit).

14.2.4 *Request Measured x, y and Lumens Setting (Command 0xA1)*

This command is used to retrieve the most recently entered external color measurements sent via the Set Measured x,y Lumens commands (0x00-0x02).

Byte 0: DSP CMD

1	0	1	0	0	0	0	1

Byte 1: Requested Color

0	0	0	0	0	c2	c1	c0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:

C[2:0] = Requested Color
0=red
1=green
2=blue
3-7=reserved

Upon receipt of this command, the LED DSP Controller places the requested measurement values into the I^2C Output FIFO. These values may then be read using I^2C.

The format of the returned values is as follows:

Byte 0: x (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

Byte 1: x (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 2: y (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

Byte 3: y (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 4: Lumens (MSB)

L15	L14	L13	L12	L11	L10	L9	L8

Byte 4: Lumens (LSB)

L7	L6	L5	L4	L3	L2	L1	L0

Where:

x u[1.15] x color point (range 0.0 < x <= 1.0)

y u[1.15] y color point (range 0.0 < x <= 1.0)

L [15:0] Lumens (range 0 – 65535)

14.2.5 *Request Internal Color Sensor Measurements (Command 0xA2)*

The Request Internal Color Sensor Measurements command is used to retrieve the most recent feedback sensor readings.

Byte 0: DSP CMD

1	0	1	0	0	0	1	0

Byte 1: Requested Color

0	0	0	0	0	c2	c1	c0

Byte 2: Measurement Selection

Inverse	0	0	0	0	0	Type1	Type0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:

C[2:0] = Requested Color
0=red
1=green
2=blue
3-7=reserved

Type[1:0] = Measurement Value Selection
0 = Max Brightness from calibration
1 = Sensor measurement at current operation DAC level
2 = Current maximum
3 = Current black level measurement

Inverse [7] = Inverse of Measurement Selection
0 = Non-inverted
1 = Inverted

Upon receipt of this command, the LED DSP Controller places the requested measurement values into the I^2C Output FIFO. These values may then be read using I^2C.

The format of the returned values is as follows:

Byte 0: Red (MSB)

R[15]	R[14]	R[13]	R[12]	R[11]	R[10]	R[9]	R[8]

Byte 1: Red (LSB)

R[7]	R[6]	R[5]	R[4]	R[3]	R[2]	R[1]	R[0]

Byte 2: Green (MSB)

G[15]	G[14]	G[13]	G[12]	G[11]	G[10]	G[9]	G[8]

Byte 3: Green (LSB)

G[7]	G[6]	G[5]	G[4]	G[3]	G[2]	G[1]	G[0]

Byte 4: Blue (MSB)

B[15]	B[14]	B[13]	B[12]	B[11]	B[10]	B[9]	B[8]

Byte 5: Blue (LSB)

B[7]	B[6]	B[5]	B[4]	B[3]	B[2]	B[1]	B[0]

Where:

R/G/B = integer sensor ADC reading for the selected color/configuration

14.2.6 *Request DynamicBlack™ Level (Command 0xA6)*

The Request DynamicBlack™ Level command retrieves the last value sent with the Set DB™ Level command, 0x35.

Byte 0: Command

1	0	1	0	0	1	1	0

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6:MSByte

0	0	0	0	0	0	0	0

Byte 7:LSByte

0	0	0	0	0	0	0	0

The returned data is 2 bytes in the following format:

DB15…..

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

…DB0

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

DB[15:0] DynamicBlack™ setting. Format is u1.15 expressed as a percentage, where 1.0 is 100 % current level, or no attenuation, i.e.:

NOTE:

This value will only take affect if DynamicBlack™ is disabled.

14.2.7 *Request Version Information (Command 0xA8)*

The Request Version Information command will query the LED DSP Controller for the current Software Build Information.

Byte 0: DSP CMD

1	0	1	0	1	0	0	0

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Upon receipt of this command, the LED DSP Controller places the software build information into the I^2C Output FIFO. This value is then read using I^2C.

The format of the returned values is as follows:

Byte 0: Major Version Number

m7	m6	m5	m4	m3	m2	m1	m0

Byte 1: Minor Version Number

n7	n6	n5	n4	n3	n2	n1	n0

Byte 2: Patch Increment

i7	i6	i5	i4	i3	i2	i1	i0

Where:

m[7:0] Major SW Version Number (range 0 – 255)

n[7:0] Minor SW Version Number (range 0 – 255)

i[7:0] Patch Increment (range 0 – 255)

14.2.8 *Request Temperature Sensor Readings (Command 0xA9)*

The LED DSP Controller has A/Ds which are used to take temperature readings. The Request Temperature Sensor Readings command is used to retrieve the most recent samples from the A/D.

Byte 0: DSP CMD

1	0	1	0	1	0	0	1

Byte 1: Table Index

0	0	0	0	0	TS1	TS2	TS3

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:

TS[2:0] is sensor location.

0 - Red LED

1 = Green LED

2 = Blue LED

3-6 = Reserved

7 = Internal Light Sensor

Upon receipt of this command, the LED DSP Controller places the requested A/D samples into the I2C Output FIFO. This value is then read using I2C.

The format of the returned values is as follows:

Byte 0: Temp Sensor Reading (MSB)

$T_1 11$	$T_1 10$	$T_1 9$	$T_1 8$	$T_1 7$	$T_1 6$	$T_1 5$	$T_1 4$

Byte 1: Temp Sensor Reading (LSB)

$T_1 3$	$T_1 2$	$T_1 1$	$T_1 0$	0	0	0	0

14.2.9 *Request Desired x, y and Gain Offset (Command 0xAF)*

The Request x and y offset command is used to retrieve the most recently entered color points sent via the Set x and y Offset command. (0x1F).

Byte 0: DSP CMD

1	0	1	0	1	1	1	1

Byte 1: Requested Color

0	0	0	0	0	c2	c1	c0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:

C[2:0] = Requested Color
0=red
1=green
2=blue
3=yellow
4=cyan
5=magenta
6=white
7=reserved

Upon receipt of this command, the LED DSP Controller places the requested measurement values into the I^{2}C Output FIFO. These values may then be read using I^{2}C.

Byte 0: Gain (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

Byte 1: Gain (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 2: x (MSB)

Sign	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^Binary point Byte 3: x (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 4: y (MSB)

Sign	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^Binary point Byte 5: y (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Where:

Gain = u[1.15] gain for color point (range 0.0 < x < 2.0)

x = s[0.15] x color point for offset (range -1< x < 1) , signed two's complement

y = s[0.15] y color point for White (range -1 < x < 1) , signed two's complement

14.2.10 *Request Color Channel DAC Settings (Command 0xB1)*

The SSI driver contains several Digital to Analog Converters (DACs) to control the current level for each color channel. This command allows read-back of the values currently being used. Since these values change on a frame by frame basis, the value read may not represent the current value being applied, unless the Color Manager Algorithm is disabled.

Byte 0: Command

1	0	1	1	0	0	0	1

Byte 1: SSI Module Selection

0	0	0	0	CLR3	CLR2	CLR1	CLR0

Byte 2: DAC Selection

0	0	0	0	DAC3	DAC2	DAC1	DAC0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6:MSByte

0	0	0	0	0	0	0	0

Byte 7:LSByte

0	0	0	0	0	0	0	0

CLR[3:0] Specifies which SSI module the DAC settings are to be read from.

0 = Red channel
1 = Green channel
2 = Blue channel

3 = Yellow channel
4 = Cyan channel
5 = Magenta channel

DAC[3:0] Specifies the DAC setting to be read.

0 = DAC setting during Red strobe
1 = DAC setting during Green strobe
2 = DAC setting during Blue strobe
3 = DAC setting during Sensor Sample 1 strobe (Subframe 0)
4 = DAC setting during Sensor Sample 2 strobe (Subframe 1)
5 = DAC setting during Yellow strobe
6 = DAC setting during Cyan strobe
7 = DAC setting during Magenta strobe
8 = DAC setting during White
9 = DAC setting during Black (i.e. when CLR strobe is off)

Returned data is 2 bytes in the following format:

Byte 0:MSByte

0	0	0	0	B11	B10	B9	B8

Byte 1:LSByte

B7	B6	B5	B4	B3	B2	B1	B0

14.2.11 *Request Driver Information (0xB3)*

The Request Driver Information command allows read-back of the driver ID and version information.

Byte 0: Command

1	0	1	1	0	0	1	1

Byte 1: SSI Module Selection

0	0	0	0	CLR3	CLR2	CLR1	CLR0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: MSByte

0	0	0	0	0	0	0	0

Byte 7: LSByte

0	0	0	0	0	0	0	0

Where:

CLR[3:0] Specifies which SSI module the time parameter applies to.
0 = Red channel
1 = Green channel
2 = Blue channel
3 = Yellow channel
4 = Cyan channel
5 = Magenta channel
6-15 = Reserved

Returned data is 3 bytes in the following format:

Byte 0: Manufacturer ID

MID7	MID6	MID5	MID4	MID3	MID2	MID1	MID0

Byte 1: Hardware ID

HID7	HID6	HID5	HID4	HID3	HID2	HID1	HID0

Byte2: Firmware ID

FID7	FID6	FID5	FID4	FID3	FID2	FID1	FID0

Byte 3: Illuminator Information

RD	GRN	BL	YLW	CYN	MG	WT	TYPE

Illuminator Information [7:0]

RD [7] = Red SSI Driver, 1 = Present/Active; 0 = Not used/inactive
GRN [6] = Green SSI Driver, 1 = Present/Active; 0 = Not used/inactive
BL [5] = Blue SSI Driver, 1 = Present/Active; 0 = Not used/inactive
YLW [4] = Yellow SSI Driver, 1 = Present/Active; 0 = Not used/inactive
CYN [3] = Cyan SSI Driver, 1 = Present/Active; 0 = Not used/inactive
MG [2] = Magenta SSI Driver, 1 = Present/Active; 0 = Not used/inactive
WT [1] = White SSI Driver, 1 = Present/Active; 0 = Not used/inactive
TYPE [0] = SSI Driver Type, 1 = Alternate; 0 = LED

14.2.12 *Request Internal Sensor Averaging (Command 0xB5)*

The Set Internal Sensor Averaging command is used to set the number of samples of the internal light sensor that will be averaged when the Color Management Algorithm is executing.

Byte 0: DSP CMD

1	0	1	1	0	1	0	1

Byte 1: Number of Averages

0	0	0	0	0	0	0	Type

Byte 2: Reserved

0	0	0	0	0	0	0	0
Byte 3: Reserved							
0	0	0	0	0	0	0	0
Byte 4: Reserved							
0	0	0	0	0	0	0	0
Byte 5: Reserved							
0	0	0	0	0	0	0	0
Byte 6: Reserved							
0	0	0	0	0	0	0	0
Byte 7: Reserved							
0	0	0	0	0	0	0	0

Where:

Type: What measurement to apply the number of samples to

0 = Return number of samples parameter applied to maximum current sensor measurements.

1 = Return number of samples parameter applied to operating current sensor measurements.

Upon receipt of this command, the LED DSP Controller places the requested byte value into the I^2C Output FIFO. These values may then be read using I^2C.

Byte 0: Sample Number Setting

B7	B6	B5	B4	B3	B2	B1	B0

14.2.13 *Request Driver Status (Command 0xB6)*

The Request Driver command is used to retrieve the status of the driver. This command will be used when the Rev B version of the Solid State Driver Interface is approved and implemented.

Byte 0: DSP CMD							
1	0	1	1	0	1	1	0
Byte 1: Requested Color							
0	0	0	0	C3	c2	c1	c0
Byte 2: Reserved							
0	0	0	0	0	0	0	0
Byte 3: Reserved							
0	0	0	0	0	0	0	0
Byte 4: Reserved							

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:

C[3:0] = Requested Color
0=red
1=green
2=blue
3=yellow
4=cyan
5=magenta
6=white
7=IR
8-15=reserved

Upon receipt of this command, the LED DSP Controller places the requested measurement values into the I^2C Output FIFO. These values may then be read using I^2C.

Byte 0: Driver Status Byte (MSB)

0	0	0	0	0	0	TS	LIT

LIT: Illumination status
0=Inactive,
1=Active

TS: Temperature Status
0=One or more temperature monitoring points is out of range,
1=All temperatures in range

NOTE:

This command is only valid with Illumination Drivers that support Rev B of the Solid State Driver Interface specification.

14.2.14 *Request Driver ADC Value (Command 0xB7)*

The Request Driver ADC Value command is used to retrieve the ADC value from the specified color driver and ADC measurement. This command will be used when the Rev B version of the Solid State Driver Interface is approved and implemented.

Byte 0: DSP CMD

1	0	1	1	0	1	1	1

Byte 1: Requested Color

0	0	0	0	C3	C2	C1	C0

Byte 2: ADC Measurement Number

0	0	0	0	M3	M2	M1	M0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:

C[3:0] = Requested Color
0=red
1=green
2=blue
3=yellow
4=cyan
5=magenta
6=white
7=IR
8-15=reserved

M[3:0] = ADC # to return measurement from

Upon receipt of this command, the LED DSP Controller places the requested measurement values into the I2C Output FIFO. These values may then be read using I2C.

Byte 0: ADC Value MSByte

ADC15	ADC14	ADC13	ADC12	ADC11	ADC10	ADC9	ADC8

Byte 1: ADC Value LSByte

ADC7	ADC6	ADC5	ADC4	ADC3	ADC2	ADC1	ADC0

NOTE:

This command is only valid with Illumination Drivers that support Rev B of the Solid State Driver Interface specification.

14.2.15 *Request Driver Capability (Command 0xB8)*

The Request Driver Capability command is used to retrieve information about the drivers capability for what color it is, if it has IR and how many IR Drivers and also for the specified color channel, how many ADC readings can be asked what bit depth the ADC readings represent. This command is only supported by some LED Drivers. Refer to the Driver Specification for compatibility.

Byte 0: DSP CMD

1	0	1	1	1	0	0	0

Byte 1: Requested Color

0	0	0	0	C3	C2	C1	C0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:

C[3:0] = Requested Color
0=red
1=green
2=blue
3=yellow
4=cyan
5=magenta
6=white
7=IR
8-15=reserved

M[3:0] = ADC # to return measurement from

Upon receipt of this command, the LED DSP Controller places the requested values into the I2C Output FIFO. These values may then be read using I2C.

Byte 0: Illumination Type

RD	GRN	BL	YLW	CYN	MG	WT	TYPE

Byte 1: IR Support

IR7	IR6	IR5	IR4	IR3	IR2	IR1	IR0

Byte 2: ADC Definition

BD1	BD0	ADC5	ADC4	ADC3	ADC2	ADC1	ADC0

RD: Red SSI Driver
- 0: Inactive
- 1: Active

GRN: Green SSI Driver
- 0: Inactive
- 1: Active

BL: Blue SSI Driver
- 0: Inactive
- 1: Active

YLW: Yellow SSI Driver
- 0: Inactive
- 1: Active

CYN: Cyan SSI Driver
- 0: Inactive
- 1: Active

MG: Magenta SSI Driver
- 0: Inactive
- 1: Active

WT: White SSI Driver
- 0: Inactive
- 1: Active

TYPE: Type SSI Driver
- 0: Inactive
- 1: Active (Alternative SSI source, i.e. IR)

IR[7:0] Number of IR illuminators used

ADC[5:0] Number of ADC measurements available

BD[7:0] Bit Depth
- 0: 8-bits
- 1: 16-bits
- 2-3:reserved

NOTE:

This command is only valid with Illumination Drivers that support Rev B of the Solid State Driver Interface specification.

14.2.16 Request DSP Sensor Timing Configuration (Command 0xB9)

The Request DSP Sensor Timing Configuration command retrieves the light sensor timing configuration that was sent with the Set DSP Sensor Timing Configuration Command, 0x89.

Byte 0: Command

1	0	1	1	1	0	0	1

Byte 1: Reserved

0	0	0	0	0	0	0	0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6:MSByte

0	0	0	0	0	0	0	0

Byte 7:LSByte

0	0	0	0	0	0	0	0

Returned data is 4 bytes in the following format:

Byte 0: Sensor Start Delay

DLY3	DLY2	DLY1	DLY0	DLY3	DLY2	DLY1	DLY0

Byte 1: Red Sensor Duration

RD7	RD6	RD5	RD4	RD3	RD2	RD1	RD0

Byte 2: Green Sensor Duration

GD7	GD6	GD5	GD4	GD3	GD2	GD1	GD0

Byte 3: Blue Sensor Duration

BD7	BD6	BD5	BD4	BD3	BD2	BD1	BD0

DLY[7:0]: Delay from LED_SENS strobe signal until integrating sensor is commanded to start. LSB = 1 uSec.
RD[7:0]: Maximum integration duration time for red sample after start delay has expired. LSB = 1 uSec.

GD[7:0]: Maximum integration duration time for green sample after start delay has expired. LSB = 1 uSec.
BD[7:0]: Maximum integration duration time for blue sample after start delay has expired. LSB = 1 uSec.

14.2.17 *Request Average Temperature Values (0xC1)*

Based on the number of seconds, minutes, and hours set with command 0x51, the DSP will measure the LED Thermistor voltages and store a running average of the voltage readings. This command allows reading back the three intervals for each LED color channel.

Byte 0: Command

1	1	0	0	0	0	0	1

Byte 1: Selection control

0	0	0	0	0	Clr2	Clr1	Clr0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

CLR[3:0] Specifies which Color the x or y returned values apply to.
0 = Red channel
1 = Green channel
2 = Blue channel
3 -15 = Reserved

Returned data is 4 bytes.

Byte 0: Average Temperature over ***n*** Seconds MSByte

ATS7	ATS6	ATS5	ATS4	ATS3	ATS2	ATS1	ATS0

Byte 1: Average Temperature over ***n*** Minutes LSByte

ATM7	ATM6	ATM5	ATM4	ATM3	ATM2	ATM1	ATM0

Byte 2: Average Temperature over ***n*** Hours LSByte

ATH7	ATH6	ATH5	ATH4	ATH3	ATH2	ATH1	ATH0

Byte 3: Peak Temperature value LSByte

PT7	PT6	PT5	PT4	PT3	PT2	PT1	PT0

Where:

ATS[7:0] Running average of Temperature readings over ***n*** seconds. Where ***n*** is specified from command 0x51. Units of degrees C.

ATM[7:0]] Running average of Temperature readings over ***n*** minutes. Where ***n*** is specified via command 0x51. Units of degrees C.

ATH[7:0]] Running average of Temperature readings over ***n*** hours. Where ***n*** is specified via command 0x51. Units of degrees C.

PT[7:0]] Peak Temperature value. Units of degrees C.

NOTE:

The Average value calculations are active after the Calibration Mode command is received.

14.2.18 *Request Desired x, y and Gain (0xCB)*

The Request Desired x, y and Gain command is used to retrieve the most recently entered color point sent via the Set Desired x, y and Gain command. (0x1E).

Byte 0: DSP CMD

1	1	0	0	1	0	1	1

Byte 1: Requested Color

0	0	0	0	0	c2	c1	c0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:

C[2:0] = Requested Color
0=Red
1=Green
2=Blue
3=Yellow
4=Cyan
5=Magenta
6=White
7-15=reserved

Upon receipt of this command, the LED DSP Controller places the requested measurement values into the I^2C Output FIFO. These values may then be read using I^2C.

The format of the returned values is shown below:

Byte 0: Gain (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

Byte 1: Gain (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 2: x (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^Binary point

Byte 3: x (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 2: y (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^Binary point

Byte 3: y (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Gain = u[1.15] gain for color point (range 0.0 < x < 2.0)

x = u[1.15] x color point for offset (range 0< x <= 1)

y = u[1.15] y color point for White (range 0 < x <= 1)

14.2.19 *Request x, y and Gain Compensation (Command 0xCC)*

The Request x, y and Gain Compensation command is used to retrieve the most recently entered color points sent via the Set x, y and Gain Compensation command. (0x58).

Byte 0: DSP CMD

1	1	0	0	1	1	0	0

Byte 1: Requested Index/Color

CURR	I5	I4	I3	I2	I0	c1	c0

Byte 2: Reserved

0	0	0	0	0	0	0	0

Byte 3: Reserved

0	0	0	0	0	0	0	0

Byte 4: Reserved

0	0	0	0	0	0	0	0

Byte 5: Reserved

0	0	0	0	0	0	0	0

Byte 6: Reserved

0	0	0	0	0	0	0	0

Byte 7: Reserved

0	0	0	0	0	0	0	0

Where:

CLR[1:0] Specifies which color the settings apply to.

0 = Red

1 = Green

2 = Blue

I[6:0] Table index, 0-63.

CURR: Specifies type of data packet.

0 = x, y, Gain data

1 = DAC level for corresponding table index.

Upon receipt of this command, the LED DSP Controller places the requested measurement values into the I2C Output FIFO. These values may then be read using I2C.

Byte 0: Delta Gain or DAC Level (MSB)

2^{0}	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

Byte 1: Delta Gain or DAC level (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 2: Delta x (MSB)

Sign	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^Binary point

Byte 3: Delta x (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Byte 2: Delta y (MSB)

Sign	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}

^Binary point

Byte 3: Delta y (LSB)

2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}	2^{-13}	2^{-14}	2^{-15}

Delta Gain [1.15] gain for color point (range 0 <= x < 2.0)

Delta x = s[0.15] x color point for offset (range -1< x < 1) , signed two's complement

Delta y = s[0.15] y color point for White (range -1 < x < 1) , signed two's complement

If CURR = 1, then only 2 bytes are returned (byte 0 and byte 1) and are the DAC level for the specified color and index in the table.

14.2.20 *Request De-saturation Mode (0xCD)*

This command is used to retrieve the type of De-saturation that is currently selected.

Byte 0: Command

1	1	0	0	1	1	0	1

Byte 1: reserved

0	0	0	0	0	0	0	0

Byte 2: reserved

0	0	0	0	0	0	0	0

Byte 3: reserved

0	0	0	0	0	0	0	0

Byte 4: reserved

0	0	0	0	0	0	0	0

Byte 5: reserved

0	0	0	0	0	0	0	0

Byte 6: reserved

0	0	0	0	0	0	0	0

Byte 7: reserved

0	0	0	0	0	0	0	0

Returned data formatted as follows:

Byte 0: De-saturation Mode

0	0	0	0	0	0	M1	M0

M[1:0] 0 = Off - No De-saturation.
1 = De-saturation via CCA
2 = De-saturation via current

15 Glossary

ABC

The three digitized outputs of the internal sensor associated with three color filters. The values are related to the brightness of the light source when measured using these filter cutoffs.

External Sensor

A colorimeter used during calibration to measure the color and brightness of the system (e.g., at the projection screen).

Internal Measured Color Point Data

The ABC values are measured by the sensor when illuminated by a specified color. If a single integrating sensor is used, then only the A values apply.

Internal Sensor

A feedback sensor in the illumination path or off-state light that provides analog outputs associated with the brightness of the light source passing through three color filters.

Override Max Current

A current setting that defines the maximum current that can be selected by the algorithms. It is based on not damaging the installed LED strings.

Appendix A: I²C Command Quick Reference

All of the I2C commands are listed here by command number for quick reference:

Device Address	Sub Address [Hex]	Register Name	Bits	Description	Reference
34h	W-00, R-1500	Offset	10-0 10-0 10-0	Offset (CA/G/Y) Offset (CB/R/Cr) Offset (CC/B/Cb)	See 7.23 on page 34
34h	W-01, R-1501	Contrast	7-0 7-0 7-0	Contrast percentage (CA/G/Y) Contrast percentage (CB/R/Cr) Contrast percentage (CC/B/Cb)	See 7.7 on page 22
34h	W-02, R-1502	Projection Mode	7-5	Projection Mode	See 7.25 on page 36
34h	W-03, R-1503	Image Orientation	1 0	E/W Flip N/S Flip	See 7.21 on page 33
34h	W-04, R-1504	Horiz Image Position	15 9-0	Horizontal Offset direction Horizontal Position (1 pixel increment)	See 7.18 on page 30
34h	W-05, R-1505	Vert Image Position	15 9-0	Vertical Offset direction Vertical Position (1 pixel increment)	See 7.30 on page 40
34h	W-06, R-1506	Pixels/Line	11-0	Pixels on each line of the DMD	See 7.24 on page 35
34h	W-07, R-1507	Lines/Frame	10-0	Lines in each frame of the DMD	See 7.22 on page 33
34h	08	Reserved			
34h	W-09, R-1509	Brightness	10-0	Degamma Enable Degamma table selection	See 7.15 on page 27
34h	W-0A, R-150A	Brightness	7 5-4 3	CSC Enable Input Data Format Data Type	See 7.1 on page 17
34h	W-0B, R-150B	Color Space Converter	7 5-0	Enable Input Data Format Data Type	See 7.6 on page 21
34h	0C	Reserved			
34h	W-0D, R-150D	PWM Enable	7 5	PWM channel 0 enable PWM channel 1 enable PWM channel 2 enable	See 7.2 on page 19
34h	0E-0F	Reserved			
34h	W-10, R-1510	PMD Fan Settings	8-0	Enable Mode	See 7.14 on page 26

Device Address	Sub Address [Hex]	Register Name	Bits	Description	Reference
34h	W-11, R-1511	Read	7-0	ARM command Read	See 7.26 on page 37
34h	W-12, R-1512	Color Selection	7 7-0	Enable Gain Select Filter Type Filter Frequency	See 7.5 on page 20
34h	W-13, R-1513	Hue, Saturation, and Gain (HSG) Control	15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0	Red Gain Red Saturation Red Hue Green Gain Green Saturation Green Hue Blue Gain Blue Saturation Blue Hue Cyan Gain Cyan Saturation Cyan Hue Magenta Gain Magenta Saturation Magenta Hue Yellow Gain Yellow Saturation Yellow Hue Red Gain for White Green Gain for White Blue Gain for White	See 7.19 on page 30
34h	W-14, R-1514	Chroma Interpolation	7 0	Enable Mode	See 7.3 on page 19
34h	W-15	Read-Prefix	7-0	Read	See 7.27 on page 37

Device Address	Sub Address [Hex]	Register Name	Bits	Description	Reference
34h	R-1516	Hue, Saturation, and Gain (HSG) from CCA	15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0 15-0	Red Gain Red Saturation Red Hue Green Gain Green Saturation Green Hue Blue Gain Blue Saturation Blue Hue Cyan Gain Cyan Saturation Cyan Hue Magenta Gain Magenta Saturation Magenta Hue Yellow Gain Yellow Saturation Yellow Hue Red Gain for White Green Gain for White Blue Gain for White	See 7.20 on page 32
34h	17	Reserved			
34h	W-18, R-1518	Chroma Transient Improvement	7 3-2 1 0	Enable Gain Select Filter Type Filter Frequency	See 7.4 on page 20
34h	19	Reserved			
34h	W-1A, R-151A	Internal VSync (for TPG)	7-0	VSync rate in Hz	See 7.13 on page 26
34h	W-1B	Reset Factory Defaults	7-0	Resets to all default values	See 7.28 on page 38
34h	1C	Reserved			
34h	W-1D, R-151D	Data Channel Swap	2-0	Channel Swap Selection	See 7.8 on page 22
34h	1E-1F	Reserved			
34h	W-20	Calibration Unlock	7-0	Calibration Unlock	See 10.1 on page 45
34h	21	Reserved			

Device Address	Sub Address [Hex]	Register Name	Bits	Description	Reference
34h	W-22, R-1522	Display Segment Color	7 2-0	Enable segment color display Display color select	See 10.2 on page 46
34h	23-28	Reserved			
34h	W-29, R-1529	OEM Data	7-0 x8	OEM Value 0 ... 7	See 10.3 on page 47
34h	2A-32	Reserved			
34h	W-33, R-1533	Test Patterns	3-0 7-4 3-0	Test pattern selection TP Period TP Width	See 12.7 on page 53
34h	34	Reserved			
34h	W-35	Degamma Mailbox Select	1-0	Degamma Mailbox Color Select	See 12.2 on page 50
34h	W-36, R-1536	Custom Test Patterns	2-0	Custom Test Pattern Selection	See 12.1 on page 49
34h	W-37	EEPROM Recording	7	Start/Stop Command Recording	See 12.6 on page 51
34h	W-38, R-1538	3D Mode Enable	7	Stereo Mode Enable	See 8.1 on page 41
34h	W-39, R-1539	3D Mode Parameters	16:8 7	Supported Glasses shutter transition time Default Left/Right polarity	See 8.2 on page 41
34h	3A-3B	Reserved			
34h	R-153C	Extended Status	Byte 0: 1 0 Byte 1: 1 0	 DSP upgrade failed DSP Part number mismatch Premium features enabled on Value DMD DMD Device ID mismatch	See 11.2 on page 48
34h	3D-44	Reserved			
34h	W-45, R-1545	Quench Pulse Width	15-0	QPW Value	See 9.2.1 on page 44
34h	W-46, R-1546	Delay Pulse Width	15-0	DPW value	See 9.2.2 on page 44
34h	W-47, R-1547	PWM High Time	15-0	PWM High Time value	See 9.2.3 on page 44
34h	W-48, R-1548	Delta Max	15-0	Delta Max Value	See 9.2.4 on page 45
34h	49	Reserved			
34h	W-4A, R-154A	DynamicBlack™ Level	15-0	Directly Sets the Percentage level for DynamicBlack™	See 12.3 on page 50
34h	4B	Reserved			

Device Address	Sub Address [Hex]	Register Name	Bits	Description	Reference
34h	W-4C, R-154C	DynamicBlack™ Min Position	15-0	Sets the Minimum Percentage level for DynamicBlack™	See 12.3 on page 50
34h	W-4D, R-154D	DynamicBlack™ Max Position	15-0	Sets the Maximum Percentage level for DynamicBlack™	See 12.5 on page 51
34h	4E-51	Reserved			
34h	W-52, R-1552	Fixed Sample Frequency	15-0	Fixed Sample Frequency Value	See 9.2.5 on page 45
34h	W-53, R-1553	Voice Coil SmoothPicture™ Actuator Control	7	Enable Actuator	See 12.8 on page 54
34h	54	Reserved			
34h	W-55, R-1555	DynamicBlack™ Configuration	15 14 13:12 8 7-0	DynamicBlack™ Enable DynamicBlack™ Border Control Enable DynamicBlack™ Border Pixel Weight LED Off Disable DynamicBlack™ Strength	See 7.9 on page 22
34h	W-56, R-1556	Set Frame Delay	19-0	Frame Delay value	See 9.1.1 on page 42
34h	W-57, R-1557	Set Number of Edge Segments	7-0	Number of segments	See 9.1.1 on page 42
34h	W-58, R-1558	Set Edge Segment Length	15-0	Segment Length	See 9.1.3 on page 42
34h	W-59, R-1559	Set Gain	7-0	Gain	See 9.1.4 on page 43
34h	W-5A, R-155A	Set Fixed Output	7-0	Output	See 9.1.5 on page 43
34h	W-5B, R-155B	Fixed Output Enable	0	Enable/Disable Fixed Output	See 9.1.6 on page 43
34h	W-5C, R-155C	Set DC Offset	5-0	DC Offset value	See 9.1.7 on page 43
34h	W-5D	Run-Time Calibration Disable	7-0 7-0 7-0	Run-Time Calibration Control DB™ Aperture Resume Limit DB™ Aperture Disable Limit	See 7.10 on page 23
34h	W-5E	DSP Write Port	*	*	See 14 on page 60
34h	5F-72	Reserved			
34h	W-73, R-1573	DynamicColor™ Contrast Control	15 14 13 9-8 7-0	DynamicColor™ Contrast Global Enable DynamicColor™ Contrast Local Enable DynamicColor™ Skin Inhibit Enable DynamicColor™ Strength DynamicColor™ Black Level Adjustment	See 7.11 on page 24

Device Address	Sub Address [Hex]	Register Name	Bits	Description	Reference
34h	W-74, R-1574	DynamicColor™ Saturation Adjustment	15 7-0	DynamicColor™ Saturation Enable DynamicColor™ Saturation Strength	See 7.12 on page 25
34h	W-75, R-1575	General Purpose Filter Control	15 11-10 9-8 7-0	GPF Enable Variance LUT Select SharpPicture™ Filter Select GPF Master Gain	See 7.16 on page 28
34h	76-9A	Reserved			
34h	R-159B	Hardware Versions (Revisions)	7-0 7-0 7-0 7-0 7-0 7-0	DMD revision DAD revision ASIC revision Reserved PMD revision BML Version	See 7.17 on page 28
34h	R-159C	Software Versions (Revisions)	7-0 7-0 15-0 7-0 7-0 15-0 7-0 7-0 7-0 7-0	ARM Major SW Revision ARM Minor SW Revision ARM Patch SW Revision ARM API Major SW Revision ARM API Minor SW Revision ARM API Patch SW Revision OEM Flash Build Revision OEM Flash Build Revision OEM Flash Build Revision OEM Flash Build Revision	See 7.29 on page 39
34h	9D-DD	Reserved			
34h	R-CE	Get Slave Status	Byte 0: 7 3 0 Byte 1: 7 6 5 4 3 2 1 0	 Bootloader Active (Programming Mode) User GPIO Status Solid State Failure RLDRAM Memory Test OK Solid State Lit Command/Parameter Error Mailbox download complete SmoothPicture™Actuator Fail Calibration Unlock System Good System Ready	See 11.1 on page 48

Device Address	Sub Address [Hex]	Register Name	Bits	Description	Reference
34h	9D-DD	Reserved			
34h	R-DE	DSP Read Port	*	*	See 14 on page 60
34h	DF-E3	Reserved			
34h	W-E4	Degamma Mailbox	15-0 x1024	Degamma Mailbox	See 13.2 on page 55
34h	W-E5	CSC Mailbox	12-0 x9	CSC Mailbox	See 13.1 on page 54
34h	E6-E9	Reserved			
34h	W-EA	PWM Mailbox	19-0 x4	PWM Mailbox	See 13.5 on page 59
34h	EB	Reserved			
34h	W-EC	DynamicBlack™ Border Config. Mailbox	11-0 x4	DynamicBlack™ Border Mailbox	See 13.3 on page 57
34h	W-F1	Waveform Edge Shape Table Mailbox	7-0 x256	Waveform Shape Mailbox	See 13.6 on page 59
34h	ED-F1	Reserved			
34h	W-F2	General Purpose Filter Mailbox	15-0 x25	General Purpose Filter Mailbox	See 13.4 on page 58
34h	F3-FF	Reserved			
35	R	Status	Byte 0: 7 3 2 0 Byte 1: 7 6 5 4 3 2 1 0	 Bootloader Active (Programming Mode) User GPIO Status EEPROM recording Solid State Failure RLDRAM Memory Test OK Solid State Lit Command/Parameter Error Mailbox download complete SmoothPicture™Actuator Fail Calibration Unlock System Good System Ready	See 11 on page 47

Table 2: I²C Command Quick Reference

Appendix B: Brightness, Contrast, and Offset Commands

OEM feedback has dictated a new way to do brightness and contrast control. This requires a change to how brightness and contrast adjustments are performed on the DDP3021 as compared to previous systems.

The previous solution exposed a Brightness interface that allowed the OEM to add or subtract a DC pedestal from the incoming data. The previous solution exposed an interface called Contrast which multiplied an OEM supplied vector by the current CSC table. This allowed the OEM to apply a gain to the incoming data.

The new interfaces consist of Offset, Contrast and Brightness. The Offset interface behaves the same as what was labeled "Brightness" in the previous solution which means it changes both the peak white and minimum black endpoints by the same amount at the same time. The Offset interface is independent from the Brightness and Contrast interfaces. The Contrast interface adjusts the peak white endpoint without changing the minimum black endpoint. The Brightness interface adjusts the minimum black endpoint without changing the peak white endpoint.

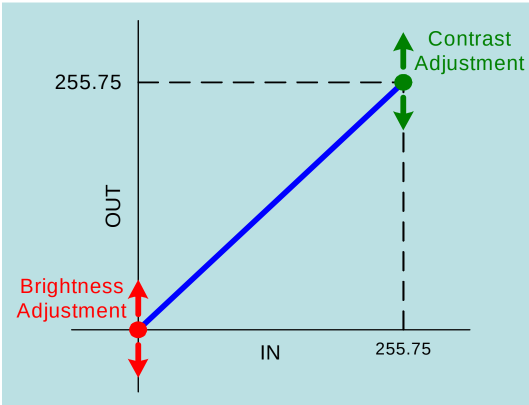

Figure 6: Nominal Transfer Function

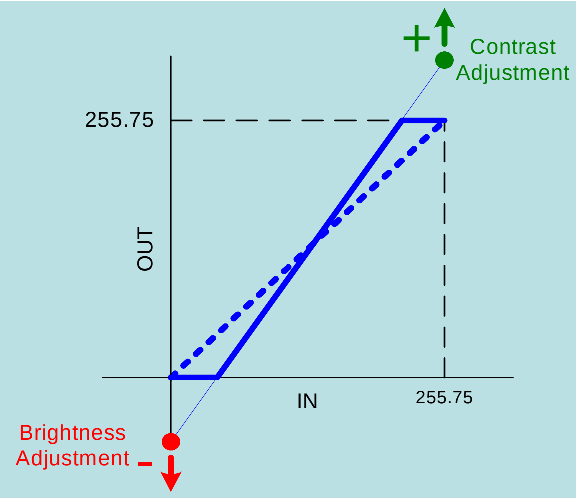

Figure 7: Contrast and Brightness Adjusted to the Point of Crushing Both Ends

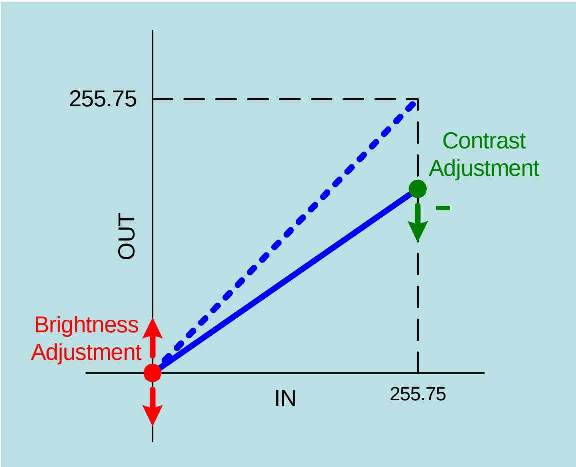

Figure 8: Contrast Adjusted Down From Nominal

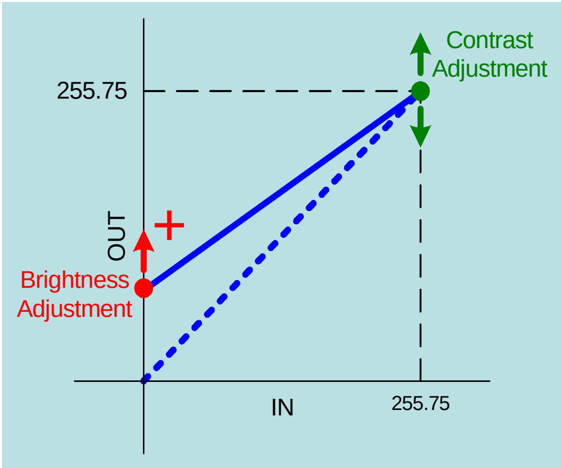

Figure 9: Brightness Adjusted Up From Nominal

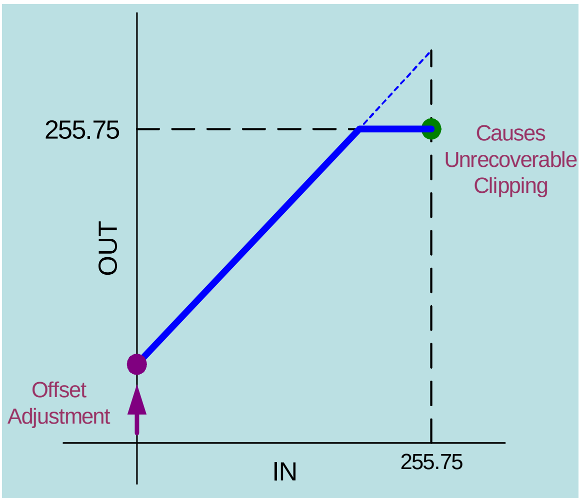

Figure 10: Offset Applied to Nominal Transfer Function

In the I^2C interface, each command accepts a value for each of the three independent data channels.

To avoid color shifting when using RGB data, the OEM should provide the contrast command with the same contrast value for all three channels. The same is true for the brightness command values (use the same value for all three channels). The Contrast values will be in the range of 50% to 150% with 100% being nominal.

When using YCrCb data, the OEM should provide their target contrast value for the Y channel and a unity value for the Cr and Cb channels. They should provide the brightness command with the same brightness value for all three channels.

NOTE:

A set of fixed offsets are automatically applied to incoming YCrCb data to normalize the values into the 0-255 range. The fixed offsets are 16(Y), 128(Cr) and 128(Cb). The values sent to the Offset command interface are additive to any fixed offset the system applies. The total offset value (system applied and the Offset command interface) cannot exceed 255.75.

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