

# 2KX2K RGB Drive Board

*For Use with eMagin 2Kx2K OLED Microdisplays*

## **USER'S MANUAL**

**VERSION 1.0**



## TABLE OF CONTENTS

<b>1. INTRODUCTION .....</b>	<b>1</b>
<b>2. FEATURES .....</b>	<b>1</b>
2.1. Software Features .....	1
<b>3. SYSTEM REQUIREMENTS &amp; SPECIFICATIONS.....</b>	<b>1</b>
3.1. System Requirements .....	1
3.2. 2KX2K RGB Drive Board. ....	2
<b>4. INTERFACE CONNECTIONS &amp; SETUP .....</b>	<b>3</b>
4.1. Setup Flow Chart.....	3
4.2. Connect Display to the RGB Drive Board .....	4
4.3. Setup PC for Proper Video Output.....	4
4.4. Power Up.....	5
4.5. Power Down .....	5
4.6. Brightness .....	5
<b>5. USING THE 2KX2K RGB DRIVE BOARD SOFTWARE .....</b>	<b>5</b>
5.1. Serial Interface Command Set .....	5
5.2. 2KX2K Design Reference Board Software Utility .....	5
5.2.1. Hardware Protocol .....	7
5.2.2. eMagin Software Command Set .....	7
5.3. Using Hyperterminal With the Design Reference Board.....	8
5.3.1. ASCII Table of Commands .....	10
5.4. Downloading New Firmware Versions to the RGB Drive Board .....	11
5.4.1. Using the Firmware Download Utility .....	11
<b>6. ADVANCED USER INFORMATION.....</b>	<b>12</b>
6.1. Microcontroller .....	12
6.2. I <sup>2</sup> C bus .....	12
6.3. SPI bus .....	12
6.4. System Hardware Overview.....	12
6.5. Voltages .....	13
6.6. Bias Control.....	13
6.7. Gamma.....	13
6.7.1. Gamma Coefficients .....	14
6.7.2. Preset Gamma Table descriptions.....	14
6.7.3. Using “Update LUT” Button for Auto-Gamma Correction.....	15
6.7.4. The “Read” Button .....	15
6.7.5. System Gamma .....	15
<b>7. REVISION HISTORY .....</b>	<b>15</b>

## List of Tables

TABLE 5-1 COMMAND SET LIST FOR ADDRESSING THE MICRODISPLAY.....	7
TABLE 5-2 TABLE OF ASCII CHARACTER CODES.....	10

## List of Figures

<i>Figure 3-1 2Kx2K RGB Drive Board Rev. 1 .....</i>	<i>2</i>
<i>Figure 4-1 Display Carrier Board ZIF Connection Orientation.....</i>	<i>4</i>
<i>Figure 5-1 Example microdisplay register value write using included software .....</i>	<i>8</i>
<i>Figure 5-2 Example microdisplay register value write using Hyperterminal.....</i>	<i>9</i>
<i>Figure 5-3 Firmware download utility .....</i>	<i>11</i>



## 1. INTRODUCTION

The 2Kx2K RGB Drive Board, provides the user with a highly compact, portable way of operating an eMagin 2KX2K OLED Microdisplay. This product was designed to deliver a complete tool for developers to evaluate and integrate eMagin 2Kx2K microdisplays into new products. The included software package provides access to the microdisplay's on-board register settings from any Windows-based PC through a serial port.

## 2. FEATURES

- DVI Input
- USB (serial) interface allows access to microdisplay registers
- Supporting Software (Windows)
- ON/OFF power switch

### 2.1. Software Features

- Read/write capabilities allow adjustments of microdisplay register settings to fine-tune image characteristics
- Software register control over the cathode voltage (Vcommon) input
- Software register control over the microdisplay's brightness
- Download and install new firmware files into your 2KX2K RGB Drive Board for easy upgrades and expanded functionality
- Ability to read the microdisplay's temperature
- Save feature stores custom register settings for convenience

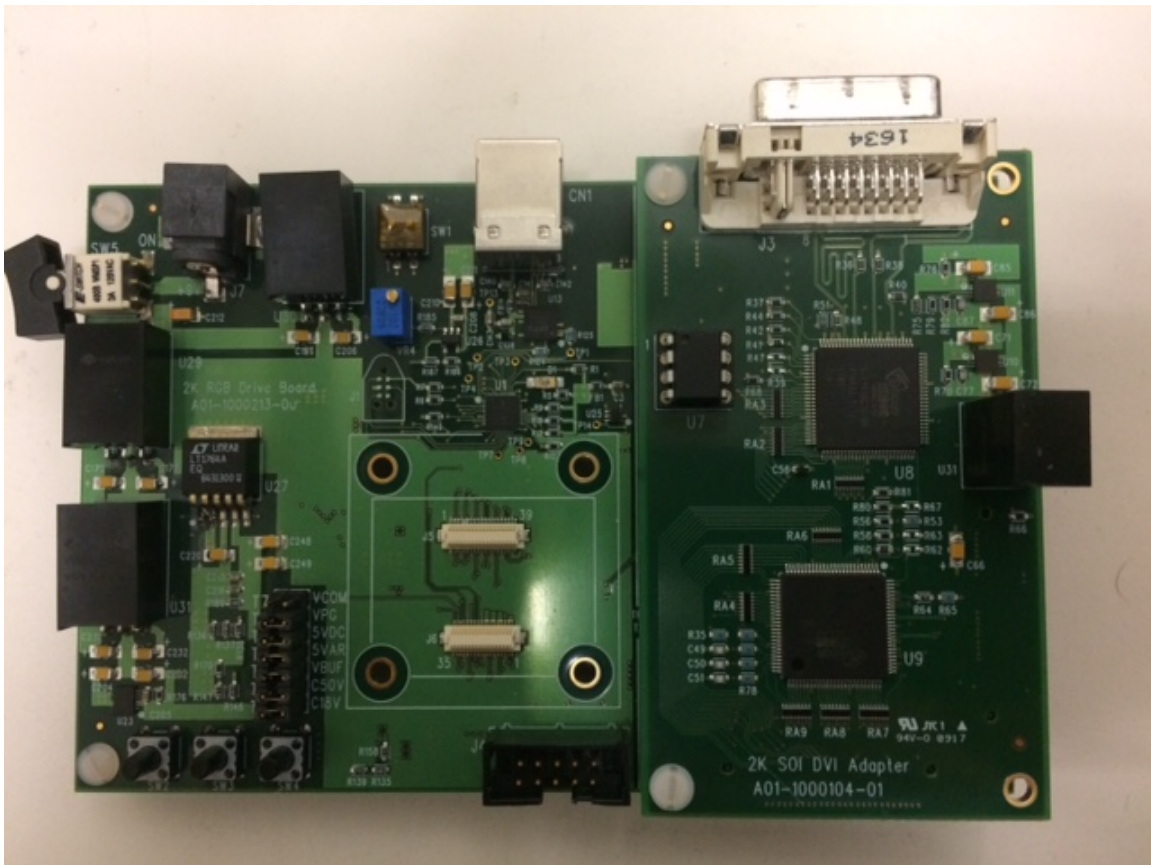
## 3. SYSTEM REQUIREMENTS & SPECIFICATIONS

### 3.1. System Requirements

- For digital RGB inputs: A PC capable of producing a digital video output compliant with the DVI standard.
- Support software requires a Windows PC with a USB serial port

### 3.2. 2Kx2K RGB Drive Board.

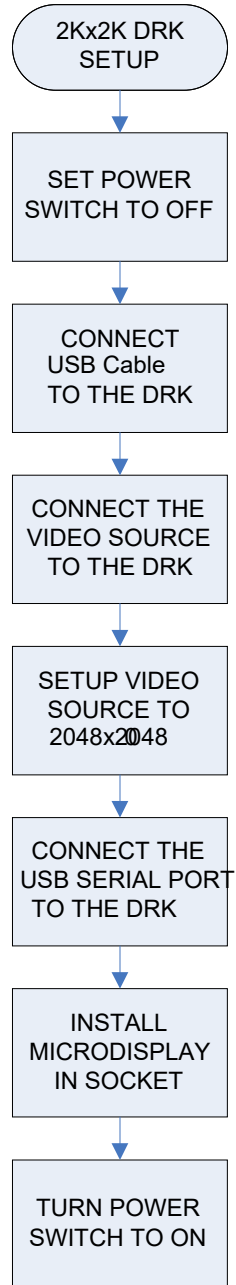
The 2Kx2K RGB Drive Board is shown in figure 3-1 below. The minimum requirements for displaying video on the 2Kx2K RGB Drive Board are; a 9v power supply, a USB cable connected to the USB connector, a digital video source connected to the HDMI connector and an 2Kx2K OLED connected to J5 and J6 connectors.



*Figure 3-1 2Kx2K RGB Drive Board*

## 4. INTERFACE CONNECTIONS & SETUP

### 4.1. Setup Flow Chart



## 4.2. Connect Display to the RGB Drive Board

The microdisplay connects to the RGB Drive Board via J1 a 36-pin board-to-board connector and a J2 a 40-pin connector. The Display Carrier board is shown in figure 4-1 below.

**Note:** The 2KX2K OLED can be damaged if it is not connected properly.



*Figure 4-1 Display Carrier Board*

Lift the display by its sides and take care not to press on the active area or leave fingerprint marks on it. Insert the display into the RGB Drive Board.

## 4.3. Setup PC for Proper Video Output

- The default compatible resolution is 2KX2K (2048x2048) with a refresh rate of 60 Hz. If you are using this input set the video resolution for 2048x2048 in your PC's display properties.
- Ensure that the refresh rate to set to 60 Hz, or other supported refresh rate per the display specification.
- If you are using a laptop PC, you may need to export the video signal to an external monitor. This is usually accomplished through a keypress including



the Fn key + a designated function key. See your PC's operation instructions for more information.

#### **4.4. Power Up**

- Set the power switch to the ON position.

#### **4.5. Power Down**

- Set the power switch to the OFF position.

#### **4.6. Brightness**

eMagin strongly recommends that you drive the microdisplay at the minimum luminance necessary for your application. This will extend the lifetime of the display to its maximum possible lifetime. As OLED microdisplays are emissive devices, driving the microdisplay at high bias levels will decrease its overall lifetime.

## **5. USING THE 2KX2K RGB DRIVE BOARD SOFTWARE**

The 2Kx2K RGB Drive Board includes a support software suite with the following functionality.

- Perform software microdisplay brightness adjustments
- Perform software adjustments of the Vcommon input to the microdisplay
- Read the microdisplay's temperature
- Download and install new versions of the 2Kx2K RGB Drive Board firmware to update or provide new functionality using a USB connection
- Read/write register values to the microdisplay to control various characteristics (see your microdisplay's User Specification for more information)

### **5.1. Serial Interface Command Set**

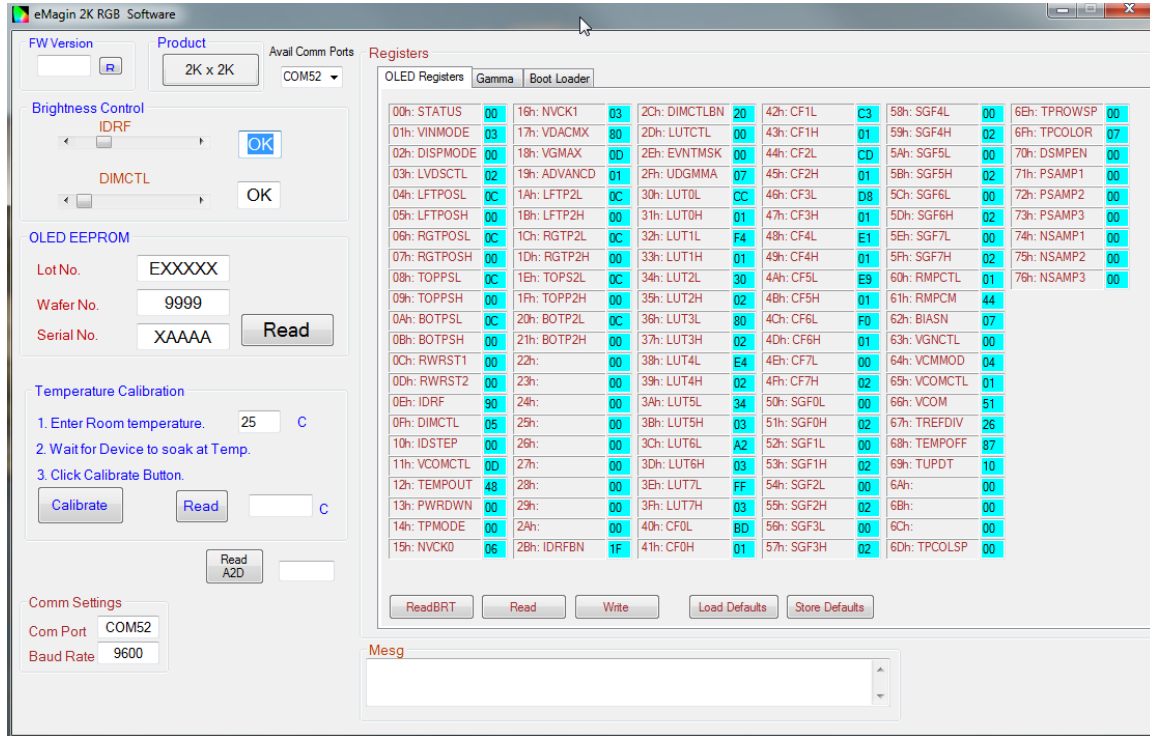
The 2Kx2K RGB Drive Board can be controlled by sending commands and data using the included USB cable. The software package includes a file called New\_**2Kx2K\_RGB\_SW.exe** developed for this purpose.

### **5.2. 2KX2K Design Reference Board Software Utility**

1. Connect the USB cable to the PC (Port 1) and to the USB connector on the 2KX2K RGB Drive Board

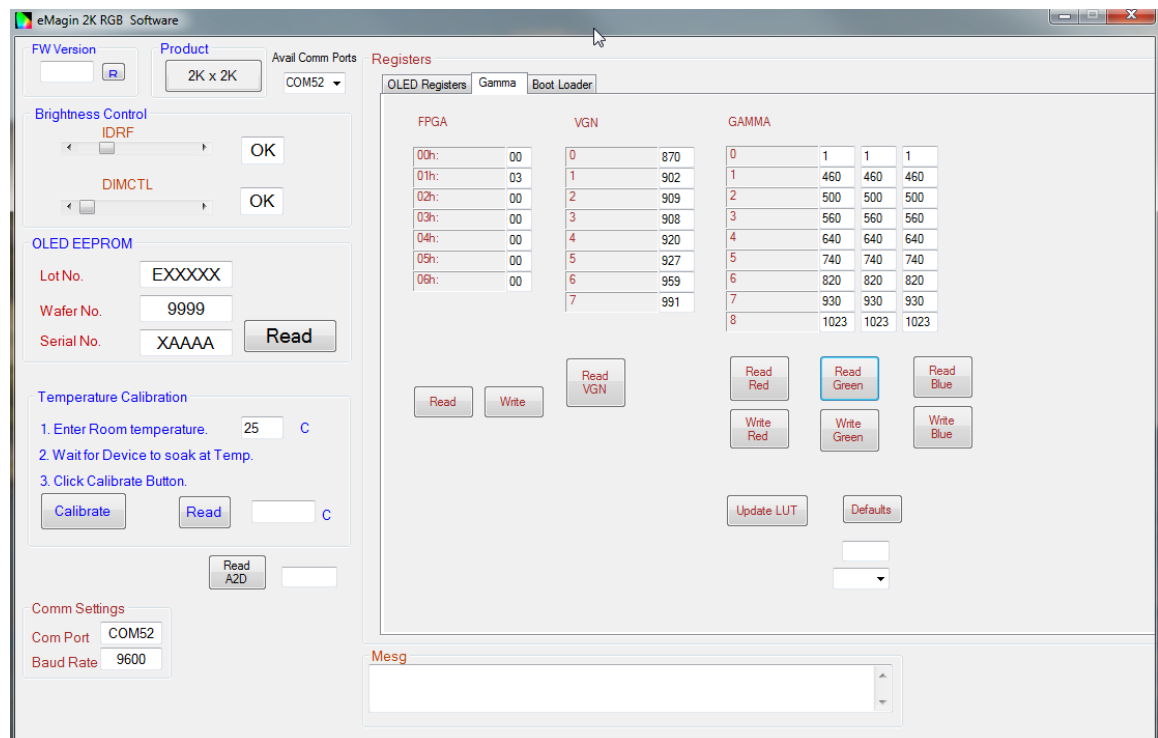


2. Connect the video source to the 2KX2K Design Reference Board
3. Turn on the 2KX2K RGB Drive Board
4. Start the **2KX2K\_SW\_V1\_1.exe** application and a screen should appear like that shown below:



**Figure 5-1 2KX2K Design Reference Board Software Utility Showing The Oled Registers**

5. The application communicates with the PIC on the 2KX2K RGB Drive Board and reads the initial status of the “OLED” and “VPG” shutdown pins.
6. The read/write buttons shown in the “OLED Registers” panel will read/write the register settings in their corresponding boxes from/to the OLED microdisplay.
7. The read/write buttons displayed in the “GAMMA” panel will read/write the values used in generating a Gamma table that resides in the display.



**Figure 5.2 2Kx2K RGB Drive Board Software Utility Showing the Gamma Tab**

Direct control of the 2Kx2K RGB Drive Board can also be implemented into a customer specific application using the following hardware protocol and command set.

### 5.2.1. Hardware Protocol

- bit, no parity
- 9600 baud
- No hardware handshake

### 5.2.2. eMagin Software Command Set

**TABLE 5-1 COMMAND SET LIST FOR ADDRESSING THE MICRODISPLAY REGISTERS**

Command	Description
O	Select the OLED device Usage: O
E	Read the EEPROM device Usage: E Note: The E command is preceded by a HX command

J	Send a data value to the 2KX2K Design Reference Board Usage: JX where X = 0 to 255
H	Send a register value to the 2KX2K Design Reference Board Usage: HX where X = 0 to 255
W	Write a register Usage: W Note: The W command is preceded by a HX JY command
G	Change the Gamma Table Usage: GX where X = 0 to 3
P	Powerdown a device on the 2KX2K Design Reference Board Usage: PX where X = 0 to 7
Q	Returns the value at the A2D pin. Usage: Q Returns two values(high byte, low byte)
R	Read a register Usage: R Note: The R command is preceded by a HX JY command
S	Returns the status of a device on the 2KX2K Design Reference Board Usage: SX where X = 0 to 7
U	Update the Gamma lookup table in the FPGA. Usage: U

**Note:** The commands and values are typically generated from a control program. The values are sent in binary format to the RGB Drive Board microcontroller, which will process these natively in binary. Below is an example write instance using the provided software:

In order to write the decimal value 81 to register 3, the following commands need to be issued: G3D81W

No space is required between the commands

*Figure 5-1 Example microdisplay register value write using included software*

### 5.3. Using Hyperterminal With the Design Reference Board

If you will use Hyperterminal to control the RGB Drive Board please note that Hyperterminal converts all input data to ASCII characters. Therefore, the X value mentioned in the table above needs first to be converted to its ASCII equivalent in order to be recognized by the RGB Drive Board firmware. Received information will also be displayed as ASCII code. An ASCII to decimal (or hexadecimal) conversion must be performed to read the correct values sent via the serial interface. We have provided an example write instance and ASCII character table for your reference.

To write the decimal value 81 to register 3, the following commands need to be issued:  
G CTRL-C D Q W

Ctrl+C (pressing the Ctrl and C key simultaneously) is the  
ASCII equivalent of decimal 3

Note: No space is required between the commands. The  
spacing above is for clarity only.

*Figure 5-2 Example microdisplay register value write using Hyperterminal*

### 5.3.1. ASCII Table of Commands

TABLE 5-2 TABLE OF ASCII CHARACTER CODES

Non-Printing Characters					Printing Characters								
Name	Ctrl char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
Null	ctrl-@	0	00	NUL	32	20	Space	64	40	@	96	60	`
start of heading	ctrl-A	1	01	SOH	33	21	!	65	41	A	97	61	a
start of text	ctrl-B	2	02	STX	34	22	"	66	42	B	98	62	b
end of text	ctrl-C	3	03	ETX	35	23	#	67	43	C	99	63	c
end of xmit	ctrl-D	4	04	EOT	36	24	\$	68	44	D	100	64	d
Enquiry	ctrl-E	5	05	ENQ	37	25	%	69	45	E	101	65	e
Acknowledge	ctrl-F	6	06	ACK	38	26	&	70	46	F	102	66	f
Bell	ctrl-G	7	07	BEL	39	27	'	71	47	G	103	67	g
Backspace	ctrl-H	8	08	BS	40	28	(	72	48	H	104	68	h
horizontal tab	ctrl-I	9	09	HT	41	29	)	73	49	I	105	69	i
line feed	ctrl-J	10	0A	LF	42	2A	*	74	4A	J	106	6A	j
vertical tab	ctrl-K	11	0B	VT	43	2B	+	75	4B	K	107	6B	k
form feed	ctrl-L	12	0C	FF	44	2C	,	76	4C	L	108	6C	l
carriage feed	ctrl-M	13	0D	CR	45	2D	-	77	4D	M	109	6D	m
shift out	ctrl-N	14	0E	SO	46	2E	.	78	4E	N	110	6E	n
shift in	ctrl-O	15	0F	SI	47	2F	/	79	4F	O	111	6F	o
data line escape	ctrl-P	16	10	DLE	48	30	0	80	50	P	112	70	p
device control 1	ctrl-Q	17	11	DC1	49	31	1	81	51	Q	113	71	q
device control 2	ctrl-R	18	12	DC2	50	32	2	82	52	R	114	72	r
device control 3	ctrl-S	19	13	DC3	51	33	3	83	53	S	115	73	s
device control 4	ctrl-T	20	14	DC4	52	34	4	84	54	T	116	74	t
neg acknowledge	ctrl-U	21	15	NAK	53	35	5	85	55	U	117	75	u
synchronous idel	ctrl-V	22	16	SYN	54	36	6	86	56	V	118	76	v
end of xmit block	ctrl-W	23	17	ETB	55	37	7	87	57	W	119	77	w
cancel	ctrl-X	24	18	CAN	56	38	8	88	58	X	120	78	x
end of medium	ctrl-Y	25	19	EM	57	39	9	89	59	Y	121	79	y
substitute	ctrl-Z	26	1A	SUB	58	3A	:	90	5A	Z	122	7A	z
escape	ctrl-[	27	1B	ESC	59	3B	;	91	5B	[	123	7B	{
file separator	ctrl-\	28	1C	FS	60	3C	<	92	5C	\	124	7C	
group separator	ctrl-]	29	1D	GS	61	3D	=	93	5D	]	125	7D	}
record separator	ctrl-^	30	1E	RS	62	3E	>	94	5E	^	126	7E	~
unit separator	ctrl- <u></u>	31	1F	US	63	3F	?	95	5F	_	127	7F	DEL

## 5.4. Downloading New Firmware Versions to the RGB Drive Board

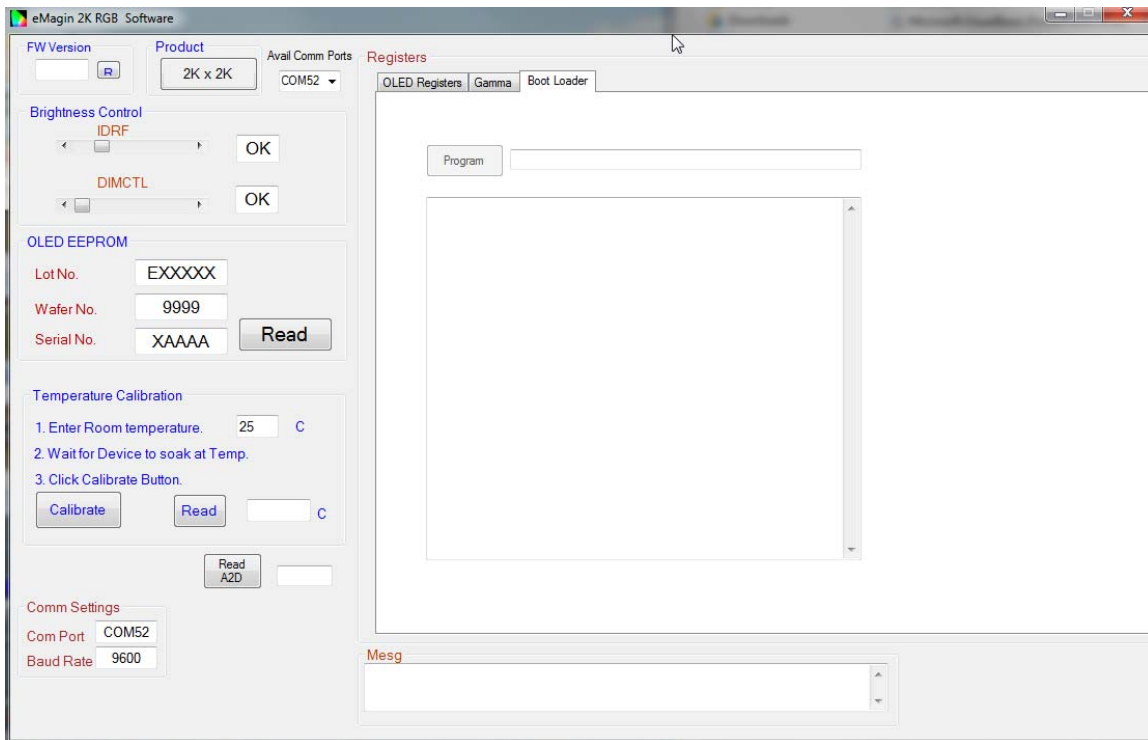
The ability to download new versions of the firmware ensures that you will have the latest functionality without having to send your 2KX2K RGB Drive Board for reprogramming. A utility that downloads and installs new firmware versions is included in the software package.

### 5.4.1. Using the Firmware Download Utility

Firmware files can be downloaded as hex files. Before attempting to download and install new firmware versions make sure that you have received a firmware hex file from an eMagin source.

To load your firmware files, follow the following steps:

1. Connect the USB cable to the PC and to the Mini USB connector on the 2KX2K RGB Drive Board
2. Connect your video source to the 2KX2K RGB Drive Board.
3. Start the New **\_2KX2K\_RGB\_SW.exe** application. Select the “Bootloader” tab at the top of the form. A window should appear like that below:



*Figure 5-3 Firmware download utility*

4. Click the “Program” button to find the hex file you wish to install.  
**Note: The power on the 2KX2K RGB Drive Board should be off while setting up your download. Only turn on the power to the**

**2KX2K RGB Drive Board when you are ready to write your new firmware to the PIC.**

5. When you turn on the 2KX2K RGB Drive Board the hex file should begin to upload. You may have to toggle the switch several times.
6. When the upload is complete, the 2KX2K RGB Drive Board will run.

## **6. ADVANCED USER INFORMATION**

### **6.1. Microcontroller**

The 2KX2K RGB Drive Board utilizes a Microchip **PIC18LF46K22** microcontroller. This is a CMOS Flash microcontroller in a 40 pin package. Provisions are on the circuit board for in circuit reprogramming but are not accessible without opening the case. Please refer to the Microchip **PIC18LF46K22** datasheet available from Microchip Technology Inc. for additional information about the microcontroller and programming.

The main function of the microcontroller is to communicate with the OLED display. All communication is over the internal I<sup>2</sup>C or SPI bus and the microcontroller acts as the bus master. On power up the registers of the OLED are initialized with the default settings programmed into the microcontroller. After initialization the microcontroller scans for user input and monitors the OLED.

### **6.2. I<sup>2</sup>C bus**

The microcontroller is the bus master and communication occurs at the standard 100KHz clock rate. The microcontroller and the OLED all operate from 2.5VDC so the I<sup>2</sup>C bus must also operate using 2.5V logic levels. The maximum speed allowed for I<sup>2</sup>C bus communication is 400KHz. Please refer to the Philips I<sup>2</sup>C bus specification available on the Philips website for detailed information.

### **6.3. SPI bus**

The microcontroller is the bus master and communication occurs at the standard 100KHz clock rate. The microcontroller and the OLED all operate from 2.5VDC so the SPI bus must also operate using 2.5V logic levels. The maximum speed allowed for SPI bus communication is 400KHz.

### **6.4. System Hardware Overview**

Figure 6-1 below is a block diagram of the main functions on the 2KX2K RGB Drive Board.

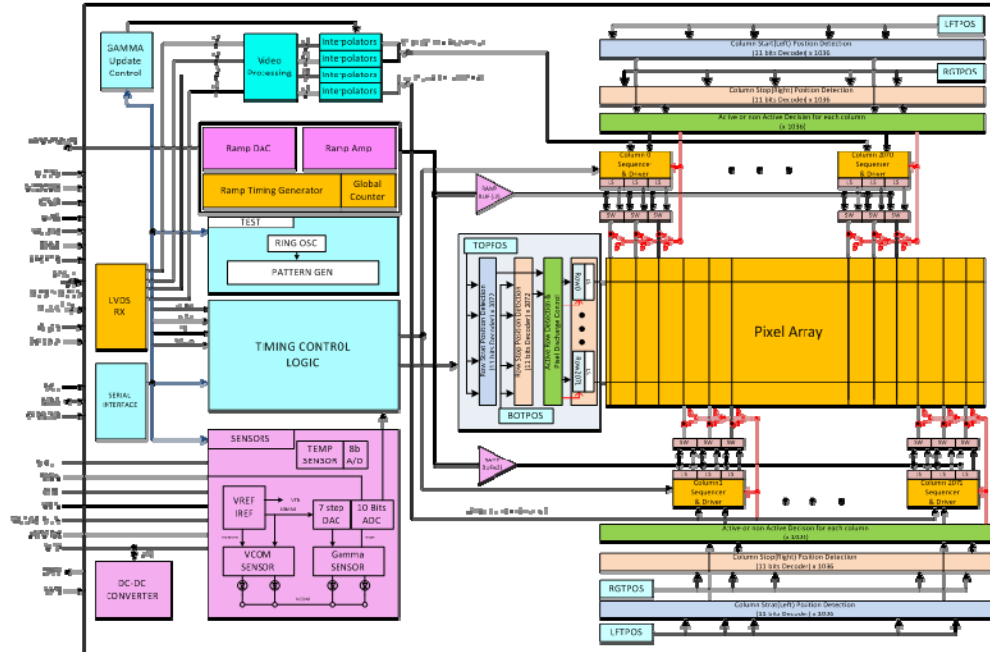


Figure 6-1 System level Block Diagram

## 6.5. Voltages

The power supply section of the 2Kx2K RGB Drive Board consists of several voltage regulators, some of which are adjustable with potentiometers. Table 6-2 below describes the voltages and there purpose.

Voltage	Range	Typical	Purpose
Vinput	+5.0 Volts	+5.0Volts	Main Supply
V5	5Volts $\pm 10\%$ (fixed)	5 Volts	LEDs, DAC
V3.3	3.3Volts $\pm 10\%$ (fixed)	3.3 Volts	DVI, RS232
V2.5	2.5Volts $\pm 10\%$ (fixed)	2.5 Volts	OLED
VAN	5.0V (adjustable with pot)	5.0 Volts	OLED Anode
VPG	-1.5V (adjustable with pot)	-1.5V	OLED Bias
VDD	2.5V $\pm 10\%$ (fixed)	2.5V	OLED

Table 6-2 shows the voltage and current relationship at power-on.

## 6.6. Bias Control

BIASN: Normal board – BIASN=2 gives the best results.

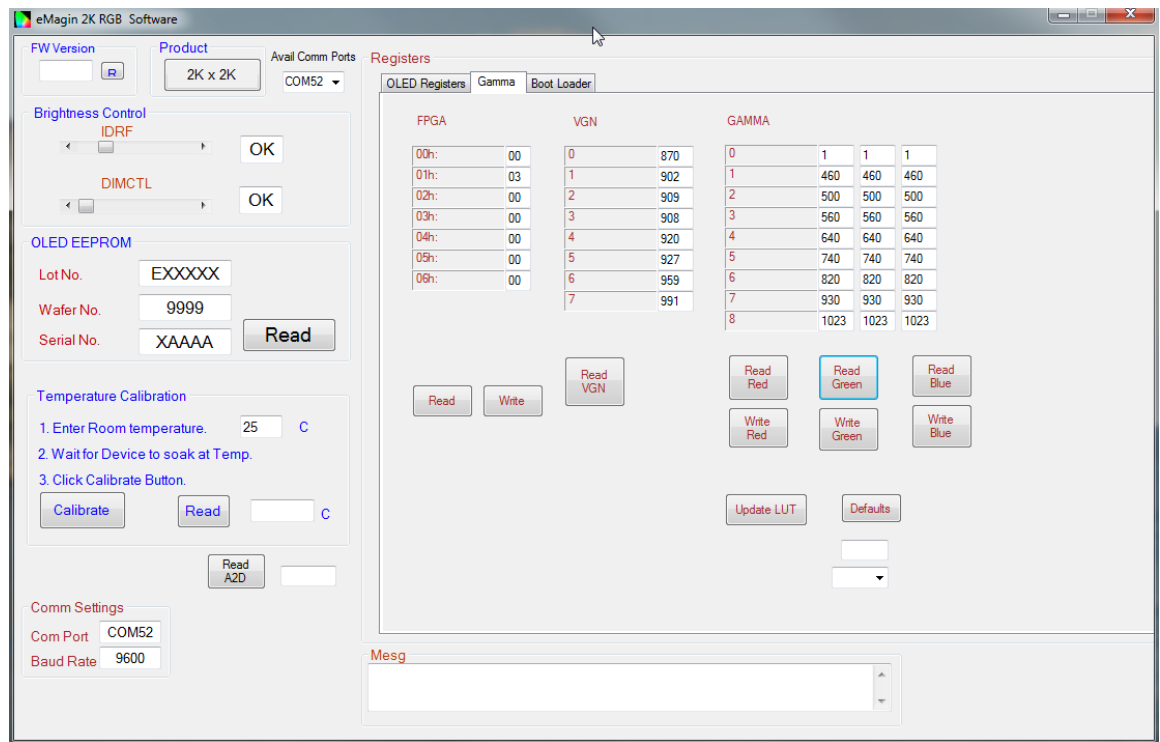
## 6.7. Gamma



To compensate for the non-linear dependency of luminance on the voltage of the OLED diode, the R, G and B signals include internal gamma correction to linearize the pixel response as a function of the input video signal.

The gamma correction consists of a 17 values whose parameters are set via registers in the “Gamma” panel on the windows software. All three color channels have the same PWL shape.

There are multiple ways to set the Gamma using the windows software. The Gamma section of the software is shown below.



*Figure 6-5 The Gamma Section of the Software*

### 6.7.1. Gamma Coefficients

The 9 boxes in the Gamma section represent the 17 values that define the gamma curve. These 9 values are used to calculate the 256 element look-up-table (LUT) that is required to transform input video data into a gamma-corrected data signal for the microdisplay input port. The “Read” button will retrieve the current 9 values from the microcontroller. The user can change any of the 9 values and see the resulting gamma corrected video by pressing the “Write” button.

### 6.7.2. Preset Gamma Table descriptions

There is 1 default Gamma table programmed into the Microcontroller firmware and can be selected from the windows software. Pressing the “Default” button in



the “Gamma” section of the software loads the default gamma values for all 3 colors. Pressing the “Write” button loads the gamma values into the display.

#### **6.7.3. Using “Update LUT” Button for Auto-Gamma Correction**

The software allows for the immediate update of the gamma tables with the push of a button, “Update LUT”. This button, located in the center of the software form, tells the firmware to calculate the Gamma coefficients using the VGN signal provided by the 2Kx2K microdisplay. This feature allows the display gamma to be automatically adjusted for any operating conditions of temperature and brightness. The firmware calculates the 9 Gamma coefficients and then the full 256 value lookup table.

#### **6.7.4. The “Read” Button**

The software allows for the reading of the full 9 values, for each of the 3 colors, using this button.

#### **6.7.5. System Gamma**

The software allows for the overall System Gamma to be set between 0.5 and 2.5 when using the Auto-Gamma feature. This System Gamma can be used to compensate for the gamma of the input video. For example, if the source video is gamma corrected to 2 then setting the System Gamma to 1.9 and pressing the “Set” button and then the “Update LUT” button will give a better overall gamma response. This does not mean that there is a 1 to 1 relationship between input gamma and the System Gamma.

## **7. REVISION HISTORY**

Revision Level	Date	Description
A	09/22/17	Initial Release.