Crystalfontz America, Incorporated

GRAPHIC OLED MODULE SPECIFICATIONS

Crystalfontz Model Number	**CFAL160128B-F-B2**
Hardware Version	**Version A, January 2010**
Data Sheet Version	**Version 1.0, January 2010**
Product pages	http://www.crystalfontz.com/product/CFAL160128BFB2.html

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REVISION HISTORY

HARDWARE	
2009/09/03	Current hardware version: **v1.0** New module.

DATA SHEET	
2010/01/18	Current Data Sheet version: 1.0 Since last Data Sheet (no version number, Preliminary): ● Moved specifications into standard Graphic OLED template. ● In Physical Characteristics (Pg. 7) (previously "Mechanical Data and Part Number"), added specifications for "Viewing Area", "Active Area Diagonal", "Overall Module Outline Dimensions", "FFC Bend Radius", "Module Connector Pitch", "Aperture Rate", and "Weight". ● To avoid damage to the module, see important information on ESD (Electro-Static Discharge) (Pg. 22). ● Added a second circuit example (see Circuit Examples – VPANEL Supply for Display (Pg. 11). ● Added information on Optimal Drive Settings (Pg. 13). ● Expanded "Precautions for Operation and Storage" with important information on CARE AND HANDLING PRECAUTIONS (Pg. 24). ● Clarified and expanded descriptions for electrical characteristics. See DC Characteristics (Pg. 19). ● In Details of Interface Pin Function (Pg. 20), used Crystalfontz standard terms for signals and improved the pin descriptions. ● Added new sections, including: - MAIN FEATURES (Pg. 5). - Absolute Maximum Ratings (Pg. 18) (previously all "TBD"). - ESD (Electro-Static Discharge) (Pg. 22). - MODULE RELIABILITY AND LONGEVITY (Pg. 24). - APPENDIX A: QUALITY ASSURANCE STANDARDS (Pg. 27). - APPENDIX B: SAMPLE CODE (Pg. 30). - APPENDIX C: OLED MODULE TERMS AND SYMBOLS (Pg. 40). ● Also improved or added these illustrations: - Module Outline Drawings (Pg. 8). - System Block Diagram (Pg. 10), - Photo Reference for Pin Functions (Pg. 22). - Definition of Viewing Angle in Optical Characteristics (Pg. 23). ● Deleted information that is repeated in the LGDP4216 Controller Data Sheet.
2009/09/03	Data Sheet version: No version number (unmarked Preliminary) New Data Sheet.

The Fine Print

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CONTENTS

LIST OF FIGURES

MAIN FEATURES

COMPARISON TO LCD (LIQUID CRYSTAL DISPLAY) MODULE

The CFAL160128B-F-B2 is a full color 160 x 128 dot matrix Organic Light-Emitting Diode (OLED) display module. The small size, ultrathin form factor, and full color capability of the CFAL160128B-F-B2 makes it possible to use this OLED module in applications where it would be difficult or impossible to fit a traditional monochrome LCD module. Because of the low power requirements, the CFAL160128B-F-B2 is suitable in battery powered portable devices such as remote controls and scientific meters (for example, temperature, sound, and gas detection). Full color allows information to be quickly perceived. For example, use red to indicate a fault and green to indicate normal operation.

Compared to most LCD modules, this OLED module has a quicker response time and an extremely wide viewing angle. At the low end of an STN LCD's temperature range, a module's contrast will typically be poor and the response time will be very slow. Unlike an STN LCD module, contrast does not diminish and response time is good at the lower end of an OLED module’s operating temperature range, allowing it to operate in cold environments without a heater.

FEATURES

- 160 x 128 module consists of an OLED panel, a COF (Chip On Flex) driver IC, and an FFC (Flat Flexible Cable) that mates with a ZIF connector.
- Module Dimensions
  - Active Area is 1.77" diagonal, 35.01 (W) x 28.01 (H) millimeters (1.39" (W) x 1.10" (H)).
  - Overall module dimension with FFC unfolded is 43.40 (W) x 72.60 (H) x 2.2 maximum (D) millimeters (1.71" (W) x 2.86" (H) x 0.09" maximum (D)).
  - Overall module dimension with FFC folded is 43.40 (W) x 35.90 (H) x 2.2 maximum (D) millimeters (1.71" (W) x 1.41" (H) x 0.09" maximum (D)).
- The FFC (Flat Flex Cable) mates with standard ZIF connectors such as 609-1244-1-ND or 609-1882-1-ND available from Digi-Key.
- Requires 3v for logic and a separate supply for V_{PANEL}.
- 6-bit, 8-bit, 9-bit, 16-bit, or 18-bit parallel (8080) interface.
- LGDP7216 or compatible controller.
- 260K or 6.5K full color emissive display. For details, see Optimal Drive Settings (Pg. 13).
- Very high contrast ratio.
- Extremely wide viewing angle is >160°.
- Wide temperature range for operation is -20°C to +70°C.
- RoHS compliant.

MODULE CLASSIFICATION INFORMATION

CFA	L	160	128	B	-	F	-	B2
❶	❷	❸	❹	❺		❻		❼

❶	Brand	Crystalfontz America, Inc.
❷	Display Type	L – OLED
❸	Number of Pixels (Width)	160 pixels
❹	Number of Pixels (Height)	128 pixels
❺	Model Identifier	B
❻	Display Color	F – Full Color
❼	Special Code	B2 – Manufacturer's code

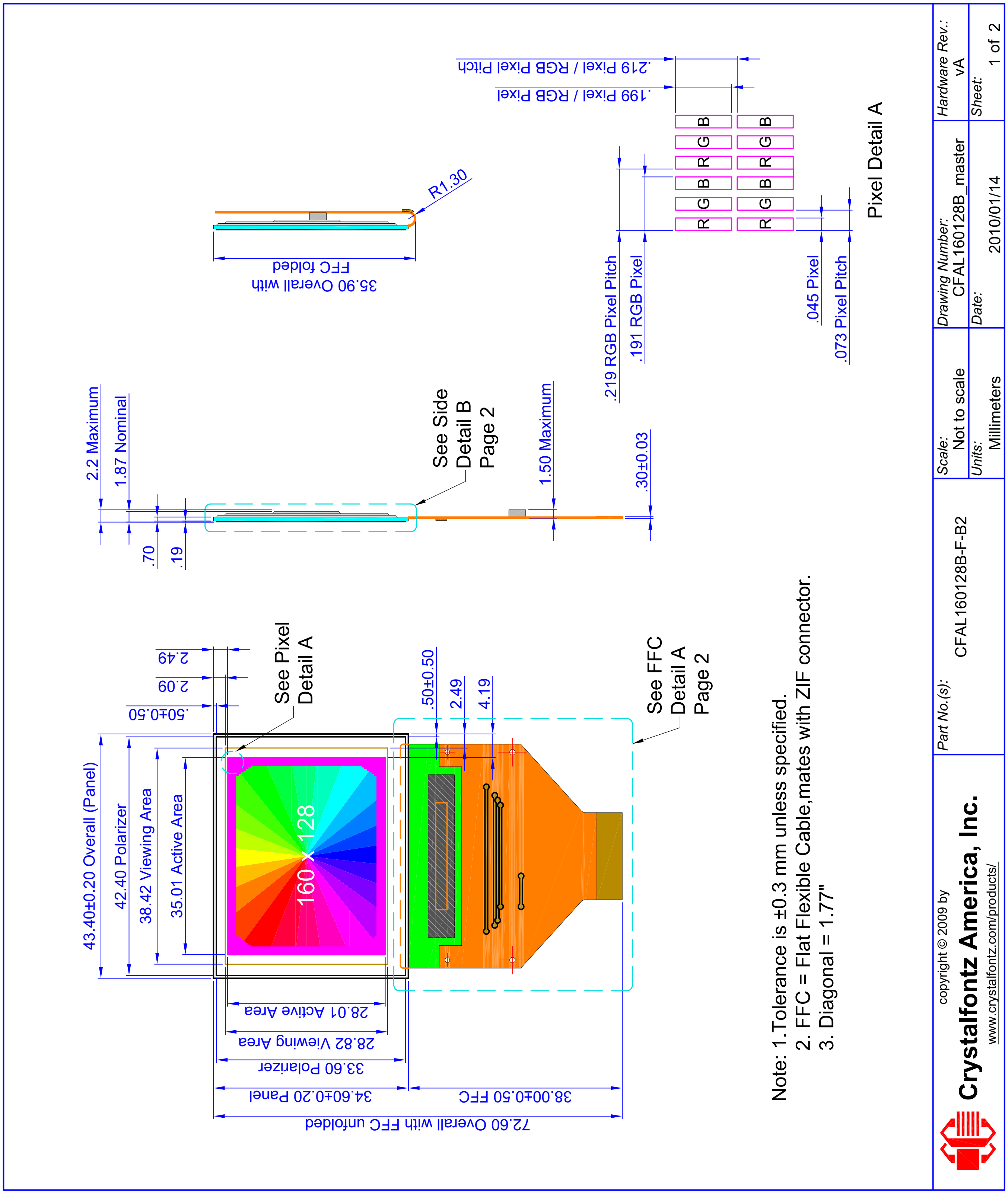
MECHANICAL SPECIFICATIONS

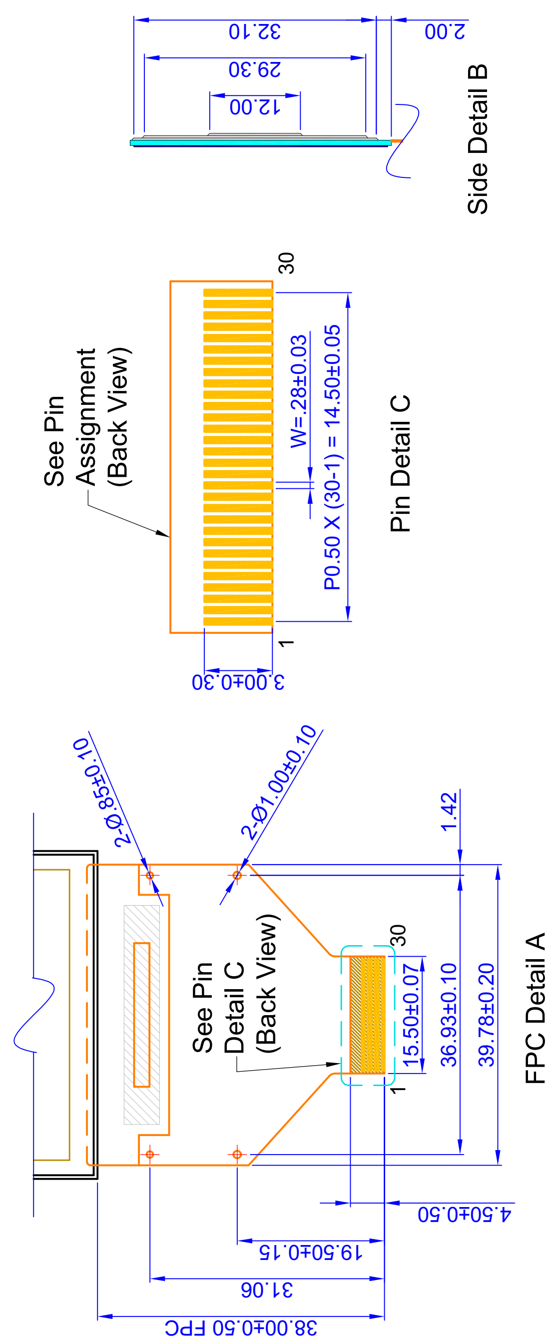
PHYSICAL CHARACTERISTICS

ITEM	SIZE
Pixels	
Number of Pixels	160 x 128 pixels = 20,480 pixels
Pixel Size (1 pixel)	0.045 (W) x 0.199 (H) mm
Pixel Pitch (1 pixel)	0.073 (W) x 0.219 (H) mm
RGB Pixel Pitch (R+G+B pixels)	0.219 (W) x 0.219 (H) mm
Viewing Area Width and Height	Millimeters: 38.42 (W) x 28.82 (H) mm Inches: 1.51" (W) x 1.13" (H)
Active Area	
Active Area Diagonal	Inches: 1.77"
Active Area Width and Height	Millimeters: 35.01 (W) x 28.01 (H) mm Inches: 1.38" (W) x 1.10" (H)
Overall Module Outline Dimensions	
Width	Millimeters: 43.40 mm Inches: 1.71"
Height (includes FFC unfolded)	Millimeters: 72.60 mm Inches: 2.86"
Height (includes FFC folded)	Millimeters: 35.90 mm Inches: 1.41"
Module Depth	Maximum: Millimeters: 2.20 mm Inches: 0.087" Nominal: Millimeters: 1.87 mm Inches: 0.074"
FFC Bend Radius	≥R 1.30 mm
Module Connector Pitch	0.5 mm
Aperture Rate*	56.01%
Weight	8 grams (typical)
Aperture rate is defined by dividing an effective display area with unit pixel area.	

MODULE OUTLINE DRAWINGS

Figure 1. Module Outline Drawings (2 pages) below





Pin Assignment

Pin	Signal
1	NC
2	GND
3	RST
4	WR 8080
5	RD 8080
6	CS
7	D/C
8	COM_SEL
9	DB0
10	DB1
11	DB2
12	DB3
13	DB4
14	DB5
15	DB6
16	DB7
17	DB8
18	DB9
19	DB10
20	DB11
21	DB12
22	DB13
23	DB14
24	DB15
25	DB16
26	DB17
27	V LOGIC
28	NC
29	V PANEL
30	NC

Note: 1. Tolerance is ±0.3 mm unless specified.
2. FFC = Flat Flexible Cable, mates with ZIF connector.
3. Diagonal = 1.77"

Part No.(s):	Scale:	Drawing Number:	Hardware Rev.:
CFAL160128B-F-B2	Not to scale	CFAL160128B_master	vA
	Units: Millimeters	Date: 2010/01/11	Sheet: 2 of 2

ELECTRICAL SPECIFICATIONS

SYSTEM BLOCK DIAGRAM

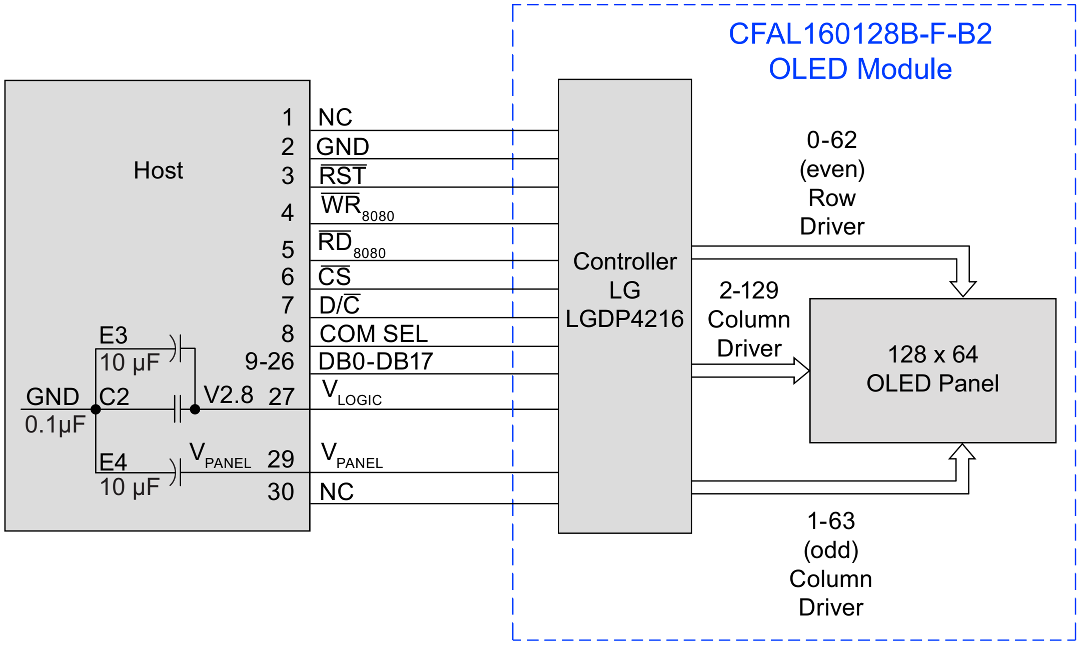


Figure 2. System Block Diagram

CIRCUIT EXAMPLES – V_{PANEL} SUPPLY FOR DISPLAY

Example 1

The Micrel MIC2290 is one of many possible V_{PANEL} supply solutions.

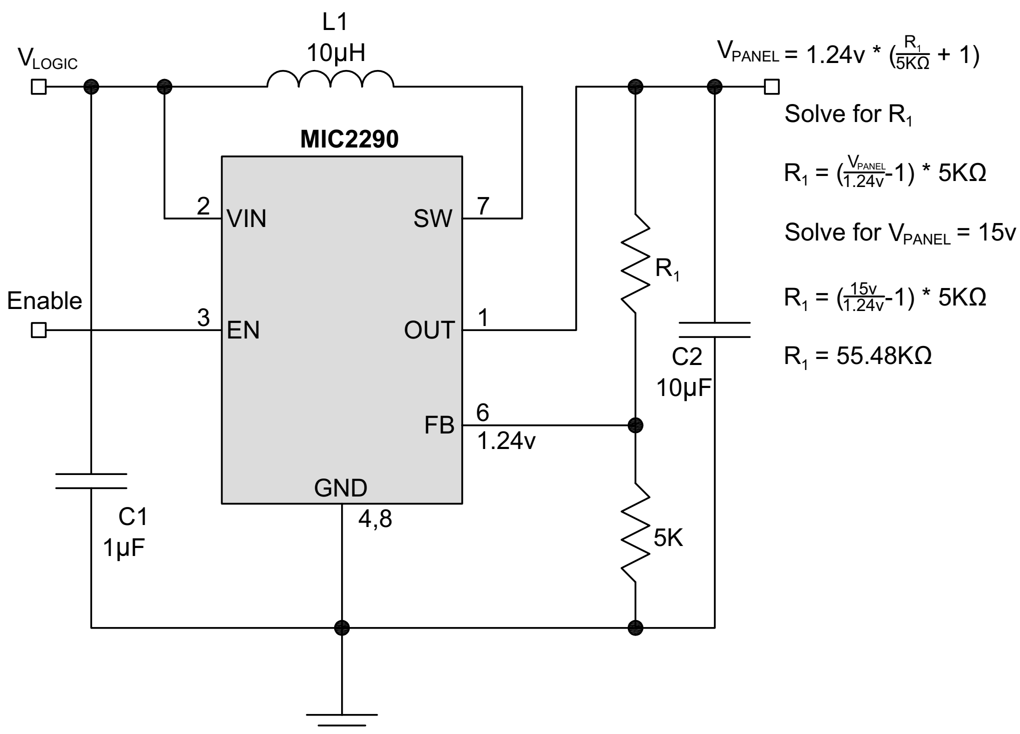
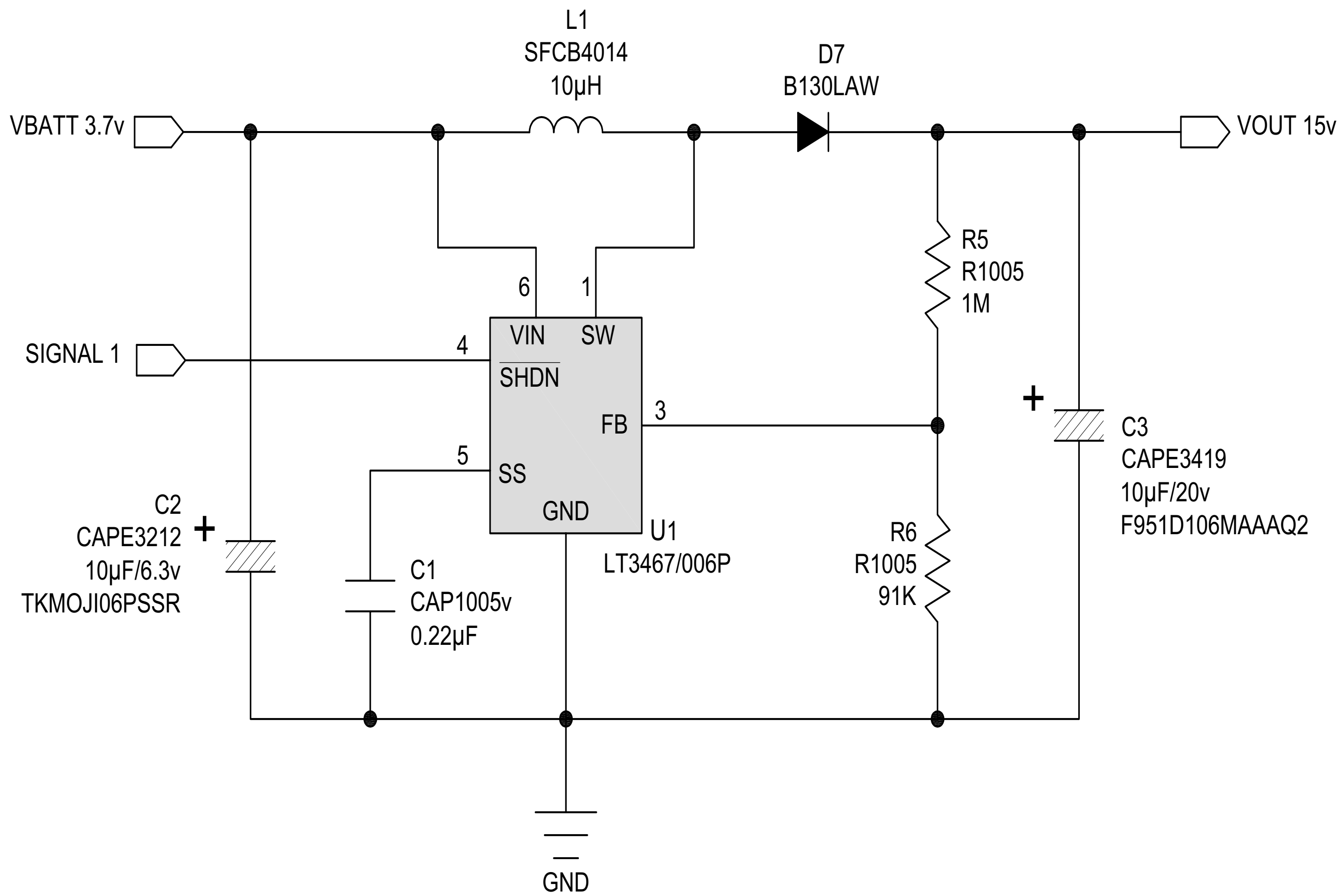


Figure 3. Circuit Example – V_{PANEL} Supply for Display

Please refer to the Micrel MIC2290 datasheet for design details. See http://micrel.com/page.do?page=/product-info/products/mic2290.shtml.

Example 2


L1
SFCB4014
10µH
D7
B130LAW
VBATT 3.7v
VOUT 15v
R5
R1005
1M
6
1
SIGNAL 1
4
VIN
SW
SHDN
FB
3
5
SS
GND
U1
LT3467/006P
C2
CAPE3212
10µF/6.3v
TKMOJI06PSSR
C1
CAP1005v
0.22µF
R6
R1005
91K
C3
CAPE3419
10µF/20v
F951D106MAAAQ2
GND

OPTIMAL DRIVE SETTINGS

Settings
Luminance = 140 nit (V_{CC}=15v) CIE = (0.29, 0.31)
Zener Diode = Red 3.0v, Green 2.7v, Blue 3.0v R_{osc} = 15kΩ, R_{IREF} = 18kΩ

Initial Conditions
V_{DD} = 0v (no power applied) V_{BAT} = 0v (no power applied) RSTB = 0v (controller held in reset)

Step 1
Bring V_{DD} to 2.8v. (Wait 50 mS.)

↓

Step 2
Bring RSTB to V_{DD} (release the controller from reset.) (Wait 50 mS.)

↓

Step 3
Bring V_{PANEL} to +15v (check). (Wait 50 mS.) Proceed with normal display operation.

Register Setting

Procedure 1: Initial Function

Register	Value	Description
0x61	0x00	Scan Regulator Off
0x60	0x00	--
0x01	**0x50**	**Display 2**
0x06	**0x9F**	**x-Start Address**
0x02	0x03	Display 3
0x43	0x00	Enable gamma
0x03	0x01	Scan direction
0x27	0x01	BP_mode
0x20	0x07	Discharge R
0x21	Ox07	Discharge G
0x22	0x07	Discharge B
0x23	0x08	R-Peak time
0x24	0x28	G-Peak time
0x25	0x1B	B-Peak time
0x50	0x6E	Dot current R
0x51	0x11	Dot current G
0x52	0x1E	Dot current B
0x26	0x09	Scan time
0x5A	0x00	Data gray level

Each register's explanation sees LGDP4216 specification and will be modified.

65K Colors and Portrait
Register [0x01] → Value [0x51]
Register [0x06] → Value [0x9F]

65K Colors and Landscape
Register [0x01] → Value [0x01]
Register [0x06] → Value [0x00]

260K Colors and Portrait (Default Value)
Register [0x01] → Value [0x50]
Register [0x06] → Value [0x9F]

260K Colors and Landscape
Register [0x01] → Value [0x00]
Register [0x06] → Value [0x00]

Procedure 2: Initial Function

Register	Value	Description
0x53	0x03	R-Peak current set
0x54	0x1F	G-Peak current set
0x55	0x1F	B-Peak current set
Ox40	Next page	R-Gamma
0x41	Next page	G-Gamma
0x42	Next page	B-Gamma
0x00	0x80	Display on

R/G/B GAMMA LOOK UP TABLE

Select the Register, than make 64 contiguous Writes to load the Gamma table.

Register	Value (Hex)																Description
0x40	00	00	00	00	00	00	00	00	02	03	05	07	09	0B	OD	OE	**R-Gamma**
	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1E	1F	21	
	23	25	27	2A	2C	2E	30	33	35	38	3A	3C	3F	41	44	46	
	49	4C	4E	51	54	57	5B	5E	62	65	69	6D	72	76	7B	7F	
0x41	00	00	00	00	00	00	00	00	02	03	05	07	09	0B	OD	OE	**G-Gamma**
	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1E	1F	21	
	23	25	27	2A	2C	2E	30	33	35	38	3A	3C	3F	41	44	46	
	49	4C	4E	51	54	57	5B	5E	62	65	69	6D	72	76	7B	7F	
0x42	00	00	00	00	00	00	00	00	02	03	05	07	09	0B	OD	OE	**B-Gamma**
	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1E	1F	21	
	23	25	27	2A	2C	2E	30	33	35	38	3A	3C	3F	41	44	46	
	49	4C	4E	51	54	57	5B	5E	62	65	69	6D	72	76	7B	7F	

Display On Procedure

Step 1

Register [0xA1] → Parameter [0x03]

Power On.

When VBAT (3.7v) inputs DC-DC converter, GPO <0> signal turns on DC-DC converter to supply V_{CC} (15v).

↓

Step 2

Register [0xA0] → Parameter [0x00]

Standby Off.

If STBY is off, the master clock of LGDP4216 is working.

↓

Step 3

Register [0x00] → Parameter [0x80]

OLED turns on.

Display Off and Power Off Procedures

Step 1

Register [0x00] → Parameter [0x00]

OLED turns off.

↓

Step 2

Register [0xA0] → Parameter [0x01]

Standby On.

If STBY is on, the master clock of LGDP4216 is stopped.

↓

Step 3

Register [0xA1] → Parameter [0x00]

Power Off.

GPO <0> signal turns off DC-DC converter to supply V_{CC} (15v).

POWER UP AND POWER DOWN SEQUENCING

You must observe proper power sequencing for V_{PANEL}.

Power Up – Display must be powered up and initialized before power is applied to V_{PANEL}.

Power Down – Power must be removed from V_{PANEL} before the display is powered off.

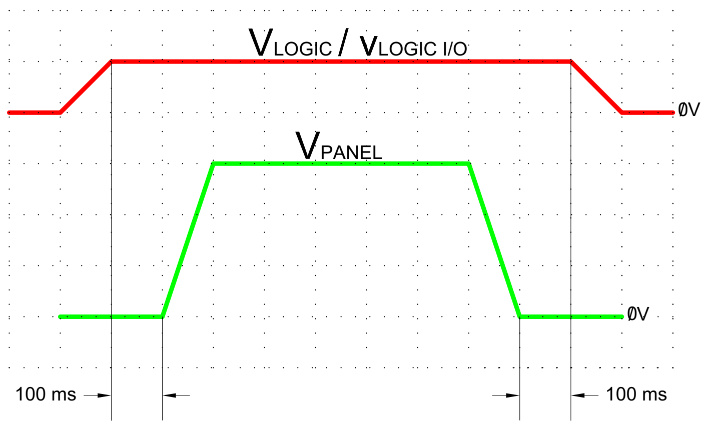


Figure 4. Power Up and Power Down Sequencing

ABSOLUTE MAXIMUM RATINGS

ABSOLUTE MAXIMUM RATINGS	SYMBOL	MINIMUM	MAXIMUM
Operating Temperature*	T_{OP}	-20°C	+70°C
Storage Temperature*	T_{ST}	-30°C	+80°C
Humidity	RH	0%	90%
Logic Supply Voltage	V_{LOGIC}	0v	+3.5v
Driver Supply Voltage	V_{PANEL}	0v	+21v
***Prolonged exposure at temperatures outside of this range may cause permanent damage to the module or decrease product lifetime.**			

DC CHARACTERISTICS

Test Conditions for all specifications below:
All pixels on
V_{LOGIC} = +2.8v
V_{PANEL} = +15v

DC CHARACTERISTICS	TEST CONDITION	SYMBOL	MINIMUM	TYPICAL	MAXIMUM
Logic Supply Voltage	T_{OP} = -20°C to +70°C	V_{LOGIC}	+2.2v	+2.8v	+3.3v[1]
OLED Driver Supply Voltage[2]	T_{OP} = -20°C to +70°C	V_{PANEL}	+10v	+15v	+21v
Input High Voltage		V_{IH}	+0.7v x V_{LOGIC} For V_{LOGIC} = +2.8v V_{IH} = +0.7v x +2.8v = +1.96v		V_{LOGIC}
Input Low Voltage		V_{IL}	0v (GND)		+0.3v x V_{LOGIC} For V_{LOGIC} = +2.8v V_{IL} = +0.3v x +2.8v = +0.84v
Output High Voltage		V_{OH}	+0.8v x V_{LOGIC} For V_{LOGIC}= +2.8v V_{OH} = +0.8v x +2.8v = +2.24v		V_{LOGIC}
Output Low Voltage		V_{OL}	0v (GND)		+0.2v x V_{LOGIC} For V_{LOGICc} = +2.8v V_{OL} = +0.2v x +2.8v = +0.56v
Normal Mode Power Consumption	All pixels on V_{LOGIC} = +2.8v V_{PANEL} = +15v Frame Rate = 90Hz	$P_{OPERATION}$		28 mA	35 mA

[1] *Do not exceed +3.3v maximum.*

[2] ***The V_{PANEL} input must be a stable value with no ripple or noise.***

This is a summary of the module's major operating parameters. For detailed information see the LGDP7216 Controller Data Sheet.

DETAILS OF INTERFACE PIN FUNCTION

PIN	SIGNAL	LEVEL	DIRECTION	DESCRIPTION
1	NC			No connection.
2	GND	0v		Ground. Must be connected to an external ground.
3	$\overline{RST}$	H/L	I	Reset signal. *Low:* Display controller is reset. The $\overline{RST}$ pin should be pulsed low shortly after power is applied. *High:* The $\overline{RST}$ pin should be brought high for normal operation.
4	$\overline{WR}_{8080}$	H/L	I	Host interface input. *8080 Host:* Active low. Signal on the databus is latched at the rising edge of $\overline{WR}$ signal.
5	$\overline{RD}_{8080}$	H/L	I	Host interface input. *8080 Host:* Active low. Signal on the databus is latched at the rising edge of $\overline{RD}$.
6	$\overline{CS}$	H/L	I	Chip select input. *Low:* Controller chip is selected. Communications with the host is possible. *High:* Controller chip is not selected. Host interface signals are ignored by the controller.
7	$D/\overline{C}$	H/L	I	Data/Command control. Determines whether data bits are data or command. *1 – High:* Addresses the data register. *2 – Low:* Addresses the command register.
8	COM SEL		I	Data bit selection signal input.
9-26	DB0 ~ DB17	H/L	I	Bidirectional databus connects to 6-bit, 8-bit, 9-bit, 16-bit, or 18-bit standard host databus.
27	V_{LOGIC}			Power supply input. Must be connected to an external source.
28	NC			No Connection

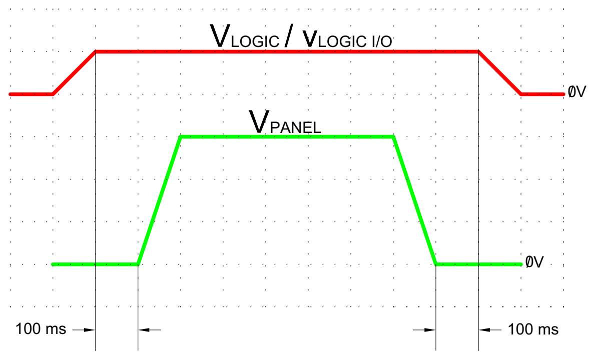
PIN	SIGNAL	LEVEL	DIRECTION	DESCRIPTION (Continued)
29	V_{PANEL}			Driver supply voltage. Only high voltage input on chip. Power must be supplied externally. *Note: You must observe power sequencing for this signal.* *Power Up* – Display must be powered up and initialized before power is applied to the signal. *Power Down* – Power must be removed from this signal before the display is powered off. 
30	NC			No Connection.

PHOTO REFERENCE FOR PIN FUNCTIONS

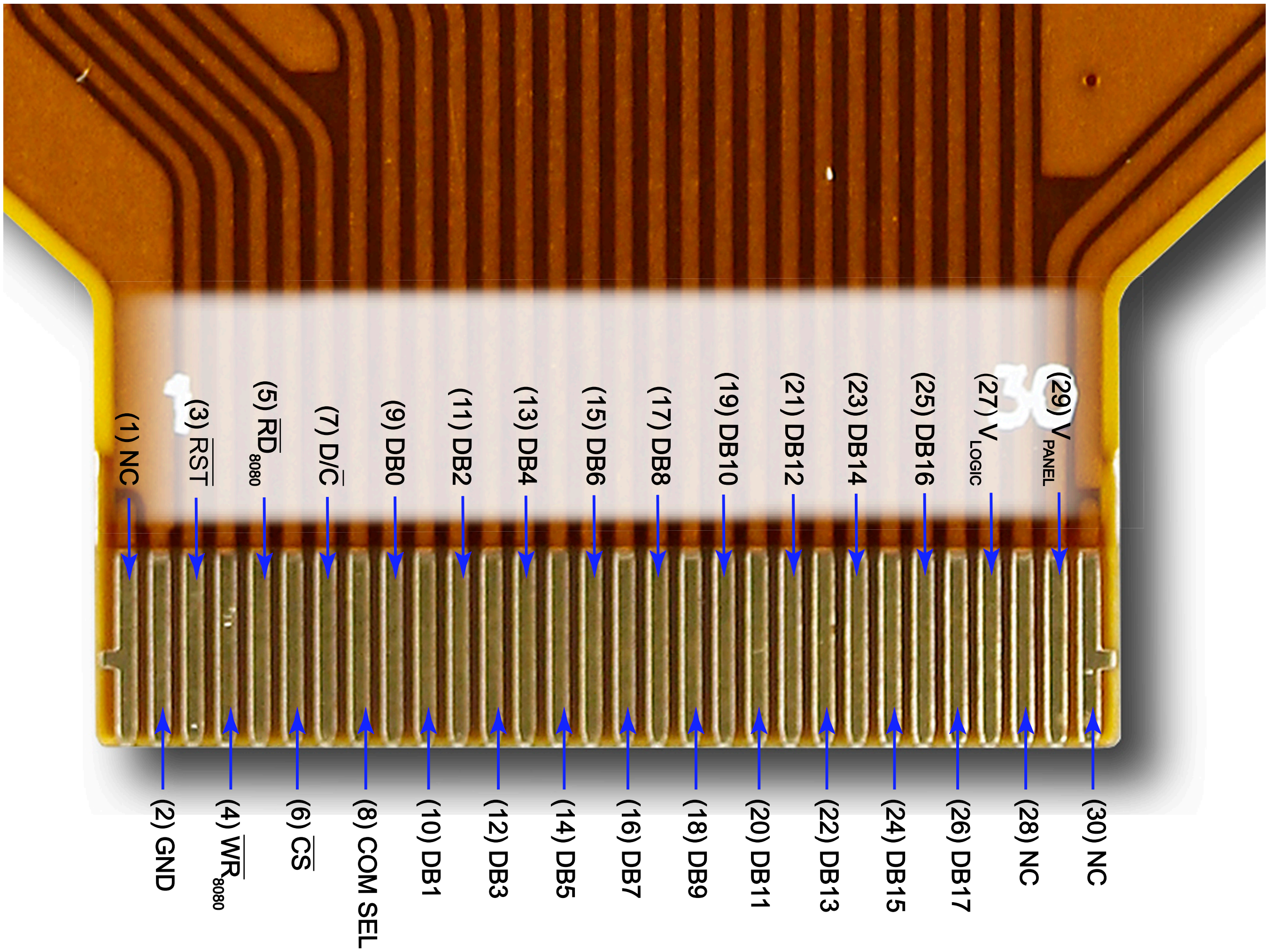


Figure 5. Photo Reference for Pin Functions

ESD (ELECTRO-STATIC DISCHARGE)

The circuitry is industry standard CMOS logic and susceptible to ESD damage. Please use industry standard antistatic precautions as you would for any other static sensitive devices such as expansion cards, motherboards, or integrated circuits. Ground your body, work surfaces, and equipment.

OPTICAL SPECIFICATIONS

OPTICAL CHARACTERISTICS

ITEM	SYMBOL	TEST CONDITION	MINIMUM	TYPICAL	MAXIMUM
Viewing Angle				≥160°	
Dark Room Contrast Ratio[1]	CR	80 cd/m^2		≥2,000:1	
Luminous Intensity, Normal	L_{BR}	With polarizer All pixels on V_{LOGIC}:+2.8v V_{PANEL}: +15V Frame rate: 90Hz	80 cd/m^2	100 cd/m^2	

[1]*Contrast Ratio = (brightness with pixels light)/(brightness with pixels dark).*

Definition of Viewing Angle

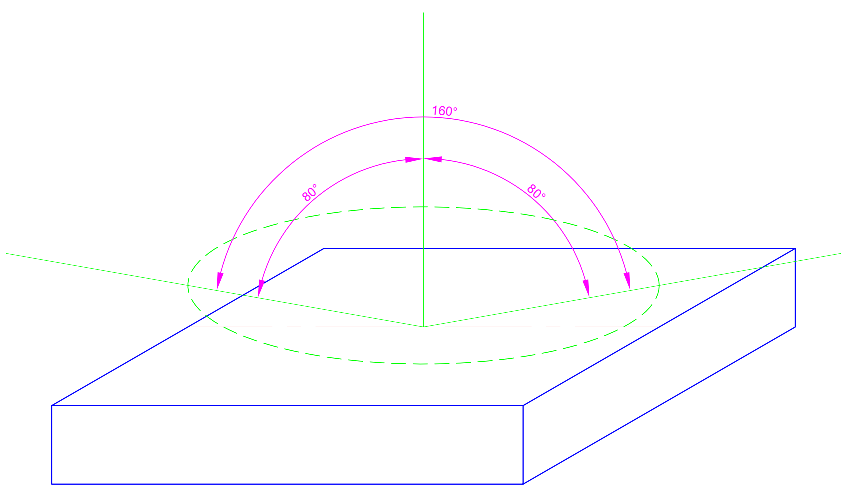


Figure 6. CFAL160128B-F-B2 has a 160° Viewing Angle

MODULE RELIABILITY AND LONGEVITY

MODULE RELIABILITY

ITEM	SPECIFICATION
CFAL160128B-F-B2	10,000 hours >50% of initial brightness at typical brightness for a new module.

OLED displays are an emissive technology. Each pixel is susceptible to dimming based on its individual use (burn-in). Frequently used pixels will dim more quickly than pixels that are not used as often. Please avoid using a bright, static, high-contrast image for a long time. If you want to leave the display powered on, please use scrolling text or alternating images to "wear level" the pixels. To conserve power and display lifetime, turn off or dim the display when it is not in use.

MODULE LONGEVITY (EOL/REPLACEMENT POLICY)

Crystalfontz is committed to making all of our modules available for as long as possible. For each module we introduce, we intend to offer it indefinitely. We do not preplan a module's obsolescence. The majority of modules we have introduced are still available.

We recognize that discontinuing a module may cause problems for some customers. However, rapidly changing technologies, component availability, or low customer order levels may force us to discontinue ("End of Life", EOL) a module. For example, we must occasionally discontinue a module when a supplier discontinues a component or a manufacturing process becomes obsolete. When we discontinue a module, we will do our best to find an acceptable replacement module with the same fit, form, and function.

In most situations, you will not notice a difference when comparing a "fit, form, and function" replacement module to the discontinued module. However, sometimes a change in component or process for the replacement module results in a slight variation, perhaps an improvement, over the previous design.

Although the replacement module is still within the stated Data Sheet specifications and tolerances of the discontinued module, changes may require modification to your circuit and/or firmware. Possible changes include:

- *Controller.* A new controller may require minor changes in your code.
- *Component tolerances.* Module components have manufacturing tolerances. In extreme cases, the tolerance stack can change the visual or operating characteristics.

Please understand that we avoid changing a module whenever possible; we only discontinue a module if we have no other option. We will post Part Change Notices on the product's webpage as soon as possible. If interested, you can subscribe to future part change notifications.

CARE AND HANDLING PRECAUTIONS

For optimum operation of the module and to prolong its life, please follow the precautions below. Excessive voltage will shorten the life of the module. You must drive the display within the specified voltage limit. See Absolute Maximum Ratings (Pg. 18).

ESD (ELECTRO-STATIC DISCHARGE)

The circuitry is industry standard CMOS logic and susceptible to ESD damage. Please use industry standard antistatic precautions as you would for any other static sensitive devices such as expansion cards, motherboards, or integrated circuits. Ground your body, work surfaces, and equipment.

DESIGN AND MOUNTING

- The exposed surface of the "glass" is actually a polarizer laminated on top of the glass. To protect the soft plastic polarizer from damage, the module ships with a protective film over the polarizer. Please peel off the protective film slowly. Peeling off the protective film abruptly may generate static electricity.
- The polarizer is made out of soft plastic and is easily scratched or damaged. When handling the module, avoid touching the polarizer. Finger oils are difficult to remove.
- To protect the soft plastic polarizer from damage, place a transparent plate (for example, acrylic, polycarbonate, or glass) in front of the module, leaving a small gap between the plate and the display surface. We use GE HP-92 Lexan, which is readily available and works well.
- Do not disassemble or modify the module.
- Do not reverse polarity to the power supply connections. Reversing polarity will immediately ruin the module.
- Sharp bends can damage the FFC. Do not crease FFC. Do not bend FFC tightly against the edge of the OLED panel. Limit bend radius to $\geq$R 1.30 mm.
- Do not repeatedly bend the FFC beyond its elastic region.
- The FFC (Flat Flex Cable) mates with standard ZIF connectors such as 609-1244-1-ND or 609-1882-1-ND available from Digi-Key.

AVOID SHOCK, IMPACT, TORQUE, OR TENSION

- Do not expose the module to strong mechanical shock, impact, torque, or tension.
- Do not drop, toss, bend, or twist the module.
- Do not place weight or pressure on the module.

CLEANING

- The polarizer (laminated to the glass) is soft plastic. The soft plastic is easily scratched or damaged. Be very careful when you clean the polarizer.
- Do not clean the polarizer with liquids. Do not wipe the polarizer with any type of cloth or swab (for example, Q-tips).
- Use the removable protective film to remove smudges (for example, fingerprints) and any foreign matter. If you no longer have the protective film, use standard transparent office tape (for example, Scotch® brand "Crystal Clear Tape"). If the polarizer is dusty, you may carefully blow it off with clean, dry, oil-free compressed air.

OPERATION

- We do not recommend connecting this module to a PC's parallel port as an "end product." This module is not "user friendly" and connecting it to a PC's parallel port is often difficult, frustrating, and can result in a "dead" display due to mishandling. For more information, see our forum thread at http://www.crystalfontz.com/forum/showthread.php?s=&threadid=3257.
- Your circuit should be designed to protect the module from ESD and power supply transients.
- Observe the operating temperature limitations: from -20°C minimum to +70°C maximum with minimal fluctuations. Operation outside of these limits may shorten the life and/or harm the display.
- Operate away from dust, moisture, and direct sunlight.

STORAGE AND RECYCLING

- Store in an ESD-approved container away from dust, moisture, and direct sunlight, fluorescent lamps, or any ultraviolet ray.
- Observe the storage temperature limitations: from -30°C minimum to +80°C maximum with minimal fluctuations. Rapid temperature changes can cause moisture to form, resulting in permanent damage.
- Do not allow weight to be placed on the modules while they are in storage.
- Please recycle your outdated Crystalfontz modules at an approved facility.

APPENDIX A: QUALITY ASSURANCE STANDARDS

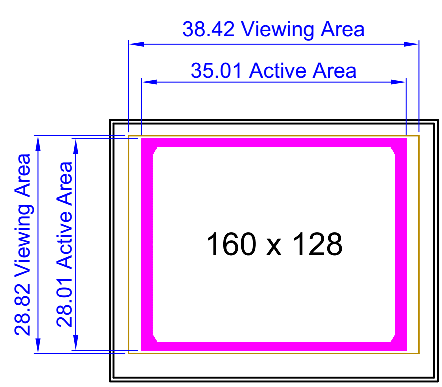
INSPECTION CONDITIONS

- Environment
  - Temperature: 25±5°C
  - Humidity: 30~85% RH (noncondensing)
- For visual inspection of active display area
  - Source lighting: two 20-Watt or one 40-Watt fluorescent light
  - Display adjusted for best contrast
  - Viewing distance: 30±5 cm (about 12 inches)
  - Viewing angle: inspect at 45° angle of vertical line right and left, top and bottom

COLOR DEFINITIONS

We try to describe the appearance of our modules as accurately as possible. For the photos, we adjust for optimal appearance. Actual display appearance may vary due to (1) different operating conditions, (2) small variations of component tolerances, (3) inaccuracies of our camera, (4) color interpretation of the photos on your monitor, and/or (5) personal differences in the perception of color.

DEFINITION OF ACTIVE AREA AND VIEWING AREA



ACCEPTANCE SAMPLING

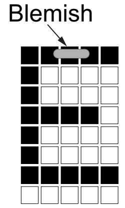
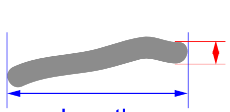
DEFECT TYPE	AQL*
Major	≤.65%
Minor	<1.0%
* Acceptable Quality Level: maximum allowable error rate or variation from standard	

DEFECTS CLASSIFICATION

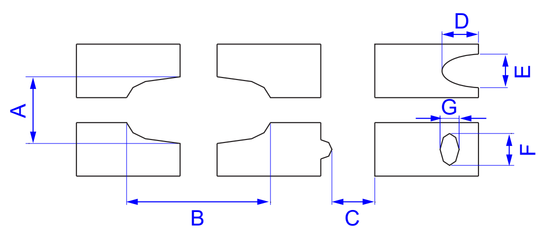
Defects are defined as:

- Major Defect: results in failure or substantially reduces usability of unit for its intended purpose.
- Minor Defect: deviates from standards but is not likely to reduce usability for its intended purpose.

ACCEPTANCE STANDARDS

#	DEFECT TYPE	CRITERIA			MAJOR / MINOR
1	Electrical defects	1. No display, display malfunctions, or shorted segments. 2. Current consumption exceeds specifications.			Major
2	Viewing area defect	Viewing area does not meet specifications.			Major
3	Blemishes or foreign matter on display segments		*Defect Size*	*Acceptable Qty*	Minor
			≤0.30 mm	3	
			≤2 defects within 10 mm of each other		
4	Dark lines or scratches in display area 	*Defect Width*	*Defect Length*	*Acceptable Qty*	Minor
		≤0.03 mm	≤3.0 mm	3	
		0.03 to 0.05	≤2.0 mm	2	
		0.05 to 0.08	≤2.0 mm	1	
		0.08 to 0.10	≤3.0 mm	0	
		≥0.10	>3.0 mm	0	

ACCEPTANCE STANDARDS

<table>
<tr><th>#</th><th>DEFECT TYPE</th><th>CRITERIA</th><th>MAJOR / MINOR</th></tr>
<tr><td>5</td><td>Bubbles between polarizer film and glass</td><td><table><tr><th>Defect Size</th><th>Acceptable Qty</th></tr><tr><td>≤0.20 mm</td><td>Ignore</td></tr><tr><td>0.20 to 0.40 mm</td><td>3</td></tr><tr><td>0.40 to 0.60 mm</td><td>2</td></tr><tr><td>≥0.60 mm</td><td>0</td></tr></table></td><td>Minor</td></tr>
<tr><td>6</td><td>Display pattern defect</td><td>

<table><tr><th>Pixel Size</th><th>Acceptable Qty</th></tr><tr><td>((A+B)/2)≤0.20 mm</td><td rowspan="4">≤3 total defects
≤2 pinholes per digit</td></tr><tr><td>C>0 mm</td></tr><tr><td>((D+E)/2)≤0.25 mm</td></tr><tr><td>((F+G)/2)≤0.25 mm</td></tr></table></td><td>Minor</td></tr>
<tr><td>7</td><td>PCB defects</td><td>1. Oxidation or contamination on connectors.*
2. Wrong parts, missing parts, or parts not in specification.*
3. Jumpers set incorrectly.
4. Solder (if any) on bezel, LED pad, zebra pad, or screw hole pad is not smooth.
*Minor if display functions correctly. Major if the display fails.</td><td>Minor</td></tr>
<tr><td>8</td><td>Soldering defects</td><td>1. Unmelted solder paste.
2. Cold solder joints, missing solder connections, or oxidation.*
3. Solder bridges causing short circuits.*
4. Residue or solder balls.
5. Solder flux is black or brown.
*Minor if display functions correctly. Major if the display fails.</td><td>Minor</td></tr>
</table>

APPENDIX B: SAMPLE CODE

SOURCES FOR DRIVER LIBRARIES

Graphic driver libraries may save a lot of time and help you develop a more professional product. Possible library sources are easyGUI, en.radzio.dxp.pl, Gwentech, Micriμm, RAMTEX, and Segger emWin.

SAMPLE CODE, 8-BIT

This code reads images off the MicroSD card which are written in the bin format used by Image2LCD. You can download the complete source from this link: http://www.crystalfontz.com/products/document/2099/CFAL160128B.zip.

Note: Please observe V_{PANEL} sequencing as described in Details of Interface Pin Function (Pg. 20). See also Power Up and Power Down Sequencing (Pg. 18).

```
hx.t#include<avr/io.h>
#include"MMC_SD/MMC_SD.h"
#include"FAT/FAT.h"
#include <util/delay.h>

// all on PORTC
#define OLED_CD   PC7
#define OLED_WR   PC6// WR in 8080 mode
#define OLED_RD   PC5// RD in 8080 mode
#define OLED_CS   PC4
#define OLED_RESPC2

#define CLR_CD PORTC &= ~(1<<OLED_CD);
#define SET_CD PORTC |=  (1<<OLED_CD);

#define CLR_CS PORTC &= ~(1<<OLED_CS);
#define SET_CS PORTC |=  (1<<OLED_CS);

#define CLR_RESET PORTC &= ~(1<<OLED_RES);
#define SET_RESET PORTC |=  (1<<OLED_RES);

// 8080 mode pin functions
#define CLR_WR PORTC &= ~(1 << OLED_WR);   // 8080 mode
#define SET_WR PORTC |=  (1 << OLED_WR);   // 8080 mode
#define CLR_RD PORTC &= ~(1 << OLED_RD);   // 8080 mode
#define SET_RD PORTC |=  (1 << OLED_RD);   // 8080 mode

// color definitions
#define BLACK      0x0000
#define BLUE       0x001F
#define RED        0xF800
#define GREEN    0x07E0
#define CYAN   0x07FF
#define MAGENTA 0xF81F
#define YELLOW   0xFFE0
#define WHITE   0xFFFF

#define uint8 unsigned char
#define uint16 unsigned int
#define uint32 unsigned long

unsigned char * PATH = "\\batch";

extern uint16 SectorsPerClust;
```

```
extern uint16 FirstDataSector;
extern uint8 FAT32_Enable;

struct FileInfoStruct FileInfo;

struct direntry PictureInfo;
uint16 totalfiles = 0;

/**************************************************/
void delay(unsigned int t)
{
        unsigned char t1;
        while(t--)
        for(t1=11;t1>0;t1--)
        {asm("nop");}
}

#define uchar unsigned char
#define uint unsigned int

//-----------------------------------------------------------------------

void SendCommand(unsigned int command)
{
        CLR_CS;
        CLR_CD;
        SET_RD;
        SET_WR;

        PORTA=command;

        CLR_WR;
        SET_WR;
        SET_CS;
}

void WriteData(unsigned int data)
{
        CLR_CS;
        SET_CD;
        SET_RD;
        SET_WR;

        PORTA=data;

        CLR_WR;
        SET_WR;
        SET_CS;
}

/**************************************************/
void initialization()
{
        SET_RD;
        SET_WR;
        SET_CS;
        SET_CD;
        PORTA=0x00;

        CLR_RESET;
        delay(200);
        SET_RESET;
        delay(500);

        SendCommand(0x61);        //scan driver control,comand explan at page 34
```

```
        WriteData(0x00);

        SendCommand(0x60);        //scan voltage setting,comand explan at page 34
        WriteData(0x00);

        SendCommand(0x01);       //command explain at page 12
        WriteData(0x03);          //address increment direction(x:0->159,y:0->128,x direction increment at
first then y direction)
        //8bit interface with 2 transmissions 65k colour

        SendCommand(0x06);       //command explain at page 17
        WriteData(0x00);          //X address

        SendCommand(0x07);       //command explain at page 17
        WriteData(0x00);          //Y address

        SendCommand(0x02);       //command explain at page 13
        WriteData(0x03);          //display size:160*128 , display frame :90Hz

        SendCommand(0x43);       //command is not explain at page
        WriteData(0x00);          //enable gamma

        SendCommand(0x04);       //command explain at page 14
        WriteData(0x00);          //no display rotate   160x128

        SendCommand(0x03);       //command explain at page 13
        WriteData(0x01);          //scan direction:0->159,scan seq direction:S0 S1 S2.....S127

        SendCommand(0x27);       //command explain at page 28
        WriteData(0x01);          //128 scan line time

        SendCommand(0x20);       //command explain at page 27
        WriteData(0x06);          //set RED disprecharge time of scan line

        SendCommand(0x21);       //command explain at page 27
        WriteData(0x04);          //set GREEN disprecharge time of scan line

        SendCommand(0x22);       //command explain at page 27
        WriteData(0x08);          //set BLUE disprecharge time of scan line

        SendCommand(0x23);       //command explain at page 28
        WriteData(0x03);          //set RED peak time of scan line

        SendCommand(0x24);       //command explain at page 28
        WriteData(0x04);          //set GREEN peak time of scan line

        SendCommand(0x25);       //command explain at page 28
        WriteData(0x04);          //set BLUE peak time of scan line

        SendCommand(0x50);          //red dot current set, command explan at page30
        WriteData(0x64);

        SendCommand(0x51);          //green dot current set, command explan at page30
        WriteData(0x62);

        SendCommand(0x52);          //blue dot current set, command explan at page31
        WriteData(0x62);

        SendCommand(0x53);            //red peak current set,command explan at page 31
        WriteData(0x03);

        SendCommand(0x54);            //green peak current set,command explan at page 32
        WriteData(0x03);

        SendCommand(0x55);            //blue peak current set,command explan at page 32
```

```
WriteData(0x03);

SendCommand(0x26);        //command explain at page 28
WriteData(0x06);           //period in scan to scan 0~63

SendCommand(0x5a);              //data gray level control set,comand explan at page 33
WriteData(0x01);

SendCommand(0xa0);                //power save set,comand explan at page 35
WriteData(0x00);                //0 go   1 stop

SendCommand(0x00);        //this command must be again at last ,command explain at page 11
WriteData(0x80);           //display off,set direction of data is nomall direction,RGB,RESET=1

//****************************************
SendCommand(0x40);        //command explain at page 29
WriteData(0x00);           //Red Lookup Set.
WriteData(0x00);
WriteData(0x00);
WriteData(0x01);
WriteData(0x02);           //5

WriteData(0x03);
WriteData(0x04);
WriteData(0x05);
WriteData(0x06);
WriteData(0x07);           //10

WriteData(0x08);
WriteData(0x09);
WriteData(0x0a);
WriteData(0x0b);
WriteData(0x0c);           //15

WriteData(0x0d);
WriteData(0x0e);
WriteData(0x0f);
WriteData(0x10);
WriteData(0x12);           //20

WriteData(0x13);
WriteData(0x14);
WriteData(0x16);
WriteData(0x17);
WriteData(0x19);           //25

WriteData(0x1b);
WriteData(0x1c);
WriteData(0x1e);
WriteData(0x20);
WriteData(0x22);           //30

WriteData(0x24);
WriteData(0x26);
WriteData(0x28);
WriteData(0x2a);
WriteData(0x2c);           //35

WriteData(0x2f);
WriteData(0x31);
WriteData(0x33);
WriteData(0x36);
WriteData(0x38);           //40

WriteData(0x3b);
```

```
WriteData(0x3d);
WriteData(0x40);
WriteData(0x43);
WriteData(0x45);          //45

WriteData(0x48);
WriteData(0x4b);
WriteData(0x4e);
WriteData(0x51);
WriteData(0x53);          //50

WriteData(0x56);
WriteData(0x59);
WriteData(0x5c);
WriteData(0x60);
WriteData(0x63);          //55

WriteData(0x66);
WriteData(0x69);
WriteData(0x6c);
WriteData(0x70);
WriteData(0x73);          //60

WriteData(0x76);
WriteData(0x79);
WriteData(0x7c);
WriteData(0x7f);          //64

//***************************************
SendCommand(0x41);       //command explain at page 30
WriteData(0x00);          //Green Lookup Set.
WriteData(0x00);
WriteData(0x00);
WriteData(0x01);
WriteData(0x02);          //5

WriteData(0x03);
WriteData(0x04);
WriteData(0x05);
WriteData(0x06);
WriteData(0x07);          //10

WriteData(0x08);
WriteData(0x09);
WriteData(0x0a);
WriteData(0x0b);
WriteData(0x0c);          //15

WriteData(0x0d);
WriteData(0x0e);
WriteData(0x0f);
WriteData(0x10);
WriteData(0x12);          //20

WriteData(0x13);
WriteData(0x14);
WriteData(0x16);
WriteData(0x17);
WriteData(0x19);          //25

WriteData(0x1b);
WriteData(0x1c);
WriteData(0x1e);
WriteData(0x20);
WriteData(0x22);          //30
```

```
WriteData(0x24);
WriteData(0x26);
WriteData(0x28);
WriteData(0x2a);
WriteData(0x2c);          //35

WriteData(0x2f);
WriteData(0x31);
WriteData(0x33);
WriteData(0x36);
WriteData(0x38);          //40

WriteData(0x3b);
WriteData(0x3d);
WriteData(0x40);
WriteData(0x43);
WriteData(0x45);          //45

WriteData(0x48);
WriteData(0x4b);
WriteData(0x4e);
WriteData(0x51);
WriteData(0x53);          //50

WriteData(0x56);
WriteData(0x59);
WriteData(0x5c);
WriteData(0x60);
WriteData(0x63);          //55

WriteData(0x66);
WriteData(0x69);
WriteData(0x6c);
WriteData(0x70);
WriteData(0x73);          //60

WriteData(0x76);
WriteData(0x79);
WriteData(0x7c);
WriteData(0x7f);          //64
//**************************************************
SendCommand(0x42);       //command explain at page 30
WriteData(0x00);          //Blue Lookup Set.
WriteData(0x00);
WriteData(0x00);
WriteData(0x01);
WriteData(0x02);          //5

WriteData(0x03);
WriteData(0x04);
WriteData(0x05);
WriteData(0x06);
WriteData(0x07);          //10

WriteData(0x08);
WriteData(0x09);
WriteData(0x0a);
WriteData(0x0b);
WriteData(0x0c);          //15

WriteData(0x0d);
WriteData(0x0e);
WriteData(0x0f);
WriteData(0x10);
```

```
        WriteData(0x12);          //20

        WriteData(0x13);
        WriteData(0x14);
        WriteData(0x16);
        WriteData(0x17);
        WriteData(0x19);          //25

        WriteData(0x1b);
        WriteData(0x1c);
        WriteData(0x1e);
        WriteData(0x20);
        WriteData(0x22);          //30

        WriteData(0x24);
        WriteData(0x26);
        WriteData(0x28);
        WriteData(0x2a);
        WriteData(0x2c);          //35

        WriteData(0x2f);
        WriteData(0x31);
        WriteData(0x33);
        WriteData(0x36);
        WriteData(0x38);          //40

        WriteData(0x3b);
        WriteData(0x3d);
        WriteData(0x40);
        WriteData(0x43);
        WriteData(0x45);          //45

        WriteData(0x48);
        WriteData(0x4b);
        WriteData(0x4e);
        WriteData(0x51);
        WriteData(0x53);          //50

        WriteData(0x56);
        WriteData(0x59);
        WriteData(0x5c);
        WriteData(0x60);
        WriteData(0x63);          //55

        WriteData(0x66);
        WriteData(0x69);
        WriteData(0x6c);
        WriteData(0x70);
        WriteData(0x73);          //60

        WriteData(0x76);
        WriteData(0x79);
        WriteData(0x7c);
        WriteData(0x7f);          //64
}

// ************************************************ /
void display_Color(unsigned int color)
{
        unsigned int k,i;
        SendCommand(0x06);       //command explain at page 17
        WriteData(0x00);          //X address

        SendCommand(0x07);       //command explain at page 17
        WriteData(0x00);          //Y address
```

```
        SendCommand(0x08);       //command explain at page 17
        WriteData(0x00);          //star address of X in the rectangle windows

        SendCommand(0x09);       //command explain at page 17
        WriteData(0x9f);          //end address of X in the rectangle windows

        SendCommand(0x0a);       //command explain at page 17
        WriteData(0x00);          //star address of Y in the rectangle windows

        SendCommand(0x0b);       //command explain at page 18
        WriteData(0x7f);          //end address of Y in the rectangle windows

        SendCommand(0x05);       //command explain at page 15

        for(k=0;k<160;k++)
        {
                for(i=0;i<128;i++)
                {
                        WriteData(color);
                        WriteData(color>>8);
                }
        }
}


/**************************************************/
void Display_Home()
{
        SendCommand(0x06);       //command explain at page 17
        WriteData(0x00);          //X address

        SendCommand(0x07);       //command explain at page 17
        WriteData(0x00);          //Y address

        SendCommand(0x08);       //command explain at page 17
        WriteData(0x00);          //star address of X in the rectangle windows

        SendCommand(0x09);       //command explain at page 17
        WriteData(0x9f);          //end address of X in the rectangle windows

        SendCommand(0x0a);       //command explain at page 17
        WriteData(0x00);          //star address of Y in the rectangle windows

        SendCommand(0x0b);       //command explain at page 18
        WriteData(0x7f);          //end address of Y in the rectangle windows

        SendCommand(0x05);       //command explain at page 15
}

void Picture_Slide_Show()
{
        uint8 i;                //loop variable
        uint16 j;               //loop variable
        uint32 p;               //cluster
        uint16 *buffer;                 //buffer
        uint16 pics = 1;
        uint16 slide_show_flag = 1;
        uint8 sector;
        uint32 pixels;

        if (totalfiles == 0)
        return;

        buffer = malloc(512);
```

```
        if (buffer == 0)
        return;

next:   //label for "goto"
        display_Color(BLACK);

        Search(PATH, &PictureInfo, &pics);                                          //find the file
        p = PictureInfo.deStartCluster + (((uint32)PictureInfo.deHighClust) << 16);//the first cluster of the
                                                                                      file

        sector = 0;

        FAT_LoadPartCluster(p, sector, buffer);//read a sector


        pixels = (uint32) 160 * 128; // total # of pixels to write

        Display_Home();

        j = 0; // byte count

        while (1)
        {
                WriteData(buffer[j]);  // write 8 bits
                WriteData(buffer[j]>>8);  // write 8 bits
                j++;
                pixels--;               // which is one pixel

                if (pixels == 0)
                break;

                if (j == 256)           // time for a new sector
                {
                        sector++;
                        if (sector == SectorsPerClust)
                        {
                                p = FAT_NextCluster(p);        // read next cluster
                                sector = 0;
                        }

                        FAT_LoadPartCluster(p, sector, buffer);// read a sector
                        j = 0;
                }
        }

        if (slide_show_flag)
        {
                for (i=0;i<30;i++)// delay for a while
                delay(0xffff);

                pics++;                                 // increment picture number
                if (pics > totalfiles)// if last
                pics = 1;              // wrap around

                goto next;                      // go show next pic
        }
        free(buffer);
}
/***************************************************/

int main()
{
        PORTD = 0xF8;     // pull-up on switches, all others off
        DDRD  = 0x0F;   // VPP and led pins output
```

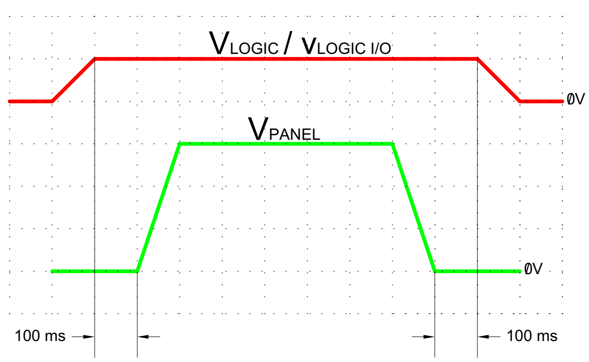
```
        DDRA = 0xFF;    // low data port, all outputs
        DDRE = 0xFF;    // low data port, all outputs

        PORTC = 0xFE;    // all pins high
        DDRC  = 0xFE;    // all outputs

        uint8 retry = 0;

        OSCCAL = 0x00;    //in order to operate some low speed card the initialization should run at lowest
                            speed

        delay(0xffff);

        MMC_SD_Init();    //SPI initialize

        // Initialize the display
        initialization();

        sd_restart: //label for "goto"

        while (MMC_SD_Reset())  // Initialize SD Card
        {
                retry++;
                if (retry > 254)
                {
                        while (1)
                        {
                                goto sd_restart;              // try again
                        }
                }
        }

        OSCCAL = 0xff;      //run at high speed for normal operation for SD Card

        delay(0xffff);

        if (FAT_Init())   //initialize file system - FAT16 and FAT32 are supported
        {
                while (1)
                {
                        goto sd_restart;              // try again
                }
        }

        Search(PATH, &PictureInfo, &totalfiles);

        Picture_Slide_Show();

        while(1)
        {
                display_Color(RED);
                delay(1000);
                display_Color(GREEN);
                delay(1000);
                display_Color(BLUE);
                delay(1000);
                display_Color(WHITE);
                delay(1000);
                display_Color(BLACK);
                delay(1000);
        }
        return 0;
}
```

APPENDIX C: OLED MODULE TERMS AND SYMBOLS

Symbol	Description
C	Capacitor
cd/m^2 nit	Candela meter squared is the standard unit of measurement for luminous intensity (photometric brightness).
CIE	A color model based on human perception developed by the CIE (Commission Internationale de l'Eclairage) committee.
CLS	Clock select pin.
COF COT TAB	Chip On Flex. Controller is on the FPC. Similar in appearance to "TAB." The flex circuit on COF is typically much thinner than the flex of a "flex tail."
COG	Chip On Glass. Controller is on the glass panel.
COM	Common driver. Common signal output for OLED display.
CR	Contrast Ratio = (brightness with pixels light)/(brightness with pixels dark).
$\overline{CS}$ CS# CSB	Chip select input. *Low:* Controller chip is selected. Communications with host is possible. *High:* Controller chip is not selected. Host interface signals are ignored by the controller.
D	Diode
DB0 ~ DB*n* D0 ~ D*n*	Bidirectional databus connects to 8-bit or 16-bit standard host databus. When SPI (serial interface) is selected, DB0 serves as the serial clock input signal (SCL or SCLK) and DB1 serves as the serial data input signal (SI or SDIN). DB2 to DBn are set to high impedance.
D/$\overline{C}$ RS A0 CD D/C#	Data/Command control. Determines whether data bits are data or command. *1 – High*: Addresses the data register. *0 – Low:* Addresses the command register.
ESD	Electro-Static Discharge. Sudden and brief electrical current that flows between two objects. ESD between a human and a TFT module can cause permanent damage.
FB	Feedback input for the booster circuit. Use to adjust booster output voltage level, V_{PANEL}.
FFC	Flat Flex Cable. Used for Touch Screen connection. Also called "pigtail."
FG	Frame Ground.
FPC	Flexible Printed Circuit. Also called "flex tail." Typically much thicker than the "flex" film of COF (Chip On Flex).
GDR	Gate Drive. Output signal drives the gate of the external NMOS of the booster circuit.
GND V_{SS}	Ground. Must be connected to an external ground.

<table>
<tr><th>Symbol</th><th>Description (Continued)</th></tr>
<tr><td>I_{LOGIC}
I_{DD}</td><td>Operating current for V_{LOGIC}.</td></tr>
<tr><td>$I_{LOGIC,\ SLEEP}$
$I_{DD,\ SLEEP}$</td><td>Sleep mode current for V_{LOGIC}.</td></tr>
<tr><td>I_{PANEL}
I_{CC}</td><td>Supply current for V_{PANEL}.</td></tr>
<tr><td>$I_{PANEL,\ SLEEP}$
$I_{CC,\ SLEEP}$</td><td>Sleep mode current for V_{PANEL}.</td></tr>
<tr><td>I_{REF}</td><td>Segment output current reference for brightness adjustment. A resistor should be connected between this pin and GND. Used to set the current.</td></tr>
<tr><td>I/O</td><td>Input/Output.</td></tr>
<tr><td>IMn</td><td>Interface mode select pin. (Where n is the corresponding number.)</td></tr>
<tr><td>IS1
BS1
C86
M80</td><td rowspan="2"><table><tr><th>IS1</th><th>IS2</th><th>Interface Mode</th></tr><tr><td>0</td><td>0</td><td>SPI (Serial), if available</td></tr><tr><td>0</td><td>1</td><td>6800 Parallel, if available</td></tr><tr><td>1</td><td>0</td><td>Not Allowed</td></tr><tr><td>1</td><td>1</td><td>8080 Parallel</td></tr></table></td></tr>
<tr><td>IS2
BS2
P/S
MS
M$\overline{S}$
M/S#</td></tr>
<tr><td>$L_{BRNORMAL}$
IV</td><td>Luminous Intensity Brightness, NORMAL operation.</td></tr>
<tr><td>$L_{BRSTANDBY}$
IV</td><td>Luminous Intensity Brightness, STANDBY.</td></tr>
<tr><td>mm</td><td>Millimeter or millimetre. Unit of length equal to one thousandth of a meter.
1 millimeter = 0.0394 inches.</td></tr>
<tr><td>mW</td><td>Milliwatt is equal to one thousandth of a Watt.
Watts = Volts x Amps.</td></tr>
<tr><td>NC
nc</td><td>No Connection.</td></tr>
<tr><td>OLED</td><td>Organic light-emitting diode.</td></tr>
<tr><td>$P_{OPERATION}$
P_T</td><td>Normal mode Power consumption.</td></tr>
<tr><td>$P_{STANDBY}$</td><td>Standby mode Power consumption.</td></tr>
<tr><td>Q</td><td>Transistor, including FET and MOSFET.</td></tr>
</table>

Symbol	Description (Continued)
R	Resistor
$\overline{RD}_{8080}$ (E_{6800}) $\overline{RD}$ (E) E ($\overline{RD}$) E RDB	Host interface input. *8080 Host:* Active low. Signal on the databus is latched at the rising edge of $\overline{RD}$. *6800 Host (if available):* Enable control signal input active high. E = *High:* Read or Write operation is active. E = *Low:* No operation.
RH Rh	Relative Humidity.
RoHS	Restriction of Hazardous Substances Directive, an environmental standard.
$\overline{RST}$ $\overline{RES}$ RST# RES# RSTB RESET	Reset signal. *Low:* Display controller is reset. The $\overline{RST}$ pin should be pulsed low shortly after power is applied. *High:* The $\overline{RST}$ pin should be brought high for normal operation.
SCL SCK	Serial Clock signal.
SEG	Segment driver. Segment signal output for OLED display.
SENSE	Source current for external NMOS of booster circuit.
SI SDA MOSI	Serial data Input signal.
SW	Switch output drives the gate of the external NMOS of the booster circuit.
Ta TA	“Ambient temperature” is the temperature of the air that surrounds a component.
T_{OP}	Operating temperature.
T_{ST} T_{STG}	Storage Temperature.
V_{BREF}	Internal voltage reference for booster circuit. A decoupling capacitor, typically 1μF, should be connected to GND.
V_{COMH}	High level voltage output for common signals. A low ESR capacitor should be connected between this pin and GND. Do not connect external power supply directly to this pin.
V_{IH} V_{ICH}	High level input voltage.

Symbol	Description (Continued)
V_{IL} V_{LCH}	Low level input voltage.
V_{LOGIC}	Power supply input. Must be connected to an external source.
$V_{LOGIC\ I/O}$ V_{DD} V_{DD1} V_{CC} (if it has PCB) $V_{DD\ I/O}$ $V_{I/O}$ V_{CCIO}	Supply voltage for I/O signals.
V_{OH} V_{OHC}	High level output voltage.
V_{OL} V_{OLC}	Low level output voltage.
V_{PANEL} V_{PP} V_{CC} (if no PCB)	Driver supply voltage. Only high voltage input on chip. Power must be supplied externally. *Note: You must observe power sequencing for this signal.* *Power Up* – Display must be powered up and initialized before power is applied to the signal. *Power Down* – Power must be removed from this signal before the display is powered off. 

Symbol	Description (Continued)
V_{REF}	Voltage reference pin for pre-charge voltage in driving OLED device. Voltage should be set to match with the OLED driving voltage in current drive phase. It can either be supplied externally or by connecting to V_{PANEL}.
V_{SL}	Segment voltage reference pin. This pin should be left open.
$\overline{WR}_{8080}$ (#R/$\overline{W}_{6800}$) R/$\overline{W}$ ($\overline{WR}$) $\overline{WR}$ (R/$\overline{W}$) R/W# WRB	Host interface input. *8080 Host:* Active low. Signal on the databus is latched at the rising edge of $\overline{WR}$ signal. *#6800 Host (if available):* Read/Write control signal output. *R/$\overline{W}$* = High: Read (Host←Module) *R/$\overline{W}$* = Low: Write (Host→Module)