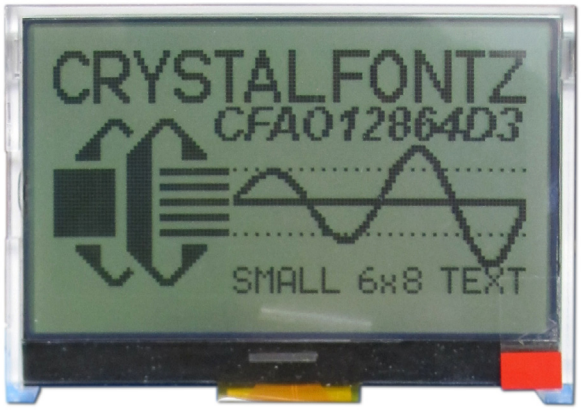
GRAPHIC DISPLAY MODULE DATA SHEET



CFAO12864D3-TFH shown above

Data Sheet Release Date 2015-08-19
for the CFAO12864D3 Series:
CFAO12864D3-TFH
CFAO12864D3-TMI

Crystalfontz America, Incorporated

12412 East Saltese Avenue
Spokane Valley, WA 99216-0357

Phone: 888-206-9720
Fax: 509-892-1203
Email: support@crystalfontz.com
URL: www.crystalfontz.com

Data Sheet Revision History

Data Sheet Release: 2015-08-19
Data Sheet for the new CFAO12864D3 series: *CFAO12864D3-TFH* and *CFAO12864D3-TMI*.

About Variations

We work continuously to improve our products. Because display technologies are quickly evolving, these products may have component or process changes. Slight variations (for example, contrast, color, or intensity) between lots are normal. If you need the highest consistency, whenever possible, order and arrange delivery for your production runs at one time so your displays will be from the same lot.

About Volatility

These display modules have volatile memory.

The Fine Print

Certain applications using Crystalfontz America, Inc. products may involve potential risks of death, personal injury, or severe property or environmental damage (“Critical Applications”). CRYSTALFONTZ AMERICA, INC. PRODUCTS ARE NOT DESIGNED, INTENDED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT APPLICATIONS, DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. Inclusion of Crystalfontz America, Inc. products in such applications is understood to be fully at the risk of the customer. In order to minimize risks associated with customer applications, adequate design and operating safeguards should be provided by the customer to minimize inherent or procedural hazard. Please contact us if you have any questions concerning potential risk applications.

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All specifications in Data Sheets and on our website are, to the best of our knowledge, accurate but not guaranteed. Corrections to specifications are made as any inaccuracies are discovered.

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CONTENTS

MAIN FEATURES ---- 5
Features ---- 5
Module Classification Information ---- 5
MECHANICAL SPECIFICATIONS ---- 6
Physical Characteristics ---- 6
Module Outline Drawing ---- 7
ELECTRICAL SPECIFICATIONS ---- 8
Driving Method ---- 8
Absolute Maximum Ratings ---- 9
DC Characteristics ---- 10
Details Interface Pin Functions ---- 11
ESD (Electro-Static Discharge) ---- 14
OPTICAL CHARACTERISTICS ---- 15
CFAO12864D3-TFH ---- 15
CFAO12864D3-TMI ---- 15
Test Conditions and Definitions for Optical Characteristics ---- 16
LED BACKLIGHT ---- 19
Additional Backlight Information ---- 19
PRODUCT RELIABILITY AND LONGEVITY ---- 22
Display Module Reliability Test Results ---- 22
Display Module Reliability ---- 22
Display Module Longevity (EOL / Replacement Policy) ---- 23
CARE AND HANDLING PRECAUTIONS ---- 23
APPENDIX A: QUALITY ASSURANCE STANDARDS ---- 26

LIST OF FIGURES

Figure 1. Module Outline Drawing - - - - 7
Figure 2. Definition Of Operation Voltage (V_{OP}) (Positive) - - - - 16
Figure 3. Definition Of Operation Voltage (V_{OP}) (Negative) - - - - 16
Figure 4. Definition Of Response Time (Tr, Tf) (Positive) - - - - 17
Figure 5. Definition Of Response Time (Tr, Tf) (Negative) - - - - 17
Figure 6. Definition Of Horizontal And Vertical Viewing Angles (CR>2) - - - - 18
Figure 7. 6:00 O'Clock And 12:00 O'Clock Viewing Angles - - - - 18
Figure 8. LED Backlight Connection Using Pin A And Pin K - - - - 20
Figure 9. Typical LED Backlight Connections For PWM Dimming - - - - 21
Figure 10. Example Of Minimum Plastic Bend Radius For FPC/FFC - - - - 24

MAIN FEATURES

FEATURES

- ❑ 128 x 64 module consists of an LCD panel, COG (Chip on Glass) controller, LED backlight, and an FFC/FPC flexible cable that mates with a ZIF connector.
- ❑ Overall module dimension without FFC is 80.00 (W) x 54.00 (H) x 6.50 (D) millimeters (3.150" (W) x 2.126" (H) x 0.256" (D)).
- ❑ Active Area dimensions are 66.52 (W) x 33.20 (H) millimeters.
- ❑ Host Interface: SPI and 8-bit (6800 or 8080) parallel interface.
- ❑ Variants are:
  - *CFAO12864D3-TFH:* White LED backlight with FSTN LCD. Displays dark (near-black) characters on light gray background. Transflective mode display is sunlight readable and also readable in dark areas.
  - *CFAO12864D3-TMI:* White LED backlight with blue STN LCD. Displays light (near-white) characters on blue background. Negative transmissive mode display is readable in dark areas and typical office lighting.
- ❑ For interface information and other details, see the Sitronix ST7565P 65 x 132 Dot Matrix LCD Controller/Driver datasheet on our website.
- ❑ Temperature range for operation is -20°C to +70°C.
- ❑ RoHS compliant.
- ❑ Crystalfontz is ISO certified.

MODULE CLASSIFICATION INFORMATION

CFA	O	128	64	D3	-	T	*	*
❶	❷	❸	❹	❺		❻	❼	❽

❶	Brand	CFA – Crystalfontz America, Incorporated
❷	Display Type	O – COG (Chip On Glass)
❸	Number of Pixels (Width)	128 Pixels
❹	Number of Pixels (Height)	64 Pixels
❺	Model Identifier	D3
❻	Backlight Type & Color	T – LED, white
❼	Fluid Type, Image (Positive or Negative), & LCD Glass Color	F – FSTN, positive M – STN, negative
❽	Polarizer Film Type & Viewing Angle (O 'Clock)	H – Transflective, 6:00 o'clock[1] I – Transmissive, 6:00 o'clock[1]

[1]*Note: For more information on Viewing Angle, see Definition of 6:00 O'clock and 12:00 O'clock Viewing Angles (Pg. 18).*

MECHANICAL SPECIFICATIONS

PHYSICAL CHARACTERISTICS

ITEM	SPECIFICATION
Pixels	
Number of Pixels	128 x 64 = 9,216 pixels
Pixel Size	0.480 (W) x 0.480 (H) mm
Pixel Pitch	0.520 (W) x 0.520 (H) mm
Active Area	
Active Area Width	Millimeters: 66.52 (W) Inches: 2.618" (W)
Active Area Height	Millimeters: 33.24 (H) mm Inches: 1.308" (H)
Viewing Area	Millimeters: 70.70 (W) x 38.80 (H) mm Inches: 2.783" (W) x 1.528" (H)
Display Module Outline Dimensions	
Overall Module Width and Height Without FFC/FPC Flexible Tail	Millimeters: 80.00 (W) x 54.00 (H) mm Inches: 3.150" (W) x 2.126" (H)
Module Depth	Millimeters: 6.50 (D) mm Inches: 0.256" (D)
Weight	40 grams
FFC/FPC Flexible Tail	>R.5.0 mm
Compatible ZIF sockets (34-pin 0.5 mm) are Digi-Key HFT134TR-ND and HFJ134TR-ND.	

MODULE OUTLINE DRAWING

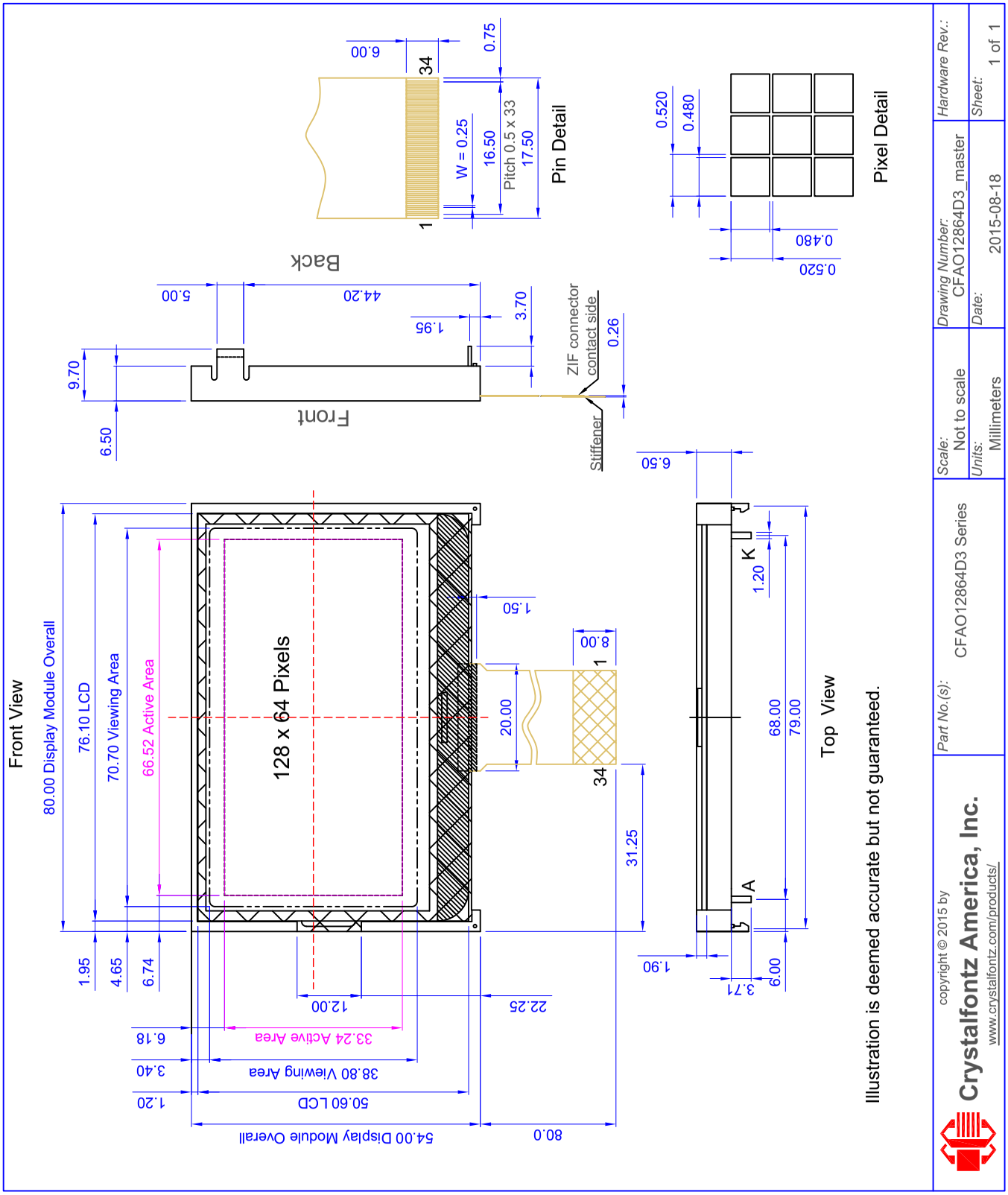


Figure 1. Module Outline Drawing

ELECTRICAL SPECIFICATIONS

DRIVING METHOD

DRIVING METHOD	SPECIFICATION
Duty[1]	1/64
Bias[2]	1/9

[1]The duty cycle, also known as duty ratio or multiplex rate, is the fraction of total frame time that each row of the LCD is addressed.

[2]The drive bias, also known as voltage margin, is related to the number of voltage levels used when driving the LCD. Bias is defined as 1/(number of voltage levels-1). The more segments driven by each driver(1), the higher number of voltage levels are required. There is a direct relationship between the bias and the duty.

ABSOLUTE MAXIMUM RATINGS

CAUTION

Ensure that you have proper current and voltage control for your backlight before connecting the backlight circuit.

ABSOLUTE MAXIMUM RATINGS	SYMBOL	MINIMUM	MAXIMUM
Operating Temperature	T_{OP}	-20°C	+70°C
Storage Temperature	T_{ST}	-30°C	+80°C
Humidity (Non-condensing)	RH	0%	90%
Input Voltage	V_I	-0.3v	+3.6v
Logic Supply Voltage	V_{LOGIC}	-0.3v	+3.6
Driver Supply Voltage	V_{PANEL}	-0.3v	+14.5

Caution

These are stress ratings only. Extended exposure to the absolute maximum ratings listed above may affect device reliability or cause permanent damage. Functional operation of the module at these conditions beyond those listed in DC Characteristics (Pg. 10) is not implied.

Changes in temperature can result in changes in contrast.

DC CHARACTERISTICS

	DC CHARACTERISTICS	TEST CONDITION	SYMBOL	MINIMUM	TYPICAL	MAXIMUM
	$V_{LOGIC} = V_{DD}$ GND = V_{SS}					
CONTROLLER AND BOARD	Supply Voltage for Logic	T_{OP} =-30°C to +70°C V_{LOGIC} - GND		+2.7v	+3.3v	+3.3v[1]
	Input High Voltage		V_{IH}	+0.8 * V_{LOGIC} V_{LOGIC} = +3.3v V_{IH} = +2.64v		V_{LOGIC}
	Input Low Voltage		V_{IL}	0 (GND)		+0.2 * V_{LOGIC} V_{LOGIC} = +3.3v V_{IL} = +0.66v
	Output High Voltage		V_{OH}	+0.8 * V_{LOGIC} V_{LOGIC} = +3.3v V_{OH} = +2.64v		V_{LOGIC}
	Output Low Voltage		V_{OL}	0 (GND)		+0.2 * V_{LOGIC} V_{LOGIC} = +3.3v V_{OL} = +0.66v
	Supply Current	Logic only, not including backlight V_{LOGIC} = +3.3v	I_{DD}		0.6 mA	1.0 mA
LCD GLASS	Supply voltage for driving LCD	T_A = -20ºC	V_{LOGIC} - V_O	+10.0v	+10.2v	+10.4v
		T_A = +25ºC		+9.8	+10.0v	+10.2v
		T_A = +70ºC		+9.6v	+9.8v	+10.0v

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

This is a summary of the module's major operating parameters. For detailed information see the Sitronix ST7565P 65 x 132 Dot Matrix LCD Controller/Driver datasheet on our website.

DETAILS INTERFACE PIN FUNCTIONS

PIN		SIGNAL	LEVEL	DIRECTION	DESCRIPTION
$V_{LOGIC} = V_{DD}$	GND = V_{SS}				
1		$\overline{CS}$	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.
2		$\overline{RST}$	L	I	Reset signal input. *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.
3		A0	H/L	I	*R/W = Low* *A0 = High:* Command Write *A0 = Low:* Data Write *R/W = High* *A0 = High:* Status Read *A0 = Low:* Data Read
4	6800 mode	R/$\overline{W}$	H/L		*6800 Host:* Read/Write control signal output. R/$\overline{W}$ = *High:* Read (Host←Module) R/$\overline{W}$ = *Low:* Write (Host→Module)
	8080 mode	$\overline{WR}$	H/L	I	1 = No operation 0 = Write
5	6800 mode	E	H, H→L	I	Read/write enable signal *High:* Read data is enabled by a high level. *High→Low:* Write data is latched on the falling edge.
	8080 mode	$\overline{RD}$	H/L	I	1 = No operation 0 = Read
6 - 13		DB0-DB7	H/L	I/O	Bidirectional databus connects to 8-bit standard host databus.

PIN		SIGNAL	LEVEL	DIRECTION	DESCRIPTION (Continued)
14		V_{LOGIC}	0v	–	Shared with the host power supply terminal V_{DD}. (+3.3v)
15		GND	0v	–	Ground. Must be connected to an external ground.
16		V_{OUT}			DC/DC voltage converter. Connect a capacitor between this terminal and GND.
17		CAP5+			DC/DC voltage converter. Connect a capacitor between this terminal and the CAP1- terminal.
18		CAP3+			DC/DC voltage converter. Connect a capacitor between this terminal and the CAP1- terminal
19		CAP1-			DC/DC voltage converter. Connect a capacitor between this terminal and the CAP1+ terminal.
20		CAP1+			DC/DC voltage converter. Connect a capacitor between this terminal and the CAP1- terminal.
21		CAP2+			DC/DC voltage converter. Connect a capacitor between this terminal and the CAP2- terminal.
22		CAP2-			DC/DC voltage converter. Connect a capacitor between this terminal and the CAP2+ terminal.
23		CAP4+			DC/DC voltage converter. Connect a capacitor between this terminal and the CAP2- terminal.
24		VRS		I	Externally-input VREG power supply for the LCD power supply voltage regulator.
25-29		V4-V0		O	This is a multi-level power supply for the LCD driver. The voltage supply applied is determined by the liquid crystal cell. It is changed through the use of a resistive voltage divided or through changing the impedance using an op-amp (operational amplifier). Voltage levels are determined based on GND and must maintain the relative magnitudes shown below. $V_{LCD} \geq V0 \geq V1 \geq V2 \geq V3 \geq V4 \geq GND$ When the power supply turns ON, the internal power supply circuits produce the V1 to V4 voltages shown below. The voltage settings are selected using the LCD bias set command

	1/65 DUTY	1/49 DUTY	1/33 DUTY	1/55 DUTY	1/53 DUTY
V1	8/9*V0,6/7*V0	7/8*V0,5/6*V0	5/6*V0,4/5*V0	7/8*V0,5/6*V0	7/8*V0,5/6*V0
V2	7/9*V0,5/7*V0	6/8*V0,4/6*V0	4/6*V0,3/5*V0	6/8*V0,4/6*V0	6/8*V0,4/6*V0
V3	2/9*V0,2/7*V0	2/8*V0,2/6*V0	2/6*V0,2/5*V0	2/8*V0,2/6*V0	2/8*V0,2/6*V0
V4	1/9*V0,1/7*V0	1/8*V0,1/6*V0	1/6*V0,1/5*V0	1/8*V0,1/6*V0	1/8*V0,1/6*V0

<table>
<tr><th colspan="2">PIN</th><th>SIGNAL</th><th>LEVEL</th><th>DIRECTION</th><th>DESCRIPTION (Continued)</th></tr>
<tr><td colspan="2">30</td><td>VR</td><td></td><td></td><td>Output voltage regulator terminal. Provides the voltage between V_{LOGIC} and V5 through a resistive voltage divider.

IRS = Low: V5 voltage regulator internal resistors are not used.

IRS = High: V5 voltage regulator internal resistors are used.</td></tr>
<tr><td colspan="2">31</td><td>C86</td><td></td><td>I</td><td>Host select.

C86 = High: 6800 host interface.

C86 = Low: 8080 host interface.
This pin must keep V_{LOGIC} for serial mode (default).</td></tr>
<tr><td colspan="2">32</td><td>P/S</td><td></td><td>I</td><td>Parallel/Serial select.

P/S = High: Parallel data input.
P/S = Low: Serial data input. (SPI)

The following applies depending on the P/S status:

<table>
<tr><th>P/S</th><th>Data/Command</th><th>Data</th><th>Read/Write</th><th>Serial Clock</th></tr>
<tr><td>“H”</td><td>A0</td><td>D0 to D7</td><td>/RD, /WR</td><td>X</td></tr>
<tr><td>“L”</td><td>A0</td><td>SI (D7)</td><td>Write only</td><td>SCL (D6)</td></tr>
</table>

When P/S = low, D0 to D5 may be high, low, or open.
$\overline{RD}$ (E) and $\overline{WR}$ (R/$\overline{W}$) are fixed to either “H” or “L”.
With serial data input, It is impossible read data from RAM.</td></tr>
<tr><td colspan="2">33</td><td>$\overline{HPM}$</td><td></td><td></td><td>Power control terminal for the power supply circuit for liquid crystal drive.

$\overline{HPM}$ = High: Normal mode

$\overline{HPM}$ = Low: High power mode</td></tr>
<tr><td colspan="2">34</td><td>IRS</td><td></td><td>I</td><td>This terminal selects the resistors for the V5 voltage level adjustment.

IRS = High: Use the internal resistors.

IRS = Low: Do not use the internal resistors. The V5 voltage level is regulated by an external resistive voltage divider attached to the VR terminal</td></tr>
<tr><td colspan="6">For backlight connections, please see LED BACKLIGHT (Pg. 19).</td></tr>
</table>

ESD (ELECTRO-STATIC DISCHARGE)

The circuitry is industry standard CMOS logic and susceptible to ESD damage. Please use industry standard anti-static 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 CHARACTERISTICS

CFAO12864D3-TFH

ITEM	SYMBOL	TEST CONDITION	MINIMUM	TYPICAL	MAXIMUM
View Angle (Vertical, Horizontal)	(V)θ	CR≥2	30°		60°
	(H)φ	CR≥2	-45°		45°
Contrast Ratio	CR			5	
LCD Response Time*	T rise	Ta = 25°C		200 ms	300 ms
	T fall	Ta = 25°C		250 ms	350 ms
**Response Time: The amount of time it takes a liquid crystal cell to go from active to inactive or back again.*					

CFAO12864D3-TMI

ITEM	SYMBOL	TEST CONDITION	MINIMUM	TYPICAL	MAXIMUM
View Angle (Vertical, Horizontal)	(V)θ	CR≥2 θ = φ - 180°			20°
	(H)φ	CR≥2 θ = φ - 0°			40°
	(V)θ	CR≥2 θ = φ - 90°			30°
	(H)φ	CR≥2 θ = φ - 270°	-		30°
Contrast Ratio	CR			3	
LCD Response Time*	T rise	Ta = 25°C		150 ms	200 ms
	T fall	Ta = 25°C		150 ms	200 ms
**Response Time: The amount of time it takes a liquid crystal cell to go from active to inactive or back again.*					

TEST CONDITIONS AND DEFINITIONS FOR OPTICAL CHARACTERISTICS

Test Conditions

- Operating Voltage (V_{LCD}): V_{OP}
- Viewing Angle
  - Vertical (V)θ: 0°
  - Horizontal (H)φ): 0°
- Frame Frequency: 64 Hz (nominal)
- Driving Waveform: 1/64 Duty, 1/9 Bias
- Ambient Temperature (Ta): 25°C

CFAO12864D3-TFH – Definition of Operation Voltage (V_{op}) (Positive)

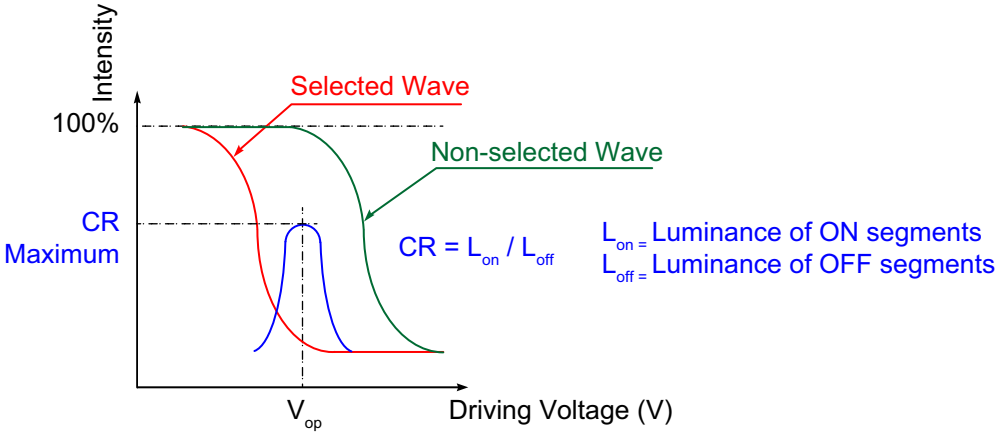


Figure 2. Definition Of Operation Voltage (V_{OP}) (Positive)

CFAO12864D3-TMI – Definition of Operation Voltage (V_{op}) (Negative)

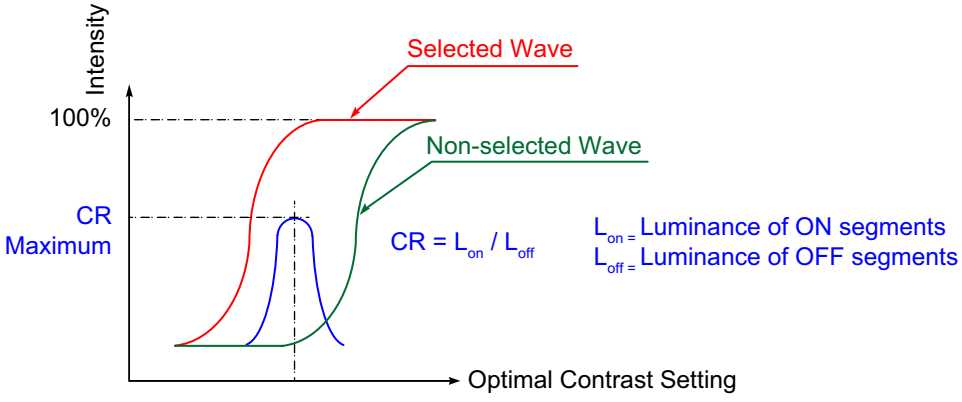


Figure 3. Definition Of Operation Voltage (V_{OP}) (Negative)

CFAO12864D3-TFH – Definition of Response Time (Tr, Tf) (Positive)

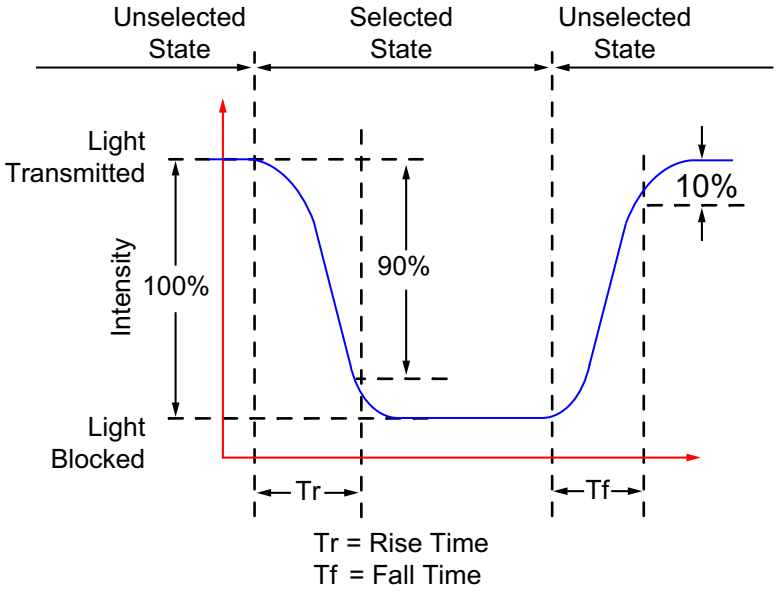


Figure 4. Definition Of Response Time (Tr, Tf) (Positive)

CFAO12864D3-TMI – Definition of Response Time (Tr, Tf) (Negative)

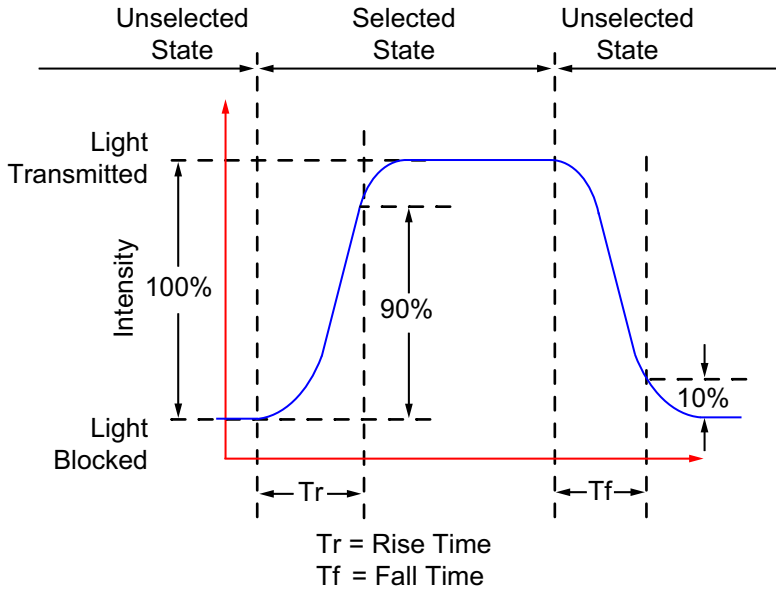


Figure 5. Definition Of Response Time (Tr, Tf) (Negative)

Definition of Horizontal and Vertical Viewing Angles (CR>2)

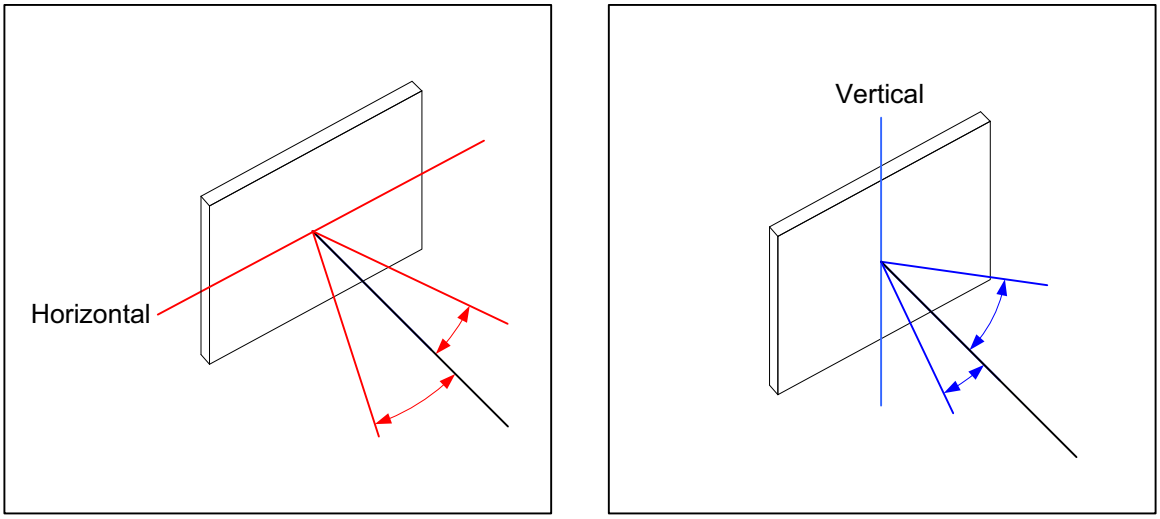


Figure 6. Definition Of Horizontal And Vertical Viewing Angles (CR>2)

Definition of 6:00 O'clock and 12:00 O'clock Viewing Angles

These display modules have a 6:00 o'clock viewing angle.

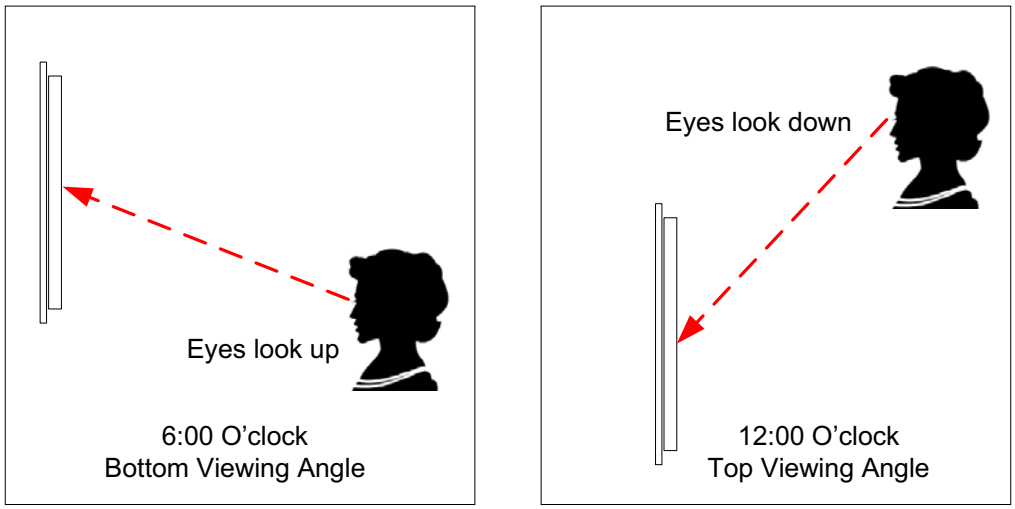


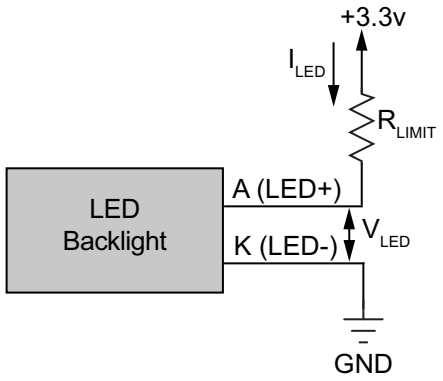
Figure 7. 6:00 O'Clock And 12:00 O'Clock Viewing Angles

LED BACKLIGHT

LED Backlight Characteristics					
ITEM	**SYMBOL**	**TEST CONDITION**	**MINIMUM**	**TYPICAL**	**MAXIMUM**
Forward Current	I_{LED}	V = +3.5v	87 mA	96 mA	120 mA*
**Driving the backlight above 144 mA will shorten its lifetime.*					
Forward Voltage	V_{LED}		+3.4v	+3.5v	+3.6v
Reverse Voltage ($V_{R)}$	V_R				+5v
Luminous Intensity*	IV	I_{LED} = 96mA	TBD	TBD	TBD
**Direct measurement of backlight. The backlight is not measured through the LCD.*					

ADDITIONAL BACKLIGHT INFORMATION

Typical Backlight Connection Always On



The backlight on these display modules use LEDs. The backlight is easy to use properly but it is also easily damaged.

Note
Do not connect +5v directly to the backlight terminals. This will ruin the backlight.

> Note
>
> We recommend that the white LED backlight be dimmed or turned off during periods of inactivity to conserve the LEDs' lifetime.

LEDs are "current" devices. The brightness is controlled by the current flowing through it, not the voltage across it. Ideally, a current source would be used to drive the LEDs. In practice, a simple current limiting resistor will work well in most applications and is much less complex than a current source.

How to Calculate the R_{Limit}

You need to know what the supply (forward) voltage of the LEDs will be so you can calculate a current limiting resistor (R_{LIMIT}). The forward voltage will vary slightly from display to display.

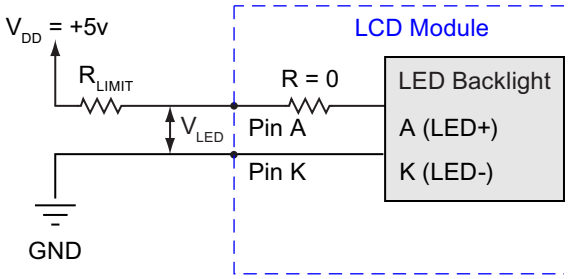


Figure 8. LED Backlight Connection Using Pin A And Pin K

The general equation to calculate R_{LIMIT} is:

$$R_{LIMIT}\text{ (minimum)} = \frac{V_{LOGIC}\text{ (supply voltage) - }V_{LED}\text{ (LED forward voltage)}}{I_{LED}\text{ (Typical LED Forward Current)}}$$

The specific R_{LIMIT} calculation for the CFAO12864D3 at V_{LOGIC} = +5v is:

$$R_{LIMIT} = \frac{5v - 3.5v}{0.096\ A} = 15.63\Omega\text{ (minimum)}$$

PWM Dimming

The backlight may be dimmed by PWM (Pulse Width Modulation). The typical range for the PWM frequency is from 100 to 300 Hz.

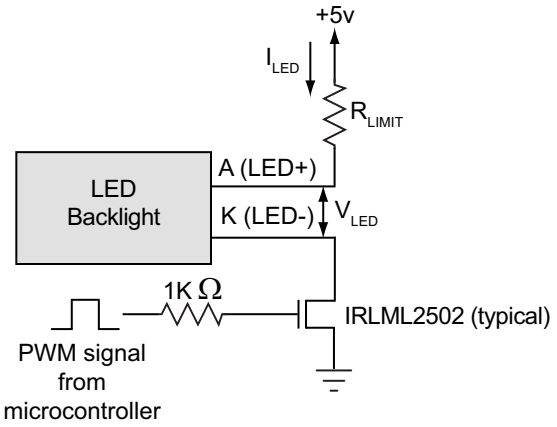


Figure 9. Typical LED Backlight Connections For PWM Dimming

PRODUCT RELIABILITY AND LONGEVITY

DISPLAY MODULE RELIABILITY TEST RESULTS

RELIABILITY TEST RESULTS	
TEST	**CONDITION**
High Temperature Operations	70°C, 200 Hours
Low Temperature Operations	-20°C, 200 Hours
Thermal Humidity	60°C, 90% RH, 96 Hours
Temperature Cycle On/Off	-20°C, 70°C, On/Off, 20 Cycles On cycle: >10 seconds Off cycle: <10 seconds
High Temperature Storage	80°C, 200 Hours
Low Temperature Storage	-30°C, 200 Hours
ESD	150pF, 330Ω, ±6KV(Contact)/± 8KV(Air), 5 points/panel, 10 times/point
Thermal Shock Resistance	See test description.

One test cycle is:

1. Test Low for 30 minutes.
2. Normal temperature for 5 minutes.
3. Test High for 30 minutes.
4. Normal temperature for 5 minutes.
5. Take out and dry at Normal temperature and allow to stand for 24 hours.

Repeat these steps for a total of 5 cycles.

DISPLAY MODULE RELIABILITY

ITEM	SPECIFICATION	
Module, excluding backlight.	50,000 to 100,000 hours (typical)	
White LED Backlight (I_{LED} <96 mA)	***Power-On Hours***	***% of Initial Brightness***
	<10,000	>70%
	<50,000	>50%
Under operating and storage temperature specification limitations, humidity (non-condensing) RH up to 60%, and no exposure to direct sunlight.Values listed above are approximate and represent typical lifetime.		

We list the lifetime of white LEDs at 10,000 hours to emphasize that white LEDs do not have the extremely long lifetime typical of red, yellow-green, or blue LEDs. The white LEDs dim over time, especially if driven with high currents. The

dimming may not be noticeable when a single display is installed. However, if a new display is installed next to a display that has been on continuously for a very long time, you will see the difference. To preserve the lifetime of white LEDs, we recommend that white LED backlights are dimmed or turned off when not needed. Also, please do not use more current than you need to achieve your brightness requirements.

DISPLAY MODULE LONGEVITY (EOL / REPLACEMENT POLICY)

Crystalfontz is committed to making all of our LCD modules available for as long as possible. For each module we introduce, we intend to offer it indefinitely. We do not pre-plan 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 it replaces. 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:

- *LCD fluid, polarizers, or the LCD manufacturing process.* These items may change the appearance of the display, requiring an adjustment to V_O.
- *Backlight LEDs.* Brightness may be affected (perhaps the new LEDs have better efficiency) or the current they draw may change (new LEDs may have a different VF).
- *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 web page as soon as possible. If interested, you can subscribe to future part change notifications.

CARE AND HANDLING PRECAUTIONS

For optimum operation of the display module and to prolong its life, please follow the precautions below.

Excessive voltage will shorten the life of the display module. You must drive the display module within the specified voltage limit. See Absolute Maximum Ratings (Pg. 9).

HANDLING CAUTION FOR DISPLAY MODULES SHIPPED IN TRAYS

If you receive display modules packed in trays, handle trays carefully by supporting the entire tray. Trays were made to immobilize the display modules inside their packing carton. Trays are not designed to be rigid. Do not carry trays by their edges; trays and display modules may be damaged.

ESD (ELECTRO-STATIC DISCHARGE)

The circuitry is industry standard CMOS logic and is susceptible to ESD damage. Please use industry standard anti-static 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 micro-controller/driver maintains its internal operating modes until something happens to change it. Excessive external noise can change these internal modes. In your packaging and system design, suppress or prevent the noise from influencing the controller. Also, refresh the operating modes periodically to prevent the effects of unanticipated noise.
- 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 display 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 display 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 display 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 display module.
- Do not reverse polarity to the power supply connections. Reversing polarity will immediately ruin the display module.
- Use care to keep the exposed terminals clean.
- Repeated sharp bends can damage the FPC/FFC tail. (FPC = Flexible Printed Circuit, FFC = Flat Flex Cable) As long as the FPC/FFC bend stays within the FPC/FFC elastic region, it can be bent multiple times. To tell if a bend is completely elastic, the FPC/FFC will return 100% to its pre-bent state. Typically this is around a 5mm radius, or 10mm from side-to-side for a 180° bend. You may bend the FPC/FFC more sharply. For instance, to pass the tail through a slot in a PCB. However these sharper bends will force the FPC/FFC into its plastic region, where it will not return to its pre-bent state on its own. The key is to make sharper bends only once and leave them. Repeatedly bending and unbending the FPC/FFC through its plastic region will cause it to fatigue and eventually fail.

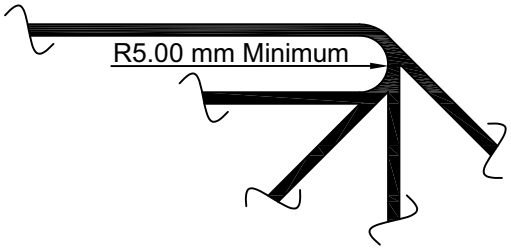


Figure 10. Example Of Minimum Plastic Bend Radius For FPC/FFC

AVOID SHOCK, IMPACT, TORQUE, OR TENSION

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

IF LCD PANEL BREAKS

All electronics may contain harmful substances. Avoid contamination by using care to avoid damage during handling. If any residues, gases, powders, liquids, or broken fragments come in contact with your skin, eyes, mouth, or lungs, immediately contact your local poison control or emergency medical center.

HOW TO CLEAN

1. Turn display module off.
2. 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”).
3. If the polarizer is dusty, you may carefully blow it off with clean, dry, oil-free compressed air.
4. If you must clean with a liquid, never use glass cleaners, as they may contain ammonia or alcohol that will damage the polarizer over time. Never apply liquids directly on the polarizer. Long contact with moisture may permanently spot or stain the polarizer. Use filtered water to slightly moisten a clean lint-free microfiber cloth designed for cleaning optics. (For example, use a cloth sold for cleaning plastic eyeglasses.)
5. The plastic is easily scratched or damaged. Use a light touch as you clean the polarizer. Wipe gently.
6. Use a dry microfiber cloth to remove any trace of moisture before turning on the display.
7. Gently wash the microfiber cloths in warm, soapy water and air dry before reuse.

OPERATION

- We do not recommend connecting display module to a PC's parallel port as an end product. These display modules are not “user friendly” and connecting it to a PC's parallel port is often difficult, frustrating, and can result in a “dead” display module 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 display module from ESD and power supply transients.
- Observe the operating temperature limitations: a minimum of -20°C to a maximum of +70°C non-condensing with minimal fluctuation. Operation outside of these limits may shorten life and/or harm the display module. Changes in temperature can result in changes in contrast.
  - At lower temperatures of this range, response time is delayed.
  - At higher temperatures of this range, display becomes dark. (You may need to adjust the contrast.)
- 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 strong ultraviolet radiation.
- 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 display modules while they are in storage.
- Please recycle your outdated Crystalfontz display modules at an approved facility.

APPENDIX A: QUALITY ASSURANCE STANDARDS

INSPECTION CONDITIONS

- Environment
  - Temperature: 25±5°C
  - Humidity: 30~85% RH (non-condensing)
- 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 LCD modules as accurately as possible. For the photos, we adjust the backlight (if any) and contrast 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.

ACCEPTANCE SAMPLING

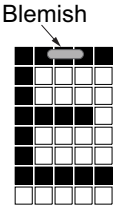
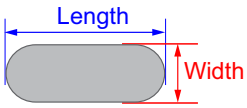
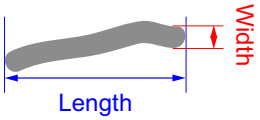
DEFECT TYPE	AQL*
Major	≤.65%
Minor	<1.0%
* Acceptable Quality Level: maximum allowable error rate or variation from standard	

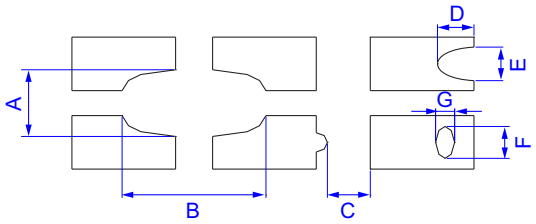
DEFECTS CLASSIFICATION

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	ACCEPTANCE STANDARDS 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	Contrast adjustment defect	Contrast adjustment fails or malfunctions.			Major
4	Blemishes or foreign matter on display segments		*Defect Size*	*Acceptable Qty*	Minor
			≤0.30 mm	3	
			≤2 defects within 10 mm of each other		
5	Blemishes or foreign matter outside of display segments	Defect Size = (Width + Length)/2 	*Defect Size*	*Acceptable Qty*	Minor
			≤0.15 mm	Ignore	
			0.15 to 0.20 mm	3	
			0.20 to 0.25 mm	2	
			> 0.30 mm	1	
6	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	
7	Bubbles between polarizer film and glass		*Defect Size*	*Acceptable Qty*	Minor
			≤0.20 mm	Ignore	
			0.20 to 0.40 mm	3	
			0.40 to 0.60 mm	2	
			≥0.60 mm	0	

<table>
<tr><th>#</th><th>DEFECT TYPE</th><th>ACCEPTANCE STANDARDS CRITERIA (Continued)</th><th>MAJOR / MINOR</th></tr>
<tr><td>8</td><td>Display pattern defect</td><td> 

<table>
<tr><th>Dot 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>9</td><td>Backlight defects</td><td>1. Light fails or flickers.*
2. Color and luminance do not correspond to specifications.*
3. Exceeds standards for display’s blemishes, foreign matter, dark lines or scratches.
*Minor if display functions correctly. Major if the display fails.</td><td>Minor</td></tr>
<tr><td>10</td><td>PCB defects (if module has PCB)</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>11</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. Solder balls.
*Minor if display functions correctly. Major if the display fails.</td><td>Minor</td></tr>
</table>