GRAPHIC TFT MODULE DATA SHEET

Data Sheet Release 2015-05-07
for
CFAF128128B-0145T

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

CFAF128128B-0145T Data Sheet Revision History

Data Sheet Release: 2015-05-07

- Wherever listed, corrected controller part number corrected from *Sitronix ST7735* to *Sitronix ST7735S*. Replaced hyperlink for the list of controller data sheets on our website with a more direct hyperlink to the Sitronix ST7735S controller data sheet.
- In Physical Characteristic (Pg. 7), added statement that Crystalfontz America, Incorporated is ISO certified.
- In Physical Characteristic (Pg. 7) and Module Outline Drawing (Pg. 8), added depth specification to distinguish between *including* the molded plastic alignment pin (2.8 mm) or *excluding* the molded plastic alignment pin (2.3 mm) that is on the back of the display. The display depth has not changed.
- In Recommended DC Characteristics (3.0v Operation) (Pg. 11),
  - Changed Digital Logic Supply and Input/Output Supply from Minimum +3.0v to +2.5v and Maximum from +3.6v to +.3.7v.
  - Expanded specifications to include Output High/Low Voltages.
  - Added Current Consumption specification.
  - Corrected Power Consumption from 8 mA (V_{LOGIC} = 2.8v) to 6.6 mW (V_{LOGIC} = 3.3v).
- Changed backlight current specification in LED Backlight Characteristics (Pg. 16) from 8 mA to 12 mA and changed Luminous Intensity from 166 cd/m^2 to 250 cd/m^2.
- In Display Module Reliability (Pg. 39), lifetime specification was changed. Product has not changed.
- Added LCD Duty And Bias (Pg. 18) specifications.
- Corrected backlight current specification in Module Longevity (EOL/Replacement Policy) (Pg. 18) from 20 mA to 12 mA.

Data Sheet Release: 2014-11-11

- In Physical Characteristics, rounded up weight of “4.8” to “5.0” grams.
- The Module Outline Drawing was improved.
- Instead of appending the controller data sheet, a link was added to our list of controller data sheet downloads.

Data Sheet Release: 2014-05-07
Shipments of the module described in this Data Sheet began the third week of March 2014.

Data Sheet Preliminary Release: 2013-08-16
This Data Sheet was for a limited quantity first time production run of this product. See Product Update Notice.

About Volatility

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 Variations

The display module has 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.

Crystalfontz America, Inc. assumes no liability for applications assistance, customer product design, software performance, or infringements of patents or services described herein. Nor does Crystalfontz America, Inc. warrant or represent that any license, either express or implied, is granted under any patent right, copyright, or other intellectual property right of Crystalfontz America, Inc. covering or relating to any combination, machine, or process in which our products or services might be or are used.

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.

Company and product names mentioned in this publication are trademarks or registered trademarks of their respective owners.

Copyright © 2015 by Crystalfontz America, Inc., 12412 East Saltese Avenue, Spokane Valley, WA 99216-0357 U.S.A

CONTENTS

LIST OF FIGURES

MAIN FEATURES

- This display module has a full color active matrix TFT (Thin Film Transistor) liquid crystal display (LCD) that uses amorphous silicon TFT as a switching device.
- Full-color (262K) 128xRGBx128 display module consists of a TFT panel, integrated controller/driver, an FPC (Flexible Printed Circuit) tail, and a white LED backlight.
- Module dimensions
  - Active Area
    - Diagonal is 36.78 millimeters
      Inches = 1.45"
    - Active area width and height is 25.50 (W) x 26.50 (H) millimeters.
      Inches = 1.00" (W) x 1.04" (H).
  - Overall module width and height:
    - With FPC *unfolded* is 33.30 (W) x 76.35 (H) mm
      Inches = 1.31" (W) x 3.00" (H)
    - With FPC *folded*, the height is approximately 39.20 mm (H).
      Inches = 1.54" (H).
  - Overall module depth:
    - Depth *excluding* the molded plastic alignment pin on the back of display is 2.30 (D) mm.
      Inches = 0.09" (D).
    - Depth *including* the molded plastic alignment pin on the back of display is 2.80 (D) mm.
      Inches = 0.11" (D).
- This display module has an integrated Sitronix ST7735SS 262K Color Single-Chip TFT Controller/Driver or compatible controller/driver. For interface information and other details, see the Sitronix ST7735S data sheet on our website.
- Requires only a single source 3.3v for both power supply and logic.
- Interface 3-wire 9-bit or 4-wire 8-bit SPI interface to host.
- To get you started, free downloadable sample code is under the DATASHEETS & FILES tab on the display module's website page.
- Transmissive display with one white LED for the backlight. The white LED backlight has anode (A,+) and cathode (K -) pins brought out on the FPC/FFC Cable (FPC = Flexible Printed Circuit, FFC = Flat Flex Cable).
- The 10-pin FPC mates with standard 0.5 mm ZIF socket such as SFV10R-2STE1HLF sold by Digi-Key.
- 12:00 o'clock viewing angle (polarizer viewing direction). Use in portrait or landscape orientation.
- Temperature operation is from -10°C to +60°C.
- RoHS compliant.
- Crystalfontz America is ISO certified.

EXPLANATION OF PART NUMBER CODES IN THIS DATA SHEET

CFA	F	128	128	B	-	0145	T
❶	❷	❸	❹	❺		❻	❼

❶	**Brand**	Crystalfontz America, Inc.
❷	**Display Type**	F – TFT
❸	**Number of Pixels (Width)**	128 pixels
❹	**Number of Pixels (Height)**	128 pixels
❺	**Model Identifier**	B
❻	**Diagonal Dimension**	0145 – 1.45-inch diagonal
❼	**Backlight Type & Color**	T – white LED backlight

MECHANICAL SPECIFICATIONS

PHYSICAL CHARACTERISTIC

ITEM	SPECIFICATION
Number of Pixels	128 x RGB x 128 pixels
Pixel Pitch	0.199 (W) x 0.207 (H) mm
Active Area	
Active Area Diagonal	Millimeters: 36.78 mm Inches: 1.45"
Active Area Width and Height	Millimeters: 25.50 (W) x 26.50 (H) mm Inches: 1.00" (W) x 1.04" (H)
Module Outline Dimensions	
Overall Module Width and Height with FPC unfolded*	Millimeters: 33.30 (W) x 76.35 (H) mm Inches: 1.31" (W) x 3.00" (H)
Overall Module Height with FPC folded	Millimeters: 33.30 (W) x 39.20 (H) mm Inches: 1.31" (W) x 1.54" (H)
Module Depth without alignment tab	Millimeters: 2.30 (D) mm. Inches = 0.09" (D).
Module Depth including alignment tab	Millimeters: 2.80 (D) mm. Inches = 0.11" (D).
Weight	5 grams

MODULE OUTLINE DRAWING

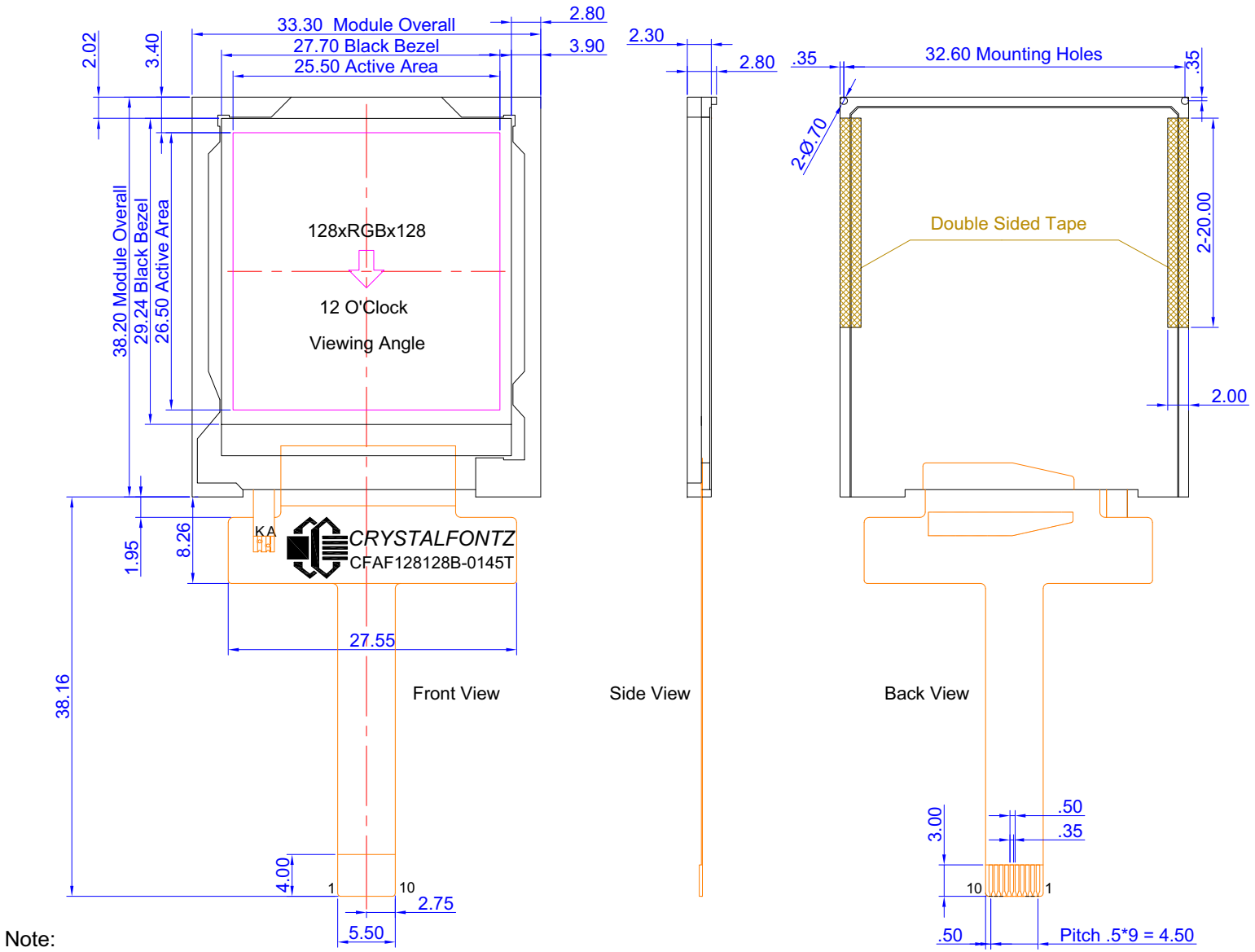


Figure 1. Module Outline Drawing

Note:

1. FFC/FPC flexible tail: dimensions may vary.
2. Diagonal = 1.45"

copyright © 2015 by

Crystalfontz America, Inc.

www.crystalfontz.com/products/

Part No.(s):	Scale:	Drawing Number:	Hardware Rev.:
CFAF128128B-0145T	Not to scale	CFAF128128B-0145T	
	Units: Millimeters	Date: 2015-05-04	Sheet: 1 of 1

ELECTRICAL SPECIFICATIONS

SYSTEM BLOCK DIAGRAM

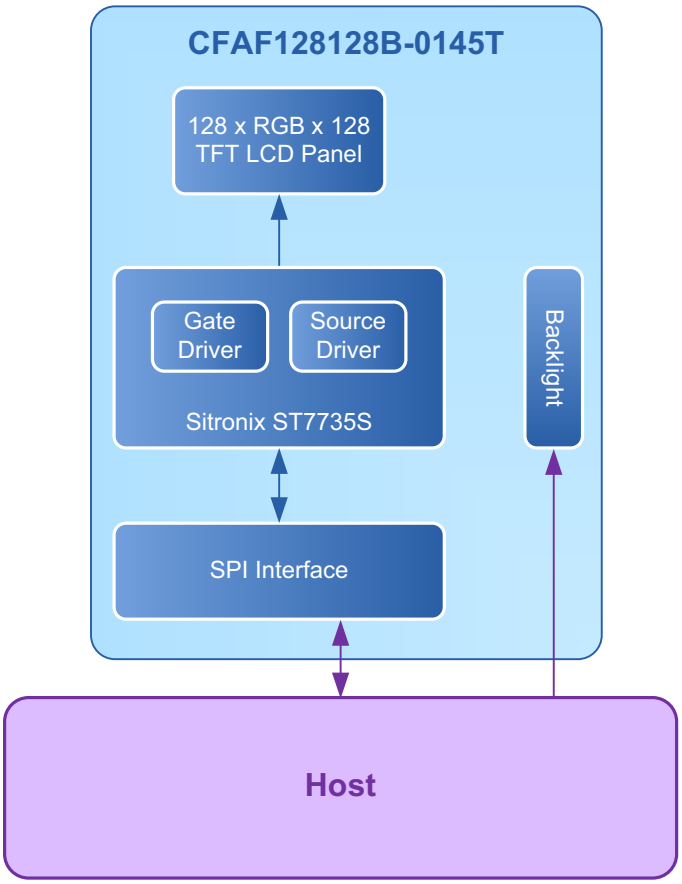


Figure 2. System Block Diagram

LCD DUTY AND BIAS

DRIVING METHOD	SPECIFICATION
Duty[1]	1/128
Bias[2]	1/12

[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

Ambient Temperature (Ta) = 25°C			
Absolute Maximum Ratings	**Symbol**	**Minimum**	**Maximum**
Digital Logic Supply and Input/Output Supply	$V_{LOGIC\ I/O}$	-0.3v	+4.6
Operating Temperature	T_{OP}	-10°C	+60°C
Storage Temperature	T_{ST}	-20°C	+60°C
Humidity	RH	0%	90%

Caution
These are stress ratings only. Functional operation of the module at these or any other conditions beyond those listed under Recommended DC Characteristics (3.0v Operation) (Pg. 11) *is not implied.*

Extended exposure to the absolute maximum ratings listed above may affect device reliability. Stresses beyond those listed above can cause permanent damage.

RECOMMENDED DC CHARACTERISTICS (3.0V OPERATION)

This is a summary of the display module's major operating parameters. For detailed information see the see the controller Sitronix ST7735S data sheet on our website. on our website.

Recommended DC CHARACTERISTICS	SYMBOL	MINIMUM	TYPICAL	MAXIMUM
Digital Logic Supply and Input/Output Supply	$V_{LOGIC\ I/O}$	+2.5v	+3.3v	+3.7v
Input High Voltage	V_{IH}	+0.7v * $V_{LOGIC\ I/O}$ for $V_{LOGIC\ I/O}$ = +3.3v V_{IH} = +0.7v * +3.3v = **+2.31v**	—	V_{LOGIC}
Input Low Voltage	V_{IL}	0v (GND)	—	+0.3v * $V_{LOGIC\ I/O}$ for $V_{LOGIC\ I/O}$ = +3.3v V_{IL} = +0.3v * +3.3v = **0.99v**
Output High Voltage (at 1mA)	V_{OH}	+0.8v * $V_{LOGIC\ I/O}$ for $V_{LOGIC\ I/O}$ = +3.3v V_{OH}= +0.8v * +3.3v = **+2.64v**	—	V_{LOGIC}
Output Low Voltage (at 1mA)	V_{OL}	0v (GND)	—	+0.2v * $V_{LOGIC\ I/O}$ for $V_{LOGIC\ I/O}$ = +3.3v V_{OL} = +0.2v * +3.3v = **0.66v**
Current Consumption (controller only, no backlight)		—	2 mA	—
Power Consumption ($V_{LOGIC\ I/O}$ = 3.3v, controller only, no backlight)		—	6.6 mW	—

DETAILS OF INTERFACE PIN FUNCTION

PIN	SIGNAL	DESCRIPTION
1	A (LED +)	Common supply pin for LEDs. “A” (anode) or “+” of LED backlight.
2	K (LED -)	Individual supply pins for LED. “K” (cathode or kathode for German and original Greek spelling) or “-” of LED backlight.
3	SPI3W/SPI4W	**SPI3W/SPI4W** 0 – 3-wire SPI enable (default) 1 – 4-wire SPI enable
4	$V_{LOGIC\ I/O}$	Digital Logic Supply and Input/Output Supply (3.0-3.6v)
5	GND	Ground. Must be connected to an external ground.
6	$\overline{CS}$	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.
7	$\overline{RST}$	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 ($V_{LOGIC\ I/O}$) for normal operation.
8	SDA	Serial data input
9	SCL	The signal for command or data select under parallel mode (not serial interface): *Low*: Command. *High*: Data. When under *serial* interface, it serves as SCL.
10	D/$\overline{C}$	For 4-wire data/command control. Determines whether data bits are data or command. 1 – *High*: Addresses the data register. 0 – *Low*: Addresses the command register. If not used, connect to $V_{LOGIC\ I/O}$.
For backlight connections, please refer to LED Backlight Characteristics (Pg. 16).		

ESD (ELECTRO-STATIC DISCHARGE)

The circuitry is industry standard CMOS logic and is 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

Ambient Temperature (Ta) = 25°C Measured in a dark room.			
ITEM	**SYMBOL**	**ADDITIONAL TEST CONDITIONS**	**TYPICAL**
Color Depth	262K		
Contrast Ratio (CR)[1]		θ = φ - 0°	350
TFT Response Time[2]	Tr		25 ms
	Tf		25 ms
Viewing Angle, Horizontal	θ_{X+}	Center CR≥10	45 degrees
	θ_{X-}		45 degrees
Viewing Angle, Vertical	θ_{Y+}		35 degrees
	θ_{Y-}		15 degrees
Viewing Direction	>12:00		

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

[2] *Response Time: The amount of time it takes a pixel to change from active to inactive or back again.Tr = T rise, Tf = T fall.*

Ambient Temperature (Ta) = 25°C Measured in a dark room.				
CHROMATICITY	**SYMBOL**	**MINIMUM**	**TYPICAL**	**MAXIMUM**
Red Chromaticity	Rx	0.548	0.608	0.668
	Ry	0.256	0.316	0.376
Green Chromaticity	Gx	0.245	0.305	0.365
	Gy	0.496	0.556	0.616
Blue Chromaticity	Bx	0.075	0.135	0.195
	By	0.077	0.137	0.197
White Chromaticity	Wx	0.245	0.305	0.365
	Wy	0.274	0.334	0.394

Definition of Response Time (Tr, Tf)

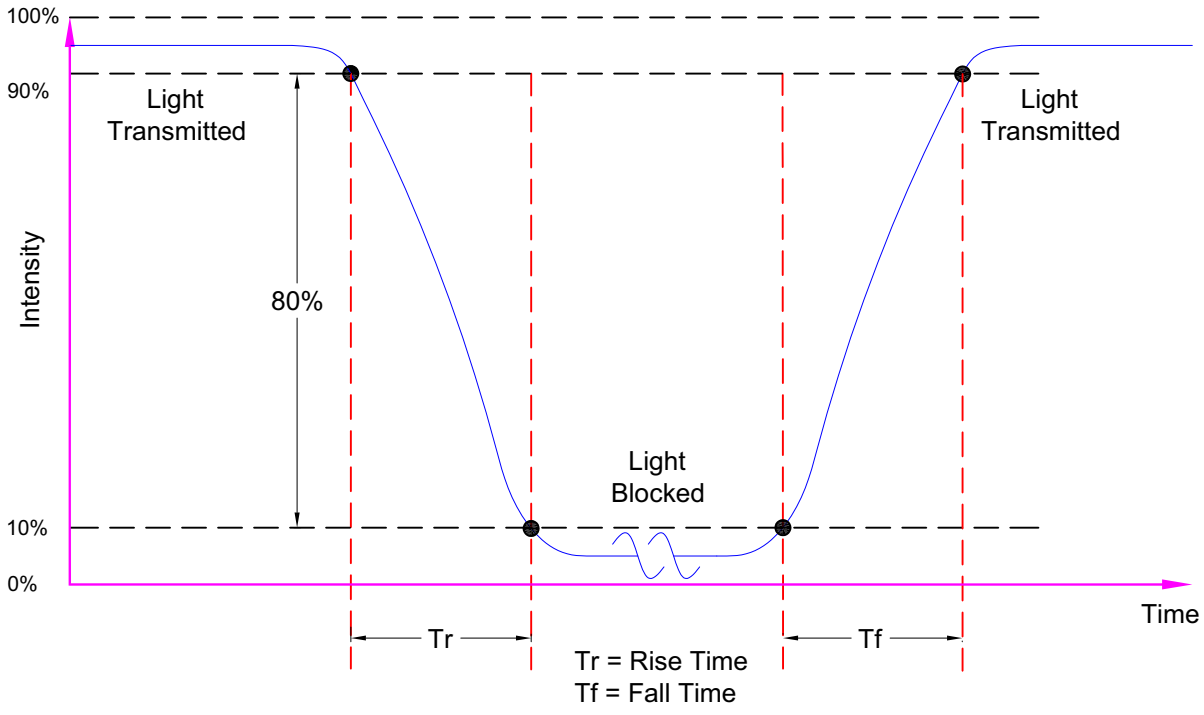


Figure 3. Definition of Response Time (Tr, Tf)

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

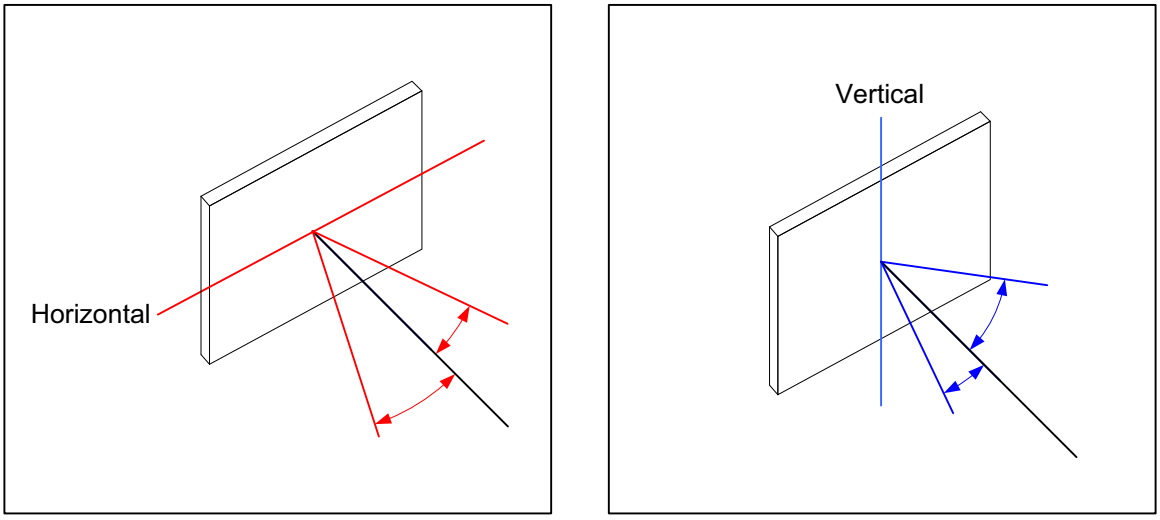


Figure 4. Definition of Horizontal and Vertical Viewing Angles (CR>2)

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

This module has a 12:00 o'clock viewing angle

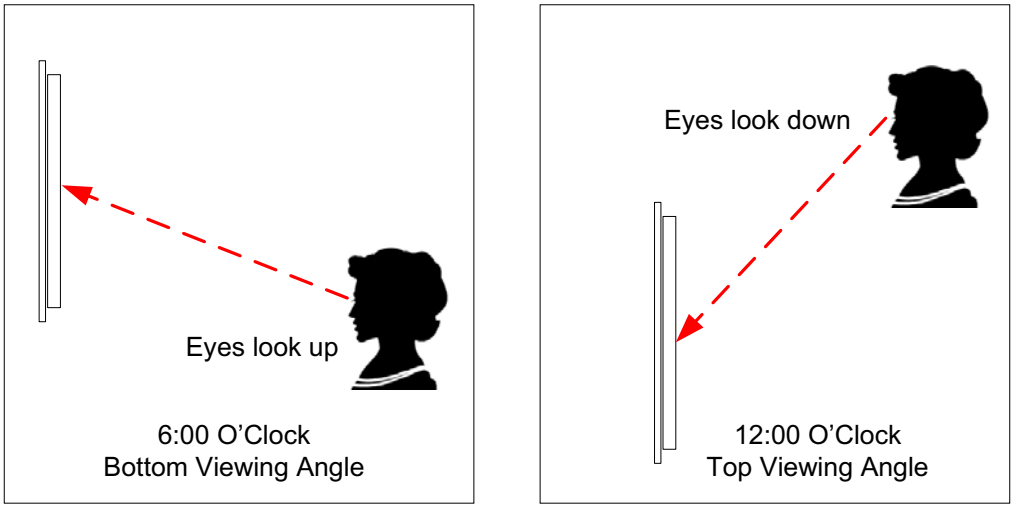


Figure 5. Definition of 6:00 O'Clock and 12:00 O'clock Viewing Angles

LED BACKLIGHT CHARACTERISTICS

LED Backlight Characteristics Edge-lit with 1 LED *Ambient temperature: Ta = 25°C*	
PARAMETER	**TYPICAL**
Forward Current (I_{LED})* (V_{LED} ≈ 3.2v)	12 mA*
**Driving the backlight above 12 mA may shorten its lifetime.*	
Forward Voltage (V_{LED})	+3.2v
Luminous Intensity* (I_V) I_{LED} = 12 mA	250 cd/m^2
Uniformity (minimum/maximum x 100%) I_{LED} = 12 mA	70% minimum

The CFAF128128B-0145T uses an LED backlight. LED backlights are easy to use, but they are also easily damaged by abuse.

CAUTION

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

NOTE

We recommend that the LED backlight be dimmed or turned off during periods of inactivity to conserve its lifetime.

LEDs are “current” devices. The important aspect of driving an LED is 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 in line from a voltage source will work well in most applications and is much less complex than a current source.

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

How to Calculate the Value of R_{Limit}

You need to know what the forward voltage of the LEDs is so you can calculate the current limiting resistor (R_{LIMIT}). The forward voltage will vary slightly from display module to display module.
The general equation to calculate each R_{LIMIT} is:

$$R_{LIMIT} = \frac{V_{LOGIC}\text{ (Supply Voltage)} - V_{LED}\text{ (Typical LED Forward Voltage)}}{I_{LED}\text{ (Typical LED Forward Current, Single LED)}}$$

The specific R_{LIMIT} calculation for the CFAF128128B-0145T at V_{LOGIC} = +3.2v is:

$$R_{LIMIT} = \frac{5.0v - 3.2v}{0.012A} = 150\Omega \text{ (minimum — use next larger standard size)}$$

How to Calculate the Power Rating of the Resistor

The general equation to calculate the power rating of the resistor is:

P = IE

where

P= Power. Measured in Watts (W).
I= Current. Measured in amperes (A). “I” is from the outdated term “Intensity”.
E= Voltage. Measured in volts (v). “E” is from the outdated term “Electromotive force”.

The specific power rating calculation for CFAF128128B-0145T is:

P = 0.012A x (5.0v - 3.2v) = 0.0216W = 2.2mW

Please select a resistor that can safely dissipate 2.2mW while keeping its temperature at an acceptably low value for your application.

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.

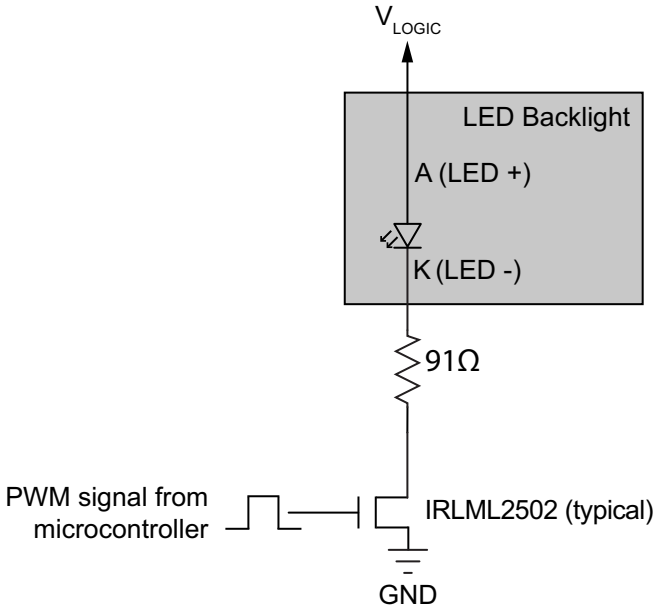


Figure 6. Typical LED Backlight Connections for PWM Dimming

DRIVERS AND SAMPLE CODE

SOURCES FOR DRIVER LIBRARIES

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

SAMPLE CODE

Free downloadable sample 3-wire 9-bit or 4-wire 8-bit SPI code is on our website under the tab DATASHEETS & FILES.

MODULE RELIABILITY AND LONGEVITY

MODULE RELIABILITY

PART NUMBER	SPECIFICATION
CFAF128128B-0145T	Brightness will be >50% of a new module's initial brightness for at least 10,000 hours of operation when supply to the one LED is below 12 mA.

Under operating and storage temperature specification limitations, humidity noncondensing) RH up to 65%, and no exposure to direct sunlight. Value listed above is approximate and represents typical lifetime.

The white LEDs dim over time, especially if driven with high currents. The dimming may not be noticeable when a single display module is installed. However, if a new display module is installed next to a display module 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.

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:

- *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 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 System Block Diagram (Pg. 9).

HANDLING CAUTION FOR MODULES SHIPPED IN TRAYS

If you receive modules packed in trays, handle trays carefully by supporting the entire tray. Trays were made to immobilize the modules inside their packing carton. Trays are not designed to be rigid. Do not carry trays by their edges; trays and 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 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 Sitronix ST7735S controller 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 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.
- The display can be mounted vertically onto a front panel using a variety of methods. If the enclosure is plastic, it can be molded to have the display snap into place. A metal enclosure can use a milled faceplate with mounting tabs to secure the module. Adhesives can be used, as long as they are not similar to “super-glue” because these emit vapors that can damage the display over time.

- Do not reverse polarity to the power supply connections. Reversing polarity will immediately ruin the 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.

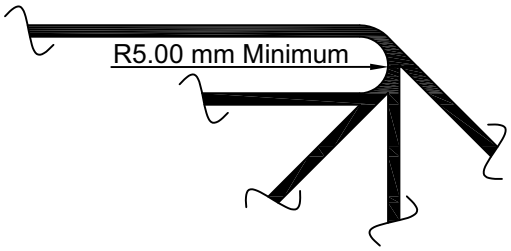


Figure 7. Example Of Minimum Plastic Bend Radius for FPC/FFC

- The 10-pin FPC mates with standard 0.5 mm ZIF socket such as SFV10R-2STE1HLF sold by 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.

IF TFT 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 TFT.
7. Gently wash the microfiber cloths in warm, soapy water and air dry before reuse.

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 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 module from ESD and power supply transients.
- Observe the operating temperature limitations: a minimum of -10°C to a maximum of +60°C noncondensing with minimal fluctuation. Operation outside of these limits may shorten life and/or harm 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 -20°C minimum to +60°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

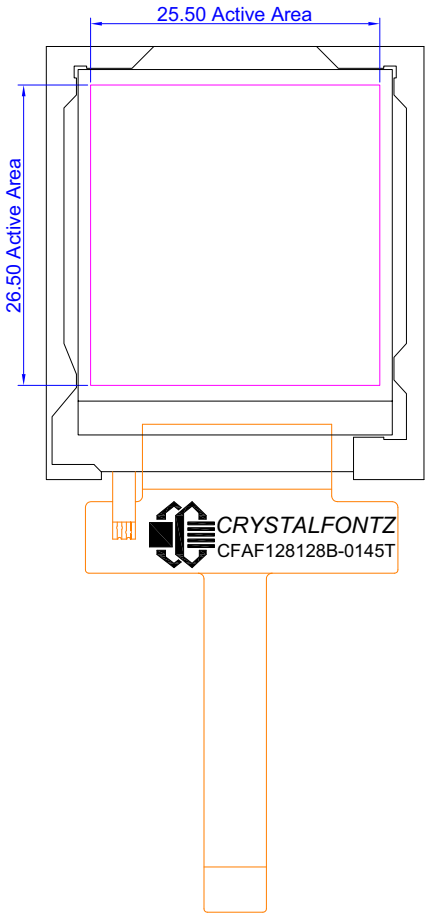
INSPECTION CONDITIONS

- 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 VIEWING AREA AND ACTIVE AREA

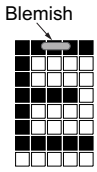
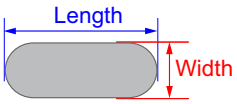
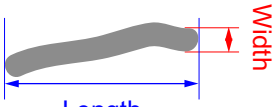


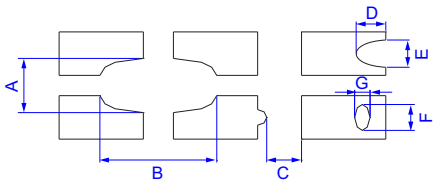
DEFECTS CLASSIFICATION

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 (mm)*	*Acceptable Qty*	Minor
			≤0.3	3	
			≤2 defects within 10 mm of each other		
5	Other blemishes or foreign matter outside of display segments	Defect size = (A + B)/2 	*Defect Size (mm)*	*Acceptable Qty*	Minor
			≤0.15	Ignore	
			0.15 to 0.20	3	
			0.20 to 0.25	2	
			0.25 to 0.30	1	
6	Dark lines or scratches in display area 	*Defect Width (mm)*	*Defect Length (mm)*	*Acceptable Qty*	Minor
		≤0.03	≤3.0	3	
		0.03 to 0.05	≤2.0	2	
		0.05 to 0.08	≤2.0	1	
		0.08 to 0.10	≤3.0	0	
		≥0.10	>3.0	0	
7	Bubbles between polarizer film and glass		*Defect Size (mm)*	*Acceptable Qty*	Minor
			≤0.20	Ignore	
			0.20 to 0.40	3	
			0.40 to 0.60	2	
			≥0.60	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 (mm)</th><th>Acceptable Qty</th></tr>
<tr><td>((A+B)/2)≤0.2</td><td rowspan="4">≤3 total defects
≤2 pinholes per digit</td></tr>
<tr><td>C>0</td></tr>
<tr><td>((D+E)/2)≤0.25</td></tr>
<tr><td>((F+G)/2)≤0.25</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 or foreign matter (see test 5, Pg. 24), and dark lines or scratches (see test 6, Pg. 24).
*Minor if display functions correctly. Major if the display fails.</td><td>Minor</td></tr>
<tr><td>10</td><td>COB defects</td><td>1. Pinholes >0.2 mm.
2. Seal surface has pinholes through to the IC.
3. More than 3 locations of sealant beyond 2 mm of the sealed areas.</td><td>Minor</td></tr>
<tr><td>11</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>12</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>

APPENDIX B: TFT MODULE TERMS AND SYMBOLS

The first (top) term / symbol listed in this table is the term used by Crystalfontz.

Term / Symbol	Description
A (LED +)	Supply pin for LED. “A” (anode) or “+” of LED backlight. If more than one, may be labeled as A_1, A_2, ...
cd/m^2 lumen nits	Candela per square meter. A unit of measurement used to measure Luminous Intensity. cd/m^2 = 1 lumen.
$\overline{CS}$ CS# CSX	Chip select input. *Low:* Controller chip is selected. Communications with host are possible. *High:* Controller chip is not selected. Host interface signals are ignored by the controller.
COF	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.
DB0 ~ DB*n* D0 ~ D*n*	Parallel databus.
D/$\overline{C}$ RS DCX 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.
DE DEN	Data Enable signal for RGB / DPI mode.
DPI DOTCLK parallel	Displays Pixel Interface
DCLK	Dot-clock signal and oscillator source. A non-stop external clock must be provided to that pin even at front or back porch non-display period. RGB interface only.
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.
FFC	Flat Flexible Cable. Also called “flex tail” or “pigtail”. Typically thinner than the “flex” film of COG (Chip On Glass).
FPC	Flexible Printed Circuit. Also called “flex tail”. Typically much thicker than the “flex” film of COF (Chip On Flex).
GND V_{SS}	Ground. Must be connected to an external ground.
H_{SYNC}	Horizontal frame/RAM write synchronizing signal used for RGB mode only.

<table>
<tr><th>Term / Symbol</th><th>Description</th></tr>
<tr><td>I_{DD}</td><td>Typical power supply current for TFT.
Total electrical current (I) in the Drains of a CMOS circuit</td></tr>
<tr><td>I_{LED}</td><td>Current used by LED backlight.</td></tr>
<tr><td>IMn</td><td>Interface mode select pin where n is the corresponding number.</td></tr>
<tr><td>I_{OP}
V_{CCI}</td><td>Current for normal OPeration, typically measured in milliamperes (mA).
1 mA = 0.001A (Ampere)</td></tr>
<tr><td>I_{ST}</td><td>Current for STandby mode, typically measured in microampere (µA).
1 µA = 0.000001A (Ampere)</td></tr>
<tr><td>I/O
IO</td><td>Input/Output</td></tr>
<tr><td>K (LED -)</td><td>Supply pin for LED. “K” (cathode or kathode for German and original Greek spelling) or “-” of LED backlight. If more than one, may be labeled as K_1, K_2, ...</td></tr>
<tr><td>MIPI</td><td>Mobile Industry Processor Interface. See MIPI Alliance.</td></tr>
<tr><td>MISO
SDO
D_{OUT}</td><td>Data output signal in serial SPI interface: Master In Slave Out. Serial Data Out.</td></tr>
<tr><td>MOSI
SDI
SI
DINI_SDA</td><td>Data output signal in serial SPI interface: Master Out Slave In. Serial Data In.</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>Make No Connection.</td></tr>
<tr><td>P_{CLK}</td><td>Pixel clock signal for RGB / DPI mode.</td></tr>
<tr><td>PSn-PS0</td><td>
<table>
<tr><th>PS3</th><th>PS2</th><th>PS1</th><th>PS0</th><th>Interface Mode</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>16-bit 6800 parallel interface. (if available)</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>1</td><td>8-bit 6800 parallel interface. (if available)</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>0</td><td>16-bit 8080 parallel interface.</td></tr>
<tr><td colspan="5">. . . . . .</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td><td>8-bit 8080 parallel interface.
(if available)</td></tr>
</table>
</td></tr>
</table>

Term / Symbol	Description
PWM	Pulse Width Modulation is a way to simulate intermediate levels by switching a level between full on and full off. PWM is typically used to control the brightness of LED backlights, relying on the natural averaging by the human eye.
$\overline{RD}_{8080}$ (E_{6800}) $\overline{RD}$ (E) E ($\overline{RD}$) E RDX	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
RGB	Typically used to indicate that Red, Green, and Blue are combined to produce a broad array of colors.
RH Rh	Relative Humidity
RoHS	Restriction of Hazardous Substances Directive, an environmental standard.
$\overline{RST}$ $\overline{RES}$ RST# RES# 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.
SCK SCL	Serial Clock
Ta TA	“Ambient temperature” is the temperature of the air that surrounds a component.
Tf	Unit of measurement for TFT response time. f = falling edge. See Definition of Response Time (Tr, Tf) (Pg. 14).
TFT	Thin-Film Transistor fabricated directly on the display substrate.
T_{OP}	OPerating Temperature.
Tr	Unit of measurement for TFT response time. r = rising edge. See Definition of Response Time (Tr, Tf) (Pg. 14).
T_{ST} T_{STG}	STorage Temperature.
V_{ANALOG} V_{CI}	Analog supply,
V_{IH} V_{ICH}	High level input voltage.
V_{IL} V_{LCH}	Low level input voltage.

Term / Symbol	Description
V_{IN} V_T	Input voltage
V_{LED}	Forward voltage for LED backlight.
V_{LOGIC} V_{CC} V_{DD} V_{CI}	Power supply input. Must be connected to an external source.
$V_{LOGIC\ I/O}$ V_{CCIO} IO_{VCC}	Digital Logic Supply and Input/Output Supply
V_{OH} V_{OHC}	High level output voltage.
V_{OL} V_{OLC}	Low level output voltage.
V_{SSD}	Digital ground.
V_{SYNC}	Vertical frame/RAM write synchronizing signal used for RGB mode only.
$\overline{WR}_{8080}$ R/$\overline{W}$ ($\overline{WR}$) $\overline{WR}$ (R/$\overline{W}$) R/W#	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)
$\overline{WR}$_SCK	*DBI Type-B:* Serves as a write signal and write data at the low level. *DBI Type-C:* it serves as SCK (Serial Clock). If unused, tie to $V_{LOGIC\ I/O}$.