Crystalfontz

TFT DISPLAY MODULE DATA SHEET

(FPC Folded)

Datasheet Release 2015-12-02
for:
CFAF320480C5-035T-TS

Crystalfontz America, Incorporated

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CFAF320480C5-035T-TS Datasheet Revision History

Datasheet Release: 2015-12-02
First Datasheet for the CFAF320480C5-035T-TS display module. This display is the replacement for the discontinued
CFAF320480C4-035T-TS.

Product Change Notifications

To check for Product Change Notifications for this display module, see the Product Notices tab on a product's web page:
https://www.crystalfontz.com/product/cfaf320480c5035tts-touchscreen-graphic-tft-display-module-320x480-lcd#pcn

Product pages without a Product Notices tab do not have Product Change Notifications.

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

This display module has volatile memory.

The Fine Print

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GENERAL CHARACTERISTICS

MAIN FEATURES

❑ Full-color (262K) 320xRGBx480 display consists of a TFT panel, integrated controller, an FPC (Flexible Printed Circuit) tail, an integrated 4-wire analog touch screen, and a white LED backlight.
❑ Module dimensions
   ● Active Area
      ■ Diagonal is 88.90 millimeters
        Inches = 3.5-inches
      ■ Active area width and height is 48.96 (W) x 73.44 (H) millimeters.
        Inches = 1.93" (W) x 2.89" (H).
   ● Display Module Overall:
      ■ FPC *unfolded* is 55.50 (W) x 127.55 (H) mm (Shape and length of FPC may vary slightly.)
         Inches = 2.185" (W) x 5.022" (H)
      ■ FPC *folded* is 55.50 (W) x (H) 85.96 mm
        Inches = 2.185" (W) x 3.384" (H).
   ● Overall module depth:
      ■ Millimeters: 3.75 mm (D) excluding the molded plastic alignment pin.
      ■ Inches = 0.148" (D). excluding the molded plastic alignment pin.
❑ The integrated Himax HX8357-B controller datasheet is available as a free download on our website.
❑ Requires only a single source 3.0v for both power supply and logic.
❑ Interface modes to host:
   ● 8-bit, 9-bit, 16-bit or 18-bit parallel.
   ● 16-bit or 18-bit "DOTCLK" RGB.
   ● 3- or 4-wire SPI.
❑ The 50-pin FPC mates with standard 0.5mm ZIF sockets such as HFJ150CT-ND and HFK150CT-ND from Digi-Key.
❑ Transmissive display with edge-lit LED backlight (6 white LEDs). The white LED backlight has anode (A,+) and cathode (K -) pins brought out on the FPC.
❑ 6:00 o'clock viewing angle (polarizer viewing direction).
❑ Temperature range for operation is from -20°C to +70°C.
❑ This display can be purchased mounted on a carrier board or as part of a complete development kit. These are available under the "Additional Options" heading on the display's web page.
❑ This display is RoHS compliant.
❑ Crystalfontz America, Incorporated is ISO 9001:2008 certified.

EXPLANATION OF PART NUMBER CODES IN THIS DATASHEET

CFA	F	320	480	C5	-	035	T	-	TS
❶	❷	❸	❹	❺		❻	❼		❽

❶	**Brand**	Crystalfontz America, Inc.
❷	**Display Type**	F – TFT
❸	**Number of Pixels (Width)**	320 pixels
❹	**Number of Pixels (Height)**	480 pixels
❺	**Model Identifier**	C4
❻	**Diagonal Dimension**	035 – 3.5-inch diagonal
❼	**Backlight Type & Color**	T – white LED backlight
❽	**Configuration Codes**	TS – with touch screen

MECHANICAL SPECIFICATIONS

PHYSICAL CHARACTERISTICS

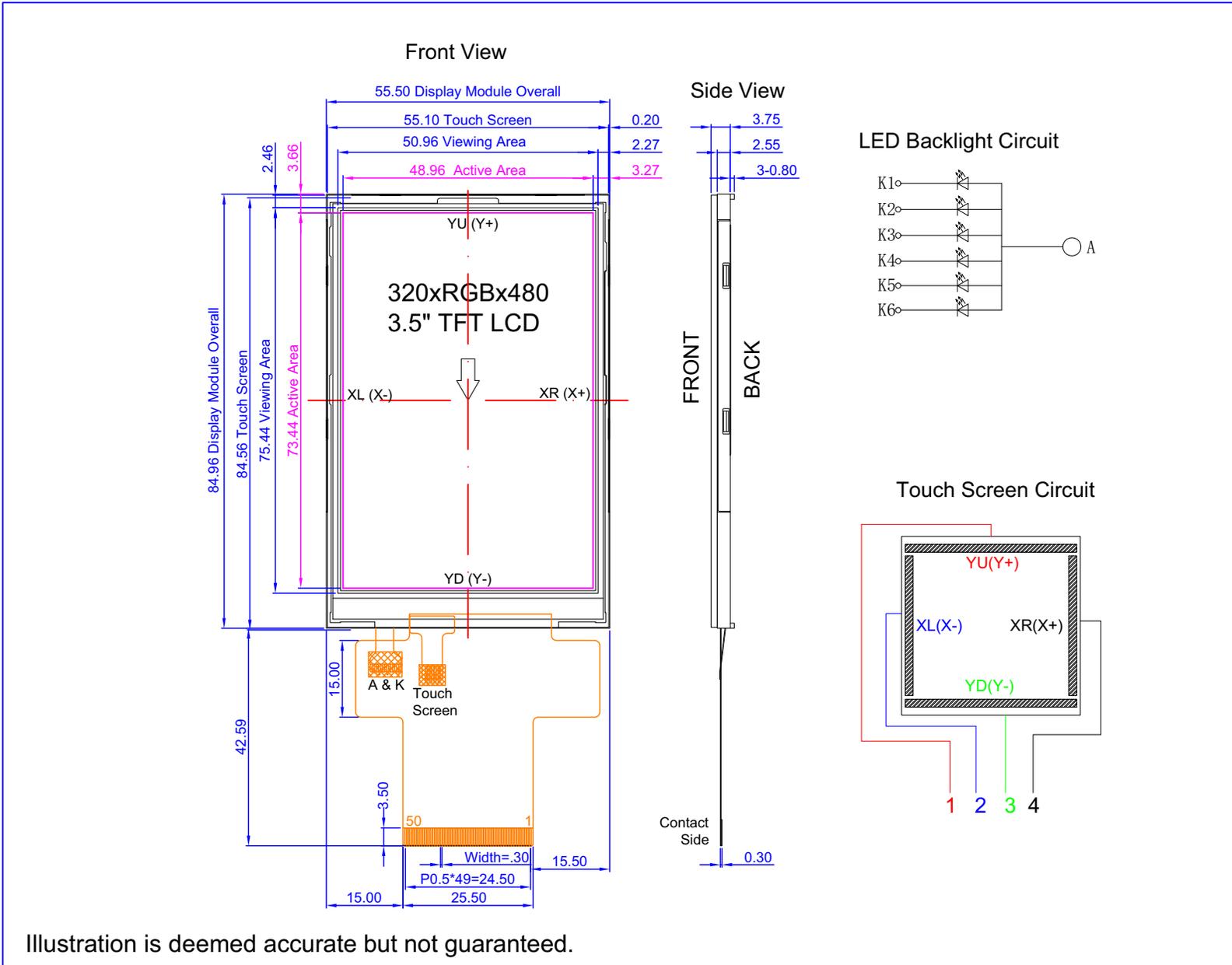| ITEM	SPECIFICATION
Number of Pixels	320 x RGB x 480 pixels
Pixel Pitch	0.051 (W) x 0.051 (H) mm
Active Area	
Active Area Diagonal	Millimeters: 88.90 mm Inches: 3.50"
Active Area Width and Height	Millimeters: 48.96 (W) x 73.44 (H) mm Inches: 1.93" (W) x 2.89" (H)
Module Outline Dimensions	
Overall module width and height with FPC unfolded*	Millimeters: 55.50 (W) x 127.55 (H) mm Inches: 2.185" (W) x 5.022" (H)
Overall module width and height with FPC folded	Millimeters: 55.50 (W) x 85.96 (H) mm Inches: 2.185" (W) x 3.384" (H)
For reference only. Shape and length of FPC may vary slightly.	
Module Depth Maximum excluding the molded plastic alignment pin	Millimeters: 3.75 (D) mm Inches: 0.148" (D)
FPC Bend Radius	>R.95 mm
Weight	28 grams

Figure 1. Module Outline Drawing, Front And Side View

Front View

55.50 Display Module Overall
55.10 Touch Screen
50.96 Viewing Area
48.96 Active Area

0.20
2.27
3.27

2.46
3.66

84.96 Display Module Overall
84.56 Touch Screen
75.44 Viewing Area
73.44 Active Area

YU (Y+)

320xRGBx480
3.5" TFT LCD

XL (X-)   XR (X+)

YD (Y-)

15.00
A & K   Touch
        Screen

42.59

-3.50

50   1
Width=.30
P0.5*49=24.50
15.00   25.50   15.50

Side View

3.75
2.55
3-0.80

FRONT   BACK

Contact
Side

0.30

LED Backlight Circuit

K1
K2
K3
K4   A
K5
K6

Touch Screen Circuit

YU(Y+)

XL(X-)   XR(X+)

YD(Y-)

1   2   3   4

Illustration is deemed accurate but not guaranteed.

Part No.(s):	Scale:	Drawing Number:	Hardware Rev.:
CFAF320480C5-035T-TS	Not to scale		
Units:	Date:		Sheet:
Millimeters	2015-12-01		1 of 2

Back View, FPC Unfolded

Back View, FPC Folded

.50

.50

54.50

.50

3 * Ø1.00

83.96

Double Sided Tape

15.50

40.39

.80

5.00

47.82

Illustration is deemed accurate but not guaranteed.

Part No.(s): CFAF320480C5-035T-TS	Scale: Not to scale	Drawing Number:	Hardware Rev.:
	Units: Millimeters	Date: 2015-12-01	Sheet: 2 of 2

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Figure 2. Module Outline Drawing, Back View

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ELECTRICAL SPECIFICATIONS

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	+4.6v
Analog Supply	V_{ANALOG}		
Operating Temperature*	T_{OP}	-20°C	+70°C
Storage Temperature*	T_{ST}	-30°C	+80°C
Humidity	RH	0%	90%
Input voltage	V_{IN}	-0.3v	$V_{LOGIC\ I/O}$+0.3v

Caution
These are stress ratings only. Functional operation of the module at these or any other conditions beyond those listed under Recommended DC Characteristics (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

RECOMMENDED DC CHARACTERISTICS	SYMBOL	MINIMUM	TYPICAL	MAXIMUM
Digital Logic Supply and Input/Output Supply	$V_{LOGIC\ I/O}$	+1.7v	+1.8v / +3.3v	+3.3v
Analog Supply	V_{ANALOG}	+2.5v	+3.3v	
Current consumption for Normal Operation	V_{OP}	—	10 mA	15 mA
Input High Voltage	V_{IH}	$+0.7v * V_{LOGIC\ I/O}$ for $V_{LOGIC\ I/O}$ = +1.8v V_{IH} = +0.7v * +1.8v = +1.26v for $V_{LOGIC\ I/O}$ = +3.3v V_{IH} = +0.7v * +3.3v = +2.31v	—	$V_{LOGIC\ I/O}$
Input Low Voltage	V_{IL}	0v (GND)	—	$+0.3v * V_{LOGIC\ I/O}$ for $V_{LOGIC\ I/O}$ = +1.8v V_{IL} = +0.3v * +1.8v = 0.54v for $V_{LOGIC\ I/O}$ = +3.3v V_{IL} = +0.3v * +3.3v = +0.99v
Output High Voltage @0.1mA	V_{OH}	$+0.8v * V_{LOGIC\ I/O}$ for $V_{LOGIC\ I/O}$ = +1.8v V_{OH}= +0.8v * +1.8v = +1.44v for $V_{LOGIC\ I/O}$ = +3.3v V_{OH}= +0.8v * +3.3v = +2.64v	—	$V_{LOGIC\ I/O}$
Output Low Voltage @0.1mA	V_{OL}	0v (GND)	—	$+0.2v * V_{LOGIC\ I/O}$ for $V_{LOGIC\ I/O}$ = +1.8v V_{OL} = +0.2v * +1.8v = 0.36v for $V_{LOGIC\ I/O}$ = +3.3v V_{OL} = +0.2v * +3.3v = +0.66v

This is a summary of the module's major operating parameters. For detailed information see the Himax HX8357-B *controller datasheet.*

DETAILS OF INTERFACE PIN FUNCTION

PIN	SIGNAL	LEVEL	DIRECTION	DESCRIPTION
1	GND	0v		Ground. Must be connected to an external ground.
2-3	$V_{LOGIC\ I/O}$	1.65v to 3.3v	I	Digital Logic Supply and Input/Output Supply
4-5	V_{ANALOG}	+2.5v to +3.3v	I	Analog supply,
6	IM0			
7	IM1			
8	IM2		I	

Content for pins 6, 7, 8:

IM2	IM1	IM0	Interface Mode	DB Pins In Use
Parallel (also known as DOTCLK or DPI) Interface				
0	0	0	18-bit RGB / DPI	DB17-BD0
0	0	1	9-bit RGB / DPI	DB8-DB0
0	1	0	16-bit RGB / DPI	DB15-DB0
0	1	1	8-bit RGB / DPI	DB7-DB0
3 or 4-wire SPI				
1	0	1	3-wire, 9-bit SPI	SDI, SCL, CS
1	1	1	4-wire, 8-bit SPI	SDI, SCL,CS, RS
Note: If pin is not used, tie to GND or make no connection.				

DPI is **D**isplay **P**ixel **I**nterface.

PIN	SIGNAL	LEVEL	DIRECTION	DESCRIPTION
9	$\overline{RST}$	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* ($V_{LOGIC\ I/O}$) for normal operation.
10	V_{SYNC}		I	**V**ertical and **H**orizontal frame synchronizing signal used for RGB / DPI mode. The pin should be pulled *high* ($V_{LOGIC\ I/O}$) when not in use.
11	H_{SYNC}			
12	P_{CLK}	H/L	I	**P**ixel **C**lock **S**ignal for RGB / DPI mode. The pin should be pulled *low* when not in use.
13	DE	H/L	I/O	**D**ata **E**nable signal for RGB / DPI mode. The pin should be pulled *low* when not in use.

PIN	SIGNAL	LEVEL	DIRECTION	DESCRIPTION (Continued)

14-31	DB17-DB0	H/L	I/O	*In MIPI databus interface mode, DB7-DB0 are used like:*
				  18-bit bidirectional data bus.
				  8-bit bus: use DB7-DB0
				  9-bit bus: use DB8-DB0
				  6-bit bus: use DB15-DB0
				  8-bit bus: use DB17-DB0
				
				In MIPI DPI interface mode, DB17-DB0 are treated as 18-bit bus
				
				RGB data bus
				6-bit bus: use DB5-DB0
				16-bit bus: use DB15-DB0
				18-bit bus: use DB17-DB0
				If not used: please connect to V_{SSD}.
				
				MIPI is **M**obile **I**ndustry **P**rocessor **I**nterface. See MIPI Alliance.

32	GND	0v		Ground. Must be connected to an external ground.
33	MISO		O	SPI data signal: **M**aster **I**n **S**lave **O**ut. If unused, leave disconnected / floating.
34	MOSI		I	SPI data signal: **M**aster **O**ut **S**lave **I**n. The data is received on the rising edge of the SCK signal. If unused, tie to V_{SSD}.
35	$\overline{RD}$		I	DBI Type-B: Serves as a read signal and read data at the low level. If unused, tie to $V_{LOGIC\ I/O}$.
36	$\overline{WR}$_SCK		I	*DBI Type-B:* Serves as a write signal and write data at the low level. *DBI Type-C:* Serves as SCK (Serial Clock). If unused, tie to $V_{LOGIC\ I/O}$.
37	D/$\overline{C}$	H/L	I	Data/Command control. Determines whether data bits are data or command. *1 – High*: Addresses the data register. *0 – Low:* Addresses the command register. If unused, tie to $V_{LOGIC\ I/O}$.
38	$\overline{CS}$	H/L	I	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.

39-42	See description column			*CFAF320480C4-035T* (no touch screen): No Connection.
				
				CFAF320480C5-035T-TS (with touch screen):
				  XR(X+): right
				  YD(Y-): down
				  XL(X-): left
				  YU(Y+): up

| PIN	SIGNAL	LEVEL	DIRECTION	DESCRIPTION (Continued)
43	A1 (LED +)			Common supply pin for LEDs. "A" (anode) or "+" of LED backlight.
44-49	LEDK1-LEDK6 (LED -)			Individual supply pins for LED. "K" (cathode or kathode for German and original Greek spelling) or "-" of LED backlight.
50	GND			Ground.
For backlight connections, please refer to LED Backlight Characteristics (Pg. 18).				

ABOUT THE 4-WIRE ANALOG RESISTIVE TOUCH SCREEN
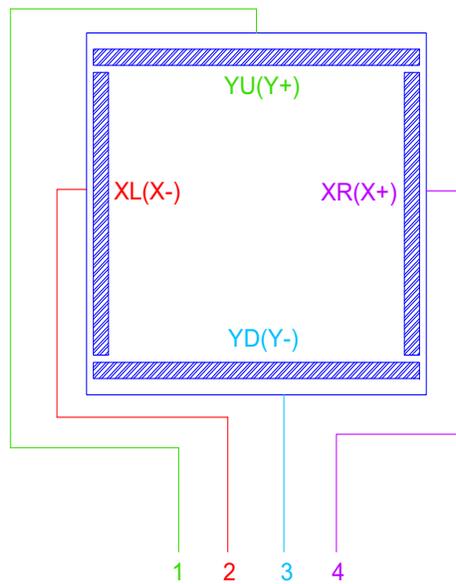
Figure 3. Touch Screen Connections For CFAF320480C5-035T-TS

The touch screen must be driven in one direction, then read in the other direction.

❑ Typically, the kind of microcontroller that supports the RGB / DPI interface (ARM9, etc) will also have ADC pins that can be used directly to read the touch screen.

❑ TI (Texas Instruments) makes I2C / SPI and low level touch screen controllers. Typical:
www.ti.com/product/tsc2046e.

❑ Some microcontrollers have analog inputs that may work directly. TSHARC (www.tsharc.com) makes a high-level controller from a preprogrammed PIC microcontroller.

Basic Concept

Put a gradient across one set of electrodes. Set both electrodes as digital outputs, driving one high and the other one low. Look at either of the *other* set of electrodes (both set as inputs, at least one analog). The analog input will pick up the voltage of the gradient at the contact point. To read the other channel, rotate the whole process 90 degrees.

You may need to address other factors, including references, calibration, drift, non-contact, detecting "taps", and "double-taps".

More Information

❑ A comparison of three types of touch screens:
www.howstuffworks.com/question716.htm.

❑ An introductory explanation of how four-wire resistive touch screens work:
www.elotouch.com/Technologies/AT4/howitworks.asp.

❑ Source for resistive touch screen construction:
http://www.ti.com/lit/an/slyt209a/slyt209a.pdf.

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

ITEM	SYMBOL	ADDITIONAL TEST CONDITIONS	MINIMUM	TYPICAL	MAXIMUM
Ambient Temperature (Ta) = 25°C, Maximum 75% Relative Humidity					
Color Depth				262K	
Contrast Ratio (CR)[1]				500	
TFT Response Time[2]	Tr			5 ms	
	Tf			15 ms	
Red Chromaticity	Rx	$\theta = \varphi - 0°$	0.611	0.641	0.671
	Ry		0.290	0.320	0.350
Green Chromaticity	Gx		0.270	0.300	0.330
	Gy		0.536	0.566	0.596
Blue Chromaticity	Bx		0.104	0.134	0.164
	By		0.098	0.128	0.158
White Chromaticity	Wx		0.267	0.297	0.327
	Wy		0.301	0.331	0.361
Viewing Angle, Horizontal	θ_{X+}	Center CR$\geq$10		70 degrees	
	θ_{X-}			70 degrees	
Viewing Angle, Vertical	θ_{Y+}			60 degrees	
	θ_{Y-}			60 degrees	
Viewing Direction				6:00	

[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.*

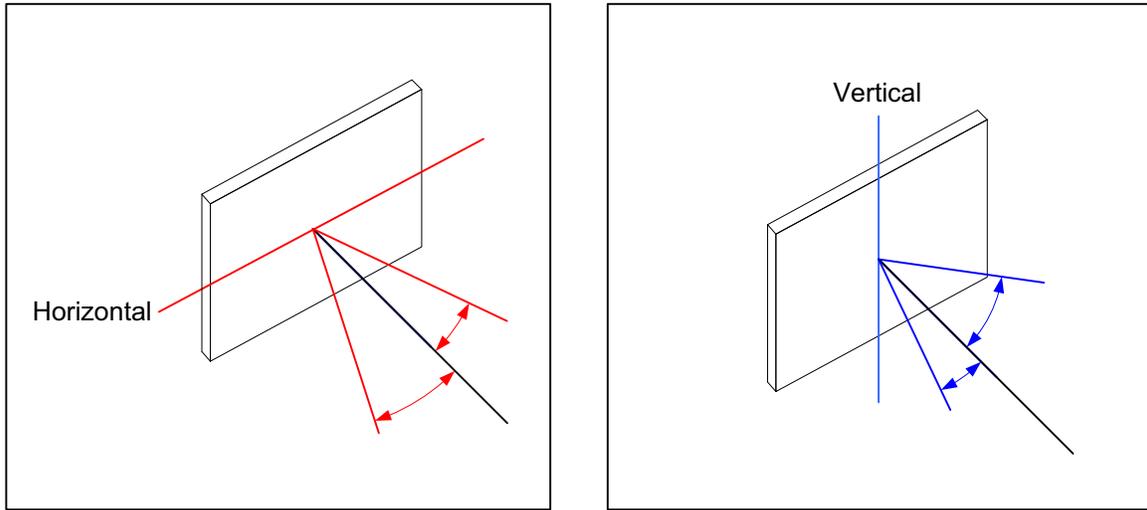## Definition of Vertical and Horizontal Viewing Angles (CR≥2)

Figure 4. Definition Of Horizontal And Vertical Viewing Angles (CR>2)

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

This display module has a 6:00 o'clock viewing angle.
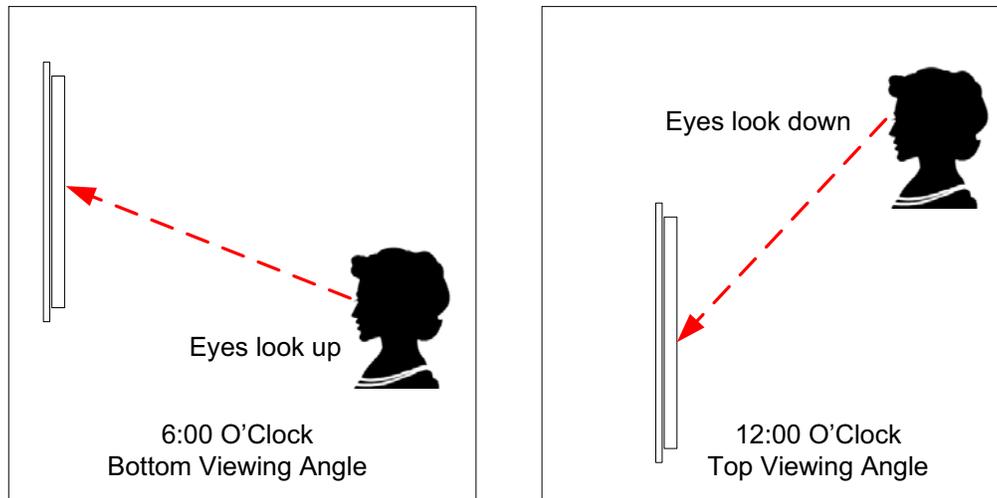
Figure 5. Definition Of 6:00 O'Clock And 12:00 O'Clock Viewing Angles

LED BACKLIGHT CHARACTERISTICS

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

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.

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 to display.
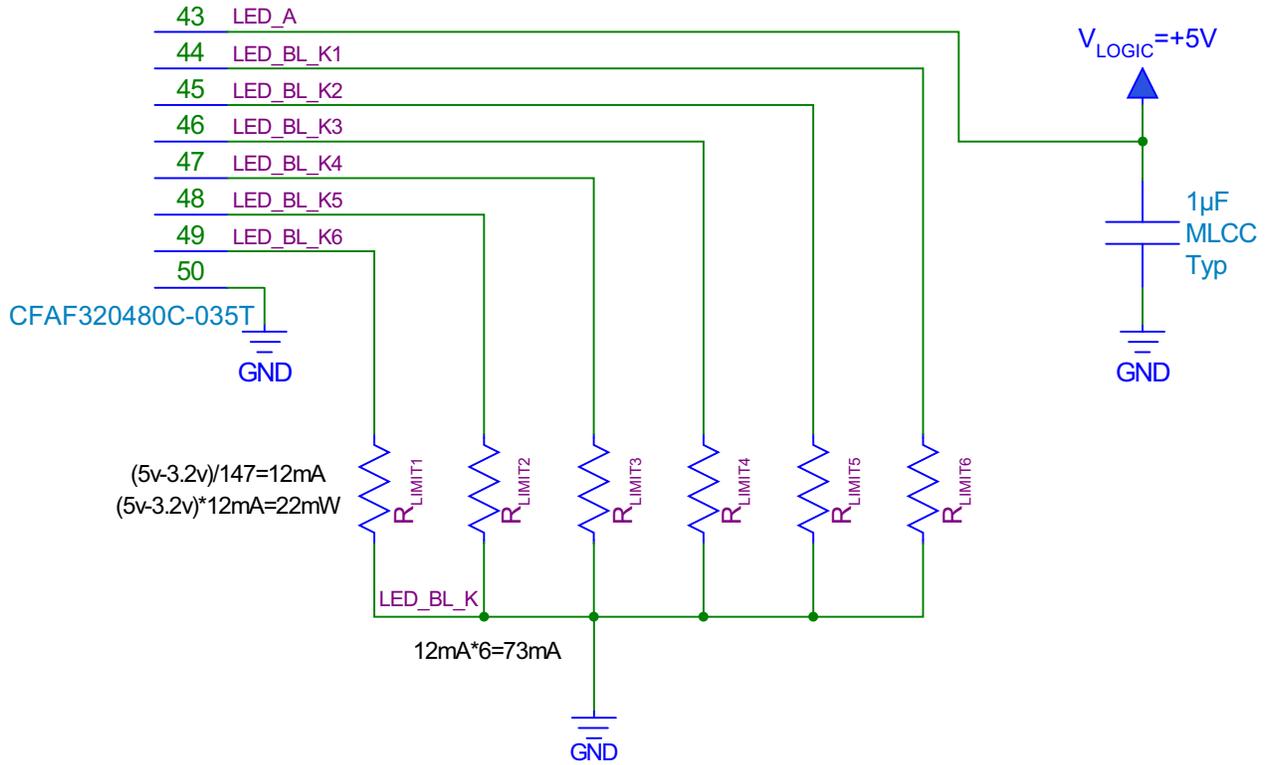
```
43   LED_A
44   LED_BL_K1
45   LED_BL_K2
46   LED_BL_K3
47   LED_BL_K4
48   LED_BL_K5
49   LED_BL_K6
50
CFAF320480C-035T
        GND
```

$V_{LOGIC}=+5V$

1µF
MLCC
Typ

GND

(5v-3.2v)/147=12mA
(5v-3.2v)*12mA=22mW

R_{LIMIT1} R_{LIMIT2} R_{LIMIT3} R_{LIMIT4} R_{LIMIT5} R_{LIMIT6}

LED_BL_K

12mA*6=73mA

GND

Figure 6. Typical LED Backlight Connections For "Always On"

The general equation to calculate 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 these display modules at V_{LOGIC} = +5.0v is:

$$R_{LIMIT} = \frac{5.0v - 3.2v}{0.015A} = 120 \ \Omega \text{ (minimum — use next larger standard size)}$$

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 these display modules is:

$$P = 0.015A \times (5.0v - 3.2v) = 0.0027W = 2.7mW$$

Please select a resistor that can safely dissipate 2.7 mW 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.
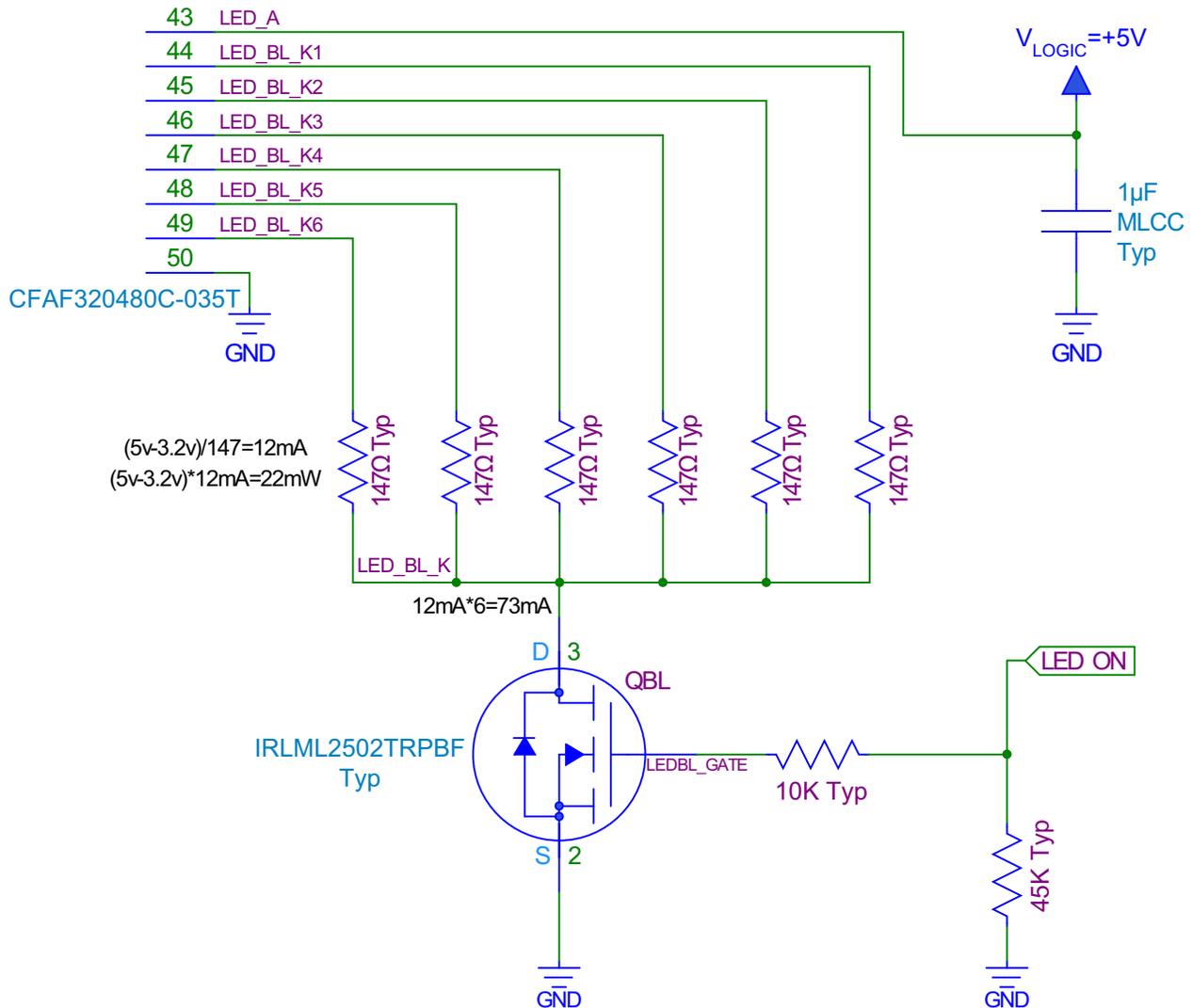

Figure 7. Typical LED Backlight Connections For PWM Dimming

CFAF320480C5-035T-TS LED Backlight Characteristics *Edge-lit with six LEDs in parallel.* *Ambient temperature: TA = 25°C*			
PARAMETER	**MINIMUM**	**TYPICAL**	**MAXIMUM**
Forward Current (I_{LED})	—	90 mA 15mA per LED 15mA x 6 = 90 mA	
Caution: Driving the backlight above 90 mA may shorten its lifetime.			
Forward Voltage (V_{LED})	—	+3.2v	—
Luminous Intensity* (IV) when I_{LED} = 90 mA Includes TFT panel and touch screen.	—	85 cd/m^2	—
The backlight is measured through the LCD. Direct backlight measurement is significantly brighter.			
Uniformity (minimum/maximum x 100%)	80%	—	—

MODULE RELIABILITY AND LONGEVITY

MODULE RELIABILITY

PART NUMBER	SPECIFICATION
CFAF320480C5-035T-TS	Brightness will be >50% of a new module's initial brightness for at least 50,000 hours of operation when supply to each LED is below 90 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 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.*	

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 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. 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 Datasheet 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 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. 10).

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 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.

- To protect the touch screen from damage, the display module ships with a protective film over the touch screen. Please peel off the protective film slowly. Peeling off the protective film abruptly may generate static electricity.

- To avoid damage, your bezel must be smooth where it touches the touch screen. Your bezel should not apply undue force to the touch screen.

- To avoid shorting, your mounting bezel should be at least 3 mm from the Active Area of the touch screen.

- Do not disassemble or modify the display module.

- The display module 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 module snap into place. A metal enclosure can use a milled faceplate with mounting tabs to secure the display module. Adhesives can be used, as long as they are not similar to "super-glue" because these emit vapors that can damage the display module over time.

- 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. Contamination, including fingerprints may make soldering difficult, and the reliability of the soldered connection poor.

- 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.

R5.00 mm Maximum
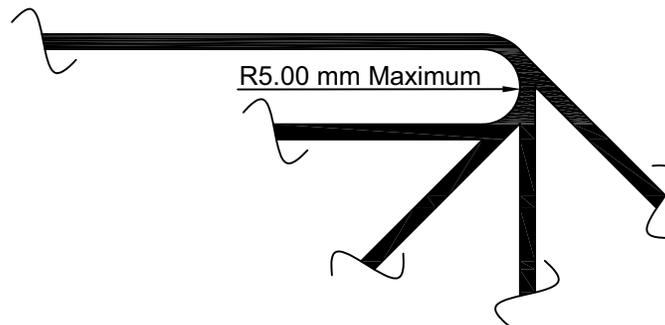
- For easy connection, the 50-pin FPC mates with standard 0.5mm ZIF sockets such as HFJ150CT-ND and HFK150CT-ND, both available from Digi-Key.

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.

CAUTION

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 touch screen 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 touch screen over time. Never apply liquids directly on the touch screen. 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 touch screen. 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 this display module to a PC's parallel port as an end product. This display 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 display module from ESD and power supply transients.
- Observe the operating temperature limitations, non-condensing with minimal fluctuations. 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 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.

# 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 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.
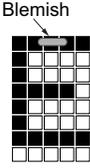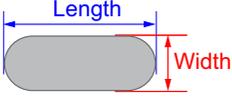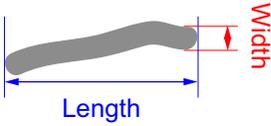
DEFINITION OF VIEWING AREA AND ACTIVE AREA
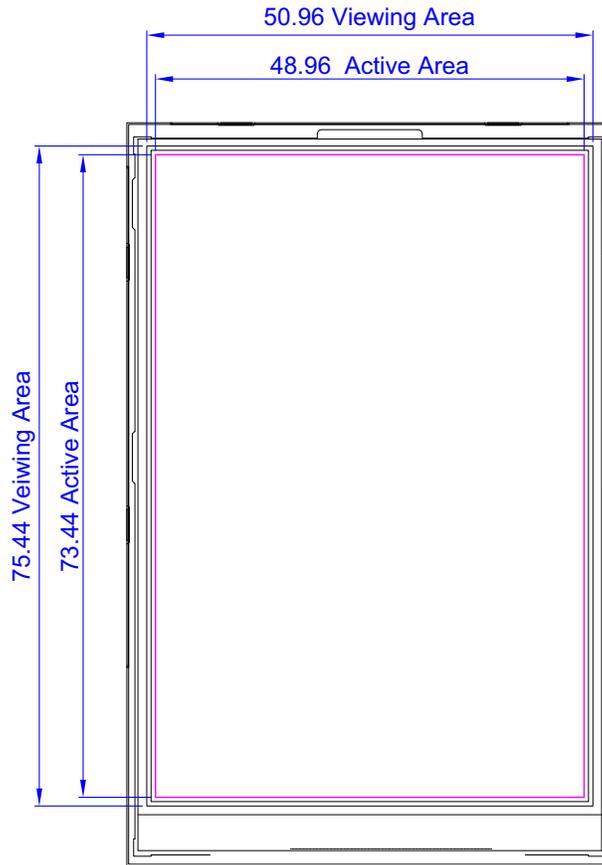
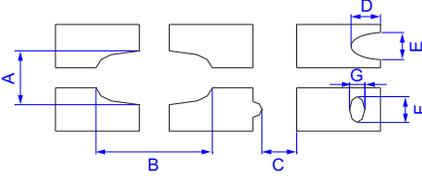# DEFECTS CLASSIFICATION

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	Blemish	*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 Length Width	*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
	Width Length	≤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		

#	DEFECT TYPE	ACCEPTANCE STANDARDS CRITERIA (Continued)	MAJOR / MINOR
8	*Display pattern defect*	<table><tr><td>*Dot Size (mm)*</td><td>*Acceptable Qty*</td></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>	Minor
9	Backlight defects	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. 27), and dark lines or scratches (see test 6, Pg. 27). *Minor if display functions correctly. Major if the display fails.*	Minor
10	COB defects	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.	Minor
11	PCB defects	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.*	Minor
12	Soldering defects	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.*	Minor

APPENDIX A: TFT MODULE TERMS AND SYMBOLS

Crystalfontz Term / Symbol	Equivalent	Equivalent	Equivalent	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 ~ DBn	D0 ~ Dn			Parallel databus.
$D/\overline{C}$	RS or DCX	A0	CD or 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				Data Enable signal for RGB / DPI mode.
DPI	DOTCLK	parallel		Displays Pixel Interface
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.
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 synchronizing signal used for RGB mode.
I_{DD}				Typical power supply current for TFT. Total electrical current (I) in the Drains of a CMOS circuit

Crystalfontz Term / Symbol (Continued)	Equivalent	Equivalent	Equivalent	Description
I_{LED}				Current used by LED backlight.
I_{OP}	V_{CCI}			Current for normal OPeration, typically measured in milliamperes (mA). 1 mA = 0.001A (Ampere)
I_{ST}				Current for STandby mode, typically measured in microampere (µA). 1 µA = 0.000001A (Ampere)
I/O	IO			Input/Output
K (LED -)				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, ...
MIPI				Mobile Industry Processor Interface. See MIPI Alliance.
MISO	D_{OUT}			SPI data signal: Master In Slave Out.
MOSI	DINI_SDA			SPI data signal: Master Out Slave In.
mm				Millimeter or millimetre. Unit of length equal to one thousandth of a meter. 1 millimeter = 0.0394 inches.
mW				Milliwatt is equal to one thousandth of a Watt. Watts = Volts x Amps.
NC	nc			No Connection.
P_{CLK}				Pixel clock signal for RGB / DPI mode.
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.
$\overline{RD}_{8080}$	$\overline{RD}$ (E)	E ($\overline{RD}$)	E or RDX	Host interface input. *8080 Host:* Active low. Signal on the databus is latched at the rising edge of $\overline{RD}$.
RGB				Typically used to indicate that Red, Green, and Blue are combined to produce a broad array of colors.
RH	Rh			Relative Humidity

Crystalfontz Term / Symbol (Continued)	Equivalent	Equivalent	Equivalent	Description
RoHS				Restriction of Hazardous Substances Directive, an environmental standard.
$\overline{RST}$	$\overline{RES}$	RST#	RES#	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.
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.
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.
V_{IN}	V_T			Input voltage
V_{LED}				Forward voltage for LED backlight.
V_{LOGIC}	V_{CC}	V_{DD}		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.

Crystalfontz Term / Symbol (Continued)	Equivalent	Equivalent	Equivalent	Description
V_{SYNC}				Vertical frame synchronizing signal used for RGB mode.
$\overline{WR}_{8080}$	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.
$\overline{WR}$_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 $V_{LOGIC\ I/O}$.