



I²C Serial LCD DATASHEET



Datasheet Release Date 2015-09-25

for

CFA533-***-KC Series

[CFA533-TFH-KC](#)

[CFA533-TMI-KC](#)

[CFA533-YYH-KC](#)

Hardware Version: v1.1, Firmware Version: c1.1

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



FORWARD

REVISION INFORMATION

Datasheet Revision History

Datasheet Release: 2015-09-25

Multiple changes, wherever shown in the datasheet:

- Datasheet was updated to meet current template standards. Information from separate datasheets for two CFA533-***-KC variants (*CFA533-TMI-KC* and *CFA533-YYH-KC*) were merged together in this datasheet along with information of a third variant, *CFA533-TFH-KC*.
- Wherever listed, changed display hardware revision from **v1.0** to **v1.1** and firmware from **c1.0** to **c1.1**.
- Wherever listed, resistor **R21** was renumbered to **R3**. Resistor **R7** was renumbered to **R2**.
- Wherever optional [WR-PWR-Y14](#) ATX power cable is suggested, added cable [WR-PWR-Y44](#). The WR-PWR-Y44 uses the same connectors as our WR-PWR-Y14. It is intended for use with rack mount chassis where extra length is necessary for routing and connectivity.
- Deleted commands labeled as "Reserved".
- Minor changes in text and illustrations to improve clarity.

Changes in command descriptions.

- Changed functionality in command [5 \(0x05\): Reboot CFA533, Reset Host, or Power Off Host \(Pg. 44\)](#).
- In command [6 \(0x06\): Clear LCD Screen \(Pg. 45\)](#), improved description to explain that command empties the contents of the LCD's DDRAM.
- Command [7 \(0x07\): Set LCD Contents, Line 1 \(Deprecated\) \(Pg. 45\)](#) and [8 \(0x08\): Set LCD Contents, Line 2 \(Deprecated\) \(Pg. 46\)](#) are deprecated.
- In command [9 \(0x09\): Set LCD Special Character Data \(Pg. 46\)](#), corrected from:
Any value is valid between 0 and **63**,
to
Any value is valid between 0 and **31**,
- In command [10 \(0x0A\): Read 8 Bytes of LCD Memory \(Pg. 46\)](#), corrected from
"0x80 (\128) to 0x93 (\147) for DDRAM, line 1
"0xC0 (\192) to 0xD3 (\211) for DDRAM, line 2"
to
"0x80 (\128) to 0x8F (\143) for DDRAM, line 1
0xC0 (\192) to 0xCF (\207) for DDRAM, line 2"
- In command [13 \(0x0D\): Set LCD Contrast \(Pg. 47\)](#), corrected
"The first byte data[0] is ignored, any value from 0 to **255** is accepted."
to
"The first byte data[0] is ignored, any value from 0 to **254** is accepted."
- In command [14 \(0x0E\): Set LCD & Keypad Backlight \(Pg. 48\)](#), changed
"1-**100** = variable brightness"
to
"1-**99** = variable brightness
100 = on"



Datasheet Revision History (Continued)

Additional changes:

- In this Forward, [Notices \(Pg. 6\)](#) notices on *About Volatility* and *About Variations* were added.
- Added [INTRODUCTION \(Pg. 10\)](#), which describes the four interfaces available in the CFA533 and the three variant choices within the CFA533-***-KC series.
- Added specifications in section [OPTICAL CHARACTERISTICS \(Pg. 18\)](#).
- Added [Absolute Maximum Ratings \(Pg. 24\)](#).
- Added [LCD Duty And Bias \(Pg. 23\)](#).
- [CONNECTION INFORMATION \(Pg. 28\)](#) was revised to reflect that you can now have the display modules customized when you place your order on our website.
- Removed *Data Communications: Details for RS232 Connections* (page 36 in previous datasheet). This information does not apply to CFA533 display modules with I²C interface.
- Added [Arduino Example Connections and Sketch \(Pg. 40\)](#) that gives a link to this information on the Crystalfontz forum.
- In [About Handshaking \(Pg. 41\)](#), changed functionality of [5 \(0x05\): Reboot CFA533, Reset Host, or Power Off Host \(Pg. 44\)](#).
- The [CARE AND HANDLING PRECAUTIONS \(Pg. 62\)](#) section was updated. Changes include adding [Handling Caution For Display Modules Shipped In Trays \(Pg. 62\)](#), a caution on excessive external noise under [Design and Mounting \(Pg. 62\)](#), and expanded information on [How to Clean \(Pg. 63\)](#).
- [APPENDIX A: QUALITY ASSURANCE STANDARDS \(Pg. 64\)](#) has been revised.
- [APPENDIX B: SAMPLE APPLICATIONS AND SOURCE CODE \(Pg. 67\)](#) has been expanded to include more resources.
- Added [APPENDIX E: VIBRATION TEST REPORT \(Pg. 90\)](#).

Data Sheet Release: v2.0, 2011-03-07 reminder:

Changes since Data Sheet version (v1.0):

- Wherever listed, changed part numbers for I²C variants of CFA533 modules to end in “-KC” instead of “-KI”.
 - Part number “CFA533-TMI-KI” changed to “CFA533-TMI-KC”.
 - Part number “CFA533-YYH-KI” changed to “CFA533-YYH-KC”.
- Wherever listed, deleted dash (“-”) from module part numbers to match how they now appear on our website without the dash (“-”).
- Wherever listed or shown in illustration, changed keypad from “10.5” millimeters to “12.00” millimeters high. This transition started 2010/06/06. See PCN 10282.
- In Features, added
 - “RoHS compliant”.
 - “Factories are ISO certified”.
 - Materials are in compliance with EU Directive “REACH”.
 - Note on CE approved modules.
- In Physical Characteristics,
 - Changed module nominal depth specification to include keypad “12.00” millimeters high (formerly 10.5 millimeters high).
 - Added a maximum depth specification of “25.90”.
 - Module weight increased from “40” grams to “41” grams.
- Updated information in Jumper Locations and Functions due to hardware revision v1.0. Changed “JPGF” to “RFG”. RFG connects 1MΩ between logic ground and frame ground.
- Added OPTICAL SPECIFICATIONS section, with definition of viewing angles.
- Added Humidity Range specification in Temperature and Humidity Ratings.



Datasheet Revision History (Continued)

- In CONNECTION INFORMATION.
 - Based on hardware revision v1.0, revised illustrations on all power and control connections.
 - Because in hardware version 1.0 resistors are loaded by default, all references to “resistors not loaded” were removed.
 - Added hyperlinks to recommended Crystalfontz cables.
 - In command 4 (0x04): Store Current State as Boot State, added Errata Note. Please read boxed note.
 - In command 8 (0x08): Set LCD Contents, Line 2, corrected screen display text from
`data[] = TOP line's display content (must supply 16 bytes)`
to
`data[] = BOTTOM line's display content (must supply 16 bytes)`
 - In command 11 (0x0B): Set LCD Cursor Position, corrected from
`data[0] = column (0-19 valid)`
`data[1] = row (0-3 valid)`
to
`data[0] = column (0-15 valid)`
`data[1] = row (0-1 valid)`
 - In command 12 (0x0C): Set LCD Cursor Style, corrected from “3 = blinking block plus underscore” to “3 = blinking underscore”. This behavior is not the same as the CFA633 series which is “3 = blinking block plus underscore”.
 - In command 22 (0x16): Send Command Directly to the LCD Controller, corrected “*The Neotec NT7070B controller on the CFA533 is S6A0073 compatible.*” to “*The controller on the CFA533 is a Neotec NT7070B (HD44780 compatible).*”
 - In command 35 (0x23): Read GPIO Pin Levels and Configuration State,
 - Replaced upper case “X” with lower case “x”.
 - Corrected “data length” from “4” to “1”.
 - In APPENDIX B: SAMPLE CODE (INCLUDES ALGORITHMS TO CALCULATE THE CRC),
 - In sample code for Algorithm 1: “C” Table Implementation and Algorithm 2: “C” Bit Shift Implementation, added typedefs for “ubyte” and “word”.
 - Added sample code Algorithm 7: For PIC18F8722 or PIC18F2685.
 - In addition to the list above, made minor changes in text and illustrations to improve clarity wherever needed.
-
- In command 35 (0x23): Read GPIO Pin Levels and Configuration State,
 - Replaced upper case “X” with lower case “x”.
 - Corrected “data length” from “4” to “1”.
 - In APPENDIX B: SAMPLE CODE (INCLUDES ALGORITHMS TO CALCULATE THE CRC),
 - In sample code for Algorithm 1: “C” Table Implementation and Algorithm 2: “C” Bit Shift Implementation, added typedefs for “ubyte” and “word”.
 - Added sample code Algorithm 7: For PIC18F8722 or PIC18F2685.
 - In addition to the list above, made minor changes in text and illustrations to improve clarity wherever needed.

Data Sheet Release: 1.0, 2009-07-10
New Data Sheet.



Current Hardware And Firmware Revisions

For information about current firmware and hardware revisions for the CFA533 series, see Part Change Notifications (PCNs) under the Notices tab on the website page for each CFA533 part number.

To ensure that the appropriate people in your organization receive notices, please ask them to subscribe at www.crystalfontz.com/news/pcn.php.

Previous Hardware Revision History

Note: The hardware revision history below is shown for historical purposes only. Hardware revision information is now within Product Change Notices.

2010-06-06	Current hardware version: v1.0 (revision number has not changed) Changes: We are transitioning to an improved keypad from “10.5” millimeters to “12.00” millimeters high. See PCN 10282 .
2010-03-18	Hardware version: v1.0 Changes since hardware version (v0.1): As the inventory of hardware version v0.1 depletes, we are phasing in the improved v1.0. The v1.0 should be a drop-in replacement for any v0.1 application. 1. Added a JPUSBSENSE jumper to help user configuration. Does not apply to I2C. See Jumper Locations and Functions. 2. Changed JPPFG to RFG. RFG connects 1MΩ between logic ground and frame ground. See Jumper Locations and Functions. 3. PCB layout changes: <ul style="list-style-type: none"> - Added more breaks to the frameground (FG) trace that surrounds the board so there is not a loop. - Added masking on FG trace where connectors may be hand soldered to ease assembly. - Moved vias from under the zebra near the ends of the bezel to assure no shorts between the vias and the bezel. - Made mounting hole annular ring (pads) larger to avoid component damage by tools during assembly. - Resistors are loaded wherever needed. 4. Module weight increased from “40” grams to “41” grams.
2007-12-31	Hardware version: v0.1 New module.

Previous Firmware Revision History

Note: The firmware revision history below is shown for historical purposes only. Firmware revision information is now within Product Change Notices.

2010-05-15	Current firmware version: c1.0 Changes since last version (i0.2): Made firmware version match hardware version.
2009-05-15	Firmware version: i0.2 New firmware.



NOTICES

About Volatility

These display modules have nonvolatile memory.

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.

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

FORWARD	2
Revision Information	2
Notices	6
INTRODUCTION	10
CFA533 Interface Choices	10
Similar Display Modules	10
Variants In The CFA533-***-KC Series	10
Main Features	11
Explanation Of Part Number Codes In This Datasheet	12
MECHANICAL SPECIFICATIONS	13
Physical Characteristics	13
Vibration	13
Display Module Outline Drawings	14
Keypad Detail Drawing	16
Panel Mounting Application Cutout Drawing	17
OPTICAL CHARACTERISTICS	18
Test Conditions and Definitions for Optical Characteristics	19
ELECTRICAL SPECIFICATIONS	22
System Block Diagram	22
LCD Duty And Bias	23
Absolute Maximum Ratings	24
Supply Voltages and Current	24
ESD (Electro-Static Discharge) Specifications	27
CONNECTION INFORMATION	28
Overview of Connection Information	28
Jumpers That Can Be Modified	29
Power Supply Connection (Non-ATX)	30
Connection through J_PWR Connector (Non-ATX)	30
Connection through J_RS232 Connector (Non-ATX)	31
ATX Power Supply and Control Connection for Host Power Sense	31
ATX Host Power Sense through +5v on J_PWR Connector	32
ATX Host Power Sense through GPIO[1] on J8 Connector	34
ATX Keypad Control	35
Data Communications: I²C Connections	36
GPIO Connections	37
Dallas Semiconductor 1-Wire Device Connections for Optional Accessories	38
Temperature Sensors	38
Other 1-Wire Devices	38
HOST COMMUNICATIONS	38
I²C Buffers	38
I²C Addressing	39
I²C Debugging	40
Arduino Example Connections and Sketch	40
Packet Structure	40



CONTENTS, CONTINUED

About Handshaking	41
Command Codes	42
0 (0x00): Ping Command	42
1 (0x01): Get Hardware & Firmware Version	42
2 (0x02): Write User Flash Area	42
3 (0x03): Read User Flash Area	43
4 (0x04): Store Current State as Boot State	43
5 (0x05): Reboot CFA533, Reset Host, or Power Off Host	44
6 (0x06): Clear LCD Screen	45
7 (0x07): Set LCD Contents, Line 1 (Deprecated)	45
8 (0x08): Set LCD Contents, Line 2 (Deprecated)	46
9 (0x09): Set LCD Special Character Data	46
10 (0x0A): Read 8 Bytes of LCD Memory	46
11 (0x0B): Set LCD Cursor Position	47
12 (0x0C): Set LCD Cursor Style	47
13 (0x0D): Set LCD Contrast	47
14 (0x0E): Set LCD & Keypad Backlight	48
15 (0x0F): Read Temperature	49
18 (0x12): Read DOW Device Information	49
20 (0x14): Arbitrary DOW Transaction	50
21 (0x15): Set Up Live Temperature Display	51
22 (0x16): Send Command Directly to the LCD Controller	52
24 (0x18): Read Keypad, Polled Mode	52
28 (0x1C): Set ATX Switch Functionality	53
29 (0x1D): Enable/Feed Host Watchdog Reset	55
30 (0x1E): Read Reporting/ATX/Watchdog (debug)	56
31 (0x1F): Send Data to LCD	56
33 (0x21): Set I2C Address	56
34 (0x22): Set/Configure GPIO	57
35 (0x23): Read GPIO Pin Levels and Configuration State	58
CHARACTER GENERATOR ROM (CGROM)	60
DISPLAY MODULE RELIABILITY AND LONGEVITY	61
Display Module Reliability	61
Display Module Longevity (EOL / Replacement Policy)	61
CARE AND HANDLING PRECAUTIONS	62
APPENDIX A: QUALITY ASSURANCE STANDARDS	64
APPENDIX B: SAMPLE APPLICATIONS AND SOURCE CODE	67
APPENDIX C: CONNECTING A DS2450 1-WIRE QUAD A/D CONVERTER	79
APPENDIX D: EXAMPLE OF I²C SOURCE CODE FOR THE ATMEL AVR ATMEGA2561	81
APPENDIX E: VIBRATION TEST REPORT	90



LIST OF FIGURES

Figure 1. Display Module Outline Drawings (two page below) -----	14
Figure 2. Keypad Detail Drawing -----	16
Figure 3. Panel Mount Application Cutout Drawing for Optional Bracket -----	17
Figure 4. Definition Of Optimal Contrast Setting (Negative Image) -----	19
Figure 5. Definition Of Optimal Contrast Setting (Positive Image) -----	19
Figure 6. Definition Of Response Time (Tr, Tf) (Negative Image) -----	20
Figure 7. Definition Of Response Time (Tr, Tf) (Positive Image) -----	20
Figure 8. Definition Of 6:00 O'Clock And 12:00 O'Clock Viewing Angles -----	21
Figure 9. Definition Of Horizontal And Vertical Viewing Angles (CR>2) -----	21
Figure 10. System Block Diagram -----	22
Figure 11. CFA533-TFH-KC Current Usage -----	25
Figure 12. CFA533-TMI-KC Current Usage -----	26
Figure 13. CFA533-YYH-KC Current Usage -----	27
Figure 14. Jumpers That Can Be Modified -----	29
Figure 15. +5v Connection through J_PWR -----	30
Figure 16. Power Connection through J-RS232 -----	31
Figure 17. ATX Host Power Sense through +5v on J_PWR Connector -----	32
Figure 18. ATX Power Supply and Control Using Crystalfontz WR-PWR-Y14 Cable -----	33
Figure 19. ATX Host Power Sense through GPIO[1] on J8 Connector-----	34
Figure 20. I ² C Connections-----	36
Figure 21. Location of GPIO Connections, Resistors, and J_DOW -----	37
Figure 22. I ² C Transactions -----	39
Figure 23. CFA533-***-KC Connection to Aardvark I ² C/SPI Host Adapter-----	40
Figure 24. Character Generator ROM (CGROM) -----	60



INTRODUCTION

CFA533 INTERFACE CHOICES

The CFA533 display modules are available with four interface choices. The host interface controls the LCD and reads the keypad.

CFA533-***-KC	I ² C interface
CFA533-***-KL	Logic level serial interlace
CFA533-***-KS	Serial interface with “full swing” RS232
CFA533-***-KU	USB Interface

This datasheet has information for the CFA533-*-KC series only.** When information in this datasheet applies to all variants (three color choices), the term “CFA533-***-KC” or the shorter term “CFA533” is used.

Datasheet files for the other interfaces listed above are on the *Datasheets & Files* tab for the web pages of each part number.

SIMILAR DISPLAY MODULES

The CFA533 is mechanically similar to the [CFA633](#) series (available with serial or USB interfaces). The CFA533 series command set is compatible with the CFA633 series. The CFA533 can be used as an economical “drop-in” replacement for most CFA633 series applications that do not need fan capabilities.

The CFA533 does not have CE certification because it is not an end product. The display module requires power and communications from another system in order to operate. If you need a CE approved module, please consider our [XES635](#) USB series.

VARIANTS IN THE CFA533-***-KC SERIES

The three variants in this series are:

CFA533-TFH-KC



Edge-lit white LED backlight with positive neutral FSTN LCD. Displays dark characters on light gray background. Integrated white LED backlit 6-button translucent silicone keypad. Positive mode display is sunlight readable and also readable in dark areas.

CFA533-TMI-KC



Edge-lit white LED backlight with negative blue STN LCD. Displays light characters on blue background. Integrated blue LED backlit 6-button translucent silicone keypad. Negative mode display is readable in normally lit and dark areas. May be difficult to read in direct sunlight



CFA533-YYH-KC



Edge-lit yellow-green LED backlight with positive yellow-green STN LCD. Displays dark characters on yellow background). Integrated yellow LED backlit 6-button translucent silicone keypad. Positive mode display is sunlight readable and also readable in dark areas.

MAIN FEATURES

- 16 characters x 2 lines LCD with keypad and high-level interface. With the optional drive bay bracket, the display will fit nicely in a 1U rack mount case (35 mm overall height).
- Only a single supply is needed. Wide power supply voltage range ($V_{DD} = +3.3v$ to $+5.0v$ is perfect for embedded systems).
- Backlight and contrast are fully voltage compensated over the power supply range. Adjustments to the contrast setting or backlight brightness can be made, although this is not necessary in most situations.
- Industry standard Philips® I²C bus compatible interface.
 - Only two pins (SDA and SCL) required to interface to I²C bus.
 - Standard data rate of 100/400 kbps, also supports 50 kbps.
 - 7-bit addressing mode.
- Integrated LED backlit 6-button translucent silicon keypad with screened legend with the popular arrows, enter and cancel layout. Fully decoded keypad: any key combination is valid and unique.
- Advanced digital GPIO control with PWM output.
- Robust packet-based communications protocol with 16-bit CRC.
- Non-volatile memory (EEPROM): Set the "power-on" display screen, plus 16-bytes for storing IP, netmask, or system serial number.
- Optional capabilities: CrystalFontz can make these modifications for you.
 - ATX power supply control functionality allows the buttons on the CFA533 to replace the Power and Reset switches on your system, simplifying front panel design. The ATX functionality can also implement a hardware watchdog that can reset host system on host software failure. Temperature monitoring: up to 32 channels at up to 0.5 degrees Celsius with absolute accuracy (using optional connector and CrystalFontz [WR-DOW-Y17](#) cable with DOW sensor).
 - "Live Display" shows up to four temperature readings without host intervention, allowing temperatures to be shown immediately at boot, even before the host operating system is loaded.
 - I²C to Dallas Semiconductor 1-Wire bridge functionality allows control of other 1-Wire compatible devices (ADC, voltage monitoring, current monitoring, RTC, GPIO, counters, identification/encryption). (Additional hardware required.)
- Get up and running quickly with [APPENDIX B: SAMPLE APPLICATIONS AND SOURCE CODE \(Pg. 67\)](#). Includes how to easily connect to an Arduino.
- RoHS compliant.
- CrystalFontz America, Incorporated is ISO 9001:2008 certified.
- Product materials are in compliance with the regulations related to the EU Directive 2006/121/EC for Registration, Evaluation, Authorization and Restriction of Chemicals (REACH).






EXPLANATION OF PART NUMBER CODES IN THIS DATASHEET

<u>CFA</u>	<u>533</u>	-	*	*	*	-	<u>K</u>	<u>C</u>	*
①	②		③	④	⑤		⑥	⑦	⑧

①	Brand	CrystalFontz America, Incorporated
②	Model Identifier	533
③	Backlight Type & Color	T – LED, white Y – LED, yellow-green
④	Fluid Type, Image (positive or negative), & LCD Glass Color	F – FSTN, positive, neutral M – STN, negative blue Y – STN, positive yellow-green
⑤	Polarizer Film Type, Temperature Range, & View Angle (O 'Clock)	I – Transmissive, Temperature, 6:00 H – Transflective, Temperature, 6:00 <i>Operating temperature range is from -20°C minimum to +70°C maximum. For more information on Viewing Angle, see ELECTRICAL SPECIFICATIONS (Pg. 22).</i>
⑥	Special Code 1	K – Manufacturer's codes
⑦	Special Code 2	C – I ² C interface
⑧	Customize Configuration Codes	= 1 or more characters

When you order a CFA533 through our website, you can customize your order with different configurations and accessories.

Part Number	 CFA533-TFH-KC	 CFA533-TMI-KC	 CFA533-YYH-KC
Fluid	FSTN	STN	STN
LCD Glass Color	neutral	blue	yellow-green
Image	positive	negative	positive
Polarizer Film	transflective	transmissive	transflective
LEDs	Backlight: white Keypad: white	Backlight: white Keypad: blue	Backlight: yellow-green Keypad: yellow-green

Notes

FSTN has better contrast than *STN*.

Positive Image: The display can be read in normal office lighting, in dark areas, and in bright sunlight.

Negative Image: Display can be read in normal office lighting and in dark areas. May be difficult to read in direct sunlight.



MECHANICAL SPECIFICATIONS

PHYSICAL CHARACTERISTICS

ITEM	SPECIFICATION
Display Module Overall Width and Height	110.5 (W) x 35.0 (H)
Depth with Keypad, with Connectors	25.60 mm nominal 25.90 mm maximum
Viewing Area	61.0 (W) x 15.8 (H) mm
Active Area	56.2 (W) x 11.5 (H) mm
Character Size	2.95 (W) x 5.55 (H) mm
Character Pitch	3.55 (W) x 5.95 (H) mm
Pixel Size	0.55 (W) x 0.65 (H) mm
Pixel Pitch	0.60 (W) x 0.70 (H) mm
Keystroke Travel (approximate)	2.4 mm
Weight	41 grams (typical)

VIBRATION

Test conditions:

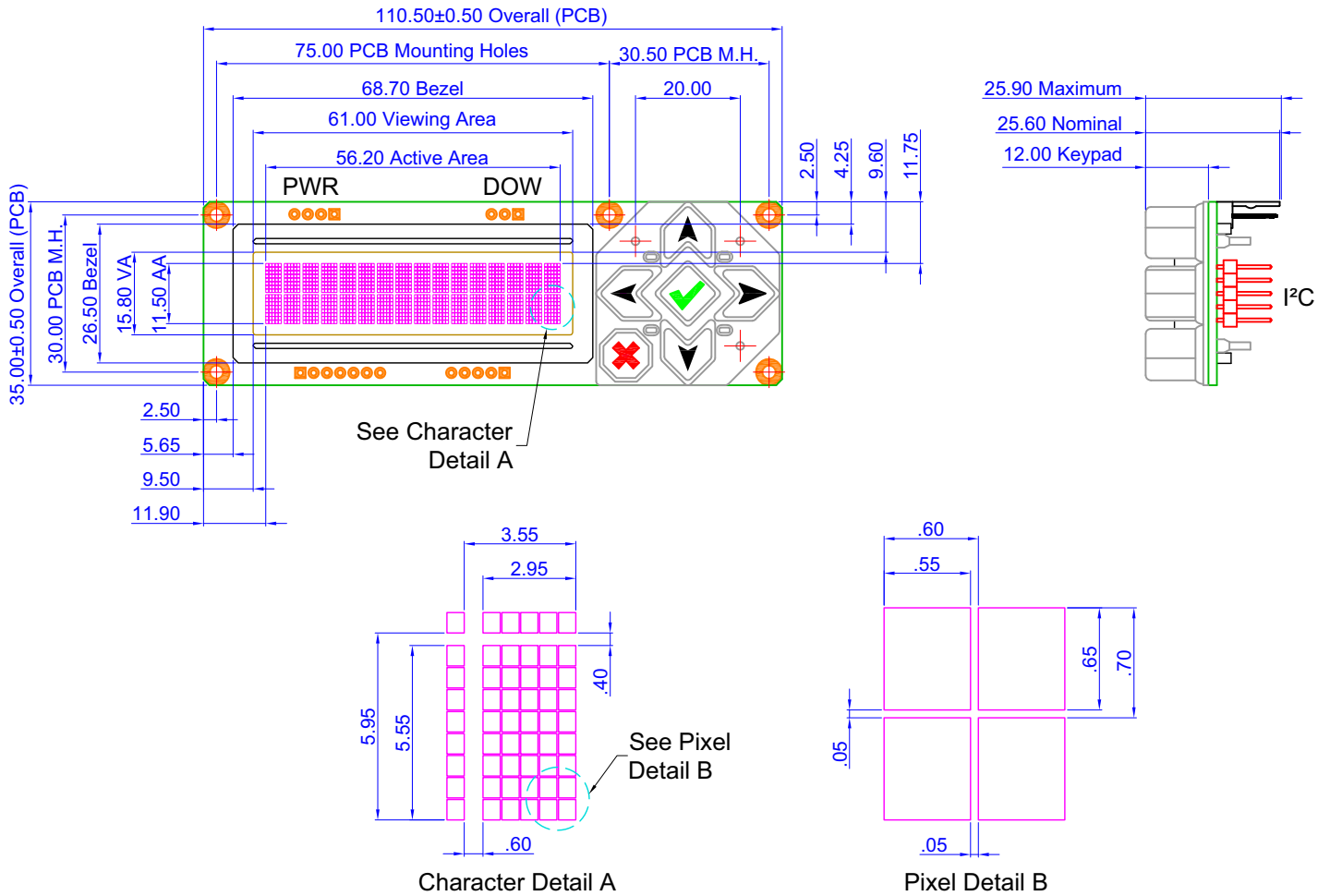
- GR-63-CORE 5.4.2, Office Vibration, Alternative Test: 5-100-5 Hz at 1.0 g with a sweep rate of .25.
- Octave/minute, 35 minutes per axis.
- MIL-STD 810F, Figure 514C-17, Random: 1 hour per axis.
- MIL-STD 810F, Figure 514C-18, Sine: 1 hour per axis.

For details see [APPENDIX E: VIBRATION TEST REPORT \(Pg. 90\)](#).



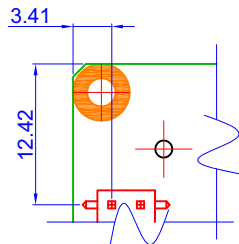
DISPLAY MODULE OUTLINE DRAWINGS

Figure 1. Display Module Outline Drawings (two page below)

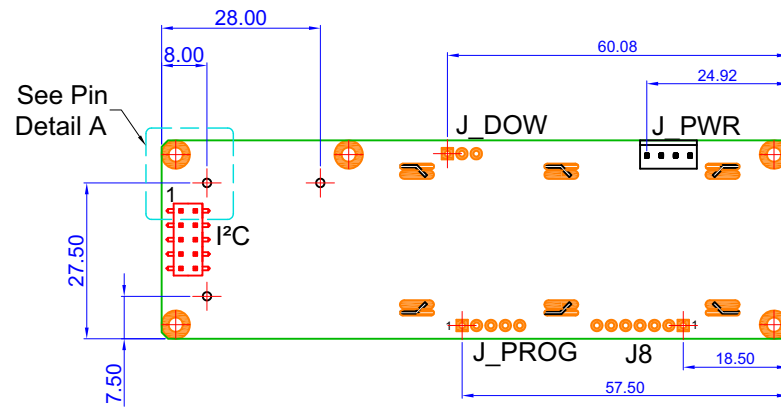
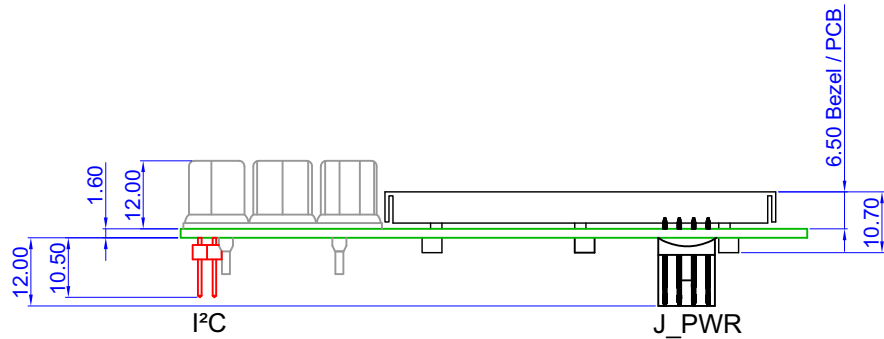
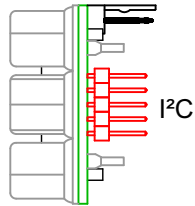


Tolerance is ±0.3 mm unless specified.





Pin Detail A



Back View

Tolerance is ± 0.3 mm unless specified.





KEYPAD DETAIL DRAWING

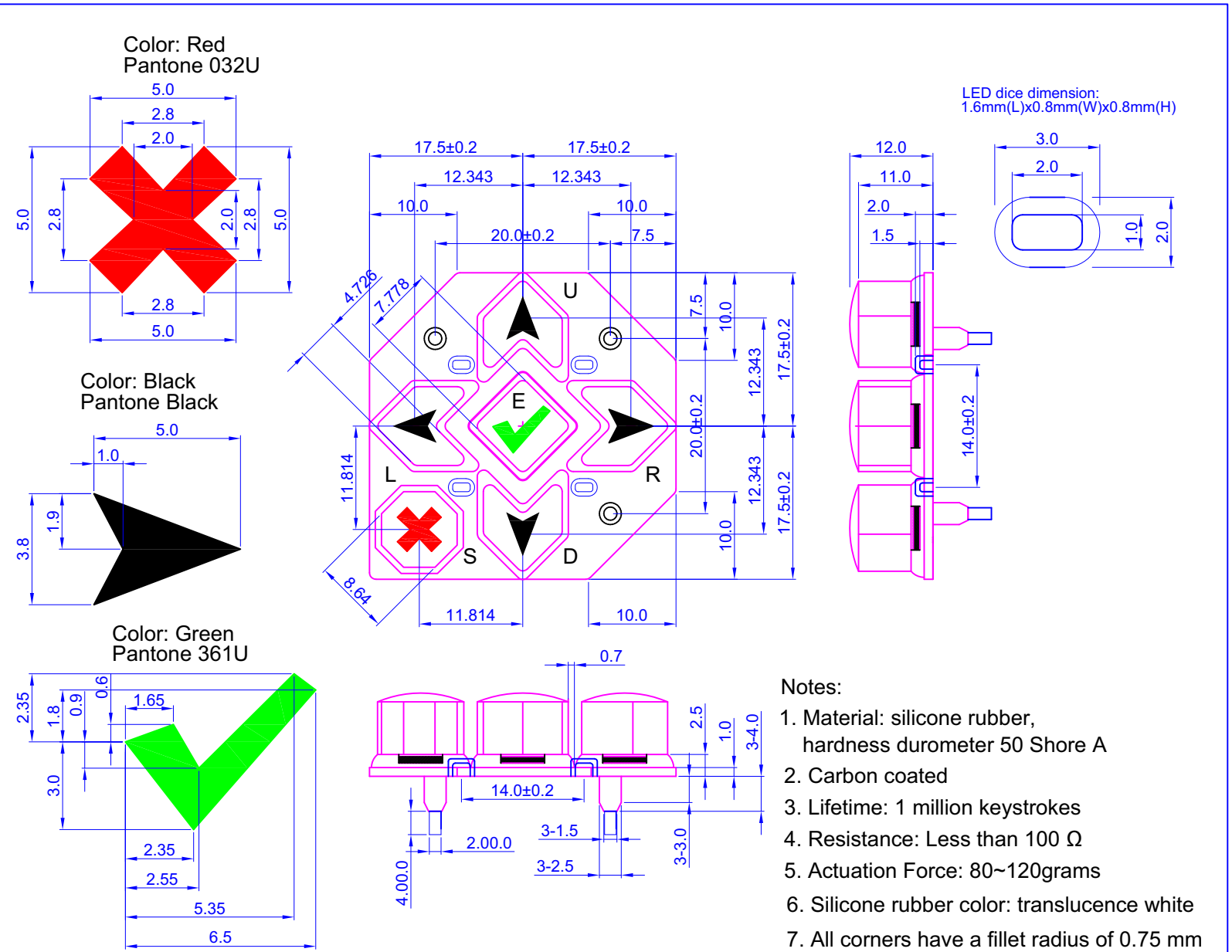



Figure 2. Keypad Detail Drawing

 <p>copyright © 2009 by Crystalfontz America, Inc. www.crystalfontz.com/products/</p>	<p>Part No.(s): CFA533 Series Keypad Detail</p>	<p>Scale: Not to scale</p>	<p>Drawing Number: CFA533_master</p>	<p>Hardware Rev.: v1.1</p>
		<p>Units: Millimeters</p>	<p>Date: 2011/07/25</p>	<p>Sheet: 1 of 1</p>



PANEL MOUNTING APPLICATION CUTOUT DRAWING

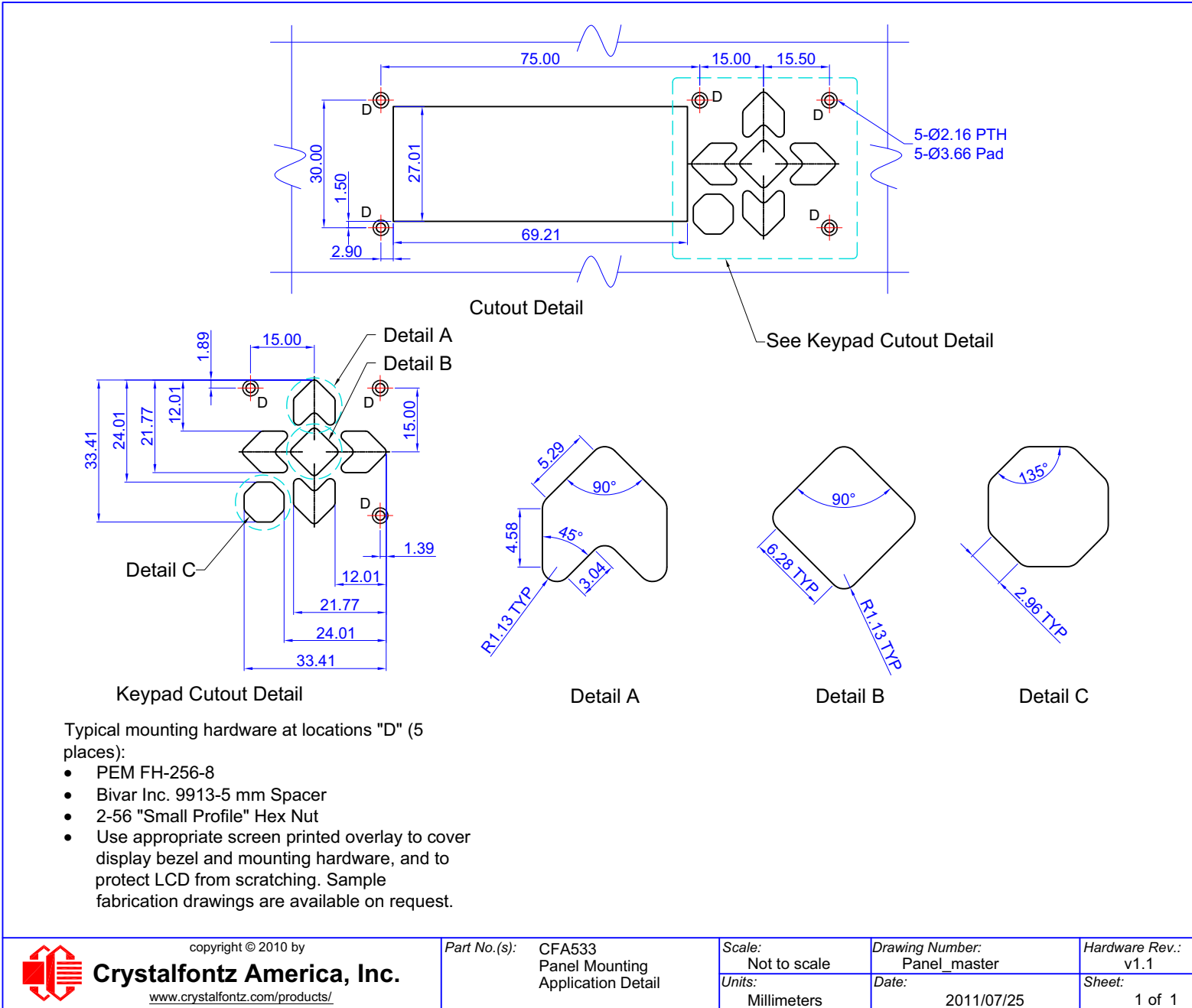


Figure 3. Panel Mount Application Cutout Drawing for Optional Bracket



OPTICAL CHARACTERISTICS

CFA533-TFH-KC	SYMBOL	CONDITION	TYPICAL	MAXIMUM
Viewing Angle (12 o'clock)	Deg $\theta = 90^\circ$	CR \geq 2	35	
	Deg $\theta = 270^\circ$		60	
	Deg $\theta = 0^\circ$		45	
	Deg $\theta = 180^\circ$		45	
Contrast Ratio ¹	CR	3.8	5	
LCD Response Time ^{2,3}	T rise	Ta = 25°C	180 ms	
	T fall		200 ms	
¹ Contrast Ratio = (brightness with pixels light)/(brightness with pixels dark). ² Response Time: The amount of time it takes a liquid crystal cell to go from active to inactive or back again ³ For reference only.				
Viewing Direction: 6 o'clock				

CFA533-TMI-KC & CFA533-YYH-KC	SYMBOL	CONDITION	TYPICAL	MAXIMUM
Viewing Angle (12 o'clock)	Deg $\theta = 90^\circ$	CR \geq 2	30	
	Deg $\theta = 270^\circ$		40	
	Deg $\theta = 0^\circ$		30	
	Deg $\theta = 180^\circ$		30	
Contrast Ratio ¹	CR	3.8	5	
LCD Response Time ^{2,3}	T rise	Ta = 25°C	180 ms	
	T fall		200 ms	
¹ Contrast Ratio = (brightness with pixels light)/(brightness with pixels dark). ² Response Time: The amount of time it takes a liquid crystal cell to go from active to inactive or back again ³ For reference only.				
Viewing Direction: 6 o'clock				



TEST CONDITIONS AND DEFINITIONS FOR OPTICAL CHARACTERISTICS

We work to continuously improve our products, including backlights that are brighter and last longer. Slight color variations from module to module and batch to batch are normal.

- Viewing Angle
 - Vertical (V) θ : 0°
 - Horizontal (H) ϕ : 0°
- Frame Frequency: 78 Hz
- Driving Waveform: 1/160 Duty, 1/13 Bias
- Ambient Temperature (Ta): 25°C

Definition Of Optimal Contrast Setting

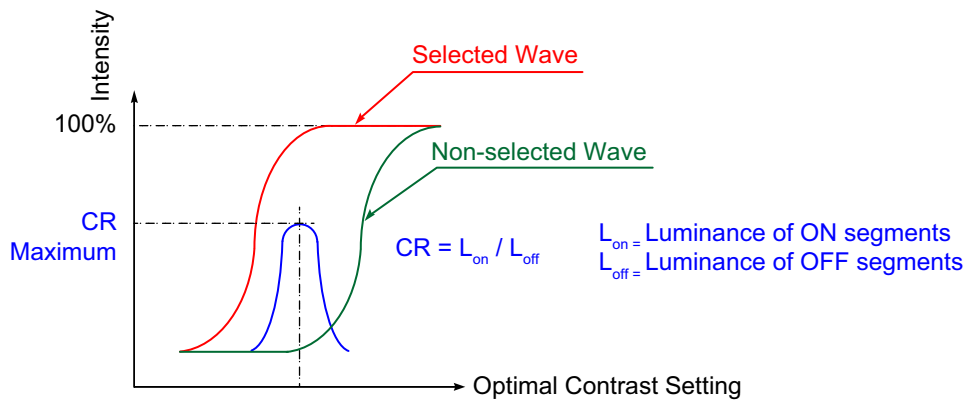


Figure 4. Definition Of Optimal Contrast Setting (Negative Image)

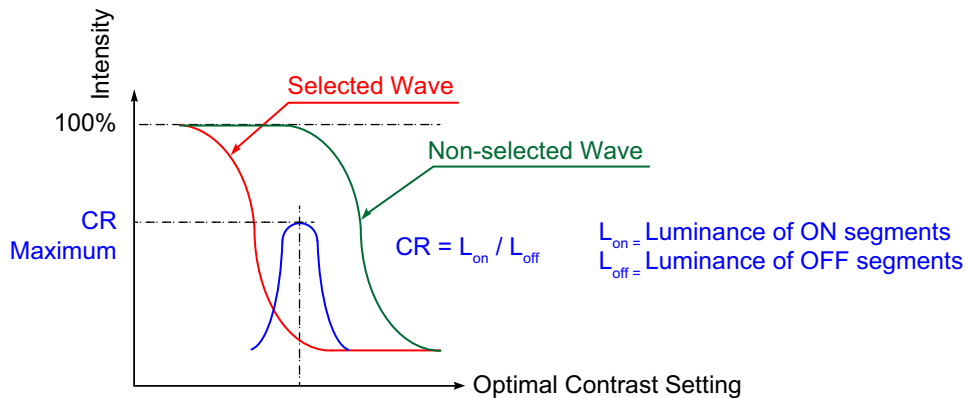
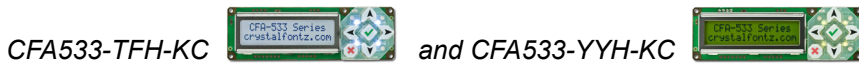


Figure 5. Definition Of Optimal Contrast Setting (Positive Image)



Definition Of Response Time (T_r , T_f)

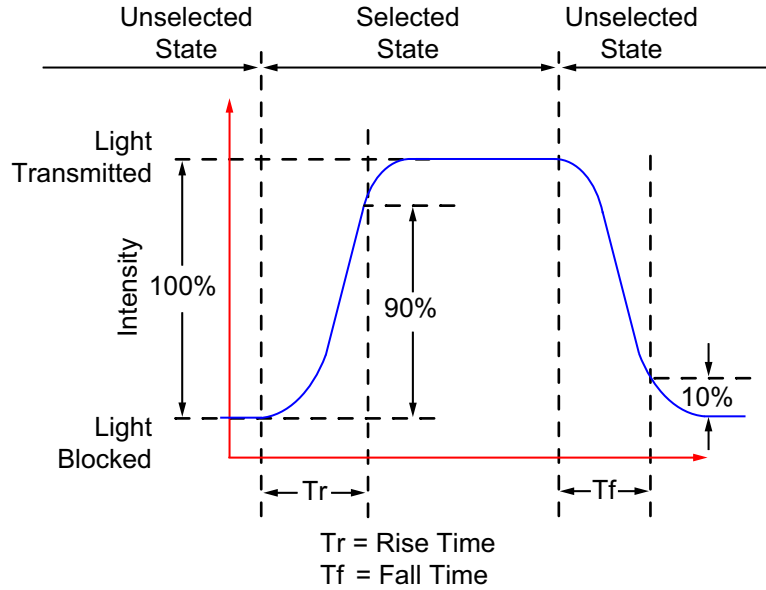


Figure 6. Definition Of Response Time (T_r , T_f) (Negative Image)

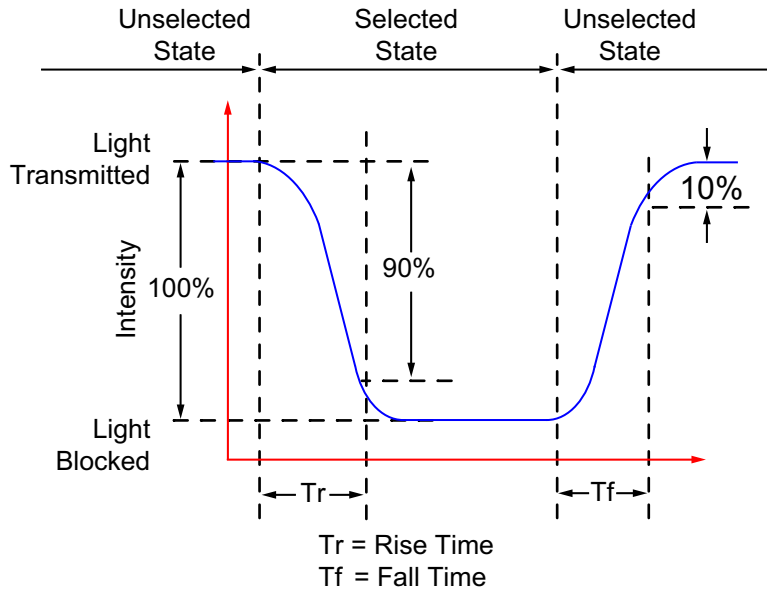
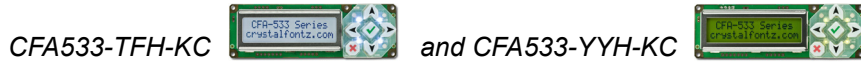


Figure 7. Definition Of Response Time (T_r , T_f) (Positive Image)



Definition Of 6 O'Clock And 12:00 O'Clock Viewing Angles

The CFA533 has a 6 o'clock viewing angle.

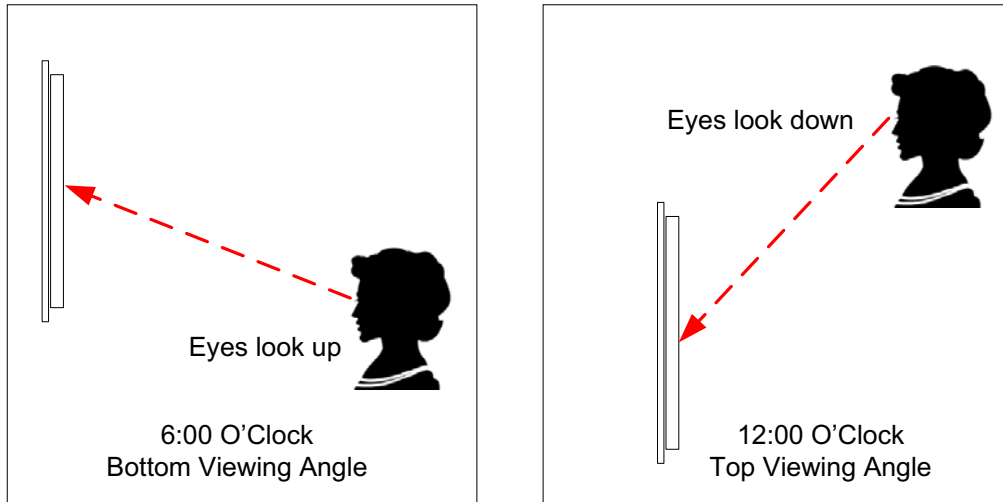


Figure 8. Definition Of 6:00 O'Clock And 12:00 O'Clock Viewing Angles

Definition Of Vertical And Horizontal Viewing Angles (CR_≥2)

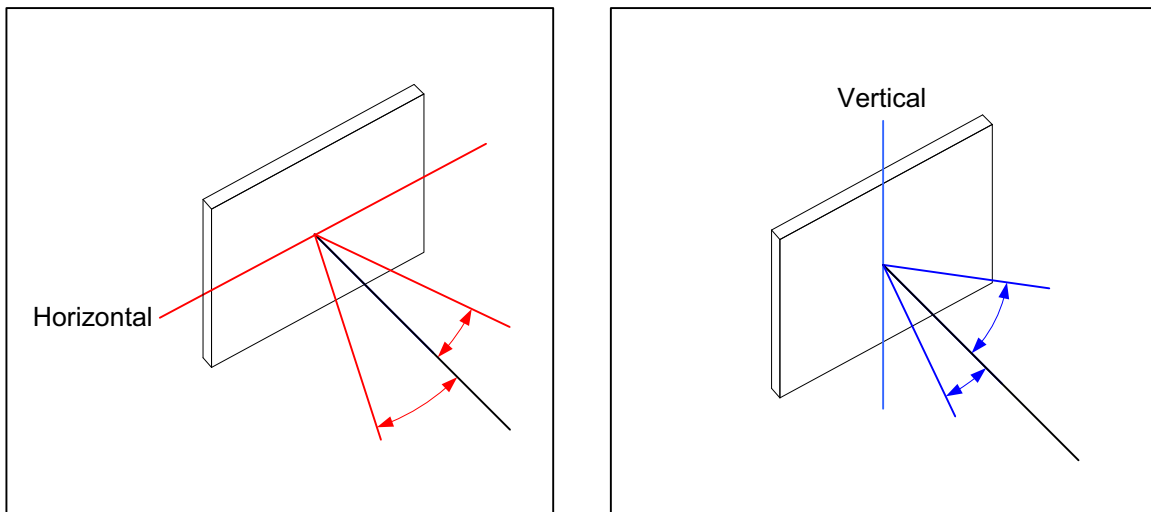


Figure 9. Definition Of Horizontal And Vertical Viewing Angles (CR_≥2)



ELECTRICAL SPECIFICATIONS

SYSTEM BLOCK DIAGRAM

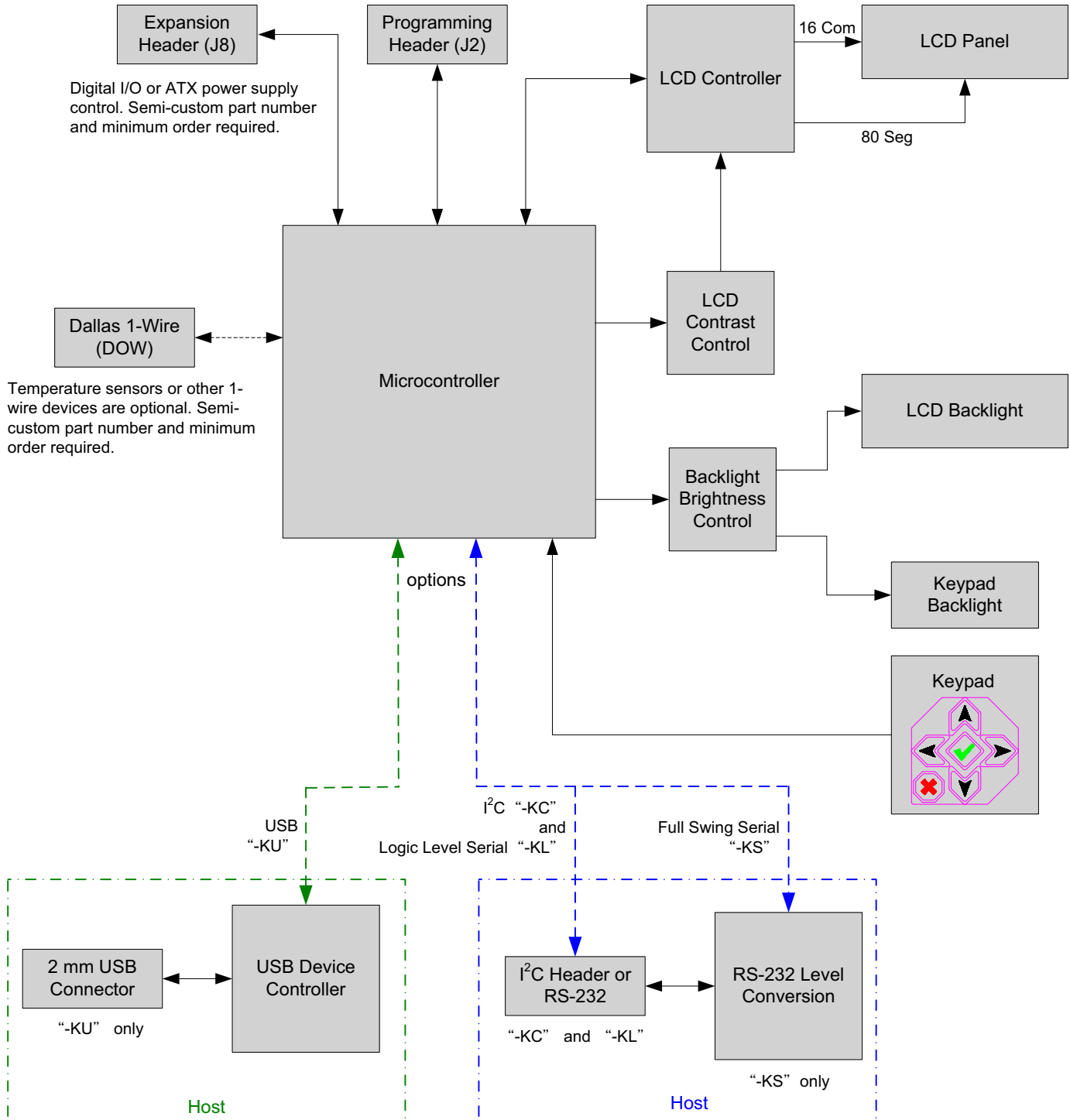


Figure 10. System Block Diagram



LCD DUTY AND BIAS

DRIVING METHOD	SPECIFICATION
Duty ¹	1/16
Bias ²	1/5

¹The 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.

²The drive bias, also known as voltage margin, is related to the number of voltage levels used when driving the LCD. Bias is defined as $1/(\text{number of voltage levels}-1)$. 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

ABSOLUTE MAXIMUM RATINGS	SYMBOL	MINIMUM	MAXIMUM
Operating Temperature	T _{OP}	-20°C	+70°C
Storage Temperature	T _{ST}	-30°C	+80°C
Humidity Range (Non-condensing)	RH	10%	90%
Supply Voltage for Logic	V _{DD}	0v	+5.5v
<p><i>Notes:</i> These are stress ratings only. Extended exposure to the absolute maximum ratings listed above may affect device reliability or cause permanent damage.</p> <p>Changes in temperature can result in changes in contrast.</p>			

SUPPLY VOLTAGES AND CURRENT

SUPPLY VOLTAGE	MINIMUM	MAXIMUM
Power Supply voltage (V _{DD})	+3.3v	+5.5v
Pull-in voltage		+3.2v
Drop-out voltage		+3.0v

PART NUMBER	ITEMS ENABLED	TYPICAL CURRENT CONSUMPTION
CFA533-***-KC (all variants)	+5v for logic (LCD + controller), backlight off	< 20mA
CFA533-TFH-KC CFA533-TMI-KC	+5v for logic (LCD + controller) + white backlight	< 100mA
CFA533-YYH-KC	+5v for logic (LCD + controller) + backlight	< 120mA

GPIO CURRENT LIMITS	SPECIFICATION
Sink	25 mA
Source	10 mA



CFA533-TFH-KC
Supply Current vs Supply Voltage (Typical)
Over Backlight Range

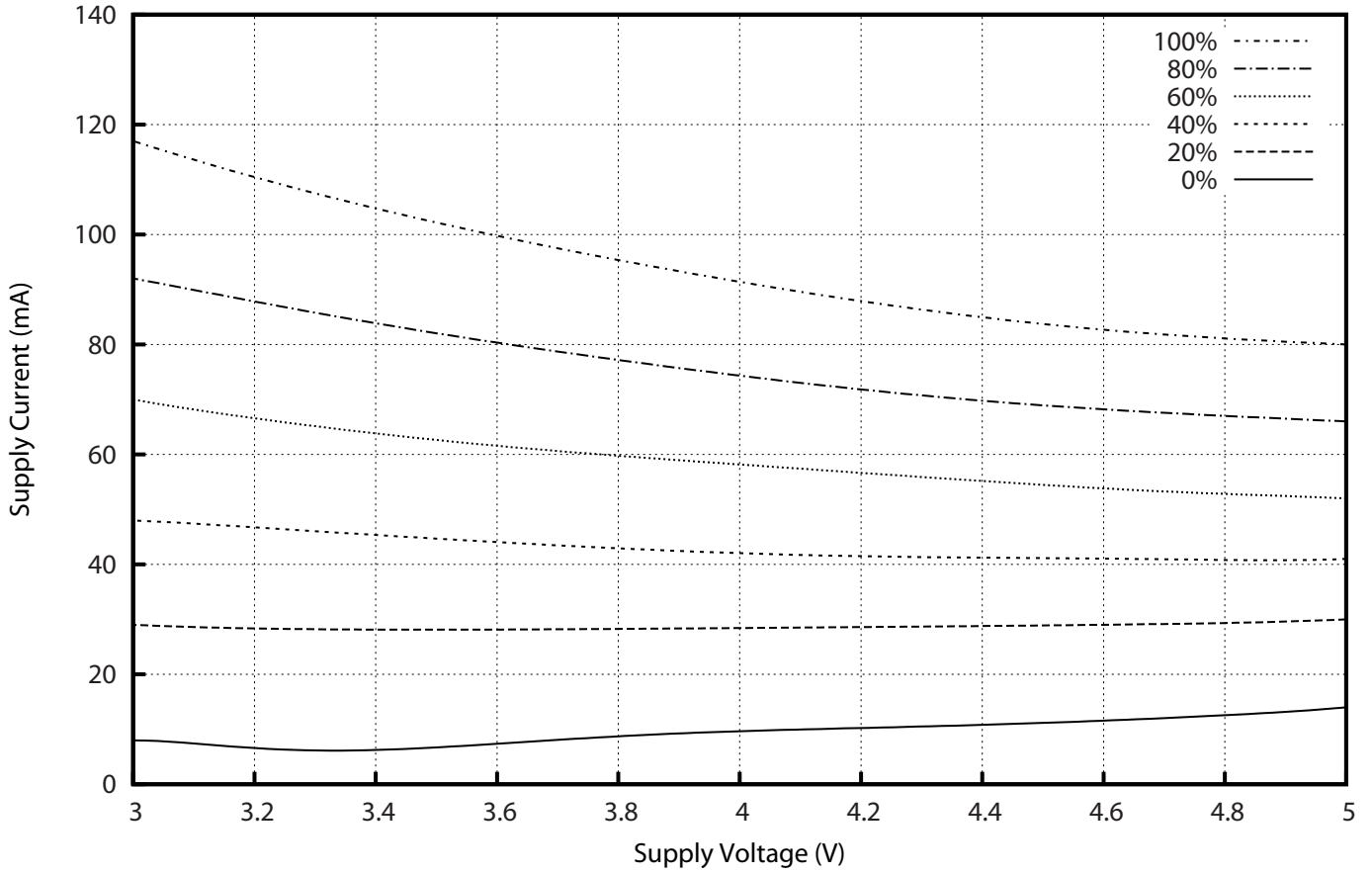


Figure 11. CFA533-TFH-KC Current Usage



CFA533-TMI-KC
Supply Current vs Supply Voltage (Typical)
Over Backlight Range

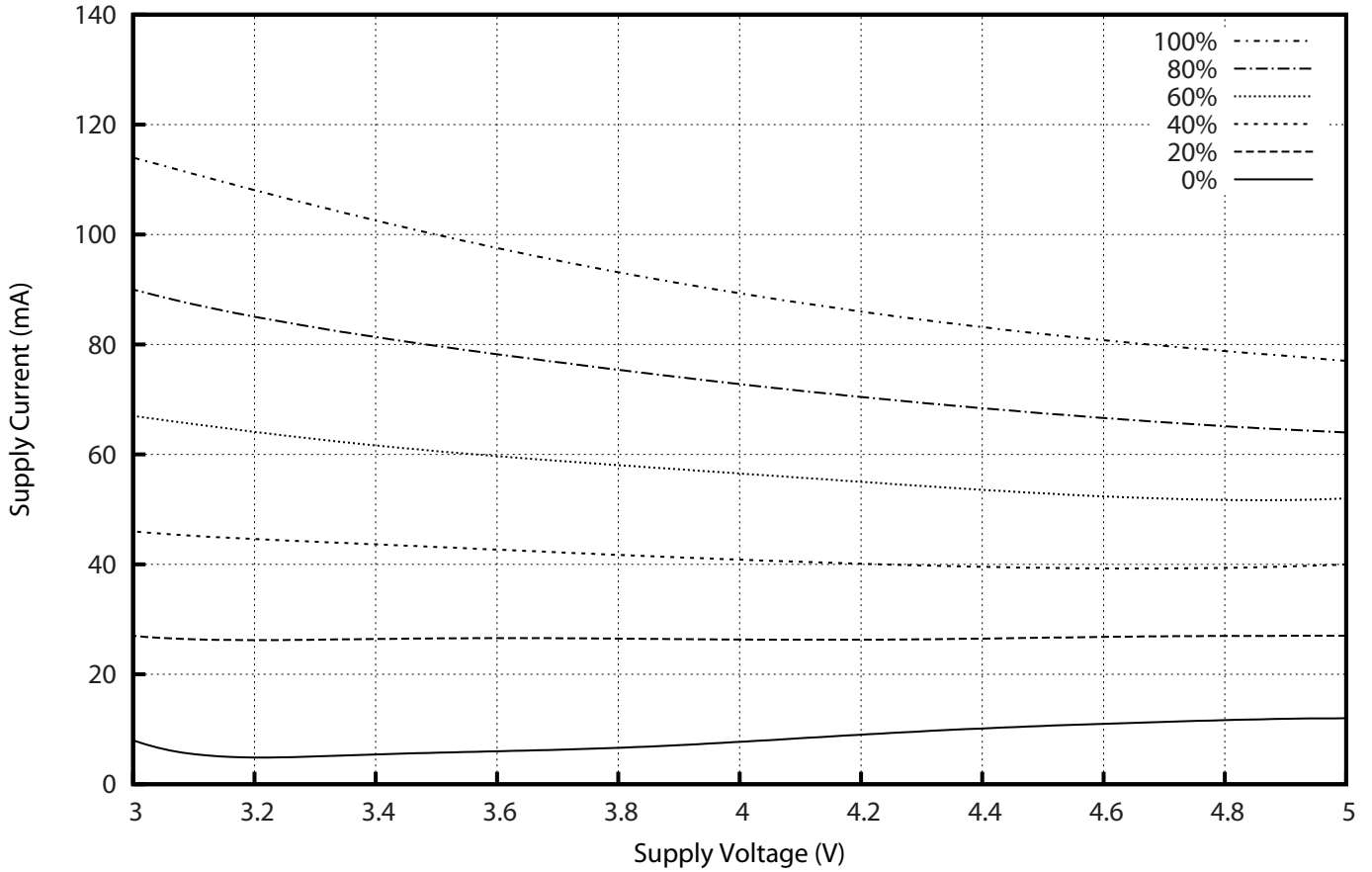


Figure 12. CFA533-TMI-KC Current Usage



CFA533-YYH-KC
Supply Current vs Supply Voltage (Typical)
Over Backlight Range

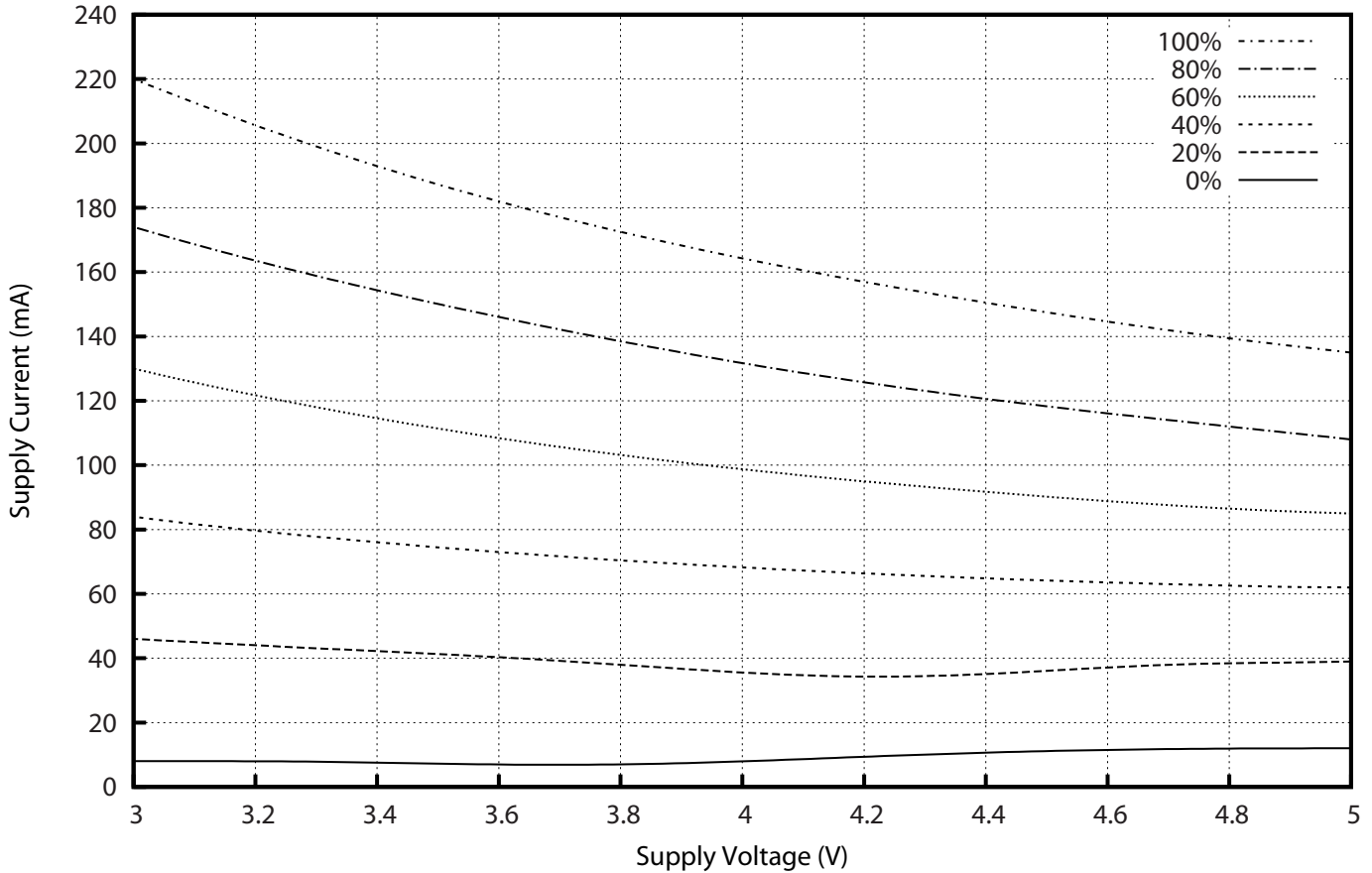


Figure 13. CFA533-YYH-KC Current Usage

ESD (ELECTRO-STATIC DISCHARGE) SPECIFICATIONS

This 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.



CONNECTION INFORMATION

OVERVIEW OF CONNECTION INFORMATION

The host power supply can power the CFA533-***-KC:

1. *Without ATX*: This is the basic method to supply power to the LCD module (“non-ATX”).
2. *ATX*: This method supplies power to the LCD module and has Host Power Sense: power on, power off, and reset functionality.

This section also describes connections for optional accessories.

[Jumpers That Can Be Modified \(Pg. 29\)](#)

[Power Supply Connection \(Non-ATX\) \(Pg. 30\)](#)

[Connection through J_PWR Connector \(Non-ATX\) \(Pg. 30\)](#)

[Connection through J_RS232 Connector \(Non-ATX\) \(Pg. 31\)](#)

[ATX Power Supply and Control Connection for Host Power Sense \(Pg. 31\)](#)

[ATX Host Power Sense through +5v on J_PWR Connector \(Pg. 32\)](#)

[ATX Host Power Sense through GPIO\[1\] on J8 Connector \(Pg. 34\)](#)

[ATX Keypad Control \(Pg. 35\)](#)

[Data Communications: I²C Connections \(Pg. 36\)](#)

[GPIO Connections \(Pg. 37\)](#)

[Dallas Semiconductor 1-Wire Device Connections for Optional Accessories \(Pg. 38\)](#)

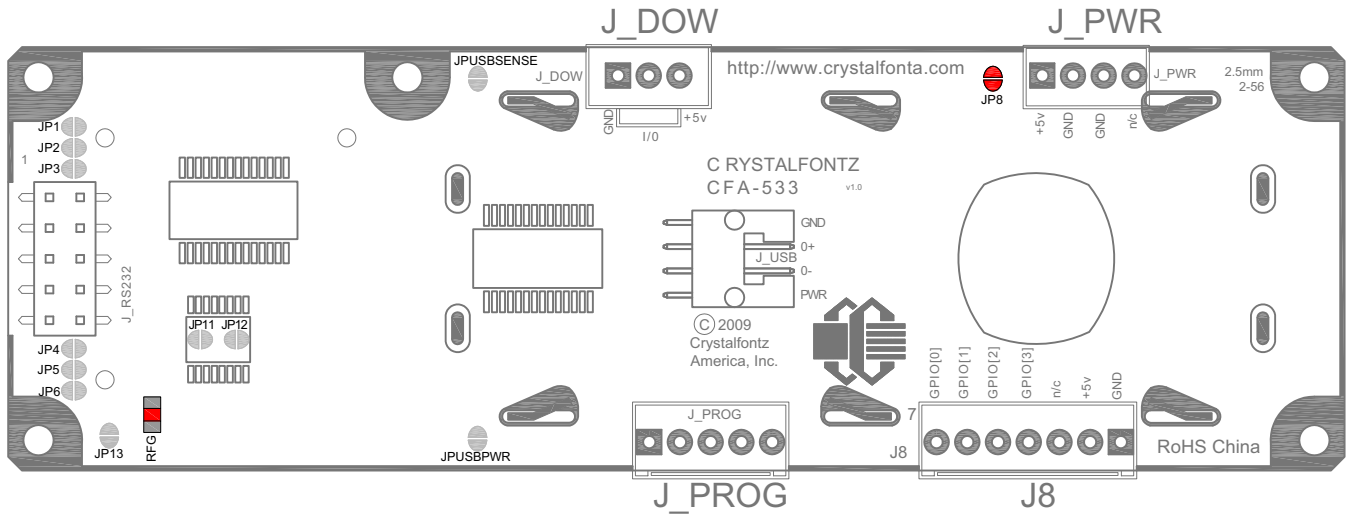
[Temperature Sensors \(Pg. 38\)](#)

[Other 1-Wire Devices \(Pg. 38\)](#)



JUMPERS THAT CAN BE MODIFIED

The CFA533-***-KC has thirteen jumpers. Only the jumpers JP8 and RFG may be changed. The displays are shipped with these jumpers closed by default. If needed, you may open these jumpers. Solder wick works well for removing solder.



JUMPER	DEFAULT	FUNCTION
JP8	open closed	+5v pin from PWR connector used only for ATX SENSE +5v pin from PWR connector supplies power to module
RFG	1MΩ 0Ω open	Mounting holes and FG trace surrounding PCB are discharged slowly to LOGIC GND. Mounting holes and FG trace are connected to LOGIC GND Mounting holes and FG trace surrounding PCB are open
Do not change JP1, JP2, JP3, JP4, JP5, JP6, JP11, JP12, JP13, JPUSBPWR, and JPUSBSense.		

Figure 14. Jumpers That Can Be Modified



POWER SUPPLY CONNECTION (NON-ATX)

Connection through J_PWR Connector (Non-ATX)

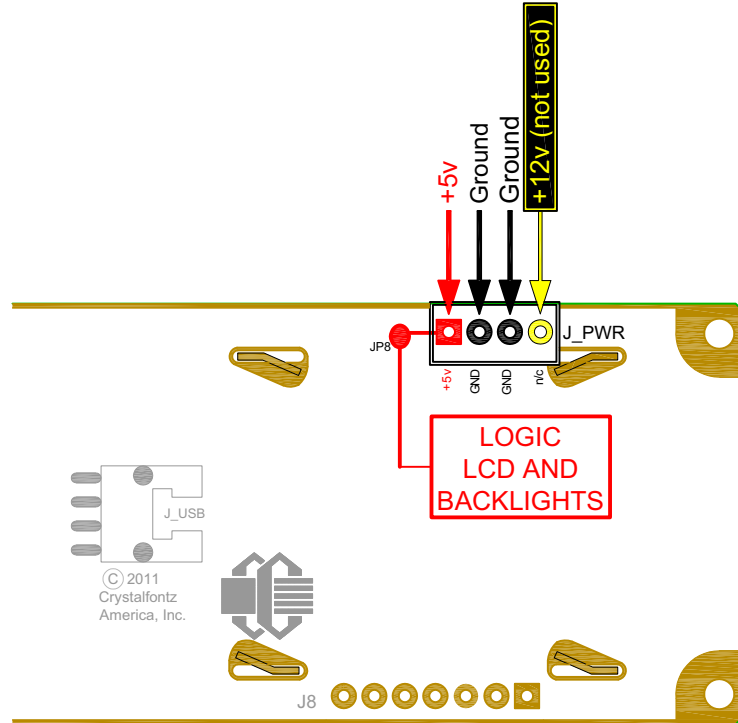


Figure 15. +5v Connection through J_PWR

You need to supply +5v to pin 1 and Ground to pin 2 or 3 on the J_PWR connector. When you buy the display through our website, you can configure your order to add the CrystalFontz cable [WR-PWR-Y12](#) to connect from the host's 4-pin power supply cable connector to the CFA533-***-KC's J_PWR connector.



Connection through J_RS232 Connector (Non-ATX)

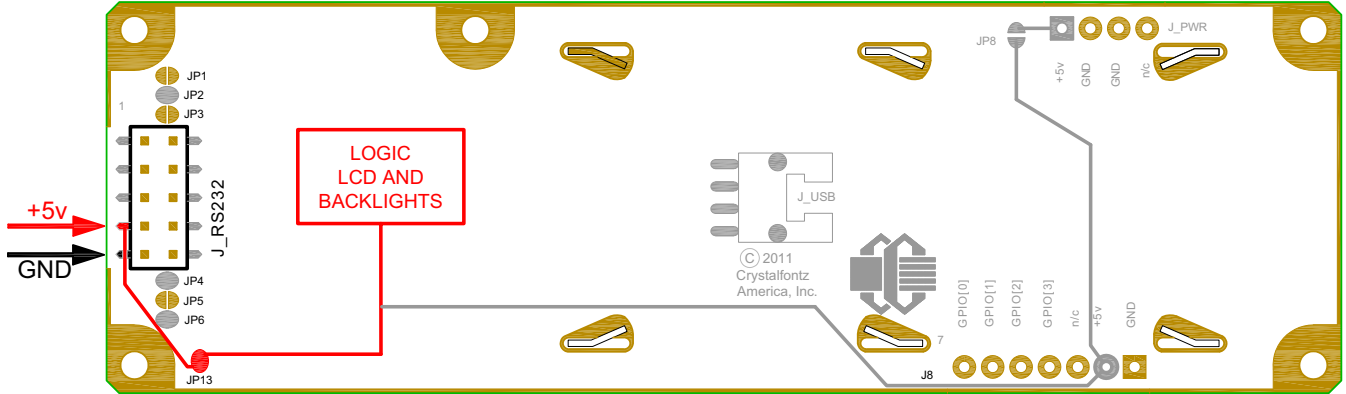


Figure 16. Power Connection through J-RS232

J-RS232 is used as an I²C connector on the CFA533-***-KC. The V_{DD} power can be supplied through connector J_RS232, allowing a single cable to contain both power and data connections. The five connections needed to operate the module are on a single column of pins on “J_RS232”. This allows a single 0.1" spacing 5-conductor cable to connect between the CFA533-***-KC and your embedded system.

When you buy displays through our website, you can configure your order to include [WR-232-Y22](#) cables (use standard or alternate pinout).

ATX POWER SUPPLY AND CONTROL CONNECTION FOR HOST POWER SENSE

The CFA533-***-KC has the ability to control power on/off and reset functions of an ATX power supply. For this functionality, the CFA533-***-KC is powered from the host's V_{SB} signal. V_{SB} is the standby power which is always-on +5v ATX power supply output.

NOTE

The GPIO pins used for ATX control must not be configured as user GPIO. If ATX Host Power Sense to LCD module is being used, do not reconfigure the GPIO pins.

Request Modification for ATX by Crystalfontz

Crystalfontz can configure the displays modules for ATX so they will be ready to use in your application without modification. Please contact technical support (+1-888-206-9720 or email support@crystalfontz.com). We will provide you with a semi-custom part number and pricing. A minimum order quantity may apply.

The two ATX connection choices are described below.



ATX Host Power Sense through +5v on J_PWR Connector

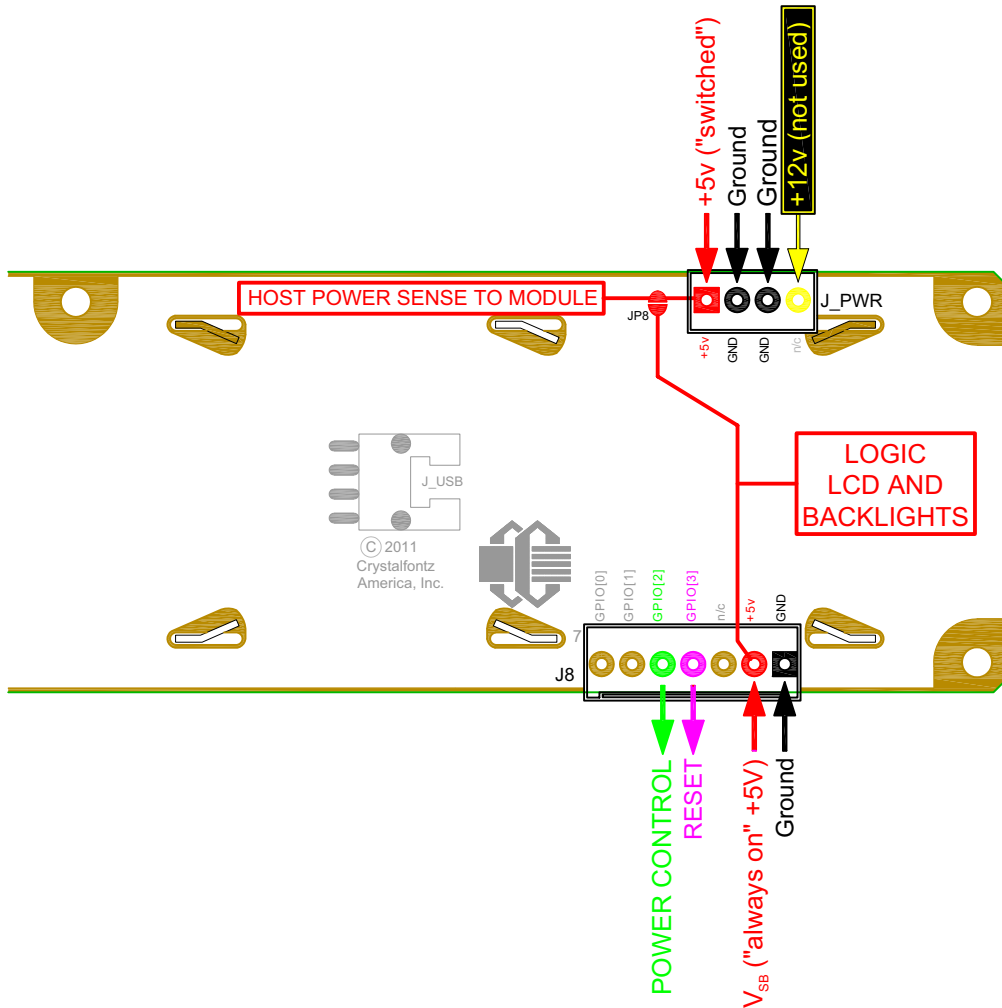


Figure 17. ATX Host Power Sense through +5v on J_PWR Connector

By default, the pin labeled +5v on the CFA533-***-KC's J_PWR connector is electrically connected to the +5v pin on the J8 connector through the normally closed JP8. **If you want to use ATX Host Power Sense through +5v on J_PWR Connector, open jumper JP8.** This will disconnect the +5v pin of the J_PWR connector from the +5v of the J8 connector. The +5v pin of the J_PWR connector will then function as the "Host Power Sense". The +5v pin of the J8 connector will function as V_{SB} power to the LCD module.

The motherboard's power switch input is connected to Pin 5 of the CFA533-***-KC's connector J8 (labeled as GPIO[2]). This pin functions as POWER CONTROL. The POWER CONTROL pin is configured as a high-impedance input until the LCD module wants to turn the host on or off, then it will change momentarily to low impedance output, driving either low or high depending on the setting of POWER_INVERT. (See command [28 \(0x1C\): Set ATX Switch Functionality \(Pg. 53\)](#).)

The motherboard's reset switch input is connected to Pin 4 of the CFA533-***-KC connector J8 (labeled as GPIO[3]). This pin functions as RESET. The RESET pin is configured as a high-impedance input until the LCD module wants to reset the host. Then it will change momentarily to low impedance output, driving either low or high.



The optional CrystalFontz [WR-PWR-Y14](#) or [WR-PWR-Y44](#) cables simplify ATX power supply control connections. JP8 from connector J_PWR is closed by default. When using either of these cables, open jumper JP8 in order to ensure correct operation.

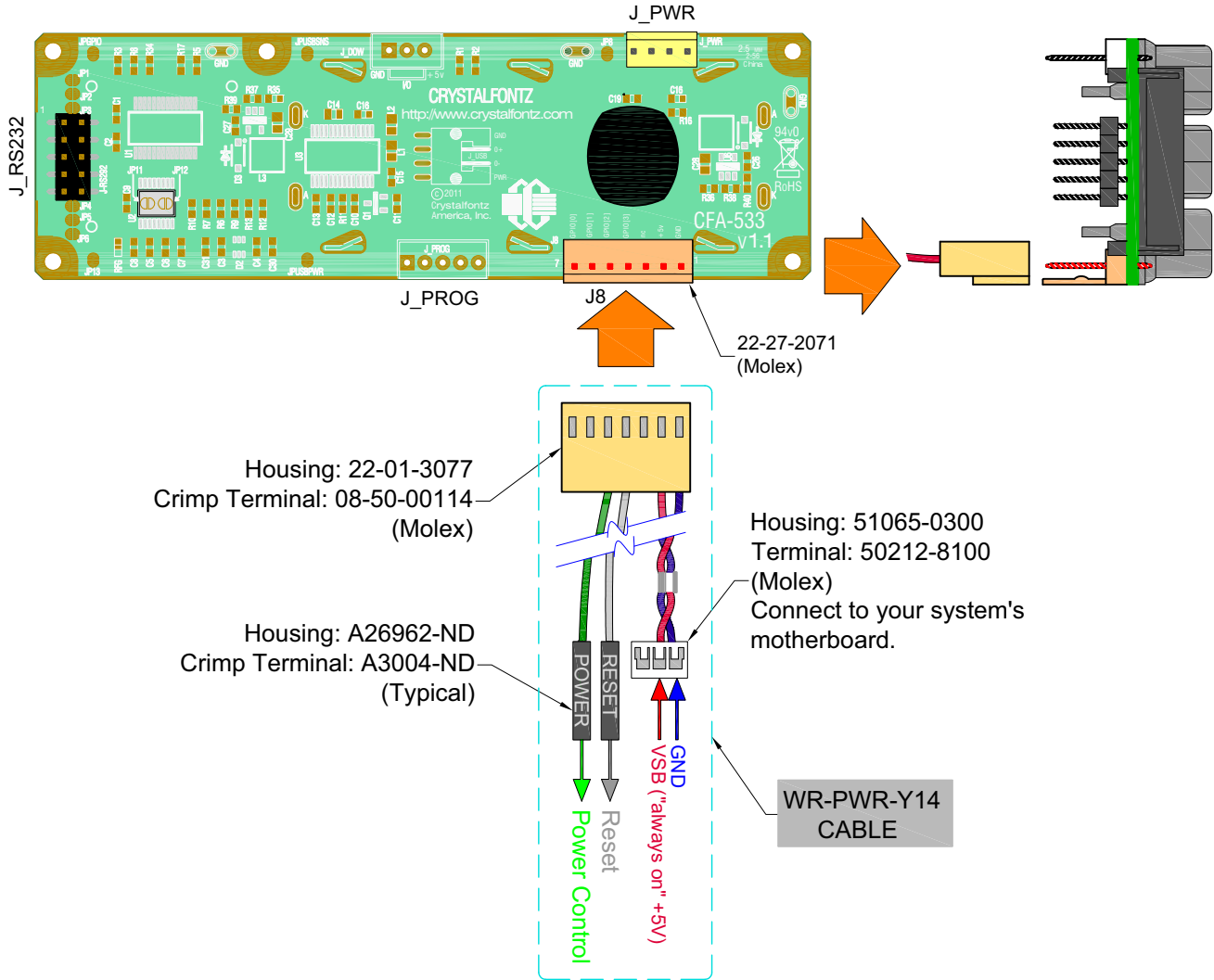


Figure 18. ATX Power Supply and Control Using CrystalFontz WR-PWR-Y14 Cable



ATX Host Power Sense through GPIO[1] on J8 Connector

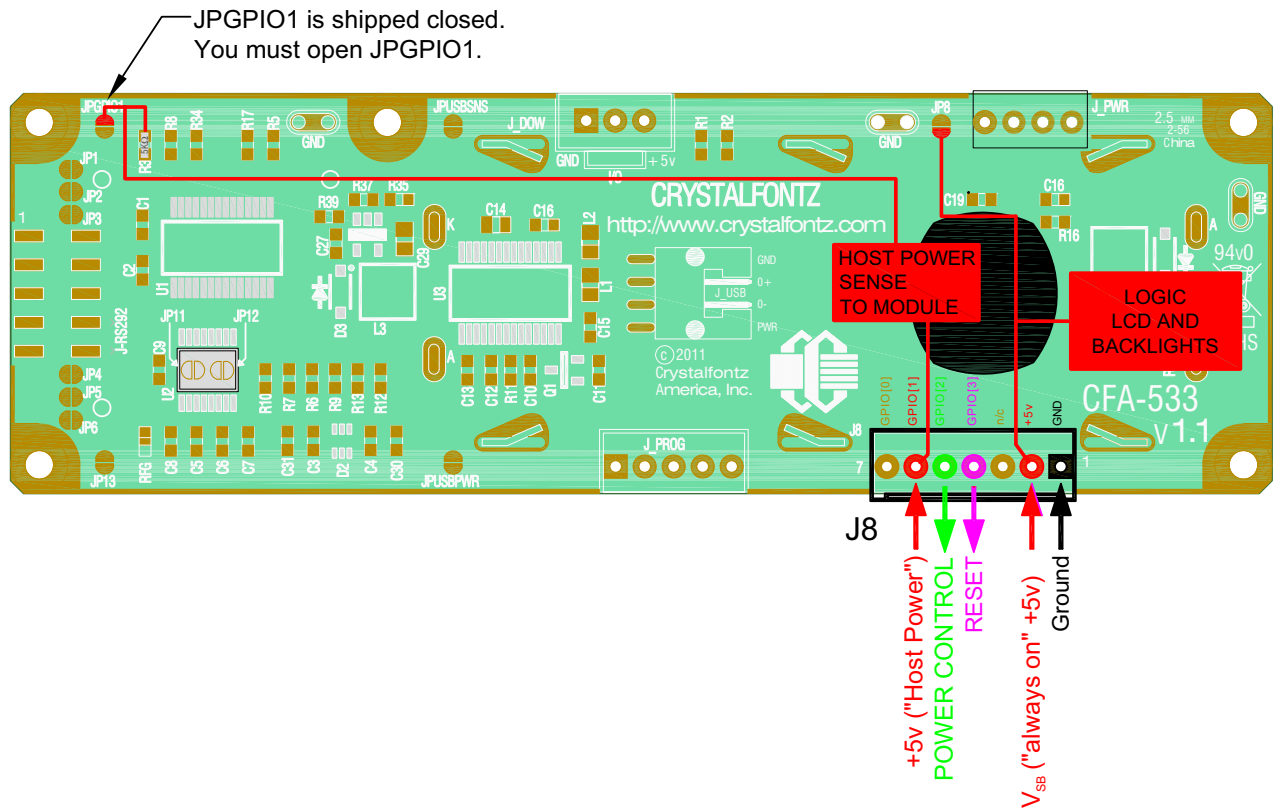


Figure 19. ATX Host Power Sense through GPIO[1] on J8 Connector

The POWER-ON SENSE can be provided through Pin 6 of J8 (GPIO[1]). This option is only provided to allow backwards compatibility for legacy CFA633 applications.

In addition to +5_{V_{SB}}, Ground, Power Control (GPIO[2]), and Reset Control (GPIO[3]) connections, you will need to supply connection to the host's +5v power to GPIO[1].

By default, the pin labeled +5v on the CFA533-***-KC's J_PWR connector is electrically connected to the +5v pin on the J8 connector through the normally closed JP8. **If you want to use ATX Host Power Sense through GPIO[1] on J8 Connector, open jumper JP8 and JPGPIO1.**



Here is an excerpt from command [28 \(0x1C\): Set ATX Switch Functionality \(Pg. 53\)](#):

NOTE ON COMMAND 28: SET ATX SWITCH FUNCTIONALITY

The GPIO pins used for ATX control must not be configured as user GPIO. The pins must be configured to their default drive mode in order for the ATX functions to work correctly.

These settings are factory default but may be changed by the user. Please see command [34 \(0x22\): Set/Configure GPIO \(Pg. 57\)](#). These settings must be saved as the boot state.

To ensure that GPIO[1] will operate correctly as ATX SENSE, user GPIO[1] must be configured as:

```
DDD = "011: 1=Resistive Pull Up, 0=Fast, Strong Drive Down".  
F = "0: Port unused for user GPIO."
```

This configuration can be assured by sending the following command:

```
command = 34  
length = 3  
data[0] = 1  
data[1] = 0  
data[2] = 3
```

To ensure that GPIO[2] will operate correctly as ATX POWER, user GPIO[2] must be configured as:

```
DDD = "010: Hi-Z, use for input".  
F = "0: Port unused for user GPIO."
```

This configuration can be assured by sending the following command:

```
command = 34  
length = 3  
data[0] = 2  
data[1] = 0  
data[2] = 2
```

To ensure that GPIO[3] will operate correctly as ATX RESET, user GPIO[3] must be configured as:

```
DDD = "010: Hi-Z, use for input".  
F = "0: Port unused for user GPIO."
```

This configuration can be assured by sending the following command:

```
command = 34  
length = 3  
data[0] = 3  
data[1] = 0  
data[2] = 2
```

These settings must be saved as the boot state.

ATX Keypad Control

Once configured by the host software (see command [28 \(0x1C\): Set ATX Switch Functionality \(Pg. 53\)](#)), the following functions may be individually enabled:

- **System power on.** If POWER-ON SENSE is low (0th), pressing the green check key (Enter key) for 0.25 seconds will turn the unit on by driving POWER CONTROL line for the pulse width set by command [28 \(0x1C\): Set ATX Switch Functionality \(Pg. 53\)](#) (1.0 seconds default).



- **System hard power off.** If POWER-ON SENSE is high (+5v power, V_{DD}) pressing the red X key (Cancel key) for 4 seconds will turn the system off by driving the POWER CONTROL line. The line will be driven for a minimum of the pulse width set by command [28 \(0x1C\): Set ATX Switch Functionality \(Pg. 53\)](#) (1.0 seconds default). If the user continues to press the key, the CFA533-***-KC will continue to drive the line for up to an additional 5 seconds.
- **System hard reset.** If POWER-ON SENSE is high (+5v power, V_{DD}) pressing the green check key (Enter key) for 4 seconds will reset the system by driving the RESET line for 1 second. The CFA533-***-KC will reboot itself immediately after resetting the host.

Since the computer and LCD module must look off if the computer's power is off, the CFA533-***-KC can be configured to monitor the POWER-ON SENSE line and blank its display any time the POWER-ON SENSE line is low.

DATA COMMUNICATIONS: I²C CONNECTIONS

Connect SDA (Serial Data) and SCL (Serial CLock) to your I²C host as shown in the figure below. The I²C bus requires external pull-up resistors. The pull-up resistors (RP) are determined by the supply voltage, clock speed, and bus capacitance. The minimum sink current for any device (master or slave) should be no less than 3 mA at $V_{OL_{MAX}} = 0.4v$ for the output stage. This limits the minimum pull-up resistor value for a 5-volt system to about 1.5k Ω . The maximum value for RP is dependent on the bus capacitance and the clock speed. For a 5-volt system with a bus capacitance of 150 pF, *the pull-up resistors should be no larger than 6k Ω* . For more information see the [UM10204 I²C-bus specification and user manual](#) on the [NXP Semiconductors](#) website.

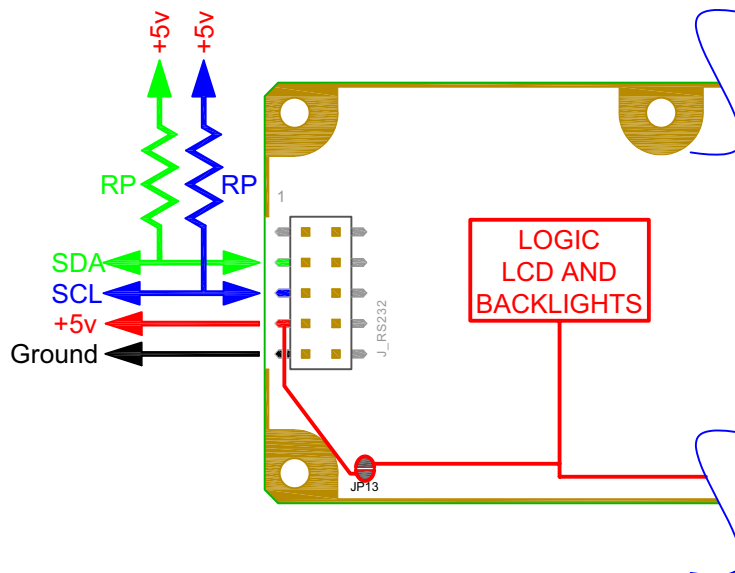


Figure 20. I²C Connections

The display module ships by default with an I²C address of 42₁₀. The I²C protocol specifies each module with two addresses. The first 7 bits of both addresses are the same, in this case 00101010₂. The address is then left bit-shifted with a read bit (1) or write bit(0). If a master device wishes to *write* to the display module, it would transmit 01010100₂ which is 42₁₀ left bit-shifted with a 0 (84₁₀). If instead a master device wishes to *read* from the display module, it would transmit 01010101₂ which is 42 left bit-shifted with a 1 (85₁₀).

Note

Each command byte and all applicable data bytes must be transmitted as a single “packet” in order to be processed correctly.



GPIO CONNECTIONS

The CFA533-***-KC has five General-Purpose Input/Output (GPIO) pins. The GPIO are port pins from the CFA533-***-KC's controller brought out to connectors. As an output, a GPIO can be used to turn on an LED, or perhaps drive a relay. As an input, a GPIO can be used to read a switch or a button. Most of the GPIOs have a default function that allows the LCD module to perform some special purpose activity with the pin.

```
GPIO[0] = J8, Pin 7
GPIO[1] = J8, Pin 6 (may be used as ATX Host Power Sense, has R3 in series)
GPIO[2] = J8, Pin 5 (default is ATX Host Power Control)
GPIO[3] = J8, Pin 4 (default is ATX Host Reset Control)
GPIO[4] = J_DOW, Pin 2 (default is DOW I/O--has 1 KΩ hardware pull-up: R2)
```

GPIO[0], GPIO[2] and GPIO[3] are connected directly from the controller port pin to the connector pin.

GPIO[1] has a series 5kΩ resistor in R3.

GPIO[4] is also used as the DOW I/O pin. Since the DOW requires a pull-up on the I/O pin, a 1kΩ resistor in R2 is loaded to pull GPIO[4] to V_{DD} (+5v power).

Please refer to commands [34 \(0x22\): Set/Configure GPIO \(Pg. 57\)](#) and [35 \(0x23\): Read GPIO Pin Levels and Configuration State \(Pg. 58\)](#) for additional details concerning the GPIO operation.

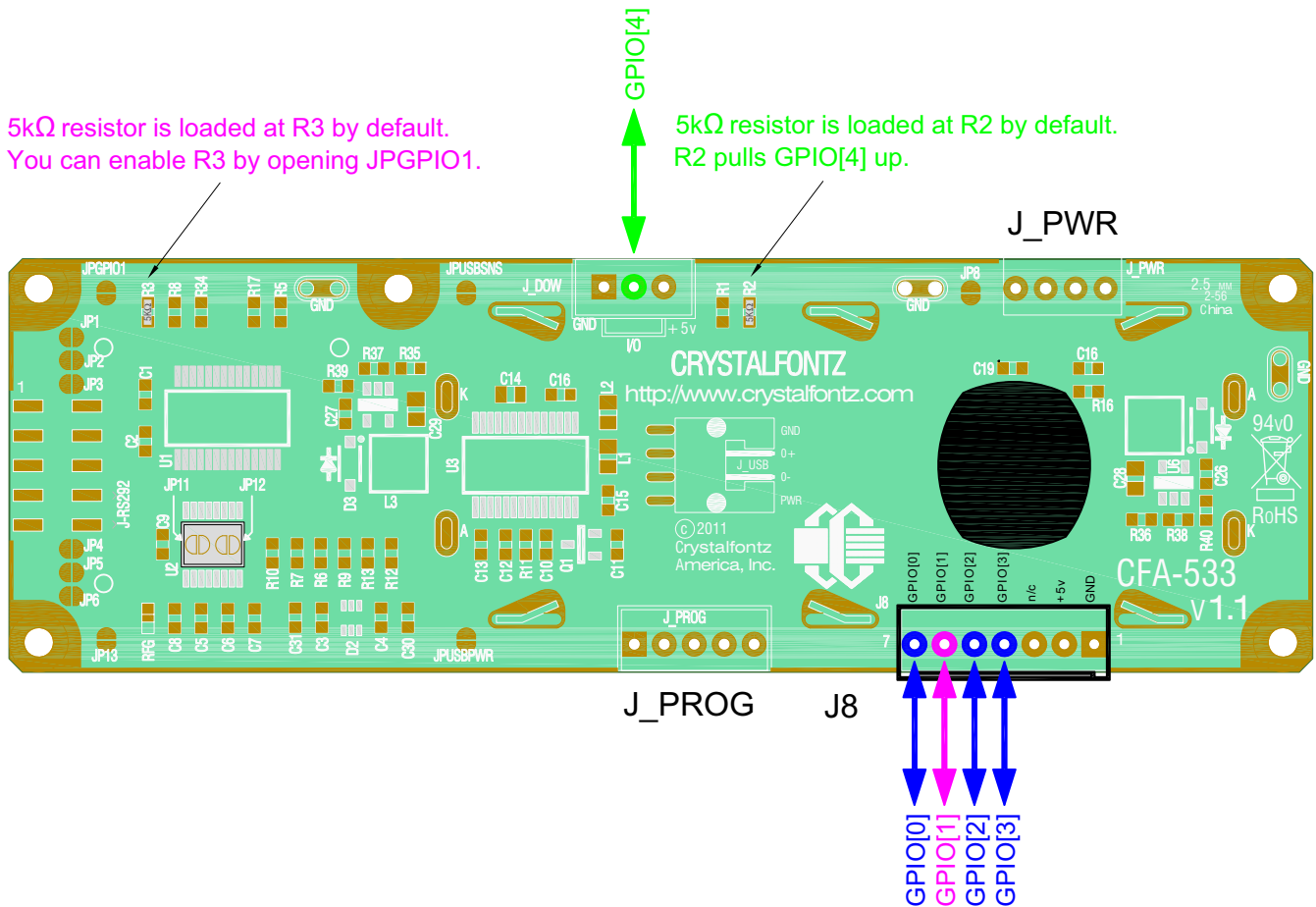


Figure 21. Location of GPIO Connections, Resistors, and J_DOW



DALLAS SEMICONDUCTOR 1-WIRE DEVICE CONNECTIONS FOR OPTIONAL ACCESSORIES

Temperature Sensors

The CFA533-***-KC supports Dallas Semiconductor 1-Wire (DOW) temperature sensors. When you order these displays through our website, you can configure your display module to include a DOW mating connector and DOW temperature sensor cables [WR-DOW-Y17](#).

The CrystalFontz WR-DOW-Y17 has a DS18B20 attached to a “daisy chain” cable. If a WR-DOW-Y17 is ordered at the same time as a CFA533-***-KC, CrystalFontz can load the WR-DOW-Y17's mating connector into the CFA533-***-KC's DOW position. For reference, the mating connector for the WR-DOW-Y17 is [Molex 0705430002](#) available from Digi-Key or other parts suppliers.

The temperature sensor can be configured to be automatically read and displayed on the CFA533-***-KC's LCD in °C or °F (see command [21 \(0x15\): Set Up Live Temperature Display \(Pg. 51\)](#)).

Other 1-Wire Devices

Other [Dallas Semiconductor 1-Wire devices](#) may be connected to the 1-Wire bus, with the CFA533-***-KC acting as a bridge between RS-232 and the 1-Wire bus (see command [21 \(0x15\): Set Up Live Temperature Display \(Pg. 51\)](#)). The total number of 1-Wire devices supported is 32, including directly supported temperature sensors and any other user-provided 1-Wire devices. (See CFA533-***-KC's DOW connection location in [Figure 21. on Pg. 37.](#)) The LCD module can send up to 15 bytes and receive up to 14 bytes. This will be sufficient for many devices but some devices require larger transactions and cannot be fully used with the module.

The CFA533-***-KC has a 1kΩ hardware pull-up on the DOW connector's I/O line.

Connect the 1-Wire sensors as detailed in the sensor's datasheet.

HOST COMMUNICATIONS

Tip: A good source for more information about I²C is [NXP Semiconductors UM10204 I2C-bus specification and user manual](#).

I²C BUFFERS

The I²C specification allows the I²C master (host) to run at clock speeds from 100 kHz down to DC.

Reading and writing data within the I²C slave (CFA533) is accomplished using buffers. The foreground process in the I²C slave (CFA533) can then operate on data deposited in its write buffer by the I²C master (host) and prepare responses to be read by the I²C master (host) from its read buffer.

During Read: If the I²C master (host) attempts to read more data than is contained in a buffer, the last byte will be retransmitted until the I²C master (host) stops reading. The I²C protocol does not define a method for the I²C slave to stop a master from reading.

During Write: When an I²C master (host) writes one or more data bytes to the I²C slave (CFA533), upon receiving the last byte for which storage is available, the I²C slave (CFA533) generates a NAK (Negative AcKnowledgegement). If the



I²C master (host) continues to write data, the slave (CFA533) will continue to NAK it. Once the first NAK is generated (data is stored in the last available location), further data is not stored.

I²C ADDRESSING

I²C addresses are contained in the upper 7-bits of the first byte of a read or write transaction. This byte is used by the I²C master to address the slave (CFA533). Valid selections are from 0-127 decimal. The lsb (least significant bit) of the byte contains the R/W bit. If this bit is 0, the address will be *written* to it; if the lsb is a 1 then the addressed slave will have data *read* from it.

The default address of the CFA533-***-KC is 42₁₀ (84₁₀ writes, 85₁₀ reads), in hexadecimal 0x2A (0x54 writes, 0x55 reads).

Display Address: To display the I²C address of the display module on the LCD, hold both the up and the down arrows for 4 seconds.

Change Address: The I²C address may be changed by command [33 \(0x21\): Set I2C Address \(Pg. 56\)](#). To make the change permanent, use command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).

The CFA533-***-KC expects to find a valid packet within the data area of I²C transactions. (See [Packet Structure \(Pg. 40\)](#)).

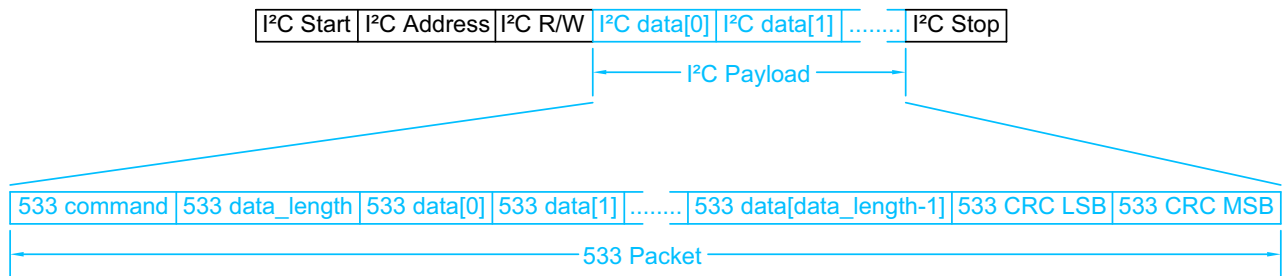


Figure 22. I²C Transactions

The host must read at least as many bytes as the size of the CFA533-***-KC response. The host may read additional bytes. These additional bytes will contain undetermined data. The host must NAK the last byte that it reads (the NAK comes just before the STOP) so the CFA533 knows that the read is terminated.



I²C DEBUGGING

The [Aardvark I²C SPI Host Adapter](#) by [Total Phase](#) may be used for debugging. We have a Windows application [533_I2C_WinTest](#) that can be used with the Aardvark to test and debug the CFA533-***-KC I²C display modules.

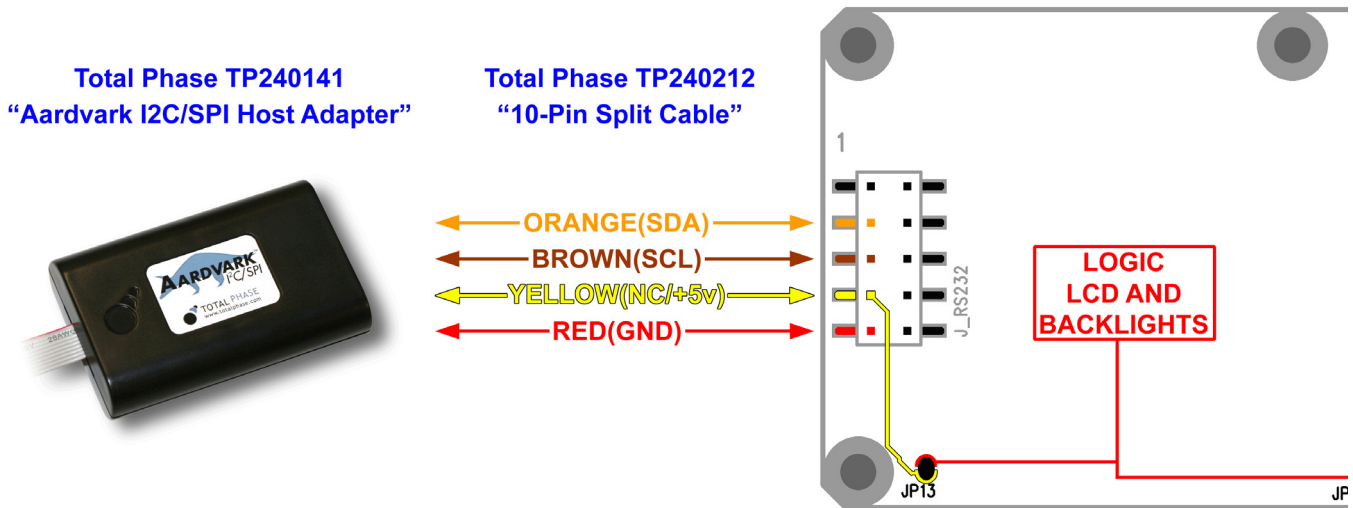


Figure 23. CFA533-***-KC Connection to Aardvark I²C/SPI Host Adapter

ARDUINO EXAMPLE CONNECTIONS AND SKETCH

We have an example project that details the steps needed to connect a CFA533 I2C LCD module to an Arduino Uno. There is a sample sketch that can be loaded into the Arduino to test it:

<https://forum.crystalfontz.com/showthread.php/7377-Connect-Arduino-Uno-to-a-CFA533-I2C-LCD-Keypad>

PACKET STRUCTURE

All communication between the CFA533 and the host takes place in the form of a simple and robust CRC checked packet. The packet format allows for very reliable communications between the CFA533 and the host without the traditional problems that occur in a stream-based serial communication (such as having to send data in inefficient ASCII format, to “escape” certain “control characters”, or losing sync if a character is corrupted, missing, or inserted).

NOTE

Reconciling packets is recommended rather than using delays when communicating with the LCD module. To reconcile your packets, please ensure that you have received the acknowledgment packet from the packet most recently sent before sending any additional packets to the LCD module. This practice will guarantee that you will not have any dropped packets or missed communication with the LCD module.

All packets have the following structure:

<type><data_length><data><CRC>

type is one byte, and identifies the type and function of the packet:



50mS (all change)

20 (0x14): Arbitrary DOW Transaction
50mS (execution time depends on the transaction)

COMMAND CODES

Below is a list of valid commands for the CFA533. Each command packet is answered by either a response packet or an error packet. The low 6 bits of the `type` field of the response or error packet is the same as the low 6 bits of the `type` field of the command packet being acknowledged.

0 (0x00): Ping Command

The CFA533 will return the Ping Command to the host.

```
type: 0x00 = 010
valid data_length is 0 to 16
data[0-(data_length-1)] can be filled with any arbitrary data
```

The return packet is identical to the packet sent, except the type will be 0x40 (normal response, Ping Command):

```
type: 0x40 | 0x00 = 0x40 = 6410
data_length: (identical to received packet)
data[0-(data_length-1)] = (identical to received packet)
```

1 (0x01): Get Hardware & Firmware Version

The CFA533 will return the hardware and firmware version information to the host.

```
type: 0x01 = 110
valid data_length is 0
```

The return packet will be:

```
type: 0x40 | 0x01 = 0x41 = 6510
data_length: 16
data[] = "CFA533:hX.X,yY.Y"
```

hX.X is the hardware revision, "1.1" for example
yY.Y is the firmware version, "c1.1" for example

2 (0x02): Write User Flash Area

The CFA533 reserves 16 bytes of nonvolatile memory for arbitrary use by the host. This memory can be used to store data such as a serial number, IP address, gateway address, netmask, or any other data required. All 16 bytes must be supplied.

You must wait up to 25mS after the I²C write phase completes to guarantee the CFA533 will have the acknowledge or response I²C packet ready to be read by the I²C host.

```
type: 0x02 = 210
valid data_length is 16
data[] = 16 bytes of arbitrary user data to be stored in the CFA533's non-volatile memory
```

The return packet will be:

```
type: 0x40 | 0x02 = 0x42 = 6610
data_length: 0
```



3 (0x03): Read User Flash Area

This command will read the User Flash Area and return the data to the host.

```
type: 0x03 = 310  
valid data_length is 0
```

The return packet will be:

```
type: 0x40 | 0x03 = 0x43 = 6710  
data_length: 16  
data[] = 16 bytes user data recalled from the CFA533's non-volatile memory
```

4 (0x04): Store Current State as Boot State

ERRATA NOTE

At voltages lower than +5v, the operation of reading from the LCD to the controller may not work correctly. If this happens, you will see corrupted characters on the LCD after using Command 4 and rebooting the LCD module.

- One workaround is to supply +5v to the module during the Command 4 operation.
- Another workaround is to have Crystalfontz set the boot state for you at the factory, using a semi-custom part number.

Please write support@crystalfontz.com if you have questions regarding this errata.

The CFA533 loads its power-up configuration from nonvolatile memory when power is applied. The CFA533 is configured at the factory to display a “welcome” screen when power is applied. This command can be used to customize the “welcome” screen, as well as the following items:

- Characters shown on LCD, which are affected by:
 - Command [6 \(0x06\): Clear LCD Screen \(Pg. 45\)](#).
 - Command [7 \(0x07\): Set LCD Contents, Line 1 \(Deprecated\) \(Pg. 45\)](#).
 - Command [8 \(0x08\): Set LCD Contents, Line 2 \(Deprecated\) \(Pg. 46\)](#).
 - Command [31 \(0x1F\): Send Data to LCD \(Pg. 56\)](#).
- Special character font definitions (command [9 \(0x09\): Set LCD Special Character Data \(Pg. 46\)](#)).
- Cursor position (command [11 \(0x0B\): Set LCD Cursor Position \(Pg. 47\)](#)).
- Cursor style (command [12 \(0x0C\): Set LCD Cursor Style \(Pg. 47\)](#)).
- Contrast setting (command [13 \(0x0D\): Set LCD Contrast \(Pg. 47\)](#)).
- LCD backlight setting (command [14 \(0x0E\): Set LCD & Keypad Backlight \(Pg. 48\)](#)).
- Keypad backlight setting (command [14 \(0x0E\): Set LCD & Keypad Backlight \(Pg. 48\)](#)).
- Settings of any live displays (command [21 \(0x15\): Set Up Live Temperature Display \(Pg. 51\)](#)).
- ATX function enable and pulse length settings (command [28 \(0x1C\): Set ATX Switch Functionality \(Pg. 53\)](#)).
- Baud rate (command [33 \(0x21\): Set I2C Address \(Pg. 56\)](#)).
- GPIO settings (command [34 \(0x22\): Set/Configure GPIO \(Pg. 57\)](#)).

You cannot store the temperature reporting (although the live display of temperatures can be saved). You cannot store the host watchdog. The host software should enable this item once the system is initialized and it is ready to receive the data.

You must wait up to 50mS after the I²C write phase completes to guarantee the CFA533 will have the acknowledge or response I²C packet ready to be read by the I²C host.



```
type: 0x04 = 410  
valid data_length is 0
```

The return packet will be:

```
type: 0x40 | 0x04 = 0x44 = 6810  
data_length: 0
```

5 (0x05): Reboot CFA533, Reset Host, or Power Off Host

This command instructs the CFA533 to simulate a power-on restart of itself, reset the host, or turn the host's power off. The ability to reset the host may be useful to allow certain host operating system configuration changes to complete. The ability to turn the host's power off under software control may be useful in systems that do not have ACPI compatible BIOS.

You must wait after the I²C write phase completes to guarantee the CFA533 will have the acknowledge or response I²C packet ready to be read by the I²C host. Execute times are up to:

500mS for parameters \008\018\099, Reboot CFA533

The CFA533 resets itself, then prepares the acknowledge packet. The host may read the acknowledge packet from the module any time starting at 500mS after the command was sent.

2mS ~ 1500mS for parameters \012\028\097, Reset host

The CFA533 prepares the acknowledge packet immediately then waits 100mS for the host to read the acknowledge packet. After that, the CFA533 will be unavailable for ~1500mS (1000mS is the length of the host reset pulse, plus ~500mS for the CFA533 to reset itself). Typically this variable delay will not be a concern, since the host system will be rebooting. When the CFA533 resets, it will display its boot screen, you may want to set the CFA533's boot screen to show a "system booting" message.

2mS ~ 9S for parameters \003\011\095, Power off host

The CFA533 prepares the acknowledge packet immediately then waits 100mS for the host to read the acknowledge packet. After that, the CFA533 will be unavailable for a variable amount of time, depending on how long after the CFA533 asserts the power signal until the host power falls. The maximum time is ~9S (1000mS is the length of the host reset pulse, up to 7.5S for the host power to fall, plus allow ~500mS for the CFA533 to reset itself), showing its boot screen. Typically this variable delay will not be a concern, since the host system will be powering down. The CFA533 can be set to blank its screen when the host power falls which makes the system appear that it is properly powered off.

NOTE

The GPIO pins used for ATX control must not be configured as user GPIO, and must be configured to their default drive mode in order for the ATX functions to work correctly. These settings are factory default, but may be changed by the user. Please see command [34 \(0x22\): Set/Configure GPIO \(Pg. 57\)](#).

Rebooting the CFA533 may be useful when testing the boot configuration. It may also be useful to re-enumerate the devices on the 1-Wire bus. To reboot the CFA533, send the following packet:

```
type: 0x05 = 510  
valid data_length is 3  
data[0] = 8  
data[1] = 18  
data[2] = 99
```



To reset the host, assuming the host's reset line is connected to GPIO[3] as described in command [28 \(0x1C\): Set ATX Switch Functionality \(Pg. 53\)](#), send the following packet:

```
type: 0x05 = 510  
valid data_length is 3  
data[0] = 12  
data[1] = 28  
data[2] = 97
```

To turn the host's power off, assuming the host's power control line is connected to GPIO[2] as described in command [28 \(0x1C\): Set ATX Switch Functionality \(Pg. 53\)](#), send the following packet:

```
type: 0x05 = 510  
valid data_length is 3  
data[0] = 3  
data[1] = 11  
data[2] = 95
```

In any of the above cases, the return packet will be:

```
type: 0x40 | 0x05 = 0x45 = 6910  
data_length: 0
```

6 (0x06): Clear LCD Screen

Empties the contents of the LCD's DDRAM and moves the cursor to the left-most column of the top line.

```
type: 0x06 = 610  
valid data_length is 0
```

The return packet will be:

```
type: 0x40 | 0x06 = 0x46 = 7010  
data_length: 0
```

The contents of DDRAM is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).

7 (0x07): Set LCD Contents, Line 1 (Deprecated)

Sets the 16 characters displayed for the top line of LCD screen.

Note

Please use this command only if you need backwards compatibility with older [CFA633](#) units. For new applications, **please use the more flexible command** [31 \(0x1F\): Send Data to LCD \(Pg. 56\)](#) which is also supported by the [CFA631](#) and [CFA635](#).

```
type: 0x07 = 710  
valid data_length is 16  
data[] = top line's display content (must supply 16 bytes)
```

The return packet will be:

```
type: 0x40 | 0x07 = 0x47 = 7110  
data_length: 0
```

Set LCD Contents, Line 1 is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).



8 (0x08): Set LCD Contents, Line 2 (Deprecated)

Sets the 16 characters displayed for the bottom line of LCD screen.

Note

Please use this command only if you need backwards compatibility with older [CFA633](#) units. For new applications, **please use the more flexible command [31 \(0x1F\): Send Data to LCD \(Pg. 56\)](#)** which is also supported by the [CFA631](#) and [CFA635](#).

```
type: 0x08 = 810
valid data_length is 16
data[] = bottom line's display content (must supply 16 bytes)
```

The return packet will be:

```
type: 0x40 | 0x08 = 0x48 = 7210
data_length: 0
```

Set LCD Contents, Line 2 is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).

9 (0x09): Set LCD Special Character Data

Sets the bitmap for each of the eight special characters (CGROM).

```
type: 0x09 = 910
valid data_length is 9
data[0] = index of special character that you would like to modify, 0-7 are valid
data[1-8] = bitmap of the new font for this character
```

`data[1-8]` are the bitmap information for this character. Any value is valid between 0 and 31, the msb is at the left of the character cell of the row, and the lsb is at the right of the character cell. `data[1]` is at the top of the cell, `data[8]` is at the bottom of the cell.

The return packet will be:

```
type: 0x40 | 0x09 = 0x49 = 7310
data_length: 0
```

Set LCD Special Character Data is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).

10 (0x0A): Read 8 Bytes of LCD Memory

This command will return the contents of the LCD's DDRAM or CGROM. This command is intended for debugging.

```
type: 0x0A = 1010
valid data_length is 1
data[0] = address code of desired data
```

`data[0]` is the address code native to the LCD controller:

```
0x40 (\064) to 0x7F (\127) for CGROM
0x80 (\128) to 0x8F (\143) for DDRAM, line 1
0xC0 (\192) to 0xCF (\207) for DDRAM, line 2
```

The return packet will be:

```
type: 0x40 | 0x0A = 0x4A = 7410
data_length: 9
```

`data[0]` of the return packet will be the address code.



data [1-8] of the return packet will be the data read from the LCD controller's memory.

11 (0x0B): Set LCD Cursor Position

This command allows the cursor to be placed at the desired location on the CFA533's LCD screen. If you want the cursor to be visible, you may also need to send a command [12 \(0x0C\): Set LCD Cursor Style \(Pg. 47\)](#).

```
type: 0x0B = 1110
valid data_length is 2
data[0] = column (0-15 valid)
data[1] = row (0-1 valid)
```

The return packet will be:

```
type: 0x40 | 0x0B = 0x4B = 7510
data_length: 0
```

Set LCD Cursor Position is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).

12 (0x0C): Set LCD Cursor Style

This command allows you to select among four hardware generated cursor options.

```
type: 0x0C = 1210
valid data_length is 1
data[0]: cursor style (0-3 valid)
    0 = no cursor
    1 = blinking block cursor
    2 = underscore cursor
    3 = blinking underscore (Note: This behavior is not the same as the CFA633 series
        which is: blinking block plus underscore.)
```

The return packet will be:

```
type: 0x40 | 0x0C = 0x4C = 7610
data_length: 0
```

Set LCD Cursor Style is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).

13 (0x0D): Set LCD Contrast

This command sets the contrast or vertical viewing angle of the display. (Initiated by the host, responded to by the CFA533.)

- [CFA633](#) Compatible

If only one byte of data is supplied, then it is the "[CFA633](#) Compatible" version of the command. Requires 1 byte (0-200) are valid, but only (0-50) are useful for this LCD.

```
type: 0x0D = 1310
valid data_length is 1
data[0]: contrast setting (0-50 valid)
    0 = light
    16 = about right
    29 = dark
    30-50 = very dark
```

The return packet for CFA633 Compatible will be:

```
type: 0x40 | 0x0D = 0x4D = 7710
data_length: 0
```

- CFA533 Enhanced

If two bytes of data are supplied, then the command takes advantage of the CFA533s native enhanced contrast resolution. Requires 2 bytes.



- The first byte data[0] is ignored, any value from 0 to 254 is accepted.
- The second byte data[1] controls the CFA533 contrast with better resolution.

```
type: 0x0D = 1310
valid data_length is 1
data[0]: required but ignored
data[1]: contrast setting (0-200 valid)
        0-99 = lighter
        100 = no correction
        101-200 = darker
```

The return packet for CFA533 Enhanced will be:

```
type: 0x40 | 0x0D = 0x4D = 7710
data_length: 0
```

Set LCD Contrast is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).

14 (0x0E): Set LCD & Keypad Backlight

This command sets the brightness of the LCD and keypad backlights. (Initiated by the host, responded to by the CFA533.)

You must wait up to 50mS (all change) after the I²C write phase completes to guarantee the CFA533 will have the acknowledge or response I²C packet ready to be read by the I²C host.

- If one byte is supplied, both the keypad and LCD backlights are set to that brightness ([CFA633](#) compatible).

```
type: 0x0E = 1410
valid data_length is 1
data[0]: keypad and LCD backlight power setting (0-100 valid)
        0 = off
        1-99 = variable brightness
        100 = on
```

The return packet if one byte is supplied will be:

```
type: 0x40 | 0x0E = 0x4E = 7810
data_length: 0
```

- If two bytes are supplied, the LCD is set to the brightness of the first byte. The keypad is set to the brightness of the second byte.

```
type: 0x0E = 1410
valid data_length is 2
data[0]: LCD backlight power setting (0-100 valid)
        0 = off
        1-99 = variable brightness
        100 = on

data[1]: keypad backlight power setting (0-100 valid)
        0 = off
        1-99 = variable brightness
        100 = on
```

The return packet if two bytes are supplied will be:

```
type: 0x40 | 0x0E = 0x4E = 7810
data_length: 0
```

Set LCD & Keypad Backlight is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).



15 (0x0F): Read Temperature

Each temperature sensor is read once every second. The most recent reading can be retrieved by the host by using this command.

```
type: 0x0F = 1510
valid_data_length: 1
data[0]: 0 to 31 DOW device index
```

The family code for the device at "device index" must be 0x22 (DS1822) or 0x28 (DS12B20). This can be verified with Command [18 \(0x12\): Read DOW Device Information \(Pg. 49\)](#).

The return packet will be:

```
type: 0x40 | 0x0F = 0x4F = 7910
data_length: 4
data[0] is the index of the temperature sensor being reported:
    0 = temperature sensor 1
    1 = temperature sensor 2
    . . .
    31 = temperature sensor 32
data[1] is the LSB of Temperature_Sensor_Counts
data[2] is the MSB of Temperature_Sensor_Counts
data[3] is DOW_crc_status
```

The following C function will decode the Temperature Sensor Report packet into °C and °F:

```
void OnReceivedTempReport(COMMAND_PACKET *packet, char *output)
{
    //First check the DOW CRC return code from the CFA533
    if(packet->data[3]==0)
        strcpy(output, "BAD CRC");
    else
    {
        double
            degc;
        degc=(*(short *)&(packet->data[1]))/16.0;

        double
            degf;
        degf=(degc*9.0)/5.0+32.0;

        sprintf(output, "%9.4f°C =%9.4f°F",
                degc,
                degf);
    }
}
```

18 (0x12): Read DOW Device Information

When power is applied to the CFA533, it detects any devices connected to the Dallas Semiconductor 1-Wire (DOW) bus and stores the device's information. This command will allow the host to read the device's information.



The first byte returned is the “family code” of the Dallas 1-Wire / iButton device. There is a list of the possible Dallas 1-Wire / iButton device family codes available in [App Note 155: 1-Wire Software Resource Guide](#) on the Maxim/Dallas website.

NOTE ON COMMAND 18: READ DOW DEVICE INFORMATION

The GPIO pin used for DOW must not be configured as user GPIO. It must be configured to its default drive mode in order for the DOW functions to work correctly.

These settings are factory default but may be changed by the user. Please see command [34 \(0x22\): Set/Configure GPIO \(Pg. 57\)](#).

In order for the DOW subsystem to be enabled and operate correctly, user GPIO[4] must be configured as:

```
DDD = "111: 1=Hi-Z, 0=Slow, Strong Drive Down".  
F = "0: Port unused for user GPIO."
```

This state is the factory default, but it can be changed and saved by the user. To ensure that GPIO[4] is set correctly and the DOW operation is enabled, send the following command:

```
command = 34  
length = 3  
data[0] = 4  
data[1] = 100  
data[2] = 7
```

This setting must be saved as the boot state, so when the CFA533 reboots it will detect the DOW devices.

```
type: 0x12 = 1810  
valid data_length is 1  
data[0] = device index (0-31 valid)
```

The return packet will be:

```
type: 0x40 | 0x12 = 0x52 = 8210  
data_length: 9  
data[0] = device index (0-31 valid)  
data[1-8] = ROM ID of the device
```

20 (0x14): Arbitrary DOW Transaction

The CFA533 can function as an I²C to Dallas 1-Wire bridge. The CFA533 can send up to 15 bytes and receive up to 14 bytes. This will be sufficient for many devices, but some devices require larger transactions and cannot be fully used with the CFA533.

This command allows you to specify arbitrary transactions on the 1-Wire bus. 1-Wire commands follow this basic layout:

```
<bus reset //Required  
<address_phase>//Must be "Match ROM" or "Skip ROM"  
<write_phase> //optional, but at least one of write_phase or read_phase must be sent  
<read_phase> //optional, but at least one of write_phase or read_phase must be sent
```

Please see [APPENDIX C: CONNECTING A DS2450 1-WIRE QUAD A/D CONVERTER \(Pg. 79\)](#) for an example of using this command.



You must wait up to 50mS after the I²C write phase completes to guarantee the CFA533 will have the acknowledge or response I²C packet ready to be read by the I²C host.

```
type: 0x14 = 2010
valid data_length is 2 to 16
  data[0] = device_index (0-32 valid)
  data[1] = number_of_bytes_to_read (0-14 valid)
data[2-15] = data_to_be_written[data_length-2]
```

If `device_index` is 32, then no address phase will be executed. If `device_index` is in the range of 0 to 31, and a 1-Wire device was detected for that `device_index` at power on, then the write cycle will be prefixed with a "Match ROM" command and the address information for that device.

If `data_length` is two, then no specific write phase will be executed (although address information may be written independently of `data_length` depending on the value of `device_index`).

If `data_length` is greater than two, then `data_length-2` bytes of `data_to_be_written` will be written to the 1-Wire bus immediately after the address phase.

If `number_of_bytes_to_read` is zero, then no read phase will be executed. If `number_of_bytes_to_read` is not zero then `number_of_bytes_to_read` will be read from the bus and loaded into the response packet.

The return packet will be:

```
type: 0x40 | 0x14 = 0x54 = 8410
data_length: 2 to 16
data[0] = device_index (0-31 valid)
data[data_length-2] = Data read from the 1-Wire bus. This is the same as
                      number_of_bytes_to_read from the command.
data[data_length-1] = 1-Wire CRC
```

21 (0x15): Set Up Live Temperature Display

You can configure the CFA533 to automatically update a portion of the LCD with a live temperature reading. Once the display is configured using this command, the CFA533 will continue to display the live reading on the LCD without host intervention. The Set Up Live Temperature Display is one of the items stored by command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#), so you can configure the CFA533 to immediately display system temperatures as soon as power is applied.

The live display is based on a concept of display slots. There are 4 slots, and each of the 4 slots may be enabled or disabled independently.

Any slot may be requested to display any data that is available. For instance, slot 0 could display temperature sensor 3 in °C, while slot 1 could simultaneously display temperature sensor 3 in °F.

Any slot may be positioned at any location on the LCD, as long as all the digits of that slot fall fully within the display area. It is legal to have the display area of one slot overlap the display area of another slot, but senseless. This situation should be avoided in order to have meaningful information displayed.



```
type: 0x15 = 2110
valid data_length is 7 or 2 (for turning a slot off)
data[0]: display slot (0-3)
data[1]: type of item to display in this slot
        0 = nothing (data_length then must be 2)
        1 = (invalid)
        2 = temperature (data_length then must be 7)
data[2]: index of the sensor to display in this slot:
        0-31 are valid for temperatures (and the temperature device must be attached)
data[3]: number of digits
        for a temperature: 3 digits (-XX or XXX)
        for a temperature: 5 digits (-XX.X or XXX.X)
data[4]: display column
        0-13 valid for a 3-digit temperature
        0-11 valid for a 5-digit temperature
data[5]: display row (0-1 valid)
data[6]: temperature units(0 = deg C, 1 = deg F)
```

If a 1-Wire CRC error is detected, the temperature will be displayed as "ERR" or "ERROR".

The return packet will be:

```
type: 0x40 | 15 = 0x55 = 8510
data_length: 0
```

22 (0x16): Send Command Directly to the LCD Controller

The controller on the CFA533 is HD44780 compatible. Generally you won't need low-level access to the LCD controller but some arcane functions of the HD44780 are not exposed by the CFA533's command set. This command allows you to access the CFA533's LCD controller directly. Note: It is possible to corrupt the CFA533 display using this command.

```
type: 0x16 = 2210
data_length: 2
data[0]: location code
        0 = "Data" register
        1 = "Control" register
data[1]: data to write to the selected register
```

The return packet will be:

```
type: 0x40 | 0x16 = 0x56 = 8610
data_length: 0
```

24 (0x18): Read Keypad, Polled Mode

In some situations, it may be convenient for the host to poll the CFA533 for key activity. This command allows the host to detect which keys are currently pressed, which keys have been pressed since the last poll, and which keys have been released since the last poll.

```
#define KP_UP      0x01
#define KP_ENTER  0x02
#define KP_CANCEL 0x04
#define KP_LEFT   0x08
#define KP_RIGHT  0x10
#define KP_DOWN   0x20

type: 0x18 = 2410
data_length: 0
```



The return packet will be:

```
type: 0x40 | 0x18 = 0x58 = 8810
data_length: 3
data[0] = bitmask showing the keys currently pressed
data[1] = bitmask showing the keys that have been pressed since the last poll
data[2] = bitmask showing the keys that have been released since the last poll
```

28 (0x1C): Set ATX Switch Functionality

The combination of the CFA533 with the Crystalfontz [WR-PWR-Y14](#) or [WR-PWR-Y44](#) cable can be used to replace the function of the power and reset switches in a standard ATX-compatible system. The ATX Power Switch Functionality is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).

NOTE ON COMMAND 28: SET ATX SWITCH FUNCTIONALITY

The GPIO pins used for ATX control must not be configured as user GPIO. The pins must be configured to their default drive mode in order for the ATX functions to work correctly.

These settings are factory default but may be changed by the user. Please see command [34 \(0x22\): Set/Configure GPIO \(Pg. 57\)](#). These settings must be saved as the boot state.

To ensure that GPIO[1] will operate correctly as ATX SENSE, user GPIO[1] must be configured as:

```
DDD = "011: 1=Resistive Pull Up, 0=Fast, Strong Drive Down".
F = "0: Port unused for user GPIO."
```

This configuration can be assured by sending the following command:

```
command = 34
length = 3
data[0] = 1
data[1] = 0
data[2] = 3
```

To ensure that GPIO[2] will operate correctly as ATX POWER, user GPIO[2] must be configured as:

```
DDD = "010: Hi-Z, use for input".
F = "0: Port unused for user GPIO."
```

This configuration can be assured by sending the following command:

```
command = 34
length = 3
data[0] = 2
data[1] = 0
data[2] = 2
```

To ensure that GPIO[3] will operate correctly as ATX RESET, user GPIO[3] must be configured as:

```
DDD = "010: Hi-Z, use for input".
F = "0: Port unused for user GPIO."
```

This configuration can be assured by sending the following command:

```
command = 34
length = 3
data[0] = 3
data[1] = 0
data[2] = 2
```

These settings must be saved as the boot state.



The RESET (GPIO[3]) and POWER CONTROL (GPIO[2]) lines on the CFA533 are normally high-impedance. Electrically, they appear to be disconnected or floating. When the CFA533 asserts the RESET or POWER CONTROL lines, they are momentarily driven high or low (as determined by the AUTO_POLARITY, RESET_INVERT or POWER_INVERT bits, detailed below). To end the power or reset pulse, the CFA533 changes the lines back to high-impedance.

FOUR FUNCTIONS MAY BE ENABLED BY COMMAND 28

Function 1: KEYPAD_RESET

If POWER-ON SENSE (GPIO[1]) is high, holding the green check key for 4 seconds will pulse RESET (GPIO[3]) pin for 1 second. During the 1-second pulse, the CFA533 will show "RESET", and then the CFA533 will reset itself, showing its boot state as if it had just powered on. Once the pulse has finished, the CFA533 will not respond to any commands until after it has reset the host and itself.

Function 2: KEYPAD_POWER_ON

If POWER-ON SENSE (GPIO[1]) is low, pressing the green check key for 0.25 seconds will pulse POWER CONTROL (GPIO[2]) for the duration specified by in data[1] or the default of 1 second. During this time the CFA533 will show "POWER ON", then the CFA533 will reset itself.

Function 3: KEYPAD_POWER_OFF

If POWER-ON SENSE (GPIO[1]) is high, holding the red X key for 4 seconds will pulse POWER CONTROL (GPIO[2]) for the duration specified by in data[1] or the default of 1 second. If the user continues to hold the power key down, then the CFA533 will continue to drive the line for a maximum of 5 additional seconds. During this time the CFA533 will show "POWER OFF".

Function 4: LCD_OFF_IF_HOST_IS_OFF

If LCD_OFF_IF_HOST_IS_OFF is set, the CFA533 will blank its screen and turn off its backlight to simulate its power being off any time POWER-ON SENSE is low.

NOTE

By default there is an internal POWER-ON-SENSE connected to the +5v pin of J_PWR, selected by setting data[2] to 1. Alternatively, GPIO[1] may be configured to act as POWER-ON-SENSE through R3 of 5k, and specifying data[2] as 0. The CFA533 will still be active (since it is powered by V_{SB}), monitoring the keypad for a power-on keystroke. Once POWER-ON SENSE goes high, the CFA533 will reboot as if power had just been applied to it.



```
#define AUTO_POLARITY          0x01 //Automatically detects polarity for reset and
                                //power (recommended)
#define RESET_INVERT          0x02 //Reset pin drives high instead of low (ignored if
                                AUTO_POLARITY is set)
#define POWER_INVERT          0x04 //Power pin drives high instead of low (ignored if
                                AUTO_POLARITY is set)
#define LCD_OFF_IF_HOST_IS_OFF 0x10
#define KEYPAD_RESET          0x20
#define KEYPAD_POWER_ON       0x40
#define KEYPAD_POWER_OFF      0x80

type: 0x1C = 2810
data_length: 1, 2 or 3
data[0]: bitmask of enabled functions
data[1]: (optional) length of power on & off pulses in 1/32 second
         1 = 1/32 sec
         2 = 1/16 sec
         16 = 1/2 sec
         255 = 8 sec
data[2]: (optional) atx_sense_on_floppy
         0: sense ATX host state on P2.1 (J8, pin 6 / GPIO [1] -- R3 must be loaded)
         1: sense ATX host state on P0.7 (JPWR,+5v -- recommended configuration)
```

The return packet will be:

```
type: 0x40 | 0x1C = 0x5C = 9210
data_length: 0
```

29 (0x1D): Enable/Feed Host Watchdog Reset

Some high-availability systems use hardware watchdog timers to ensure that a software or hardware failure does not result in an extended system outage. Once the host system has booted, a system monitor program is started. The system monitor program would enable the watchdog timer on the CFA533. If the system monitor program fails to feed the CFA533's watchdog timer, the CFA533 will reset the host system.

NOTE

The GPIO pins used for ATX control must not be configured as user GPIO. They must be configured to their default drive mode in order for the ATX functions to work correctly. These settings are factory default, but may be changed by the user. Please see the note under command [28 \(0x1C\): Set ATX Switch Functionality \(Pg. 53\)](#) or command [34 \(0x22\): Set/Configure GPIO \(Pg. 57\)](#).

```
type: 0x1D = 2910
data_length: 1
data[0] = enable/timeout
```

If timeout is 0, the watchdog is disabled.

If timeout is 1-255, then this command must be issued again within timeout seconds to feed the watchdog and avoid a watchdog reset.

To turn the watchdog off once it has been enabled, simply set timeout to 0.

If the command is not re-issued within timeout seconds, then the CFA533 will reset the host (see command 28 for details). Since the watchdog is off by default when the CFA533 powers up, the CFA533 will not issue another host reset until the host has once again enabled the watchdog.

The return packet will be:

```
type: 0x40 | 0x1D = 0x5D = 9310
data_length: 0
```



30 (0x1E): Read Reporting/ATX/Watchdog (debug)

This command can be used to verify the current items configured to report to the host, as well as some other miscellaneous status information. Please note that the information returned by the CFA533 is not identical to the information returned by similar Crystalfontz displays.

```
type: 30
data_length: 0
```

The return packet will be:

```
type: 0x1E = 3010
data_length: 15
data[0] = 0
data[1] = 0
data[2] = 0
data[3] = 0
data[4] = 0
data[5] = 0
data[6] = 0
data[7] = ATX Power Switch Functionality (as set by command 28)
data[8] = current watchdog counter (as set by command 29)
data[9] = User Contrast Adjust (as set by command 13, data\[1\])
data[10] = Key backlight setting (as set by command 14, data\[1\])
data[11] = atx_sense_on_floppy (as set by command 28)
data[12] = 0
data[13] = CFA633-style contrast setting (as set by command 13, data\[0\])
data[14] = LCD backlight setting (as set by command 14, data\[0\])
```

Please Note: Previous and future firmware versions may return fewer or additional bytes.

31 (0x1F): Send Data to LCD

This command allows data to be placed at any position on the LCD.

```
type: 0x1F = 3110
data_length: 3 to 18
data[0]: col = x = 0 to 15
data[1]: row = y = 0 to 1
data[2-21]: text to place on the LCD, variable from 1 to 16 characters
```

The return packet will be:

```
type: 0x40 | 0x1F = 0x5F = 9510
data_length: 0
```

Send Data to LCD is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).

33 (0x21): Set I2C Address

This command sets the I²C address. This number is bit shifted left by one and combined with the R/W bit to make the actual I²C address byte. For example, if 10 is set as the address, the I²C address byte for *writes* is 20 and for *reads* is 21.

The default address of the CFA533-***-KC is 42₁₀ (84₁₀ writes, 85₁₀ reads), in hexadecimal 0x2A (0x54 writes, 0x55 reads).

Debugging Tip: To display the I²C address of the display module on the LCD, hold both the up and the down arrows for 4 seconds.

```
type: 0x21 = 3310
data_length: 1
data[0]: 0 to 127
```




The return packet will be:

```
type: 0x40 | 0x21 = 0x61 = 9710
data_length: 0
```

34 (0x22): Set/Configure GPIO

The CFA533 has five pins for user-definable general-purpose input / output (GPIO). These pins are shared with the DOW and ATX functions. Be careful when you configure the GPIO if you want to use the ATX or DOW at the same time.

The architecture of the CFA533 allows great flexibility in the configuration of the GPIO pins. They can be set as input or output. They can output constant high or low signals or a variable duty cycle 100 Hz PWM signal. (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 done by the human eye.)

In output mode using the PWM (and a suitable supporting circuit), an LED may be turned on or off and even dimmed under host software control. With suitable external circuitry, the GPIOs can also be used to drive external logic or power transistors.

The CFA533 continuously polls the GPIOs as inputs at 32 Hz. The present level can be queried by the host software at a lower rate. The CFA533 also keeps track of whether there were rising or falling edges since the last host query (subject to the resolution of the 32 Hz sampling). This means that the host is not forced to poll quickly in order to detect short events. The algorithm used by the CFA533 to read the inputs is inherently “debounced”.

The GPIOs also have “pull-up” and “pull-down” modes. These modes can be useful when using the GPIO as an input connected to a switch since no external pull-up or pull-down resistor is needed. For instance, the GPIO can be set to pull up. Then when a switch connected between the GPIO and ground is open, reading the GPIO will return a “1”. When the switch is closed, the input will return a “0”.

Pull-up/pull-down resistance values are approximately 5kΩ. Do not exceed current of 25 mA per GPIO.

GPIO[1] may be connected to the host’s power in order to sense the host’s power on/off state. There is 5kΩ resistor for R3 in series with GPIO[1] to limit the possibility of latchup.

NOTE ON SETTING AND CONFIGURING GPIO PINS

The GPIO pins may also be used for ATX control through header J8 and temperature sensing through the CFA533’s DOW header. By factory default, the GPIO output setting, function, and drive mode are set correctly to enable operation of the ATX and DOW functions. **The GPIO output setting, function, and drive mode must be set to the correct values in order for the ATX and DOW functions to work. Improper use of this command can disable the ATX and DOW functions.**

The GPIO configuration is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 43\)](#).

```
type: 0x22 = 3410
data_length:
  2 bytes to change value only
  3 bytes to change value and configure function and drive mode

data[0]: index of GPIO to modify
  0 = GPIO[0] = J8, Pin 7
  1 = GPIO[1] = J8, Pin 6 (may be ATX Host Power Sense, as configured by
    command 28, data\[2\])
  2 = GPIO[2] = J8, Pin 5 (default is ATX Host Power Control)
  3 = GPIO[3] = J8, Pin 4 (default is ATX Host Reset Control)
  4 = GPIO[4] = J9, Pin 2 (default is DOW I/O--has 1kΩ hardware pull-up)
  5-255 = reserved
```



Please note: Future versions of this command on future hardware models may accept additional values for data[0], which would control the state of future additional GPIO pins

data[1]: Pin output state (actual behavior depends on drive mode):
 0 = Output set to low
 1-99 = Output duty cycle percentage (100 Hz nominal)
 100 = Output set to high
 101-255 = invalid

data[2]: Pin function select and drive mode (optional)

```

---- FDDD
|||| -- DDD = Drive Mode (based on output state of 1 or 0)
=====
000: 1=Fast, Strong Drive Up, 0=Resistive Pull Down
001: 1=Fast, Strong Drive Up, 0=Fast, Strong Drive Down
010: Hi-Z, use for input
011: 1=Resistive Pull Up,      0=Fast, Strong Drive Down
100: 1=Slow, Strong Drive Up, 0=Hi-Z
101: 1=Slow, Strong Drive Up, 0=Slow, Strong Drive Down
110: reserved, do not use
111: 1=Hi-Z,                  0=Slow, Strong Drive Down

----- F = Function
=====
0: Port unused for GPIO. It will take on the default
   function such as ATX, DOW or unused. The user is
   responsible for setting the drive to the correct
   value in order for the default function to work
   correctly.
1: Port used for GPIO under user control. The user is
   responsible for setting the drive to the correct
   value in order for the desired GPIO mode to work
   correctly.
----- reserved, must be 0
  
```

The return packet will be:

```

type: 0x40 | 0x22 = 0x62 = 9810
data_length: 0
  
```

35 (0x23): Read GPIO Pin Levels and Configuration State

Please see command [34 \(0x22\): Set/Configure GPIO \(Pg. 57\)](#) for details on the GPIO architecture.

```

type: 0x23 = 3510
data_length: 1
  
```

data[0]: index of GPIO to query
 0 = GPIO[0] = J8, Pin 7
 1 = GPIO[1] = J8, Pin 6 (may be ATX Host Power Sense, as configured
 by [command 28, data\[2\]](#))
 2 = GPIO[2] = J8, Pin 5 (default is ATX Host Power Control)
 3 = GPIO[3] = J8, Pin 4 (default is ATX Host Reset Control)
 4 = GPIO[4] = J9, Pin 2 (default is DOW I/O--may have a 1kΩ hardware pull-up)
 5-255 = reserved

Please note: Future versions of this command on future hardware models may accept additional values for data[0], which would return the status of future additional GPIO pins.



CHARACTER GENERATOR ROM (CGROM)

To find the code for a given character, add the two numbers that are shown in bold for its row and column. For example, the Greek letter "β" is in the column labeled "224_d" and in the row labeled "2_d". So 224 + 2 = 226. When you send a byte with the value of 226 to the display, the Greek letter "β" will be shown.

upper 4 bits lower 4 bits	0 _d 0000.	16 _d 0001.	32 _d 0010.	48 _d 0011.	64 _d 0100.	80 _d 0101.	96 _d 0110.	112 _d 0111.	128 _d 1000.	144 _d 1001.	160 _d 1010.	176 _d 1011.	192 _d 1100.	208 _d 1101.	224 _d 1110.	240 _d 1111.
0 _d 0000.	CGRAM [0]															
1 _d 0001.	CGRAM [1]															
2 _d 0010.	CGRAM [2]															
3 _d 0011.	CGRAM [3]															
4 _d 0100.	CGRAM [4]															
5 _d 0101.	CGRAM [5]															
6 _d 0110.	CGRAM [6]															
7 _d 0111.	CGRAM [7]															
8 _d 1000.	CGRAM [0]															
9 _d 1001.	CGRAM [1]															
10 _d 1010.	CGRAM [2]															
11 _d 1011.	CGRAM [3]															
12 _d 1100.	CGRAM [4]															
13 _d 1101.	CGRAM [5]															
14 _d 1110.	CGRAM [6]															
15 _d 1111.	CGRAM [7]															

Figure 24. Character Generator ROM (CGROM)



DISPLAY MODULE RELIABILITY AND LONGEVITY

DISPLAY MODULE RELIABILITY

Under operating and storage temperature specification limitations, humidity non-condensing RH up to 65%, and no exposure to direct sunlight. Values listed below are approximate and represent typical lifetime.”

PART NUMBER	ITEM	SPECIFICATION	
CFA533-***-KC (all variants)	LCD portion (excluding keypad and backlights)	50,000 to 100,000 hours	
	Keypad	1,000,000 keystrokes	
CFA533-TFH-KC CFA533-TMI-KC	White LED display backlights and white or blue keypad backlights <i>Note: We recommend that white LED backlights be dimmed or turned off during periods of inactivity to conserve their lifetime.</i>	<i>Power-On Hours</i>	<i>% of Initial Brightness</i>
		<10,000	>90%
		<50,000	>50%
CFA533-YYH-KC	Yellow-green LED backlights	50,000 to 100,000 hours (typical)	

DISPLAY MODULE LONGEVITY (EOL / REPLACEMENT POLICY)

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

We recognize that discontinuing a display 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 display module. For example, we must occasionally discontinue a display module when a supplier discontinues a component or a manufacturing process becomes obsolete. When we discontinue a display module, we will do our best to find an acceptable replacement display 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 display module to the discontinued display module it replaces. However, sometimes a change in component or process for the replacement display module results in a slight variation, perhaps an improvement, over the previous design.

Although the replacement display module is still within the stated Datasheet specifications and tolerances of the discontinued display 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.** Display 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 display module whenever possible; we only discontinue a display module if we have no other option. We will post Part Change Notices (PCN) 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.

Note: 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 \(Pg. 24\)](#).

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.

ELECTROSTATIC DISCHARGE (ESD)

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.

DESIGN AND MOUNTING

- The 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 LCD “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 Lexan®, which is readily available and works well.
- Do not disassemble or modify the module.
- Do not modify the six tabs of the metal bezel or make connections to them.
- Solder only to the I/O terminals. Use care when removing solder—it is possible to damage the PCB.
- Do not reverse polarity to the power supply connections. Reversing polarity will immediately ruin the module.

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.

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 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

- Your circuit should be designed to protect the CFA533-***-KC from ESD and power supply transients.
- Observe the operating temperature limitations: a minimum of 0°C to a maximum of 50°C with minimal fluctuation. Operation outside of these limits may shorten life and/or harm display.
 - 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.
- For the *CFA533-TFH-KC* and *CFA533-TMI-KC* with white LEDs, adjust backlight brightness so the display is readable but not too bright. Dim or turn off the backlight during periods of inactivity to conserve the white LED backlight lifetime.

STORAGE AND RECYCLING

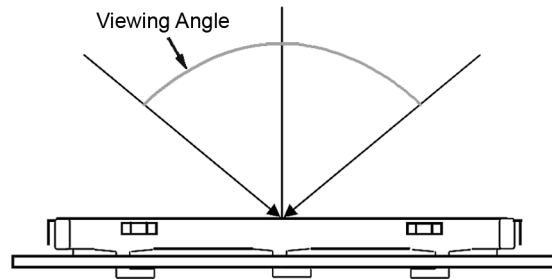
- Store in an ESD-approved container away from dust, moisture, and direct sunlight, fluorescent lamps, or any strong ultraviolet radiation. Ensure humidity is less than 90% non-condensing.
- Observe the storage temperature limitations: -10°C minimum, 60°C maximum with minimal fluctuation. Rapid temperature changes can cause moisture to form, resulting in permanent damage.
- Do not allow weight to be placed on the CFA533-***-KCs while they are in storage.
- Please recycle your outdated Crystalfontz modules at an approved facility.



APPENDIX A: QUALITY ASSURANCE STANDARDS

INSPECTION CONDITIONS

- Environment
 - Temperature: $25\pm 5^{\circ}\text{C}$
 - Humidity: 30~85% RH
- 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)
 - Viewable 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.

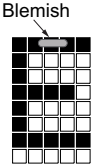
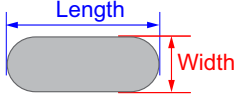
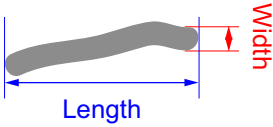
DEFECTS CLASSIFICATION

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		<i>Defect Size (mm)</i>	<i>Acceptable Qty</i>	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 	<i>Defect Size (mm)</i>	<i>Acceptable Qty</i>	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		<i>Defect Width (mm)</i>	<i>Defect Length (mm)</i>	<i>Acceptable Qty</i>	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		<i>Defect Size (mm)</i>	<i>Acceptable Qty</i>	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		Minor							
		<table border="1"> <thead> <tr> <th>Dot Size (mm)</th> <th>Acceptable Qty</th> </tr> </thead> <tbody> <tr> <td>$((A+B)/2) \leq 0.2$</td> <td rowspan="5"> ≤ 3 total defects ≤ 2 pinholes per digit </td> </tr> <tr> <td>$C > 0$</td> </tr> <tr> <td>$((D+E)/2) \leq 0.25$</td> </tr> <tr> <td>$((F+G)/2) \leq 0.25$</td> </tr> </tbody> </table>		Dot Size (mm)	Acceptable Qty	$((A+B)/2) \leq 0.2$	≤ 3 total defects ≤ 2 pinholes per digit	$C > 0$	$((D+E)/2) \leq 0.25$	$((F+G)/2) \leq 0.25$
		Dot Size (mm)		Acceptable Qty						
		$((A+B)/2) \leq 0.2$		≤ 3 total defects ≤ 2 pinholes per digit						
		$C > 0$								
$((D+E)/2) \leq 0.25$										
$((F+G)/2) \leq 0.25$										
9	Backlight defects	<ol style="list-style-type: none"> 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. 65), and dark lines or scratches (see test 6, Pg. 65). <p><i>*Minor if display functions correctly. Major if the display fails.</i></p>	Minor							
10	COB defects	<ol style="list-style-type: none"> 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	<ol style="list-style-type: none"> 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. <p><i>*Minor if display functions correctly. Major if the display fails.</i></p>	Minor							
12	Soldering defects	<ol style="list-style-type: none"> 1. Unmelted solder paste. 2. Cold solder joints, missing solder connections, or oxidation.* 3. Solder bridges causing short circuits.* 4. Solder balls. <p><i>*Minor if display functions correctly. Major if the display fails.</i></p>	Minor							



APPENDIX B: SAMPLE APPLICATIONS AND SOURCE CODE

ARDUINO EXAMPLE CONNECTIONS AND SKETCH

We have an [example project](#) that details the steps needed to connect a CFA533 I²C LCD module to an Arduino Uno. There is a sample sketch that can be loaded into the Arduino to test it.

DEMONSTRATION CODE FOR ATMEL AVR ATMEGA 2561

Available for download on the *Datasheets & Files* tab for the web pages of each CFA533 part number.

533 I2C WINTEST

The [533 I2C WinTest](#) works with [TotalPhase Aardvark I2C/SPI Adapter](#) to demonstrate the display's features.

ALGORITHMS TO CALCULATE THE CRC

Below are eight sample algorithms that will calculate the CRC of a CFA533 packet. Some of the algorithms were contributed by forum members and originally written for the [CFA631](#) or [CFA635](#). The CRC used in the CFA533 is the same one that is used in IrDA, which came from PPP, which seems to be related to a CCITT (ref: Network Working Group Request for Comments: 1171) standard. At that point, the trail was getting a bit cold and diverged into several referenced articles and papers, dating back to 1983.

The polynomial used is $X^{16} + X^{12} + X^5 + X^0$ (0x8408)
The result is bit-wise inverted before being returned.

Algorithm 1: "C" Table Implementation

This algorithm is typically used on the host computer, where code space is not an issue.

```
//This code is from the IRDA LAP documentation, which appears to
//have been copied from PPP:
//
// http://irda.affiniscape.com/associations/2494/files/Specifications/IrLAP11_Plus_Er-
rata.zip
//
//I doubt that there are any worries about the legality of this code,
//searching for the first line of the table below, it appears that
//the code is already included in the linux 2.6 kernel "Driver for
//ST5481 USB ISDN modem". This is an "industry standard" algorithm
//and I do not think there are ANY issues with it at all.
typedef unsigned char ubyte;
typedef unsigned short word;
word get_crc(ubyte *bufptr, word len)
{
    //CRC lookup table to avoid bit-shifting loops.
    static const word crcLookupTable[256] =
        {0x0000, 0x01189, 0x02312, 0x0329B, 0x04624, 0x057AD, 0x06536, 0x074BF,
        0x08C48, 0x09DC1, 0x0AF5A, 0x0BED3, 0x0CA6C, 0x0DBE5, 0x0E97E, 0x0F8F7,
        0x01081, 0x00108, 0x03393, 0x0221A, 0x056A5, 0x0472C, 0x075B7, 0x0643E,
        0x09CC9, 0x08D40, 0x0BFDB, 0x0AE52, 0x0DAED, 0x0CB64, 0x0F9FF, 0x0E876,
        0x02102, 0x0308B, 0x00210, 0x01399, 0x06726, 0x076AF, 0x04434, 0x055BD,
        0x0AD4A, 0x0BCC3, 0x08E58, 0x09FD1, 0x0EB6E, 0x0FAE7, 0x0C87C, 0x0D9F5,
        0x03183, 0x0200A, 0x01291, 0x00318, 0x077A7, 0x0662E, 0x054B5, 0x0453C,
        0x0BDCB, 0x0AC42, 0x09ED9, 0x08F50, 0x0FBEF, 0x0EA66, 0x0D8FD, 0x0C974,
```



```
0x04204,0x0538D,0x06116,0x0709F,0x00420,0x015A9,0x02732,0x036BB,
0x0CE4C,0x0DFC5,0x0ED5E,0x0FCD7,0x08868,0x099E1,0x0AB7A,0x0BAF3,
0x05285,0x0430C,0x07197,0x0601E,0x014A1,0x00528,0x037B3,0x0263A,
0x0DECD,0x0CF44,0x0FDDF,0x0EC56,0x098E9,0x08960,0x0BBFB,0x0AA72,
0x06306,0x0728F,0x04014,0x0519D,0x02522,0x034AB,0x00630,0x017B9,
0x0EF4E,0x0FEC7,0x0CC5C,0x0DDD5,0x0A96A,0x0B8E3,0x08A78,0x09BF1,
0x07387,0x0620E,0x05095,0x0411C,0x035A3,0x0242A,0x016B1,0x00738,
0x0FFCF,0x0EE46,0x0DCDD,0x0CD54,0x0B9EB,0x0A862,0x09AF9,0x08B70,
0x08408,0x09581,0x0A71A,0x0B693,0x0C22C,0x0D3A5,0x0E13E,0x0F0B7,
0x00840,0x019C9,0x02B52,0x03ADB,0x04E64,0x05FED,0x06D76,0x07CFF,
0x09489,0x08500,0x0B79B,0x0A612,0x0D2AD,0x0C324,0x0F1BF,0x0E036,
0x018C1,0x00948,0x03BD3,0x02A5A,0x05EE5,0x04F6C,0x07DF7,0x06C7E,
0x0A50A,0x0B483,0x08618,0x09791,0x0E32E,0x0F2A7,0x0C03C,0x0D1B5,
0x02942,0x038CB,0x00A50,0x01BD9,0x06F66,0x07EEF,0x04C74,0x05DFD,
0x0B58B,0x0A402,0x09699,0x08710,0x0F3AF,0x0E226,0x0D0BD,0x0C134,
0x039C3,0x0284A,0x01AD1,0x00B58,0x07FE7,0x06E6E,0x05CF5,0x04D7C,
0x0C60C,0x0D785,0x0E51E,0x0F497,0x08028,0x091A1,0x0A33A,0x0B2B3,
0x04A44,0x05BCD,0x06956,0x078DF,0x00C60,0x01DE9,0x02F72,0x03EFB,
0x0D68D,0x0C704,0x0F59F,0x0E416,0x090A9,0x08120,0x0B3BB,0x0A232,
0x05AC5,0x04B4C,0x079D7,0x0685E,0x01CE1,0x00D68,0x03FF3,0x02E7A,
0x0E70E,0x0F687,0x0C41C,0x0D595,0x0A12A,0x0B0A3,0x08238,0x093B1,
0x06B46,0x07ACF,0x04854,0x059DD,0x02D62,0x03CEB,0x00E70,0x01FF9,
0x0F78F,0x0E066,0x0D49D,0x0C514,0x0B1AB,0x0A022,0x092B9,0x08330,
0x07BC7,0x06A4E,0x058D5,0x0495C,0x03DE3,0x02C6A,0x01EF1,0x00F78};
```

```
register word
newCrc;
newCrc=0xFFFF;
//This algorithm is based on the IrDA LAP example.
while(len--)
    newCrc = (newCrc >> 8) ^ crcLookupTable[(newCrc ^ *bufptr++) & 0xff];

//Make this crc match the one's complement that is sent in the packet.
return(~newCrc);
}
```

Algorithm 2: "C" Bit Shift Implementation

This algorithm was mainly written to avoid any possible legal issues about the source of the routine (at the request of the LCDproc group). This routine was "clean" coded from the definition of the CRC. It is ostensibly smaller than the table driven approach but will take longer to execute. This routine is offered under the GPL.

```
typedef unsigned char ubyte;
typedef unsigned short word;
word get_crc(ubyte *bufptr,word len)
{
    register unsigned int
        newCRC;
    //Put the current byte in here.
    ubyte
        data;
    int
        bit_count;
    //This seed makes the output of this shift based algorithm match
    //the table based algorithm. The center 16 bits of the 32-bit
    //"newCRC" are used for the CRC. The MSb of the lower byte is used
    //to see what bit was shifted out of the center 16 bit CRC
    //accumulator ("carry flag analog");
    newCRC=0x00F32100;
    while(len--)
    {
        //Get the next byte in the stream.
        data=*bufptr++;
        //Push this byte's bits through a software
        //implementation of a hardware shift & xor.
        for(bit_count=0;bit_count<=7;bit_count++)
            {
```



```
//Shift the CRC accumulator
newCRC>>=1;

//The new MSB of the CRC accumulator comes
//from the LSB of the current data byte.
if(data&0x01)
    newCRC|=0x00800000;

//If the low bit of the current CRC accumulator was set
//before the shift, then we need to XOR the accumulator
//with the polynomial (center 16 bits of 0x00840800)
if(newCRC&0x00000080)
    newCRC^=0x00840800;
//Shift the data byte to put the next bit of the stream
//into position 0.
data>>=1;
}
}

//All the data has been done. Do 16 more bits of 0 data.
for(bit_count=0;bit_count<=15;bit_count++)
{
    //Shift the CRC accumulator
    newCRC>>=1;

    //If the low bit of the current CRC accumulator was set
    //before the shift we need to XOR the accumulator with
    //0x00840800.
    if(newCRC&0x00000080)
        newCRC^=0x00840800;
}
//Return the center 16 bits, making this CRC match the one's
//complement that is sent in the packet.
return((~newCRC)>>8);
}
```

Algorithm 2B: “C” Improved Bit Shift Implementation

This is simplified algorithm that implements the CRC.



```

unsigned short get_crc(unsigned char count,unsigned char *ptr)
{
  unsigned short
    crc; //Calculated CRC
  unsigned char
    i; //Loop count, bits in byte
  unsigned char
    data; //Current byte being shifted

  crc = 0xFFFF; // Preset to all 1's, prevent loss of leading zeros

  while(count--)
  {
    data = *ptr++;
    i = 8;
    do
    {
      if((crc ^ data) & 0x01)
      {
        crc >>= 1;
        crc ^= 0x8408;
      }
      else
        crc >>= 1;
      data >>= 1;
    } while(--i != 0);
  }
  return (~crc);
}

```

Algorithm 3: “PIC Assembly” Bit Shift Implementation

This routine was graciously donated by one of our customers.

```

;=====
; Crystalfontz CFA533 PIC CRC Calculation Example
;
; This example calculates the CRC for the hard coded example provided
; in the documentation.
;
; It uses "This is a test. " as input and calculates the proper CRC
; of 0x93FA.
;=====
#include "p16f877.inc"
;=====
; CRC16 equates and storage
;-----
accuml      equ    40h      ; BYTE - CRC result register high byte
accumh      equ    41h      ; BYTE - CRC result register low byte
datareg     equ    42h      ; BYTE - data register for shift
j           equ    43h      ; BYTE - bit counter for CRC 16 routine
Zero       equ    44h      ; BYTE - storage for string memory read
index       equ    45h      ; BYTE - index for string memory read
savchr      equ    46h      ; BYTE - temp storage for CRC routine
;
seedlo      equ    021h     ; initial seed for CRC reg lo byte
seedhi      equ    0F3h     ; initial seed for CRC reg hi byte
;

```



```

polyL      equ      008h      ; polynomial low byte
polyH      equ      084h      ; polynomial high byte
;=====
; CRC Test Program
;-----
        org      0          ; reset vector = 0000H
;
        clr     PCLATH      ; ensure upper bits of PC are cleared
        clr     STATUS      ; ensure page bits are cleared
        goto    main        ; jump to start of program
;
; ISR Vector
;
        org      4          ; start of ISR
        goto    $           ; jump to ISR when coded
;
        org      20         ; start of main program
main
        movlw   seedhi      ; setup initial CRC seed value.
        movwf   accumh      ; This must be done prior to
        movlw   seedlo      ; sending string to CRC routine.
        movwf   accuml      ;
        clr     index       ; clear string read variables
;
main1
        movlw   HIGH InputStr ; point to LCD test string
        movwf   PCLATH      ; latch into PCL,
        movfw   index       ; get index
        call    InputStr    ; get character
        movwf   Zero        ; setup for terminator test
        movf    Zero,f      ; see if terminator
        btfsc   STATUS,Z    ; skip if not terminator
        goto    main2       ; else terminator reached, jump out of loop
        call    CRC16       ; calculate new crc
        call    SENDUART    ; send data to LCD
        incf   index,f     ; bump index
        goto    main1       ; loop
;
main2
        movlw   00h         ; shift accumulator 16 more bits.
        call    CRC16       ; This must be done after sending
        movlw   00h         ; string to CRC routine.
        call    CRC16       ;
;
        comf   accumh,f     ; invert result
        comf   accuml,f     ;
;
        movfw   accuml      ; get CRC low byte
        call    SENDUART    ; send to LCD
        movfw   accumh      ; get CRC hi byte
        call    SENDUART    ; send to LCD
;
stop    goto    stop        ; word result of 0x93FA is in accumh/accuml
;=====
; calculate CRC of input byte
;-----
CRC16
        movwf   savchr      ; save the input character
        movwf   datareg     ; load data register
        movlw   .8         ; setup number of bits to test
        movwf   j           ; save to incrementor
_loop
        clr     carry       ; clear carry for CRC register shift
        rrf     datareg,f   ; perform shift of data into CRC register
        rrf     accumh,f    ;
        rrf     accuml,f    ;
        btfss  STATUS,C    ; skip jump if if carry
        goto   _notset     ; otherwise goto next bit

```



```

        movlw      polyL      ; XOR poly mask with CRC register
        xorwf     accumul,F   ;
        movlw     polyH      ;
        xorwf     accumh,F    ;
_notset
        decfsz   j,F          ; decrement bit counter
        goto    _loop        ; loop if not complete
        movfw   savchr       ; restore the input character
        return  ; return to calling routine
;=====
; USER SUPPLIED Serial port transmit routine
;-----
SENDUART
        return              ; put serial xmit routine here
;=====
; test string storage
;-----
        org     0100h
;
InputStr
        addwf   PCL,f
        dt     7h,10h,"This is a test. ",0
;
;=====
        end

```

Algorithm 4: “Visual Basic” Table Implementation

Visual BASIC has its own challenges as a language (such as initializing static arrays), and it is also challenging to use Visual BASIC to work with “binary” (arbitrary length character data possibly containing nulls—such as the “data” portion of the CFA533 packet) data. This routine was adapted from the C table implementation. The complete project can be found in our forums.

```

'This program is brutally blunt. Just like VB. No apologies.
'Written by CrystalFontz America, Inc. 2004 http://www.crystalfontz.com
'Free code, not copyright copyleft or anything else.
'Some visual basic concepts taken from:
'http://www.planet-source-code.com/vb/scripts/ShowCode.asp?txtCodeId=21434&lngWId=1
'most of the algorithm is from functions in 633 WinTest:
'https://www.crystalfontz.com/product/633WinTest#docs
'Full zip of the project is available in our forum:
'http://www.crystalfontz.com/forum/showthread.php?postid=9921#post9921

```

```

Private Type WORD
    Lo As Byte
    Hi As Byte
End Type

```

```

Private Type PACKET_STRUCT
    command As Byte
    data_length As Byte
    data(22) As Byte
    crc As WORD
End Type

```

```
Dim crcLookupTable(256) As WORD
```

```

Private Sub MSComm_OnComm()
'Leave this here
End Sub

```

```

'My understanding of visual basic is very limited--however it appears that there is no way
'to initialize an array of structures. Nice language. Fast processors, lots of memory, big
'disks, and we fill them up with this . . this . . this . . STUFF.
Sub Initialize_CRC_Lookup_Table()
    crcLookupTable(0).Lo = &H0
    crcLookupTable(0).Hi = &H0

```




```
. . .
'For purposes of brevity in this data sheet, I have removed 251 entries of this table, the
'full source is available in our forum:
'http://www.crystalfontz.com/forum/showthread.php?postid=9921#post9921
. . .
```

```
    crcLookupTable(255).Lo = &H78
    crcLookupTable(255).Hi = &HF
End Sub
```

```
'This function returns the CRC of the array at data for length positions
Private Function Get_Crc(ByRef data() As Byte, ByVal length As Integer) As WORD
    Dim Index As Integer
    Dim Table_Index As Integer
    Dim newCrc As WORD
    newCrc.Lo = &HFF
    newCrc.Hi = &HFF
    For Index = 0 To length - 1
        'exclusive-or the input byte with the low-order byte of the CRC register
        'to get an index into crcLookupTable
        Table_Index = newCrc.Lo Xor data(Index)
        'shift the CRC register eight bits to the right
        newCrc.Lo = newCrc.Hi
        newCrc.Hi = 0
        ' exclusive-or the CRC register with the contents of Table at Table_Index
        newCrc.Lo = newCrc.Lo Xor crcLookupTable(Table_Index).Lo
        newCrc.Hi = newCrc.Hi Xor crcLookupTable(Table_Index).Hi
    Next Index
    'Invert & return newCrc
    Get_Crc.Lo = newCrc.Lo Xor &HFF
    Get_Crc.Hi = newCrc.Hi Xor &HFF
End Function
```

```
Private Sub Send Packet(ByRef packet As PACKET_STRUCT)
    Dim Index As Integer
    'Need to put the whole packet into a linear array
    'since you can't do type overrides. VB, gotta love it.
    Dim linear_array(26) As Byte
    linear_array(0) = packet.command
    linear_array(1) = packet.data_length
    For Index = 0 To packet.data_length - 1
        linear_array(Index + 2) = packet.data(Index)
    Next Index
    packet.crc = Get_Crc(linear_array, packet.data_length + 2)
    'Might as well move the CRC into the linear array too
    linear_array(packet.data_length + 2) = packet.crc.Lo
    linear_array(packet.data_length + 3) = packet.crc.Hi
    'Now a simple loop can dump it out the port.
    For Index = 0 To packet.data_length + 3
        MSComm.Output = Chr(linear_array(Index))
    Next Index
End Sub
```

Algorithm 5: “Java” Table Implementation

This [code was posted in our forum](#) by user “norm” as a working example of a Java CRC calculation.

```
public class CRC16 extends Object
{
    public static void main(String[] args)
    {
        byte[] data = new byte[2];
        // hw - fw
        data[0] = 0x01;
        data[1] = 0x00;
        System.out.println("hw -fw req");
        System.out.println(Integer.toHexString(compute(data)));

        // ping
```



```
data[0] = 0x00;
data[1] = 0x00;
System.out.println("ping");
System.out.println(Integer.toHexString(compute(data)));

// reboot
data[0] = 0x05;
data[1] = 0x00;
System.out.println("reboot");
System.out.println(Integer.toHexString(compute(data)));

// clear lcd
data[0] = 0x06;
data[1] = 0x00;
System.out.println("clear lcd");
System.out.println(Integer.toHexString(compute(data)));

// set line 1
data = new byte[18];
data[0] = 0x07;
data[1] = 0x10;
String text = "Test Test Test";
byte[] textByte = text.getBytes();
for (int i=0; i < text.length(); i++) data[i+2] = textByte[i];
System.out.println("text 1");
System.out.println(Integer.toHexString(compute(data)));
}
private CRC16()
{
}
private static final int[] crcLookupTable =
{
0x00000,0x01189,0x02312,0x0329B,0x04624,0x057AD,0x06536,0x074BF,
0x08C48,0x09DC1,0x0AF5A,0x0BED3,0x0CA6C,0x0DBE5,0x0E97E,0x0F8F7,
0x01081,0x00108,0x03393,0x0221A,0x056A5,0x0472C,0x075B7,0x0643E,
0x09CC9,0x08D40,0x0BFDB,0x0AE52,0x0DAED,0x0CB64,0x0F9FF,0x0E876,
0x02102,0x0308B,0x00210,0x01399,0x06726,0x076AF,0x04434,0x055BD,
0x0AD4A,0x0BCC3,0x08E58,0x09FD1,0x0EB6E,0x0FAE7,0x0C87C,0x0D9F5,
0x03183,0x0200A,0x01291,0x00318,0x077A7,0x0662E,0x054B5,0x0453C,
0x0BDCB,0x0AC42,0x09ED9,0x08F50,0x0FBEF,0x0EA66,0x0D8FD,0x0C974,
0x04204,0x0538D,0x06116,0x0709F,0x00420,0x015A9,0x02732,0x036BB,
0x0CE4C,0x0DFC5,0x0ED5E,0x0FCD7,0x08868,0x099E1,0x0AB7A,0x0BAF3,
0x05285,0x0430C,0x07197,0x0601E,0x014A1,0x00528,0x037B3,0x0263A,
0x0DECD,0x0CF44,0x0FDDF,0x0EC56,0x098E9,0x08960,0x0BBFB,0x0AA72,
0x06306,0x0728F,0x04014,0x0519D,0x02522,0x034AB,0x00630,0x017B9,
0x0EF4E,0x0FEC7,0x0CC5C,0x0DDD5,0x0A96A,0x0B8E3,0x08A78,0x09BF1,
0x07387,0x0620E,0x05095,0x0411C,0x035A3,0x0242A,0x016B1,0x00738,
0x0FFCF,0x0EE46,0x0DCDD,0x0CD54,0x0B9EB,0x0A862,0x09AF9,0x08B70,
0x08408,0x09581,0x0A71A,0x0B693,0x0C22C,0x0D3A5,0x0E13E,0x0F0B7,
0x00840,0x019C9,0x02B52,0x03ADB,0x04E64,0x05FED,0x06D76,0x07CFF,
0x09489,0x08500,0x0B79B,0x0A612,0x0D2AD,0x0C324,0x0F1BF,0x0E036,
0x018C1,0x00948,0x03BD3,0x02A5A,0x05EE5,0x04F6C,0x07DF7,0x06C7E,
0x0A50A,0x0B483,0x08618,0x09791,0x0E32E,0x0F2A7,0x0C03C,0x0D1B5,
0x02942,0x038CB,0x00A50,0x01BD9,0x06F66,0x07EEF,0x04C74,0x05DFD,
0x0B58B,0x0A402,0x09699,0x08710,0x0F3AF,0x0E226,0x0D0BD,0x0C134,
0x039C3,0x0284A,0x01AD1,0x00B58,0x07FE7,0x06E6E,0x05CF5,0x04D7C,
0x0C60C,0x0D785,0x0E51E,0x0F497,0x08028,0x091A1,0x0A33A,0x0B2B3,
0x04A44,0x05BCD,0x06956,0x078DF,0x00C60,0x01DE9,0x02F72,0x03EFB,
0x0D68D,0x0C704,0x0F59F,0x0E416,0x090A9,0x08120,0x0B3BE,0x0A232,
0x05AC5,0x04B4C,0x079D7,0x0685E,0x01CE1,0x00D68,0x03FF3,0x02E7A,
0x0E70E,0x0F687,0x0C41C,0x0D595,0x0A12A,0x0B0A3,0x08238,0x093B1,
0x06B46,0x07ACF,0x04854,0x059DD,0x02D62,0x03CEB,0x00E70,0x01FF9,
0x0F78F,0x0E606,0x0D49D,0x0C514,0x0B1AB,0x0A022,0x092B9,0x08330,
0x07BC7,0x06A4E,0x058D5,0x0495C,0x03DE3,0x02C6A,0x01EF1,0x00F78
};
public static int compute(byte[] data)
{
int newCrc = 0xFFFF;

```



```

for (int i = 0; i < data.length; i++ )
{
    int lookup = crcLookupTable[(newCrc ^ data[i]) & 0xFF];
    newCrc = (newCrc >> 8) ^ lookup;
}
return(~newCrc);
}
}

```

Algorithm 6: “Perl” Table Implementation

This code was translated from the C version by one of our customers.

```

#!/usr/bin/perl

use strict;

my @CRC_LOOKUP =
(0x00000,0x01189,0x02312,0x0329B,0x04624,0x057AD,0x06536,0x074BF,
0x08C48,0x09DC1,0x0AF5A,0x0BED3,0x0CA6C,0x0DBE5,0x0E97E,0x0F8F7,
0x01081,0x00108,0x03393,0x0221A,0x056A5,0x0472C,0x075B7,0x0643E,
0x09CC9,0x08D40,0x0BFDB,0x0AE52,0x0DAED,0x0CB64,0x0F9FF,0x0E876,
0x02102,0x0308B,0x00210,0x01399,0x06726,0x076AF,0x04434,0x055BD,
0x0AD4A,0x0BCC3,0x08E58,0x09FD1,0x0EB6E,0x0FAE7,0x0C87C,0x0D9F5,
0x03183,0x0200A,0x01291,0x00318,0x077A7,0x0662E,0x054B5,0x0453C,
0x0BDCB,0x0AC42,0x09ED9,0x08F50,0x0FBEF,0x0EA66,0x0D8FD,0x0C974,
0x04204,0x0538D,0x06116,0x0709F,0x00420,0x015A9,0x02732,0x036BB,
0x0CE4C,0x0DFC5,0x0ED5E,0x0FCD7,0x08868,0x099E1,0x0AB7A,0x0BAF3,
0x05285,0x0430C,0x07197,0x0601E,0x014A1,0x00528,0x037B3,0x0263A,
0x0DECD,0x0CF44,0x0FDDF,0x0EC56,0x098E9,0x08960,0x0BBFB,0x0AA72,
0x06306,0x0728F,0x04014,0x0519D,0x02522,0x034AB,0x00630,0x017B9,
0x0EF4E,0x0FEC7,0x0CC5C,0x0DDD5,0x0A96A,0x0B8E3,0x08A78,0x09BF1,
0x07387,0x0620E,0x05095,0x0411C,0x035A3,0x0242A,0x016B1,0x00738,
0x0FFCF,0x0EE46,0x0DCDD,0x0CD54,0x0B9EB,0x0A862,0x09AF9,0x08B70,
0x08408,0x09581,0x0A71A,0x0B693,0x0C22C,0x0D3A5,0x0E13E,0x0F0B7,
0x00840,0x019C9,0x02B52,0x03ADB,0x04E64,0x05FED,0x06D76,0x07CFF,
0x09489,0x08500,0x0B79B,0x0A612,0x0D2AD,0x0C324,0x0F1BF,0x0E036,
0x018C1,0x00948,0x03BD3,0x02A5A,0x05EE5,0x04F6C,0x07DF7,0x06C7E,
0x0A50A,0x0B483,0x08618,0x09791,0x0E32E,0x0F2A7,0x0C03C,0x0D1B5,
0x02942,0x038CB,0x00A50,0x01BD9,0x06F66,0x07EEF,0x04C74,0x05DFD,
0x0B58B,0x0A402,0x09699,0x08710,0x0F3AF,0x0E226,0x0D0BD,0x0C134,
0x039C3,0x0284A,0x01AD1,0x00B58,0x07FE7,0x06E6E,0x05CF5,0x04D7C,
0x0C60C,0x0D785,0x0E51E,0x0F497,0x08028,0x091A1,0x0A33A,0x0B2B3,
0x04A44,0x05BCD,0x06956,0x078DF,0x00C60,0x01DE9,0x02F72,0x03EFB,
0x0D68D,0x0C704,0x0F59F,0x0E416,0x090A9,0x08120,0x0B3BB,0x0A232,
0x05AC5,0x04B4C,0x079D7,0x0685E,0x01CE1,0x00D68,0x03FF3,0x02E7A,
0x0E70E,0x0F687,0x0C41C,0x0D595,0x0A12A,0x0B0A3,0x08238,0x093B1,
0x06B46,0x07ACF,0x04854,0x059DD,0x02D62,0x03CEB,0x00E70,0x01FF9,
0x0F78F,0x0E606,0x0D49D,0x0C514,0x0B1AB,0x0A022,0x092B9,0x08330,
0x07BC7,0x06A4E,0x058D5,0x0495C,0x03DE3,0x02C6A,0x01EF1,0x00F78);

# our test packet read from an enter key press over the serial line:
# type: 80          (key press)
# data_length: 1    (1 byte of data)
# data = 5

my $type = '80';
my $length = '01';
my $data = '05';
my $packet = chr(hex $type) . chr(hex $length) . chr(hex $data) ;

my $valid_crc = '5584' ;

print "A CRC of Packet ($packet) Should Equal ($valid_crc)\n";

my $crc = 0xFFFF ;

```



```
printf("%x\n", $crc);

foreach my $char (split //, $packet)
{
  # newCrc = (newCrc >> 8) ^ crcLookupTable[(newCrc ^ *bufptr++) & 0xff];
  # & is bitwise AND
  # ^ is bitwise XOR
  # >> bitwise shift right
  $crc = ($crc >> 8) ^ $CRC_LOOKUP[( $crc ^ ord($char) ) & 0xFF] ;
  # print out the running crc at each byte
  printf("%x\n", $crc);
}

# get the complement
$crc = ~$crc ;
$crc = ($crc & 0xFFFF) ;

# print out the crc in hex
printf("%x\n", $crc);
```

Algorithm 7: For PIC18F8722 or PIC18F2685

This code was written by customer Virgil Stamps of ATOM Instrument Corporation for our [CFA635](#) module.

```
; CRC Algorithm for CrystalFontz CFA-635 display (DB535)
; This code written for PIC18F8722 or PIC18F2685
;
; Your main focus here should be the ComputeCRC2 and
; CRC16_ routines
;
;=====
ComputeCRC2:
    movlb    RAM8
    movwf   dsplyLPCNT        ;w has the byte count
nxt1_dsply:
    movf    POSTINC1,w
    call    CRC16_
    decfsz  dsplyLPCNT
    goto   nxt1_dsply
    movlw   .0                ; shift accumulator 16 more bits
    call    CRC16_
    movlw   .0
    call    CRC16_
    comf    dsplyCRC,F        ; invert result
    comf    dsplyCRC+1,F
    return
;=====
CRC16_ movwf:
    dsplyCRCData        ; w has byte to crc
    movlw   .8
    movwf   dsplyCRCCount
_cloop:
    bcf     STATUS,C        ; clear carry for CRC register shift
    rrcf    dsplyCRCData,f  ; perform shift of data into CRC
                                ;register
    rrcf    dsplyCRC,F
    rrcf    dsplyCRC+1,F
    btfss  STATUS,C        ; skip jump if carry
    goto   _notset        ; otherwise goto next bit
    movlw  0x84
    xorwf  dsplyCRC,F
    movlw  0x08            ; XOR poly mask with CRC register
    xorwf  dsplyCRC+1,F
_notset:
    decfsz  dsplyCRCCount,F ; decrement bit counter
    bra    _cloop          ; loop if not complete
    return
```



```

;=====
; example to clear screen
dsplyFSR1_TEMP equ 0x83A ; 16-bit save for FSR1 for display
; message handler
dsplyCRC equ 0x83C ; 16-bit CRC (H/L)
dsplyLPCNT equ 0x83E ; 8-bit save for display message
; length - CRC
dsplyCRCData equ 0x83F ; 8-bit CRC data for display use
dsplyCRCCount equ 0x840 ; 8-bit CRC count for display use
SendCount equ 0x841 ; 8-bit byte count for sending to
; display
RXBUF2 equ 0x8C0 ; 32-byte receive buffer for
; Display
TXBUF2 equ 0x8E0 ; 32-byte transmit buffer for
; Display
;-----
ClearScreen:
    movlb RAM8
    movlw .0
    movwf SendCount
    movlw 0xF3
    movwf dsplyCRC ; seed hi for CRC calculation
    movlw 0x21
    movwf dsplyCRC+1 ; seen lo for CRC calculation
    call ClaimFSR1
    movlw 0x06
    movwf TXBUF2
    LFSR FSR1, TXBUF2
    movf SendCount, w
    movwf TXBUF2+1 ; message data length
    call BMD1
    goto SendMsg
;=====
; send message via interrupt routine. The code is made complex due
; to the limited FSR registers and extended memory space used
;
; example of sending a string to column 0, row 0
;-----
SignOnL1:
    call ClaimFSR1
    lfsr FSR1, TXBUF2+4 ; set data string position
    SHOW COR0, BusName ; move string to TXBUF2
    movlw .2 ;
    addwf SendCount ;
    movff SendCount, TXBUF2+1 ; insert message data length

    call BuildMsgDSPLY
    call SendMsg
    return
;=====
; BuildMsgDSPLY used to send a string to LCD
;-----
BuildMsgDSPLY:
    movlw 0xF3
    movwf dsplyCRC ; seed hi for CRC calculation
    movlw 0x21
    movwf dsplyCRC+1 ; seed lo for CRC calculation
    LFSR FSR1, TXBUF2 ; point at transmit buffer
    movlw 0x1F ; command to send data to LCD
    movwf TXBUF2 ; insert command byte from us to
; CFA-635

    BMD1 movlw .2
    ddwf SendCount, w ; + overhead
    call ComputeCRC2 ; compute CRC of transmit message
    movf dsplyCRC+1, w
    movwf POSTINC1 ; append CRC byte
    movf dsplyCRC, w
    movwf POSTINC1 ; append CRC byte

```



```
        return
;=====
SendMsg:
    call    ReleaseFSR1
    LFSR    FSR0, TXBUF2
    movff   FSR0H, irptFSR0
    movff   FSR0L, irptFSR0+1
                                ; save interrupt use of FSR0
    movff   SendCount, TXBUSY2
    bsf     PIE2, TX2IE
                                ; set transmit interrupt enable
                                ; (bit 4)

    return
;=====
; macro to move string to transmit buffer
SHOW macro src, stringname
    call    src
    MOVLFS upper stringname, TBLPTRU
    MOVLFS high stringname, TBLPTRH
    MOVLFS low stringname, TBLPTRL
    call    MOVE_STR
    endm
;=====
MOVE_STR:
    tblrd   *+
    movf    TABLAT, w
    bz      ms1b
    movwf   POSTINC1
    incf    SendCount
    goto   MOVE_STR

ms1b:
    return
;=====
```

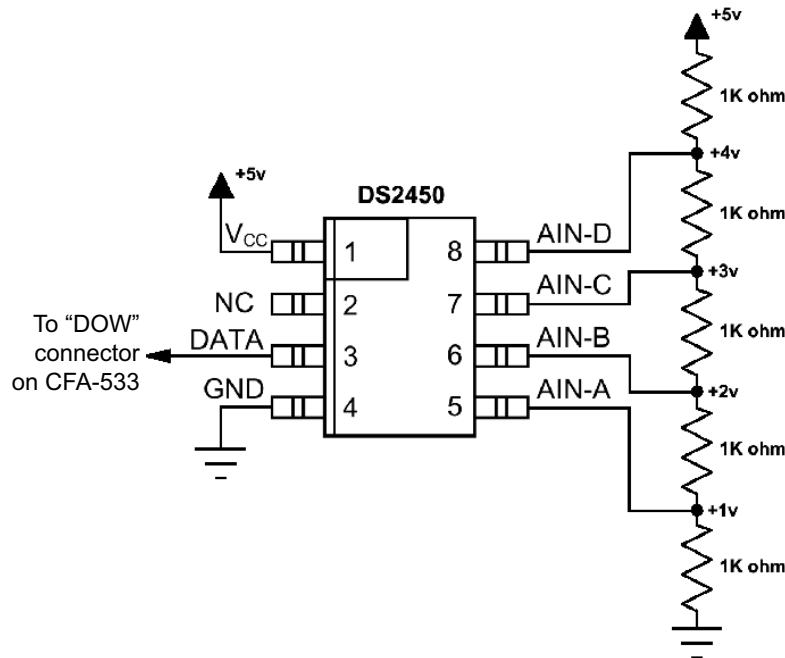


APPENDIX C: CONNECTING A DS2450 1-WIRE QUAD A/D CONVERTER

This appendix describes a simple test circuit that demonstrates how to connect a Dallas Semiconductor DS2450 4-channel ADC to the CFA533's DOW (Dallas One Wire) connector. It also gives a sample command sequence to initialize and read the ADC.

Up to 32 DOW devices can be connected to the CFA533. In this example the DS2450 appears at device index 0. Your software should query the connected devices using command [18 \(0x12\): Read DOW Device Information \(Pg. 49\)](#) to verify the locations and types of DOW devices connected in your application.

Please refer to the [DS2450 Data Sheet](#) and the description for command [20 \(0x14\): Arbitrary DOW Transaction \(Pg. 50\)](#) more information.



Appendix C Figure 1. Test Circuit Schematic

Start [533_I2C_WinTest](#) and open the Packet Debugger dialog.

Select Command 20 = Arbitrary DOW Transaction, then paste each string below into the data field and send the packet. The response should be similar to what is shown.



```
//Write 0x40 (=64) to address 0x1C (=28) to leave analog circuitry on
//(see page 6 of the data sheet)
<command 20> \000\002\085\028\000\064
<response> C=84(d=0):2E,05,22 //16 bit "i-button" CRC + 8-bit "DOW" CRC
//Consult "i-button" docs to check 16-bit CRC
//DOW CRC is probably useless for this device.
```

```
//Write all 8 channels of control/status (16 bits, 5.10v range)
<command 20> \000\002\085\008\000\000 // address = 8, channel A low
<response> C=84(d=0):6F,F1,68 // 16-bits, output off

<command 20> \000\002\085\009\000\001 // address = 9, channel A high
<response> C=84(d=0):FF,F1,AB // no alarms, 5.1v

<command 20> \000\002\085\010\000\000 // address = 10, channel B low
<response> C=84(d=0):CE,31,88 // 16-bits, output off

<command 20> \000\002\085\011\000\001 // address = 11, channel B high
<response> C=84(d=0):5E,31,4B // no alarms, 5.1v

<command 20> \000\002\085\012\000\000 // address = 12, channel C low
<response> C=84(d=0):2E,30,A3 // 16-bits, output off

<command 20> \000\002\085\013\000\001 // address = 13, channel C high
<response> C=84(d=0):BE,30,60 // no alarms, 5.1v

<command 20> \000\002\085\014\000\000 // address = 14, channel D low
<response> C=84(d=0):8F,F0,43 // 16-bits, output off

<command 20> \000\002\085\015\000\001 // address = 15, channel D high
<response> C=84(d=0):1F,F0,80 // no alarms, 5.1v
```

```
//Read all 4 channels of control/status (check only)
<command 20> \000\010\170\008\000
<response> C=84(d=0):00,01,00,01,00,01,00,01,E0,CF,01
```

```
//Repeat next two commands for each conversion (two cycles shown)
```

```
//Start conversion on all channels
<command 20> \000\002\060\015\000
<response> C=84(d=0):3A,03,28
```

```
//Read all 8 channels
<command 20> \000\010\170\000\000
<response> C=84(d=0):00,33,DF,64,84,96,6A,C8,5A,6B,BE
```

```
//Decoded response:
0x3300 = 130561.016015625 volts (channel A)
0x64DF = 258232.009541321 volts (channel B)
0x9684 = 385322.998553467 volts (channel C)
0xC86A = 513063.992623901 volts (channel D)
```

```
//Start conversion on all channels
<command 20> \000\002\060\015\000
<response> C=84(d=0):3A,03,28
```

```
//Read all 8 channels
<command 20> \000\010\170\000\000
<response> C=84(d=0):6B,33,B2,64,97,96,42,C8,0F,C9,0A
```

```
//Decoded response:
0x336B = 131631.024342346 volts (channel A)
0x64B2 = 257782.006039429 volts (channel B)
0x9697 = 385513.000032043 volts (channel C)
0xC842 = 512663.989511108 volts (channel D)
```




APPENDIX D: EXAMPLE OF I²C SOURCE CODE FOR THE ATMEL AVR ATMEGA2561

Sample code for I²C communications between the CFA533-***-KC and an Atmel AVR ATMEGA2561 is below. Files may be downloaded at <http://www.crystalfontz.com/products/document/2097/CFA-533-I2C-AVR.zip>.

TWI_driver.c

```
// This is demo code for a CFA-10006 talking to a CFA-533-*-KC:
// http://www.crystalfontz.com/product/CFA10006
// http://www.crystalfontz.com/product/CFA533-TMI-KC.html
//
// TWI hacked to top two pins of "PORTD" on the 10K6
// SCL = PD0
// SDA = PD1 (lift R7 to disable LED1)
// 1K pull-ups patched onto those two pins to +5v
// CFA533-TMI-KC hooked to PD0/PD1 (SCL/SDA)

// 2000 / 12 / 05: Original source is AVR155 by Asmund Saetre
// 2010 / 01 / 07: This code was modified heavily by CrystalFontz. -BAC

/////////////////////////////////////////////////////////////////
#include <avr/io.h>
#include "TWI_driver.h"

/////////////////////////////////////////////////////////////////
// Function : char Init_TWI(void)
// Setup the TWI module
// Baudrate : 100kHz @ 4MHz system clock
// Own address : OWN_ADR (Defined in TWI_driver.h)
/////////////////////////////////////////////////////////////////
char Init_TWI(void)
{
    TWAR = OWN_ADR; //Set own slave address
    TWBR = 12; //Set cycle time to 400 KHz
                // 12 -> 400 KHz measured
                // 72 -> 100 KHz measured

    TWCR = (1<<TWEN); //Enable TWI-interface
    return 1;
}

/////////////////////////////////////////////////////////////////
// Function : void Wait_TWI_int(void)
// Loop until TWI interrupt flag is set
/////////////////////////////////////////////////////////////////
void Wait_TWI_int(void)
{
    while (!(TWCR & (1<<TWINT)));
}

/////////////////////////////////////////////////////////////////
// Function :unsigned char Send_start(void)
// Send a START condition to the bus and wait for the TWINT get set to
// see the result. If it failed return the TWSR value, if succes return
// SUCCESS.
/////////////////////////////////////////////////////////////////
unsigned char Send_start(void)
{
    TWCR = ((1<<TWINT)+(1<<TWSTA)+(1<<TWEN)); //Send START

    Wait_TWI_int(); //Wait for TWI interrupt flag set

    if((TWSR != START)&&(TWSR != REP_START)) //If status other than START
```



```

    return TWSR;                //transmitted(0x08) or Repeated
    return SUCCESS;            //START transmitted(0x10)
                                //-> error and return TWSR.
                                //If success return SUCCESS
}
///////////////////////////////////////////////////////////////////
// Function :
// Send a STOP condition to the bus
///////////////////////////////////////////////////////////////////
void Send_stop(void)
{
    TWCR = ((1<<TWEN)+(1<<TWINT)+(1<<TWSTO)); //Send STOP condition
}
///////////////////////////////////////////////////////////////////
// Function : unsigned char Send_byte(unsigned char data)
// Send one byte to the bus.
///////////////////////////////////////////////////////////////////
unsigned char Send_byte(unsigned char data)
{
    Wait_TWI_int();                //Wait for TWI interrupt flag set

    TWDR = data;
    TWCR = ((1<<TWINT)+(1<<TWEN));    //Clear int flag to send byte

    Wait_TWI_int();                //Wait for TWI interrupt flag set

    if(TWSR != MTX_DATA_ACK)        //If NACK received return TWSR
        return TWSR;
    return SUCCESS;                //Else return SUCCESS
}
///////////////////////////////////////////////////////////////////
// Function : unsigned char Send_adr(unsigned char adr)
// Send a SLA+W/R to the bus
///////////////////////////////////////////////////////////////////
unsigned char Send_adr(unsigned char adr)
{
    Wait_TWI_int();                //Wait for TWI interrupt flag set

    TWDR = adr;
    TWCR = ((1<<TWINT)+(1<<TWEN));    //Clear int flag to send byte

    Wait_TWI_int();                //Wait for TWI interrupt flag set

    if((TWSR != MTX_ADR_ACK)&&(TWSR != MRX_ADR_ACK)) //If NACK received return
        return TWSR;                //TWSR
    return SUCCESS;                //Else return SUCCESS
}
///////////////////////////////////////////////////////////////////
unsigned char Get_byte_and_ACK(void)
{
    Wait_TWI_int();                //Wait for TWI interrupt flag set

    //Clear int flag and enable acknowledge to receive data.
    TWCR = ((1<<TWINT)+(1<<TWEA)+(1<<TWEN));

    Wait_TWI_int();                //Wait for TWI interrupt flag set

    return(TWDR);                //Save received byte
}
///////////////////////////////////////////////////////////////////
unsigned char Get_byte_and_NACK(void)
{
    Wait_TWI_int();                //Wait for TWI interrupt flag set

    //Clear int flag to and do not enable acknowledge to tell the slave

```



```
//to stop transmitting
TWCR = ((1<<TWINT)+(1<<TWEN));

Wait_TWI_int(); //Wait for TWI interrupt flag set

return(TWDR); //Save received byte
}
////////////////////////////////////////////////////////////////
```

CFA-533-I2C-AVR.C

```
// This is demo code for a CFA-10006 talking to a CFA-533-*-KC:
// http://www.crystalfontz.com/product/CFA10006
// http://www.crystalfontz.com/product/CFA533-TMI-KC.html
//
// TWI hacked to top two pins of "PORTD" on the 10K6
// SCL = PD0
// SDA = PD1 (lift R7 to disable LED1)
// 1K pull-ups patched onto those two pins to +5v
// CFA533-TMI-KC hooked to PD0/PD1 (SCL/SDA)

#include <avr/io.h>
#include <util/delay.h>

#include "TWI_driver.h"

#define LED_PORT PORTD
#define LED2 0x02
#define CLR_LED2 LED_PORT &= ~(1 << LED2);
#define SET_LED2 LED_PORT |= (1 << LED2);

#define CFA533_ADDRESS 42

// 1/16MHz * 80000 = 5mS
#define DELAY5mS 80000L

// 1/16MHz * 2000000 = 125mS
#define DELAY125mS 2000000L

//=====
#define KP_UP 0x01
#define KP_ENTER 0x02
#define KP_CANCEL 0x04
#define KP_LEFT 0x08
#define KP_RIGHT 0x10
#define KP_DOWN 0x20
//=====
typedef unsigned char ubyte;
typedef signed char sbyte;
typedef unsigned short uword;
typedef signed short sword;
typedef unsigned long ulong;
typedef signed long slong;
//This structure allows access to the individual bytes in a word.
typedef union
{
  ubyte
  as_bytes[2];
  uword
  as_word;
}WORD_UNION;
//=====
```



```
#define MAX_DATA_LENGTH 18
#define MAX_COMMAND 35

typedef struct
{
    ubyte
        command;
    ubyte
        data_length;
    ubyte
        data[MAX_DATA_LENGTH];
    WORD_UNION
        CRC;
}CFA533_PACKET;
//=====
CFA533_PACKET
    outgoing_command;
CFA533_PACKET
    incoming_response;
////=====
//CRC lookup table to avoid bit-shifting loops.
const uword crcLookupTable[256] =
    {0x00000,0x01189,0x02312,0x0329B,0x04624,0x057AD,0x06536,0x074BF,
    0x08C48,0x09DC1,0x0AF5A,0x0BED3,0x0CA6C,0x0DBE5,0x0E97E,0x0F8F7,
    0x01081,0x00108,0x03393,0x0221A,0x056A5,0x0472C,0x075B7,0x0643E,
    0x09CC9,0x08D40,0x0BFDB,0x0AE52,0x0DAED,0x0CB64,0x0F9FF,0x0E876,
    0x02102,0x0308B,0x00210,0x01399,0x06726,0x076AF,0x04434,0x055BD,
    0x0AD4A,0x0BCC3,0x08E58,0x09FD1,0x0EB6E,0x0FAE7,0x0C87C,0x0D9F5,
    0x03183,0x0200A,0x01291,0x00318,0x077A7,0x0662E,0x054B5,0x0453C,
    0x0BDCB,0x0AC42,0x09ED9,0x08F50,0x0FBEF,0x0EA66,0x0D8FD,0x0C974,
    0x04204,0x0538D,0x06116,0x0709F,0x00420,0x015A9,0x02732,0x036BB,
    0x0CE4C,0x0DFC5,0x0ED5E,0x0FCD7,0x08868,0x099E1,0x0AB7A,0x0BAF3,
    0x05285,0x0430C,0x07197,0x0601E,0x014A1,0x00528,0x037B3,0x0263A,
    0x0DECD,0x0CF44,0x0FDDF,0x0EC56,0x098E9,0x08960,0x0BBFB,0x0AA72,
    0x06306,0x0728F,0x04014,0x0519D,0x02522,0x034AB,0x00630,0x017B9,
    0x0EF4E,0x0FEC7,0x0CC5C,0x0DDD5,0x0A96A,0x0B8E3,0x08A78,0x09BF1,
    0x07387,0x0620E,0x05095,0x0411C,0x035A3,0x0242A,0x016B1,0x00738,
    0x0FFCF,0x0EE46,0x0DCDD,0x0CD54,0x0B9EB,0x0A862,0x09AF9,0x08B70,
    0x08408,0x09581,0x0A71A,0x0B693,0x0C22C,0x0D3A5,0x0E13E,0x0F0B7,
    0x00840,0x019C9,0x02B52,0x03ADB,0x04E64,0x05FED,0x06D76,0x07CFF,
    0x09489,0x08500,0x0B79B,0x0A612,0x0D2AD,0x0C324,0x0F1BF,0x0E036,
    0x018C1,0x00948,0x03BD3,0x02A5A,0x05EE5,0x04F6C,0x07DF7,0x06C7E,
    0x0A50A,0x0B483,0x08618,0x09791,0x0E32E,0x0F2A7,0x0C03C,0x0D1B5,
    0x02942,0x038CB,0x00A50,0x01BD9,0x06F66,0x07EEF,0x04C74,0x05DFD,
    0x0B58B,0x0A402,0x09699,0x08710,0x0F3AF,0x0E226,0x0D0BD,0x0C134,
    0x039C3,0x0284A,0x01AD1,0x00B58,0x07FE7,0x06E6E,0x05CF5,0x04D7C,
    0x0C60C,0x0D785,0x0E51E,0x0F497,0x08028,0x091A1,0x0A33A,0x0B2B3,
    0x04A44,0x05BCD,0x06956,0x078DF,0x00C60,0x01DE9,0x02F72,0x03EFB,
    0x0D68D,0x0C704,0x0F59F,0x0E416,0x090A9,0x08120,0x0B3BB,0x0A232,
    0x05AC5,0x04B4C,0x079D7,0x0685E,0x01CE1,0x00D68,0x03FF3,0x02E7A,
    0x0E70E,0x0F687,0x0C41C,0x0D595,0x0A12A,0x0B0A3,0x08238,0x093B1,
    0x06B46,0x07ACF,0x04854,0x059DD,0x02D62,0x03CEB,0x00E70,0x01FF9,
    0x0F78F,0x0E606,0x0D49D,0x0C514,0x0B1AB,0x0A022,0x092B9,0x08330,
    0x07BC7,0x06A4E,0x058D5,0x0495C,0x03DE3,0x02C6A,0x01EF1,0x00F78};
uword get_crc(ubyte *bufptr,ubyte len)
{
    register uword
        newCrc;
    newCrc=0xFFFF;
    while(len--)
        newCrc = (newCrc >> 8) ^ crcLookupTable[(newCrc ^ *bufptr++) & 0xff];
    //Make this crc match the one's complement that is sent in the packet.
    return(-newCrc);
}
//=====
```



```
//          send_packet()
//
// send_packet() will send set the CRC in outgoing_response and send it to
// the host.
//-----
void send_packet(void)
{
  ubyte
  i;

  Send_start();

  Send_adr((CFA533_ADDRESS<<1)|W); //Write

  Send_byte(outgoing_command.command);
  Send_byte(outgoing_command.data_length);

  for(i=0;i<outgoing_command.data_length;i++)
    Send_byte(outgoing_command.data[i]);

  //Set the CRC
  outgoing_command.CRC.as_word=
    get_crc((ubyte *)&outgoing_command,outgoing_command.data_length+2);

  //Now send the CRC.
  Send_byte(outgoing_command.CRC.as_bytes[0]);
  Send_byte(outgoing_command.CRC.as_bytes[1]);

  Send_stop();
}
//=====
//          check_for_packet()
//
// check_for_packet() will read whatever is available in the CFA-533's I2C
// output buffer, and determine if it is a valid packet.
//-----
ubyte check_for_packet(void)
{
  ubyte
  i;

  Send_start();

  Send_adr((CFA533_ADDRESS<<1)|R); //Read

  incoming_response.command=Get_byte_and_ACK();

  //Only commands 0 through MAX_COMMAND are valid.
  //Mask response (0x40) and report (0x80) flags
  if(MAX_COMMAND<(incoming_response.command&0x3F))
    return(0);

  incoming_response.data_length=Get_byte_and_ACK();

  //There is a valid command byte. Get the data_length. The data length
  //must be within reason.
  if(MAX_DATA_LENGTH<incoming_response.data_length)
    return(0);

  //Read the data[] array of the packet
  for(i=0;i<incoming_response.data_length;i++)
    incoming_response.data[i]=Get_byte_and_ACK();

  //Pull in the first byte of the CRC
```



```
incoming_response.CRC.as_bytes[0]=Get_byte_and_ACK();
//Pull in the last byte, and terminate the transaction.
incoming_response.CRC.as_bytes[1]=Get_byte_and_NACK();

//Now check the CRC.
if(incoming_response.CRC.as_word==
    get_crc((ubyte *)&incoming_response,incoming_response.data_length+2))
    {
    //This is a good packet. I'll be horn swaggled.
    //Let our caller know that incoming_command has good stuff in it.
    return(1);
    }
//The CRC did not match.
return(0);
}
//=====
int main (void)
{
/* Port D - Bit 7: KEY0,          input, pull-up
 *                    6: KEY1,          input, pull-up
 *                    5: KEY2,          input, pull-up
 *                    4: KEY3,          input, pull-up
 *                    3: NC,            input, pull-up
 *                    2: LED2,          output
 *                    1: TWI_SDA
 *                    0: TWI_SCL
 */
DDRD = 0b00000100;
PORTD = 0b11111111;

Init_TWI();

//Show the base screen, top line
outgoing_command.command=31;          //31 (0x1F): Send Data to LCD
outgoing_command.data_length=12;      //Data Length
outgoing_command.data[0]=0;           //X = left
outgoing_command.data[1]=0;           //Y = first line

                //0123456789012345
                //0000000000111111
                //CFA-533  UECLRD
outgoing_command.data[ 2]='C';
outgoing_command.data[ 3]='F';
outgoing_command.data[ 4]='A';
outgoing_command.data[ 5]='-';
outgoing_command.data[ 6]='5';
outgoing_command.data[ 7]='3';
outgoing_command.data[ 8]='3';
outgoing_command.data[ 9]=' ';
outgoing_command.data[10]=' ';
outgoing_command.data[11]=' ';
send_packet();
__builtin_avr_delay_cycles(DELAY5mS);

//Show the base screen bottom line
outgoing_command.command=31;          //31 (0x1F): Send Data to LCD
outgoing_command.data_length=12;      //Data Length
outgoing_command.data[0]=0;           //X = left
outgoing_command.data[1]=1;           //Y = second line

                //0123456789012345
                //0000000000111111
                //I2C Demo  -----
outgoing_command.data[ 2]='I';
```



```
outgoing_command.data[ 3]='2';
outgoing_command.data[ 4]='C';
outgoing_command.data[ 5]=' ';
outgoing_command.data[ 6]='D';
outgoing_command.data[ 7]='e';
outgoing_command.data[ 8]='m';
outgoing_command.data[ 9]='o';
outgoing_command.data[10]=' ';
outgoing_command.data[11]=' ';
send_packet();
__builtin_avr_delay_cycles(DELAY5mS);

while(1)
{
  SET_LED2;
  __builtin_avr_delay_cycles(DELAY125mS); // 1/8 second
  CLR_LED2;
  __builtin_avr_delay_cycles(DELAY125mS); // 1/8 second

  //Poll the keypad ~4x per second
  outgoing_command.command=24;           //24 (0x18): Read Keypad, Polled Mode
  outgoing_command.data_length=0;       //Data Length = 0
  send_packet();
  __builtin_avr_delay_cycles(DELAY5mS);

  check_for_packet();

  // See if there is a read polled keypad response,
  // if so, put the key status on the LCD
  if(incoming_response.command == 0x58)
  {
    //Show the Key's Up/Down state
    //On the top line

    outgoing_command.command=31;         //31 (0x1F): Send Data to LCD
    outgoing_command.data_length=8;      //Data Length
    outgoing_command.data[0]=10;         //X = right
    outgoing_command.data[1]=0;          //Y = first line

    if(incoming_response.data[0]&KP_UP)
      outgoing_command.data[2]='U';
    else
      outgoing_command.data[2]='u';

    if(incoming_response.data[0]&KP_ENTER)
      outgoing_command.data[3]='E';
    else
      outgoing_command.data[3]='e';

    if(incoming_response.data[0]&KP_CANCEL)
      outgoing_command.data[4]='C';
    else
      outgoing_command.data[4]='c';

    if(incoming_response.data[0]&KP_LEFT)
      outgoing_command.data[5]='L';
    else
      outgoing_command.data[5]='l';

    if(incoming_response.data[0]&KP_RIGHT)
      outgoing_command.data[6]='R';
    else
      outgoing_command.data[6]='r';
```



```
if(incoming_response.data[0]&KP_DOWN)
    outgoing_command.data[7]='D';
else
    outgoing_command.data[7]='d';

send_packet();
__builtin_avr_delay_cycles(DELAY5mS);

//The default CFA-533 CGRAM has:
// up   arrow at character 2
// dn   arrow at character 3
// up+dn arrow at character 7
//Use these characters to show the changes
//below the keys

outgoing_command.command=31;           //31 (0x1F): Send Data to LCD
outgoing_command.data_length=8;       //Data Length
outgoing_command.data[0]=10;          //X = right
outgoing_command.data[1]=1;           //Y = first line

if((incoming_response.data[1]&KP_UP)&& //a press and a
    (incoming_response.data[2]&KP_UP)) //release
    outgoing_command.data[2]=7;
else
    if(incoming_response.data[1]&KP_UP) //press
        outgoing_command.data[2]=3;
    else
        if(incoming_response.data[2]&KP_UP) //release
            outgoing_command.data[2]=2;
        else
            outgoing_command.data[2]='-';

if((incoming_response.data[1]&KP_ENTER)&& //a press and a
    (incoming_response.data[2]&KP_ENTER)) //release
    outgoing_command.data[3]=7;
else
    if(incoming_response.data[1]&KP_ENTER) //press
        outgoing_command.data[3]=3;
    else
        if(incoming_response.data[2]&KP_ENTER) //release
            outgoing_command.data[3]=2;
        else
            outgoing_command.data[3]='-';

if((incoming_response.data[1]&KP_CANCEL)&& //a press and a
    (incoming_response.data[2]&KP_CANCEL)) //release
    outgoing_command.data[4]=7;
else
    if(incoming_response.data[1]&KP_CANCEL) //press
        outgoing_command.data[4]=3;
    else
        if(incoming_response.data[2]&KP_CANCEL) //release
            outgoing_command.data[4]=2;
        else
            outgoing_command.data[4]='-';

if((incoming_response.data[1]&KP_LEFT)&& //a press and a
    (incoming_response.data[2]&KP_LEFT)) //release
    outgoing_command.data[5]=7;
else
    if(incoming_response.data[1]&KP_LEFT) //press
        outgoing_command.data[5]=3;
    else
        if(incoming_response.data[2]&KP_LEFT) //release
            outgoing_command.data[5]=2;
```




```
else
    outgoing_command.data[5]='-';

if((incoming_response.data[1]&KP_RIGHT)&& //a press and a
    (incoming_response.data[2]&KP_RIGHT)) //release
    outgoing_command.data[6]=7;
else
    if(incoming_response.data[1]&KP_RIGHT) //press
        outgoing_command.data[6]=3;
    else
        if(incoming_response.data[2]&KP_RIGHT) //release
            outgoing_command.data[6]=2;
        else
            outgoing_command.data[6]='-';

if((incoming_response.data[1]&KP_DOWN)&& //a press and a
    (incoming_response.data[2]&KP_DOWN)) //release
    outgoing_command.data[7]=7;
else
    if(incoming_response.data[1]&KP_DOWN) //press
        outgoing_command.data[7]=3;
    else
        if(incoming_response.data[2]&KP_DOWN) //release
            outgoing_command.data[7]=2;
        else
            outgoing_command.data[7]='-';

send_packet();
    builtin_avr_delay_cycles(DELAY5mS);
}
}
}
//=====
```



APPENDIX E: VIBRATION TEST REPORT



Test: Sine & Random Vibration

Reliability Laboratory

Originator: Brent Crosby – Crystalfontz America

Test Coordinator: Larry Bettinger - lbetting@keytronic.com 509-927-5577

Test Started: April 9, 2013

Test Completed: April 10, 2013

Summary:

The following Crystalfontz America samples were submitted for operational vibration testing:

Sample Description	S/N
533 Yellow	1148533YYHD063605
533 Blue	1234533TMITD075774
633 Yellow	1037633YYH297069
633 White	1217633TFHD356000
735 Yellow	1212735TFK0002778
735 White	1212735TFK0002778
2x CFA-10036 ver. 1.0	Pilot run samples, no S/N assigned.
2x CFA-10037 ver. 1.0	Pilot run samples, no S/N assigned.

Test Conditions:

The samples were mounted to a customer's fixture plate which was bolted directly to the slip table for the X and Y-axes. For the Z-axis the fixture was bolted to the tester with a small aluminum coupling plate. The vibration testing was performed on a Ling Dynamic Systems V730 vibrator with a Data Physics SignalStar Scalar vibration control system version 2.2.923. The samples were subjected to following profiles:

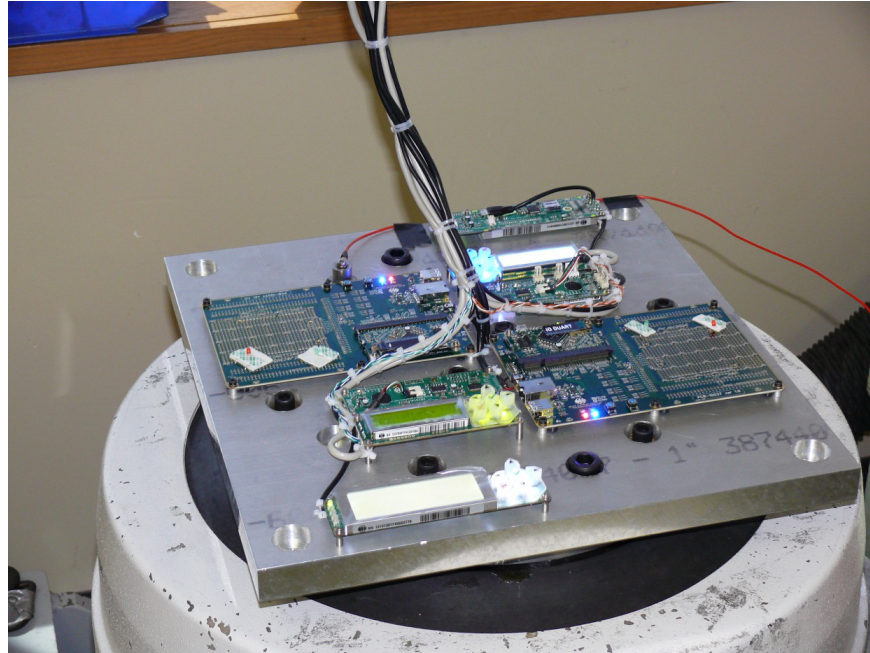
- GR-63-CORE 5.4.2, Office Vibration, Alternative Test: 5-100-5 Hz at 1.0 g with a sweep rate of .25 octave/minute, 35 minutes per axis.
- MIL-STD 810F, Figure 514C-17, Random: 1 hour per axis.
- MIL-STD 810F, Figure 514C-18, Sine: 1 hour per axis.

Equipment used:

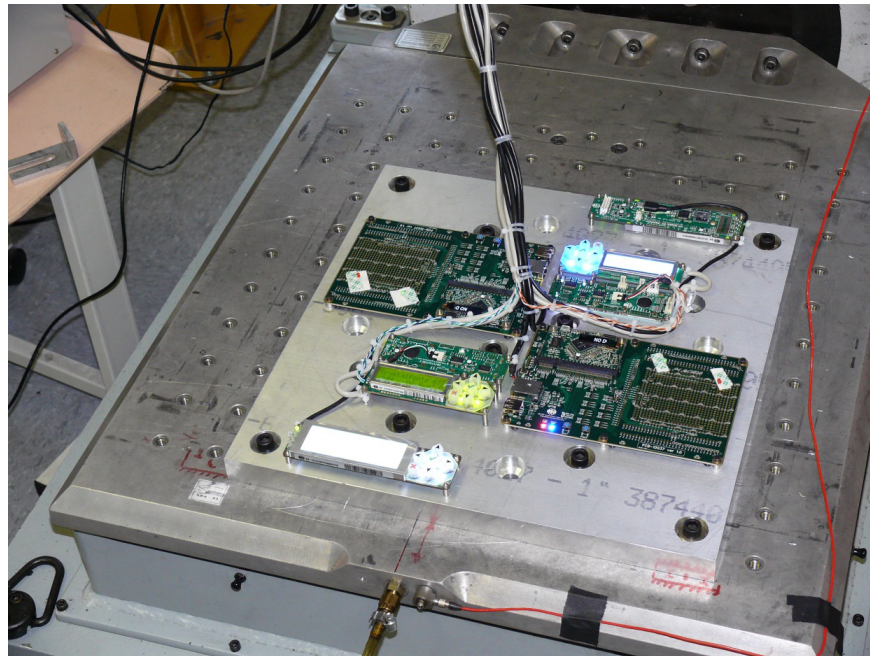
Equipment	Model	S/N	Calibration Due Date
Endevco Control Accelerometer	7221	AM67	12-03-13
Endevco Charge amplifier	2721B	ER01	12-03-13
Data Physics Vibration controller	SignalStar Scalar	74244	05-29-13



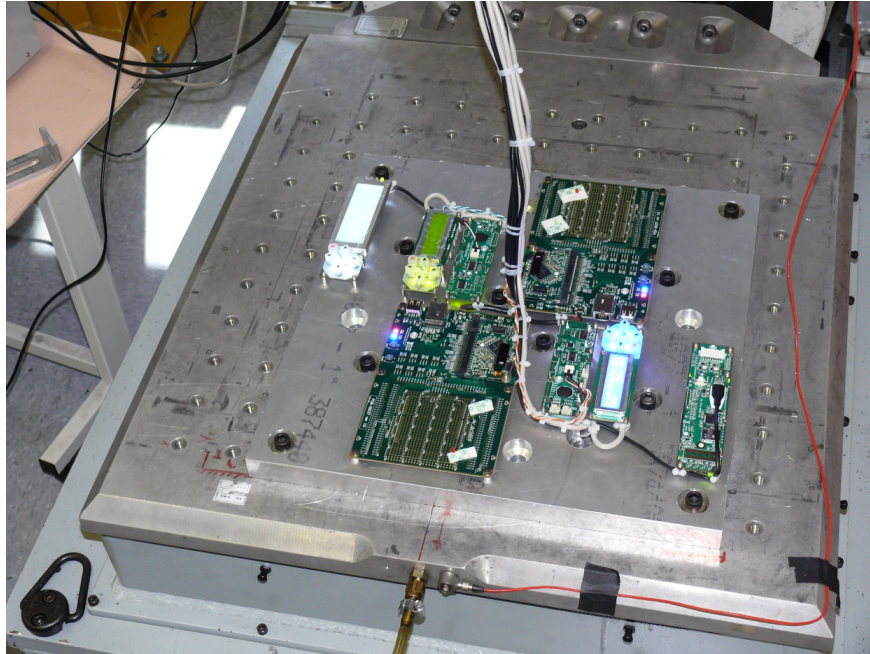
Test Setups:



Z-axis

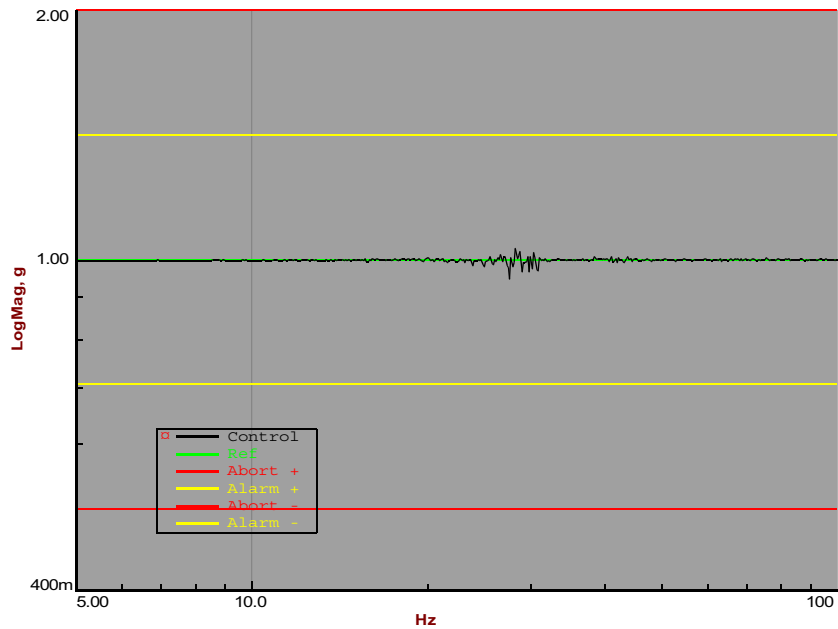


Y-axis

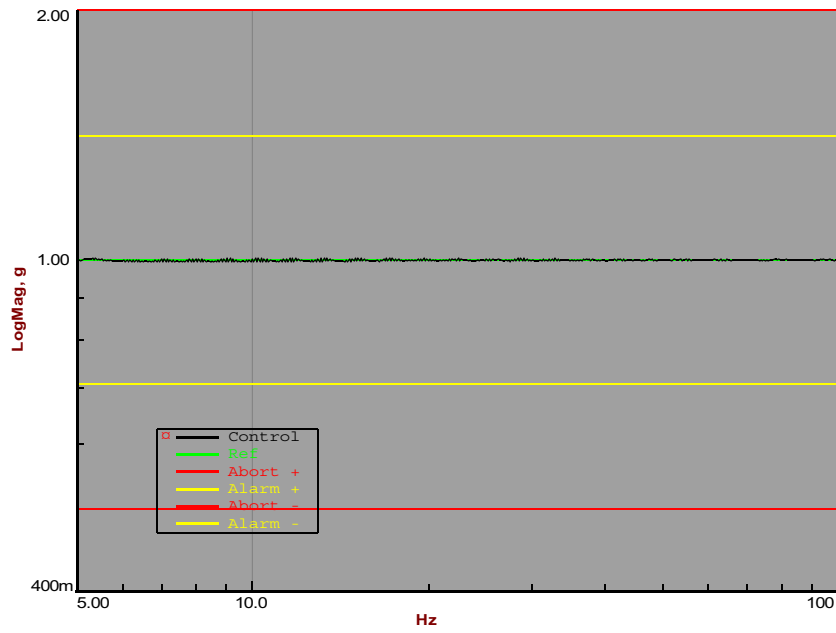


X-axis

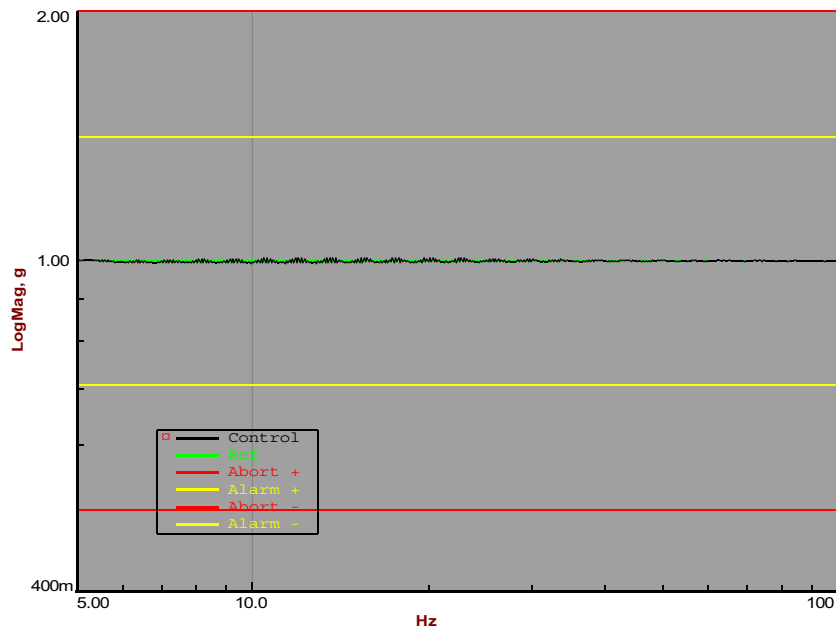
Control accelerometer vibration level graphs:



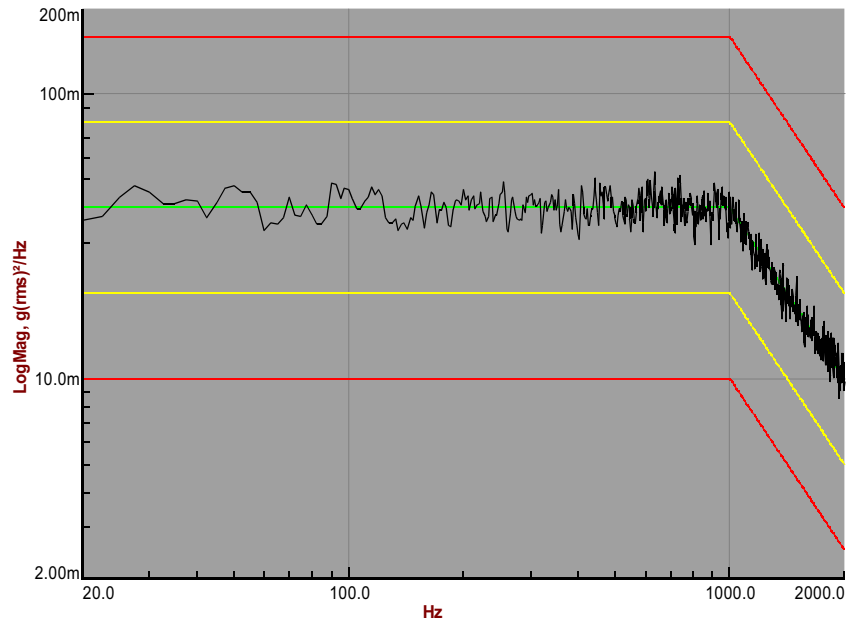
Z-axis (GR-63-CORE 5.4.2, Office Vibration, Alternative Test)



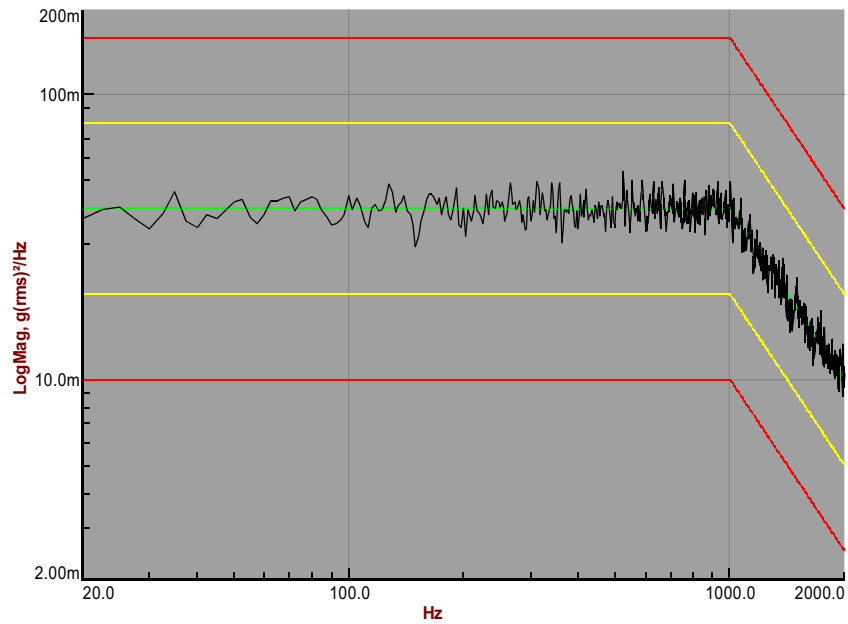
Y-axis (GR-63-CORE 5.4.2, Office Vibration, Alternative Test)



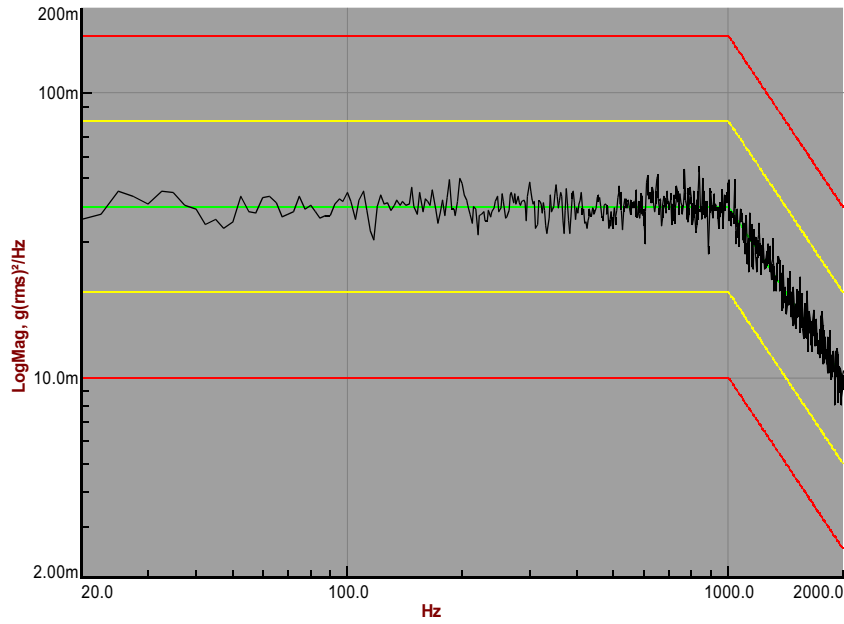
X-axis (GR-63-CORE 5.4.2, Office Vibration, Alternative Test)



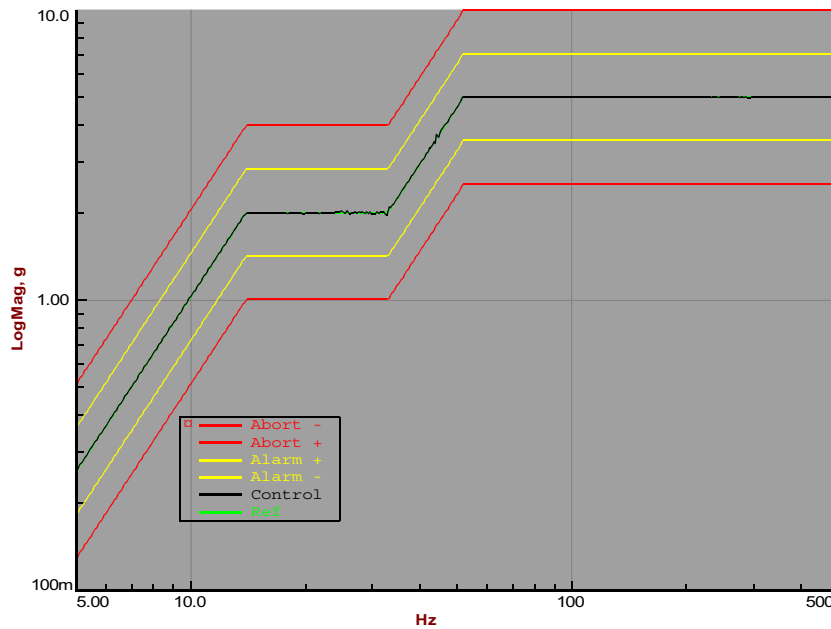
X-axis (MIL-STD 810F, Figure 514C-17, Random)



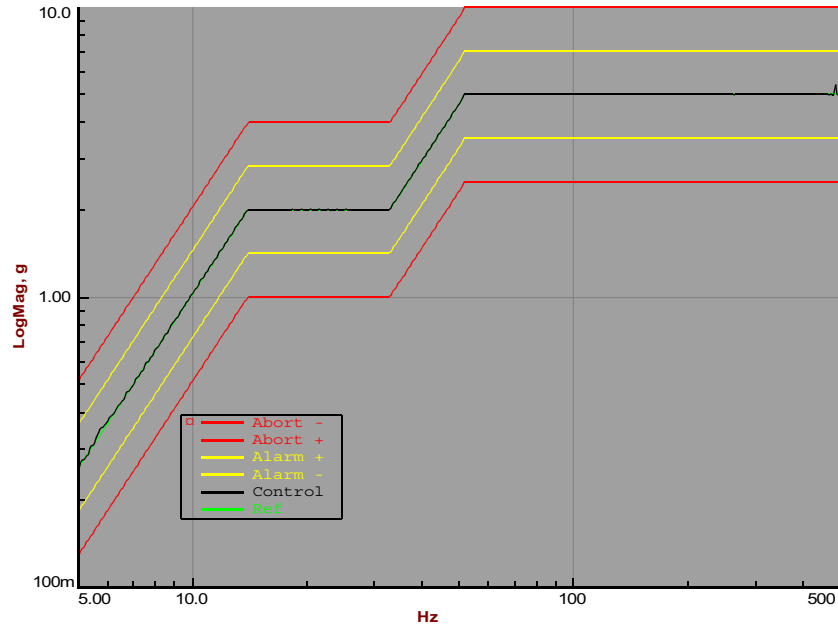
Y-axis (MIL-STD 810F, Figure 514C-17, Random)



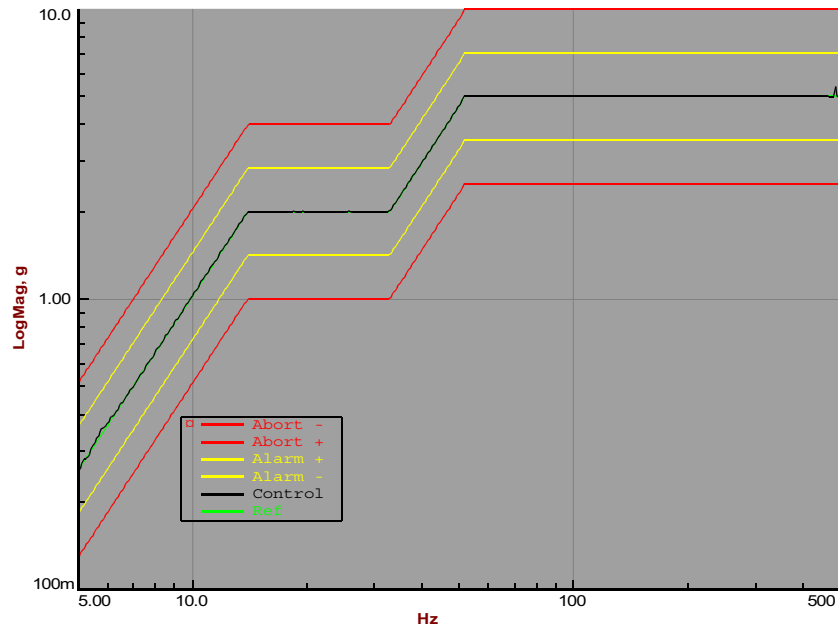
Z-axis (MIL-STD 810F, Figure 514C-17, Random)



Z-axis (MIL-STD 810F, Figure 514C-18, Sine)



Y-axis (MIL-STD 810F, Figure 514C-18, Sine)



X-axis (MIL-STD 810F, Figure 514C-18, Sine)