



Crystalfontz America, Incorporated

INTELLIGENT I²C LCD MODULE SPECIFICATIONS



Crystalfontz Model Number	CFA533-TMI-KC
Hardware Version	Revision 1.0, March 2010
Firmware Version	Revision c1.0, April 2010
Data Sheet Version	Revision 2.0, March 2011
Product Pages	http://www.crystalfontz.com/product/CFA533-TMI-KC.html

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REVISION HISTORY

HARDWARE	
2010/06/06	<p>Current hardware version: v1.0 (revision number has not changed)</p> <p>Changes: We are transitioning to an improved keypad from “10.5” millimeters to “12.00” millimeters high. See PCN 10282.</p>
2010/03/18	<p>Hardware version: v1.0</p> <p>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.</p> <ol style="list-style-type: none">1. Added a JPUSBSENSE jumper to help user configuration. Does not apply to I2C. See Jumper Locations and Functions (Pg. 13).2. Changed JPFG to RFG. RFG connects $1M\Omega$ between logic ground and frame ground. See Jumper Locations and Functions (Pg. 13).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	<p>Hardware version: v0.1</p> <p>New module.</p>

FIRMWARE	
2010/05/15	<p>Current firmware version: c1.0</p> <p>Changes since last version (i0.2): Made firmware version match hardware version.</p>
2009/05/15	<p>Firmware version: i0.2</p> <p>New firmware.</p>



DATA SHEET

Current Data Sheet version: **v2.0**

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 \(Pg. 8\)](#), added
 - “RoHS compliant”.
 - “Factories are ISO certified”.
 - Materials are in compliance with EU Directive “REACH”.
 - Note on CE approved modules.
- In [Physical Characteristics \(Pg. 10\)](#),
 - 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 \(Pg. 13\)](#) due to hardware revision v1.0. Changed “JPFG” to “RFG”. RFG connects 1MΩ between logic ground and frame ground.
- Added [OPTICAL CHARACTERISTICS \(Pg. 18\)](#) section, with definition of viewing angles.
- Added Humidity Range specification in [Temperature and Humidity Ratings \(Pg. 19\)](#).
- In [CONNECTION INFORMATION \(Pg. 21\)](#),
 - 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 \(Pg. 38\)](#), added Errata Note. Please read boxed note.
- In command [8 \(0x08\): Set LCD Contents, Line 2 \(Pg. 41\)](#), 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 \(Pg. 42\)](#), 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 \(Pg. 42\)](#), 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 \(Pg. 46\)](#), corrected “The Neotec [NT7070B](#) controller on the CFA533 is [S6A0073](#) compatible.” to “The controller on the CFA533 is a Neotec [NT7070B](#) ([HD44780](#) compatible).”

2011/03/07



DATA SHEET (Continued)	
2011/03/07	<ul style="list-style-type: none">● In command 35 (0x23): Read GPIO Pin Levels and Configuration State (Pg. 54),<ul style="list-style-type: none">- 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) (Pg. 66),<ul style="list-style-type: none">- In sample code for Algorithm 1: "C" Table Implementation (Pg. 66) and Algorithm 2: "C" Bit Shift Implementation (Pg. 67), added typedefs for "ubyte" and "word".- Added sample code Algorithm 7: For PIC18F8722 or PIC18F2685 (Pg. 74).● In addition to the list above, made minor changes in text and illustrations to improve clarity wherever needed.
2009/07/10	Data Sheet version: 1.0 New Data Sheet.

The Fine Print

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CONTENTS

MAIN FEATURES	8
Features	8
Module Classification Information	9
Ordering Information	9
MECHANICAL SPECIFICATIONS	10
Physical Characteristics	10
Module Outline Drawings	11
Jumper Locations and Functions	13
Keypad Detail Drawing	14
CFA533 Panel Mounting Application Cutout Drawing	15
OPTICAL CHARACTERISTICS	16
ELECTRICAL SPECIFICATIONS	17
System Block Diagram	17
Supply Voltages and Current	18
Temperature and Humidity Ratings	19
ESD (Electro-Static Discharge) Specifications	20
CONNECTION INFORMATION	21
Overview of Connection Information	21
Standard (+5v) Power Supply Connection	21
1. Standard (+5v) Connection through J_PWR Connector	22
2. Standard (+5v) Connection through J8 Connector	23
3. Standard (+5v) Connection through J_RS232 Connector	24
ATX Power Supply and Control Connection for Host Power Sense	24
ATX Power Supply Connection	24
ATX Control Connections for Host Power Sense through J_PWR or J8 Connector	24
ATX Keypad Control	29
Data Communications: I ² C Connections	29
Data Communications: Details for RS232 Connections	30
GPIO Connections	31
Dallas Semiconductor 1-Wire Device Connections for Optional Accessories	32
Temperature Sensors	32
Other 1-Wire Devices	33
HOST COMMUNICATIONS	33
I ² C Buffers	33
I ² C Addressing	34
I ² C Debugging	35
Packet Structure	35
About Handshaking	36
Command Codes	37
0 (0x00): Ping Command	37
1 (0x01): Get Hardware & Firmware Version	37
2 (0x02): Write User Flash Area	38
3 (0x03): Read User Flash Area	38
4 (0x04): Store Current State as Boot State	38



CONTENTS, CONTINUED

5 (0x05): Reboot CFA533, Reset Host, or Power Off Host	39
6 (0x06): Clear LCD Screen	40
7 (0x07): Set LCD Contents, Line 1	40
8 (0x08): Set LCD Contents, Line 2	41
9 (0x09): Set LCD Special Character Data	41
10 (0x0A): Read 8 Bytes of LCD Memory	41
11 (0x0B): Set LCD Cursor Position	42
12 (0x0C): Set LCD Cursor Style	42
13 (0x0D): Set LCD Contrast	42
14 (0x0E): Set LCD & Keypad Backlight	43
15 (0x0F): Read Temperature	44
18 (0x12): Read DOW Device Information	44
20 (0x14): Arbitrary DOW Transaction	45
21 (0x15): Set Up Live Temperature Display	46
22 (0x16): Send Command Directly to the LCD Controller	47
24 (0x18): Read Keypad, Polled Mode	47
28 (0x1C): Set ATX Switch Functionality	49
29 (0x1D): Enable/Feed Host Watchdog Reset	51
30 (0x1E): Read Reporting/ATX/Watchdog (debug)	51
31 (0x1F): Send Data to LCD	52
33 (0x21): Set I ² C Address	52
34 (0x22): Set/Configure GPIO	53
35 (0x23): Read GPIO Pin Levels and Configuration State	54
CHARACTER GENERATOR ROM (CGROM)	56
MODULE RELIABILITY AND LONGEVITY	57
Module Reliability	57
Module Longevity (EOL / Replacement Policy)	57
CARE AND HANDLING PRECAUTIONS	58
APPENDIX A: QUALITY ASSURANCE STANDARDS	60
APPENDIX B: SAMPLE CODE (INCLUDES ALGORITHMS TO CALCULATE THE CRC)	66
Sample Code	66
Algorithms to Calculate the CRC	66
Algorithm 1: "C" Table Implementation	66
Algorithm 2: "C" Bit Shift Implementation	67
Algorithm 2B: "C" Improved Bit Shift Implementation	69
Algorithm 3: "PIC Assembly" Bit Shift Implementation	69
Algorithm 4: "Visual Basic" Table Implementation	71
Algorithm 5: "Java" Table Implementation	72
Algorithm 6: "Perl" Table Implementation	74
Algorithm 7: For PIC18F8722 or PIC18F2685	75
APPENDIX C: CONNECTING A DS2450 1-WIRE QUAD A/D CONVERTER	78
APPENDIX D: EXAMPLE OF I²C SOURCE CODE FOR THE ATMEL AVR ATMEGA2561	80



LIST OF FIGURES

Figure 1. Module Outline Drawings (two page below))-----	11
Figure 2. Jumper Locations and Functions-----	13
Figure 3. Keypad Detail Drawing -----	14
Figure 4. Panel Mounting Application Cutout Drawing for Optional Bracket -----	15
Figure 5. Definition of 6:00 O'clock and 12:00 O'clock Viewing Angles -----	16
Figure 6. System Block Diagram -----	17
Figure 7. CFA533-TMI-KC Current Usage -----	20
Figure 8. Standard (+5v) Connection through J_PWR-----	22
Figure 9. Standard (+5v) Connection through J8 -----	23
Figure 10. CFA533-TMI-KC Standard (+5v) Connection through J_RS232 Connector -----	24
Figure 11. ATX Host Power Sense through +5v on J_PWR Connector -----	25
Figure 12. ATX Power Supply and Control Using Crystalfontz WR-PWR-Y14 Cable -----	26
Figure 13. ATX Host Power Sense through GPIO[1] on J8 Connector-----	27
Figure 14. I ² C Connections-----	29
Figure 15. J_RS232 Default and Alternate Pin Assignments -----	31
Figure 16. Location of GPIO Connections, Resistors, and J_DOW-----	32
Figure 17. I ² C Transactions -----	34
Figure 18. CFA533-TMI-KC Connection to Aardvark I ² C/SPI Host Adapter-----	35
Figure 19. Character Generator ROM (CGROM) -----	56



MAIN FEATURES

COMPARISON TO CFA633

If your project does not need the fan connections, the CFA533 series is an economical replacement for the CFA633 series. In November 2010, we issued a Technical Bulletin that describes the differences between the CFA533 series and three versions of the CFA633 series. Please see [Part Change Notice #10291](#).

FEATURES

- ❑ 16 characters x 2 lines LCD with keypad and high-level interface. 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. No adjustments to the contrast setting or backlight brightness are needed.
 - ❑ The CFA533 series is mechanically similar to the the [CFA633](#) series. The CFA533 series command set is compatible with the [CFA633](#) series. The CFA533 can be used as a “drop-in” replacement for most [CFA633](#) series applications that do not need fan capabilities.
 - ❑ 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.
 - ❑ 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 wash out in extremely bright environments.)
 - ❑ Fully decoded keypad: any key combination is valid and unique.
 - ❑ Robust packet-based communications protocol with 16-bit CRC.
 - ❑ Nonvolatile memory capability (EEPROM):
 - Customize the “power-on” display settings.
 - 16-byte “scratch” register for storing data such as IP address, netmask, system serial number . . .
 - ❑ Optional capabilities. Crystalfontz can make these modifications for you. A semi-custom part number and minimum order may apply.
 - ATX power supply control functionality allows the buttons on the CFA533-TMI-KC 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 Dallas 1-Wire 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.)
 - ❑ RoHS compliant.
 - ❑ Factories are ISO 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).



- If you need a CE approved module, please see our XES635 USB series (<http://www.crystalfontz.com/product/XES635BK-YYE-KU.html>, <http://www.crystalfontz.com/product/XES635BK-TMF-KU.html>, or <http://www.crystalfontz.com/product/XES635BK-TFE-KU.html>). The CFA533-TMI-KC does not have CE certification because it is not an end product. The module requires power and communications from another system in order to operate.

MODULE CLASSIFICATION INFORMATION

CFA 533 - T M I - K C

①	Brand	Crystalfontz America, Inc.
②	Model Identifier	533
③	Backlight Type & Color	T – LED, white
④	Fluid Type, Image (positive or negative), & LCD Glass Color	M – STN, negative blue
⑤	Polarizer Film Type, Temperature Range, & View Angle (O 'Clock)	I – Transmissive, Wide Temperature ¹ , 6:00
⑥	Special Code 1	K – Manufacturer's codes
⑦	Special Code 2	C – I ² C interface

¹Wide Temperature Range is -20°C minimum to +70°C maximum

ORDERING INFORMATION

PART NUMBER	FLUID	LCD GLASS COLOR	IMAGE	POLARIZER FILM	BACKLIGHT COLOR/TYPE	
CFA533-TMI-KC (I ² C)	STN	blue	negative	transmissive	LCD: white edge LEDs Keypad: blue LEDs	
CFA533-TMI-KL ("logic-level" RS-232)	STN	blue	negative	transmissive	LCD: white edge LEDs Keypad: blue LEDs	
CFA533-TMI-KS ("full swing" RS-232)	STN	blue	negative	transmissive	LCD: white edge LEDs Keypad: blue LEDs	
CFA533-TMI-KU (USB)	STN	blue	negative	transmissive	LCD: white edge LEDs Keypad: blue LEDs	
CFA533-YYH-KC (I ² C)	STN	yellow-green	positive	transflective	LCD: yellow-green edge LEDs Keypad: yellow-green LEDs	
CFA533-YYH-KL ("logic-level" RS-232)	STN	yellow-green	positive	transflective	LCD: yellow-green edge LEDs Keypad: yellow-green LEDs	
CFA533-YYH-KS ("full swing" RS-232)	STN	yellow-green	positive	transflective	LCD: yellow-green edge LEDs Keypad: yellow-green LEDs	
CFA533-YYH-KU (USB)	STN	yellow-green	positive	transflective	LCD: yellow-green edge LEDs Keypad: yellow-green LEDs	



MECHANICAL SPECIFICATIONS

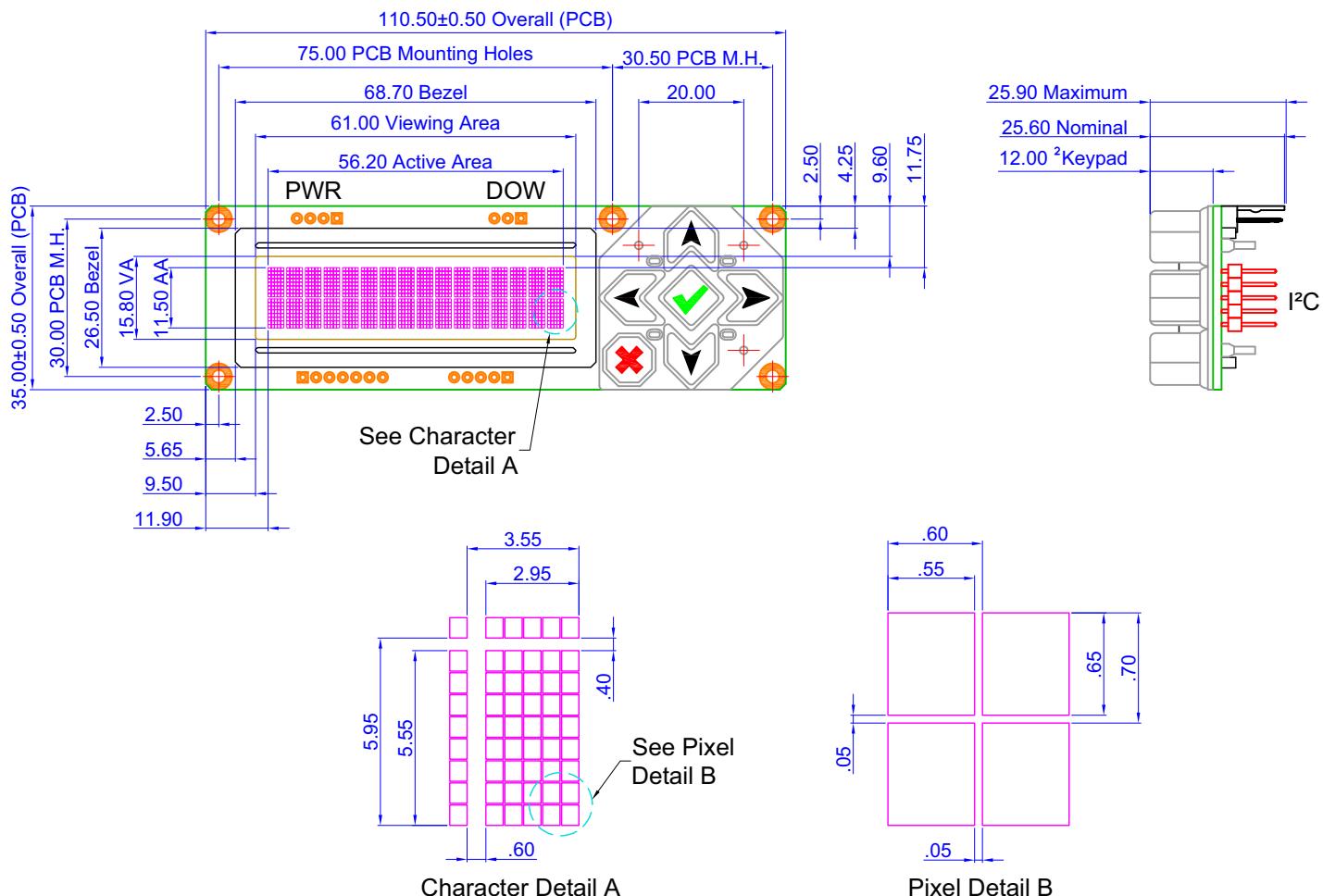
PHYSICAL CHARACTERISTICS

ITEM	SIZE
Module Overall Dimensions	
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)



MODULE OUTLINE DRAWINGS

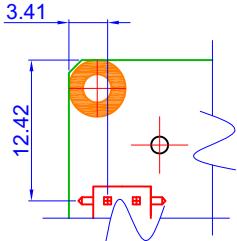
Figure 1. Module Outline Drawings (two page below))



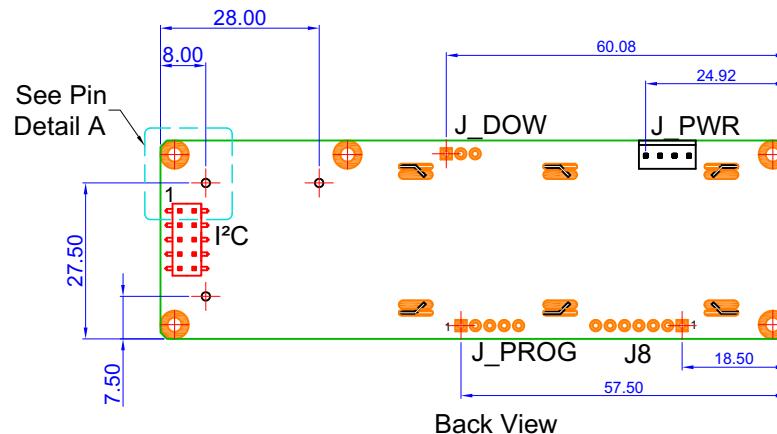
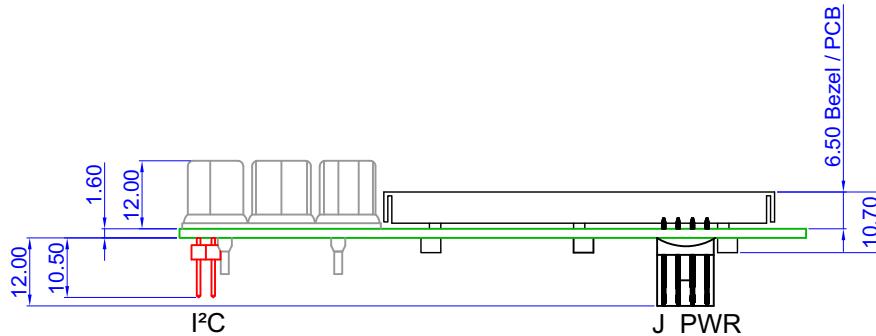
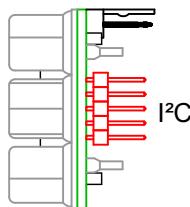
Note:

1. Tolerance is ±0.5 mm unless specified.
2. June 2010, we are transitioning from a keypad 10.5 mm high to a keypad 12 mm high.

copyright © 2010 by Crystalfontz America, Inc. www.crystalfontz.com/products/	Part No.(s): CFA533-TMI-KC CFA533-YYH-KC	Scale: Not to scale	Drawing Number: CFA533_master	Hardware Rev.: v1.0
		Units: Millimeters	Date: 2010/10/14	Sheet: 1 of 2



Pin Detail A



See Pin
Detail A

Note:

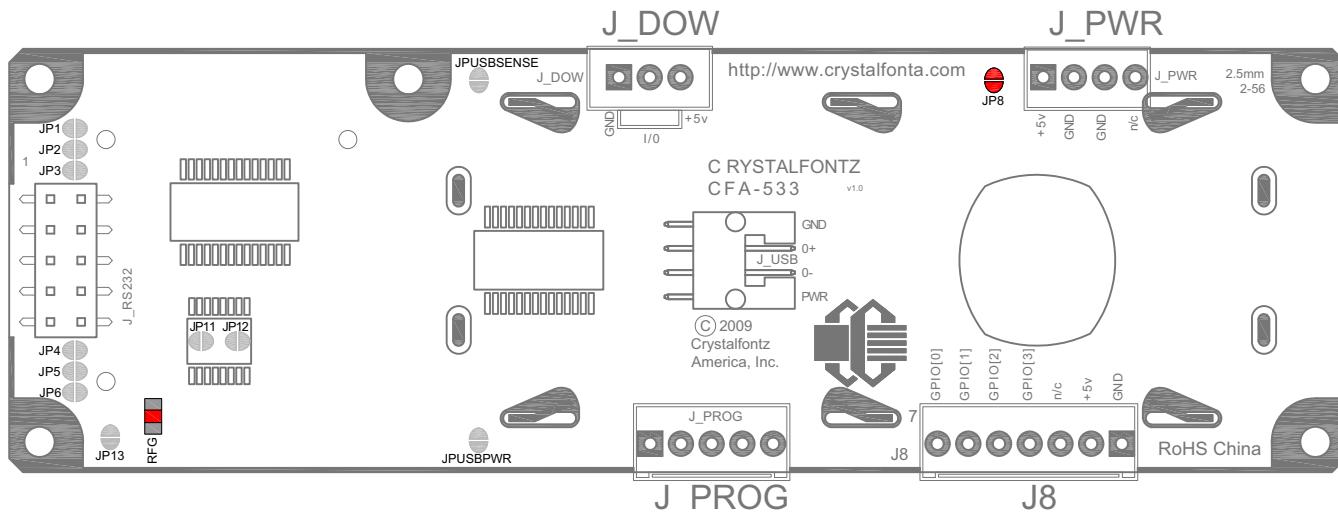
1. Tolerance is ± 0.5 mm unless specified.
2. June 2010, we are transitioning from a keypad 10.5 mm high to a keypad 12 mm high.





JUMPER LOCATIONS AND FUNCTIONS

The CFA533-TMI-KC has thirteen jumpers. Only the jumpers JP8 and RFG may be changed. The jumpers may be closed by melting a ball of solder across their gap. You may re-open these jumpers by removing the solder. 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, JUSBPWR, and JUSBSENSE.		

Figure 2. Jumper Locations and Functions

KEYPAD DETAIL DRAWING

June 2010, we are transitioning from a keypad 10.5 mm high to a keypad 12 mm high. PCN at <http://www.crystalfontz.com/products/pcn.phtml?id=10282>

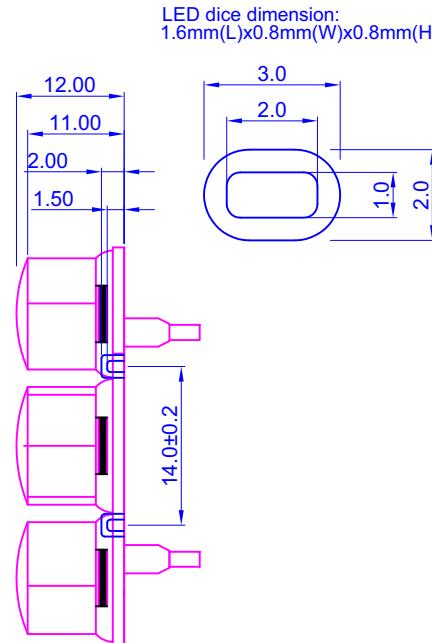
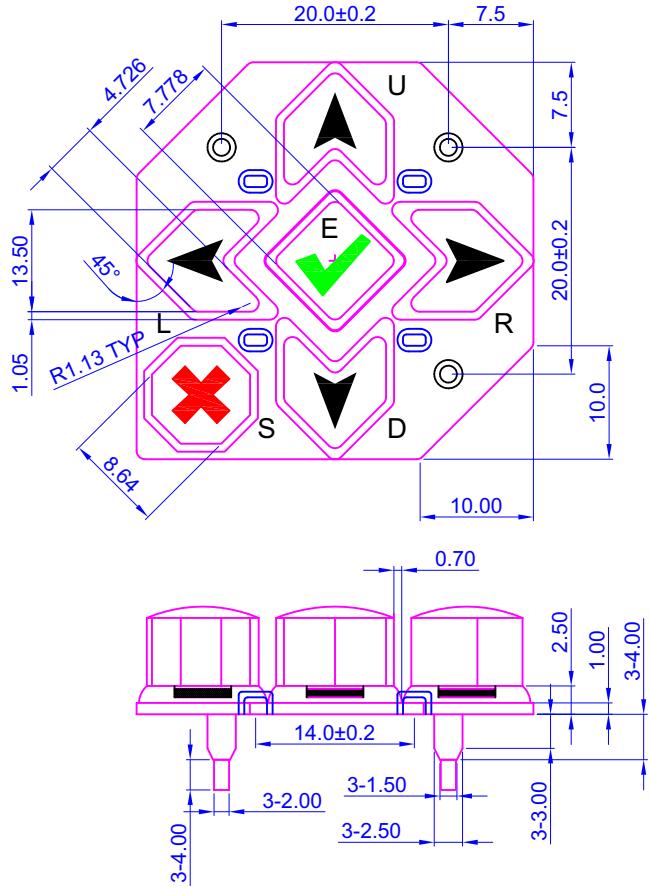


Figure 3. Keypad Detail Drawing

Notes:

1. Material: silicone rubber,
hardness durometer 50 Shore A
 2. Carbon coated
 3. Lifetime: 100 million keystrokes
 4. Resistance: Less than 100 Ohms
 5. Actuation Force: 80~120 grams
 6. Silicone rubber color: translucence white
 7. All corners have a fillet radius of 0.75 mm

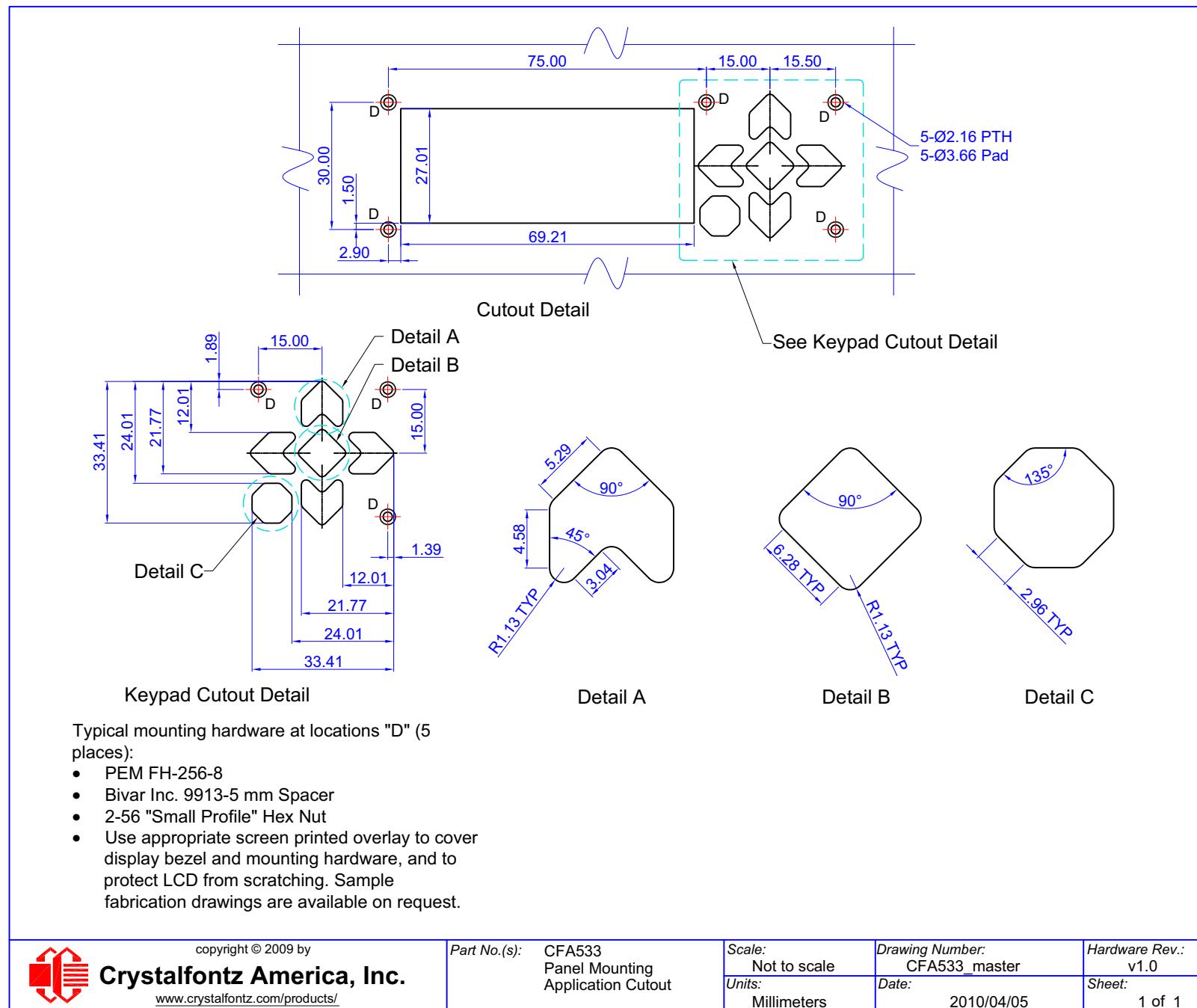


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Part No.(s):	CFA533 Keypad Detail	Scale: Not to scale	Drawing Number: Keypad_master	Hardware Rev.: v1.1
		Units: Millimeters	Date: 2010/10/14	Sheet: 1 of 1



CFA533 PANEL MOUNTING APPLICATION CUTOUT DRAWING





OPTICAL CHARACTERISTICS

Viewing Direction	6 o'clock
-------------------	-----------

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

This module has a 6:00 o'clock viewing angle. A 6:00 o'clock viewing angle is a bottom viewing angle like what you would see when you look at a cell phone or calculator. A 12:00 o'clock viewing angle is a top viewing angle like what you would see when you look at the gauges in a golf cart or airplane.

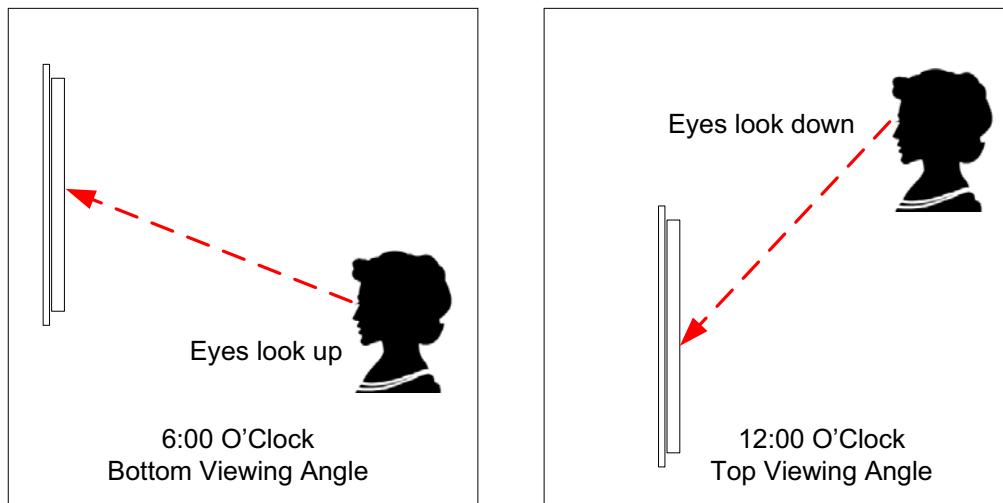


Figure 5. Definition of 6:00 O'clock and 12:00 O'clock Viewing Angles



ELECTRICAL SPECIFICATIONS

SYSTEM BLOCK DIAGRAM

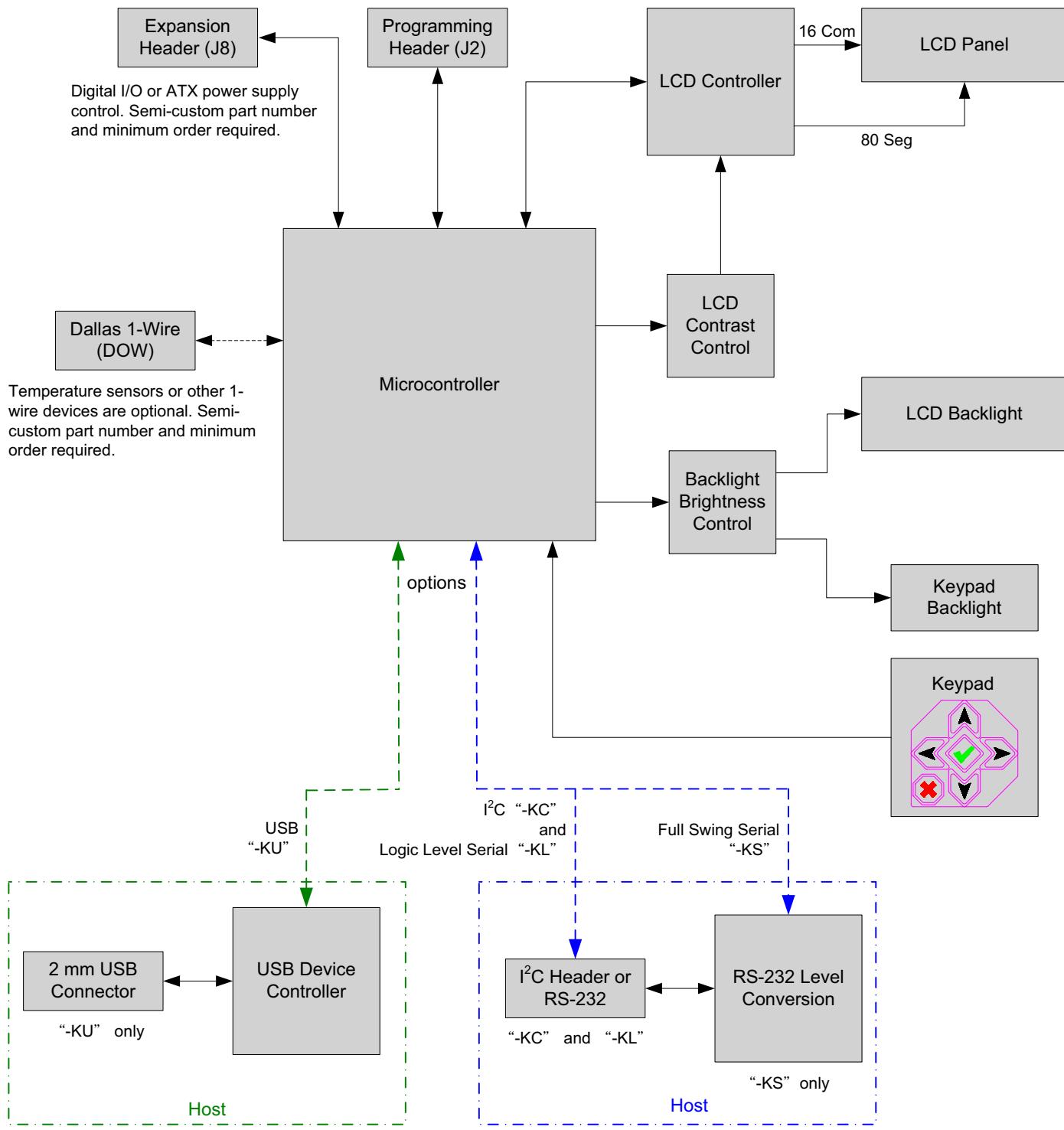


Figure 6. System Block Diagram



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

ITEMS ENABLED	TYPICAL CURRENT CONSUMPTION
+5v for logic (LCD + microcontroller)	< 20mA
+5v for logic (LCD + microcontroller) + TMI backlight	< 100mA

GPIO CURRENT LIMITS	SPECIFICATION
Sink	25 mA
Source	10 mA

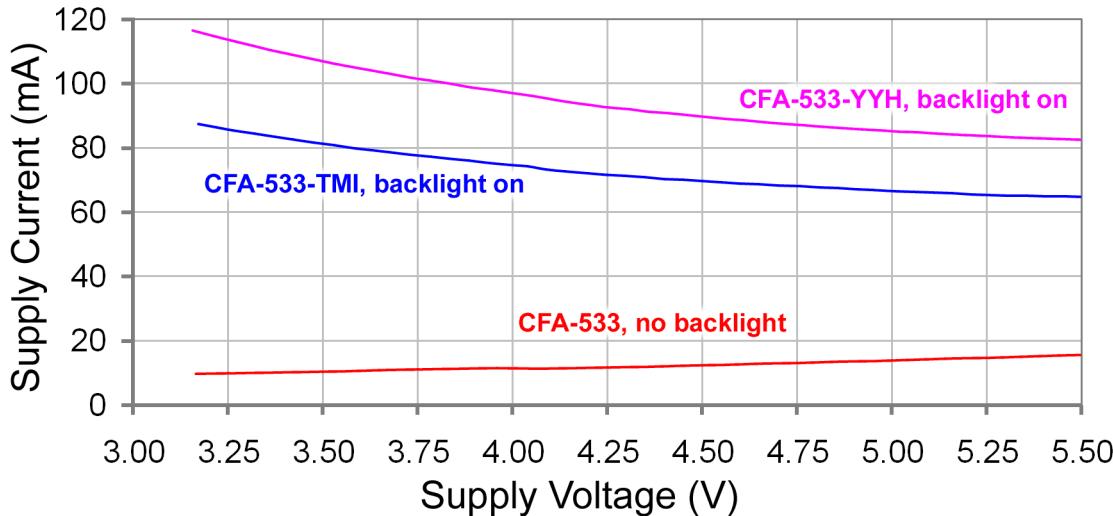


TEMPERATURE AND HUMIDITY RATINGS

ABSOLUTE MAXIMUM RATINGS	SYMBOL	MINIMUM	MAXIMUM
Operating Temperature	T_{OP}	0°C	+50°C
Storage Temperature	T_{ST}	-10°C	+60°C
Humidity Range (noncondensing)	RH	10%	90%



CFA 533 supply current vs supply voltage (typical)



CFA 533-TMI supply current vs backlight setting (typical)

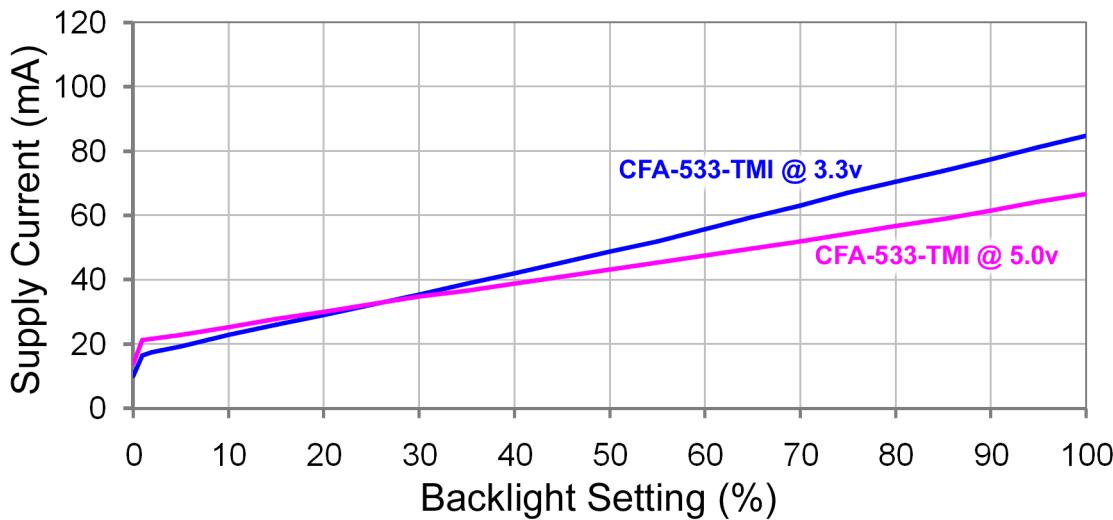


Figure 7. CFA533-TMI-KC Current Usage

ESD (ELECTRO-STATIC DISCHARGE) SPECIFICATIONS

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



CONNECTION INFORMATION

OVERVIEW OF CONNECTION INFORMATION

This section describes your choices of methods to connect power and host power sense to the LCD module. The section also describes connections for optional accessories.

The host power supply can power the CFA533-TMI-KC in one of two ways:

1. *Standard*: This is the basic method to supply power to the module ("non-ATX").
2. *ATX*: This method supplies power to the module and has power on, power off, and reset functionality.

For your convenience, here are links to the connection descriptions:

[Standard \(+5v\) Power Supply Connection \(Pg. 21\)](#)

- [1. Standard \(+5v\) Connection through J_PWR Connector \(Pg. 22\)](#)
- [2. Standard \(+5v\) Connection through J8 Connector \(Pg. 23\)](#)
- [3. Standard \(+5v\) Connection through J_RS232 Connector \(Pg. 24\)](#)

[ATX Power Supply and Control Connection for Host Power Sense \(Pg. 24\)](#)

- [1. ATX Host Power Sense through +5v on J_PWR Connector \(Pg. 25\)](#)
- [2. ATX Host Power Sense through GPIO\[1\] on J8 Connector \(Pg. 27\)](#)

[ATX Keypad Control \(Pg. 29\)](#)

[Data Communications: I²C Connections \(Pg. 29\)](#)

[Data Communications: Details for RS232 Connections \(Pg. 30\)](#)

[GPIO Connections \(Pg. 31\)](#)

[Dallas Semiconductor 1-Wire Device Connections for Optional Accessories \(Pg. 32\)](#)

- [Temperature Sensors \(Pg. 32\)](#)
- [Other 1-Wire Devices \(Pg. 33\)](#)

In the sections listed above, we describe which jumpers, if any, must be opened or closed for the different connection methods. A helpful reference is [Jumper Locations and Functions \(Pg. 13\)](#). The table lists the open/close defaults for all jumpers.

STANDARD (+5V) POWER SUPPLY CONNECTION

For a standard power connection from your host to the CFA533-TMI-KC, choose one of the three methods described below.

1. Standard (+5v) Connection through J_PWR Connector
2. Standard (+5v) Connection through J8 Connector
3. Standard (+5v) Connection through J_RS232 Connector



1. Standard (+5v) Connection through J_PWR Connector

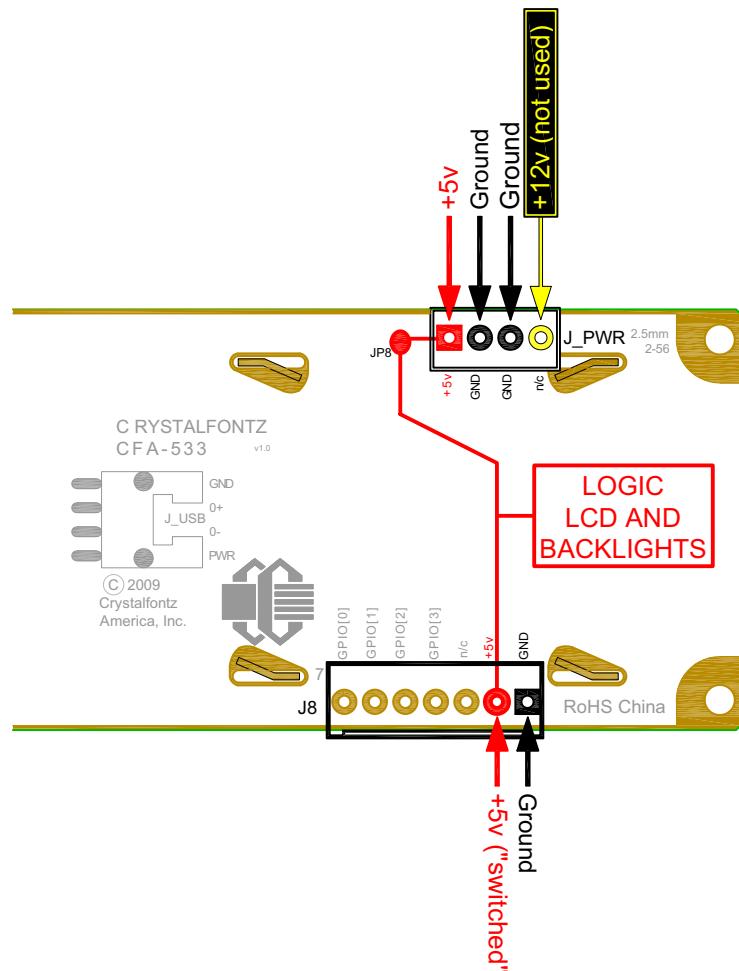


Figure 8. Standard (+5v) Connection through J_PWR

1. JP8 is closed by default. Leave JP8 closed so that the J8 connector is electrically connected to J_PWR.
2. You will need to supply +5v to pin 1 and Ground to pin 2 or 3 on the J_PWR connector. Use the Crystalfontz cable [WR-PWR-Y12](#) (or equivalent) to connect from the host's 4-pin power supply cable connector to the CFA533-TMI-KC's J_PWR connector.



2. Standard (+5v) Connection through J8 Connector

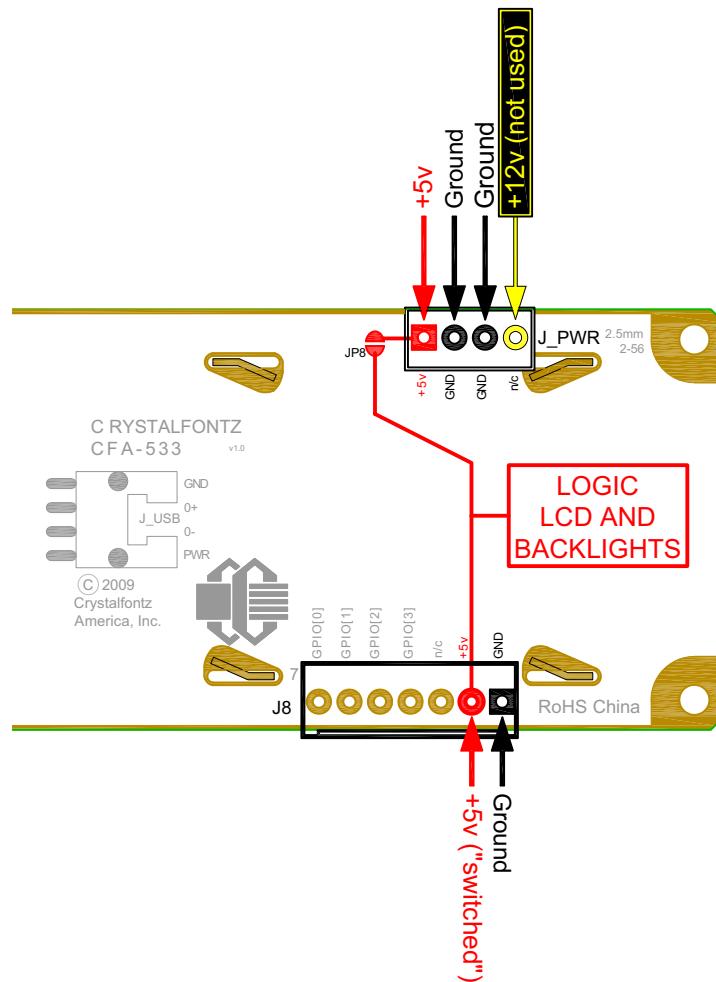


Figure 9. Standard (+5v) Connection through J8

Please see the previous illustration ([Standard \(+5v\) Connection through J_PWR \(Pg. 22\)](#)) for this connection method.

1. Open JP8 when powering from the J8 connector. (JP8 is closed by default. JP8 should remain closed only when powering from J_PWR.)
2. You will need to supply +5v to pin 2 and Ground to pin 1 on the J8 connector.

Modification by Crystalfontz

Crystalfontz can configure the LCD modules so they will be ready to use in your application without modification. We can open JP8 and load a connector at J8. For information, please contact technical support (+1-888-206-9720 or email techinfo@crystalfontz.com). We will provide you with a semi-custom part number and pricing. A minimum order quantity may apply.



3. Standard (+5v) Connection through J_RS232 Connector

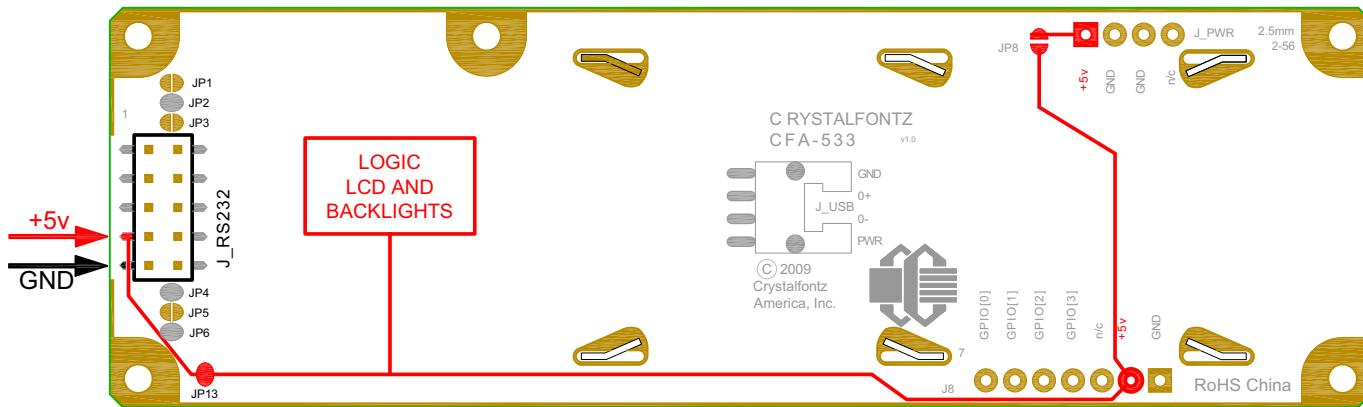


Figure 10. CFA533-TMI-KC Standard (+5v) Connection through J_RS232 Connector

The +5v power can be supplied through connector J_RS232, allowing a single cable to contain both power and data connections.

1. Close JP13. (JP13 is open by default.)
2. Open JP8.
3. If the "Default RS-232 Pin Assignments" (see [Figure 15. on Pg. 31](#)) are selected, the five connections needed to operate the LCD module are all on a single column of pins on J_RS232. You can connect a single 0.1-inch spacing 5-conductor cable to connect between the CFA533-TMI-KC and your host.

Modification by Crystalfontz

Crystalfontz can configure the LCD modules so they will be ready to use in your application without modification. We will close JP13 and open JP8. For information, please contact technical support (+1-888-206-9720 or email techinfo@crystalfontz.com). We will provide you with a semi-custom part number and pricing. A minimum order quantity may apply.

ATX POWER SUPPLY AND CONTROL CONNECTION FOR HOST POWER SENSE

ATX Power Supply Connection

The CFA533-TMI-KC has the ability to control power on/off and reset functions of an ATX power supply.

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.

For this functionality, the CFA533-TMI-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).

ATX Control Connections for Host Power Sense through J_PWR or J8 Connector

For ATX control, choose one of these two connection methods described below.

1. ATX Host Power Sense through +5v on J_PWR Connector
 2. ATX Host Power Sense through GPIO[1] on J8 Connector

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

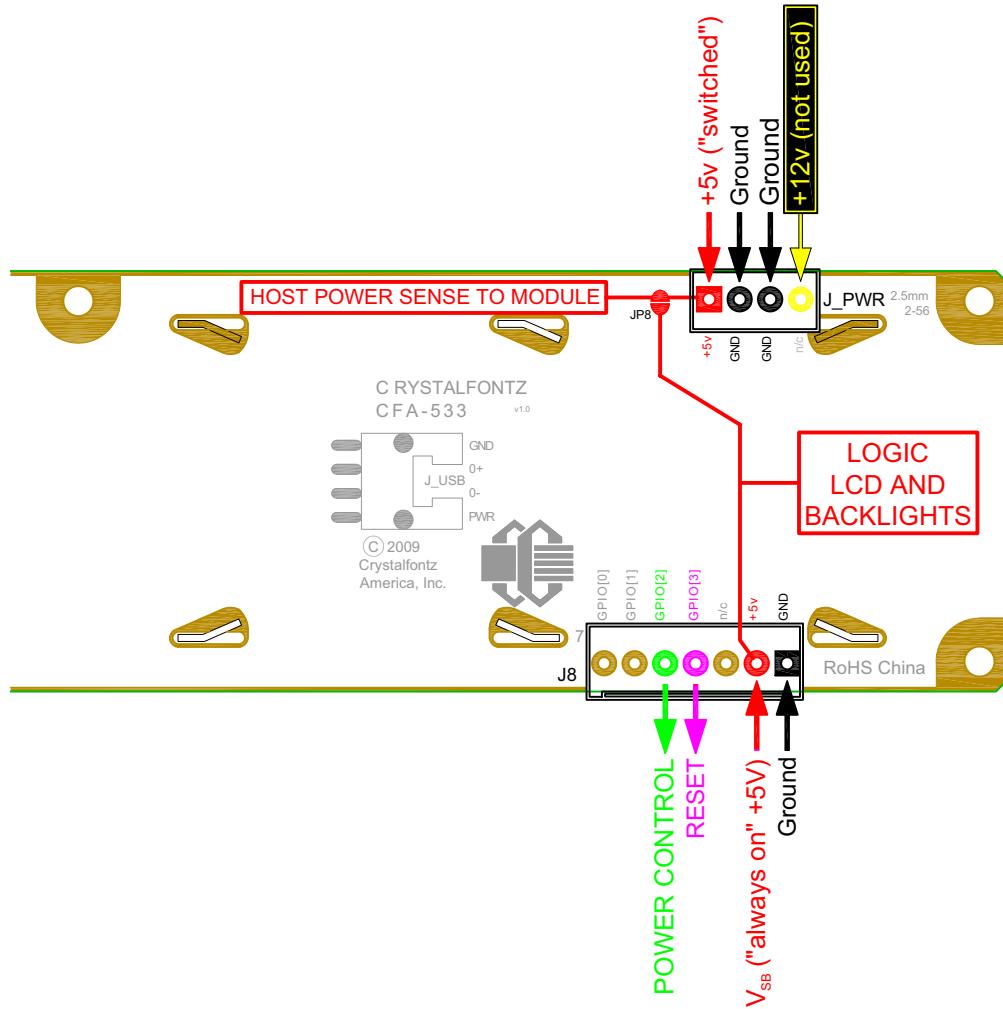


Figure 11. ATX Host Power Sense through +5v on J_PWR Connector

By default, the pin labeled +5v on the CFA533-TMI-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 the CFA533-TMI-KC to do ATX power supply control, 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-TMI-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 \(Pg. 49\)](#).)

The motherboard's reset switch input is connected to Pin 4 of the CFA533-TMI-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](#) cable simplifies ATX power supply control connections. JP8 from connector J_PWR is closed by default. When using this cable, open jumper JP8 in order to ensure correct operation.

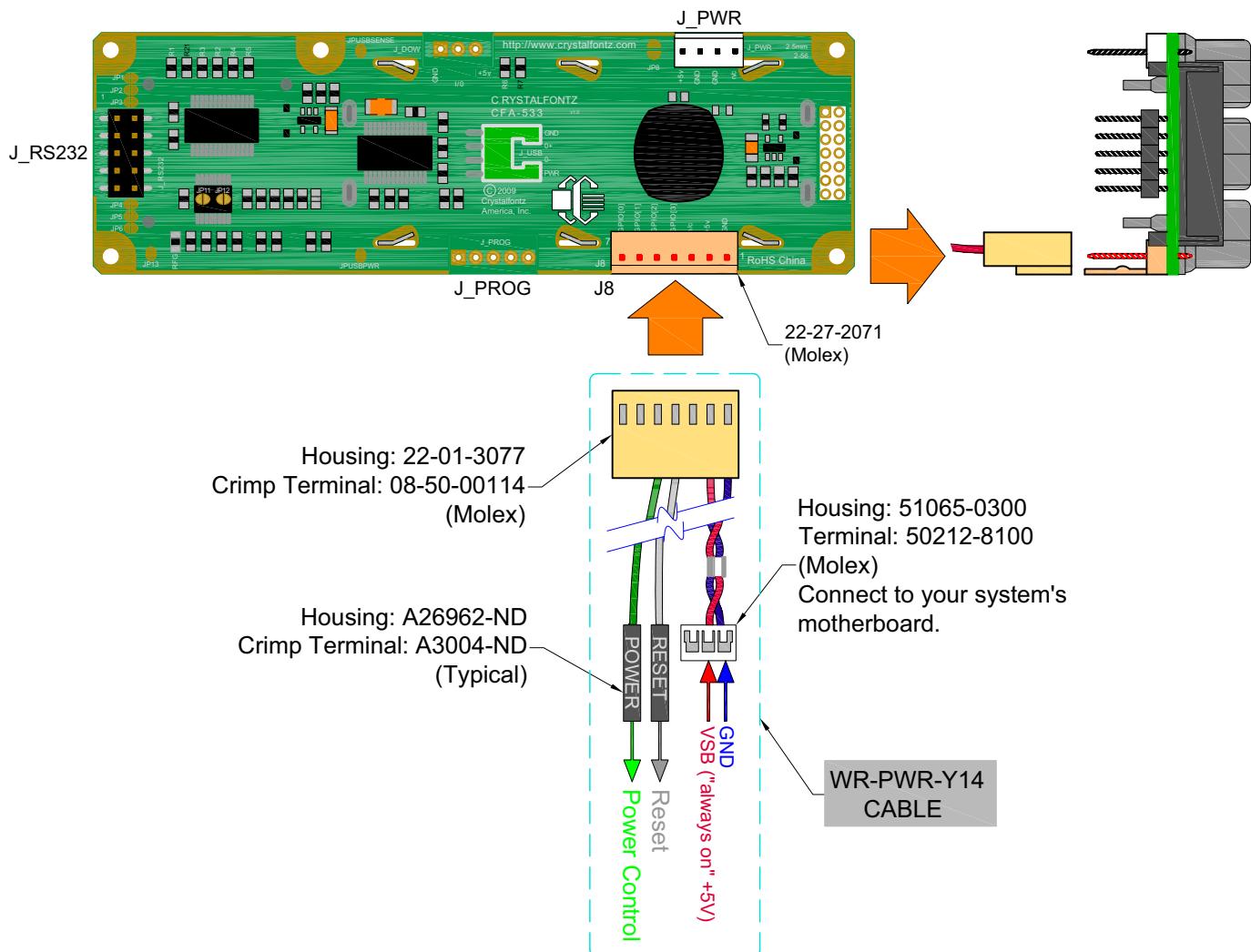


Figure 12. ATX Power Supply and Control Using Crystalfontz WR-PWR-Y14 Cable

NOTE

If the Crystalfontz [WR-PWR-Y14](#) cable is ordered at the same time as the LCD module, Crystalfontz will install the [WR-PWR-Y14](#) connector, open jumper JP8 and send the following software configuration commands (unless we are otherwise instructed).

```
command = 28 // Set ATX Switch Functionality
length = 3
data[0] = 241 // Enable:
              // KEYPAD_POWER_OFF
              // KEYPAD_POWER_ON
              // KEYPAD_RESET
              // LCD_OFF_IF_HOST_IS_OFF
              // AUTO_POLARITY
data[1] = 16 // One half second power pulses
data[2] = 0 // sense ATX host power state on P0.7 (J_PWR, +5v)
command = 4 // Store current state as boot state
length = 0
```

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

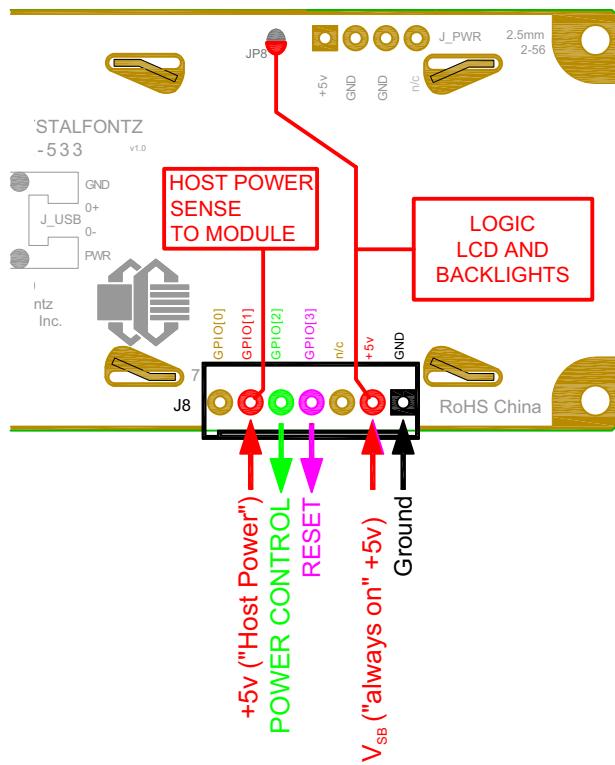


Figure 13. ATX Host Power Sense through GPIO[1] on J8 Connector



The CFA533-TMI-KC can be configured to sense host power through GPIO[1] on connector J8. In addition to +5_{VS}, 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]. JP8 is closed by default. To properly function, JP8 must be opened.

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. R21 is loaded with a 5kΩ 0805 SMT resistor for this functionality. See location of R21 illustration in [Jumper Locations and Functions \(Pg. 13\)](#).

Here is an excerpt from command [28 \(0x1C\): Set ATX Switch Functionality \(Pg. 49\)](#):

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 \(Pg. 53\)](#). 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 \(Pg. 49\)](#)), 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 \(Pg. 49\)](#) (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 \(Pg. 49\)](#) (1.0 seconds default). If the user continues to press the key, the CFA533-TMI-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-TMI-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-TMI-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 VOL_{MAX} = 0.4V for the output stage. This limits the minimum pull-up resistor value for a 5-volt system to about 1.5kΩ. 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 6kΩ. For more information see the [UM10204 I²C-bus specification and user manual](#) on the [NXP Semiconductors](#) website.

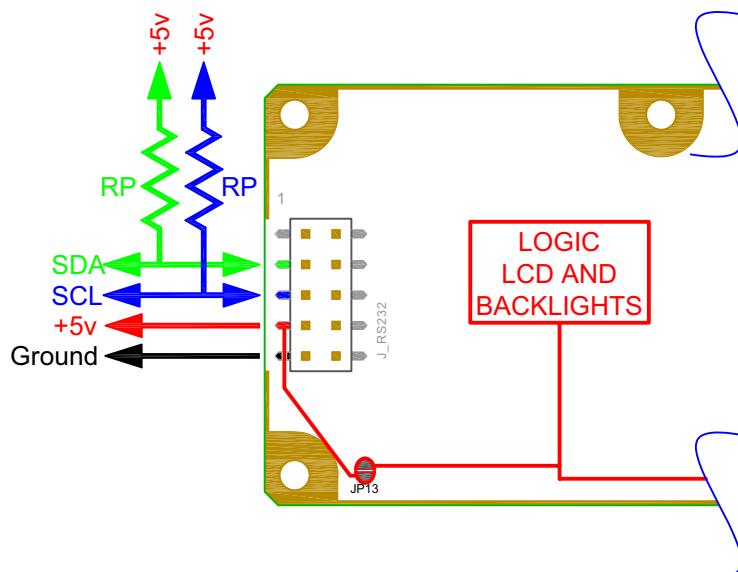


Figure 14. I²C Connections



DATA COMMUNICATIONS: DETAILS FOR RS232 CONNECTIONS

JP2, JP4, and JP6 are closed at the factory, selecting the “Default RS-232 Pin Assignments” (see [Figure 15. on Pg. 31](#)). This connection allows a low-cost ribbon cable (Crystalfontz [WR-232-Y08](#)) to connect the CFA533-TMI-KC to a host's DB-9 COM port.

If you are connecting the CFA533-TMI-KC to a host system (such as a PC motherboard) that has a similar 10-pin 0.1-inch connector, rather than a standard RS-232 DB-9 connector common to rear panels, the pinouts may need to be changed from “Default” to “Alternate”.

For an RS-232 connection, you can modify the LCD modules or have Crystalfontz modify them for you.

Choose one of two methods described below to make the connection.

Method 1: Use Crystalfontz [WR-232-Y22](#) cable

The easiest method is to use a Crystalfontz [WR-232-Y22](#) cable. Connect the single end of the [WR-232-Y22](#) cable to the CFA533-TMI-KC. On the double end of the [WR-232-Y22](#) cable, one connector will work for host connections that use “default” numbering; the other end will work for host connections that use the “alternate” numbering.

Method 2: Use Straight-through 10-pin to 10-pin ribbon cable

Use a straight-through 10-pin to 10-pin ribbon cable (for example, CW Industries' [C3AAG-1018G-ND](#) cable available from Digi-Kith pin order of your motherboard's header will determine if the CFA533-TMI-KC's pin assignments need to be “Default” or “Alternate”. Open or close jumpers JP1-JP6 as necessary to set the CFA533-TMI-KC to “Default” or “Alternate” that matches your motherboard.

Modification by Crystalfontz

We can configure the LCD module for you by opening JP8, loading the mating connector for the Crystalfontz [WR-PWR-Y14](#) cable in J8, and configuring the ATX firmware functions. The modules will be ready to use in your application without modification by you. For information, please contact technical support (+1-888-206-9720, techinfo@crystalfontz.com). We will provide you with a semi-custom part number and pricing. A minimum order quantity may apply.



Please note that the CFA533-TMI-KC can be powered through this header. Please refer to [3. Standard \(+5v\) Connection through J_RS232 Connector \(Pg. 24\)](#).

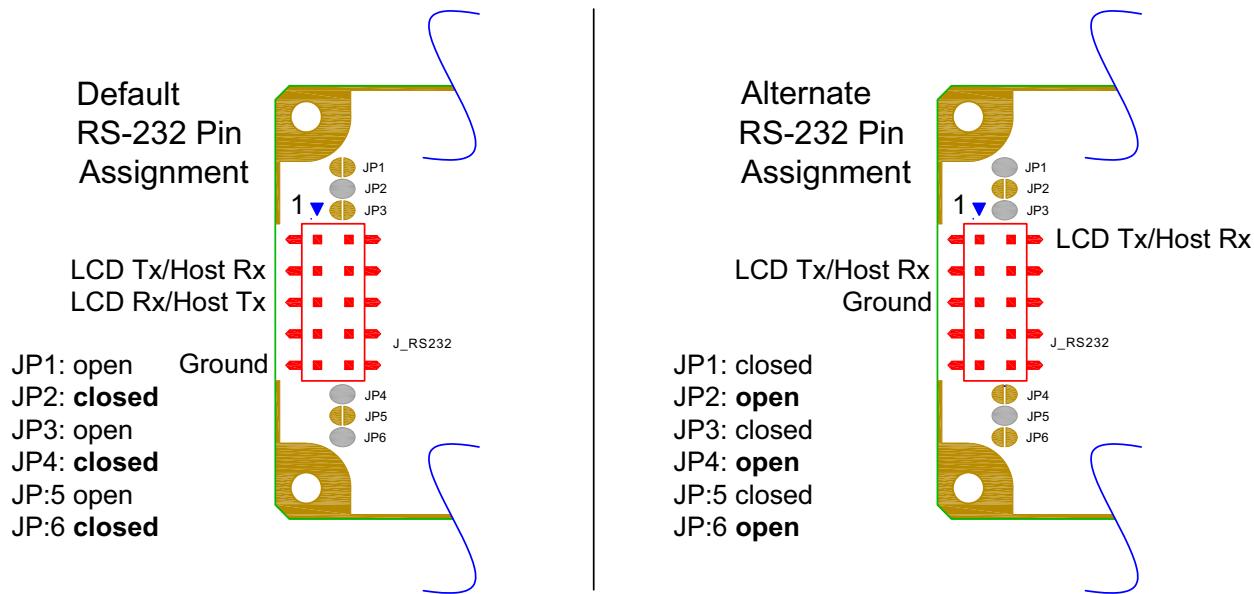


Figure 15. J_RS232 Default and Alternate Pin Assignments

GPIO CONNECTIONS

The CFA533-TMI-KC has five General-Purpose Input/Output (GPIO) pins. The GPIO are port pins from the CFA533-TMI-KC's microcontroller 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 R21 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--may have 1 kΩ hardware pull-up: R7)
```

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

GPIO[1] has a series 5kΩ resistor in R21.

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 R7 is loaded to pull GPIO[4] to V_{DD} (+5v power).



Please refer to commands [34 \(0x22\): Set/Configure GPIO \(Pg. 53\)](#) and [35 \(0x23\): Read GPIO Pin Levels and Configuration State \(Pg. 54\)](#) for additional details concerning the GPIO operation.

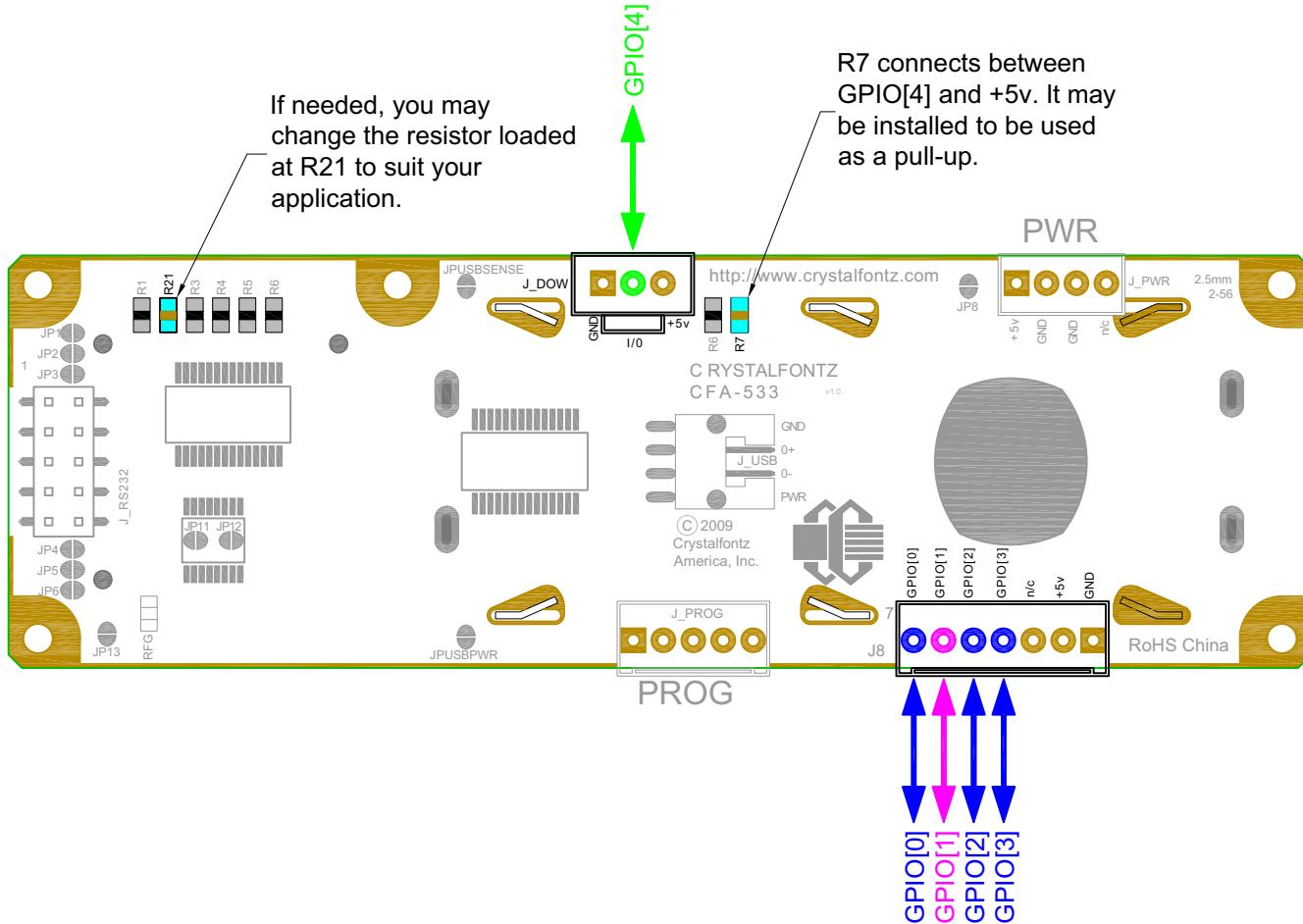


Figure 16. Location of GPIO Connections, Resistors, and J_DOW

DALLAS SEMICONDUCTOR 1-WIRE DEVICE CONNECTIONS FOR OPTIONAL ACCESSORIES

Temperature Sensors

The CFA533-TMI-KC supports Dallas Semiconductor 1-Wire (DOW) temperature sensors. See location of J_DOW in [Figure 16. on Pg. 32](#). By default, J_DOW is not loaded with a connector. If you request it, Crystalfontz can load a Molex 70543-0002. For information, please contact technical support (+1-888-206-9720 or email techinfo@crystalfontz.com). We will provide you with a semi-custom part number and pricing. A minimum order quantity may apply.

Any combination of up to 32 [DS1822](#) Econo 1-Wire Digital Thermometer (2°C absolute accuracy) or [DS18B20](#) High Precision 1-Wire Digital Thermometer (0.5°C absolute accuracy) temperature sensors or other DOW compatible devices are directly supported.



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-TMI-KC, Crystalfontz can load the WR-DOW-Y17’s mating connector into the CFA533-TMI-KC’s DOW position. For reference, the mating connector for the [WR-DOW-Y17](#) is [Molex 70543-0002](#) available from Digi-Key or other parts suppliers.

The temperature sensor can be configured to be automatically read and displayed on the CFA533-TMI-KC’s LCD in °C or °F (see command [21 \(0x15\): Set Up Live Temperature Display \(Pg. 46\)](#)). Independently, any temperature sensor can be configured to report to the host (see [19 \(0x13\): \(reserved\) \(Pg. 45\)](#)). The sensors configured to be reported are updated once each second.

Other 1-Wire Devices

Other [Dallas Semiconductor 1-Wire devices](#) may be connected to the 1-Wire bus, with the CFA533-TMI-KC acting as a bridge between RS-232 and the 1-Wire bus (see command [21 \(0x15\): Set Up Live Temperature Display \(Pg. 46\)](#)). 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-TMI-KC’s DOW connection location in [Figure 16. on Pg. 32](#).) 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-TMI-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 data sheet.

HOST COMMUNICATIONS

NOTE

Because there is no difference in communications and commands for I²C variants (part numbers ending in “-KC”), serial variants (part numbers ending in “-KL” or “-KS”) and USB variants (part numbers ending in “-KU”) of the CFA533, the Host Communications section of this Data Sheet uses the shorter term “CFA533” instead of CFA533-TMI-KC”.

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 Acknowledgement). 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-TMI-KC is 42₁₀ (84₁₀ writes, 85₁₀ reads), in hexadecimals 0x2A (0x54 writes, 0x55 reads).

Display Address: To display the I²C address of the 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 \(Pg. 52\)](#). To make the change permanent, use command [4 \(0x04\): Store Current State as Boot State \(Pg. 38\)](#).

The CFA533-TMI-KC expects to find a valid packet within the data area of I²C transactions. (See [Packet Structure \(Pg. 35\)](#)).

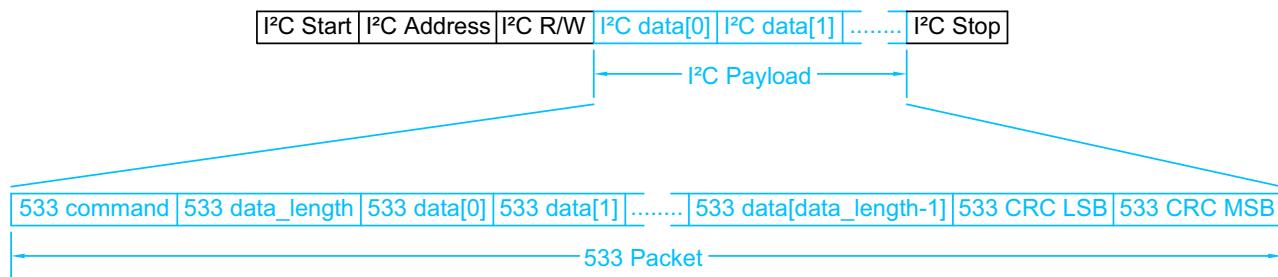


Figure 17. I²C Transactions

The host must read at least as many bytes as the size of the CFA533-TMI-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. See pages 14-15 in [NXP's I²C-bus specification and user manual \(UM10204\) \(www.standardics.nxp.com/support/documents/i2c/pdf/i2c.bus.specification.pdf\)](#).



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 CFA533 I²C modules.

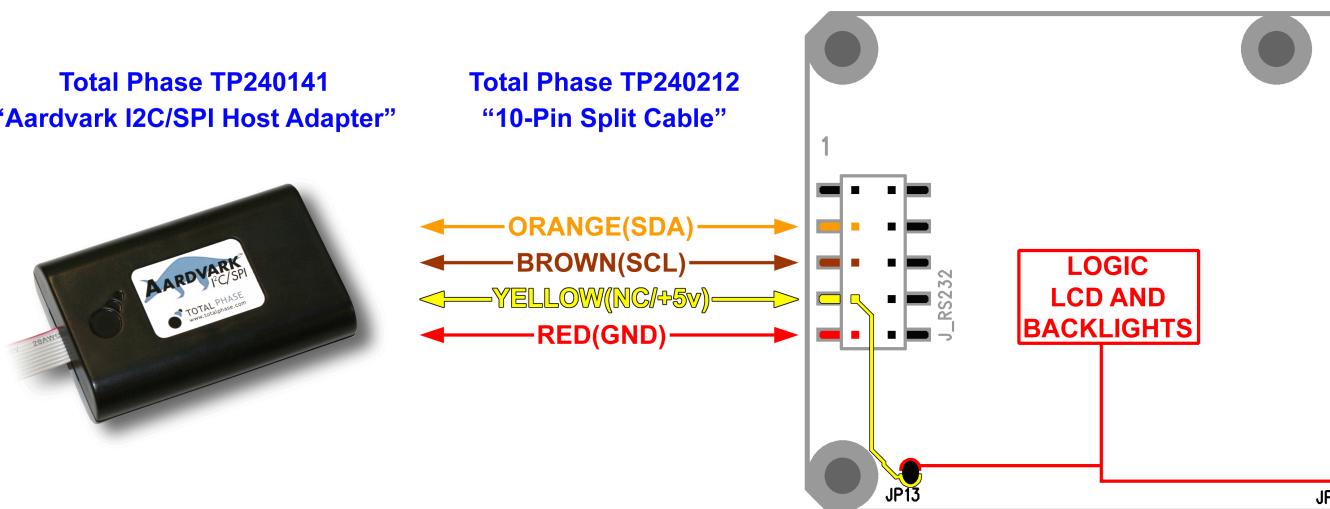


Figure 18. CFA533-TMI-KC Connection to Aardvark I²C/SPI Host Adapter

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 module. To reconcile your packets, please ensure that you have received the acknowledgement 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:

```
TTcc cccc
||| | | | --Command, response, error or report code 0-63
|-----Type:
    00 = normal command from host to CFA533
    01 = normal response from CFA533 to host
    10 = normal report from CFA533 to host (not indirect response to a command
          from the host)
    11 = error response from CFA533 to host (a packet with valid structure but
          illegal content was received by the CFA533)
```



`data_length` specifies the number of bytes that will follow in the data field. The valid range of `data_length` is 0 to 18.

`data` is the payload of the packet. Each `type` of packet will have a specified `data_length` and format for `data` as well as algorithms for decoding `data` detailed below.

`CRC` is a standard 16-bit CRC of all the bytes in the packet except the CRC itself. The CRC is sent LSB first. At the port, the CRC immediately follows the last used element of `data` []. See [APPENDIX B: SAMPLE CODE \(INCLUDES ALGORITHMS TO CALCULATE THE CRC\) \(Pg. 66\)](#) for several examples of how to calculate the CRC in different programming languages.

The following concept may be useful for understanding the packet structure.

```
typedef struct
{
    unsigned char
        command;
    unsigned char
        data_length;
    unsigned char
        data[data_length];
    unsigned short
        CRC;
}COMMAND_PACKET;
```

Crystalfontz supplies a demonstration and test program [533_I2C_WinTest](#) along with its C source code. Included in the [533_I2C_WinTest](#) source is a CRC algorithm and an algorithm that validates packets. Please follow the validation algorithm in the sample code closely in order to realize the benefits of using the packet communications.

ABOUT HANDSHAKING

The I²C bus master (host) must initiate all transactions. When the host writes a command to the input buffer of the slave (CFA533), the CFA533 will execute the appropriate functions, then write the resulting acknowledge or response packet into the CFA533's output buffer.

The host can read the CFA533's output buffer to verify the command or to read the result of a query.

The CFA533 takes a small amount of time to execute the command before the result can be read. For many commands 5mS is plenty of time for the CFA533 to complete its processing and have the result ready for the host to read.



Commands that may take longer are:

2 (0x02): Write User Flash Area
25mS

4 (0x04): Store Current State as Boot State
50mS

5 (0x05): Reboot CFA533, Reset Host, or Power Off Host
500mS (for parameters \008\018\099, Reboot CFA533)
2S (for parameters \012\028\097 Reset host)
2S (for parameters \003\011\095 Power off host)

14 (0x0E): Set LCD & Keypad Backlight
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, "1.0" for example
yY.Y is the firmware version, "c1.0" 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 microcontroller may not work correctly. If this happens, you will see corrupted characters on the LCD after using Command 4 and rebooting the 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 techinfo@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 \(Pg. 40\)](#).
 - command [7 \(0x07\): Set LCD Contents, Line 1 \(Pg. 40\)](#).
 - command [8 \(0x08\): Set LCD Contents, Line 2 \(Pg. 41\)](#).
 - command [31 \(0x1F\): Send Data to LCD \(Pg. 52\)](#).
- Special character font definitions (command [9 \(0x09\): Set LCD Special Character Data \(Pg. 41\)](#)).



- Cursor position (command [11 \(0x0B\): Set LCD Cursor Position \(Pg. 42\)](#)).
- Cursor style (command [12 \(0x0C\): Set LCD Cursor Style \(Pg. 42\)](#)).
- Contrast setting (command [13 \(0x0D\): Set LCD Contrast \(Pg. 42\)](#)).
- LCD backlight setting (command [14 \(0x0E\): Set LCD & Keypad Backlight \(Pg. 43\)](#)).
- Keypad backlight setting (command [14 \(0x0E\): Set LCD & Keypad Backlight \(Pg. 43\)](#)).
- Settings of any live displays (command [21 \(0x15\): Set Up Live Temperature Display \(Pg. 46\)](#)).
- ATX function enable and pulse length settings (command [28 \(0x1C\): Set ATX Switch Functionality \(Pg. 49\)](#)).
- Baud rate (command [33 \(0x21\): Set I²C Address \(Pg. 52\)](#)).
- GPIO settings (command [34 \(0x22\): Set/Configure GPIO \(Pg. 53\)](#)).

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)

2S (for parameters \012\028\097 Reset host)

2S (for parameters \003\011\095 Power off host)

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 \(Pg. 53\)](#).

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 \(Pg. 49\)](#), 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 \(Pg. 49\)](#), 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

Sets the contents of the LCD screen DDRAM to '' = 0x20 = 32₁₀ 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
```

Clear LCD Screen is one of the items stored by the command [4 \(0x04\): Store Current State as Boot State \(Pg. 38\)](#).

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

Sets the center 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 \(Pg. 52\)](#) which is also supported by the [CFA631](#) and [CFA635](#).

```
type: 0x7 = 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 \(Pg. 38\)](#).



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

Sets the center 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 \(Pg. 52\)](#) which is also supported by the [CFA631](#) and [CFA635](#).

```
type: 0x8 = 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 \(Pg. 38\)](#).

9 (0x09): Set LCD Special Character Data

Sets the font definition for one of the special characters (CGRAM).

```
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 63, 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 \(Pg. 38\)](#).

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

This command will return the contents of the LCD's DDRAM or CGRAM. 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 CGRAM
0x80 (\128) to 0x93 (\147) for DDRAM, line 1
0xC0 (\192) to 0xD3 (\211) 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 \(Pg. 42\)](#).

```
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 \(Pg. 38\)](#).

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 \(Pg. 38\)](#).

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 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 CFA533's native enhanced contrast resolution. Requires 2 bytes.

- The first byte data[0] is ignored, any value from 0 to 255 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 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 \(Pg. 38\)](#).

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
    1-100 = variable brightness
```

The return packet 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
    1-100 = variable brightness

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

The return packet 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 \(Pg. 38\)](#).

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 \(Pg. 44\)](#).

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);
    }
}
```

16-17 (0x10-0x11): (reserved)

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 \(Pg. 53\)](#).

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
```

19 (0x13): (reserved)

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 \(Pg. 78\)](#) 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 \(Pg. 38\)](#), 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 (0-7)
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 a Neotec [NT7070B](#) (HD44780 compatible). Generally you won't need low-level access to the LCD controller but some arcane functions of the [NT7070B](#) 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
```

23 (0x17): (reserved)

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] = bit mask showing the keys currently pressed
data[1] = bit mask showing the keys that have been pressed since the last poll
data[2] = bit mask showing the keys that have been released since the last poll
```

25-27 (0x19-0x1B): (reserved)



28 (0x1C): Set ATX Switch Functionality

The combination of the CFA533 with the Crystalfontz [WR-PWR-Y14](#) 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 \(Pg. 38\)](#).

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 \(Pg. 53\)](#). 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 R21 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
#define POWER_INVERT             0x04 //Power pin drives high instead of low
#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]: bit mask 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] -- R21 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 \(Pg. 49\)](#) or command [34 \(0x22\): Set/Configure GPIO \(Pg. 53\)](#).

```
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 other models in this family ([CFA631](#), [CFA633](#), [CFA635](#)).

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



The return packet will be:

```
type: 0x1E = 3010
data_length: 15
data[0] = 0 (reserved)
data[1] = temperatures 1-8 reporting status (reserved)
data[2] = temperatures 9-15 reporting status (reserved)
data[3] = temperatures 16-23 reporting status (reserved)
data[4] = temperatures 24-32 reporting status (reserved)
data[5] = key presses (reserved)
data[6] = key releases (reserved)
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 (reserved)
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 \(Pg. 38\)](#).

32 (0x20): (Reserved for [CFA631](#) Key Legends)

33 (0x21): Set I²C Address

This command sets the I²C address. This number is 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-TMI-KC is 42₁₀ (84₁₀ writes, 85₁₀ reads), in hexadecimals 0x2A (0x54 writes, 0x55 reads).

Debugging Tip: To display the I²C address of the 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 "bounce-free".

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 resistor for R21 in series with GPIO[1] to limit the possibility of [latchup](#). To use GPIO[1] as a general-purpose input/output, you may need to change R21 with a resistor suitable for your application. It is loaded with a 5kΩ resistor that is suitable for most applications.

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 \(Pg. 38\)](#).



```
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 \(Pg. 53\)](#) 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.

returns:

```
data[0]: index of GPIO read
data[1]: Pin state & changes since last poll
----- RFS
| | | | -- S = state at the last reading
| | | | --- F = at least one falling edge has
| | | |     been detected since the last poll
| | | | --- R = at least one rising edge has
| | | |     been detected since the last poll
| | | | ----- reserved
```

(This reading is the actual pin state, which may or may not agree with the pin setting, depending on drive mode and the load presented by external circuitry. The pins are polled at approximately 32 Hz asynchronously with respect to this command. Transients that happen between polls will not be detected.)

data[2]: Requested Pin level/PWM level

0-100 = Output duty cycle percentage

(This value is the requested PWM duty cycle. The actual pin may or may not be toggling in agreement with this value, depending on the drive mode and the load presented by external circuitry)

data[3]: Pin function select and drive mode

```
----- FDDD
| | | | -- DDD = Drive Mode
| | | | =====
| | | | 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
| | | | 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, will return 0
```



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

Figure 19. Character Generator ROM (CGROM)



MODULE RELIABILITY AND LONGEVITY

MODULE RELIABILITY

ITEM	SPECIFICATION	
LCD portion (excluding Keypad and Backlights)	50,000 to 100,000 hours (typical)	
Keypad	1,000,000 keystrokes	
White* LED Display and Blue LED Keypad Backlights <i>*We recommend that the backlight of the white LED backlit modules be dimmed or turned off during periods of inactivity to conserve the white LED backlight lifetime.</i>	<i>Power-On Hours</i>	<i>% of Initial Brightness</i>
	<10,000	>90%
	<50,000	>50%

MODULE LONGEVITY (EOL / REPLACEMENT POLICY)

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

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

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

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

- *Backlight LEDs.* Brightness may be affected (perhaps the new LEDs have better efficiency) or the current they draw may change (new LEDs may have a different VF).
- *Controller.* A new controller may require minor changes in your code.
- *Component tolerances.* Module components have manufacturing tolerances. In extreme cases, the tolerance stack can change the visual or operating characteristics.

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



CARE AND HANDLING PRECAUTIONS

For optimum operation of the CFA533-TMI-KC and to prolong its life, please follow the precautions described below.

ELECTROSTATIC DISCHARGE (ESD)

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

DESIGN AND MOUNTING

- The exposed surface of the 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 GE HP-92 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.

CLEANING

- The polarizer (laminated to the glass) is soft plastic. The soft plastic is easily scratched or damaged. Be very careful when you clean the polarizer.
- Do not clean the polarizer with liquids. Do not wipe the polarizer with any type of cloth or swab (for example, Q-tips).
- Use the removable protective film to remove smudges (for example, fingerprints) and any foreign matter. If you no longer have the protective film, use standard transparent office tape (for example, Scotch® brand “Crystal Clear Tape”). If the polarizer is dusty, you may carefully blow it off with clean, dry, oil-free compressed air.
- *CFA533-TMI-KC without Crystalfontz overlay:* The exposed surface of the LCD “glass” is actually the front polarizer laminated to the glass. The polarizer is made out of a fairly soft plastic and is easily scratched or damaged. The polarizer will eventually become hazy if you do not take great care when cleaning it. Long contact with moisture (from condensation or cleaning) may permanently spot or stain the polarizer.



OPERATION

- Your circuit should be designed to protect the CFA533-TMI-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.
- 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

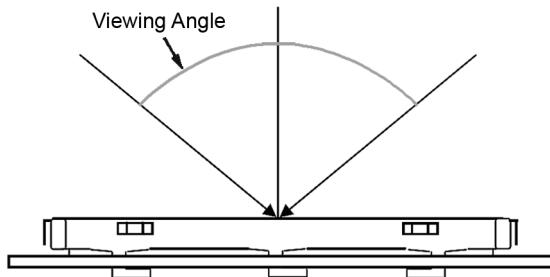
- Store in an ESD-approved container away from dust, moisture, and direct sunlight.
- Observe the storage temperature limitations: -10°C minimum, 60°C maximum with minimal fluctuation. Rapid temperature changes can cause moisture to form, resulting in permanent damage.
- Do not allow weight to be placed on the CFA533-TMI-KCs while they are in storage.
- Please recycle your outdated Crystalfontz modules at an approved facility.



APPENDIX A: QUALITY ASSURANCE STANDARDS

INSPECTION CONDITIONS

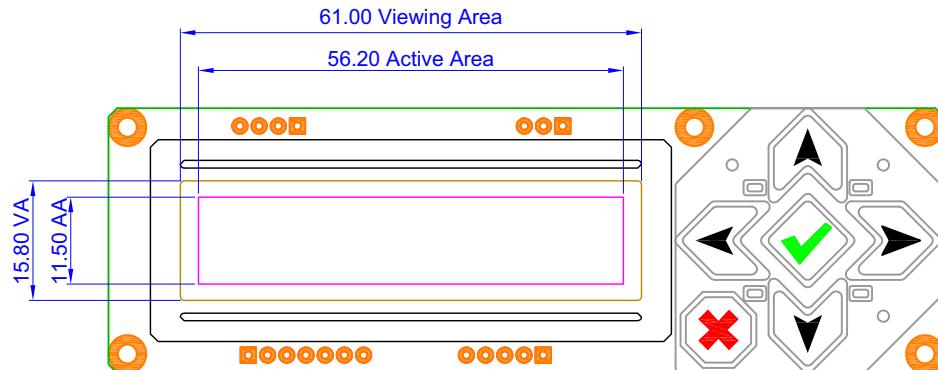
- Environment
 - Temperature: $25\pm5^{\circ}\text{C}$
 - Humidity: 30~85% RH
- For visual inspection of active display area
 - Source lighting: two 20 Watt or one 40 Watt fluorescent light
 - Display adjusted for best contrast
 - Viewing distance: 30 ± 5 cm (about 12 inches)
 - Viewable angle: inspect 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.

DEFINITION OF ACTIVE AREA AND VIEWABLE AREA





ACCEPTANCE SAMPLING

DEFECT TYPE	AQL*
Major	$\leq 0.65\%$
Minor	$\leq 1.00\%$

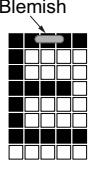
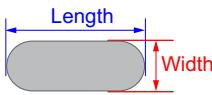
*Acceptable Quality Level: maximum allowable error rate or variation from standard.

DEFECTS CLASSIFICATION

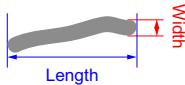
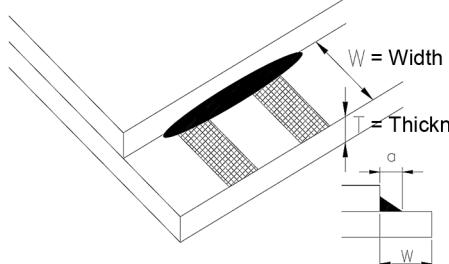
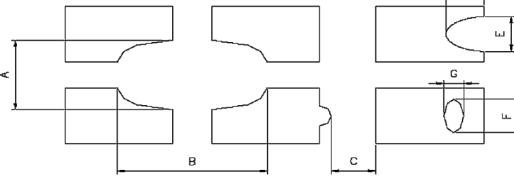
Defects are defined as:

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

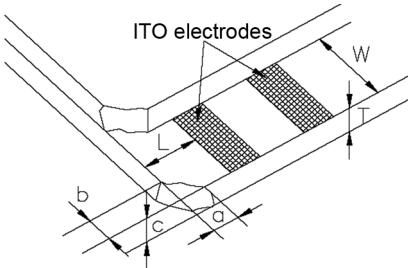
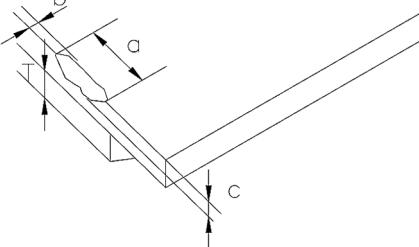
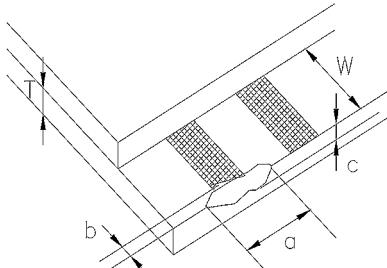
ACCEPTANCE STANDARDS

#	DEFECT TYPE	CRITERIA			MAJOR / MINOR
1	Electrical defects	1. No display, display malfunctions, or shorted segments. 2. Current consumption exceeds specifications.			Major
2	Viewing area defect	Viewing area does not meet specifications. (See Inspection Conditions (Pg. 60) .)			Major
3	Contrast adjustment defect	Contrast adjustment fails or malfunctions.			Major
4	Blemishes or foreign matter on display segments	 	Defect Size (mm)	Acceptable Qty	Minor
		≤ 0.3	3		
		≤ 2 defects within 10 mm of each other			
5	Other blemishes or foreign matter outside of display segments	Defect size = $(A + B)/2$	Defect Size (mm)	Acceptable Qty	Minor
			≤ 0.15	Ignore	
			0.15 to 0.20	3	
			0.20 to 0.25	2	
			0.25 to 0.30	1	



#	DEFECT TYPE	CRITERIA			MAJOR / MINOR	
6	Dark lines or scratches in display area 	Defect Width (mm)	Defect Length (mm)	Acceptable Qty	Minor	
		≤ 0.03	≤ 3.0	3		
		0.03 to 0.05	≤ 2.0	2		
		0.05 to 0.08	≤ 2.0	1		
		0.08 to 0.10	≤ 3.0	0		
		≥ 0.10	> 3.0	0		
7	Bubbles between polarizer film and glass	Defect Size (mm)	Acceptable Qty		Minor	
		≤ 0.20	Ignore			
		0.20 to 0.40	3			
		0.40 to 0.60	2			
		≥ 0.60	0			
8	Glass rest defect				Minor	
9	Display pattern defect				Minor	
		Dot Size (mm)	Acceptable Qty			
		$((A+B)/2) \leq 0.2$	≤ 3 total defects ≤ 2 pinholes per digit			
		$C > 0$				
		$((D+E)/2) \leq 0.25$				
		$((F+G)/2) \leq 0.25$				



#	DEFECT TYPE	CRITERIA				MAJOR / MINOR
10	Chip in corner					Minor
		<i>a</i>	<i>b</i>	<i>c</i>	<i>Acceptable Qty</i>	
		<4 mm	$\leq W$	$c \leq T$	3	
11	Chip on "non-contact" edge of LCD					Minor
		<i>a</i>	<i>b</i>	<i>c</i>		
		≤ 3 mm	≤ 1 mm	$\leq T$		
12	Chip on "contact" edge of LCD, on the active side					Minor
		<i>a</i>	<i>b</i>	<i>c</i>	<i>Acceptable Qty</i>	
		≤ 2 mm	$\leq W/4$	$\leq T$	Ignore	
		≤ 3 mm	$\leq W/4$	$\leq T$	3	



#	DEFECT TYPE	CRITERIA				MAJOR / MINOR
13	Chip on "contact" edge of LCD, on the inactive side					Minor
		<i>a</i>	<i>b</i>	<i>c</i>	Acceptable Qty	
		$\leq 3 \text{ mm}$	$\leq 1 \text{ mm}$	$\leq T$	Ignore	
		$\leq 4 \text{ mm}$	$\leq 1.5 \text{ mm}$	$\leq T$	3	
14	Chip in seal area					Minor
		<i>a</i>	<i>b</i>	<i>c</i>	Acceptable Qty	
		$< 3 \text{ mm}$	$\leq 1.5 \text{ mm}$	$\leq 1/2 T$	3	
		Unacceptable if $c > 50\%$ of glass thickness or if the seal area is damaged.				Major
15	Backlight defects	<ol style="list-style-type: none">Light fails or flickers.*Color and luminance do not correspond to specifications.*Exceeds standards for display's blemishes or foreign matter (see test 5, Pg. 61), and dark lines or scratches (see test 6, Pg. 62). <p>*Minor if display functions correctly. Major if the display fails.</p>				Minor
16	COB defects	<ol style="list-style-type: none">Pinholes $> 0.2 \text{ mm}$.Seal surface has pinholes through to the IC.More than 3 locations of sealant beyond 2 mm of the sealed areas.				Minor
17	PCB defects	<ol style="list-style-type: none">Oxidation or contamination on connectors.*Wrong parts, missing parts, or parts not in specification.*Jumpers set incorrectly.Solder (if any) on bezel, LED pad, zebra pad, or screw hole pad is not smooth. <p>*Minor if display functions correctly. Major if the display fails.</p>				Minor



Crystalfontz America, Inc.

www.crystalfontz.com

March 2011

CFA533-TMI-KC Intelligent I2C Module Data Sheet

Hardware v1.0 / Firmware vc1.0 / Data Sheet v2.0

Page 65

#	DEFECT TYPE	CRITERIA	MAJOR / MINOR
18	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. Residue or solder balls.5. Solder flux is black or brown. <p><i>*Minor if display functions correctly. Major if the display fails.</i></p>	Minor



APPENDIX B: SAMPLE CODE (INCLUDES ALGORITHMS TO CALCULATE THE CRC)

SAMPLE CODE

Free downloadable code is on our website <http://www.crystalfontz.com/products/document/2097/CFA-533-I2C-AVR.zip> (demonstration code for Atmel AVR ATmega 2561) and http://www.crystalfontz.com/product/533_I2C_WinTest (Windows compatible test/demonstration program and source). Please leave the original copyrights in the code.

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_Errata.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] =
    {0x00000,0x01189,0x02312,0x0329B,0x04624,0x057AD,0x06536,0x074BF,
     0x08C48,0x09DC1,0x0AF5A,0x0BED3,0x0CA6C,0x0DBE5,0x0E97E,0x0F8F7,
     0x01081,0x00108,0x03393,0x0221A,0x056A5,0x0472C,0x075B7,0x0643E,
     0x09CC9,0x08D40,0x0BFD8,0x0AE52,0x0DAED,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,0x0AC42,0x09ED9,0x08F50,0x0FBF,0x0EA66,0x0D8FD,0x0C974,
     0x04204,0x0538D,0x06116,0x0709F,0x00420,0x015A9,0x02732,0x036BB,
     0x0CE4C,0x0DFC5,0x0ED5E,0x0FCDD,0x08868,0x099E1,0x0AB7A,0x0BAF3,
     0x05285,0x0430C,0x07197,0x0601E,0x014A1,0x00528,0x037B3,0x0263A,
     0x0DECD,0x0CF44,0x0FDFF,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};  
  
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
;
        clrf    PCLATH     ; ensure upper bits of PC are cleared
        clrf    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 intial CRC seed value.
        movwf   accumh     ; This must be done prior to
        movlw   seedlo     ; sending string to CRC routine.
        movwf   accuml     ;
        clrf    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     clrc              ; clear carry for CRC register shift
```



```
rrf      datareg,f ; perform shift of data into CRC register
rrf      accumh,f ;
rrf      accuml,f ;
btcss   STATUS,C ; skip jump if if carry
goto    _notset ; otherwise goto next bit
movlw   polyL   ; XOR poly mask with CRC register
xorwf   accuml,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
;=====
; 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, 0x0FBEEF, 0x0EA66, 0x0D8FD, 0x0C974,
    0x04204, 0x0538D, 0x06116, 0x0709F, 0x00420, 0x015A9, 0x02732, 0x036BB,
    0x0CE4C, 0x0DFC5, 0x0ED5E, 0x0FCDF, 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, 0x0DDDD5, 0x0A96A, 0x0B8E3, 0x08A78, 0x09BF1,
    0x07387, 0x0620E, 0x05095, 0x0411C, 0x035A3, 0x0242A, 0x016B1, 0x00738,
    0x0FFCF, 0x0EE46, 0x0DCD, 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  
};  
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,  
0x0BDCCB, 0x0AC42, 0x09ED9, 0x08F50, 0x0FBFF, 0x0EA66, 0x0D8FD, 0x0C974,  
0x04204, 0x0538D, 0x06116, 0x0709F, 0x00420, 0x015A9, 0x02732, 0x036BB,  
0x0CE4C, 0x0DFC5, 0x0ED5E, 0x0FC7, 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  dsplayLPCNT      ;w has the byte count
nxt1_dsplay:
    movf   POSTINC1,w
    call   CRC16
    decfsz dsplayLPCNT
    goto   nxt1_dsplay
    movlw  .0                 ; shift accumulator 16 more bits
    call   CRC16_
    movlw  .0
    call   CRC16_
    comf   dsplay_CRC,F      ; invert result
    comf   dsplay_CRC+1,F
    return
;=====
CRC16_ movwf:
    dsplay_CRCData          ; w has byte to crc
    movlw  .8
    movwf  dsplay_CRCCount
_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
btfs  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 ho 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  C0R0,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    dsplayCRC      ; seed hi for CRC calculation
        movlw    0x21
        movwf    dsplayCRC+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    dsplayCRC+1,w
        movwf    POSTINC1        ; append CRC byte
        movf    dsplayCRC,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
        MOVLF   upper stringname, TBLPTRU
        MOVLF   high stringname, TBLPTRH
        MOVLF   low stringname, TBLPTRL
        call    MOVE_STR
        endm

;=====
MOVE_STR:
        tblrd  *+
        movf    TABLAT,w
        bz     ms1b
        movwf    POSTINC1
        incf    SendCount
        goto    MOVE_STR
ms1b:
        return
=====
```

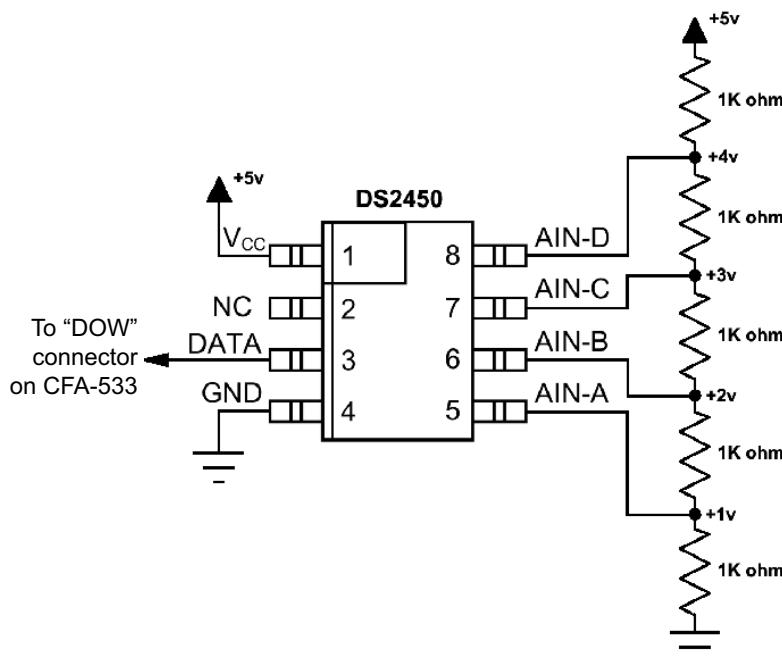


APPENDIX C: CONNECTING A DS2450 1-WIRE QUAD A/D CONVERTER

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 \(Pg. 44\)](#) 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 \(Pg. 45\)](#) for 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 // address = 8, channel A low
<response> C=84(d=0):6F,F1,68 // 16-bits, output off

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

<command 20> \000\002\085\010\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 // address = 11, channel B high
<response> C=84(d=0):5E,31,4B // no alarms, 5.1v

<command 20> \000\002\085\012\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 // address = 13, channel C high
<response> C=84(d=0):BE,30,60 // no alarms, 5.1v

<command 20> \000\002\085\014\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 // 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-TMI-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_ADDR_ACK)&&(TWSR != MRX_ADDR_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] =
{0x000000,0x01189,0x02312,0x0329B,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,0x0AC42,0x09ED9,0x08F50,0x0FBF,0x0EA66,0x0D8FD,0x0C974,
 0x04204,0x0538D,0x06116,0x0709F,0x00420,0x015A9,0x02732,0x036BB,
 0x0CE4C,0x0DFC5,0x0ED5E,0x0FCDD,0x08868,0x099E1,0x0AB7A,0x0BAF3,
 0x05285,0x0430C,0x07197,0x0601E,0x014A1,0x00528,0x037B3,0x0263A,
 0x0DEC0,0x0CF44,0x0FDDE,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_addr((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_addr((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);
}
}
}

//=====
```