INTELLIGENT LCD MODULE SPECIFICATIONS

Datasheet Release 2017-08-31
for
XES635BK-TFK-KU
XES635BK-TML-KU
XES635BK-YYK-KU

Enclosure Version: v3.9a
Hardware Version: v1.5
Firmware Version: u2.3

Crystalfontz America, Inc.
12412 East Saltese Avenue
Spokane Valley, WA 99216-0357
Phone: 888-206-9720
Fax: 509-892-1203
Email: support@crystalfontz.com
URL: www.crystalfontz.com

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1. General Information

Datasheet Revision History
Datasheet Version: **2017-08-31** Enclosure Version: **v3.9a** Hardware Version: **v1.5** Firmware Version: **u2.3** This datasheet has been updated to reflect hardware version v1.5, firmware u2.3 for the XES635BK-TFK-KU, XES635BK-TML-KU, and the XES635BK-YYK-KU LCD modules. For information about firmware and hardware revisions, see the Part Change Notifications (PCNs) under "News" in our website's navigation bar. To see the most recent PCN for the XES635BK-xxx-KU family at the time of this datasheet release, see PCN #10860. Previous datasheet Version: **2017-05-03** For reference, previous datasheets may be downloaded by clicking the "Show Previous Versions of Datasheet" link under the "Datasheets and Files" tab of the product web page.

Product Change Notifications
To check for or subscribe to "Part Change Notices" for this display module, see the Product Notices tab on the product's web page.

Variations
Slight variations (for example, contrast, color, or intensity) between lots are normal.

Volatility
This display module has volatile memory.

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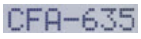
2. Introduction

The CFA635 family of modules has four interface choices:

- CFA635-xxx-KL (logic-level serial / UART)
- CFA635-xxx-KS (CFA-RS232)
- CFA635-xxx-KU (USB)
- XES635BK-xxx-KU (enclosed USB)

This datasheet has information for these USB interface modules:

- XES635-TFK-KU  (USB, dark letters on a light background; this display can be read in normal office lighting, in dark areas, and in bright sunlight.)
- XES635-TML-KU  (USB, light letters on a blue background; this display can be read in normal office lighting and in dark areas.)
- XES635-YYK-KU  (USB, dark letters on a yellow background; this display can be read in normal office lighting, in dark areas, and in bright sunlight.)

When information in this datasheet applies to all three colors the term “XES635BK” or “CFA635” is used.

2.1. Main Features

- Large, easy-to-read, 20-character x 4-line LCD in a compact overall size.
- The LCD has a wide viewing angle, with a 12 o’clock preferred viewing direction.
- USB interface 2.0 full-speed interface.
- Six-button, LED backlit, translucent silicone keypad with screened legend. Fully decoded keypad: any key combination is valid and unique.
- LCD is edge-lit with 8 long-life, high performance, LEDs (4 per side).
- Adjustable contrast. The default contrast value for the module will be acceptable for many applications. If necessary, you can adjust the contrast using command 13 (0x0D): Set LCD Contrast.
- The front of the display has four bicolor (red + green), LED status lights. The LEDs' brightness can be set by the host software that allows for smoothly adjusting the LEDs to produce other colors (for example, yellow, and orange).
- Robust, packet-based protocol with 16-bit CRC ensures error-free communications.
- Nonvolatile memory capability (EEPROM):
  - Customize the “power-on” display settings (backlight brightness, boot screen, LED settings).
  - 16-byte “scratch” register for storing IP address, netmask, system serial number.
- Crystalfontz America, Inc. is ISO 9001:2008 certified.
- A Declaration for Conformity, RoHS, and REACH:SVHC are available under the Datasheets & Files tab on display web pages.

2.2. Module Classification Information

XES	635	BK	-	x	x	x	-	K	U
❶	❷	❸		❹	❺	❻		❼	❽

❶	**Brand**	XES – e**X**ternal **E**nclosure, **S**teel
❷	**Model Identifier**	635
❸	**Bracket Type**	BK = Black Steel
❹	**Backlight Type & Color**	x = T – LED, white Y – LED, yellow, green
❺	**Fluid Type, Image (positive or negative), & LCD Glass Color**	x = F – FSTN, positive, neutral M – STN, negative blue Y – STN, positive, yellow-green
❻	**Polarizer Film Type, Temperature Range, & Viewing Direction (o'clock)**	x = K – Transflective, WT, 12:00 L – Transmissive, WT, 12:00
❼	**Special Code**	K – Manufacturer's code
❽	**Interface**	U – USB interface

2.3. Ordering Information

Part Number	Fluid	LCD Glass Color	Image	Polarizer Film	Backlight Color/Type
XES635BK-TFK-KU	FSTN	neutral	positive	transflective	Backlight: white Keypad: white 
XES635BK-TML-KU	STN	blue	negative	transmissive	Backlight: white Keypad: blue 
XES635BK-YYK-KU	STN	yellow-green	positive	transflective	Backlight: yellow-green Keypad: yellow-green 

Additional modules in the CFA635 family are:

- A serial interface using a CFA-RS232 level translator board. Part numbers end in "-KS". Suitable for embedded controller or host system that has a "real" RS232 serial port (-5v to +5v "full swing" serial interface).
- A serial "logic level, inverted" 0v to +3.3v nominal interface (typical for direct connection to a microcontroller's UART pins). Part numbers end in "-KL".
- An external enclosure with a captive USB "A" cable connection. Please see https://www.crystalfontz.com/family/XES635BK?family=XES635BK.

3. Mechanical Characteristics

3.1. Physical Characteristics

Item	Specification (mm)	Specification (inch, reference)
Overall Width and Height	146.0 (W) x 39.3 (H)	5.59 (W) x 1.55 (H)
Viewing Area	80.90 (W) x 25.5 (H)	3.19 (W) x 1.00 (H)
Active Area	77.95 (W) x 22.35 (H)	3.07 (W) x 0.88 (H)
5x7 Standard Character Size	3.20 (W) x 4.85 (H)	0.126 (W) x 0.190 (H)
Pixel Size	0.60 (W) x 0.65 (H)	0.024 (W) x 0.026 (H)
Pixel Pitch	0.65 (W) x 0.70 (H)	0.026 (W) x 0.028 (H)
Depth with Keypad	23.6 (D)	0.93 (D)
Keystroke Travel (approximate)	~2.4	~0.1
Weight with Cable (typical)	297 grams	10.48 ounces

4. Optical Characteristics

4.1. CFA635 Series

Item	Symbol	Condition	Min	Typ	Max	Direction
Viewing Angle (12 o'clock is the preferred direction for this module)	θ	CR≧2	40°	–	–	above, 12 o'clock
	θ	CR≧2	20°	–	–	below, 6 o'clock
	θ	CR≧2	30°	–	–	right, 3 o'clock
	θ	CR≧2	30°	–	–	left, 9 o'clock
Contrast Ratio	CR	–	–	10	15	–
Response Time	T rise	–	–	80	160	ms
	T fall	–	–	100	200	ms

4.2. LED Backlight Information

The backlights used in the XES635BK are designed for a very long life, but their lifetime is finite. To conserve the LED lifetime and reduce power consumption you can dim or turn off the backlights during periods of inactivity.

5. Electrical Specifications

5.1. System Block Diagram

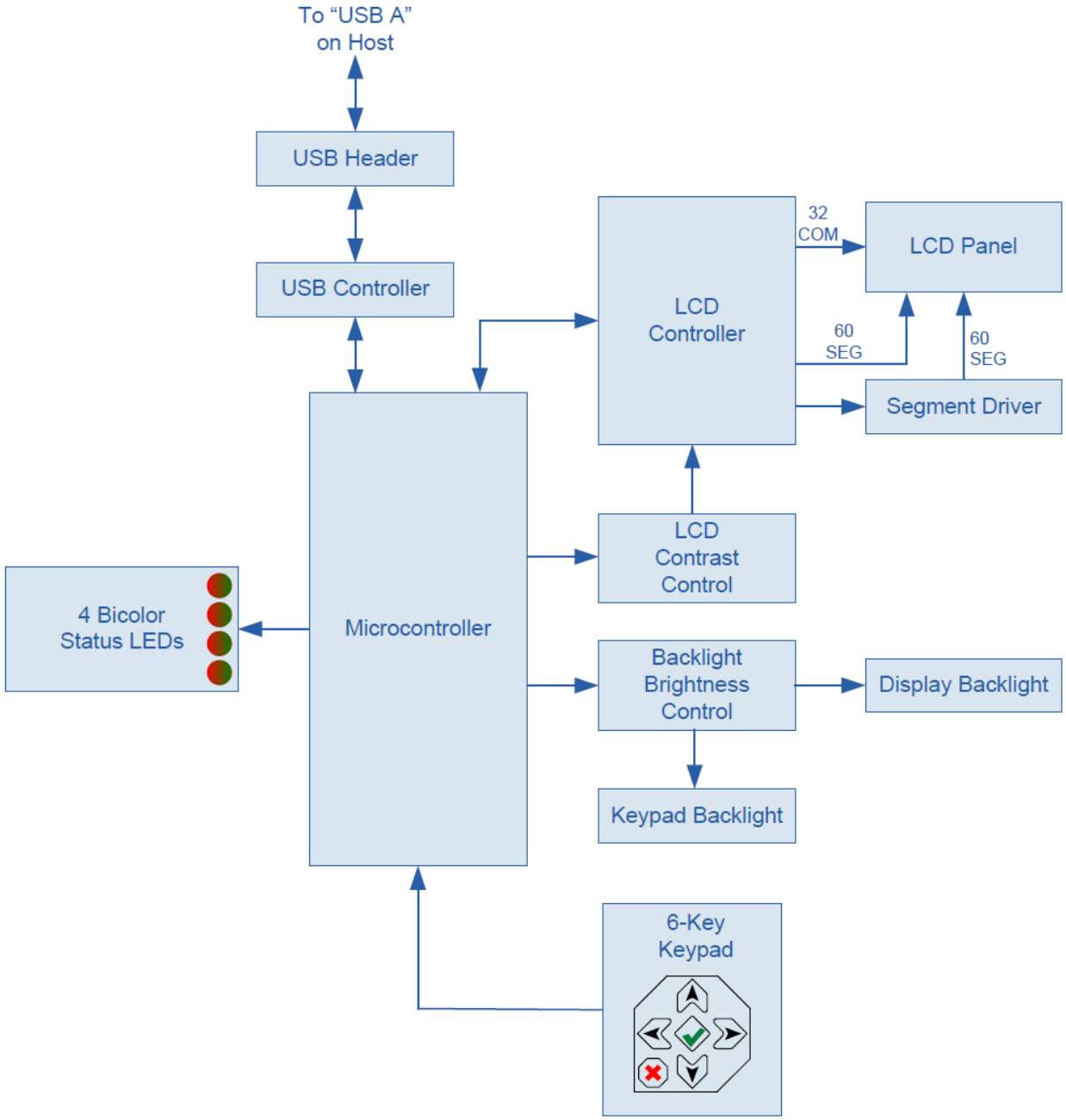


Figure 1. System Block Diagram

6. Supply Voltages and Current

6.1. Absolute Maximum Ratings

Absolute Maximum Ratings	Symbol	Minimum	Maximum
Operating Temperature	T_{OP}	-20°C	+70°C
Storage Temperature	T_{ST}	-30°C	+80°C
Humidity Range (Non-condensing)	RH	10%	90%
Supply Voltage for Logic	V_{DD}	-0.3v	+5.5v
Please note that these are stress ratings only. Extended exposure to the absolute maximum ratings listed above may affect device reliability or cause permanent damage. Functional operation of the module at these conditions beyond those listed under DC Characteristics is not implied. Changes in temperature can result in changes in contrast.			

6.2. DC Characteristics

Specifications	Symbol	Minimum	Typical	Maximum
Supply Voltage	V_{DD}	+2.9v	+5.0v	+5.5v

6.3. Typical Current Consumption

Variables that affect current consumption include the choice of color, brightness of backlights, brightness of the four status lights.

XES635BK-TFK-KU CFA-635 (dark characters on a light background)

Items Enabled			Typical Current Consumption	
Logic	**LCD and Keypad Backlights at 100%**	**All Status LEDs 4 Red + 4 Green at 100%**	**V_{DD}=+4.75**	**V_{DD}=+5.25v**
X	-	-	18 mA	17 mA
X	X	-	110 mA	100 mA
X	-	X	110 mA	100 mA
X	X	X	190 mA	175 mA

XES635-TML-KU CFA-635 (light characters on a deep blue background)

Items Enabled			Typical Current Consumption	
Logic	**LCD and Keypad Backlights at 100%**	**All Status LEDs 4 Red + 4 Green at 100%**	**V_{DD}=+4.75**	**V_{DD}=+5.25v**
X	-	-	18 mA	17 mA
X	X	-	110 mA	100 mA
X	-	X	110 mA	100 mA
X	X	X	190 mA	175 mA

XES635-YYK-KU CFA-635 (dark characters on a yellow-green background)

Items Enabled			Typical Current Consumption	
Logic	**LCD and Keypad Backlights at 100%**	**All Status LEDs 4 Red + 4 Green at 100%**	**V_{DD}=+4.75**	**V_{DD}=+5.25v**
X	-	-	18 mA	17 mA
X	X	-	125 mA	115 mA
X	-	X	110 mA	100 mA
X	X	X	220 mA	200 mA

6.4. USB ESD Characteristics

The D+ and D- pins of the USB connector have IEC 61000-4-2 level 4 compliant ESD Protection:

- 15 kV (air discharge)
- 8 kV (contact discharge)

7. Host Communications

XES635BK-xxx-KU communicates with its host using the USB interface through the virtual COM port (VCP) drivers. Using the driver makes it appear to the host software as if there is an additional serial port (the VCP), on the host system when the XES635BK-xxx-KU is connected. This VCP should be opened at 115200 baud, 8 data bits, no parity, 1 stop bit.

7.1. Packet Structure

All communication between the XES635BK and the host takes place in the form of a simple, robust CRC checked packet. The packet format allows for very reliable communications between the XES635BK 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.

> 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 before sending any additional packets.

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 XES635-xxx-KU
            01 = normal response from XES635-xxx-KU to host
            10 = normal report from XES635-xxx-KU to host (not in
                 direct response to a command from the host)
            11 = error response from XES635-xxx-KU to host (a packet
                 with valid structure but illegal content
                 was received by the XES635-xxx-KU)
```

data_length specifies the number of bytes that will follow in the data field. The valid range of **data_length** is 0 to 22.

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 A: Demonstration Software and Sample Code, for details.

The following C definition may be useful for understanding the packet structure.

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

Crystalfontz supplies a demonstration and test program, cfTest, that can be used to experiment with and test the XES635BK’s operation. We also offer 635WinTest, which is a simpler, open-source program. Included in the 635WinTest source is a CRC algorithm and an algorithm that detects and reconciles packets. The algorithm will automatically re-synchronize to the next valid packet in the

event of any communications errors. Please follow the algorithm in the sample code closely in order to realize the benefits of using the packet communications.

7.2. About Handshaking

The nature of XES635BK-xxx-KU's packets makes it unnecessary to implement traditional hardware or software handshaking.

The host should wait for a corresponding acknowledge packet from the XES635BK before sending the next command packet. The XES635BK will respond to all packets within 250 mS. The host software should stop waiting and retry the packet if the XES635BK fails to respond within 250 mS. The host software should report an error if a packet is not acknowledged after several retries. This situation indicates a hardware problem – for example, a disconnected cable.

Please note that some operating systems may introduce delays between when the data arrives at the physical port from the XES635BK until it is available to the user program. In this case, the host program may have to increase its timeout window to account for the additional overhead of the operating system.

The XES635BK can be configured to send several types of report packets along with regular acknowledge packets. The host should be able to buffer several incoming packets and must guarantee that it can process and remove packets from its input buffer faster than the packets can arrive given the baud rate and the reporting configuration of the XES635BK. For any modern PC using reasonably efficient software, this requirement will not pose a challenge.

The report packets are sent asynchronously with respect to the command packets received from the host. The host should not assume that the first packet received after it sends a command is the acknowledge packet for that command. The host should inspect the **`type`** field of incoming packets and process them accordingly.

7.3. Report Codes

The XES635BK can be configured to report three items. The XES635BK sends reports automatically when the data becomes available. Reports are not sent in response to a particular packet received from the host. The three report types are (1) 0x80: Key Activity, (2) 0x81: Fan Speed Report (FBSCAB Required), and (3) 0x82: Temperature Sensor Report (FBSCAB Required). The three report types are below.

0x80: Key Activity
If a key is pressed or released, the XES635BK sends a Key Activity report packet to the host. Key event reporting may be individually enabled or disabled by command 23 (0x17): Configure Key Reporting.

```
type = 0x80
data_lenght = 1
data[0] is the type of keyboard activity:
        KEY_UP_PRESS                1
        KEY_DOWN_PRESS              2
        KEY_LEFT_PRESS              3
        KEY_RIGHT_PRESS             4
        KEY_ENTER_PRESS             5
        KEY_EXIT_PRESS              6
        KEY_UP_RELEASE              7
        KEY_DOWN_RELEASE            8
        KEY_LEFT_RELEASE            9
        KEY_RIGHT_RELEASE           10
        KEY_ENTER_RELEASE           11
        KEY_EXIT_RELEASE            12
```

0x81: Not Supported (Fan Speed Report)

0x82: Not Supported (Temperature Sensor Report)

7.4. Command Codes

Below is a list of valid commands for the XES635BK-xxx-KU. 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 XES635BK-xxx-KU will return the Ping Command to the host.

```
type: 0x00 = 0(10)
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 = 64(10)
data_length = (identical to received packet)
data[0-(data_length-1)] = (identical to received packet)
```

1 (0x01): Get Hardware & Firmware Version
The XES635BK-xxx-KU will return the hardware and firmware version information to the host.

```
type: 0x01 = 1(10)
data_length: 0 or 1
data[0]: module information to return (optional)
   0 = Hardware and firmware version (text string)
   1 = Module serial number (text string)
   2 = Bootloader version (text string)
```

The return packet will be **(data_length=0 or data[0]=0):**

```
type: 0x40 | 0x01 = 0x41 = 65(10)
data_length = 16
data[] = "CFA635: h1.5,u2.2

h1.5 is the hardware revision
u2.2 is the firmware version
```

The return packet will be **(data[0]=1):**

```
type: 0x40 | 0x01 = 0x41 = 65(10)
data_length = 16
data[] = "aabbccddeeffaabbccdd"
```

The return packet will be **(data[0]=2):**

```
type: 0x40 | 0x01 = 0x41 = 65(10)
data_length = 3
data[] = "X.X"
```

2 (0x02): Write User Flash Area
The XES635BK reserves 16 bytes of nonvolatile memory for arbitrary use by the host. This memory can be used to store a serial number, IP address, gateway address, netmask, or any other data required. All 16 bytes must be supplied.

```
type: 0x02 = 2(10)
valid data_length is 16
data[] = 16 bytes of arbitrary user data to be stored in the XES635BK-xxx-KU's
         non-volatile memory
```

The return packet will be:

```
type: 0x40 | 0x02 = 0x42 = 66(10)
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 = 3(10)
valid data_length is 0
```

The return packet will be:

```
type: 0x40 | 0x03 = 0x43 = 67(10)
data_length = 16
data[] = 16 bytes user data recalled from the XES635BK-xxx-KU's non-volatile
         memory
```

4 (0x04): Store Current State as Boot State
The XES635BK loads its power-up configuration from nonvolatile memory when power is applied. The XES635BK 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.
  - Command 31 (0x1F): Send Data to LCD.
- Special character font definitions (Command 9 (0x09): Set LCD Special Character Data).
- Cursor position (Command 11 (0x0B): Set LCD Cursor Position).
- Cursor style (Command 12 (0x0C): Set LCD Cursor Style).
- Contrast setting (Command 13 (0x0D): Set LCD Contrast).
- Backlight setting (Command 14 (0x0E): Set LCD & Keypad Backlight).
- Baud rate (Command 33 (0x21): Set Baud Rate).
- GPIO settings (Command 34 (0x22): Set or Set and Configure GPIO Pins).

To store the current state as the boot state, send the following packet:

```
type: 0x04 = 4(10)
valid data_length is 0
```

The return packet will be:

```
type: 0x40 | 0x04 = 0x44 = 68(10)
data_length = 0
```

If the current state and the boot state do not match after saving, the module will return an error instead of an ACK. In this unlikely error case, the boot state will be undefined.

5 (0x05): Reboot XES635BK-xxx-KU
This command instructs the XES635BK to simulate a power-on restart of itself, additional features/actions not supported are *Reset Host and Power Off Host*.

Rebooting the XES635BK may be useful when testing the boot configuration. To reboot the XES635BK, send the following packet:

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

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 = 32 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 changes the LCD. The LCD contents is one of the items stored by the command 4 (0x04): Store Current State as Boot State.

7 (0x07): Deprecated

8 (0x08): Deprecated

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.

If you set bit 7 of any of the data bytes, the entire line of pixels within this character will blink.

NOTE: If you set bit 7 of any of the data bytes, the entire line will blink.

The return packet will be:

type: 0x40 | 0x09 = 0x49 =
73_{10} 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.

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 = 10_{10}
valid data_length
is 1
data[0] = address code of desired data

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

0x40 (64) to 0x7F (127) for CGRAM
0x80 (128) to 0x93 (147) for DDRAM, line 0
0xA0 (160) to 0xB3 (179) for DDRAM, line 1
0xC0 (192) to 0xD3 (211) for DDRAM, line 2
0xE0 (224) to 0xF3 (243) for DDRAM, line 3

The return packet will be:

type: 0x40 | 0x0A = 0x4A = 74_{10}
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 XES635BK-xxx-KU'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.

type: 0x0B = 11_{10}
valid data_length is 2
data[0] = column (0-19 valid)
data[1] = row (0-3 valid)

The return packet will be:

type: 0x40 | 0x0B = 0x4B = 75_{10}
data_length = 0

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

12 (0x0C): Set LCD Cursor Style
This command allows you to select among four hardware generated cursor options.

```
type: 0x0C = 12(10) valid
data_length is 1
data[0] = cursor style (0-4 valid)
        0 = no cursor
        1 = blinking block cursor
        2 = underscore cursor
        3 = blinking block plus underscore
        4 = blinking underscore
```

The return packet will be:

```
type: 0x40 | 0x0C = 0x4C = 76(10)
data_length = 0
```

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

13 (0x0D): Set LCD Contrast
This command sets the contrast or vertical viewing angle of the display.

```
type: 0x0D = 13(10)
valid data_length is 1
data[0] = contrast setting (0-254 valid)
       60 = light
       120 = about right
       150 = dark
       151-254 = very dark (may be useful at cold temperatures)
```

The return packet will be:

```
type = 0x40 | 0x0D = 0x4D = 77(10)
data_length = 0
```

Set LCD Contrast is one of the items stored by the command 4 (0x04): Store Current State as Boot State.

14 (0x0E): Set LCD & Keypad Backlights
If one byte is supplied, both the keypad and LCD backlights are set to that brightness.

```
type: 0x0E = 14(10)
valid data_length is 1

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

The return packet will be:

```
type: 0x40 | 0x0E = 0x4E = 78(10)
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 = 14(10)
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 = 78(10)
data_length: 0
```

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

15 (0x0F): Deprecated

16 (0x10): Not Supported

17 (0x11): Not Supported

18 (0x12): Not Supported

19 (0x13): Not Supported

20 (0x14): Not Supported

21 (0x15): Deprecated

22 (0x16): Send Command Directly to the LCD Controller
This command allows you to access the XES635BK-xxx-KU's LCD controller directly.

IMPORTANT: It is possible to corrupt the XES635BK display using this command.

```
type: 0x16 = 22(10)
data_length: 2
data[0]: location code
       0 = "Data" register
       1 = "Control" register, RE=0
       2 = "Control" register, RE=1
data[1]: data to write to the selected register
```

The return packet will be:

```
type: 0x40 | 0x16 = 0x56 = 86(10)
data_length = 0
```

23 (0x17): Configure Key Reporting
By default, the XES635BK reports any key event to the host. This command allows the key events to be enabled or disabled on an individual basis. The key events set to report are one of the items stored by the command 4 (0x04): Store Current State as Boot State.

```
#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: 0x17 = 23(10) data_length = 2
data[0]: press mask data[1]: release mask
Valid values of the mask are \000-\063.
```

The return packet will be:

```
type: 0x40 | 0x17 = 0x57 = 87(10)
data_length = 0
```

Configure Key Reporting is one of the items stored by the command 4 (0x04): Store Current State as Boot State.

24 (0x18): Read Keypad, Polled Mode
In some situations, it may be convenient for the host to poll the XES635BK 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.

This command is independent of the key reporting masks set by command 23 (0x17): Configure Key Reporting. All keys are always visible to this command. Typically, both masks of command 23 would be set to "0" if the host is reading the keypad in polled mode.

```
#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 = 24(10)
data_length = 0
```

The return packet will be:

```
type: 0x40 | 0x18 = 0x58 = 88(10)
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 (0x19): Not Supported

26 (0x1A): Not Supported

27 (0x1B): Not Supported

28 (0x1C): Not Supported

29 (0x1D): Not Supported

30 (0x1E): Read Reporting & Status
This command can be used to verify the current items configured to report to the host, as well as some other miscellaneous status information.

```
type = 0x1E = 30(10)
data_length = 0
```

The return packet will be:

```
type = 0x40 | 0x1E = 0x5E = 94(10)
data_length = 15
data[ 0] = Not Relevant
data[ 1] = Not Relevant
data[ 2] = Not Relevant
data[ 3] = Not Relevant
data[ 4] = Not Relevant
data[ 5] = key presses (as set by command 23)
data[ 6] = key releases (as set by command 23)
data[ 7] = Not Relevant
data[ 8] = Not Relevant
data[ 9] = Not Relevant
data[10] = Not Relevant
data[11] = Not Relevant
data[12] = Not Relevant
data[13] = contrast setting (as set by command 13)
data[14] = backlight setting (as set by command 14)
```

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 = 31(10)
data_length = 3 to 22
data[0]: col = x = 0 to 19
data[1]: row = y = 0 to 3
data[2-21]: text to place on the LCD, variable from 1 to 20 characters
```

The return packet will be:

```
type: 0x40 | 0x1F = 0x5F = 95(10)
data_length = 0
```

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

32 (0x20): Not Supported

33 (0x21): Set Baud Rate
This command has no effect on the XES635BK-xxx-KU module. It will return an acknowledge for compatibility with older versions of host software.

34 (0x22): Set GPO Pin
The XES635BK has four bicolor status LEDs to the left of the LCD on the front panel. These LEDs are controlled by the GPO (general purpose output) pins on the module. The GPO can output constant high or low signals or a variable duty cycle 100 Hz PWM signal. The GPO configuration is one of the items stored by the command 4 (0x04): Store Current State as Boot State.

```
type: 0x22 = 34(10)
data_length:2 bytes to change value only

data[0]: index of GPIO/GPO to modify
       0 = GPIO[0] = (not accessible)
       1 = GPIO[1] = (not accessible)
       2 = GPIO[2] = (not accessible)
       3 = GPIO[3] = (not accessible)
       4 = GPIO[4] = (not accessible)
       5 = GPO[ 5] = H2, Pin 15 = LED 3 (bottom) green die
       6 = GPO[ 6] = H2, Pin 13 = LED 3 (bottom) red die
       7 = GPO[ 7] = H2, Pin 11 = LED 2 green die
       8 = GPO[ 8] = H2, Pin 9 = LED 2 red die
       9 = GPO[ 9] = H2, Pin 7 = LED 1 green die
       10 = GPO[10] = H2, Pin 5 = LED 1 red die
       11 = GPO[11] = H2, Pin 3 = LED 0 (top)green die
       12 = GPO[12] = H2, Pin 1 = LED 0 (top) red die
   13-255 = (not accessible)
)
```

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 GPO 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
```

The return packet will be:

```
type = 0x40 | 0x22 = 0x62 = 98(10)
data_length = 0
```

35 (0x23): Not Supported

8. 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”. Add 224 + 2 to get 226. When you send a byte with the value of 226 to the display, the Greek letter "β" will be shown.

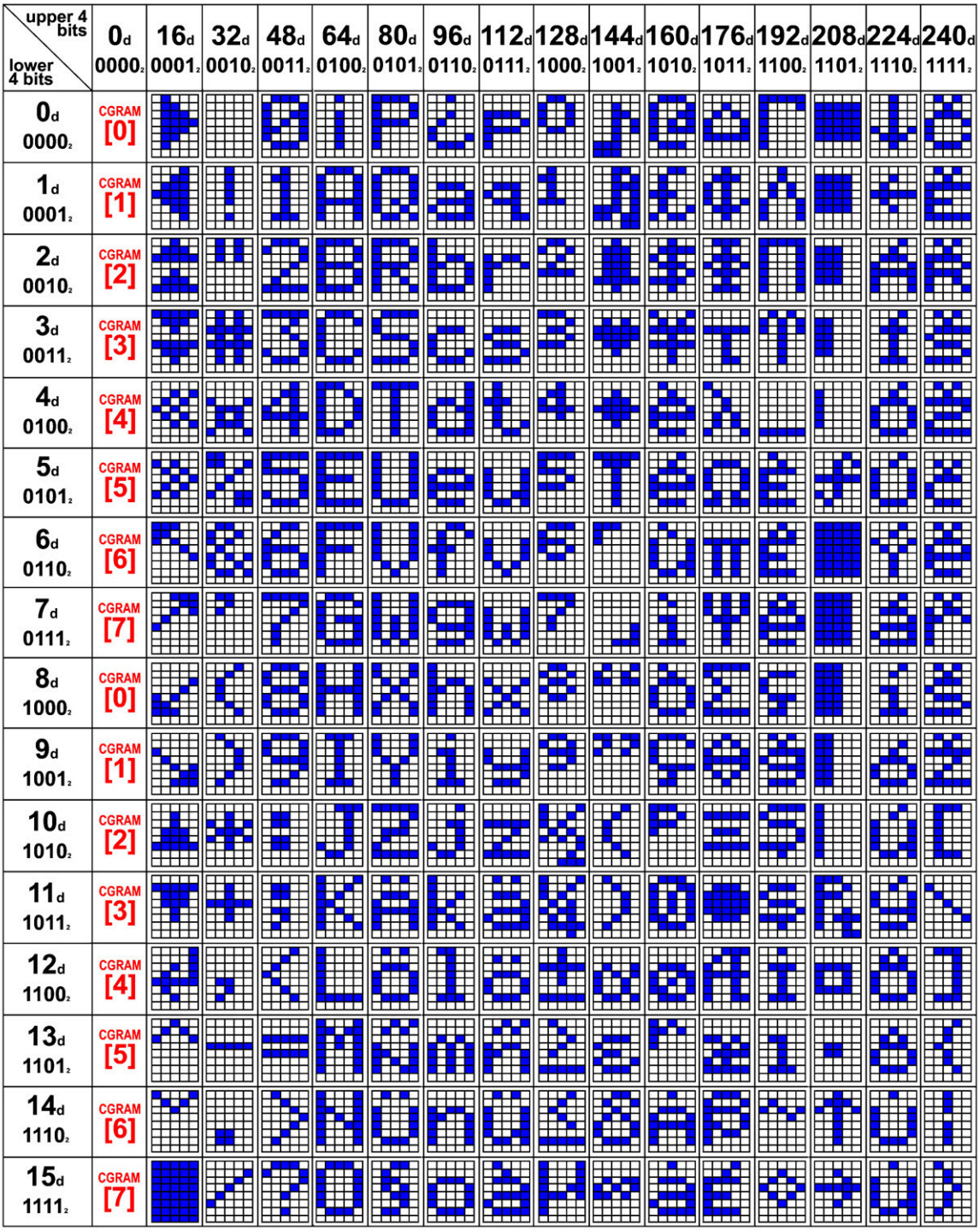


Figure 2. Character Generator ROM (CGROM)

9. LCD Module Reliability and Longevity

We work to continuously improve our products, including backlights that are brighter and last longer. Slight color variations from module to module and batch to batch are normal. ***If you need modules with consistent color, please ask for a custom order.***

ITEM	SPECIFICATION	
LCD portion (excluding Keypad and Backlights)	50,000 to 100,000 hours (typical)	
Keypad	1,000,000 keystrokes	
Bicolor status LEDs	50,000 to 100,000 hours	
Yellow-green LED Display and Keypad Backlight (XES635BK-xxx-KU)	50,000 to 100,000 hours	
White LED Display and Blue LED Keypad Backlights ***NOTE**: 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.* Values listed above are approximate and represent typical lifetime.	Power-On Hours	% of Initial Brightness
	<10,000	>90%
	<50,000	>50%

9.1. Module Longevity (EOL / Replacement Policy)

Crystalfontz is committed to making all of our LCD modules available for as long as possible. For each module that 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 datasheet specifications and tolerances of the discontinued module, changes may require modification to your circuit and/or firmware. Possible changes include:

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

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

10. Care and Handling Precautions

For optimum operation of the XES635BK-xxx-KU and to prolong its life, please follow the precautions described below.

10.1. ESD (Electrostatic Discharge)

The USB D+ & D- lines have enhanced ESD protection following industry standard practice, please see USB ESD Characteristics.

The remainder of 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.

10.2. Design and Mounting

- Do not remove the module from the case.
- Do not disassemble or modify the module.

10.3. Avoid Shock, Impact, Torque, or Tension

- Do not expose the XES635BK to strong mechanical shock, impact, torque, or tension.
- Do not drop, toss, bend, or twist the XES635BK.
- Do not place weight or pressure on the XES635BK.

10.4. If LCD Panel Breaks

- If the LCD panel breaks, be careful to not get the liquid crystal fluid in your mouth or eyes.
- If the liquid crystal fluid touches your skin, clothes, or work surface, wash it off immediately using warm soapy water.

10.5. Cleaning

- The window gasket is made of plastic that can easily be scratched or damaged, so use extra care when you clean it.
    - Do not clean the window gasket with liquids.
    - Do not wipe the window gasket 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 window gasket becomes dusty, carefully blow it off with clean, dry, oil-free compressed air.
    - The window gasket will eventually become hazy if you do not use care when cleaning it.
    - Contact with moisture may permanently spot or stain the window gasket.

10.6. Operation

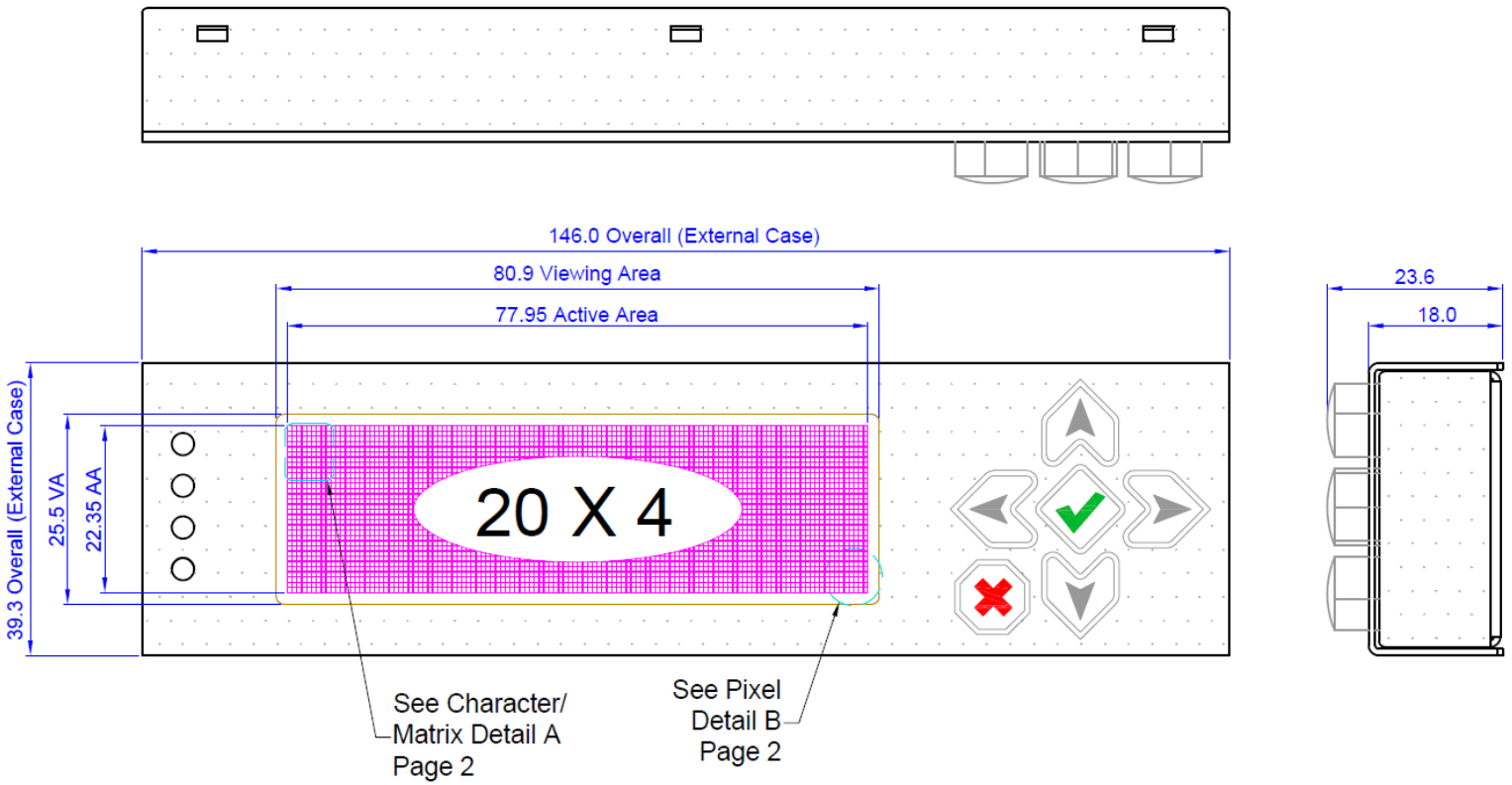
- Protect the XES635BK from ESD and power supply transients.
- Observe the operating temperature limitations: a minimum of -20°C to a maximum of +70°C with minimal fluctuation. Operation outside of these limits may shorten life and/or harm the display.
    - At lower temperatures of this range, response 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 that the display is readable, but not too bright.
- Dim or turn off the backlight during periods of inactivity to conserve the backlight lifetime.

10.7. Storage and Recycling

- Store the XES635BK away from dust, moisture, and direct sunlight.
- Observe the storage temperature limitations: -30°C minimum, +80°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 XES635BK-xxx-KU while in storage.
- Please recycle your outdated Crystalfontz modules at an approved facility.

11. Mechanical Drawings

Module Outline Drawing (1 of 2)

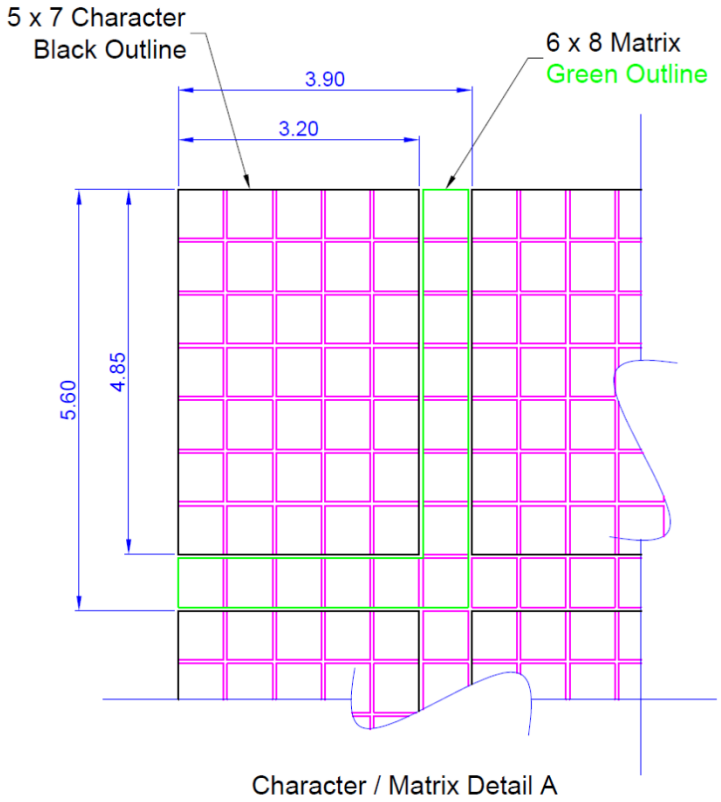


Tolerance is ±0.5 mm unless specified.

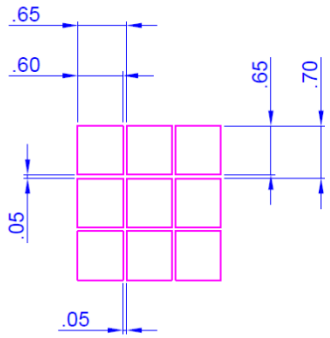
Crystalfontz America, Inc.
www.crystalfontz.com/products/

Part No.(s): XES635BK-TFE-KU, XES635BK-TMF-KU, XES635BK-YYE-KU	Scale: Not to scale	Drawing Number: XES635BK_master	
	Units: Millimeters	Date: 2017-05-03	Sheet: 1 of 2

Module Outline Drawing (2 of 2)



Character / Matrix Detail A



Pixel Detail B

Tolerance is ±0.5 mm unless specified.

Copyright © 2017 by **Crystalfontz America, Inc.** www.crystalfontz.com/products/	*Part No.(s):* XES635BK-TFE-KU, XES635BK-TMF-KU, XES635BK-YYE-KU	*Scale:* Not to scale	*Drawing Number:* XES635BK_master	
		Units: Millimeters	*Date:* 2017-05-03	*Sheet:* 2 of 2

12. Appendix A: Demonstration Software and Sample Code

Sample Code

We encourage you to use the free sample code listed below. Please leave the original copyrights in the code.

- Windows compatible test/demonstration program: https://www.crystalfontz.com/product/cftest
- Windows compatible example program and source: https://www.crystalfontz.com/product/635wintest
- Linux compatible command-line demonstration program with C source code. 8K. https://www.crystalfontz.com/product/linuxexamplecode
- Supported by CrystalControl freeware: https://www.crystalfontz.com/product/CrystalControl2.html

In addition, see http://lcdproc.org/index.php3 for Linux LCD drivers. LCDproc is an open source project that supports many of the Crystalfontz displays.

Algorithms to Calculate the CRC

Below are eight sample algorithms that will calculate the CRC of a XES635BK-xxx-KU packet. Some of the algorithms were contributed by forum members and originally written for CFA631 and XES635BK-xxx-KU. The CRC used in the XES635BK-xxx-KU 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,
     0x09CC9,0x08D40,0x0BFDB,0x0AE52,0x0DAED,0x0CB64,0x0F9FF,0x0E876,
     0x02102,0x0308B,0x00210,0x01399,0x06726,0x076AF,0x04434,0x055BD,
     0x0AD4A,0x0BCC3,0x08E58,0x09FD1,0x0EB6E,0x0FAE7,0x0C87C,0x0D9F5,
     0x03183,0x0200A,0x01291,0x00318,0x077A7,0x0662E,0x054B5,0x0453C,
     0x0BDCB,0x0AC42,0x09ED9,0x08F50,0x0FBEF,0x0EA66,0x0D8FD,0x0C974,
     0x04204,0x0538D,0x06116,0x0709F,0x00420,0x015A9,0x02732,0x036BB,
     0x0CE4C,0x0DFC5,0x0ED5E,0x0FCD7,0x08868,0x099E1,0x0AB7A,0x0BAF3,
     0x05285,0x0430C,0x07197,0x0601E,0x014A1,0x00528,0x037B3,0x0263A,
     0x0DECD,0x0CF44,0x0FDDF,0x0EC56,0x098E9,0x08960,0x0BBFB,0x0AA72,
     0x06306,0x0728F,0x04014,0x0519D,0x02522,0x034AB,0x00630,0x017B9,
     0x0EF4E,0x0FEC7,0x0CC5C,0x0DDD5,0x0A96A,0x0B8E3,0x08A78,0x09BF1,
     0x07387,0x0620E,0x05095,0x0411C,0x035A3,0x0242A,0x016B1,0x00738,
```

```
    0x0FFCF,0x0EE46,0x0DCDD,0x0CD54,0x0B9EB,0x0A862,0x09AF9,0x08B70,
    0x08408,0x09581,0x0A71A,0x0B693,0x0C22C,0x0D3A5,0x0E13E,0x0F0B7,
    0x00840,0x019C9,0x02B52,0x03ADB,0x04E64,0x05FED,0x06D76,0x07CFF,
    0x09489,0x08500,0x0B79B,0x0A612,0x0D2AD,0x0C324,0x0F1BF,0x0E036,
    0x018C1,0x00948,0x03BD3,0x02A5A,0x05EE5,0x04F6C,0x07DF7,0x06C7E,
    0x0A50A,0x0B483,0x08618,0x09791,0x0E32E,0x0F2A7,0x0C03C,0x0D1B5,
    0x02942,0x038CB,0x00A50,0x01BD9,0x06F66,0x07EEF,0x04C74,0x05DFD,
    0x0B58B,0x0A402,0x09699,0x08710,0x0F3AF,0x0E226,0x0D0BD,0x0C134,
    0x039C3,0x0284A,0x01AD1,0x00B58,0x07FE7,0x06E6E,0x05CF5,0x04D7C,
    0x0C60C,0x0D785,0x0E51E,0x0F497,0x08028,0x091A1,0x0A33A,0x0B2B3,
    0x04A44,0x05BCD,0x06956,0x078DF,0x00C60,0x01DE9,0x02F72,0x03EFB,
    0x0D68D,0x0C704,0x0F59F,0x0E416,0x090A9,0x08120,0x0B3BB,0x0A232,
    0x05AC5,0x04B4C,0x079D7,0x0685E,0x01CE1,0x00D68,0x03FF3,0x02E7A,
    0x0E70E,0x0F687,0x0C41C,0x0D595,0x0A12A,0x0B0A3,0x08238,0x093B1,
    0x06B46,0x07ACF,0x04854,0x059DD,0x02D62,0x03CEB,0x00E70,0x01FF9,
    0x0F78F,0x0E606,0x0D49D,0x0C514,0x0B1AB,0x0A022,0x092B9,0x08330,
    0x07BC7,0x06A4E,0x058D5,0x0495C,0x03DE3,0x02C6A,0x01EF1,0x00F78};

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 a 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 XES635-xxx-KU  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 high 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     ;
            btfss       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                   ; return to calling routine
;=====================================================================
; USER SUPPLIED Serial port transmit routine
;---------------------------------------------------------------------
SENDUART
            return                   ; put serial xmit routine here
```

```
;=====================================================================
; test string storage
;---------------------------------------------------------------------
            org         0100h
;
InputStr
            addwf       PCL,f
            dt          7h,10h,"This is a test. ",0
;
;=====================================================================
            end
```

Algorithm 4: "Visual Basic" Table Implementation

Visual BASIC has its own challenges as a language (such as initializing static arrays), and it is also challenging to use Visual BASIC to work with "binary" (arbitrary length character data possibly containing nulls such as the "data" portion of the XES635BK-xxx-KU packet) data. This routine was adapted from the C table implementation. The complete project can be found in our forums.

```
'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:
'http://www.crystalfontz.com/products/633/633_WinTest.zip
'Full zip of the project is available in our forum:
'https://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.
    Sub Initialize_CRC_Lookup_Table()
      crcLookupTable(0).Lo = &H0
      crcLookupTable(0).Hi = &H0
      . . .
    'For purposes of brevity in this Datasheet, I have removed 251 entries of this
    table, the  'full source is available in our forum:
    'https://www.crystalfontz.com/forum/showthread.php?postid=9921#post9921
      . . .
      crcLookupTable(255).Lo = &H78
      crcLookupTable(255).Hi = &HF
    End Sub

    'This function returns the CRC of the array at data for length positions
    Private Function Get_Crc(ByRef data() As Byte, ByVal length As Integer) As WORD
      Dim Index As Integer
```

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

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

Algorithm 5: "Java" Table Implementation

This code was posted in our forum by user "norm" as a working example of a Java CRC calculation.

```
public class CRC16 extends Object
  {
  public static void main(String[] args)

    {
    byte[] data = new byte[2];
    // hw - fw
    data[0] = 0x01;
    data[1] = 0x00;
    System.out.println("hw -fw req");
    System.out.println(Integer.toHexString(compute(data)));

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

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

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

  // set line 1
  data = new byte[18];
  data[0] = 0x07;
  data[1] = 0x10;
  String text = "Test Test Test   ";
  byte[] textByte = text.getBytes();
  for (int i=0; i < text.length(); i++) data[i+2] = textByte[i];
  System.out.println("text 1");
  System.out.println(Integer.toHexString(compute(data)));
  }
private CRC16()
  {
  }
private static final int[] crcLookupTable =
  {
  0x00000,0x01189,0x02312,0x0329B,0x04624,0x057AD,0x06536,0x074BF,
  0x08C48,0x09DC1,0x0AF5A,0x0BED3,0x0CA6C,0x0DBE5,0x0E97E,0x0F8F7,
  0x01081,0x00108,0x03393,0x0221A,0x056A5,0x0472C,0x075B7,0x0643E,
  0x09CC9,0x08D40,0x0BFDB,0x0AE52,0x0DAED,0x0CB64,0x0F9FF,0x0E876,
  0x02102,0x0308B,0x00210,0x01399,0x06726,0x076AF,0x04434,0x055BD,
  0x0AD4A,0x0BCC3,0x08E58,0x09FD1,0x0EB6E,0x0FAE7,0x0C87C,0x0D9F5,
  0x03183,0x0200A,0x01291,0x00318,0x077A7,0x0662E,0x054B5,0x0453C,
  0x0BDCB,0x0AC42,0x09ED9,0x08F50,0x0FBEF,0x0EA66,0x0D8FD,0x0C974,
  0x04204,0x0538D,0x06116,0x0709F,0x00420,0x015A9,0x02732,0x036BB,
  0x0CE4C,0x0DFC5,0x0ED5E,0x0FCD7,0x08868,0x099E1,0x0AB7A,0x0BAF3,
  0x05285,0x0430C,0x07197,0x0601E,0x014A1,0x00528,0x037B3,0x0263A,
  0x0DECD,0x0CF44,0x0FDDF,0x0EC56,0x098E9,0x08960,0x0BBFB,0x0AA72,
  0x06306,0x0728F,0x04014,0x0519D,0x02522,0x034AB,0x00630,0x017B9,
  0x0EF4E,0x0FEC7,0x0CC5C,0x0DDD5,0x0A96A,0x0B8E3,0x08A78,0x09BF1,
  0x07387,0x0620E,0x05095,0x0411C,0x035A3,0x0242A,0x016B1,0x00738,
  0x0FFCF,0x0EE46,0x0DCDD,0x0CD54,0x0B9EB,0x0A862,0x09AF9,0x08B70,
  0x08408,0x09581,0x0A71A,0x0B693,0x0C22C,0x0D3A5,0x0E13E,0x0F0B7,
  0x00840,0x019C9,0x02B52,0x03ADB,0x04E64,0x05FED,0x06D76,0x07CFF,
  0x09489,0x08500,0x0B79B,0x0A612,0x0D2AD,0x0C324,0x0F1BF,0x0E036,
  0x018C1,0x00948,0x03BD3,0x02A5A,0x05EE5,0x04F6C,0x07DF7,0x06C7E,
  0x0A50A,0x0B483,0x08618,0x09791,0x0E32E,0x0F2A7,0x0C03C,0x0D1B5,
  0x02942,0x038CB,0x00A50,0x01BD9,0x06F66,0x07EEF,0x04C74,0x05DFD,
  0x0B58B,0x0A402,0x09699,0x08710,0x0F3AF,0x0E226,0x0D0BD,0x0C134,
  0x039C3,0x0284A,0x01AD1,0x00B58,0x07FE7,0x06E6E,0x05CF5,0x04D7C,
  0x0C60C,0x0D785,0x0E51E,0x0F497,0x08028,0x091A1,0x0A33A,0x0B2B3,
  0x04A44,0x05BCD,0x06956,0x078DF,0x00C60,0x01DE9,0x02F72,0x03EFB,
  0x0D68D,0x0C704,0x0F59F,0x0E416,0x090A9,0x08120,0x0B3BB,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 = 0x0FFFF;
  for (int i = 0; i < data.length; i++ )
    {
    int lookup = crcLookupTable[(newCrc ^ data[i]) & 0xFF];
    newCrc = (newCrc >> 8) ^ lookup;
    }
  return(~newCrc);
  }
}
```

Algorithm 6: "Perl" Table Implementation

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

```
#!/usr/bin/perl

use strict;

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

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

   my $type = '80';
   my $length = '01';
   my $data = '05';

   my $packet = chr(hex $type) .chr(hex $length) .chr(hex $data);

   my $valid_crc = '5584' ;

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

   my $crc = 0xFFFF ;

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

   foreach my $char (split //, $packet)
     {
     # newCrc = (newCrc >> 8) ^ crcLookupTable[(newCrc ^ *bufptr++) & 0xff];
     # & is bitwise AND
     # ^ is bitwise XOR
     # >> bitwise shift right
```

```
      $crc = ($crc >> 8) ^ $CRC_LOOKUP[($crc ^ ord($char) ) & 0xFF] ;
      # print out the running crc at each byte
      printf("%x\n", $crc);
      }

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

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

Algorithm 7: For PIC18F8722 or PIC18F2685

This code was written by customer Virgil Stamps of ATOM Instrument Corporation for our XES635BK-xxx-KU module.

```
;CRC Algorithm for CrystalFontz XES635BK-xxx-KU display (DB535)
; This code written for PIC18F8722 or PIC18F2685
;
; Your main focus here should be the ComputeCRC2 and
; CRC16_ routines
;
;=====================================================================
ComputeCRC2:
      movlb       RAM8
      movwf       dsplyLPCNT          ;w has the byte count
nxt1_dsply:
      movf        POSTINC1            ;w
      call        CRC16
      decfsz      dsplyLPCNT
      goto        nxt1_dsply
      movlw       .0                  ;shift accumulator 16 more bits
      call        CRC16
      movlw       .0
      call        CRC16
      comf        dsplyCRC,F          ;invert result
      comf        dsplyCRC+1,F
      return
;=====================================================================
CRC16 movwf:
      dsplyCRCData                    ;w has the byte crc
      movlw       .8
      movwf       dsplyCRCCount
_cloop:
      bcf         STATUS,C            ; clear carry for CRC register shift
      rrcf        dsplyCRCData,f      ; perform shift of data into CRC
                                      ; register
      rrcf        dsplyCRC,F
      rrcf        dsplyCRC+1,F
      btfss       STATUS,C            ; skip jump if carry
      goto    _   notset              ; otherwise goto next bit
      movlw       0x84                ; XOR poly mask with CRC register
      xorwf       dsplyCRC,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         dsplyCRC           ; seed hi for CRC calculation
      movlw         0x21
      movwf         dsplyCRC+1         ; seed lo for CRC calculation
      LFSR          FSR1,TXBUF2        ; point at transmit buffer
      movlw         0x1F               ; command to send data to LCD
      movwf         TXBUF2             ; insert command byte from us to
                                       ; XES635-xxx-KU
      BMD1          movlw .2
      ddwf          SendCount,w        ; + overhead
      call          ComputeCRC2        ; compute CRC of transmit message
      movf          dsplyCRC+1,w
      movwf         POSTINC1           ; append CRC byte
      movf          dsplyCRC,w
      movwf         POSTINC1           ; append CRC byte
      return
;=============================================================================
```

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