LCD4041

User Manual

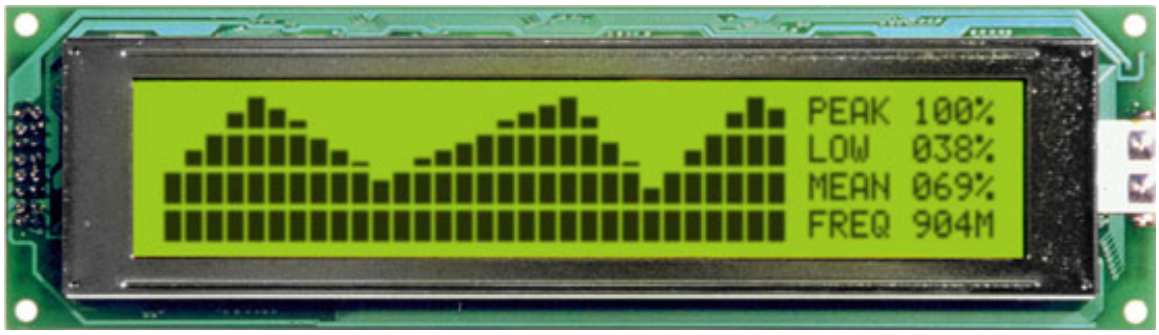


Table of Contents

1. Introduction

Your LCD4041 has the following features:

- 40 column by 4 line text display
- Built-in font with provision for up to 8 user-defined characters
- Speeds from 1200 bps to a lighting fast 19.2 Kbps over RS232
- Communicate over I²C or RS232 (with software controlled speed)
- Use up to 127 modules on the same 2-wire I²C interface
- Fully buffered so that no delays in transmission should be necessary
- Add your own Splash/Start-up screen
- Software controlled contrast
- Backlight with configurable time-out setting up to 180 minutes
- Seven general purpose outputs for a variety of applications
- Horizontal or Vertical bar graphs
- Variable power options, +5V or +7V to +35V
- Extended temperature option.

1.1 What it Does

The LCD4041 is designed as the display unit for an associated controller. The controller may be anything from a single board, special purpose microcontroller to a PC, depending on the application. This controller is responsible for what you see on the screen of the LCD4041.

The LCD4041 provides a simple command structure to allow text and bar graphs to be displayed on the screen. Text fonts are built in, and use standard ASCII mapping. Provision is made for up to 8 user-defined characters.

The screen is backlit for low-light situations. Backlighting may be turned on or off under program control. Contrast is adjustable to compensate for differing lighting conditions and viewing angles.

A General purpose output allows the controller to switch an electronic or electro-mechanical device by issuing commands to the display unit. This can be used for controlling LEDs, relays, etc.

1.2 What it Does Not Do

The LCD4041 does not include bitmap graphics capability, except that permitted by defining special characters. The LCD4041 does not have a keypad interface.

1.3 Setup for Testing

Before setting up your application you may want to try out the LCD4041. This is easily done with a PC. Here's what you'll need:

- A power cable with a 4 pin connector (same connector as used to connect 3.5 inch floppy drive). Do not connect the LCD4041 to an unmodified spare power connector in a PC.
- A power supply.
- A PC with a spare RS-232 port (COM1 or COM2).
- A 9 or 25 pin RS-232 serial cable. If you use a 25-conductor cable you'll also need a 9 to 25-pin adapter.

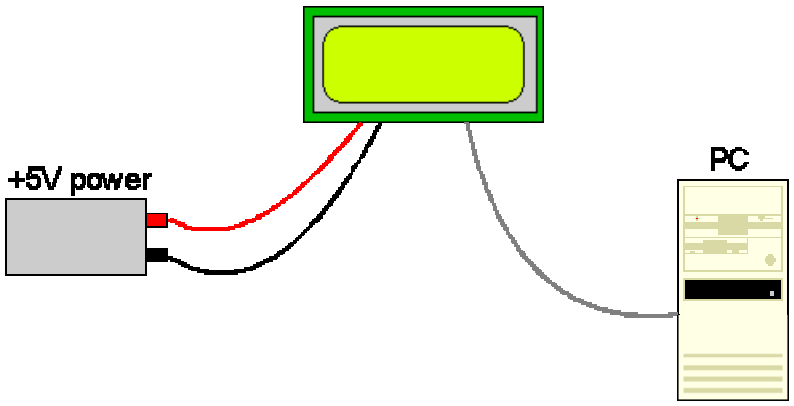


Figure 1-1 Connections for Testing

1. Refer to the diagram above and Figure 2-1 for the following steps.
2. Wire the connector to the power supply. On most connectors the RED lead will go to power and the BLACK lead to GND. **Note: The manufacturer's warranty is void if the unit is subjected to over-voltage or reversed polarity.**
3. Connect the LCD4041 to the PC using the serial cable and adapter if required. **Make sure the RS-232 cable includes the required ground lead. There must be no voltage differential between the RS-232 ground and the power supply ground.**
4. Connect the power connector, making sure that the power goes to V+ as shown in Figure 2-2. Turn on the power: the LCD backlight should come on.

Now you're ready to try it out.

1.4 Trying Out your LCD4041

The unit is connected to power and the PC and the backlight is on. You're ready to make sure it's working properly.

- To experiment with typing text, run a PC terminal program, such as Hyperterm. Make sure it's configured to use the correct port (please have hardware handshaking turned off). Set the baud rate to 19,200.

If you type characters on the keyboard, they should now appear on the LCD4041 screen. Text will wrap around to the next line when you reach the end of a line. A few common ASCII control characters work as follows:

Character	Hex value	Function
CR	0x0D	Moves cursor to beginning of the current line.
LF	0x0A	Moves cursor to the beginning of the next (or previous) line.
FF	0x0C	Clears the display and puts the cursor at the top left
BS	0x08	Moves the cursor one position to the left and clears that position.

Note: These command characters are not guaranteed to work on other Matrix Orbital display modules. If you want your code to be portable, use the appropriate commands listed later in the manual instead.

If you want to exercise some of the other features of the LCD4041 you'll need to write a program (in any convenient language such as Basic or C) to issue the required command strings. Most terminal programs are unable to issue the 0xFE character needed as a command prefix. You probably won't need to do this at the initial testing stage.

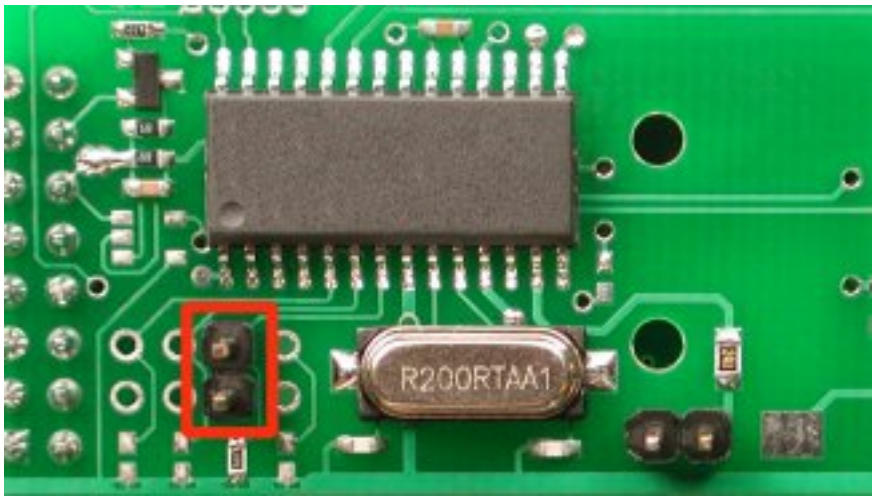
If you've reached this point and operation is normal, you can be confident that your LCD4041 works properly.

1.5 Manual Override

Manual override should only be required in one instance. If for some reason the module is set at a baud rate which cannot be produced by the host system and all communication to the display is lost, then the user should follow this simple procedure:

1. Turn off the display
2. Put a jumper on the indicated pins.
3. Power up the display. The baud rate is now set to 19,200.
4. Remove the jumper and change the RS-232 port settings to the desired baud rate.
5. Turn off the display.
6. Power up the display.

Refer to the “Set RS-232 Port Speed” command (section 5.1.10) for acceptable baud rates.



Manual Override Jumper

2. Connections

2.1 Connector Pinout

Refer to the diagram below for this chapter.

Figure 2-1 Electrical Connections

The LCD4041 has four connectors:

Connector	Function
2 pin header	General purpose output (see section 2.2)
4 pin	Power (Vdc) and I²C communications or RS232
DB-9F	RS-232/power (see section 2.1.1.1)

2.1.1 Power Connection

Power is applied via pins 1 and 4 as shown in Figure 2-1.

Power requirement is:

+5Vdc ±0.25V on standard voltage units,
+7Vdc to +30Vdc with Wide Voltage and Efficient Switching Power supply (-VPT).

Power may also be supplied via the RS-232 connector as described in the next section.

Warning:

- Do not apply any power with reversed polarization.
- Do not apply any voltage other than the specified voltage.
- Do not use any cables other than the cables supplied by Matrix Orbital, unless you are aware of the modifications required.
- Do not apply more then +5Vdc to pin #9 on the DB-9 connector.
- Do not apply power to the DB-9 connector AND the 4-pin power connector

Connector pinout is as follows:

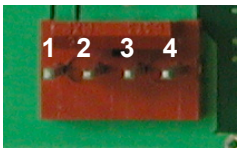


Figure 2-2 Power connector

Pin 1	Vdc
Pin 2	SCL (I²C clock)
Pin 3	SDA (I²C data)
Pin 4	Ground

2.1.1.1 Five Volt Modules

If the LCD4041 is used in a PC it is tempting to plug a spare power connector into the unit. **Don't do this!** Wiring for the PC power connector and that required for the LCD4041 are different as shown in Figure 2-3 below.

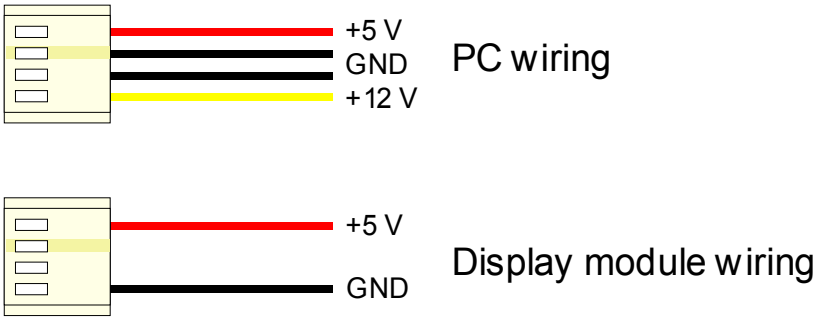


Figure 2-3 Power Connector wiring differences

If you don't want to modify cable wiring yourself, Matrix Orbital can supply an adapter cable designed to use with the LCD4041 when it's installed in a PC. The cable is wired as shown in Figure 2-4 below. Note that this cable does not provide connections for I²C.

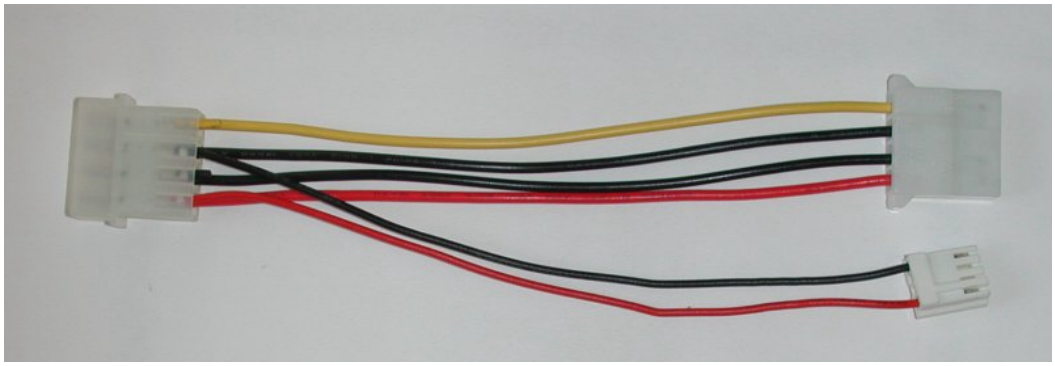


Figure 2-4 Five volt Power Cable

2.1.1.2 VPT

Note: Do not use this cable unless your display module has the "wide voltage range" option (option V). **Use of the 12 volt power cable with 5 volt modules will damage the module.**

The 12 volt power cable is designed for use with wide voltage range display modules mounted in a PC. Wiring required for the 12 volt power connector is shown in Figure 2-5 below.

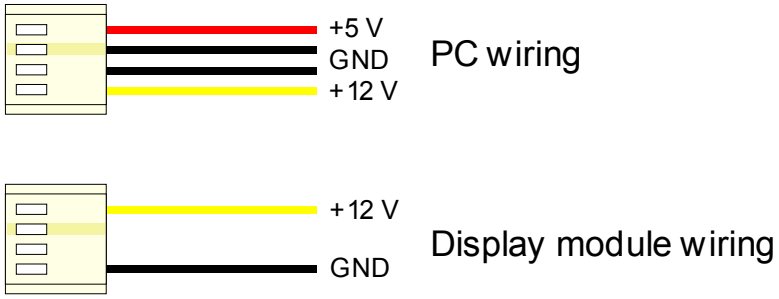


Figure 2-5 Wiring for 12 volt modules

If you don't want to modify cable wiring yourself, Matrix Orbital can supply an adapter cable designed to use with the display module when it's installed in a PC. The cable is wired as shown in Figure 2-6 below.

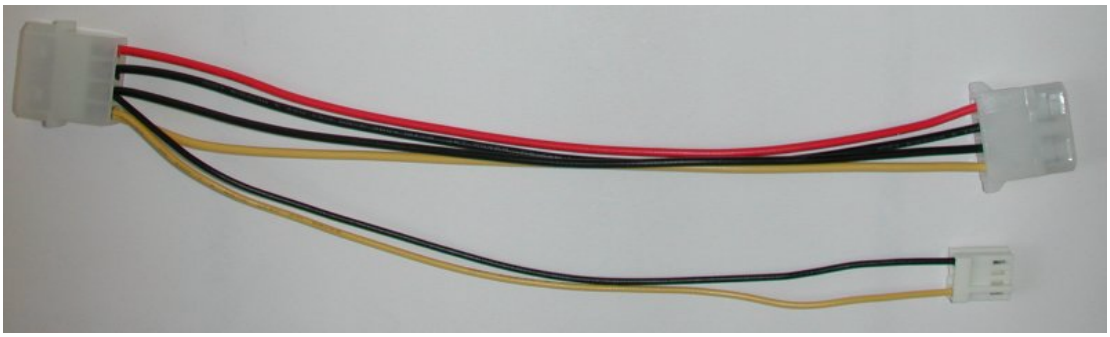
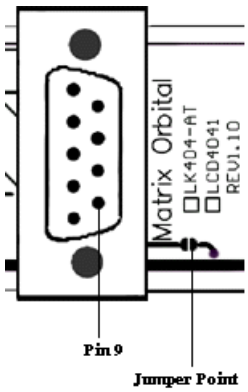


Figure 2-6 Twelve volt power cable

2.1.2 Power through the DB-9 Connector

The LCD4041 can be powered by pin #9 on the DB-9 connector. If power is applied here, power **cannot** be applied to the other power connector. The input voltage for pin #9 can only be +5Vdc (+/- 0.25V), even if the unit is wide voltage. Not following these instructions can destroy the unit.

To use the DB-9 connector for power you will have to solder a jumper as show in the bellow image.



2.1.3 RS-232 Communications

A standard DB-9F is provided for RS-232 communications. Power may also be supplied via this connector if desired. See Figure 2-7 for pin connections. As well, you can use the two middle pins of the power connector or serial communications. Please see the bottom of this topic.

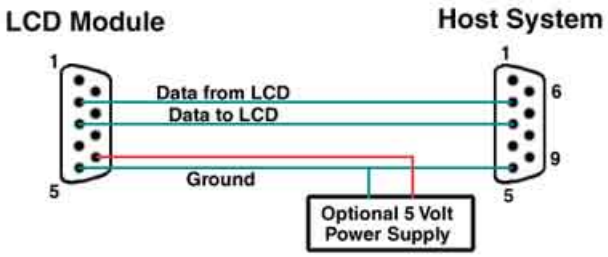


Figure 2-7 RS-232 and power connector

The RS-232 connector on the PC cable is wired so that a standard "straight through" 9 pin D-sub cable may be used to connect the modules to a standard serial port such as COM ports on PCs. Note that this device complies with the EIA232 standard in that it uses signal levels from +/-12V to +/- 12V. To use standard RS232 no modifications are required. The LCD4041 does not allow the use of TTL.

Pin Number	Direction	Description	LCD	Host
2	Data from LCD	Data out (LCD)	Tx	Rx
3	Data to LCD	Data in (LCD)	Rx	Tx
5	-	Ground	gnd	gnd

2.1.4 I²C Communications

The LCD4041 I²C communications runs at 100 kBps and supports up to 127 units on a single communications line. The I2C data line operates on 5 volt CMOS levels.

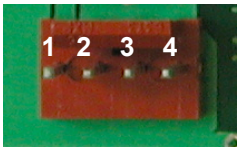


Figure 2-8 Power connector

Pin 1 Vdc
Pin 2 SCL (I²C clock)
Pin 3 SDA (I²C data)
Pin 4 Ground

The idea of ACK is to indicate when the data has been received correctly. ACK does not indicate data incorrectly received. ACK simply fails to indicate when data is correctly received. Clearly, this is of limited usefulness and even less so with Matrix Orbital modules. Matrix orbital modules are not capable of failing to acknowledge an incorrectly received byte in response to that bytes transition. They are only capable of failing to acknowledge the bytes following the byte, which was not received. To fully understand the

reasons for this one needs to understand something about how a Matrix Orbital module processes data. Basically the reason why a Matrix Orbital module might fail to receive a byte correctly is that it was unable to process the byte previous before the failed byte was transmitted. Because the module cannot possibly know that it would be unable to store the byte before the next byte was received it cannot know to not ACK. The reason for this situation in deference to situations you might be familiar with (i.e. memory chips, etc…) is that the Matrix Orbital module employs a microprocessor to perform these data storage functions. A memory chip takes care of these things entirely with in hardware subsystems that operate at the same speed as the transmission themselves.

The LCD4041 uses a standard Phillips 7bit address as defined by Phillips. How ever, we at Matrix Orbital specify I^2C address in 8bits. The 8^{th} bit, least significant bit (LSB or Low Order Bit) of the 8bit address is read/write bit. If we take a standard Phillips 7bit address of 45hex this would be in binary 1000101. This is 7bits. If one adds the read write bit to this 7bit address and you assume that you are writing one gets 10001010. Matrix Orbital would describe the Philips I^2C address of 45hex as 8Ahex. The read address would be 8Bhex.

For more information on Phillips I^2C please visit…
http://www.ping.be/~ping0751/i2cfaq/i2cindex.htm

2.2 General Purpose Output

The LCD4041 has a general purpose output which can be used to control relays or other electronic devices. This allows external devices to be turned on or off using your PC or controller and software commands. (See sections 5.1.6 and 5.1.7 for the command syntax.)

The output is wired as shown in Figure 2-9. The + terminal is connected to the module positive supply, the – terminal is connected through a 240 ohm current limiting resistor and the electronic switch to ground.

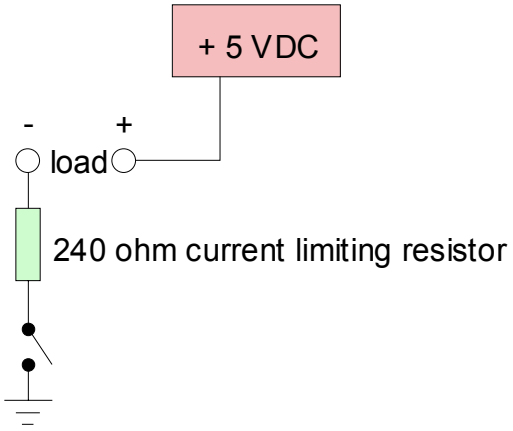


Figure 2-9 General Purpose Output

Maximum allowable current is 20 mA, which is enforced by the current limiting resistor. If the device being switched has a resistance of 240 ohms or more the corresponding resistor may be shorted

Note: The GPOs do not have any over current or over/under voltage protection so care must be taken when using them. For instance if the external device is a relay it must be fully clamped (using a diode and capacitor) to absorb any generated back electro-motive force (EMF).

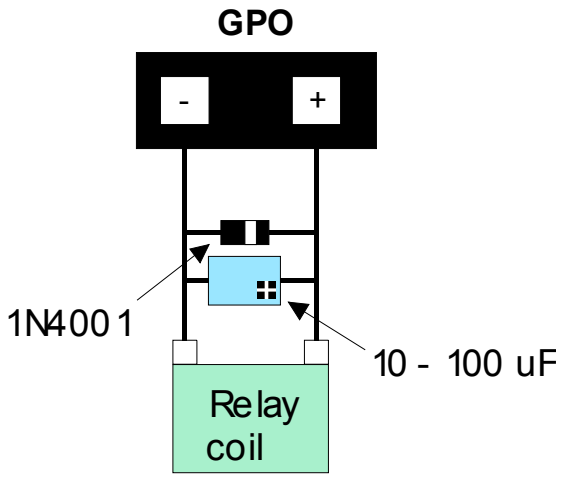


Figure 2-10 Clamping a Relay

3. Displaying Text

This chapter describes the various text-display commands in detail. A quick reference summary of all text commands is found in section 6.4.

3.1 General

Text is displayed on the LCD4041 using the built-in 5 x 7 dot matrix font (plus up to 8 user-defined characters.

3.2 The Built-In Character Font

The LCD4041 includes a built-in 5 x 7 dot matrix font with the full range of ASCII characters plus a variety of extended characters, as shown in Figure 3-1.

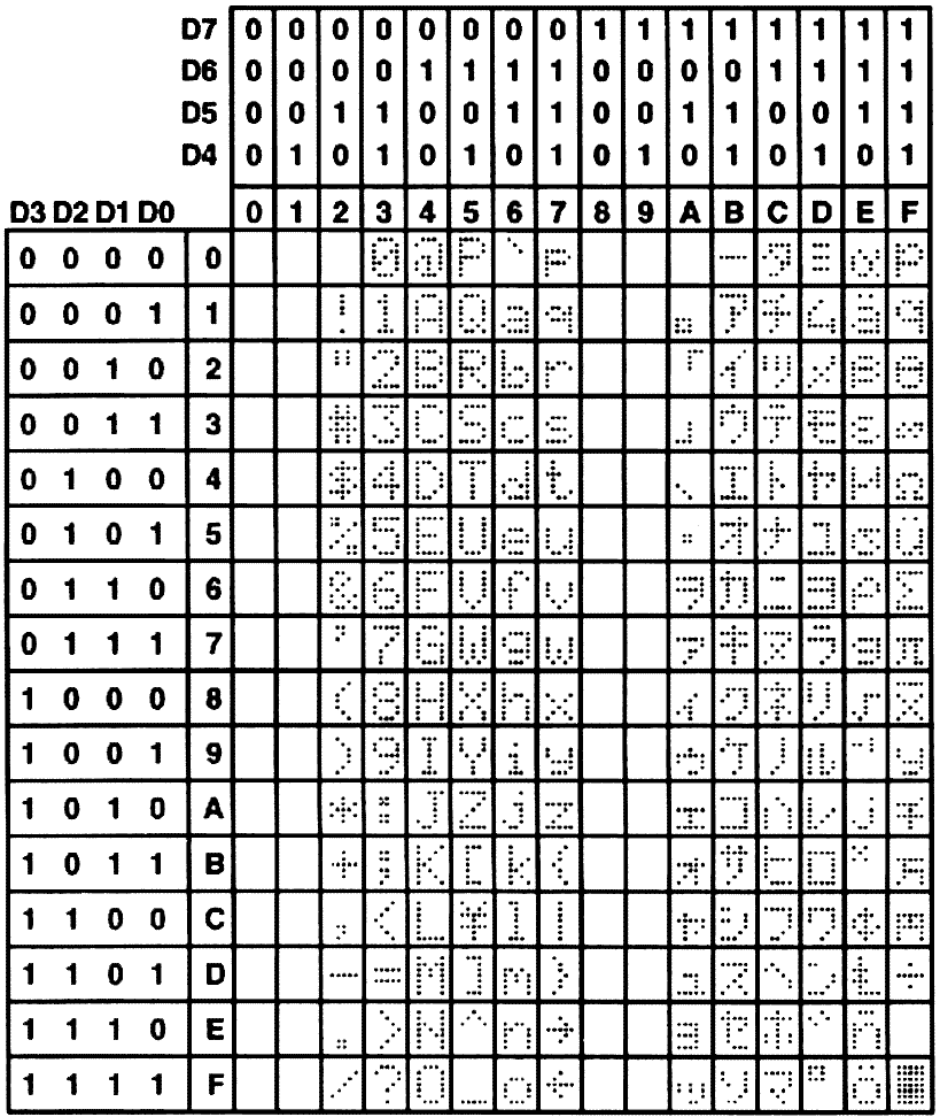


Figure 3-1 Character Set

In addition to the built-in characters, users may define up to 8 special characters (which, once defined, occupy positions 0x00 to 0x07 in the above chart). The LCD4041 does not have provision to download other fonts.

3.3 Writing Text to the Display

When the display receives a character, it displays that character at the position currently defined. The next character sent to the module then advances to the following position on the display. Characters are drawn using the built-in font, and only characters defined in the font are actually displayed. Characters that are not defined by the built-in font print as a space (i.e. the cursor is advanced for the next character).

The position where text is to be inserted is a character location stored in the LCD4041's volatile memory and maintained internally by the LCD4041's firmware. This position is manipulated by the commands shown in the following section.

3.4 Text Commands

In this section commands are identified by their names and decimal values. Hex and ASCII equivalents are given in the summary (Table 6-1). **Before issuing commands to the LCD4041 please read sections 6.2 and 6.3.**

3.4.1 Auto scroll on (254 81)

When auto scrolling is on, it causes the LCD4041 to shift the entire display's contents up to make room for a new line of text when the text reaches the scroll position (the bottom right character position).

3.4.2 Auto scroll off (254 82)

When auto scrolling is disabled, text will wrap to the top left corner of the display area. Existing text in the display area is not erased before new text is placed. A series of "spaces" followed by a Cursor Home command may be used to erase the top line of text.

3.4.3 Set cursor position (254 71 [column] [row])

This command sets the cursor position (text insertion point) to the [column] and [row] specified. Columns have values from 1 to 20 (0x01 to 0x14) and rows have values of 1 and 2 (0x01 and 0x02).

3.4.4 Send cursor home (254 72)

This command moves the cursor position (text insertion point) to the top left of the display area.

3.4.5 Turn on underline cursor (254 74)

Turns on the underline cursor. The cursor shows the current text insertion point. Both underline and blinking cursors may be turned on or off independently. The cursor is off by default.

3.4.6 Turn off underline cursor (254 75)

Turns off the underline cursor. Does not affect the blinking block cursor.

3.4.7 Turn on block (blinking) cursor (254 83)

Turns on the blinking block cursor. The cursor shows the current text insertion point. Both blinking and underline cursors may be turned on or off independently. The cursor is off by default.

3.4.8 Turn off block (blinking) cursor (254 84)

Turns off the blinking block cursor. Does not affect the underline cursor.

3.4.9 Cursor left (254 76)

Moves the cursor one position to the left but does not erase any character that may be in that position. Note that this command moves the text insertion point even if the cursor is turned off.

Note: A "destructive backspace", which erases the character to the left of the original position, may be done by issuing the following sequence: cursor left, space, cursor left.

3.4.10 Cursor right (254 77)

Moves the cursor one position to the right but does not erase any character that may be in that position. Note that this command moves the text insertion point even if the cursor is turned off.

4. Bar Graphs and Special Characters

The LCD4041 includes the ability to draw bar graphs (either horizontal or vertical) and allows users to define up to eight special characters. **Before issuing commands to the LCD4041 please read sections 6.2 and 6.3.**

Eight characters (ASCII values 0x00 to 0x07) are set aside for use with bar graphs, user defined characters, and big numbers. Since the same 8 characters are used for each function, the functions may not be used simultaneously. The characters may be defined or redefined at any time by issuing the commands shown in this section. Once defined, they may be used either by means of the bar graph commands, or by simply issuing one of the ASCII values 0x00 to 0x07 (which is not prefixed by the command byte, 254).

4.1 Command List

4.1.1 Initialize wide vertical bar graph (254 118)

This command defines the 8 special/user characters to be blocks suitable for use in drawing wide (5 pixel) vertical bar graphs. Any previously existing definitions will be lost. Once this command has been issued, any number of vertical bar graphs may be drawn unless the characters are redefined by another command.

4.1.2 Initialize narrow vertical bar graph (154 115)

This command defines the 8 special/user characters to be blocks suitable for use in drawing narrow (2 pixel) vertical bar graphs. Any previously existing definitions will be lost. Once this command has been issued, any number of vertical bar graphs may be drawn unless the characters are redefined by another command.

4.1.3 Draw vertical bar graph (254 61 [column] [height])

Draws a vertical bar graph in [column] having a height of [height] pixels. The height may range from 0 to 20 (0x00 to 0x14) pixels. The necessary characters must first be initialized by either of the commands shown in section 4.1.1 or 4.1.2, which will determine the width of the graph drawn. Graph may be erased by drawing a bar graph of height = 0 in the same column.

4.1.4 Initialize horizontal bar graph (254 104)

This command defines the 8 special/user characters to be blocks suitable for use in drawing horizontal bar graphs. Any previously existing definitions will be lost. Once this command has been issued, any number of horizontal bar graphs may be drawn unless the characters are redefined by another command.

4.1.5 Draw horizontal bar graph (254 124 [column] [row] [dir] [length])

Draws a horizontal bar graph in [row] starting at [column] with a length of [length] pixels. [row] may have a value of 0x01 or 0x02, column may range from 0x01 to 0x14 and length may be from 0x00 to 0x64 (0 to 100) if the graph can extend the full width of the screen. Each column is 5 pixels wide (spaces between the columns don't count).

[dir] specifies the direction: 0x00 goes from left to right, 0x01 goes from right to left.

4.1.6 Define custom character (254 78 [c] [8 bytes])

The LCD4041 allows up to 8 user defined (custom) characters. These characters occupy the first 8 (0x00 to 0x07) places in the character set (see Figure 3-1).

Custom characters occupy a 5 x 8 pixel matrix. Built-in characters are 5 x 7: the bottom row of pixels is normally reserved for the underline cursor. The underline cursor should be turned off if the bottom row of pixels forms part of a custom character.

The characters are defined by issuing the command 254 78 [c] followed by 8 bytes to define the character. [c] is the character number (0x00 to 0x07). The 8 bytes are mapped as shown below:

MSB							**LSB**	
*	*	*	1	2	3	4	5	Data Byte 1
*	*	*	6	7	8	9	10	Data Byte 2
*	*	*	11	12	13	14	15	Data Byte 3
*	*	*	16	17	18	19	20	Data Byte 4
*	*	*	21	22	23	24	25	Data Byte 5
*	*	*	26	27	28	29	30	Data Byte 6
*	*	*	31	32	33	34	35	Data Byte 7
*	*	*	36	37	38	39	40	Data Byte 8

A "1" bit indicates an on (black) pixel, a "0" bit indicates an off (clear) pixel.

Once defined, a character is displayed simply by issuing a value (0x00 to 0x07) corresponding to the character number. The character will be laid out as follows:

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35
36	37	38	39	40
Cursor Line				

Note: Custom characters will be erased if any of the "initialize bar graph" commands are issued.

4.1.7 Initialize large digits (254 110)

This command defines the 8 special/user characters to be blocks suitable for use in drawing large digits. Any previously existing definitions will be lost. Once this command has been issued, any number of large characters may be placed until the characters are redefined by another command.

4.1.8 Place large digit (254 35 [col] [digit])

This command allows the large digits to be drawn on the LCD screen. Numbers of almost full display height may be placed along side regular text on four row displays. The column number has a maximum value which is less than the display width because the digits are all three columns wide.

Before using this command the Initialize Large Digits command must be issued to define the blocks necessary to make up the digits. If regular text and large digits are mixed on one screen, the user should always set the display cursor position before placing regular text because the creation of a large digit will leave the cursor position to the bottom right of the large digit and not at the last regular text write position.

[col] can have values from 0x01 to 0x12 (1 to 18). [digit] has values from 0x00 to 0x09 (0 to 9).

5. Miscellaneous Commands

The commands listed in this chapter don't readily fit in any of the other categories, or are used in more than one category. **Before issuing commands to the LCD4041 please read sections 6.2 and 6.3.**

5.1 Command List

5.1.1 Clear display (254 88)

This command clears the display and resets the text insertion point to the top left of the screen.

5.1.2 Set contrast (254 80 [contrast])

This command sets the display's contrast to [contrast], where [contrast] is a value between 0x00 and 0xFF (between 0 and 255). Lower values cause "on" elements in the display area to appear lighter, while higher values cause "on" elements to appear darker.

Lighting conditions will affect the actual value used for optimal viewing. Individual LCD4041 modules will also differ slightly from each other in appearance. In addition, values for optimal viewing while the LCD4041 backlight is on may differ from values used when backlight is off.

5.1.3 Backlight on (254 66 [minutes])

This command turns on the backlight for a time of [minutes] minutes. If [minutes] is zero (0), the backlight will remain on indefinitely. Note: the factory default for backlight is on.

5.1.4 Backlight off (254 70)

This command turns the backlight of the LCD4041 off.

5.1.5 Load startup screen (254 64 [80 characters])

This command sets and memorizes the startup screen that will appear each time the LCD4041 is turned on. By default the screen shows:

```
Matrix Orbital
LCD4041
```

The 80 characters define the two 40 character rows of the screen. They may be any characters from the character set shown in Figure 3-1.

```
Character 1 ---------- Character 40
Character 41 ---------- Character 80
Character 81 ---------- Character 120
Character 121 ---------- Character 160
```

5.1.6 General purpose output off (254 86)

This command turns OFF any of the General Purpose Outputs (see section 2.2 for a description of the GPOs). Note that OFF means that the output floats.

5.1.7 General purpose output on (254 87)

This command turns ON any of the General Purpose Outputs.

5.1.8 Set I²C address 254 51 [address])

This command sets the I²C write address of the module. This value must be an even number and the read address is one higher. For example if the I²C write address is set to 0x50, then the read address is 0x51. The change in address is immediate. This address is 0x50 by default, and is reset temporarily back to that value when the "Manual Over-ride" jumper is used on power up.

5.1.9 Read module type (254 55)

This command will return, over the RS-232 interface, the model type value of the module. This command will return a 1-byte hex value. Values for various modules at the time of this publication are as follows:

LCD0821 - 0x01	LCD2021 - 0x03	LCD1641 - 0x04
LCD2041 - 0x05	LCD4021 - 0x06	**LCD4041 - 0x07**
LK202-25 - 0x08	LK204-25 - 0x09	LK404-55 - 0x0A
VFD2021 - 0x0B	VFD2041 - 0x0C	VFD4021 - 0x0D
VK202-25 - 0x0E	VK204-25 - 0x0F	GLC12232 - 0x10
GLC12864 - 0x11	GLC128128 - 0x12	GLC24064 - 0x13
GLK12864-25 - 0x14	GLK24064-25 - 0x15	GLK128128-25 - 0x21
GLK12232-25 - 0x22	LK404-AT - 0x31	VFD1621 - 0x32
LK402-12 - 0x33	LK162-12 - 0x34	LK204-25PC - 0x35

5.1.10 Set RS232 port speed (254 57 [speed])

This command sets the RS232 port to the specified [speed]. The change takes place immediately. [speed] is a single byte specifying the desired port speed. Valid speeds are shown in the table below. The speed can be manually reset to 19,200 baud in the event of an error during transmission (including transmitting a value not listed below) by setting the "manual override" jumper on the module during power up (see section)This command is ignored until this jumper is removed again.

Speed Value	Speed
FF Hex	1200 baud
81 Hex	2400 baud
20 Hex	9600 baud
0F Hex	**19200 baud**

5.1.11 Set Serial Number (254 52 [byte1] [byte2]

Modules may be delivered with the serial number blank. In this case the user may set the desired two-byte serial number using this **one time only** command.

Upon the execution of this command, the module will echo these two bytes back over the RS-232 interface. The serial number may be set only once. Any future attempt to execute this command will result in no change and the module will return to the originally set serial number.

5.1.12 Read Serial Number (254 53)

This command will return, over the RS-232 interface, the serial number of the module as it was previously stored. This will return a two-byte value.

5.1.13 Read Version Number 254 54)

This command will return the firmware version number of the LCD4041. This will return a one-byte value.

5.2 Flow Control

The LCD4041 has built-in flow control which may be useful when long strings of text are downloaded to the display. Flow control is enabled or disabled by two commands (see Table 6-3 and the next two sections). If flow control is enabled, the LCD4041 will return an "almost full" message (0xFE) to the controller when its internal buffer fills to a defined level, and an "almost empty" message (0xFF) when the buffer contents drop to a defined level.

5.2.1 Enter Flow Control Mode (254 58 [full][empty])

Note: Flow control applies only to the RS-232 interface. It is not available for I²C .

This command enables flow control. When the buffer fills so that only [full] bytes are available the LCD4041 will return an "almost full" message (0xFE) to the controller. When the buffer empties so that only [empty] bytes remain the LCD4041 will return an "almost empty" message (0xFF) to the controller.

The LCD4041 will return the "almost full" message for every byte sent to the LCD4041 until the used buffer space once more drops below the [full] level.

Whether the user is in 'Flow Control Mode' or not, the module will ignore display or command bytes which would overrun the buffer. While in 'Flow Control Mode' the unit will return 0xFE when buffer is almost full even though it may have already thrown rejected data away. The buffer size for the LCD4041 is 80 bytes.

When using this command in an application, selection of the value for the buffer almost full should be considered very carefully. This is a critical aspect of using this command to it's full potential. When using a host system or PC which contains a FIFO, the user should set the value of [full] equal to or greater than the size of the FIFO. The reason for this is that the FIFO may be full when the host system receives 0xFE. In the case of 16550 UART the size at its maximum is 16, therefore the value of should be set to 16 or greater.

5.2.2 Exit Flow Control Mode (254 59)

This command turns off flow control. Bytes may overflow the buffer without warning.

6. Appendix: Command Summary

6.1 General

The operation of the LCD4041 is controlled by a simple and consistent command set. Commands control

- text display
- miscellaneous operating parameters

This chapter includes summary tables of all commands. Individual commands are discussed in detail in Chapters 3 to 5 in the same sequence as in the following tables.

6.2 Issuing Commands

Commands are issued to the LCD4041 by the controller. In a test setup, commands can be issued to the LCD4041 by means of a BASIC program, using the chr$( ) function. In the tables below, we've shown commands in hex, ASCII and decimal form. All commands begin with the prefix character 0xFE (254 decimal). These commands are issued on the serial communications link (I²C or RS-232) at the currently defined baud rate.

For example (using BASIC in a test setup), you could issue the command to clear the screen on the

LCD4041 by including the line:

```
PRINT#1,chr$(254);chr$(88)
```

in your BASIC program.

Or with C you could (using Zcomm serial library)

```
ZComm1->WriteCommByte(0xfe);
ZComm1->WriteCommByte('X');
```

6.3 On Numbers

Like all computerized devices, the LCD4041 operates with commands and values in the form of binary numbers. These binary numbers are arranged in 8 digit (i.e. 8 bit) groups called bytes. The decimal value of a byte may have any value from 0 to 255.

Bytes are usually specified in either decimal or hexadecimal (base 16) form for convenience, since binary numbers are confusing to deal with directly. Hexadecimal (hex) numbers are particularly convenient because exactly two hexadecimal digits make up one byte, each hex digit representing 4 binary digits (4 bits) as shown here:

Binary	Hex	Decimal	Binary	Hex	Decimal
0000	0	0	1000	8	8
0001	1	1	1001	9	9
0010	2	2	1010	A	10
0011	3	3	1011	B	11
0100	4	4	1100	C	12
0101	5	5	1101	D	13
0110	6	6	1110	E	14

0111	7	7	1111	F	15

Based on the table, the byte 01001011 can be represented in hex as 4B, which is usually written as any of 4Bh, 4BH, 4B hex or 0x4B.

The numbers can also be expressed in decimal form if preferred.

6.3.1 ASCII Characters

Since computers deal internally with numbers only, but externally with both letters and numbers, several schemes were developed to "map" written characters to numeric values. One such scheme has become universal, the American Standard Code for Information Interchange, or ASCII. ASCII tables are readily available from a number of sources. A few examples will do here:

The letter	A	has a value of	65 decimal or	41 hex
The letter	a	has a value of	97 decimal or	61 hex
The number	0	has a value of	48 decimal or	30 hex
The number	9	has a value of	57 decimal or	39 hex

This gives rise to the possibility of confusion when parameters are being set on the LCD4041 For example, the GPO ON and OFF commands use a number to indicate which GPO is being controlled. We're told that acceptable values are 0 to 6. **All such parameters must use numeric values (i.e. the actual byte values).** If we send the ASCII number 0 by mistake it will actually give the value 48 decimal (30 hex) to the parameter, which is wrong.

In the tables given in the following sections ASCII characters are shown as 'A', with single quotes.

6.4 Text Commands

See Chapter 3 for command descriptions. Syntax in the tables below is given in hex, decimal and decimal with ASCII, in that order, one per line.

Table 6-1 Text Commands

Command	Syntax	Default	Notes
Auto scroll on	FE 51 254 81 254 'Q'	off	Enables scroll at bottom of screen. Text will push display up one line to make room for new line.
Auto scroll off	FE 52 254 82 254 'R'	off	Disables auto scroll. Text will wrap to top left and overwrite existing text.
Set cursor position	FE 47 [col] [row] 254 71 [col] [row] 254 'G' [col] [row]	n/a	Moves cursor to the specified column and row. **The cursor marks the text insertion point in this and all commands.**
Send cursor home	FE 48 254 72 254 'H'		This command moves the cursor to the top left of the display area.

Underline cursor on	FE 4A 254 74 254 'J'	off	Turns on the underline cursor.
Underline cursor off	FE 4B 254 75 254 'K'		Turns off the underline cursor.
Block cursor on	FE 53 254 83 254 'S'	on	Turns on the blinking block cursor.
Block cursor off	FE 54 254 84 254 'T'		Turns off the blinking block cursor.
Cursor left	FE 4C 254 76 254 'L'		Moves the cursor one position to the left. If the cursor is already at the beginning of a line it will move to the end of the other line.
Cursor right	FE 4D 254 77 254 'M'		Moves the cursor one position to the right. If the cursor is already at the end of a line it will move to the beginning of the other line.

6.5 Bar Graphs and Special Characters

The commands in this section are used to define and display bar graphs and special characters.

Table 6-2 Bar Graph and Special Character Commands

Command	**Syntax**	**Notes**
Initialize thick vertical bar graph	FE 76 254 118 254 'v'	Initializes the user character set to make wide vertical bar graphs.
Initialize thin vertical bar graph	FE 73 254 115 254 's'	Initializes the user character set to make narrow vertical bar graphs.
Initialize horizontal bar graph	FE 68 254 104 254 'h'	Initializes the user character set to make horizontal bar graphs.
Define custom character	FE 4E [c][8 bytes] 254 78 [c][8 bytes] 254 'N' [c][8 bytes]	Defines one of 8 custom "user" characters. Character number is [c] between 0x00 and 0x07. The 8 bytes are described in section 4.1.6.
Draw vertical bar graph	FE 3D [col][length] 254 61 [col][length] 254 '=' [col][length]	Draws a vertical bar graph at column [col] of length [length]. Length is measured in pixels (0x00 to 0x14). User must first use the 'v' or 's' command to initialize characters.
Draw horizontal bar graph	FE 7C [c][r][d][length] 254 124 [c][r][d][length] 254 '|' [c][r][d][length]	Draws a horizontal bar graph starting at column [c] on row [r] with direction [d] (0 is right, 1 is left) of length [length]. Length is measured in pixels (0x00 to 0x64 if starting in column 1). User must first use the 'h' command to initialize characters.
Initialize large digits	FE 6E 254 110 254 'n'	Initializes the user character set to make large digits.

Place large digits	FE 23 [col] [digit] 254 35 [col] [digit] 254 '#' [col] [digit]	Place large digit number [digit] in column [col] of the display. Cursor moves to bottom right of large digit. [digit] is 0x00 to 0x09, [col] is 0x01 to 0x12 (i.e. 1 to 18 decimal).

6.6 Miscellaneous Commands

Table 6-3 Miscellaneous Commands

Command	Syntax	Default	Notes
Clear display	FE 58 254 88 254 'X'	n/a	Clears screen of text and graphics, places text cursor at top left.
Set contrast	FE 50 [contrast] 254 80 [contrast] 254 'P' [contrast]	0x80 128	Sets display contrast. Compensates for viewing angle. Contrast is a value between 0 and 255 (hex 0 to FF). Larger = darker.
Backlight on	FE 42 [minutes] 254 66 [minutes] 254 'B' [minutes]	on	Backlight will stay on for [minutes]. If [minutes] = 0 backlight will stay on permanently.
Backlight off	FE 46 254 70 254 'F'	on	Turns off backlight.
Load startup screen	FE 40 [80 char] 254 64 [80 char] 254 '@' [80 char]	Matrix Orbital LCD4041	Loads new startup screen (80 characters). Screen is remembered for subsequent power ups.
General purpose output off	FE 56 254 86 254 'V'	off	Turns the general purpose output OFF.
General purpose output on	FE 57 254 87 254 'W'	off	Turns a general purpose output ON.
Set I²C address	FE 33 [address] 254 51 [address] 254 '3' [address]	0x50	Value is write address and must be even, read address is 1 higher.
Set RS232 port speed	FE 39 [speed] 254 57 [speed] 254 '9' [speed]	19,200 baud	Sets RS232 speed. See table in section 5.1.10 for values of [speed]
Set Serial Number	FE 34 [byte1][byte2] 254 52 [byte1][byte2] 254 '4' [byte1][byte2]		This is a one-time-use command which works only on units without factory set serial numbers.

Read Serial Number	FE 35 254 53 254 '5'		Reads the two-byte serial number of the module.
Read Version Number	FE 36 254 54 254 '6'		Reads the firmware version number of the module. Returns a 1-byte value.
Read module type	FE 37 254 55 254 '7'	see table	Reads the module type. See table in section 5.1.9. Returns a 1-byte value.
Enter flow control mode	FE 3A [full] [empty] 254 58 [full] [empty] 254 ':' [full] [empty]	off	Sets "full" and "empty" marks for the 80-byte display buffer. When buffer reaches [full] display will return 0xFE to host. When buffer reaches [empty] display will return 0xFF.
Exit flow control mode	FE 3B 254 59 254 ';'		Turns off flow control.

7. Appendix: Specifications and Options

7.1 Specifications

Environmental Specifications		
	Standard Temperature	Extended Temperature
Operating Temperature	0°C to +50°C	-20°C to +70°C
Storage Temperature	-20°C to +70°C	-40°C to +85°C
Operating Relative Humidity	90% max non-condensing	90% max non-condensing

Electrical Specifications	
Supply Voltage	4.75 - 5.25 Vdc (optional 7 – 35 Vdc)
Supply Current	10 mA typical
Supply Backlight Current	115 mA typical

Optical Characteristics	
Number of Characters	160 (40 characters by 4 lines)
Matrix format	5 x 7 with underline
Display Area	155.1 x 16.5 mm XxY
Character Size	3.20 x 5.55 mm (XxY), not including underline
Character Pitch	3.7 mm
Line pitch	5.95 mm
Dot Size	0.60 x 0.65 mm (XxY)
Dot Pitch	0.65 x 0.70 mm (XxY)
LED Backlight Life	100,000 hours typical
Color of Illumination	Yellow Green

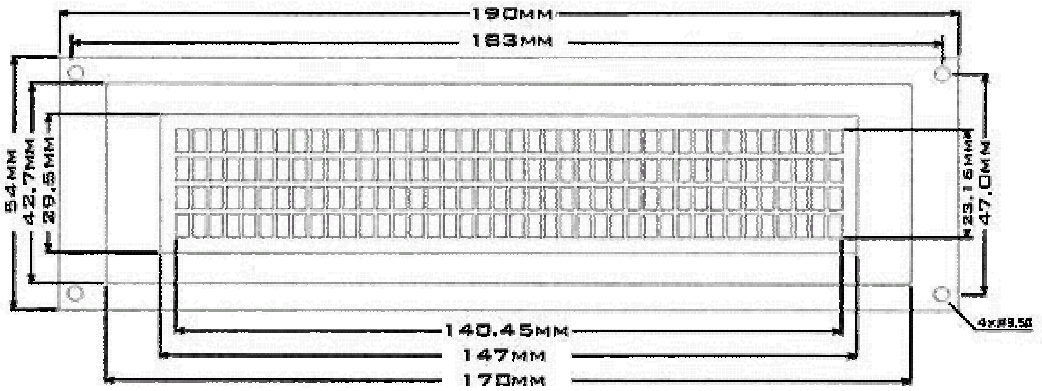


Figure 7-1 Physical Layout

7.2 Options

Options Available on LCD4041	
Extended Temperature	E
Wide Voltage with Efficient Switching Power Supply	VPT

8. Appendix: Glossary

ASCII	American Standard Code for Information Interchange. A 7 bit binary code representing the english alphabet, decimal numbers and common punctuation marks. "Also includes control characters" such as carriage return or end of text. An 8 bit superset of the standard ASCII codes is often used today to include foreign characters and other symbols. These supersets are often called extended ASCII character sets.
Backlight	A backlit display is illuminated from behind to provide nighttime and improved daytime readability.
Baud Rate	The (data and signaling) bit transmission rate of an RS232 device.
Binary Number	A number written using binary notation which only uses zeros and ones
Bit	The smallest unit of information a computer can work with. Each bit is either 0 or 1. Binary digit.
Bitmap	A representation, consisting of rows and columns of dots, of a graphics image in computer memory. The value of each dot (whether it is filled in or not) is stored in one or more bits of data.
Byte	A grouping of eight binary bits
CCFL	Cold Cathode Fluorescent Lamp. A high brightness backlighting source consists of a fluorescent tube powered by a high voltage A.C. source.
Configuration	The way a system is set up, or the assortment of components that make up the system. Configuration can refer to either hardware or software, or the combination of both.
Contrast	The ratio of luminance between the light state of the display to the dark state of the display.
Controller	The microcontroller or PC used to control the Matrix Orbital display unit.
DB-9	The designation of a connector used in the RS232 interface: 9 pin connector
Firmware	Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. ROMs, PROMs and EPROMs and flash EEPROMs that have data or programs recorded on them are firmware.
Font	A design for a set of characters. A font is the combination of typeface and other qualities, such as size, pitch, and spacing.
Font Metric	A definition of where font is to be placed, such as margins and spacing between characters and lines.
Hexadecimal	Refers to the base-16 number system, which consists of 16 unique symbols: the numbers 0 to 9 and the letters A to F. For example, the decimal number 15 is represented as F in the hexadecimal numbering system. The hexadecimal system is useful because it can represent every byte (8 bits) as two consecutive hexadecimal digits. It is easier for humans to read hexadecimal numbers than binary numbers.
I²C	Short for Inter-IC, a type of bus designed by Philips Semiconductors in the early 1980s, which is used to connect integrated circuits (ICs). I²C is a multi-master bus, which means that multiple chips can be connected to the same bus and each one can act as a master by initiating a data transfer.
Interface	A means by which two systems interact.

LCD	Liquid Crystal Display
Module Type Value	This refers to the model number of the module.
Pixel	The smallest individually controllable element of a display.
Pre-Generated Fonts	Pre-determined fonts which can be downloaded into graphic liquid crystal displays.
Primitive	A low-level object or operation from which higher-level, more complex objects and operations can be constructed. In graphics, primitives are basic elements, such as lines, curves, and polygons, which you can combine to create more complex graphical images
RS-232	Short for recommended standard-232C, a standard interface approved by the Electronic Industries Association (EIA) for connecting serial devices.
Scroll	To view consecutive lines of data on the display screen. The term scroll means that once the screen is full, each new line appears at the bottom edge of the screen and all other lines move up one position.
Serial Number	A number that is one of a series and is used for identification of the module
Serial Port	A port, or interface, that can be used for serial communication, in which only 1 bit is transmitted at a time.
Version Number	This refers to the firmware revision number of the module.
Volatile Memory	Temporary memory. Once the power supply is turned off volatile memory is then erased.