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# LK402-25

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Including LK402-25-422 and LK402-25-USB

## Technical Manual

Revision 1.3

**PCB Revision: 3.0 or Higher**

**Firmware Revision: 7.0 or Higher**

## Revision History

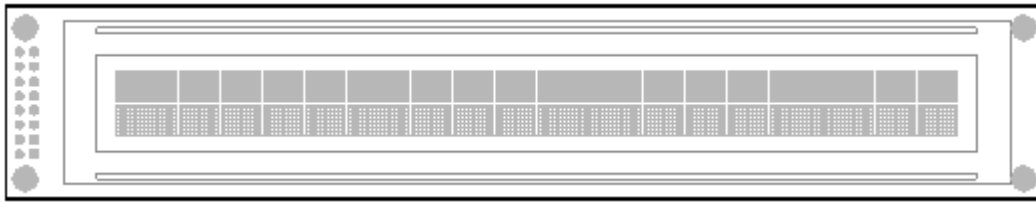
Revision	Description	Author
1.3	Added Power Directions for the RS422 Model	Clark
1.2	Added Command Summary Addition	Clark
1.1	Grammatical and Ease of Reading Enhancements	Clark
1.0	Initial Release	Clark

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## Introduction



*Figure 1: LK402-25 Display*

The LK402-25 is an intelligent alphanumeric liquid crystal display designed to decrease development time by providing an instant solution to any project. In addition to the RS232, TTL and I<sup>2</sup>C protocols available in the standard model, USB and RS422 communication models allow the LK402-25 to be connected to a wide variety of host controllers. Communication speeds of up to 115.2kbps for serial protocols and 100kbps for I<sup>2</sup>C ensure lightning fast data display.

The simple command structure provided permits easy software control of many settings including backlight brightness, screen contrast, and baud rate. On board memory provides up to thirty-two custom characters which can be saved and recalled for start screens, bar graphs or larger numbers.

User input is available through a five by five matrix style keypad, and six general purpose outputs provide simple switchable five volt sources. In addition, a Dallas One-Wire header provides a convenient communication interface for up to thirty-two devices.

The versatile LK402-25, with all the features mentioned above, is available in a variety of colour, voltage, and temperature options to suit almost any application.

# Quick Connect Guide

## Standard Module

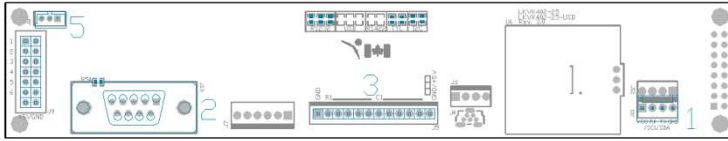


Figure 2: Standard Connections

Table 1: Standard Headers

#	Header	Mate
1	Communication/ Power	SCCPC5V/ BBC
2	DB9	CSS1FT/CSS4FT
3	Keypad	KPP4x4
4	GPO	None Offered
5	Dallas One-Wire	Temperature Probe

The standard version of the LK402-25 allows for user configuration of three common communication protocols. First, the unit can communicate using serial protocol at either RS232 or TTL voltage levels. Second, it can communicate using the Inter-Integrated Circuit, or I<sup>2</sup>C protocol. Connections for each protocol can be accessed through the four pin Communication/Power Header as outlined in the Serial Connections and I<sup>2</sup>C Connections sections below.

### Recommended Parts



Figure 3: Communication/Power Cable (SCCPC5V)

The most common cable choice for any standard Matrix Orbital display, the Communication/Power Cable offers a simple connection to the unit with familiar interfaces. DB9 and floppy power headers provide all necessary input to drive your display.



Figure 4: Breadboard Cable (BBC)

For a more flexible interface to the LK402-25, a Breadboard Cable may be used. This provides a simple four wire connection that is popular among developers for its ease of use in a breadboard environment.

## Serial Connections

The serial interface provides a classic connection to the LK402-25. The Communication/Power Cable is most commonly used for this setup as it provides connections for DB9 serial and floppy power cables.

To place your board in serial mode, adhere to the steps laid out below.

1. Set the Protocol Select Jumpers.
  - RS232: Connect the three jumpers\* in the 232 protocol box with the zero ohm jumper resistors provided or an alternate wire or solder solution.
  - TTL: Connect the two jumpers\* in the TTL protocol box.

**\*Note:** Jumpers must be removed from all protocol boxes save for the one in use.

2. Make the connections.
  - a. Connect the four pin female header of the Communication/Power Cable to the Communication/Power Header of your LK402-25.
  - b. Insert the male end of your serial cable to the corresponding DB9 header of the cable and mate the female connector with the desired communication port of your computer.
  - c. Select an unmodified floppy cable from a PC power supply and connect it to the power header of the Communication/Power Cable.
3. Create.
  - uProject or hyperterminal will serve to get you started, and then move on with your own development. Instructions for the former can be found below and a variety of application notes are available for the latter at [www.matrixorbital.ca/appnotes](http://www.matrixorbital.ca/appnotes).



## I<sup>2</sup>C Connections

A more advanced connection to the LK402-25 is provided by the I<sup>2</sup>C protocol setting. It requires a connection directly to your project. This is best accomplished using a breadboard and the Breadboard Cable. Power must be supplied from your breadboard or another external source. To dive right into your application and use the LK402-25 in I<sup>2</sup>C mode, get started with the guidelines below.

1. Set the Protocol Select Jumpers.
  - I<sup>2</sup>C: Ensure that the two I<sup>2</sup>C jumpers in the corresponding protocol box are connected while all others are open.
2. Make the connections.
  - a. Connect the Breadboard Cable to the Communication/Power Header on your LK402-25 and plug the four leads into your breadboard. The red lead will require power, while the black should be connected to ground, and the green and yellow should be connected to your controller clock and data lines respectively.
  - b. Pull up the clock and data lines to five volts using a resistance between one and ten kilohms on your breadboard.
3. Create.
  - This time you're on your own. While there are many examples within the Matrix Orbital AppNote section, [www.matrixorbital.ca/appnotes](http://www.matrixorbital.ca/appnotes), too many controllers and languages exist to cover them all. If you get stuck in development, it is possible to switch over to another protocol on the standard board, and fellow developers are always on our forums for additional support.

## USB Module

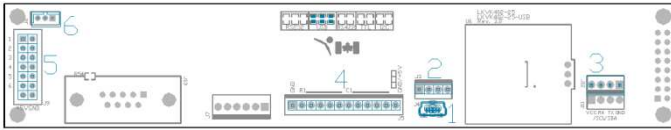


Figure 5: USB Connections

Table 2: Standard Headers

#	Header	Mate
1	Mini USB	EXTMUSB3FT/ INTMUSB3FT
2	Alternate USB	None Offered
3	Alternate Power	PCS
4	Keypad	KPP4x4
5	GPO	None Offered
6	Dallas One-Wire	Temperature Probe

The LK402-25-USB offers a single USB interface supplying an easy connection to a host computer. The simple and widely available protocol can be accessed using the on board mini B style USB connector as outlined in the USB Connections section.

## Recommended Parts



Figure 6: External Mini USB Cable (EXTMUSB3FT)

The External Mini USB Cable is recommended for the LK402-25-USB display. It will connect to the miniB style header on the unit and provide a connection to a regular A style USB connector, commonly found on a PC.

## USB Connections

The USB connection is the quickest, easiest solution for PC development. After driver installation, the LK402-25-USB will be accessible through a virtual serial port, providing the same result as a serial setup without the cable hassle. To connect to your LK402-25-USB, please follow the steps below.

1. Set the Protocol Select Jumpers.
  - USB: The LK402-25-USB offers USB protocol only. Model specific hardware prevents this unit from operating in any other protocol, and does not allow other models to operate in the USB protocol. Protocol Select Jumpers on the USB model cannot be moved.
2. Make the connections.
  - Plug the mini-B header of your External Mini USB Cable into your LK402-25-USB and the regular USB header into your computer USB jack.
3. Install the drivers.
  - a. Download the latest drivers at [www.matrixorbital.ca/drivers](http://www.matrixorbital.ca/drivers), and save them to a known location.
  - b. When prompted, install the USB bus controller driver automatically.
  - c. If asked, continue anyway, even though the driver is not signed.
  - d. When the driver install is complete, your display will turn on, but communication will not yet be possible.
  - e. At the second driver prompt, install the serial port driver automatically.
  - f. Again, if asked, continue anyway.
4. Create.
  - Use uProject or hyperterminal to get started, and then move on with your own development. Instructions for the former can be found below and a number of application notes are available for the latter at [www.matrixorbital.ca/appnotes](http://www.matrixorbital.ca/appnotes).

## RS422 Module

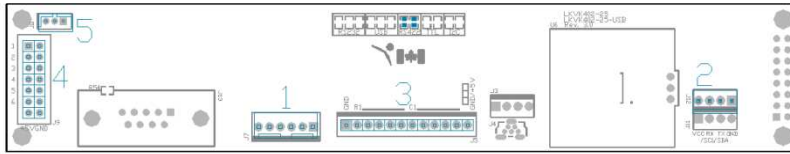


Figure 7: RS422 Connections

Table 3: Standard Headers

#	Header	Mate
1	RS422	16-30 AWG Wire
2	Alternate Power	PCS
3	Keypad	KPP4x4
4	GPO	None Offered
5	Dallas One-Wire	Temperature Probe

The LK402-25-422 provides an industrial alternative to the standard RS232 communication protocol. Rather than single receive and transmit lines, the RS422 model uses a differential pair for each of the receive and transmit signals to reduce degradation and increase transmission lengths. Power can be transmitted at distance to a -VPT module or supplied from the immediate vicinity to a regular or -V unit. RS422 signals are available in a six pin connector as described in the RS422 Connections section.

### RS422 Connections

The LK402-25-422 provides a robust RS422 interface to the display line. For this interface, a series of six wires are usually screwed into the RS422 terminal block provided. An alternate header is also available to provide local power to a regular or -V unit. To connect to your LK402-25-422, follow the steps below.

1. Set the Protocol Select Jumpers.
  - RS422: The LK402-25-422 offers only RS422 protocol and does not require any jumper changes.
2. Make the connections.
  - a. Screw one wire; sized 16 to 30 on the American Wire Gauge, into each of the six terminal block positions. When local power is supplied, a floppy cable may link to the alternate power header.
  - b. Connect the Vcc wire to the positive terminal of your power supply and the GND terminal to the negative or ground lead to provide appropriate power as in Table 42.
  - c. Secure the A and B wires to your non-inverting and inverting output signals respectively, while attaching the Z and Y wires to your inverting and non-inverting inputs.
3. Create.
  - In a PC environment, uProject or hyperterminal will serve to get you started. In addition, a variety of application notes are also available in a number of different languages to aid in development. Instructions for the former can be found below and the simple C# example at [www.matrixorbital.ca/appnotes](http://www.matrixorbital.ca/appnotes) is a great first reference for the latter.

## Software

The multiple communication protocols available and simple command structure of the LK402-25 means that a variety of applications can be used to communicate with the display. Text is sent to the display as a character string, for example, sending the decimal value 41 will result in an 'A' appearing on the screen. A number of control characters are also activated. Commands are merely values prefixed with a special command byte, 254 in decimal. While many software programs are available to communicate with the LK402-25, a number of more common samples are detailed in depth below.

Table 4: Reserved Control Characters

Control Characters							
8	Backspace	10	Line feed / New line	12	Clear screen / New page	13	Carriage return

## Hyperterminal

Installed on most Windows computers, hyperterminal can be run by selecting run and typing 'hypertrm' in the command line. This basic program will allow communication between a PC and your display.

When starting up, a name must be given to your connection, and an icon may be chosen, neither is consequential. Next, it's important to select the appropriate communication port to which your display is connected. Finally, the settings below must be entered to complete the port setup.

Table 5: Hyperterminal Settings

BPS	Data Bits	Parity	Stop Bits	Flow Control
19200	8	None	1	None

Once a port is successfully set up, data can be sent to an attached display by typing on the keyboard. At this point, it may be helpful to echo keys to the monitor by selecting properties from the file menu and opening the ASCII settings from settings tab.

Commands can be sent to an attached display by issuing decimal commands using the number pad. While the ALT key is held down, four digit decimal values can be sent as a single ASCII character. For example, to clear the screen, try the following sequence.

**ALT +0254 ALT +0088**

Figure 8: Hyperterminal Command

Any commands or text desired can be sent to the communication port using this method to provide total control of any Matrix Orbital display.

## uProject

The Matrix Orbital alphanumeric display tuner, or uProject, is offered as a free download from the [www.matrixorbital.ca](http://www.matrixorbital.ca) support site. It allows the basic functionality of any display\* to be tested using a simple graphical user interface system.

While basic functionality can be tested using the GUI portion of the program, more advanced users will enjoy the scripting capability found in the uploader tab. Here commands can be stacked, run, and saved for later use. Although many commands are available to be dragged into the script dialog, perhaps the most powerful is the raw data command found in the other branch.

This command allows raw bytes to be sent to the display, permitting many different formats for entry and displaying in decimal notation. Any command from this manual may be entered in decimal notation separated by slashes.

***/254/ /88/***

*Figure 9: uProject Command*

Again, the clear screen command is sent to a connected display, this time using uProject raw data command style. Scripts can be run as a whole using the execute command from the script menu, or as single commands by selecting execute once. Before issuing commands, it is a good idea to ensure communication with a display is successful using some of the more basic GUI functions in the main window.

This program provides scratch pad upon which a tome of display projects and ideas can be assembled.

**\*Note:** The uProject AutoDetect function will not perform correctly when a USB display is connected. Please manually configure any USB display.

## Application Notes

Full demonstration programs and code are available for Matrix Orbital displays in the C# language from Simple C# AppNote Pack in the Matrix Orbital Application Note section at [www.matrixorbital.ca/appnotes](http://www.matrixorbital.ca/appnotes). Difficulty increases from beginner, with the Hello World program, to advanced with the Dallas One-Wire temperature reading application.

Many additional applications are available in a number of different programming languages. These programs are meant to showcase the capability of the display and are not intended to be integrated into a final design. For additional information regarding code, please read the On Code document also found on the support site.

# Hardware

## Standard Model

### Communication/Power Header

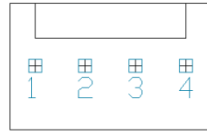


Figure 10: Communication/Power Header

Table 6: Communication/Power Pinout

Pin	Function
1	Vcc
2	Rx (SCL)
3	Tx (SDA)
4	Gnd

The Communication/Power Header provides a standard connector for interfacing to the LK402-25. Voltage is applied through pins one and four of the four pin Communication/Power Header. Please ensure the correct voltage input for your display by referencing the electrical specifications in Table 42 before connecting power. Pins two and three are reserved for serial transmission, using either the RS-232/TTL or clocking data through the I<sup>2</sup>C protocol, depending on what has been selected by the Protocol Select Jumpers. The versatile Tyco 640456-4-LF style header employed here can be mated to a wide array of female connectors for a perfect fit in any project.

### Serial DB9 Connector

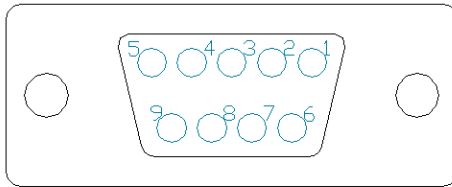


Figure 11: Serial DB9 Connector

Table 7: Serial DB9 Pinout

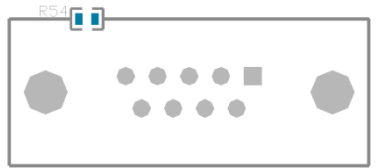
Pin	Function
5	Gnd
3	Rx
2	Tx
9	NC/Vcc*

The LK402-25 provides a DB-9 Connector to readily interface with serial devices using EIA232 standard signal levels. It is also possible to communicate at TTL levels of 0 to +5V by setting the Protocol Select Jumpers to TTL. As an added feature it is also possible to apply power through pin 9 of the DB-9 Connector in order to reduce cable clutter. A standard male DB9 header will provide the perfect mate for this connector.

**\*Note:** Do not apply voltage through pin 9 of the DB-9 Connector AND through the Communication/Power Header at the same time.

### Power Through DB9 Jumper

In order to provide power through pin 9 of the DB-9 Connector you must connect the Power Through DB-9 Jumper labelled R54, as illustrated below. This connection can be made using a zero ohm resistor, recommended size 0603, or a solder bridge. The LK402-25 allows all voltage models to use the power through DB-9 option, see the electrical specifications in Table 42 for voltage requirements.



Power Through DB9 Jumper

### Protocol Select Jumpers

The Protocol Select Jumpers provide the means necessary to toggle the LK402-25 between RS-232, TTL and I<sup>2</sup>C protocols. As a default, the jumpers are set to RS-232 mode with solder jumps on the 232 jumpers. In order to place the display module in I<sup>2</sup>C mode you must first remove the solder jumps from the 232 jumpers and then place them on the I<sup>2</sup>C jumpers. The display will now be in I<sup>2</sup>C mode and have a default slave address of 0x50, unless it has been changed. Similarly, in order to change the display to TTL mode, simply remove the zero ohm resistors from the 232 or I<sup>2</sup>C jumpers and solder them to the TTL jumpers. Protocol tables are shown below where an `X` designates a connected jump while an `O` signifies an open connection.

Table 8: RS232 Protocol Settings

RS232			TTL		I <sup>2</sup> C	
X	X	X	0	0	0	0

Table 9: TTL Protocol Settings

RS232			TTL		I <sup>2</sup> C	
0	0	0	X	X	0	0

Table 10: I<sup>2</sup>C Protocol Settings

RS232			TTL		I <sup>2</sup> C	
0	0	0	0	0	X	X



## USB Model

### Mini USB Connector

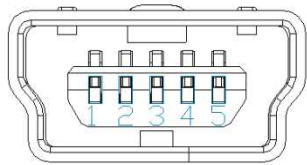


Figure 12: Mini USB Connector

Table 11: Mini USB Pinout

Pin	Function
1	Vcc
2	D-
3	D+
5	Gnd

The LK402-25-USB comes with a familiar Mini USB Connector to fulfill both communication and power needs. The standard MiniB style header can be connected to any other USB style using the appropriate cable. Most commonly used with a PC, this connection creates a virtual com port that offers a simple power solution with a familiar communication scheme.

### Alternate USB Header

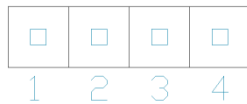


Figure 13: Alternate USB Header

Table 12: Alternate USB Pinout

Pin	Function
1	Gnd
2	D+
3	D-
4	Vcc

Some advanced applications may prefer the straight four pin connection offered through the Optional Alternate USB Header. This header offers power and communication access in a simple interface package. The Optional Alternate USB Header may be added to the LK402-25-USB for an added charge as part of a custom order. Please use the Contact section to request for more information from the friendly Matrix Orbital sales team.

### Alternate Power Connector

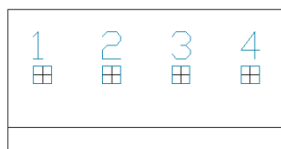


Figure 14: Alternate Power Connector

Table 13: Alternate Power Pinout

Pin	Function
1	NC
2	Gnd
3	Gnd
4	Vcc

The Alternate Power Connector provides the ability to power the LK402-25-USB using a second cable. The Tyco 171825-4 style header is particularly useful for connecting to an unmodified floppy power cable from a PC power supply for a simple bench power solution.

## RS422 Model

### RS422 Header

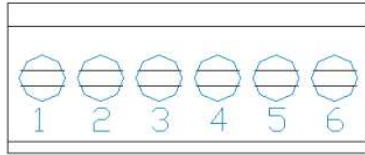


Figure 15: RS422 Header

Table 14: RS422 Pinout

Pin	Function
1	Gnd
2	Rx (Y)
3	Inv Rx (Z)
4	Inv Tx (B)
5	Tx (A)
6	Vcc

The six pin RS422 interface header of the LK402-25-422 offers power and ground connections as well as two differential pair communication lines. Regular and inverted lines are provided for both receive and transmit signals. Power is supplied locally to the regular or  $-V$  variants while the  $-VPT$  can receive power over a distance. The Tyco 282834-6 style header is most suited to a simple wire connection.

### Alternate Power Connector

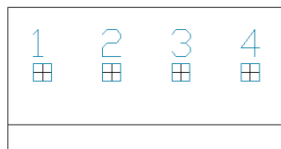


Figure 16: Alternate Power Connector

Table 15: Alternate Power Pinout

Pin	Function
1	NC
2	Gnd
3	Gnd
4	Vcc

The Alternate Power Connector provides the ability to power the LK402-25-422 using a second cable. This is particularly useful for the regular or  $-V$  modules that are to be powered locally. The Tyco 171825-4 style header will fit a floppy power cable from a PC power supply for a simple bench power solution.

## Common Features

### General Purpose Outputs

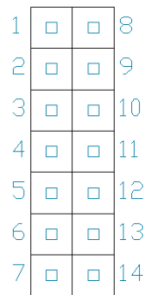


Figure 17: GPO Header

Table 16: GPO Pinout

Pin	Function	Pin	Function
1	GPO 1	8	Gnd
2	GPO 1	9	Gnd
3	GPO 1	10	Gnd
4	GPO 1	11	Gnd
5	GPO 1	12	Gnd
6	GPO 1	13	Gnd
7	Vcc	14	Gnd

A unique feature of the LK402-25 is the ability to control relays\* and other external devices using one of six General Purpose Outputs. Each can source up to 20mA of current at five volts when on or sink 10mA at zero volts when off. The two row, fourteen pin header can be interfaced to a number of female connectors to provide control to any peripheral devices required.

**\*Note:** If connecting a relay, be sure that it is fully clamped using a diode and capacitor in order to absorb any electro-motive force (EMF) which will be generated.

### Dallas One-Wire Connector

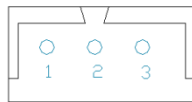


Figure 18: Dallas One-Wire Connector

Table 17: Dallas One-Wire Pinout

Pin	Function
1	Vcc
2	D
3	Gnd

In addition to the six general purpose outputs the LK402-25 offers an Optional Dallas One-Wire bridge, to allow for an additional thirty two one-wire devices to be connected to the display. This header can be populated with a Tyco 173979 connector at an added cost by custom order only. Please use the Contact section to request for more information from the Matrix Orbital sales team.

## Keypad Header



Figure 19: Keypad Header

Table 18: Keypad Pinout

Pin	Function
1	Gnd
2	Row 1
3	Row 2
4	Row 3
5	Row 4
6	Row 5
7	Column 1
8	Column 2
9	Column 3
10	Column 4
11	Column 5
12	Gnd/Vcc*

To facilitate user input, the LK402-25 provides a Keypad Interface Connector which allows a matrix style keypad of up to twenty-five keys to be directly connected to the display module. Key presses are generated when a short is detected between a row and a column. When a key press is generated, a character specific to that key press is automatically sent on the Tx communication line. If the display module is running in I<sup>2</sup>C mode, the “Auto Transmit Keypress” function may be turned off to allow the key presses to remain in the buffer so that they may be polled. The character that is associated with each key press may also be altered using the “Assign Key Codes” command. The straight twelve pin header of the Keypad Interface Connector will interface to a variety of different devices including the Matrix Orbital KPP4x4 keypad.

**\*Note:** The Ground / +5V pin is toggled by the jumper to the right of the keypad connector. Jump pads 1 & 2 for +5V or 2 & 3 for GND.

## Troubleshooting

### Power

In order for your Matrix Orbital display to function correctly, it must be supplied with the appropriate power. If the D2 power LED near the top right corner of the board is not illuminated, power is not applied correctly. Try following the tips below.

- First, make sure that you are using the correct power connector. Standard floppy drive power cables from your PC power supply may fit on the Communication/Power Header; however they do not have the correct pin out to provide power. Matrix Orbital supplies power cable adapters for connecting to a PC, which can be found in the accessories section.
- Next, check the power cable which you are using for continuity. If you don't have an ohm meter, try using a different power cable, if this does not help try using a different power supply.
- If power is applied through the DB9 connector, ensure that the Power Through DB9 Jumper is connected.
- If changes have been made to the protocol select block, ensure all the appropriate Protocol Select Jumpers are connected and all unused protocol jumpers are disconnected.
- The last step will be to check the power interface connector in use on your display. If the power connections have become loose, or you are unable to resolve the issue, please contact Matrix Orbital for more information.

### Display

If your display is powered successfully, the Matrix Orbital logo, or user created screen should display on start up. If this is not the case, check out these tips.

- Ensure the contrast is not too high or too low. This can result in a darkened or blank screen respectively. See the Manual Override section to reset to default.
- Make sure that the start screen is not blank. It is possible to overwrite the Matrix Orbital logo start screen, if this happens the screen may be blank. Try writing to the display to ensure it is functional, after checking the contrast above.

## Communication

When communication of either text or commands is interrupted, try the steps below.

- First, check the communication cable for continuity. If you don't have an ohm meter, try using a different communication cable. If you are using a PC try using a different Com Port.
- Next, please ensure that the display module is set to communicate on the protocol that you are using, by checking the Protocol Select Jumpers.
- In serial protocol, ensure that the host system and display module are both communicating on the same baud rate. The default baud rate for the display module is 19200 bps.
- Match Rx from the LK204-25 to the transmitting pin from your host and the Tx pin to the receiving pin.
- If you are communicating to the display via I<sup>2</sup>C\* please ensure that the data is being sent to the correct address. The default slave address for the display module is 80.
- In I<sup>2</sup>C mode, connect Rx to the data line of your controller and Tx to the data output.
- Unlock the display. See the Set and Save Data Lock command for more info.
- Finally, you may reset the display to its default settings using the Manual Override procedure outlined below.

**\*Note:** I<sup>2</sup>C communication will always require pull up resistors on SCL and SDA of one to ten kilohms.

## Manual Override

Should the settings of your display become altered in a way that dramatically impacts usability, the default settings can be temporarily restored. To override the display, please follow the steps below.

1. Disconnect power from your display.
2. Place a jumper on the middle two pins of the keypad header, R5 and C1.
3. Reconnect power to your unit, and wait for the start screen before removing the override jumper.
4. Settings will be temporarily\*\* overridden to the defaults listed in the Manual Override Settings table. At this point any important settings, such as contrast, backlight, or baud rate, should not only be set but saved so they remain when the override is removed.

Parameter	Value
Backlight	255
Contrast	128
Baud Rate	19200
I <sup>2</sup> C Address	80

*Table 19: Manual Override Settings*

**\*\*Note:** The display module will revert back to the old settings once turned off, unless desired settings are saved.

# Commands

## 1. Communications

<b>1.1. Changing the I2C Slave Address</b>	Dec	<b>254 51</b>	Address
	Hex	<b>FE 33</b>	Address
	ASCII	<b>■ 3</b>	Address
Immediately changes the I2C write address. Only even values are permitted as the next odd address will become the read address. Default is 80.			
Address	1 byte, even value		

<b>1.2. Changing the Baud Rate</b>	Dec	<b>254 57</b>	Speed
	Hex	<b>FE 39</b>	Speed
	ASCII	<b>■ 9</b>	Speed
Immediately changes the baud rate. Not available in I2C. Baud rate can be temporarily forced to 19200 by a manual override. Default is 19200.			
Speed	1 byte, valid settings shown below		

Table 20: Accepted Baud Rate Values

<b>Rate</b>	1200	2400	4800	9600	19200	28800	38400	57600	115200
<b>Speed</b>	83	41	207	103	51	34	25	16	8

<b>1.3. Setting a Non-Standard Baud Rate</b>	Dec	<b>254 164</b>	Speed
	Hex	<b>FE A4</b>	Speed
Immediately changes the baud rate to a non-standard value. Speed must be a whole number between 977 and 153800. Due to rounding, error increases with baud rate, actual baud must be within 3% of desired baud to ensure accurate communication. Not available in I2C. Can be temporarily forced to 19200 by a manual override.			
Speed	2 bytes, calculations shown below, standard crystal speed is 16MHz		

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Equation 1: Speed Byte Calculation

Equation 2: Actual Baud Rate Calculation

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Equation 3: Baud Rate Error Calculation

<b>1.4. Transmission Protocol Select</b>	Dec	<b>254 160</b>	Protocol
	Hex	<b>FE A0</b>	Protocol
Selects the protocol used for data transmission from the display. Data transmission to the display is not affected. Must be set to the protocol in use to receive data correctly.			
Protocol	1 byte, 1 for Serial (RS232/RS422/TTL/USB) or 0 for I2C		

## 2. Text

2.1. Auto Scroll On	Dec	254 81
	Hex	FE 51
	ASCII	■ Q

The entire contents of screen are shifted up one line when the end of the screen is reached. Default is on.

2.2. Auto Scroll Off	Dec	254 82
	Hex	FE 52
	ASCII	■ R

New text is written over the top line when the end of the screen is reached. Default is Auto Scroll on.

2.3. Clear Screen	Dec	254 88
	Hex	FE 58
	ASCII	■ X

Clears the contents of the screen.

2.4. Changing the Start Up Screen	Dec	254 64	Characters
	Hex	FE 40	Characters
	ASCII	■ @	Characters

Changes the message displayed on start up. Custom characters can be included by adding their decimal value (0-7). Characters will automatically wrap on the display.

**Characters** 80 bytes, space characters can be added as needed

2.5. Set Cursor Position	Dec	254 71	Column Row
	Hex	FE 47	Column Row
	ASCII	■ G	Column Row

Sets the cursor to a specific position where the next transmitted character is printed.

**Column** 1 byte, value between 1 and 40

**Row** 1 byte, value between 1 and 2

2.6. Go Home	Dec	254 72
	Hex	FE 48
	ASCII	■ H

Returns the cursor to the top left of the screen.



<b>2.7. Move Cursor Back</b>	Dec	<b>254 76</b>
	Hex	<b>FE 4C</b>
	ASCII	<b>■ L</b>

Moves cursor one position to the left. Cursor will obey wrap settings.

<b>2.8. Move Cursor Forward</b>	Dec	<b>254 77</b>
	Hex	<b>FE 4D</b>
	ASCII	<b>■ M</b>

Moves cursor one position to the right. Cursor will obey wrap settings.

<b>2.9. Underline Cursor On</b>	Dec	<b>254 74</b>
	Hex	<b>FE 4A</b>
	ASCII	<b>■ J</b>

Displays a line under the current cursor position. Can be used with block cursor.

<b>2.10. Underline Cursor Off</b>	Dec	<b>254 75</b>
	Hex	<b>FE 4B</b>
	ASCII	<b>■ K</b>

Removes line under current cursor position. Setting is only saved when remember is set on.

<b>2.11. Blinking Block Cursor On</b>	Dec	<b>254 83</b>
	Hex	<b>FE 53</b>
	ASCII	<b>■ S</b>

Displays a blinking block over the current cursor position. Can be used with underline.

<b>2.12. Blinking Block Cursor Off</b>	Dec	<b>254 84</b>
	Hex	<b>FE 54</b>
	ASCII	<b>■ T</b>

Removes blinking block over current cursor position.

### 3. Special Characters

<b>3.1. Creating a Custom Character</b>	Dec	<b>254 78</b>	ID Data
	Hex	<b>FE 4E</b>	ID Data
	ASCII	<b>■ N</b>	ID Data
Creates a custom character. Each character is divided into 8 rows of 5 pixels; each data byte represents one row. Each byte is padded by three zero bits followed by five bits representing each pixel state. A one represents an on condition while a zero is off. Characters are lost when a new memory bank is loaded, unless they are saved.			
ID	1 byte, character ID, value between 0 and 7		
Data	8 bytes, character pixel data as shown below		

Table 21: Custom Degree Character

Data1	000	p1	p2	p3	p4	p5	00001000	8
Data2	000	p1	p2	p3	p4	p5	00010100	20
Data3	000	p1	p2	p3	p4	p5	00001000	8
Data4	000	p1	p2	p3	p4	p5	00000011	3
Data5	000	p1	p2	p3	p4	p5	00000100	4
Data6	000	p1	p2	p3	p4	p5	00000100	4
Data7	000	p1	p2	p3	p4	p5	00000011	3
Data8	000	p1	p2	p3	p4	p5	00000000	0

<b>3.2. Saving Custom Characters</b>	Dec	<b>254 193</b>	Bank ID Data
	Hex	<b>FE C1</b>	Bank ID Data
Provides access to all memory banks to create and save custom characters, graph bars, and large digits. Any new characters saved will overwrite the old, so care should be taken when writing to any bar or digit memory bank. Bank structure is shown below.			
Bank	1 byte, memory bank ID, value between 0 and 4		
ID	1 byte, character ID, value between 0 and 7		
Data	8 bytes, character pixel data as above		

Table 22: Custom Character Banks

<b>0</b>	Start-up Characters	<b>1</b>	Horizontal Bars	<b>2</b>	Vertical Bars	<b>3</b>	Medium Digits	<b>4</b>	Large Digits
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<b>3.3. Loading Custom Characters</b>	Dec	<b>254 192</b>	Bank
	Hex	<b>FE C0</b>	Bank
Loads a bank of custom characters into memory for use. Must be issued before using a bank of characters. Alternatively, an appropriate initialize command can be used.			
Bank	1 byte, memory bank ID, value between 0 and 4		