GLK24064-25/GLT24064

Including GLK24064-25-422, GLK24064-25-USB, GLT24064-422, and GLT24064-USB

Technical Manual

Revision 1.3

PCB Revision: 1.0 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	Added 1.7 Read Screen and 14.5 Flow Control Response Commands	Clark
1.0	Initial Release	Clark

Contents

Introduction

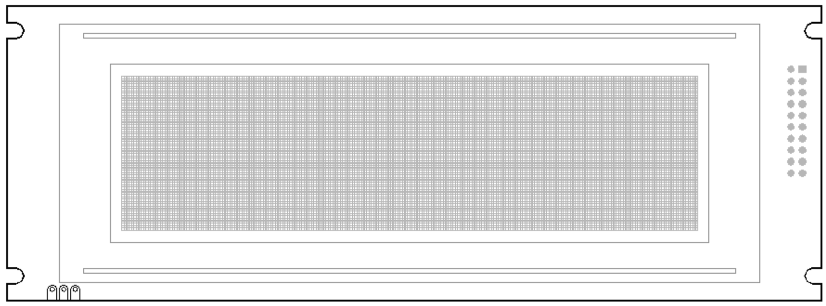


Figure 1: GLK24064-25/GLT24064 Display

The GLK24064-25/GLT24064 is an intelligent graphic liquid crystal engineered to quickly and easily add an elegant creativity to any application. In addition to the RS232, TTL and I2C protocols available in the standard model, USB and RS422 communication models allow the GLK24064-25/GLT24064 to be connected to a wide variety of host controllers. Communication speeds of up to 115.2kbps for serial protocols and 100kbps for I^2C ensure lightning fast text and graphic display.

The simple command structure permits easy software control of many settings including backlight brightness, screen contrast, and baud rate. On board memory provides thirty-two kilobytes of customizable fonts and bitmaps to enhance the graphical user experience.

User input on the GLK24064-25 is available through a five by five matrix style keypad or a resistive touch overlay on the GLT24064. Six general purpose outputs provide simple switchable five volt sources on each model. In addition, a versatile Dallas One-Wire header provides a communication interface for up to thirty-two devices.

The versatile GLK24064-25/GLT24064, 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

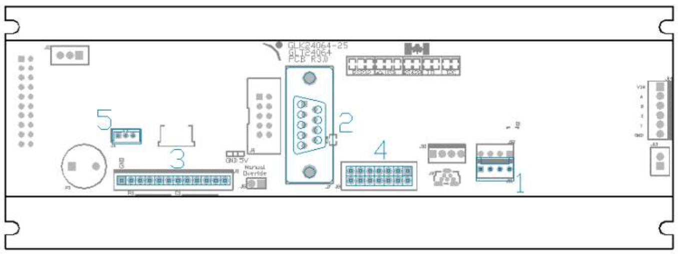


Figure 2: Standard Connections

Table 1: Standard Headers

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

The standard version of the GLK24064-25/GLT24064 allows for user configuration of three common communication protocols. First, the unit can communicate using serial protocol at either RS323 or TTL voltage levels. Second, it can communicate using the Inter-Integrated Circuit connect, or I^2C protocol. Connections for each protocol can be accessed through the four pin Communication/Power Header as outlined in the Serial Connections and I^2C 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 GLK24064-25/GLT24064, 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

Serial protocol provides a classic connection to the GLK24064-25/GLT24064. The Communication/Power Cable is most commonly used for this set up 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 GLK24064-25/GLT24064.
   b. Insert the male end of your serial cable to the corresponding DB9 header of the Communication/Power Cable and the 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.
   - MOGD# or hyperterminal will serve to get you started, and then you can 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.

I²C Connections

A more advanced connection to the GLK24064-25/GLT24064 is provided by the I²C protocol setting. 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 GLK24064-25/GLT24064 in I²C mode, get started with the guidelines below.

1. Set the Protocol Select switches.
   - I²C: Ensure that the two I²C 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 GLK24064-25/GLT24064 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, 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

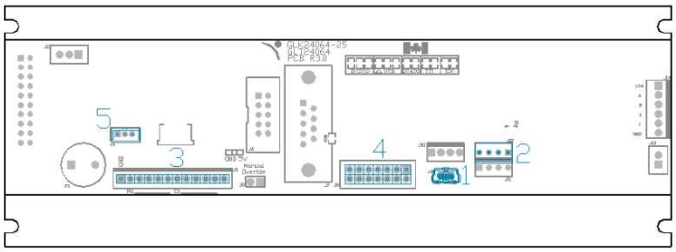


Figure 5: USB Connections

Table 2: Standard Headers

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

The USB version of the GLK24064-25/GLT24064 offers a single USB protocol for 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: Mini USB Cable (EXTMUSB3FT)

The External Mini USB cable is recommended for the GLK24064-25-USB /GLT24064-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 GLK24064-25-USB/GLT24064-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 GLK24064-25-USB/GLT24064-USB, please follow the steps below.

1. Set the Protocol Select jumpers.
   - USB: The GLK24064-25-USB/GLT24064-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 GLK24064-25-USB/GLT24064-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, 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 MOGD# 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.

RS422 Module

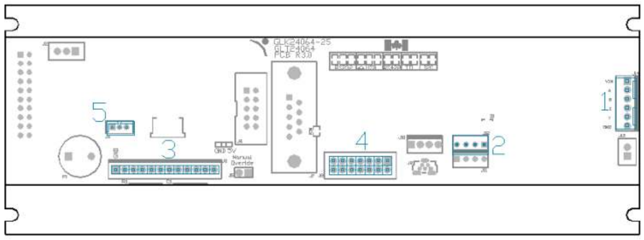


Figure 7: RS422 Connections

Table 3: Standard Headers

#	Header	Mate
1	RS422	S422CCPC5V
2	Alternate Power	PCS
3	Keypad	KPP4x4
4	GPO	None Offered
5	Dallas One-Wire	Temperature Probe

The GLK24064-25-422/GLT24064-422 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 GLK24064-25-422/GLT24064-422 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 GLK24064-25-422/GLT24064-422, adhere to the steps laid out below.

1. Set the Protocol Select jumpers.
   - RS422: The GLK24064-25-422/GLT24064-422 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 65.
   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, MOGD# or hyperterminal will serve to get you started. In addition, a variety of application notes are available online in a number of different languages to aid in the development of a display controller. Instructions for the former can be found below and the simple C# example at www.matrixorbital.ca/appnotes is a great first reference for the latter.

Software

The multiple communication protocols available and simple command structure of the GLK24064-25/GLT24064 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. Commands are merely values prefixed with a special command byte, 254 in decimal. While many software programs are available to communicate with the GLK24064-25/GLT24064, a number of more common samples are detailed in depth below.

Table 4: Reserved Control Characters

Control Characters	
10	Line feed / New line

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.

MOGD#

The Matrix Orbital Graphic Display interface, MOGD#, is offered as a free download from the www.matrixorbital.ca support site. It provides a simple graphical interface that allows settings, fonts, and bitmaps to be easily customised for any application.

While monotone bitmaps can easily be created in virtually any image editing program, MOGD# provides an extensive font generation quite to stylize your display to any project design. In addition to standard font wide modifications, character ranges can be specified by start and end values to eliminate unused symbols, and individual glyphs can be modified with a double click. Finally, text spacing can be tailored and a complete font library built with your Matrix Orbital graphic display.

Like uProject, MOGD# offers a scripting capability that provides the ability to stack, run, and save a series of commands. The most basic function is the Send Numeric tool which is used to transmit a string of values to the display to write text or execute a command.

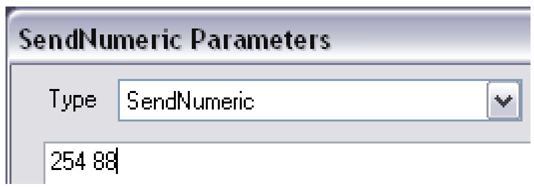


Figure 9: MOGD# Command Example

Again, the clear screen command is sent to a connected display, this time using the MOGD# Send Numeric function command style. Scripts can be run as a whole using the Play button from the toolbar or as single commands by selecting Step; once executed it must be Reset. Before issuing commands, it is a good idea to ensure communication with a display is successful using the autodetect button.

This program provides both a staging areas for your graphics display and a proving ground that will prepare it for any application environment.

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. 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

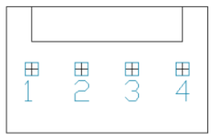


Figure 10: Communication/Power Header

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 GLK24064-25/GLT24064. 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 65 before connecting power. Pins two and three are reserved for serial transmission, using either the RS-232/TTL or clocking data through the I²C 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

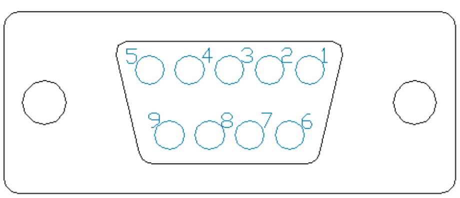


Figure 11: Serial DB9 Connector

Table 7: Serial DB9 Pinout

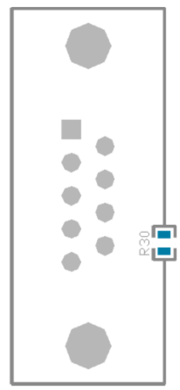
Pin	Function
5	Gnd
3	Rx
2	Tx
9	NC/Vcc*

The GLK24064-25/GLT24064 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 R30, as illustrated below. This connection can be made using a zero ohm resistor, recommended size 0603, or a solder bridge. The GLK24064-25/GLT24064 allows all voltage models to use the power through DB-9 option, see the specifications in Table 65 for voltage requirements.



Power Through DB9 Jumper

Protocol Select Jumpers

The Protocol Select Jumpers provide the means necessary to toggle the standard GLK24064-25/GLT24064 model between RS-232, TTL and I²C 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 I²C mode you must first remove the solder jumps from the 232 jumpers and then place them on the I²C jumpers. The display will now be in I²C 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 I²C 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		I²C	
X	X	X	0	0	0	0

Table 9: TTL Protocol Settings

RS232			TTL		I²C	
O	O	O	X	X	O	O

Table 10: I²C Protocol Settings

RS232			TTL		I²C	
O	O	O	O	O	X	X

USB Model

Mini USB Connector

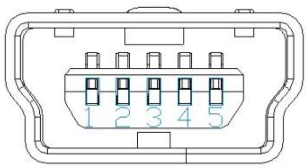


Figure 12: Mini USB Connector

Table 11: Mini USB Pinout

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

The GLK24064-25-USB/GLT24064-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

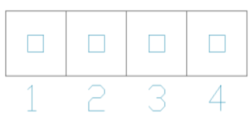


Figure 13: Alternate USB Header

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 GLK24064-25-USB/GLT24064-USB for an added charge as part of a custom order. Please use the Contact section to request more information from the friendly Matrix Orbital sales team.

Alternate Power Connector

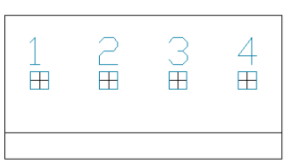


Figure 14: Alternate Power Connector

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 GLK24064-25-USB/GLT24064-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

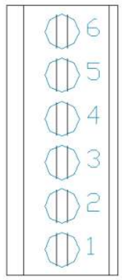


Figure 15: RS422 Header

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 GLK24064-25-422/GLT24064-422 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

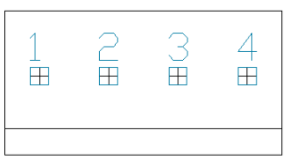


Figure 16: Alternate Power Connector

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 GLK24064-25-422/GLT24064-422 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.

GLK Model

Keypad Header

Figure 17: Keypad Header

Table 16: 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 GLK24064-25 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 I²C 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.

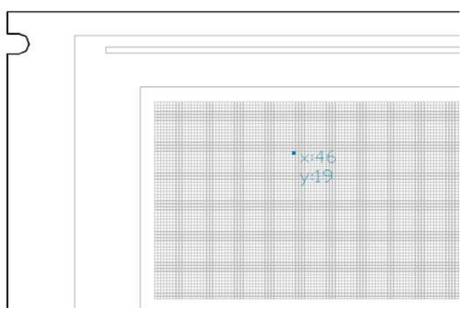
***Note:** The Ground / +5V pin is toggled by the jumper to the right of the keypad connector. Jump pads 1 & 2 for +5V or 2 & 3 for GND.

GLT Model

Touch Screen

The GLT24064 facilitates user touch input in one of two distinct ways. Coordinate mode will report events by supplying their exact position on the screen. Region mode will report events within defined boundaries on the screen. Both modes are outlined below.

Coordinate Mode

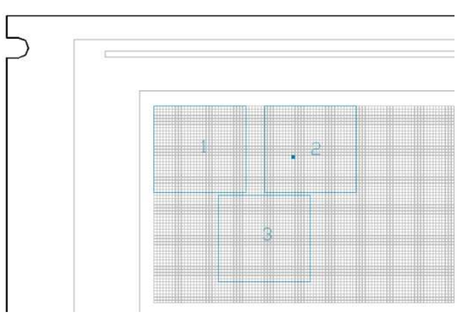


In coordinate mode all touch events are reported using three single byte values. First, the type of event is transmitted, followed by the x and y coordinates of its position. Pressure and drag thresholds must be exceeded for an event to be registered. A low drag threshold will result in greater tracking accuracy but transmits much more data to the host. Care should be taken to find balance. This mode offers a great degree of flexibility and creativity.

Table 17: Coordinate Mode Event Prefixes

Return Value	1	2	4
Touch Event	Press	Release	Drag

Region Mode



A simpler, keypad style alternative to coordinate mode, region mode offers only a single byte for each touch event. Unique regions are created by specifying a position, size, and return values. A value corresponding to a specific region is returned when an event occurs within its bounds. Events outside of regions result in transmission of the value 255. Regions can be deleted individually or collectively when no longer needed. This mode allows quick and easy set up.

Table 18: Region Mode Event Responses

Return Value	Key Down	Key Up	Key Down	255
Touch Event	Press	Release	Drag	Out of Region

Common Features

General Purpose Outputs

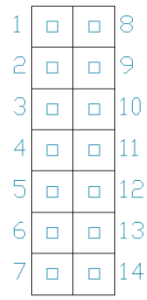


Figure 18: GPO Header

Table 19: GPO Pinout

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

A unique feature of the GLK24064-25/GLT24064 is the ability to control relays* and other external devices using one of six General Purpose Outputs. Each can source up to 10mA of current at five volts when on or sink 20mA 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

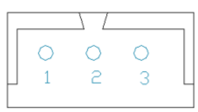


Figure 19: Dallas One-Wire Connector

Table 20: Dallas One-Wire Pinout

Pin	Function
1	Vcc
2	D
3	Gnd

In addition to the six general purpose outputs the GLK24064-25/GLT24064 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.

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 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 GLK24064-25/GLT24064 to the transmitting pin from your host and the Tx pin to the receiving pin.
- If you are communicating to the display via I^2C***** please ensure that the data is being sent to the correct address. The default slave address for the display module is 80.
- In I^2C mode, connect Rx to the clock 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 Contact procedure.

***Note:** I^2C 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 two manual override pins next to the keypad header.
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^2C Address	80

Table 21: 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

1.1. Changing the I2C Slave Address			
	Dec	**254 51**	Address
	Hex	**FE 33**	Address
	ASCII	**■ 3**	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

1.2. Changing the Baud Rate			
	Dec	**254 57**	Speed
	Hex	**FE 39**	Speed
	ASCII	**■ 9**	Speed

Immediately changes the baud rate. Not available in I2C. Baud rate can be temporarily forced to 19200 by a manual override.

Speed	1 byte, valid settings shown below

Table 22: Accepted Baud Rate Values

Rate	9600	14400	19200	28800	38400	57600	76800	115200
Speed	207	138	103	68	51	34	25	16

1.3. Setting a Non-Standard Baud Rate			
	Dec	**254 164**	Speed
	Hex	**FE A4**	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

Equation 1: Speed Byte Calculation

Equation 2: Actual Baud Rate Calculation

Equation 3: Baud Rate Error Calculation

1.4. Transmission Protocol Select			
	Dec	**254 160**	Protocol
	Hex	**FE A0**	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

1.5. Turn Flow Control On

Dec	254 58	Full Empty
Hex	FE 3A	Full Empty
ASCII	■ :	Full Empty

Enables simple flow control. The display will return a single, Xoff, byte to the host when the display buffer is almost full and a different, Xon, byte when the buffer is almost empty. Full value should provide enough room for the largest data packet to be received without buffer overflow. No data should be sent to the display between full and empty responses to permit processing. Buffer size is 128 bytes. Not available in I^2C. Default off.

Full	1 byte, number of bytes remaining before buffer is completely full, 0 < Full < Empty < 128
Empty	1 byte, number of bytes remaining before buffer can be considered empty enough to accept more data

1.6. Turn Flow Control Off

Dec	254 59
Hex	FE 3B
ASCII	■ ;

Disables flow control. Bytes sent to the display may be permitted to overflow the buffer resulting in data loss.

1.7. Set Flow Control Response

Dec	254 60	Xon Xoff
Hex	FE 3C	Xon Xoff
ASCII	■ <	Xon Xoff

Sets the values returned for almost full and almost empty messages when in flow control mode. This command permits the display to utilize standard flow control values of 0x11 and 0x13, note that defaults are 0xFF and 0xFE.

Xon	1 byte, value returned when display buffer is almost empty, permitting transmission to resume
Xoff	1 byte, value returned when display buffer is almost full, signalling transmission to halt

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

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

Column	1 byte, value between 1 and number of character columns
Row	1 byte, value between 1 and number of character rows

2.5. Set Cursor Coordinate			
	Dec	254 121	X Position Y Position
	Hex	FE 79	X Position Y Position
	ASCII	■ y	X Position Y Position

Sets the cursor to an exact pixel position where the next transmitted character is printed.

X Position	1 byte, value between 1 and screen width, represents leftmost character position
Y Position	1 byte, value between 1 and screen height, represents topmost character position

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

Returns the cursor to the top left of the screen.

3. Fonts

3.1. Upload a Font File

Dec	254 36	ID Size Data
Hex	FE 24	ID Size Data
ASCII	■ $	ID Size Data

Upload a font to a graphic display. To create a font see the Font File Creation section, for upload protocol see the File Upload Protocol or XModem Upload Protocol entries.

ID	1 byte, unique font identification number, must be less than 128
Size	2 bytes, LSB followed by MSB, size of the entire font file
Data	variable length, font file data, see Font File Creation for example

3.2. Set the Current Font

Dec	254 49	ID
Hex	FE 31	ID
ASCII	■ 1	ID

Set the font in use by specifying a unique identification number. Characters sent after the command will appear in the font specified; previous text will not be affected. Default is 1.

ID	1 byte, unique font identification number

3.3. Set Font Metrics

Dec	254 50	Line Margin Top Margin Character Spacing Line Spacing Scroll Start
Hex	FE 32	Line Margin Top Margin Character Spacing Line Spacing Scroll Start
ASCII	■ 2	Line Margin Top Margin Character Spacing Line Spacing Scroll Start

Set the font spacing, or metrics, used with the current font. Changes only appear in text sent after command.

Line Margin	1 byte, space between left of display and first column of text. Default 0.
Top Margin	1 byte, space between top of display area and first row of text. Default 0.
Character Spacing	1 byte, space between characters. Default 0.
Line Spacing	1 byte, space between character rows. Default 1.
Scroll Start	1 byte, point at which text scrolls up screen to display additional rows. Default height-1.

3.4. Set Box Space Mode

Dec	254 172	Switch
Hex	FE AC	Switch

Toggle box space on or off. When on, a character sized box is cleared from the screen before a character is written. This eliminates any text or bitmap remnants behind the character. Default is on.

Switch	1 byte, 1 for on or 0 for off

Font File Creation

Matrix Orbital graphic displays are capable of displaying text in a wide variety of styles customizable to suit any project design. Front files alter the style of text and appearance of the display.

By default, a Matrix Orbital graphic display is loaded with a small filled font in slot one and a future bk bt 16 style in slot two. Both are available in the software download section at www.matrixorbital.ca.

The easiest way to create, add, or modify the fonts of any graphic display is through the MOGD# tool. This provides a simple graphic interface that hides the more complex intricacies of the font file.

Table 23: Example Font File Header

Maximum Width	Character Height	ASCII Start Value	ASCII End Value
5	7	72	74

The font file header contains four bytes: First, the number of columns in the widest character; usually 'w', second, the pixel height of each character, and finally, the start and end values of the character range. The range represents the values that must be sent to the display to trigger the characters to appear on the screen. In the example, the decimal values corresponding to the lowercase letters 'h' through 'j' will be used resulting in the range shown.

Table 24: Example Character Table

	MSB	LSB	Width
h	0	13	5
i	0	18	3
j	0	21	4

The character table contains information that allows the display to locate each individual character in a mass of character data. Each character has three bytes; two indicating it's offset in the character data and one indicating its width. The offset takes into account the header and table bytes to point to the first byte of the character data it references. The first byte of the file, maximum width, has an offset of zero. The width byte of each character can be identical as in a fixed width font, or in our case, variable. The character table will become clearer after analyzing the final part of the font file, character data.

Table 25: Character 'h' Bitmap

1	0	0	0	0
1	0	0	0	0
1	0	1	1	0
1	1	0	0	1
1	0	0	0	1
1	0	0	0	1
1	0	0	0	1

Table 26: Character 'h' Data

1	0	0	0	0	1	0	0	84	132
0	0	1	0	1	1	0	1	2D	45
1	0	0	1	1	0	0	0	98	152
1	1	0	0	0	1	1	0	C6	198
0	0	1	0	0	0	0	0	20	32

The character data is a binary graphical representation of each glyph in a font. Each character is drawn on a grid containing as many rows as the height specified in the header and as many columns as the width specified in the character table. Cells are drawn by writing a one in their location and cleared by setting a value of zero. Starting at the top left, moving right, then down, eight of these cells form a character data byte. When all cells are accounted for, zeroes may be added to the last byte to complete it. A sample of an 'h' glyph is shown above. The data for the 'i' and 'j' characters will follow to complete the custom font file displayed below.

Table 27: Example Font File

Header		5 7 72 74
Character Table	h	0 13 5
	i	0 18 3
	j	0 21 4
Character Data	h	132 45 152 198 32
	i	67 36 184
	j	16 49 25 96

4. Bitmaps

4.1. Upload a Bitmap File			
	Dec	254 94	ID Size Data
	Hex	FE 5E	ID Size Data
	ASCII	■ ^	ID Size Data

Upload a bitmap to a graphic display. To create a bitmap see the Bitmap File Creation section, for upload protocol see the File Upload Protocol or XModem Upload Protocol entries.

ID	1 byte, unique bitmap identification number, must be less than 128
Size	2 bytes, width and height of the bitmap
Data	variable length, bitmap file data, see Bitmap File Creation example

4.2. Draw a Bitmap from Memory			
	Dec	254 98	ID X Position Y Position
	Hex	FE 62	ID X Position Y Position
	ASCII	■ b	ID X Position Y Position

Draw a previously uploaded bitmap from memory. Top left corner must be specified for drawing.

ID	1 byte, unique bitmap identification number
X Position	1 byte, leftmost coordinate of bitmap
Y Position	1 byte, topmost coordinate of bitmap

4.3. Draw a Bitmap Directly			
	Dec	254 100	X Position Y Position Width Height Data
	Hex	FE 64	X Position Y Position Width Height Data
	ASCII	■ d	X Position Y Position Width Height Data

Draw a bitmap directly to the graphic display without saving to memory.

X Position	1 byte, leftmost coordinate of bitmap
Y Position	1 byte, topmost coordinate of bitmap
Width	1 byte, width of bitmap
Height	1 byte, height of bitmap
Data	bitmap dependent, see Bitmap File Creation example

Bitmap File Creation

In addition to fonts, Matrix Orbital graphic displays can also hold a number of customizable bitmaps to provide further stylistic product integration. Like font files, bitmaps files are most easily uploaded to a display using MOGD#. However, the critical data component of the bitmap upload command is detailed below for reference.

The bitmap data block is similar to that of a font. However, as a bitmap is only a single glyph, no header or table is required. Each bitmap is merely encoded in binary fashion using a series of ones and zeroes. Again a grid can be created using the width and height specified in the upload command, populated in the manner above, and converted into byte values. A smiley face example is shown below to indicate the ultimate affect of the Matrix Orbital graphic stylization ability.

Table 28: Smiley Face Bitmap

0	**1**	0	**1**	0
0	0	0	0	0
1	0	0	0	**1**
0	**1**	**1**	**1**	0

Table 29:Smiley Face Data

0	**1**	0	**1**	0	0	0	0	50	80
0	0	**1**	0	0	0	**1**	0	22	34
1	**1**	**1**	0	0	0	0	0	E0	224

5. Drawing

5.1. Set Drawing Colour	Dec	254 99	Colour
	Hex	FE 63	Colour
	ASCII	■ c	Colour

Change the drawing colour used for all subsequent drawing commands that do not implicitly specify colour.

Colour	1 byte, 0 for background or 1 to 255 for text colour

5.2. Draw Pixel	Dec	254 112	X Position	Y Position
	Hex	FE 70	X Position	Y Position
	ASCII	■ p	X Position	Y Position

Draw a single pixel on the graphic display using the current drawing colour.

X Position	1 byte, horizontal position of pixel, value between 0 and 239
Y Position	1 byte, vertical position of pixel, value between 0 and 63

5.3. Draw a Line	Dec	254 108	X1 Position	Y1 Position	X2 Position	Y2 Position
	Hex	FE 6C	X1 Position	Y1 Position	X2 Position	Y2 Position
	ASCII	■ l	X1 Position	Y1 Position	X2 Position	Y2 Position

Draw a line connecting two termini. Lines may be rendered differently when drawn right to left versus left to right.

X1 Position	1 byte, horizontal coordinate of first terminus, value between 0 and 239
Y1 Position	1 byte, vertical coordinate of first terminus, value between 0 and 63
X2 Position	1 byte, horizontal coordinate of second terminus, value between 0 and 239
Y2 Position	1 byte, vertical coordinate of second terminus, value between 0 and 63

5.4. Continue a Line	Dec	254 101	X Position	Y Position
	Hex	FE 65	X Position	Y Position
	ASCII	■ e	X Position	Y Position

Draw a line from the last point drawn to the coordinate specified using the current drawing colour.

X Position	1 byte, left coordinate of terminus, value between 0 and 239
Y Position	1 byte, top coordinate of terminus, value between 0 and 63

5.5. Draw a Rectangle	Dec	254 114	Colour	X1 Position	Y1 Position	X2 Position	Y2 Position
	Hex	FE 72	Colour	X1 Position	Y1 Position	X2 Position	Y2 Position
	ASCII	■ r	Colour	X1 Position	Y1 Position	X2 Position	Y2 Position

Draw a rectangular frame one pixel wide using the colour specified; current drawing colour is ignored.

Colour	1 byte, 0 for background or 1 to 255 for text colour
X1 Position	1 byte, leftmost coordinate, value between 0 and 239
Y1 Position	1 byte, topmost coordinate, value between 0 and 63
X2 Position	1 byte, rightmost coordinate, value between X1 and 239
Y2 Position	1 byte, bottommost coordinate, value between Y1 and 63

5.6. Draw a Solid Rectangle	Dec	254 120	Colour X1 Position Y1 Position X2 Position Y2 Position
	Hex	FE 78	Colour X1 Position Y1 Position X2 Position Y2 Position
	ASCII	■ x	Colour X1 Position Y1 Position X2 Position Y2 Position

Draw a filled rectangle using the colour specified; current drawing colour is ignored.

Colour	1 byte, 0 for background or 1to 255 for text colour
X1 Position	1 byte, leftmost coordinate, value between 0 and 239
Y1 Position	1 byte, topmost coordinate, value between 0 and 63
X2 Position	1 byte, rightmost coordinate, value between 0 and 239
Y2 Position	1 byte, bottommost coordinate, value between 0 and 63

5.7. Initialize a Bar Graph	Dec	254 103	ID Type X1 Position Y1 Position X2 Position Y2 Position
	Hex	FE 67	ID Type X1 Position Y1 Position X2 Position Y2 Position
	ASCII	■ g	ID Type X1 Position Y1 Position X2 Position Y2 Position

Initialize a bar graph in memory for later implementation. Graphs can be located anywhere on the screen, but overlapping may cause distortion. Graph should be filled using the Draw Bar Graph command below.

ID	1 byte, unique bar identification number, between 0 and 15
Type	1 byte, graph style, see Table 30
X1 Position	1 byte, leftmost coordinate, value between 0 and 239
Y1 Position	1 byte, topmost coordinate, value between 0 and 63
X2 Position	1 byte, rightmost coordinate, value between 0 and 239
Y2 Position	1 byte, bottommost coordinate, value between 0 and 63

Table 30: Bar Graph Types

Type	Direction	Base
0	Vertical	Bottom
1	Horizontal	Left
2	Vertical	Top
3	Horizontal	Right

5.8. Draw a Bar Graph	Dec	254 105	ID Value
	Hex	FE 69	ID Value
	ASCII	■ i	ID Value

Fill in a portion of a bar graph after initialization. Any old value will be overwritten by the new. Setting a value of zero before setting a new value will restore a graph should it become corrupted.

ID	1 byte, unique bar identification number, between 0 and 15
Value	1 byte, portion of graph to fill in pixels, will not exceed display bounds

5.9. Initialize a Strip Chart			
	Dec	**254 106**	ID X1 Position Y1 Position X2 Position Y2 Position
	Hex	**FE 6A**	ID X1 Position Y1 Position X2 Position Y2 Position
	ASCII	**■ j**	ID X1 Position Y1 Position X2 Position Y2 Position

Designate a portion of the screen for horizontal scrolling. Can be used to create scrolling graphs or marquee text.

ID	1 byte, unique chart identification number, between 0 and 6
X1 Position	1 byte, leftmost coordinate, value between 0 and 239
Y1 Position	1 byte, topmost coordinate, value between 0 and 63
X2 Position	1 byte, rightmost coordinate, must be separated from 0 by a multiple of eight
Y2 Position	1 byte, bottommost coordinate, value between 0 and 63

5.10. Shift a Strip Chart			
	Dec	**254 107**	Direction & ID
	Hex	**FE 6B**	Direction & ID
	ASCII	**■ k**	Direction & ID

Shift a designated strip chart area eight bits left or right. All text and fonts within the area are shifted.

Direction & ID	1 byte, MSB is direction, 0 for left or 1 for right, remaining bits indicate chart number

Table 31: Strip Chart Shift Example

Direction	ID	Byte	Value	Description
0	000 0001	01	1	Shift chart 1 left
1	000 0001	81	129	Shift chart 1 right

6. General Purpose Output

6.1. General Purpose Output Off			
	Dec	**254 86**	Number
	Hex	**FE 56**	Number
	ASCII	**■ V**	Number

Turns the specified GPO off, sinking current to an output of zero volts.

Number	1 byte, GPO to be turned off, value between 1 and 6

6.2. General Purpose Output On			
	Dec	**254 87**	Number
	Hex	**FE 57**	Number
	ASCII	**■ W**	Number

Turns the specified GPO on, sourcing current from an output of five volts.

Number	1 byte, GPO to be turned on, value between 1 and 6

6.3. Set Start Up GPO State			
	Dec	**254 195**	Number State
	Hex	**FE C3**	Number State

Sets and saves the start up state of the specified GPO in non volatile memory. Changes will be seen on start up.

Number	1 byte, GPO to be controlled, value between 1 and 6
State	1 byte, 1 for on or 0 for off

7. Dallas One-Wire

7.1. Search for a One-Wire Device	Dec	254 200 2
	Hex	FE C8 02

Sends a search query to each of the up to 32 devices on the one wire bus. Any connected device will respond with an identification packet.

Response	14 bytes, identification packet as shown below

Table 32: Dallas One-Wire Packet Information

Offset	Length	Value	Description
0	2	9002	Preamble
2	1	138	Another device packet will follow OR
		10	Last device packet
3	1	49	Packet Type
4	1	0	Error Code (0 indicates success)
5	8		Device Address
13	1	0	CRC8 address check (0 indicates validity)

7.2. Dallas One-Wire Transaction	Dec	254 200 1	Flags Send Bits Receive Bits Data
	Hex	FE C8 01	Flags Send Bits Receive Bits Data

Performs a single Dallas 1-Wire transaction. Consult your device documentation for information regarding device specific protocols. If an error is encountered, a corresponding value will be returned by the device.

Flags	1 byte, flags for transaction, see below
Send Bits	1 byte, number of bytes to be sent to the device
Receive Bits	1 byte, number of bytes expected to be received from the device
Data	Variable, data to be transmitted LSB to MSB

Table 33: Dallas One-Wire Flag Table

Bit	Flag Description
7	
6	Unused
5	
4	0 (Future Compatibility)
3	Add CRC8 to transaction
2	0 (Future Compatibility)
1	Read CRC8 from transaction
0	Reset Bus prior to transaction

Table 34: Dallas One-Wire Error Table

Code	Error Description
0	Success
1	Unknown Command
2	No Devices Found
3	Fatal Search Error

8. Piezo Buzzer

8.1. Activate Piezo Buzzer	Dec	254 140	Time
	Hex	FE 8C	Time

Activates a 488Hz buzz from the onboard piezo buzzer for a specified length of time.

Time	Length of buzzer sound in 100ms.

9. Keypad

9.1. Auto Transmit Key Presses On	Dec	254 65
	Hex	FE 41
	ASCII	■ A

Key presses are automatically sent to the host when received by the display. Default is Auto Transmit on.

9.2. Auto Transmit Key Presses Off	Dec	254 79
	Hex	FE 4F
	ASCII	■ O

Key presses are held in the 10 key buffer to be polled by the host using the Poll Key Press command. Use this mode for I2C transactions. Default is Auto Transmit on.

9.3. Poll Key Press	Dec	254 38
	Hex	FE 26
	ASCII	■ &

Reads the last unread key press from the 10 key display buffer. If another key is stored in the buffer the MSB will be 1, the MSB will be 0 when the last key press is read. If there are no stored key presses a value of 0 will be returned. Auto transmit key presses must be turned off for this command to be successful.

Response	1 byte, value of key pressed (MSB determines additional keys to be read)

9.4. Clear Key Buffer	Dec	254 69
	Hex	FE 45
	ASCII	■ E

Clears all key presses from the key buffer.

9.5. Set Debounce Time	Dec	254 85	Time
	Hex	FE 55	Time
	ASCII	■ U	Time

Sets the time between a key press and a key read by the display. Most switches will bounce when pressed; the debounce time allows the switch to settle for an accurate read. Default is 8 representing a debounce time of approximately 52ms.

Time	1 byte, debounce increment (debounce time = Time * 6.554ms)

9.6. Set Auto Repeat Mode

Dec	254 126	Mode	
Hex	FE 7E	Mode	

Sets key press repeat mode to typematic or hold. In typematic mode if a key press is held, the key value is transmitted immediately, then 5 times a second after a 1 second delay. In hold mode, the key down value is transmitted once when pressed, and then the key up value is sent when the key is released. Default is typematic.

Mode	1 byte, 1 for hold mode or 0 for typematic

9.7. Auto Repeat Mode Off

Dec	254 96
Hex	FE 60

Turns auto repeat mode off. Default is on (typematic).

9.8. Assign Keypad Codes

Dec	254 213	Key Down	Key Up
Hex	FE D5	Key Down	Key Up

Assigns the key down and key up values sent to the host when a key press is detected. A key up and key down value must be sent for every key, a value of 255 will leave the key unaltered. Defaults are shown below.

Key Down	25 bytes, key down values
Key Up	25 bytes, key up values

Table 35: Default Key Down Values

Key Down				
A(65)	B(66)	C(67)	D(68)	E(69)
F(70)	G(71)	H(72)	I(73)	J(74)
K(75)	L(76)	M(77)	N(78)	O(79)
P(80)	Q(81)	R(82)	S(83)	T(84)
U(85)	V(86)	W(87)	X(88)	Y(89)

Table 36: Default Key Up Values

Key Up				
a(97)	b(98)	c(99)	d(100)	e(101)
f(102)	g(103)	h(104)	i(105)	j(106)
k(107)	l(108)	m(109)	n(110)	o(111)
p(112)	q(113)	r(114)	s(115)	t(116)
u(117)	v(118)	w(119)	x(120)	y(121)

10. Touchpad

10.1. Set Touch Region	Dec	254 132	ID X Position Y Position Width Height Key Down Key Up
	Hex	FE 84	ID X Position Y Position Width Height Key Down Key Up

Creates a region of the screen that responds when pressed and released with a defined single byte.

ID	1 byte, unique region identification number, maximum 32 regions
X Position	1 byte, leftmost coordinate, value between 0 and 239
Y Position	1 byte, topmost coordinate, value between 0 and 63
Width	1 byte, width of region, must be within screen bounds
Height	1 byte, height of region, must be within screen bounds
Key Down	1 byte, value returned when region is pressed
Key Up	1 byte, value returned when region is released

10.2. Delete a Touch Region	Dec	254 133	ID
	Hex	FE 85	ID

Deletes a previously created touch region. Events from undefined regions return the value 255 by default. Please ensure remember is set on before executing this command.

ID	1 byte, unique region identification number

10.3. Delete All Touch Regions	Dec	254 134
	Hex	FE 86

Deletes all previously created touch regions. Recommended for use before dividing the screen into new regions. Please ensure remember is set on before executing this command.

10.4. Set Touch Mode	Dec	254 135	Mode
	Hex	FE 87	Mode

Sets the method used to return touch events. Region mode will return a single value for events in defined areas. Coordinate mode will return event, x position, and y position bytes for each press, drag, or release.

Mode	1 byte, touch reporting mode, 0 for region or 1 for coordinate mode. Default is coordinate.

10.5. Set Region Reporting Mode

Dec	**254 136**	Mode
Hex	**FE 88**	Mode

Defines the events transmitted in region mode. Allows only events specified to return a value to the host. Key down values are transmitted for press and drag events, key up for release, and the value 255 for out of region.

Mode	1 byte, region reporting mode, see table below. Default reporting returns all events.

Table 37: Region Reporting Mode Byte

Byte	7-4	3	2	1	0
Event	Reserved	Out of Region	Drag	Release	Press

10.6. Set Dragging Threshold

Dec	**254 137**	Threshold
Hex	**FE 89**	Threshold

Sets the distance a press is required to travel before a drag event is reported. Precision will vary inversely to data transmitted; care should be taken to find a suitable balance. Distance is calculated as .

Threshold	1 byte, threshold value between 1 and 255. Default is 8.

10.7. Set Pressure Threshold

Dec	**254 138**	Threshold
Hex	**FE 8A**	Threshold

Sets the pressure required to trigger a touch event.

Threshold	2 bytes, threshold value between 1 and 65535. Default is 1000.

10.8. Run Touchpad Calibration

Dec	**254 139**
Hex	**FE 8B**

Triggers an interactive calibration of the touchpad. User will be required to touch various points on the screen during calibration. This command is recommended for use when environmental or user conditions change to ensure correct operation.

Response	2 bytes, command byte 254, then 21 for success or 20 for failure.

11. Display Functions

11.1. Display On			
	Dec	254 66	Minutes
	Hex	FE 42	Minutes
	ASCII	■ B	Minutes

Turns the display backlight on for a specified length of time. If an inverse display color is used this command will essentially turn on the text.

Minutes	1 byte, number of minutes to leave backlight on, a value of 0 leaves the display on indefinitely

11.2. Display Off		
	Dec	254 70
	Hex	FE 46
	ASCII	■ F

Turns the display backlight off. If an inverse display colour is used this command will turn off the text.

11.3. Set Brightness			
	Dec	254 153	Brightness
	Hex	FE 99	Brightness

Immediately sets the backlight brightness. If an inverse display color is used this represents the text colour intensity instead. Default is 255.

Brightness	1 byte, brightness level from 0(Dim) to 255(Bright)

11.4. Set and Save Brightness			
	Dec	254 152	Brightness
	Hex	FE 98	Brightness

Immediately sets and saves the backlight brightness. Although brightness can be changed using the set command, it is reset to this saved value on start up. Default is 255.

Brightness	1 byte, brightness level from 0(Dim) to 255(Bright)

11.5. Set Contrast			
	Dec	254 80	Contrast
	Hex	FE 50	Contrast
	ASCII	■ P	Contrast

Immediately sets the contrast between background and text. If an inverse display color is used this also represents the text brightness. Default is 128.

Contrast	1 byte, contrast level from 0(Light) to 255(Dark)

11.6. Set and Save Contrast			
	Dec	254 145	Contrast
	Hex	FE 91	Contrast

Immediately sets and saves the contrast between background and text. Although contrast can be changed using the set command, it is reset to this saved value on start up. Default is 128.

Contrast	1 byte, contrast level from 0(Light) to 255(Dark)

12. Filesystem

12.1. Wipe Filesystem		
	Dec	254 33 89 33
	Hex	FE 21 59 21
	ASCII	■ ! Y !

Completely erase all fonts and bitmaps from a graphic display. Extended length of the command is intended to prevent accidental execution. To ensure filesystem integrity, cycle power to the display after erasure.

12.2. Delete a File			
	Dec	254 173	Type ID
	Hex	FE AD	Type ID

Removes a single font or bitmap file given the type and unique identification number. Cycle power after deletion.

Type	1 byte, 0 for font or 1 for bitmap
ID	1 byte, unique identification number of font or bitmap to be deleted

12.3. Get Filesystem Space		
	Dec	254 175
	Hex	FE AF

Returns the amount of space remaining in the display for font or bitmap uploads.

Response	4 bytes, number of bytes remaining in 32KB memory, LSB to MSB

12.4. Get Filesystem Directory		
	Dec	254 179
	Hex	FE B3

Returns a directory to the contents of the filesystem. The total number and type of each entry will be provided.

Response	variable length, 1 byte representing number of entries followed by 4 identification bytes for each entry

Table 38: Filesystem Identification Bytes

Byte	3	2	1	0
Description	Size MSB	Size LSB	Type/ID	Flag

Table 39: Extended Byte Descriptions

Size MSB	most significant byte of the file size
Size LSB	least significant byte of the file size
Type/ID	MSB designates file type, 0 for font or 1 for bitmap, remaining bits indicate ID number
Flag	a value of 0 indicates entry is not in use

12.5. Download a File

Dec	254 178	Type	ID
Hex	FE B2	Type	ID

Downloads a single font or bitmap file from the display to the host.

Type	1 byte, 0 for font or 1 for bitmap
ID	1 byte, unique identification number of font or bitmap to download
Response	variable length, first 2(font) or 4(bitmap) bytes represent file size followed by file data

12.6. Move a File

Dec	254 180	Old Type	Old ID	New Type	New ID
Hex	FE B4	Old Type	Old ID	New Type	New ID

Used to move a single file and/or alter the type of an existing file. Old ID location must be valid and new ID empty.

Old Type	1 byte, original file type, 0 for font or 1 for bitmap
Old ID	1 byte, original unique file identification number
New Type	1 byte, new file type, 0 for font or 1 for bitmap
New ID	1 byte, new unique file identification number, must be less than 128

12.7. Dump the Filesystem

Dec	254 48
Hex	FE 30
ASCII	■ 0

Downloads complete filesystem containing all fonts and bitmaps stored in the display. A veritable heap of data.

Response	32772 bytes, 4 bytes of size LSB to MSB followed by entire 32KB filesystem

File Upload Protocol

Once a bitmap or font file has been created and paired to its command it must be sent using a file protocol developed specifically for Matrix Orbital displays. Once a file upload command has been sent requesting a unique reference number and specifying the file size required, the display will respond indicating whether it has enough room to save the file or not. As is the case throughout the upload protocol, a response of 1 will indicate confirmation while an 8 corresponds to rejection and will terminate the session.

Table 40: Upload Protocol Responses

Value	Action	Description
1	Confirm	Transfer successful, upload continues
8	Decline	Transfer failed, abort upload

Once a file is confirmed to fit within the display, the upload will begin. A protocol is used here to ensure each byte is uploaded successfully. After each byte is sent, the module will echo it back to the host. It should then be checked against the value originally sent before a confirmation byte of 1 is returned. If the transmitted and echoed values do not match the upload should be aborted by sending a value of 8 instead. The upload will continue in this manner as indicated by the examples below which utilize familiar font and bitmap files.

Table 41: Font Upload Protocol

Host	Display	Comments
254		Command Prefix
36		Upload Font File Command
1		Reference ID
31		Font File LSB
0		Font File MSB
	1	Size Confirmation
5		First Font Data Byte
	5	Echo Data Byte
1		Confirm Data Byte
...	...	...
96		Last Font Data Byte
	96	Echo Data Byte
1		Confirm Data Byte

Table 42: Bitmap Upload Protocol

Host	Display	Comments
254		Command Prefix
94		Upload Bitmap File Command
1		Reference ID
5		Bitmap File LSB
0		Bitmap File MSB
	1	Size Confirmation
5		First Bitmap Data Byte
	5	Echo Data Byte
1		Confirm Data Byte
...	...	...
224		Last Bitmap Data Byte
	224	Echo Data Byte
1		Confirm Data Byte

It should be noted that the display has a timeout setting of 2.1 seconds before it resets to prevent it from hanging during the upload process. Upon reset, the values 254 and 212 will be returned to indicate an error or lengthy delay has occurred in the upload process. If everything goes smoothly, the protocol will end with the host transmitting a final confirmation byte and the font will be stored in the display ready for any application.

XModem Upload Protocol

In addition to its original simple upload format, Matrix Orbital has added an XModem based protocol. This facilitates much faster download speeds by increasing the packet size from 1 byte to 128 bytes greatly increasing throughput. Though a protocol similar to the original upload scheme is used, a two byte CRC check is preformed at the end of each packet in place of the byte echo system. To begin the upload, a series of command bytes are sent, much however, no distinction is made between bitmap and font as the XModem protocol is used to upload bin or ebin files that contain all the bitmaps and fonts required for the unit. Once the command bytes are sent, the size of the file is sent in two bytes, least significant byte first. Then two additional bytes are sent of the value zero. At this point the display will respond with an ACK if the file fits or a NAK otherwise. Please note that these values are different than those of the original protocol as seen in the table below. If a NAK is seen at any point by the host, the upload is to be aborted in the same fashion as the regular protocol. If the file will fit, the start of header byte will be sent by the host, followed by a block count, in regular and inverted format, representing the number of 128 byte blocks remaining to. The display will then check to make sure the block count value matches its own before ACKing. The host can then send a 128 byte block of data followed by that blocks high and low CRC16 bytes. The display then performs a CRC check on the data receive and ACKs if it matches that which was sent. Transfer continues with a block count and continues in this way until the end of file is reached. Once the end of the upload file is reached, the host should transmit a single end of transmission byte. If the end of file is expected, the display will ACK one last time. This EOT byte along with the other special characters mentioned above is listed in the table below.

Table 43: XModem Upload Protocol:

Host	Display	Comments
254		Command Prefix
219		XModem Upload Command
133		Command Byte One
6		Command Byte Two
48		Command Byte Three
0		Size LSB
64		Size MSB
0		Zero
0		Zero
	6	ACK (NAK if file is too big)
1		Start of Header
128		Block Count
127		Inverted Block Count (255-Count)
	6	ACK (NAK if counts don’t match)
<128 B>		128 Byte Data Block
30		CRC MSB
71		CRC LSB
	6	ACK (NAK if CRCs don’t match)
…	…	…
4		End of Transmission
	6	ACK (NAK if EOT is not expected)

Table 44: XModem Protocol Message Bytes

Value	Action	Description
6	Acknowledged	Transfer successful, upload continues
33	Not Acknowledged	Transfer failed, upload aborted
1	Start of Header	Begin upload transfer
4	End of Transmission	End completed upload transfer

13. Data Security

13.1. Set Remember	Dec	254 147	Switch
	Hex	FE 93	Switch

Allows changes to specific settings to be saved to the display memory. Writing to non-volatile memory can be slow and each change consumes 1 write of approximately 100,000 available. The Command Summary outlines which commands are saved always, never, and when this command is on only. Remember is off by default.

Switch	1 byte, 1 for on or 0 for off

13.2. Set Data Lock	Dec	254 202 245 160	Level
	Hex	FE CA F5 A0	Level

Temporarily locks certain aspects of the display to ensure no inadvertent changes are made. The lock is released after a power cycle. A new level overrides the old, and levels can be combined. Default is 0.

Level	1 byte, each bit representing a level, see Table 45

Table 45: Data Lock Bits

Display	Command	Filesystem	Setting	Address	Reserved	Reserved	Reserved
7	6	5	4	3	2	1	0

Table 46: Lock Parameters

Reserved	Place holders only, should be 0
Address	Locks the Baud Rate and I^2C address
Setting	Locks all settings from being saved
Filesystem	Locks all bitmaps and fonts
Command	Locks all commands, text can still be written
Display	Locks entire display, no new text can be displayed

13.3. Set and Save Data Lock	Dec	254 203 245 160	Level
	Hex	FE CB F5 A0	Level

Locks certain aspects of the display to ensure no inadvertent changes are made. The lock is not affected by a power cycle. A new level overrides the old, and levels can be combined. Default is 0.

Level	1 byte, see data lock table

14. Miscellaneous

14.1. Write Customer Data	Dec	254 52	Data
	Hex	FE 34	Data
	ASCII	■ 4	Data

Saves a user defined block of data to non-volatile memory. Useful for storing display information for later use.

Data	16 bytes, user defined data

14.2. Read Customer Data	Dec	254 53
	Hex	FE 35
	ASCII	■ 5

Reads data previously written to non-volatile memory. Data is only changed when written, surviving power cycles.

Response	16 bytes, previously saved user defined data

14.3. Read Version Number	Dec	254 54
	Hex	FE 36
	ASCII	■ 6

Causes display to respond with its firmware version number.

Response	1 byte, convert to hexadecimal to view major and minor revision numbers

14.4. Read Module Type	Dec	254 55
	Hex	FE 37
	ASCII	■ 7

Causes display to respond with its module number.

Response	1 byte, module number, see partial list below

Table 47: Sample Module Type Responses

21	GLK24064-25	105	GLT24064
107	GLK24064-25-USB	106	GLT24064-USB
109	GLK24064-25-422	110	GLT24064-422

14.5. Read Screen	Dec	254 184
	Hex	FE B8

Return the current commanded state of each pixel on the screen.

Response	1920 bytes, 30 bytes per display row, 64 rows of data representing the Boolean value of each pixel

Appendix

Command Summary

Available commands below include identifying number, required parameters, the returned response and an indication of whether settings are remembered always, never, or with remember set to on.

Table 48: Communication Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Changing the I2C Slave Address	51	33	3	Address	None	Always
Changing the Baud Rate	57	39	9	BaudRate	None	Always
Setting a Non-Standard Baud Rate	164	A4	ñ	Speed	None	Always
Transmission Protocol Select	160	A0	á	Protocol	None	Remember On
Turn Flow Control On	58	3A	:	Full, Empty	None	Remember On
Turn Flow Control Off	59	3B	;	None	None	Remember On
Set Flow Control Response	60	3C	<	Xon, Xoff	None	Remember On

Table 49: Text Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Auto Scroll On	81	51	Q	None	None	Remember On
Auto Scroll Off	82	52	R	None	None	Remember On
Clear Screen	88	58	X	None	None	Never
Set Cursor Position	71	47	G	Col, Row	None	Never
Set Cursor Coordinate	121	79	y	X, Y	None	Never
Go Home	72	48	H	None	None	Never

Table 50: Font Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Upload a Font File	36	24	$	ID, Size [2], Data []	See File Upload Protocol	Always
Set the Current Font	49	31	1	ID	None	Remember On
Set Font Metrics	50	32	2	LineMargin, TopMargin, CharSpace, LineSpace, ScrollStart	None	Remember On
Set Box Space Mode	172	AC	¼	Switch	None	Remember On

Table 51: Bitmap Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Upload a Bitmap File	94	5E	^	ID, Size [2], Data []	See File Upload Protocol	Always
Draw a Bitmap from Memory	98	62	b	ID, X, Y	None	Never
Draw a Bitmap Directly	100	64	d	X, Y, Width, Height, Data []	None	Never

Table 52: Drawing Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Set Drawing Colour	99	63	c	Colour	None	Remember On
Draw Pixel	112	70	p	X, Y	None	Never
Draw a Line	108	6C	l	X1, Y1, X2, Y2	None	Never
Continue a Line	101	65	e	X, Y	None	Never
Draw a Rectangle	114	72	r	Colour, X1, Y1, X2, Y2	None	Never
Draw a Solid Rectangle	120	78	x	Colour, X1, Y1, X2, Y2	None	Never
Initialize a Bar Graph	103	67	g	ID, Type, X1, Y1, X2, Y2	None	Remember On
Draw a Bar Graph	105	69	i	ID, Value	None	Never
Initialize a Strip Chart	106	6A	j	ID, X1, Y1, X2, Y2	None	Remember On
Shift a Strip Chart	107	6B	k	DirectionID	None	Never

Table 53: General Purpose Output Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
General Purpose Output Off	86	56	V	Number	None	Never
General Purpose Output On	87	57	W	Number	None	Never
Set Start Up GPO State	195	C3	├	Number, State	None	Always

Table 54: Dallas One-Wire Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Search for a One-Wire Device	200, 2	C8, 02	╚, ☻	None	Data [14]	Never
Dallas One-Wire Transaction	200, 1	C8, 01	╚, ☺	Flags, Send, Receive, Data []	Data []	Never

Table 55: Piezo Buzzer Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Activate Piezo Buzzer	140	8C	Î	Time	None	Never

Table 56: Keypad Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Auto Transmit Key Presses On	65	41	A	None	None	Remember On
Auto Transmit Key Presses Off	79	4F	O	None	None	Remember On
Poll Key Press	38	26	&	None	KeyPress	Never
Clear Key Buffer	69	45	E	None	None	Never
Set Debounce Time	85	55	U	Time	None	Remember On
Set Auto Repeat Mode	126	7E	~	Mode	None	Remember On
Auto Repeat Mode Off	96	60	`	None	None	Remember On
Assign Keypad Codes	213	D5	╒	KeyUp [25], KeyDown [25]	None	Always

Table 57: Touchpad Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Set Touch Region	132	84	ä	ID, X, Y, Width, Height, KeyUp, KeyDown	None	Remember On
Delete a Touch Region	133	85	à	ID	None	Remember On
Delete All Touch Regions	134	86	å	None	None	Remember On
Set Touch Mode	135	87	ç	Mode	None	Remember On
Set Region Reporting Mode	136	88	ê	Mode	None	Remember On
Set Dragging Threshold	137	89	ë	Threshold	None	Remember On
Set Pressure Threshold	138	8A	è	Threshold	None	Remember On
Run Touchpad Calibration	139	8B	ï	None	Outcome [2]	Always

Table 58: Display Functions Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Display On	66	42	B	Minutes	None	Remember On
Display Off	70	46	F	None	None	Remember On
Set Brightness	153	99	Ö	Brightness	None	Remember On
Set and Save Brightness	152	98	ÿ	Brightness	None	Always
Set Contrast	80	50	P	Contrast	None	Remember On
Set and Save Contrast	145	91	æ	Contrast	None	Always

Table 59: Filesystem Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Wipe Filesystem	33, 89, 33	21, 59, 21	!, Y, !	None	None	Always
Delete a File	173	AD	¡	Type, ID	None	Always
Get Filesystem Space	175	AF	»	None	Space [4]	Never
Get Filesystem Directory	179	B3	│	None	Entries []	Never
Download a File	178	B2	▓	Type, ID	Data []	Never
Move a File	180	B4	┤	Old Type, Old ID, New Type, New ID	None	Always
Dump the Filesystem	48	30	0	None	Size [4], Data [32768]	Never

Table 60: Data Security Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Set Remember	147	93	ô	Switch	None	Always
Set Data Lock	202, 245, 160	CA, F5, A0	╩, ⌡, á	Level	None	Remember On
Set and Save Data Lock	203, 245, 160	CB, F5, A0	╦, ⌡, á	Level	None	Always

Table 61: Miscellaneous Command Summary

Name	Dec	Hex	ASCII	Parameters	Response	Remembered
Write Customer Data	52	34	4	Data [16]	None	Always
Read Customer Data	53	35	5	None	Data [16]	Never
Read Version Number	54	36	6	None	Version	Never
Read Module Type	55	37	7	None	Module	Never
Read Screen	184	B8	╕	None	Pixels [1920]	Never

Environmental Specifications

Table 62: Environmental Limits

	Standard	Extended (-E)
Operating Temperature	0°C to +50°C	-10°C to +60°C
Storage Temperature	-10°C to +60°C	-20°C to +70°C
Operating Relative Humidity	Maximum 90% non-condensing	

Electrical Tolerances

Current Consumption

Table 63: Current Consumption

Board		Backlight		GPOs
45mA	+	50 to 220 mA	+	20mA each maximum

Table 64: Backlight Current Draw

YG	GW & WB
220mA	50mA

Input Voltage Specifications

Table 65: Voltage Specifications

Standard*	Wide Voltage (-V)*	Extended Wide Voltage (-VPT)
4.75-5.25V	9.0-15.0V	9.0-35.0V

***Note:** Standard and Wide Voltage variants of the RS422 model should be powered from a local source only.

Optical Characteristics

Table 66: Display Optics

Module Size	180.00 x 65.00 x 30.5	mm
Viewing Area	132.2 x 39.2	mm
Active Area	127.16 x 33.88	mm
Pixel Size	0.49 x 0.49	mm
Pixel Pitch	0.53 x 0.53	mm
Viewing Direction	12	O'clock
Viewing Angle	-30 to +30	°
Contrast Ratio	3	
Backlight Half-Life	50,000	Hours

Dimensional Drawings

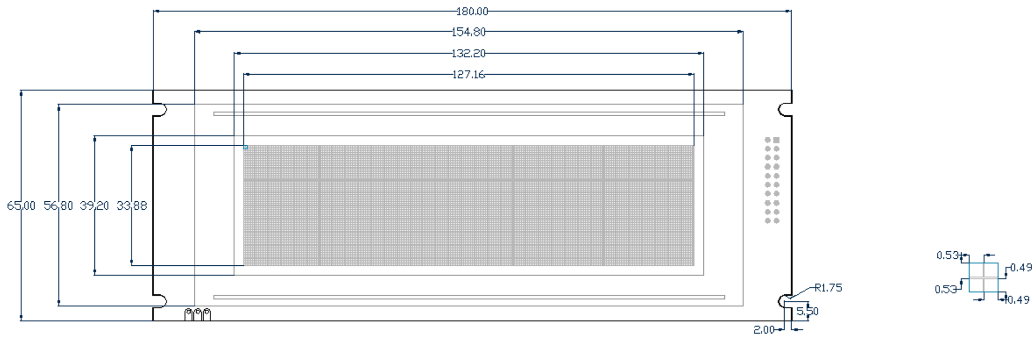


Figure 20: Display Dimensional Drawing

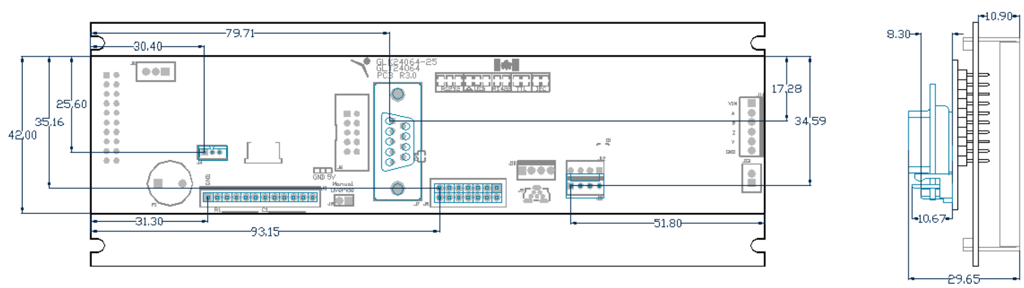


Figure 21: Standard Model Dimensional Drawing

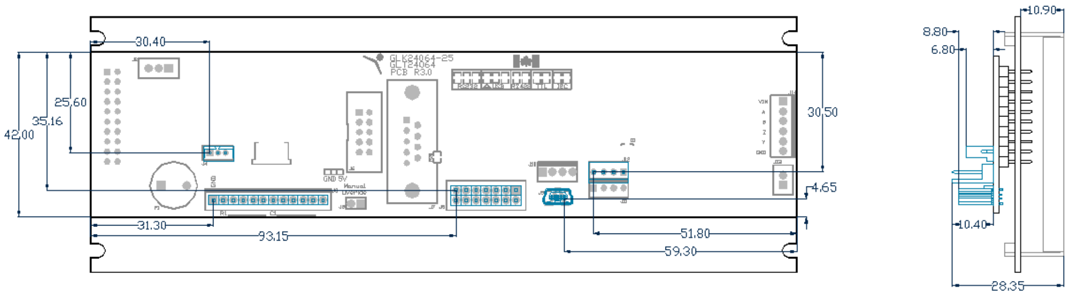


Figure 22: USB Model Dimensional Drawing

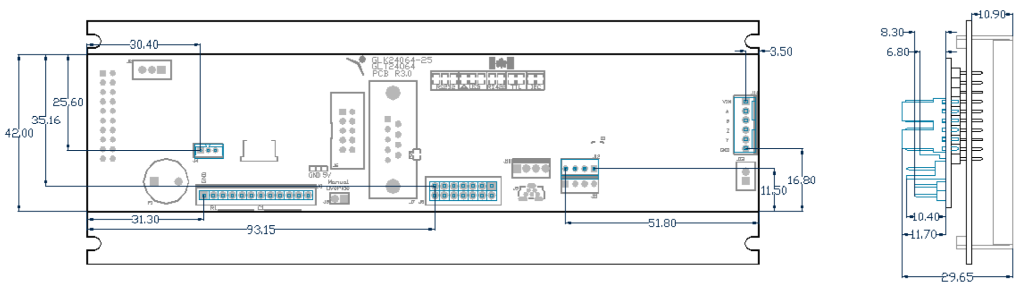


Figure 23: RS422 Model Dimensional Drawing

Ordering

Part Numbering Scheme

Table 67: Part Numbering Scheme

GLT	-24064		-GW	-V		-E
1	2	3	4	5	6	7

Options

Table 68: Display Options

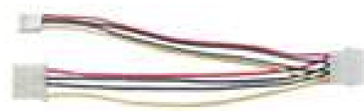
#	Designator	Options
1	Product Type	GLK: Graphic Liquid Crystal Display with Keypad Input GLT: Graphic Liquid Crystal Display with Touchpad Input
2	Display Size	24064: 240 pixel columns by 64 rows
3	Keypad Size	NP: No keypad 25: 25 key maximum
4	Colour	NP: Standard (Grey Text with Yellow-Green Background) GW: Grey Text with White Background WB: White Test with Blue Background
5	Voltage	NP: Standard Voltage -V: Wide Voltage -VPT: Wide Voltage with Efficient Switching Power Supply
6	Protocol	NP: Standard Model -USB: USB Only Model -422: RS422 Only Model*
7	Temperature	NP: Standard -E: Extended Temperature

***Note:** The RS422 model should only be powered from a local source, unless the –VPT variant is used.

Accessories

Power

Table 69: Power Accessories

PCS	Standard Power Cable	

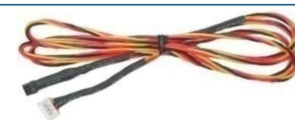
Communication

Table 70: Communication Accessories

CSS4FT	4 ft. Serial Cable	
EXTMUSB3FT	Mini-USB Cable	
INTMUSB3FT	Internal Mini-USB Cable	
SCCPC5V	Serial Communication/5V Power Cable	
BBC	Breadboard Cable	

Peripherals

Table 71: Peripheral Accessories

KPP4x4	16 Button Keypad	
Temperature Probe	Dallas One-Wire Temperature Probe	

Definitions

ASCII: American standard code for information interchange used to give standardized numeric codes to alphanumeric characters.

BPS: Bits per second, a measure of transmission speed.

DOW: Dallas One-Wire protocol, similar to I^2C, provides reduced data rates at a greater distance. One wire carries data, while two others supply power and ground. Matrix Orbital tests non-parasitic devices only, those that do not draw power from the data line; however, some parasitic devices may work.

FFSTN: Double film super-twisted nematic in reference to an LCD. The addition of two layers of film between the STN display and polarizer improves contrast.

GPO: General purpose output, used to control peripheral devices from a display.

GUI: Graphical user interface.

Hexadecimal: A base 16 number system utilizing symbols 0 through F to represent the values 0-15.

I^2C: Inter-integrated circuit protocol uses clock and data lines to communicate short distances at slow speeds from a master to up to 128 addressable slave devices. A display is a slave device.

LSB: Least significant bit or byte in a transmission, the rightmost when read.

MSB: Most significant bit or byte in a transmission, the leftmost when read.

RS232: Recommended standard 232, a common serial protocol. A high level is -30V, a low is +30V.

RS422: Recommended standard 422, a more robust differential pair serial protocol.

SDA: Serial data line used to transfer data in I^2C protocol. This open drain line should be pulled high through a resistor. Nominal values are between 1K and 10K Ω.

SCL: Serial clock line used to designate data bits in I^2C protocol. This open drain line should be pulled high through a resistor. Nominal values are between 1K and 10K Ω.

STN: Super-twisted nematic in reference to an LCD. In a relaxed or nematic state, crystals orientate themselves in the same direction and pass light. In an excited state these crystals align to block light. Super-twisted crystals move from 180 to 270 degrees between to increase contrast over TN models.

TTL: Transistor-transistor logic applied to serial protocol. Low level is 0V while high logic is 5V.

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