melabs Serial LCD

Firmware Version 1.0
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The melabs Serial LCD (SLCD) can display serial data from either asynchronous RS232-style or synchronous I^2C input. A range of baud rates from 2400 to 57,600 is available and the serial data is buffered so that no delay is necessary when transmitting data to the SLCD.

The SLCD is available with a 16-character by 2-line or a 20-character by 4-line liquid crystal display. Other display formats may be available by request. The display includes an LED backlight with variable brightness. The melabs Serial LCD board is also available separately to attach to other displays that utilize a Hitachi HD44780 or equivalent controller IC. Instructions for attaching a different display are toward the end of this document.

Serial Connections

Serial data, along with power, is supplied to the SLCD through connectors J1 and J2. Connector J1 is for asynchronous RS232-style serial data and connector J2 is for synchronous I^2C serial data. The SLCD includes an 80 character buffer so that no delays are necessary when sending usual amounts of serial data to it.

The SLCD can also accept data from both the asynchronous and synchronous inputs at the same time. However, it does not differentiate between the inputs so care must be taken when sending commands from one input so that no characters from the other input interfere with their interpretation.

Also note that jumpers JP1 and JP2 affect both serial inputs. If a specific baud rate is necessary, be sure to use the I^2C address offset that matches that jumper setting.

RS232-style USART Serial Connection

Asynchronous RS232-style serial data is applied to the pin labeled 'RX' on connector J1. The data format is a start bit followed by 8 data bits and a stop bit (8N1). There is no parity.

J1:

Pin	Name	Function
1	+5	+5 volts
2	G	Ground
3	RX	Serial data

The default baud rate is 9600. Other baud rates may be selected by shorting jumpers JP1 and/or JP2. The table below shows the baud rate selections. Note that these same jumpers are also used to select the I^2C address offset.

Baud	JP1	JP2
2400	SHORTED	SHORTED
9600 (default)	OPEN	OPEN
19,200	OPEN	SHORTED
57,600	SHORTED	OPEN

Jumper JP3 selects whether the serial signal is true or inverted. The default (open) state is inverted. This allows for direct connection to a PC without the need for an RS232 driver IC. The true state can be selected by shorting JP3.

As mentioned, direct connection to a PC is possible. The SLCD includes a series resistor and diode so that it can handle voltages between +15 and -15 volts on the RX line only, as may be present on a PC RS232 port.

I^2C Serial Connection

I^2C synchronous serial data is applied to connector J2. 'SC' is the serial clock connection and 'SD' is the serial data connection. The SLCD board includes a 4.7k pullup resistor on each of these lines.

J2:

Pin	Name	Function
1	+5	+5 volts
2	SD	Serial data
3	G	Ground
4	SC	Serial clock

The default I^{2}C address is hexadecimal 50. This default can be changed using a command. See the section on commands later in these instructions for more information. Jumpers JP1 and JP2 are used to select an address offset. The alternate addresses for the default I^{2}C address are as shown in the table below. Note that these same jumpers are also used to select the baud rate.

I^{2}C Address	JP1	JP2
Hex 50 (default)	OPEN	OPEN
Hex 52	SHORTED	OPEN
Hex 54	OPEN	SHORTED
Hex 56	SHORTED	SHORTED

Power Supply

The SLCD is powered by 5 volts to either of the 2 serial input connectors, J1 or J2. The connectors are labeled '+5' for the 5 volt connection and 'G' for the ground connection. During normal operation, very little current is consumed by the SLCD. At 5 volts with the backlight off, the current consumption is typically less than 4ma. However, turning on the LED backlight can add hundreds of milliamps to the power requirement.

Contrast Control

POT1 on the SLCD is used to set the contrast for the LCD. If it is turned too far in one direction, the screen will just show dark rectangles. If it is turned too far the other direction, the screen will appear to be blank. Adjust it for the best character visibility, darkest characters on the lightest background. A test screen can be displayed to provide visible characters for adjusting the potentiometer.

Test Screen

Connecting both 'SC' and 'SD' on connector J2 to ground on power up will display a test screen for a short time. Depending on the size of the display, this screen shows the SLCD firmware version number, baud rate and mode, I2C address, backlight level, and the number of characters and lines the controller is set for. The LED backlight will also be lit to approximately half brightness. The display will clear and enter regular operation after 5 seconds.

Characters

The melabs Serial LCD displays ASCII characters sent to it over the serial connection. These characters are sent either as the character itself ('X' or "Hello"), or as a number represented in the ASCII table for the display (hexadecimal 58 or decimal 88 is the same as 'X').

There are also 3 additional characters available that are not shown in the ASCII character table for the display. These custom characters are accessed by their numeric value only as there is no keyboard letter to type for them. They are character numbers 5 through 7. Character 5 is the Greek character mu (used for micro). Character 6 is the Greek character omega (used for ohms). Character 7 is the degree symbol.

These custom characters are loaded by default, along with the 5 horizontal bar graph characters, described later, when the display is first turned on and anytime the horizontal bar graph setup command is executed.

```
Serout 0, N9600, (5)         ' Display the Greek letter mu (micro symbol)
Serout 0, N9600, ("100", 6)  ' Display 100 followed by the ohms symbol
Serout 0, N9600, ("75", 7)   ' Display 75 followed by the degree symbol
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Command Format 1

The melabs Serial LCD will accept 2 different command formats. The first format is a 2 byte command starting with a hexadecimal **fe** (decimal **254**) followed by a command byte that is sent directly to the Hitachi HD44780 controller on the actual LCD. The commands that may be sent are outlined in the data sheet for the Hitachi controller which is available on the melabs web site.

Commands are available to clear the display and set the cursor position. For example, to clear the display, send the hexadecimal value **fe** (or decimal **254**), followed by the value **1**. Some of the other commands are shown in the table below.

Hex Command	Operation
fe, 1	Clear display and move cursor to beginning of first line
fe, 80	Move cursor to beginning of first line
fe, c0	Move cursor to beginning of second line
fe, 94	Move cursor to beginning of third line
fe, d4	Move cursor to beginning of fourth line

    Serout 0, N9600, ($fe, $1)   ' Clear screen and move cursor to start of first line

The characters are mapped to addresses on the display, as shown in the charts below. To move the cursor to a specific address, send the hexadecimal value **fe** (or decimal **254**), followed by the address from the chart for the display that is being used. For example, to move the cursor to the 4[th] character on line 1, send the hexadecimal value **fe**, followed by the hexadecimal value **83**.

    Serout 0, N9600, ($fe, $83)   ' Move cursor to 4[th] character position of first line

Character positions in hexadecimal for 16x2 display:

80	81	82	83	84	85	85	87	88	89	8a	8b	8c	8d	8e	8f
c0	c1	c2	c3	c4	c5	c6	c7	c8	c9	ca	cb	cc	cd	ce	cf

Character positions in hexadecimal for 20x4 display:

80	81	82	83	84	85	85	87	88	89	8a	8b	8c	8d	8e	8f	90	91	92	93
c0	c1	c2	c3	c4	c5	c6	c7	c8	c9	ca	cb	cc	cd	ce	cf	d0	d1	d2	d4
94	95	96	97	98	99	9a	9b	9c	9d	9e	9f	a0	a1	a2	a3	a4	a5	a6	a7
d4	d5	d6	d7	d8	d9	da	db	dc	dd	de	df	e0	e1	e2	e3	e4	e5	e6	e7

Command Format 2

The second of the two command formats uses an escape sequence which starts with an escape character, (hexadecimal **1b** or decimal **27**) and is followed by a command character and optionally followed by one or more data characters. For example, to clear the screen, send an escape (hexadecimal **1b** or decimal **27**) followed by a '0' (hexadecimal **30** or decimal **48**) :

    Serout 0, N9600, ($1b, $30)   ' Clear screen and move cursor to start of first line

The escape sequences are summarized in the following table. Detailed information for each command, including examples written in PICBASIC[TM], follows it.

Escape Code	Hexadecimal Code	Data	Command
ESC *	1b 2a	*n*	Set backlight brightness to *n*
ESC +	1b 2b		Scroll display down one line
ESC -	1b 2d		Scroll display up one line
ESC 0	1b 30		Clear screen and go to beginning of line 1
ESC 1	1b 31		Go to beginning of line 1
ESC 2	1b 32		Go to beginning of line 2
ESC 3	1b 33		Go to beginning of line 3
ESC 4	1b 34		Go to beginning of line 4
ESC <	1b 3c	*n*	Display horizontal bargraph of *n* bars from right to left
ESC >	1b 3e	*n*	Display horizontal bargraph of *n* bars from left to right
ESC B	1b 42		Blinking cursor on
ESC F	1b 46		Blinking or underline cursor off
ESC H	1b 48	*n*	Set up horizontal bargraph of *n* bars maximum length
ESC R	1b 52	*n c*	Repeat character *c*, *n* times
ESC S	1b 53	*n*	Display string starting at EEPROM address *n*
ESC U	1b 55		Underline cursor on
ESC c	1b 63	*n*	Set number of characters per line to *n*
ESC dw	1b 64 77		Save defaults to EEPROM
ESC i	1b 69	*n*	Set I^2C address to *n*
ESC l	1b 6c	*n*	Set number of lines to *n*
ESC w	1b 77	*n s*	Write string *s* to EEPROM address *n*

Set Backlight Brightness ESC * *n* (1b 2a *n*)

The brightness of the LED backlight of the display may be set from off to full on in 256 steps

using this command. First an escape character is sent (hexadecimal **1b** or decimal **27**) followed by an asterisk (hexadecimal **2a** or decimal **42**) and then a single character, represented by *n* above, of hexadecimal **0** to **ff** (decimal **0** to **255)** where **0** is off and **ff** (**255**) is full on.

       Serout 0, N9600, ($1b, $2a, $80)   ' Set LCD backlight to about half brightness

Clear Screen ESC 0 (1b 30)

Erase the display and position the cursor at the first character of the first line.

       Serout 0, N9600, ($1b, $30)   ' Clear screen and move cursor to start of first line

Line 1 ESC 1 (1b 31)

Position the cursor at the first character of the first line.

       Serout 0, N9600, ($1b, $31)   ' Move cursor to start of first line

Line 2 ESC 2 (1b 32)

Position the cursor at the first character of the second line.

       Serout 0, N9600, ($1b, $32)   ' Move cursor to start of second line

Line 3 ESC 3 (1b 33)

Position the cursor at the first character of the third line.

       Serout 0, N9600, ($1b, $33)   ' Move cursor to start of third line

Line 4 ESC 4 (1b 34)

Position the cursor at the first character of the fourth line.

       Serout 0, N9600, ($1b, $34)   ' Move cursor to start of fourth line

Scroll Down ESC + (1b 2b)

The Scroll Down command moves each line on the display down one position. The cursor is

then positioned to the first character of the first line.

      Serout 0, N9600, ($1b, $2b) ' Scroll down one line

Scroll Up ESC - (1b 2d)

The Scroll Up command moves each line on the display up one position. The cursor is then positioned to the first character of the second or fourth line, depending on the display format. See the Set Number of Chars and Set Number of Lines commands for more information on setting the display format.

      Serout 0, N9600, ($1b, $2d) ' Scroll up one line

Blinking Cursor ESC B (1b 42)

Normally the cursor position in not indicated on the display. A new character just shows up at the next position. A blinking cursor can be displayed by executing this Blinking Cursor command.

      Serout 0, N9600, ($1b, $42) ' Turn on blinking cursor

Underline Cursor ESC U (1b 55)

Normally the cursor position in not indicated on the display. A new character just shows up at the next position. An underline cursor can be displayed by executing this Underline Cursor command.

      Serout 0, N9600, ($1b, $55) ' Turn on underline cursor

Cursor Off ESC F (1b 46)

Executing this command turns off any previously selected blinking or underline cursor. New characters will show up at the next position on the display with no cursor shown.

      Serout 0, N9600, ($1b, $46) ' Turn off blinking or underline cursor

Repeat ESC R *n c* (1b 52 *n c*)

The Repeat command will show the character represented by *c* above on the display *n* times. *n* can be any number between 0 and the number of characters on the line. *c* can be any character.

This command can be useful to blank out a single line on the display by sending 16 or 20 spaces, for example.

      Serout 0, N9600, ($1b, $52, 10, "X")   ' Repeat the character X 10 times

Set Up Horizontal Bar Graph ESC H *n* (1b 48 *n*)

The SLCD includes commands to automatically display a horizontal (on one line) bar graph, either going from left to right, right to left, or both at the same time. A volt meter reading or stereo level display can be shown using these commands, for example.

The bar graph commands use custom characters on the display to create the necessary bar characters. The display allows up to 8 custom characters, 5 or which are used for the horizontal bar graph. These characters are preloaded when the SLCD is first powered up and are also loaded each time the Set Up Horizontal Bar Graph command is executed.

The value *n*, above, specifies the maximum number of bars in the bar graph. Three bars fit into each character position on the display. The default maximum value for the bar graph is 24 bars. 24 bars takes up 8 character positions. Two 24-bar bar graphs fit on a 16 character line. A bar graph 60 bars long will fit onto a single line of a 20 character display. The SLCD will allow you to set a maximum length that is longer than will fit on one line so care should be exercised when setting the length.

      Serout 0, N9600, ($1b, $48, 30)   ' Set up horizontal bar graph 30 bars long

Display Horizontal Bar Graph From Left ESC > *n* (1b 3e *n*)

This command will display a horizontal bar graph *n* bars long going from left to right on the display. The cursor should be positioned to the left of where the bar graph is desired to be displayed before executing this command. See the command Set Up Horizontal Bar Graph for more information about displaying bar graphs.

      Serout 0, N9600, ($1b, $3e, 10)   ' Display 10 bars of horizontal bar graph

Display Horizontal Bar Graph From Right ESC < *n* (1b 3c *n*)

This command will display a horizontal bar graph *n* bars long going from right to left on the display. The cursor should be positioned to the left of where the bar graph is desired to be displayed before executing this command. See the command Set Up Horizontal Bar Graph for more information about displaying bar graphs.

      Serout 0, N9600, ($1b, $3c, 10)   ' Display 10 bars of horizontal bar graph

Display String ESC S *n* (1b 53 *n*)

The SLCD includes 240 characters of non-volatile EEPROM memory that can be used to store message strings that can then be displayed to the screen using the Display String command. These strings are retained in EEPROM memory, even if the power is turned off. *n* above specifies the starting address of the string in the EEPROM memory, starting with address 0. Each string in EEPROM memory must end with a null character (hexadecimal or decimal 0). Strings may contain any command other than another Display String.

A special string begins at address 0 which is used as a splash screen that appears when the display is first turned on. If no splash screen is desired, address 0 must contain the null (hexadecimal or decimal 0) end of string character. The next string would then start at address 1.

Strings are written to the EEPROM memory using the Write String (ESC w) command.

    Serout 0, N9600, ($1b, $53, 0)   ' Display string starting from position 0

Write String ESC w *n s* (1b 77 *n s*)

The SLCD includes 240 characters of non-volatile EEPROM memory that can be used to store message strings that can then be displayed to the screen using the Display String command. These strings are retained in EEPROM memory, even if the power is turned off. *n* above specifies the starting address of the string in the EEPROM memory, starting with address 0. Each string in EEPROM memory must end with a null character (hexadecimal or decimal 0). Strings may contain any command other than another Display String.

A special string begins at address 0 which is used as a splash screen that appears when the display is first turned on. If no splash screen is desired, address 0 must contain the null (hexadecimal or decimal 0) end of string character. The next string would then start at address 1.

Strings are displayed using the Display String (ESC S) command.

    Serout 0, N9600, ($1b, $77, 0, "melabs.com", 0)   ' Write splash screen to EEPROM

Set Number of Chars ESC c *n* (1b 63 *n*)

Set Number of Chars is one of 2 commands to set the display format, the other being Set Number of Lines. This command tells the SLCD how many characters are on each line for use with the scrolling commands. The default for *n* is 20 which is usually adequate for either a 16 or 20 character per line display. Scrolling can be sped up a bit for a 16 character wide display by setting the number of characters per line to 16. It can also be set to 8, 12, 24 or 40 to match whatever size display is used with the SLCD controller.

The value can be made permanent (saved to EEPROM) using the Write Defaults to EEPROM command. Otherwise the setting only lasts until the power is turned off.

       Serout 0, N9600, ($1b, $63, 16)   ' Set number of chars per line to 16

Set Number of Lines ESC l *n* (1b 6c *n*)

Set Number of Lines is one of 2 commands to set the display format, the other being Set Number of Chars. This command tells the SLCD how many lines the display has for use with the scrolling commands. The default for *n* is 4 which usually works for either a 2 or 4 line display. Scrolling can be sped up a bit for a 2 line display by setting the number of lines to 2. This also ensures the cursor is set to the second line instead of the fourth line after scrolling up.

The value can be made permanent (saved to EEPROM) using the Write Defaults to EEPROM command. Otherwise the setting only lasts until the power is turned off.

       Serout 0, N9600, ($1b, $6c, 2)   ' Set number of lines to 2

Set I^{2}C Address ESC i *n* (1b 69 *n*)

The default base I^{2}C address for the SLCD is hexadecimal 50. This address may be changed to any other even, non-zero value using the Set I^{2}C Address command with *n*, above, specifying the new address. The address change will take place immediately and the display will stop responding to the old address.

The value can be made permanent (saved to EEPROM) using the Write Defaults to EEPROM command. Otherwise the setting only lasts until the power is turned off.

Jumpers JP1 and JP2 control the addition of an offset to the base I^{2}C address. If both jumpers are open, there is no offset and the address is simply the base address. If both jumpers are shorted, for example, then an offset of 6 is added to the base address. The table below shows what the offsets would be for the 4 jumper combinations. Note that these same jumpers are also used to select the baud rate.

I^{2}C Address	JP1	JP2
Base + 0 (default)	OPEN	OPEN
Base + 2	SHORTED	OPEN
Base + 4	OPEN	SHORTED
Base + 6	SHORTED	SHORTED

Serout 0, N9600, ($1b, $69, $60)   ' Set base I^{2}C address to hexadecimal 60

Write Defaults to EEPROM ESC d w (1b 64 77)

The values for the I^{2}C address, number of characters per line, number of lines on the display, cursor settings and backlight brightness can all be changed using commands, as shown above. These changes remain in effect until the power is turned off. The changes can be made permanent (saved to EEPROM) using the Write Defaults to EEPROM command. The Write Defaults to EEPROM command makes all the current values of these setting the default so the next time the power is turned on, the SLCD uses the values set in the commands above..

This command requires 2 bytes as an extra security measure to ensure the default are not changed inadvertently.

Serout 0, N9600, ($1b, $64, $77)   ' Write defaults to EEPROM

Using Other LCDs

The melabs Serial LCD board is available separately and can be connected to other displays that utilize a Hitachi HD44780 or equivalent controller IC. The HD44780 is the most commonly used controller on character LCDs.

The melabs SLCD includes 2 16-pin connectors to connect to the 2 most commonly used LCD interfaces. These are a 16-pin single-row connection and 8-pin by 2-row connection. The SLCD is intended to be mounted on the back of the LCD to one of these 16-pin connections. Make sure the LCD you intend to use with the melabs SLCD board matches the pinouts of the SLCD connectors, as shown in the table below. The last 2 pins of the 16 are for the backlight LED.

J4, J5:

Pin	Name	Function
1	Vss	Ground
2	Vdd	+5 volts
3	Vo	Contrast pot
4	RS	Register select
5	R/W	Read / write
6	E	Chip enable
7	DB0	Data bit 0
8	DB1	Data bit 1
9	DB2	Data bit 2
10	DB3	Data bit 3
11	DB4	Data bit 4
12	DB5	Data bit 5
13	DB6	Data bit 6
14	DB7	Data bit 7
15	A	LED +
16	K	LED -

Assembly Instructions

1. Break 4 of the pins from the 20-pin single-row header strip. If using the I^2C interface, solder these 4 pins to the top of the SLCD board (soldering from the back) into the area labeled J2. If using the RS232-style interface, break 1 more pin off the 4 and solder the remaining 3 pins to the top of the SLCD board (soldering from the back) into the area labeled J1.

2. If the LCD has a single-row connector on it, solder the remaining 16 pins to the back of the SLCD board (soldering from the top) into the area labeled J4. If the LCD has a 2-row connector on it, break the remaining 16-pin strip into 2 8-pin strips. Solder each of these strips to the back of the SLCD board (soldering from the top) into the area labeled J5.

3. Using double-sided foam, stick the SLCD board to the back of the LCD while aligning the pins previously soldered to the SLCD with the mating holes in the LCD.

4. Solder the 16 pins into the LCD.

5. Power up the board and set the contrast using POT1 as outlined in a previous section.

If you have questions regarding the melabs Serial LCD, our contact information is provided below.

microEngineering Labs, Inc.
Box 60039
Colorado Springs CO 80960-0039
USA
(719) 520-5323
(719) 520-1867 fax
http://www.melabs.com
email:support@melabs.com