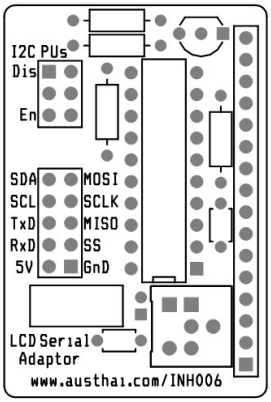
# Serial LCD Adaptor (INH006)

## User Guide (Version 1.0)

This user guide describes the use of the Maker's Corner *Serial LCD Adaptor* kit. The *Serial LCD Adaptor* reduces the number of pins used on the host microcontroller. The *Serial LCD Adaptor* works with three types of serial link and has two operating modes to provide maximum flexibility. The two operating modes used to communicate with the *Serial LCD Adaptor*: *terminal mode* and *native mode*.

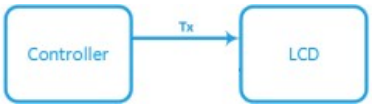
## Hardware Connections




The *Serial LCD Adaptor* connects to the LCD module through a 16 pin connector. There are two versions of the adaptor. The one shown on the right is designed to fit most LCD modules. It has a single row of 16 pins. Some LCDs use two rows of 8 pins. There is a version of the *Serial LCD Adaptor* available for these displays.

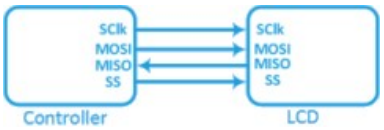
Serial connections are made using the 10 pin header on the left hand side of the board. All pins are clearly labelled. In all cases a 5 volt power supply should be connected. The ground should be connected to the pin labelled GnD and the 5 volt supply should be connected to the pin labelled 5V. Only one of the serial links should be connected at any time.

## UART Link



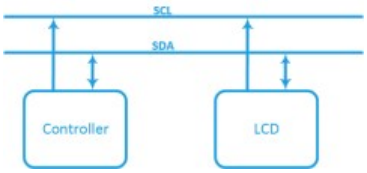

To use the UART link one additional connection is required between the 'RxD' pin on the *Serial LCD Adaptor* and the Tx data pin of the host microcontroller. (The TxD pin is not needed for normal operation.) The default speed for the UART link is 9600 baud. The speed can be changed using a control command if necessary.

## SPI Link




There are four pins for the SPI interface. These should be connected to the corresponding pins on the host microcontroller. Since communication is only in one direction it is not necessary to connect the 'MISO' pin. If the *Serial LCD Adaptor* is the only 'SPI' slave device on the bus the SS pin can be tied to ground.

## $I^2C$ Link




The $I^2C$ link uses 2 pins. These should be connected to the corresponding pins on the host microcontroller. If pull ups are not provided by the host these can be enabled on the *Serial LCD Adaptor* using the jumpers on the 'I2C PUs' selector. If pull ups are already provided by the host the jumpers can be set to 'Dis' to disable them. The default $I^2C$ address for the *Serial LCD Adaptor* is 0x76. This address can be changed using a control command if necessary.

When the *Serial LCD Adaptor* powers up it listens to all three serial ports until it receives a valid signal from one of them. It then switches exclusively to that port.

## Terminal Mode

In terminal mode the LCD acts like a mini terminal. Simply send single byte ASCII characters and they will appear on the LCD. When the cursor reaches the end of the line on the LCD it will automatically move to the beginning of the next line. When the cursor reaches the end on the last line on the LCD it will roll over to the beginning of the first line.

Several of the ASCII control characters work as would normally be expected. Carriage return (CR) moves the cursor back to the beginning of the line, Line Feed (LF) moves down one line, and so on. In addition, there are some special control codes for the *Serial LCD Adaptor*. The control codes are accessible by sending the decimal (or hex) value to the Serial LCD. They can also be invoked on a keyboard using common keystrokes as shown in the table below.

| Code | Keystroke | ASCII function | Serial LCD function |
|---|---|---|---|
| 3 (0x03) | Ctrl-C | | Move cursor. Moves cursor to the position given by the next code. See note 1 for details. |
| 8 (0x08) | Ctrl-H | Backspace | Moves the cursor back one space and deletes the character there. |
| 9 (0x09) | Tab (Ctrl-I) | Tab | Moves the cursor to the next tab position. Tab positions are spaced 4 characters apart. |
| 10 (0x0A) | Ctrl-J | Linefeed | Moves the cursor down one line. If the cursor is on the bottom line it 'rolls over' to the top line. The x-position of the cursor is not changed. |
| 12 (0x0C) | Ctrl-L | Formfeed | Clears the LCD screen and moves the cursor back to the top left hand position. |
| 13 (0x0D) | Ctrl-M | Carriage Return | Returns the cursor to the beginning of the current line. |
| 16 (0x10) | Ctrl-P | | Print Control Character. Prints the next code as a character. Used to print LCD characters from 0 (0x00) to 31 (0x1F). |
| 17 (0x11) | Ctrl-Q | | Turn on the backlight. |
| 18 (0x12) | Ctrl-R | | Turn off the backlight. |
| 19 (0x13) | Ctrl-S | | Set cursor to underline style. |
| 20 (0x14) | Ctrl-T | | Set Cursor to block style. |
| 21 (0x15) | Ctrl-U | | Turn off the cursor. |
| 27 (0x1B) | Esc | Escape | Switch to Native mode. |
| 127 (0x7F) | Del | Forward Delete | Delete the character immediately after the cursor. |

Note 1: In the case of the move cursor code (0x03) a second value must follow the code to specify the cursor position. The top left hand corner is defined as cursor position zero. The cursor position is numbered from left to right and from top to bottom. The numbering depends of the dimensions of the LCD being used. Appendix A shows the cursor positioning for each supported display type.

The *terminal mode* allows the user to quickly and easily use the LCD as an output device. To access the more advanced features of the LCD and to setup the operation of the *Serial LCD Adaptor* the user can switch to *native mode* using code 27 (0x1B).

## Native Mode

There are many features of the LCD module that can be accessed by using the LCD module's control commands. These are accessed when the *Serial LCD Adaptor* is operating in *native mode*. These commands are the same as those that are available when the LCD module is used in its normal parallel mode. They can be used to move the cursor to a specific position, control the flashing of the cursor and so on. Details of the LCD module's control commands can be found in the datasheet for the specific LCD module you are using. The commonly commands used in most LCD modules are given in the table in appendix B.

There are additional commands available that are specific to the *Serial LCD Adaptor*. These allow the user to control the backlight, set the baud rate of the UART link, set the I2C address, adjust the initial settings or enable/disable the splash screen. All commands used in *native mode* are shown in the table below. The commands are shown in hex format. Note that all commands in *native mode* are two bytes long.

| Code (hex) | Function name | Description |
|---|---|---|
| 0x00pp | Print Character | Prints the character specified by the code *pp*. |
| 0x01nn | LCD Command | Sends the command *nn* directly to the LCD. (See appendix B for details of the LCD commands.) |
| 0x7F7F | Exit Native Mode | Returns to *terminal mode*. |
| 0x7F1B | Reset | Resets the Serial LCD module. |
| 0xB000 | Backlight off | Turns off the Backlight. |
| OxB001 | Backlight on | Turns on the Backlight. |
| 0xC0nn | Set Startup options | Sets the initial values for the LCD display and cursor on startup. See note 2 below for the list of options. See note 1 below. |
| 0xC1nn | Set Splash time | Sets the time, in seconds, for display of the splash screen when the module starts. (A setting of zero disables the splash screen.) See note 1 below. |
| 0xC2tt | Set LCD Display | Sets the LCD display type. See note 3 below for the list of LCD module codes. See note 1 below. |
| 0xCAii | Set I2C address | Sets the I2C address to the value *ii*. (Default value is 0x76) See note 1 below. |
| 0xCBrr | Set Baud rate | Sets the baud rate for the UART connection. See note 4 below for the list of baud rate codes. See note 1 below. |
| 0xCF00 | Load Config | Load the saved configuration from the flash. |
| 0xCF01 | Save Config | Save the current configuration to the flash. |
| 0xCF02 | Restore Defaults | Set all values in the current configuration to the default settings. (This change must be saved to take effect.) |

Note 1: Changes made to the module configuration take effect after the configuration is saved and the Serial LCD is reset.

Note 2: The low four bits configure the LCD display at startup as follows:

| Bit | Description |
|---|---|
| 0 | 1 = Solid block displayed at cursor position<br>0 = No block displayed at cursor position (default) |
| 1 | 1 = Flashing underline displayed at cursor position (default)<br>0 = No flashing underline displayed at cursor position |
| 2 | 1 = Display is on (default)<br>0 = Display is off |
| 3 | 1 = Backlight is on (default)<br>0 = Backlight is off |

Note 3: The one byte code determines the LCD type that is in use. The *Serial LCD Adaptor* uses this setting to control the cursor movements in terminal mode. In the case of 1x16 and 4x16 LCDs there are two types in common use. Sixteen LCD types are supported as follows:

| Code | LCD type |
|---|---|
| 0 (0x00) | 1x8 LCD |
| 1 (0x01) | 1x16 Type 1 LCD |
| 2 (0x02) | 1x16 Type 2 LCD |
| 3 (0x03) | 1x20 LCD |
| 4 (0x04) | 1x24 LCD |
| 5 (0x05) | 1x32 LCD |
| 6 (0x06) | 1x40 LCD |
| 7 (0x07) | 2x8 LCD |
| 8 (0x08) | 2x16 LCD (default) |
| 9 (0x09) | 2x20 LCD |
| 10 (0x0A) | 2x24 LCD |
| 11 (0x0B) | 2x32 LCD |
| 12 (0x0C) | 2x40 LCD |
| 13 (0x0D) | 4x16 Type 1 LCD |
| 14 (0x0E) | 4x16 Type 2 LCD |
| 15 (0x0F) | 4x20 LCD |

Note 4: The one byte code determines the baud rate used in the UART by the *Serial LCD Adaptor*. There are four values possible as follows:

| Code | Baud rate |
|---|---|
| 0 (0x00) | 4800 |
| 1 (0x01) | 9600 (default) |
| 2 (0x02) | 19200 |
| 3 (0x03) | 38400 |

## Appendix A: Cursor Positions on LCDs

| | | | |
|---|---|---|---|
| 1 x 8 LCD | 0 | --- | 7 |
| 1 x 16 LCD | 0 | --- | 15 |
| 1 x 20 LCD | 0 | --- | 19 |
| 1 x 24 LCD | 0 | --- | 23 |
| 1 x 32 LCD | 0 | --- | 31 |
| 1 x 40 LCD | 0 | --- | 39 |
| 2 x 8 LCD | 0 | --- | 7 |
| | 8 | --- | 15 |
| 2 x 16 LCD | 0 | --- | 15 |
| | 16 | --- | 31 |
| 2 x 20 LCD | 0 | --- | 19 |
| | 20 | --- | 39 |
| 2 x 24 LCD | 0 | --- | 23 |
| | 24 | --- | 47 |
| 2 x 32 LCD | 0 | --- | 31 |
| | 32 | --- | 63 |
| 2 x 40 LCD | 0 | --- | 39 |
| | 40 | --- | 79 |
| 4 x 16 LCD | 0 | --- | 15 |
| | 16 | --- | 31 |
| | 32 | --- | 47 |
| | 48 | --- | 63 |
| 4 x 20 LCD | 0 | --- | 19 |
| | 20 | --- | 39 |
| | 40 | --- | 59 |
| | 60 | --- | 79 |

## Appendix B: Commonly Used LCD Commands

| Instruction | Instruction Code | | | | | | | | | | Description Instruction Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | RS | R/W | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | |
| Clear Display | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | Write "20H" to DDRAM. and set DDRAM address to "00H" from AC. |
| Return Home | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | X | Set DDRAM address to "00H" from AC and return cursor to its original position if shifted. The contents of DDRAM are not changed. |
| Entry Mode Set | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | I/D | SH | Assign cursor moving direction and make shift of entire display enable. |
| Display ON/OFF Control | 0 | 0 | 0 | 0 | 0 | 0 | 1 | D | C | B | Set display(D), cursor(C), and blinking of cursor(B) on/off control bit. |
| Cursor or Display Shift | 0 | 0 | 0 | 0 | 0 | 1 | S/C | R/L | X | X | Set cursor moving and display shift control bit, and the direction, without changing DDRAM data. |
| Function Set | 0 | 0 | 0 | 0 | 1 | DL | N | F | X | X | Set interface data length (DL : 4-bit/8-bit), numbers of display line (N : 1-line/2-line), display font type(F : 5 X 8 dots/ 5 X 11 dots) |
| Set CGRAM Address | 0 | 0 | 0 | 1 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 | Set CGRAM address in address counter. |
| Set DDRAM Address | 0 | 0 | 1 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 | Set DDRAM address in address counter. |
| Read Busy Flag and Address | 0 | 1 | BF | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 | Whether during internal operation or not can be known by reading BF. The contents of address counter can also be read. |
| Write Data to RAM | 1 | 0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Write data into internal RAM (DDRAM/CGRAM). |
| Read Data from RAM | 1 | 1 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Read data from internal RAM (DDRAM/CGRAM). |