

This is the Revision A version of the [LCD32 RoboBrick](#). The status of this project is [work in progress](#).

LCD32 Module (Revision D)

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1. Introduction

The LCD32 module can display a total 4 lines of 16 characters each, of which only 2 lines are visible at a time. The characters are displayed using a 5×7 dot matrix. There is a mechanical switch labeled LINES on the LCD32 module that switches between displaying lines 1–2 and lines 3–4. The LCD32 module is based upon the inexpensive Lumex[®] LCM–S01602DTR/M 2×16 liquid crystal display (LCD) module available from both Digikey[®] and Mouser[®]. The LCD32 module has a small trim potentiometer that allows you adjust the display contrast.

The LCD32 can be used in two ways:

User Mode

In user mode, the LCD32 is being used as an output device under user control. All serial data communication is between the master connected on N1 and the LCD32 module. In this mode, connectors N2 and N3 are left disconnected. A pull-up on one of the N2 connector pins allows the LCD32 module to determine that it is in this mode.

Debug Mode

In debug mode, the LCD32 module is inserted between a master brick and a slave brick. The master brick is connected on N1 and the slave brick is connected on N3. In addition, there is another connection from a "debug" port on the slave brick and connector N2 on the LCD32. In this mode, the master brick does not even know that the LCD32 is present. However, the slave brick can detect that LCD32 is present and output additional debugging information to the LCD32. There are two sub-modes of operation in this mode -- 1) slave sending data to the master and 2) slave sending data to the LCD32. The LCD32 module determines this by examining the "select" line on connector N2.

The various paths for serial data are summarized in the table below:

Description	Mode	Select	Master Out	Slave Out	LCD32 RX
	(S1)	(S0)	(N1–5)	(N3–4)	(U1–5)
Master to LCD32 (User Mode)	1	x	LCD32 TX (U1–6)	x (Master In) (N1–4)	Master In (N3–4)
Slave to LCD32 (Debug Mode)	0	1	idle (high)	Master In (N1–4)	Slave In (N3–5)

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Slave to Master (Debug Mode)	0	0	Slave In (N3–5)	Master In (N1–4)	idle (high)
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The LCD32 module is meant to be used in conjunction with the LCD32Holder (Rev. A) board which carries the actual LCM–201602DTR/M and plugs onto the top of the LCD32 module.

2. Programming

Command	Send/ Receive	Byte Value								Discussion
		7	6	5	4	3	2	1	0	
Back Space	Send	0	0	0	0	1	0	0	0	Move cursor to the left.
Line Feed	Send	0	0	0	0	1	0	1	0	Advance cursor to beginning of next line; clear the next line
Form Feed	Send	0	0	0	0	1	1	0	0	Clear entire display and place cursor at home
Carriage Return	Send	0	0	0	0	1	1	0	1	Return cursor to beginning of line
Character 32 to 63	Send	0	0	1	x	x	x	x	x	Enter the character on the display and advance cursor.
Character 64 to 127	Send	0	1	x	x	x	x	x	x	Enter the character on the display and advance cursor.
Line Set	Send	1	0	0	0	0	0	<i>l</i>	<i>l</i>	Move cursor to line <i>ll</i>
Line Clear	Send	1	0	0	0	0	1	<i>l</i>	<i>l</i>	Move cursor to line <i>ll</i> and clear it
Cursor Mode Set	Send	1	0	0	0	1	0	<i>v</i>	<i>b</i>	Cursor mode is set (<i>v</i> =1 visible cursor) (<i>b</i> =1 blinking cursor)
Cursor Mode Read	Send	1	0	0	0	1	1	0	0	Read cursor mode (<i>v</i> =1 visible cursor) (<i>b</i> =1 blinking cursor)
	Receive	0	0	0	0	0	0	<i>v</i>	<i>b</i>	
Character Read	Send	1	0	0	0	1	1	0	1	Read the current character <i>ccc cccc</i> ; advance cursor
	Receive	0	<i>c</i>	<i>c</i>	<i>c</i>	<i>c</i>	<i>c</i>	<i>c</i>	<i>c</i>	
Line Read	Send	1	0	0	0	1	1	1	0	Read the current line <i>ll</i>
	Receive	0	0	0	0	0	0	<i>l</i>	<i>l</i>	
Position Read	Send	1	0	0	0	1	1	1	1	Read the current character position <i>pppp</i>
	Receive	0	0	0	0	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	
Position Set	Send	1	0	0	1	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	Move cursor to character position <i>pppp</i>
Position Set	Send	1	0	1	0	<i>p</i>	<i>p</i>	<i>p</i>	<i>p</i>	Move cursor to character position <i>pppp</i> ; clear to end of line
Shared Commands	Send	1	1	1	1	1	<i>c</i>	<i>c</i>	<i>c</i>	Execute <u>shared command</u> <i>ccc</i> .

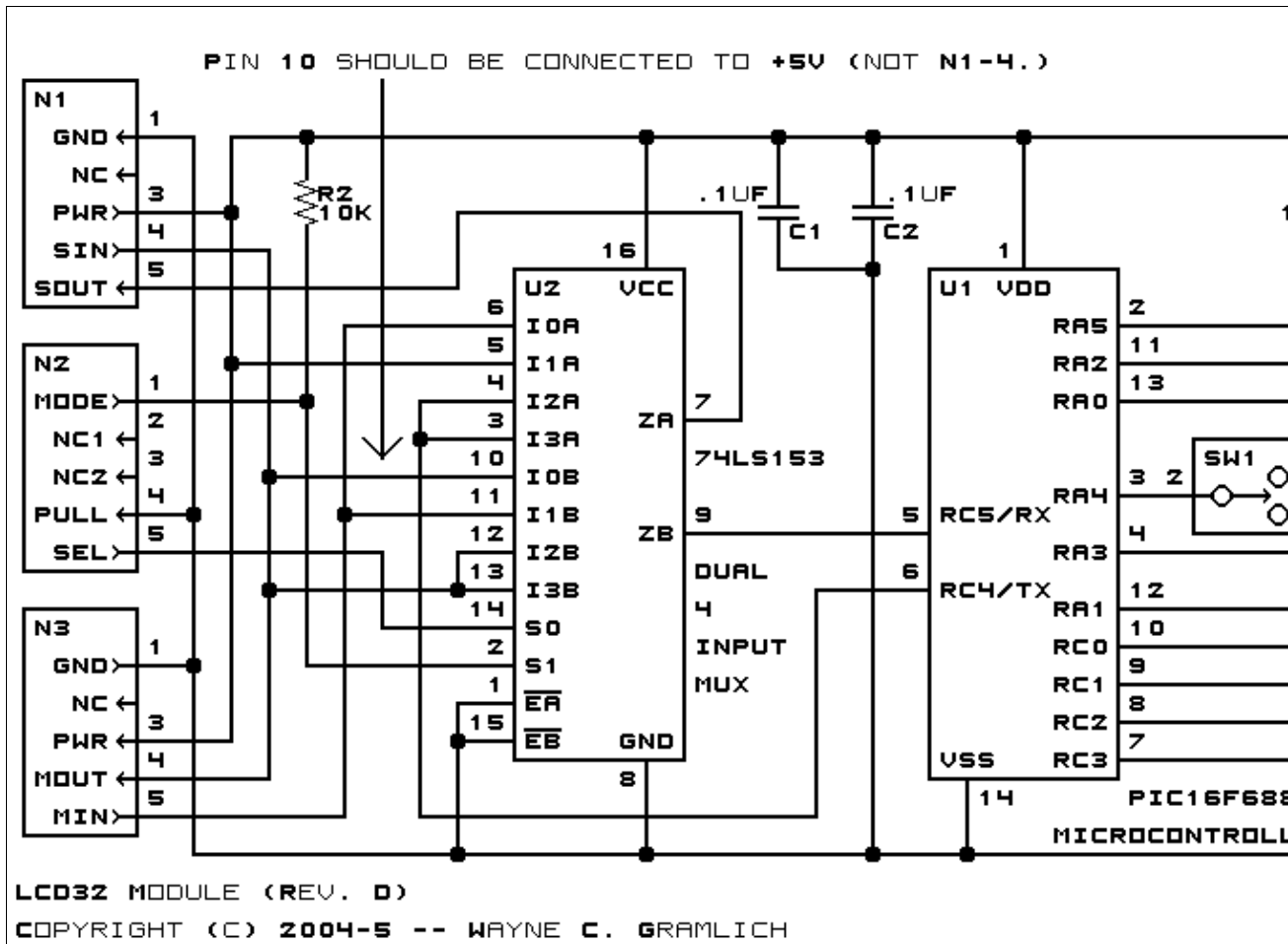
3. Hardware

The hardware consists of a circuit schematic and a printed circuit board.

3.1 Circuit Schematic

The schematic for the LCD32 RoboBrick is shown below:

LCD32 Module (Revision D)



The parts list kept in a separate file -- [lcd32.ptl](#).

3.2 Printed Circuit Board

The printed circuit board files are listed below:

[lcd32_back.png](#)

The solder side layer.

[lcd32_front.png](#)

The component side layer.

[lcd32_artwork.png](#)

The artwork layer.

[lcd32.gbl](#)

The RS-272X "Gerber" back (solder side) layer.

[lcd32.gtl](#)

The RS-272X "Gerber" top (component side) layer.

[lcd32.gal](#)

The RS-272X "Gerber" artwork layer.

[lcd32.drl](#)

The "Excellon" NC drill file.

[lcd32.tol](#)

The "Excellon" tool rack file.

4. Software

The LCD32 software is available as one of:

lcd32.ucl

The μ CL source file.

lcd32.asm

The resulting human readable PIC assembly file.

lcd32.lst

The resulting human readable PIC listing file.

lcd32.hex

The resulting Intel[®] Hex file.

5. Issues

The following fabrication issues need to be dealt with:

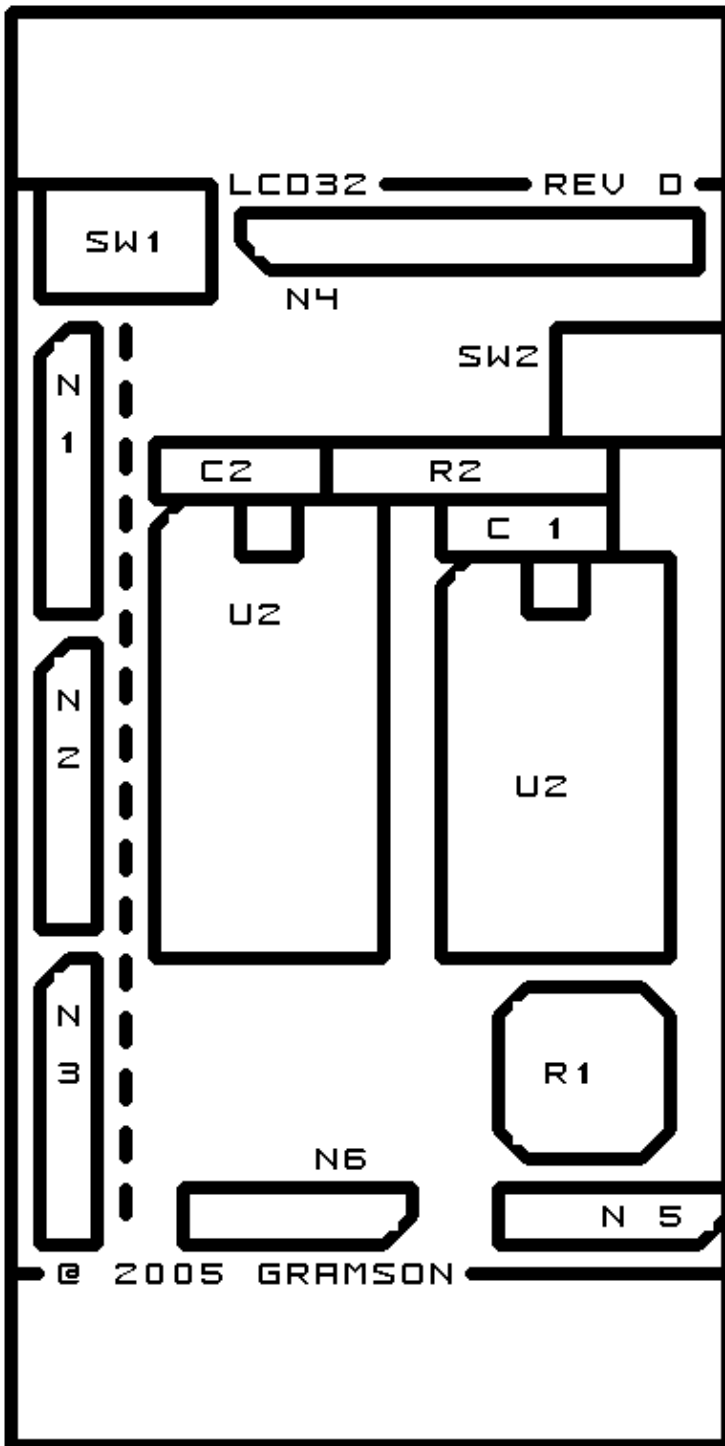
- Use a 74HC153 instead of a 74LS153. The leakage current drops 1V across the 10K resistor on all the debug ports.
- The switches are really inaccessible to human fingers. Perhaps move them to the "back" edge of the board.
- The trim pot is not accessible. Perhaps move it to where SW1 is.
- Pin 10 of the '153 needs to be connected to Vcc.

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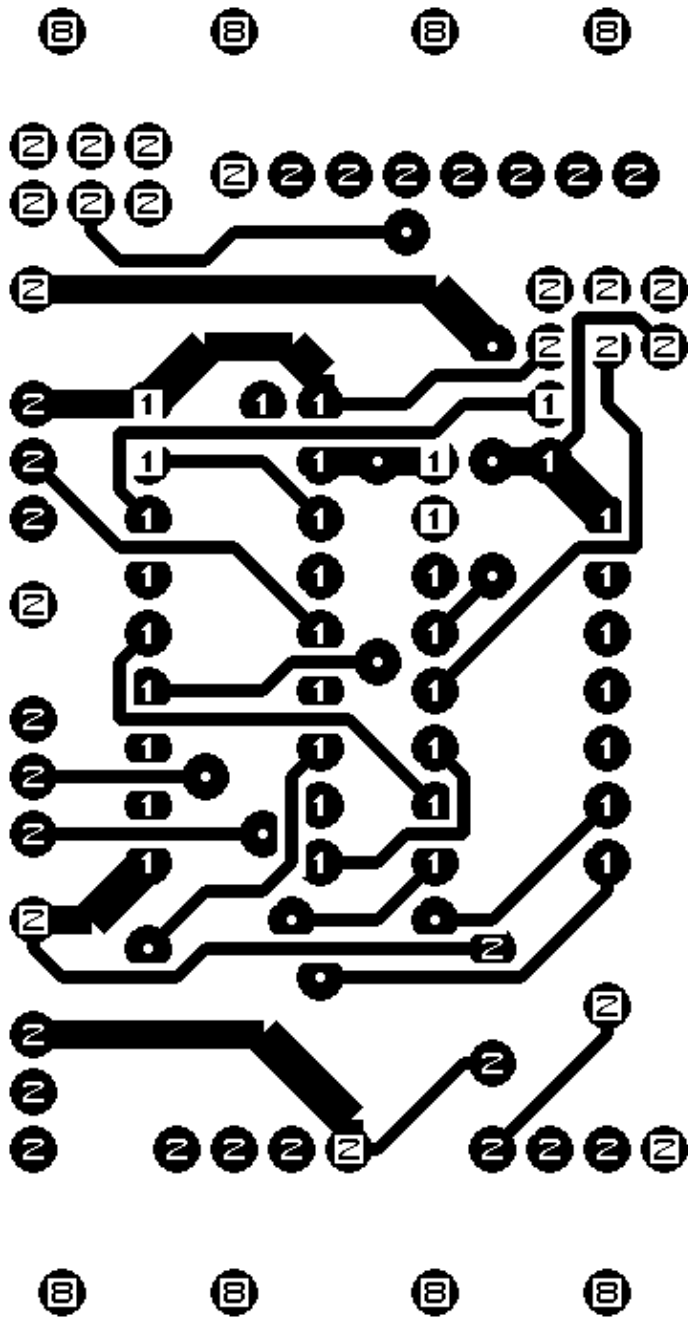
A. Appendix A: Parts List

```
# Parts list for LCD32 Module (Rev. D)
#
C1-2: Capacitor100nF - .1uF Capacitor [Jameco: 25524]
N1: Header1x5.Slave - 1x5 Male Header [5/40 Jameco: 160881]
N2: Header1x5.LCD32 - 1x5 Male Header [5/40 Jameco: 160881]
N3: Header1x5.Master - 1x5 Male Header [5/40 Jameco: 160881]
N4: Header1x8.LCD32 - 1x8 Male Header [8/40 Jameco: 160881]
N5: Header1x4.LCD32 - 1x4 Male Header [4/40 Jameco: 160881]
N6: Header1x4.LCD32 - 1x4 Male Header [4/40 Jameco: 160881]
R1: ResistorTrimPot10K - 10K Ohm Trim Pot [Digikey: D4AA14-ND]
R2: Resistor10K - 10K Ohm 1/4 Watt Resistor [Jameco: 29911]
SW1-2: SwitchSmallDPDT - Small DPDT Switch [Jameco: 161816]
U1: PIC16F688.LCD32 - Microchip PIC16F688 [Digikey: PIC16F688-I/P-ND]
U2: 74LS153 - Dual 4-Input Multiplexer [Jameco: 46720]
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B. Appendix B: Artwork Layer



C. Appendix C: Back (Solder Side) Layer



D. Appendix D: Front (Component Side) Layer

