ComputerVoltageSource LCD Software Guide
June 25, 2006

Overview
The ComputerVoltageSource LCD Support module provides control for a 2 row by 16 character LCD.

Display Commands
Character display operations are controlled through eighteen commands. These commands control the active display position where characters are written, whether the display overwrites previous characters or scrolls, selects the character set to be displayed, and clears the display. A cursor is not displayed since this requires a character position and reduces the number of displayed characters.

At power-on the LCD is set to overwrite mode, character set0, and displays the message:
```
ComputerVoltSrce
(c) D.Brown 2006
```

The first LCD display byte received will clear the display.

Control characters 0x08 to 0x1f implement the following display functions:
0x08: (backspace) Moves the active display position one backwards
0x09: (tab) Moves the active display position one forward
0x0a: (line feed) Clears the display and sets the active display position to beginning of line 1
0x0b: (vertical tab) Sets the active display position to beginning of line 2
0x0c: (form feed) Clears the display and sets the active display position to beginning of line 2
0x0d: (carriage return) Sets the active display position to beginning of line 1
0x0e: (shift out) Selects the lower characters set for display
0x0f: (shift in) Selects the upper characters set for display
0x10: Program Character0 <data>,<data> … <data> (8 bytes total)
0x11: Program Character1 <data>,<data> … <data> (8 bytes total)
0x12: Program Character2 <data>,<data> … <data> (8 bytes total)
0x13: Program Character3 <data>,<data> … <data> (8 bytes total)
0x14: Program Character4 <data>,<data> … <data> (8 bytes total)
0x15: Program Character5 <data>,<data> … <data> (8 bytes total)
0x16: Program Character6 <data>,<data> … <data> (8 bytes total)
0x17: Program Character7 <data>,<data> … <data> (8 bytes total)
0x18: Sets the display mode to overwrite; new characters overwrite previous
0x19: Sets the display mode to scroll; display scrolls for new characters
0x1a: Sets Absolute Position <data> (2 bytes total)
0x1b: Sets Relative Position <data> (2 bytes total)
0x1c: Reserved
0x1d: Reserved
0x1e: Reserved
0x1f: Write Message <data>,<data> … <data> (33 bytes total)

User-Programmable Characters
The display supports 8 user-programmable characters. These are selected by character codes 0x00 to 0x07. These characters have been pre-programmed with useful music characters and symbols and may be reprogrammed.

Default programmable characters	
0x00	Treble Clef
0x01	Bass Clef
0x02	Sharp symbol
0x03	Flat symbol
0x04	Natural symbol
0x05	Note symbol
0x06	dc (sideways for *decimal*)
0x07	hx (sideways for *hex*)

Default 5x7 programmable character font:

Control characters 0x10 to 0x18 define the user-programmable characters:
Each of the following eight byte control character programs a specific user programmable character independently:

Program Character	Programs character 0x00							
	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Byte 1	0	0	0	1	0	0	0	0
Byte 2	0	n/a	n/a	row7 b4	row7 b3	row7 b2	row7 b1	row7 b0
Byte 3	0	n/a	n/a	row6 b4	row6 b3	row6 b2	row6 b1	row6 b0
Byte 4	0	n/a	n/a	row5 b4	row5 b3	row5 b2	row5 b1	row5 b0
Byte 5	0	n/a	n/a	row4 b4	row4 b3	row4 b2	row4 b1	row4 b0
Byte 6	0	n/a	n/a	row3 b4	row3 b3	row3 b2	row3 b1	row3 b0
Byte 7	0	n/a	n/a	row2 b4	row2 b3	row2 b2	row2 b1	row2 b0
Byte 8	0	n/a	n/a	row1 b4	row1 b3	row1 b2	row1 b1	row1 b0

Program Character	Programs characters 0x00 – 0x07							
	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Byte 1	0	0	0	1	0	cc b2	cc b1	cc b0
Byte 2	0	n/a	n/a	row7 b4	row7 b3	row7 b2	row7 b1	row7 b0
Bytes 3 – 8 repeat as above for each character row								
Note: cc b2 – cc b0 specifies the user-programmed character at 0x00 to 0x07								

The 5x7 programmable character cell format is defined by the following table:

5 x 7 Character Cell Format					
	b4	b3	b2	b1	b0
row7	p	p	p	p	p
row6	p	p	p	p	p
row5	p	p	p	p	p
row4	p	p	p	p	p
row3	p	p	p	p	p
row2	p	p	p	p	p
row1	p	p	p	p	p
Note: pixel p displays if set to 1					

The Display Position command is a two byte sequence that will set an absolute or relative display position for the next character.

The absolute display position (0x0a) sets the position for the next character to be written in from the start of the display. The range is 0 – 31.

The relative display position (0x1b) sets the position for the next character to be written in from the current position. The range is 0-31. Numbers which are larger than the remaining characters in the display will wrap back to the beginning of the display. Thus 31 will move 1 position backwards to overwrite the last character. This is the same as -1 in two's compliment. MIDI data is 7 bits so -1 and must be coded as -1&$1f to strip off the upper bits. Scrolling, if enabled, will not occur until characters reach the end of the display.

Display Position	Sets active display position 0x1A, 0x1B							
	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Byte 1	0	0	0	1	1	0	1	d0
Byte 2	0	0	0	b4	b3	b2	b1	b0
d0=0 for absolute position, d0=1 for relative position								
Note: b4 –b0 specifies the display position value 0 - 31								

The Write Message command (0x1f) is a 33 byte sequence that will store a new power-on message in the eeprom. The 32 remaining bytes will be the display character codes starting from the first character. The first character must be non-zero to indicate that a valid message is saved in the eeprom. Programmed characters should not be used since the characters will not have yet been programmed by the microcontroller. Note that 8 bits may be used to access nearly all characters in the ROM font which does not conform to MIDI protocol for 7 bit data. Characters 0xf8 – 0xff are recognized as MIDI real-time messages and are ignored. A credit message will be displayed at the completion of the write message sequence and the microcontroller will restart. The MIDI sysex termination byte (0xf7) does not need to be sent and any data beyond 33 bytes will be ignored. Any message in eeprom may be cleared by writing a new message with a first byte of 0x00.

Characters
The following characters are supported using a Seiko Instruments L1672B1J000 LCD module:

Higher 4 Bits Lower 4 Bits	0010	0011	0100	0101	0110	0111	1010	1011	1100	1101	1110	1111
XXXX 0000												
XXXX 0001												
XXXX 0010												
XXXX 0011												
XXXX 0100												
XXXX 0101												
XXXX 0110												
XXXX 0111												
XXXX 1000												
XXXX 1001												
XXXX 1010												
XXXX 1011												
XXXX1100												
XXXX 1101												
XXXX 1110												
XXXX 1111												

Notes:

1. Characters 0x00 to 0x07 are user programmable
2. Characters 0x08 to 0x1f are reserved for LCD commands
3. Characters 0x80 to 0x9f are blank (e.g. space).
4. MIDI data is restricted to 7 bits. Character set0 mode adds the 8th bit as a 0 and character set1 mode adds the 8th bit as a 1. For example, in character set1 mode, 0x00 is changed to 0x80 and displays as a space, 0x74 is changed to 0xf4 and displays as a Ω.

Communications

The CVS communicates to the display through a MIDI sysex message. The MIDI sysex command consist of a message byte (0xf0) followed by the identification of the display (0x7d). All subsequent bytes will be routed to the display until a termination byte (0xf7) is received. Note that if MIDI out will not used the MIDI sysex does not ever need to be terminated. All MIDI messages excluding display messages will be routed to MIDI out. Any connected MIDI device will never be sent a display message. The LED will flash for each MIDI byte sent and can be used as a general MIDI traffic indicator.

Using MIDI sysex messages, the following AtomPro28 commands can be used:

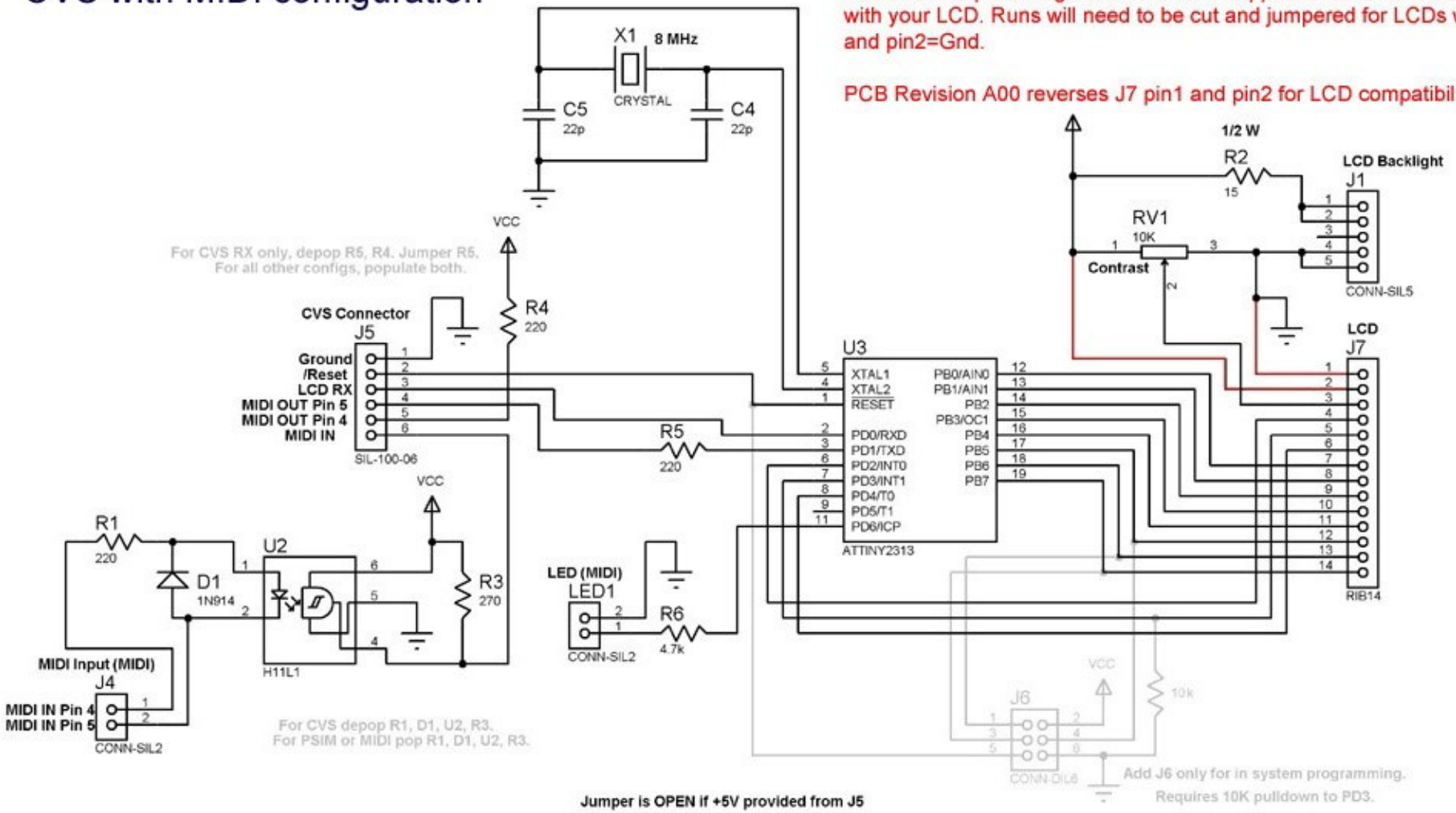
sethserial h31200,h8databits,hnoparity,h1stopbits
This statement initializes the hserial system for MIDI communications.

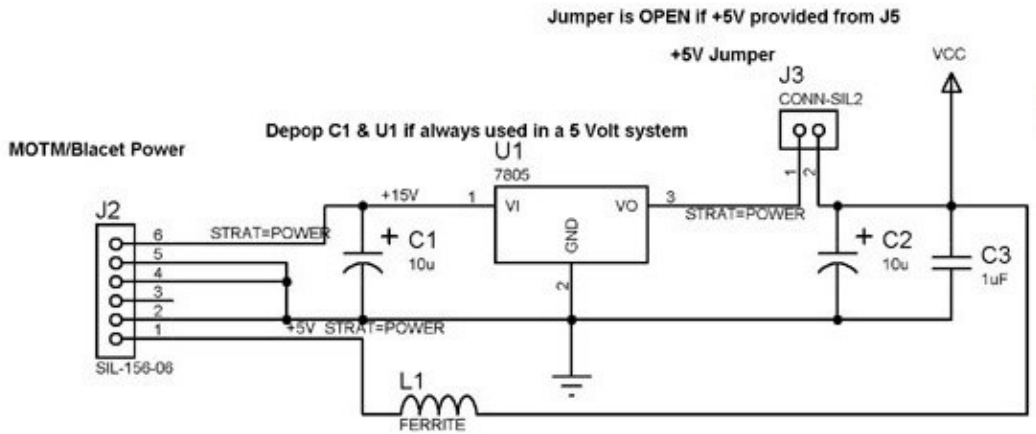
hserout [0xf0,0x7d,0x1e,0x1b,"Hello World",0xf7]
This statement clears the display, enables scrolling, and displays: `Hello World`

CVS with MIDI configuration

Note: The original PCB was routed with J7 pin1=Gnd and pin2=5 Volts. Most LCDs have a pin configuration that is the opposite. Be sure to check compatibility with your LCD. Runs will need to be cut and jumpered for LCDs with pin1=5 Volts and pin2=Gnd.

PCB Revision A00 reverses J7 pin1 and pin2 for LCD compatibility.





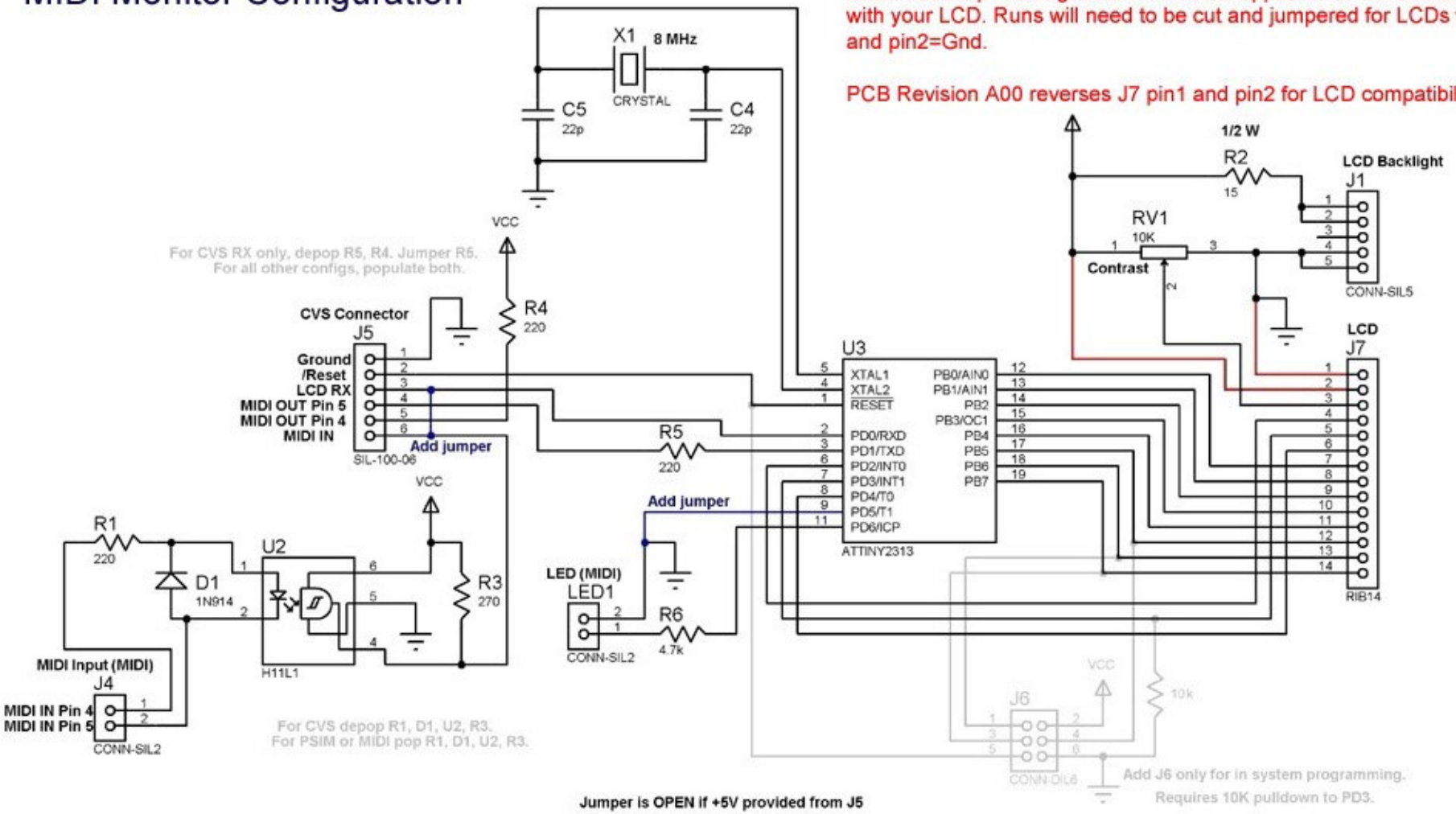
For 5 volt operation install L1 and remove J3 or delete U1 and C1
For 15 volt operation do not install L1

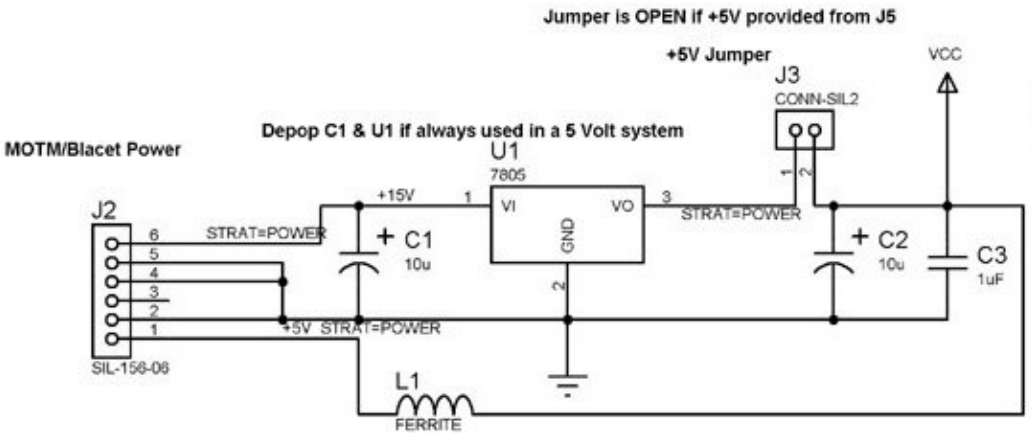
FILE NAME:	LCD_SUPPORT		7/15/2006
DESIGN TITLE:	LCD Support		PAGE: 1 of 1
PATH:	D:\My Schematics\Schematics\		TIME: 3:45:20 PM
BY:	John Loffink	REV: A	

MIDI Monitor Configuration

Note: The original PCB was routed with J7 pin1=Gnd and pin2=5 Volts. Most LCDs have a pin configuration that is the opposite. Be sure to check compatibility with your LCD. Runs will need to be cut and jumpered for LCDs with pin1=5 Volts and pin2=Gnd.

PCB Revision A00 reverses J7 pin1 and pin2 for LCD compatibility.





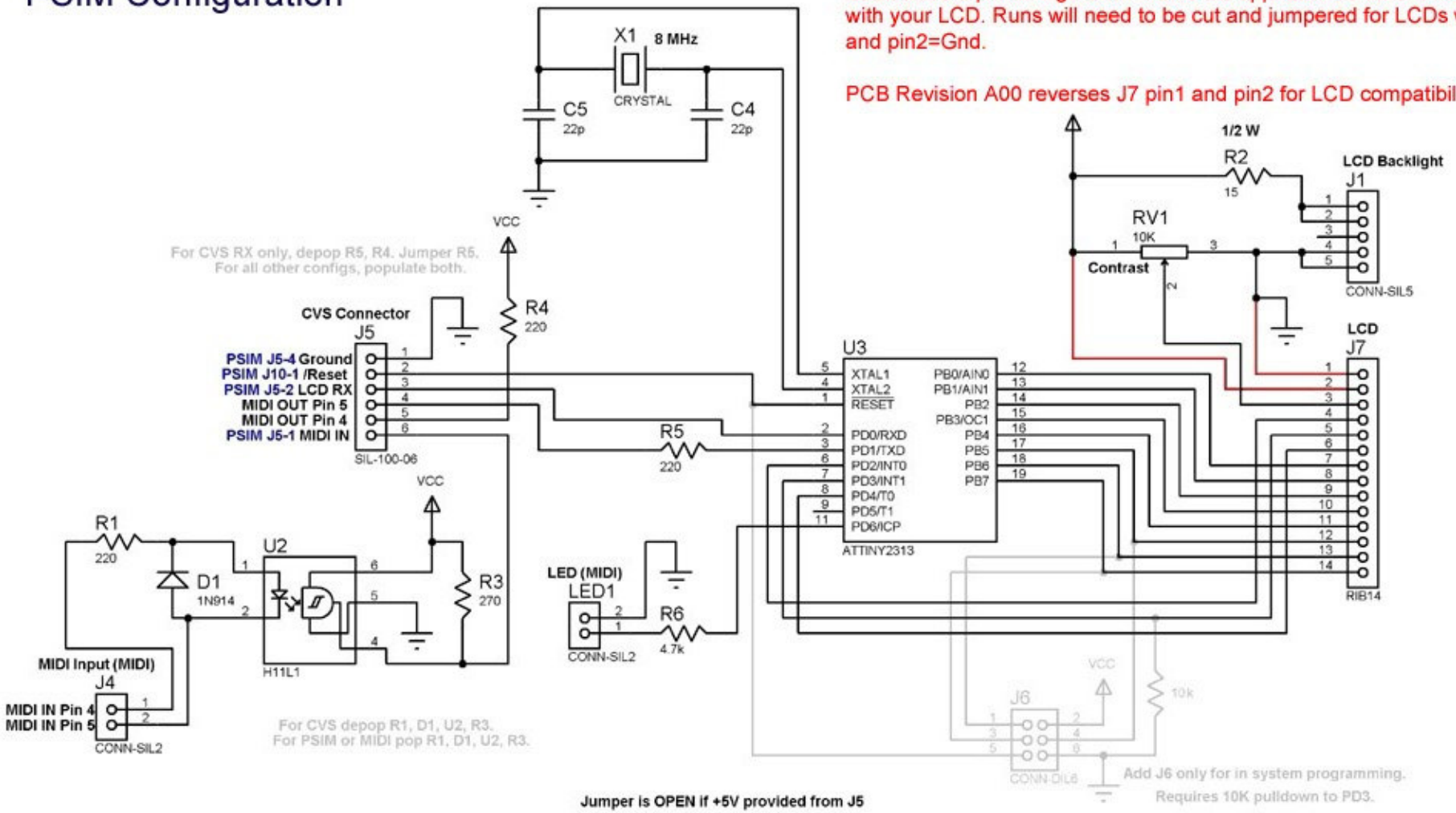
For 5 volt operation install L1 and remove J3 or delete U1 and C1
For 15 volt operation do not install L1

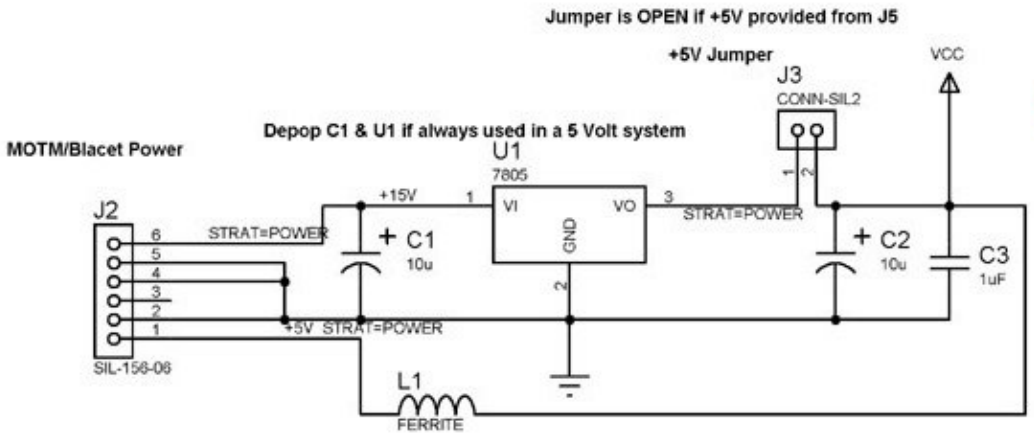
FILE NAME:	LCD_SUPPORT
DESIGN TITLE:	LCD Support
PATH:	D:\My Schematics\Schematics\
BY: John Loffink	REV: A
7/15/2006	
PAGE: 1 of 1	
TIME: 3:45:20 PM	

PSIM Configuration

Note: The original PCB was routed with J7 pin1=Gnd and pin2=5 Volts. Most LCDs have a pin configuration that is the opposite. Be sure to check compatibility with your LCD. Runs will need to be cut and jumpered for LCDs with pin1=5 Volts and pin2=Gnd.

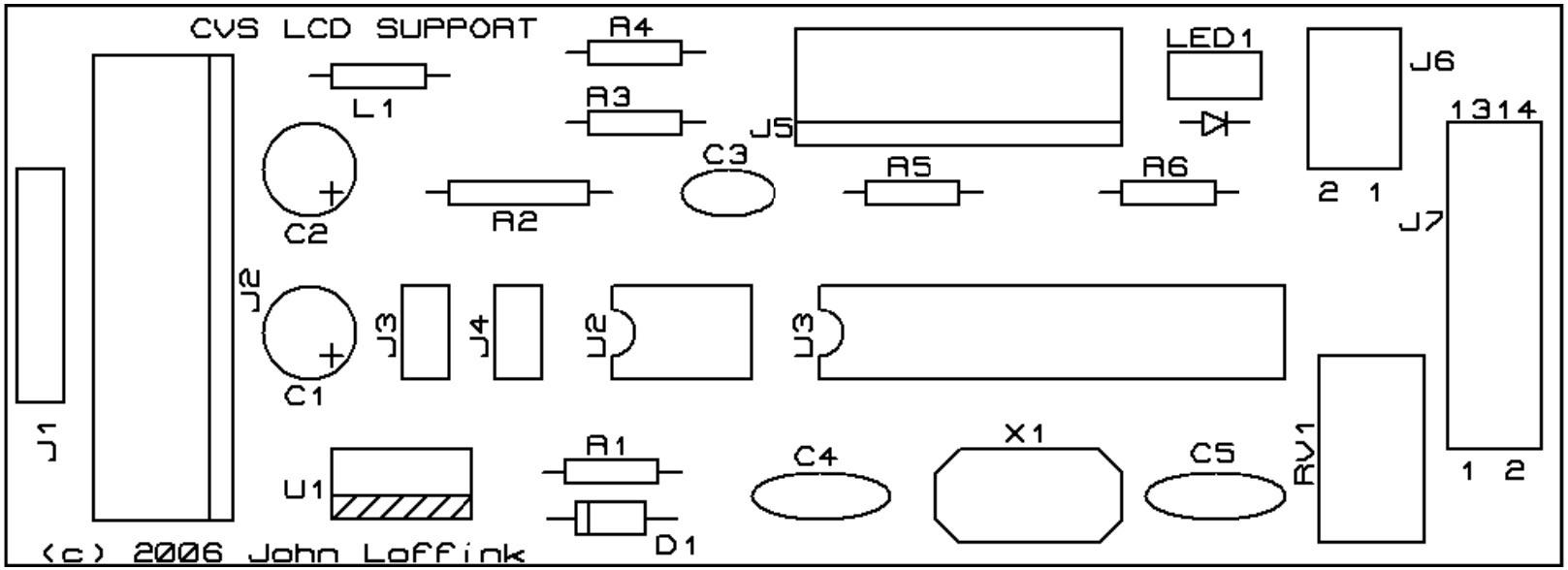
PCB Revision A00 reverses J7 pin1 and pin2 for LCD compatibility.





For 5 volt operation install L1 and remove J3 or delete U1 and C1
For 15 volt operation do not install L1

FILE NAME:	LCD_SUPPORT	7/15/2006
DESIGN TITLE:	LCD Support	PAGE: 1 of 1
PATH:	D:\My Schematics\Schematics\	
BY: John Loffink	REV: A	TIME: 3:45:20 PM


CVS LCD SUPPORT
R4
L1
R3
J5
LED1
J6
1 3 1 4
C3
R5
R6
2 1
C2
R2
J7
J2
J3
J4
U2
U3
C1
J1
U1
R1
C4
X1
C5
RV1
1 2
D1
(c) 2006 John Loffink

LCD_Support

You can build the LCD_Support in a single sequence.

1. Verify pin 1 and 2 power supply compatibility with your LCD display module and modify the PCB as required.

2. Install all parts.

3. Power up the LCD. Adjust RV1 until you see the default display message "ComputerVoltSrce (c) D.Brown 2006".

4. Temporarily connect U3 pin 9 to ground and connect J5 pin 3 to J5 pin 6. Cycle power and connect a MIDI instrument to MIDI input connector. The LCD should display the hex values of all MIDI data. Remove the temporary connections to U3 pin 9 and J5 pins 3 and 6.

Congratulations. Your LCD_Support module is built and verified.

David. J Brown
September 21, 2007

LAUNCH Groups

Name: LCD_Support FAQ

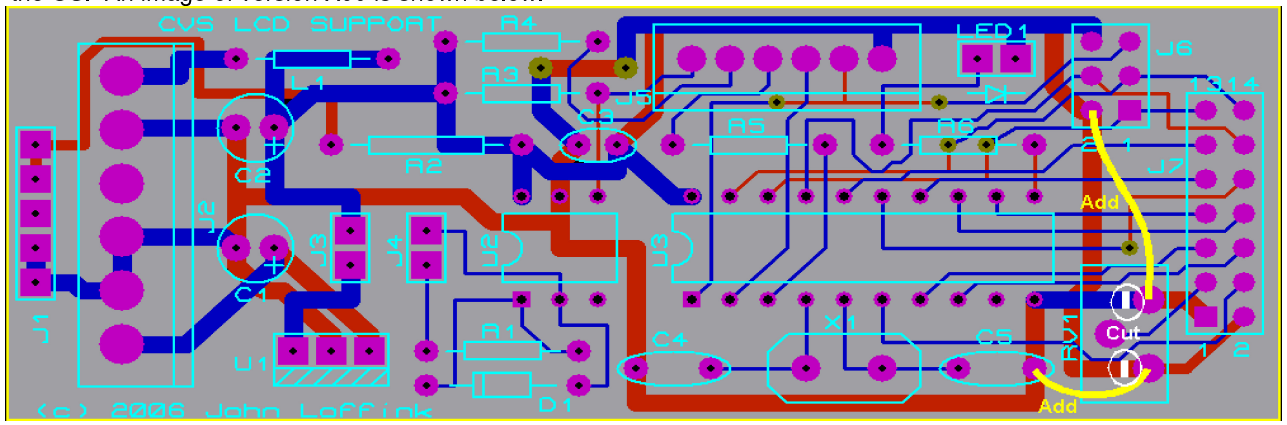
Table Description: LCD_Support PCB Build Guide

Tip	Description	Author
+5 or +15 power supply configuration	This module can be powered from either +5 volts or +15 volts (through regulator U1). If powered by +15 volts, a 4 pin MTA connector may be used, L1 not installed, and J3 replaced with a wire jumper. If +5 volts is used, C1 and U1 should not be installed or jumper J3 removed. For maximum flexibility, all components may be installed but be sure to remove jumper J3 if +5 volts is applied to J2.	Dave Brown
Assembled views	There are two photos of an assembled module. "LCD Support PCB Side" in the Photo Albums > LCD Support PCB folder and "CVS LCD assembly" in the Photo Albums > Dave Brown folder.	Dave Brown
Backlight current	The value of R2 may be chosen to vary the backlight brightness. A higher value resistor will lower the brightness and current to reduce power dissipation of U1 if powered from a +15 volt supply.	Dave Brown
Contrast adjustment	The contrast control works over the very end of the range. A power up message will be displayed (unless reprogrammed). Adjust the contrast control if no message is displayed.	Dave Brown
J1 / J7 installation	Remember that J1 and J7 are on the solder side (back) since the PCB mates on the back of the LCD module.	Dave Brown
J6 installation	The 2x3 pin J6 connector is only used for in-circuit programming of the AVR processor and may be not installed.	Dave Brown
LCD pinout compatibility (important)	The PCB was designed with J7-1=ground and J7-2=5 volts. Currently available LCD modules have these two pins reversed. You need to verify the pinout of the LCD module and verify compatibility with the LCD_Support PCB. Swapping these pins requires cutting and jumpering traces. This is described in the BOM.	Dave Brown
LED1 / R6	LED1 will blink for each byte of MIDI data that is passed through the LCD_Support module. MIDI sysex commands to control the display are not sent to MIDI out and will not blink the LED. R6 should be chosen for the appropriate brightness. Maximum current allowed is 10 mA.	Dave Brown
MIDI in / out configuration	This PCB supports MIDI input and output for the CVS. If this capability is not needed, do not install R1, R3, R4, R5, R6, D1, U2, and J4.	Dave Brown
PSIM configuration	To use this display with a PSIM, wire J5-1 to PSIM J5-4, J5-2 to PSIM J10-1, J5-3 to PSIM J5-2, J5-6 to PSIM J5-1. Wire J5-4 and J5-5 to the MIDI out connector if used. A schematic is in the LCD-support folder.	Dave Brown
Software guide	A complete software guide is in the LCD-support folder. This describes all operations and also how to reprogram the default power-on message.	Dave Brown
Stand alone MIDI monitor configuration	The LCD_Support module can operate as a stand-alone MIDI monitor displaying hex data. Wire J5-3 to J5-6 and ground pin 9 of U3. MIDI data received will be displayed in a scrolling format. A schematic is in the LCD-support folder	Dave Brown

Version Notes

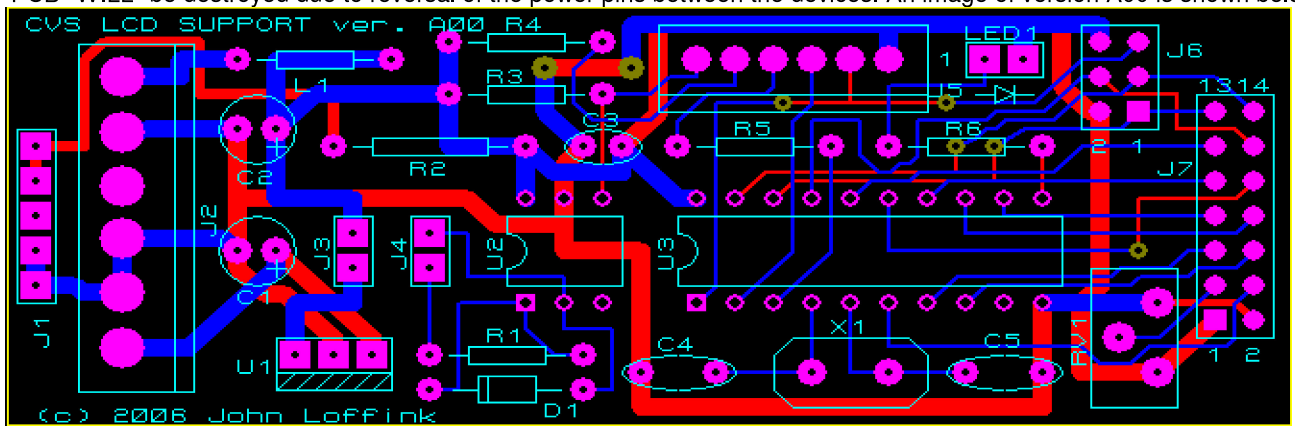
LCD Support PCB version X00

Version "X00" of the LCD Support PCB is labeled "CVS LCD SUPPORT." It requires modification if used with Lumex or Vishay/Dale LCDs. It does not require modification if used with a Seiko LCD, but these are no longer generally available in the US. An image of version X00 is shown below.



LCD Support PCB version A00

Version "A00" of the LCD Support PCB is labeled "CVS LCD SUPPORT ver. A00." It does not require modification if using Lumex or Vishay/Dale LCDs. *DO NOT* use Seiko LCDs with version A00. Both your LCD and parts on your LCD Support PCB *WILL* be destroyed due to reversal of the power pins between the devices. An image of version A00 is shown below.



Frac-Rac BOM Revision A00							
Reference Designator	**Description**	**Supplier**	**Supplier #**	**Quan.**	**Cost**	**Subtotal**	**Notes**
	LCD Support PCB						
R2	Resistor, 15 Ohm, 1/2 W	Mouser	293-15-RC	1	$0.0800	$0.08	May substitute 18, 22 or 24 ohm, may use 1/4 watt
R6	Resistor, 4.7K Carbon 5%	Mouser	291-4.7K-RC	1	$0.0700	$0.07	
C1,C2	Capacitor 10 uF 25V Electrolytic 5mm	Mouser	140-XRL25V10-RC	2	$0.0600	$0.12	
C3	Capacitor, 0.1 uF, X7R	Mouser	80-C320C104K5R	1	$0.1600	$0.16	
C4,C5	Capacitor, 22 pF ceramic	Mouser	140-50N5-220J	2	$0.0600	$0.12	
U1	IC, LM7805 Regulator	Mouser	511-L7805CV	1	$0.2400	$0.24	
U1 heatsink	Heatsink, AAVID TO-220 TR Hat Section	Mouser	532-507002B00	1	$0.2400	$0.24	
U1 mounting kit	Heatsink, AAVID mounting kit	Mouser	532-4880SG	1	$0.8100	$0.81	requires heatsink grease
U3 socket	IC Socket, 20 pin DIP	Mouser	575-199320	1	$0.7800	$0.78	
J1	Header, 5 pin 0.1" 0.318" Pin length	Mouser	571-1029765	1	$0.5500	$0.55	
J1 LCD	Socket, 5 pin 0.1" (1x50 cut to length) .276 height	Mouser	575-093050	1	$6.7700	$6.77	Cut/break to length, one 5 pin segment and two 6 or 7 pin segments
J2	MTA .156 4 pin header	Mouser	571-6404454	1	$0.1600	$0.16	4 pin MOTM/Blacet style power PCB connector
(J2)	MTA-156 receptacle dust cover	Mouser	571-6405514	2	$0.1800	$0.36	4 pin MOTM/Blacet style power cable connector
(J2)	MTA-156 locking receptacle for cable	Mouser	571-6404264	2	$0.3100	$0.62	4 pin MOTM/Blacet style power cable connector dust cover
(J2)	Dust cover for 6 pin 0.156" MTA, feed-thru	Mouser	571-6406436	1	$0.1500	$0.15	same as above
J3	Header, 2 pin 0.1"	Mouser	571-6404522	1	$0.2100	$0.21	
(J3)	Shunt, 2 pin, for headers	Mouser	517-952-10	1	$0.1500	$0.15	
J5	MTA 100 6 pin header	Mouser	571-6404546	1	$0.1700	$0.17	
(J5)	Mating connector 6 pin 0.1" MTA header, polarized	Mouser	571-6404416	2	$0.2400	$0.48	Only need one for PSIM, wires solder to PSIM
(J5)	Dust cover for 6 pin 0.1" MTA	Mouser	571-6405506	2	$0.2000	$0.40	same as above
J6	Header, 2x3 0.1", .230" post height	Mouser	571-1033283-3	1	$0.3000	$0.30	
J7	Header, 2x7 0.1", .318" post height	Mouser	571-1029777	1	$1.1100	$1.11	
L1	Ferrite Bead	Mouser	623-2743002112	1	$0.1200	$0.12	
RV1	Potentiometer, Vertical Trimmer, 10K, 10mm	Mouser	531-PTC10H-10K	1	$0.4700	$0.47	
X1	Crystal, 8 MHz	Mouser	520-HCU800-20X	1	$0.4600	$0.46	
	Standoff #2/56 x .375	Mouser	534-1797D	4	$0.8200	$3.28	
	Standoff #2/56 x .250	Mouser	534-1797B	4	$0.7600	$3.04	
	Standoff #2/56 x .187 (alt.)	Mouser	534-1797A	4	$0.7100	$2.84	
	Screw #2/56 1/4" Pan Head	Mouser	534-9355	4	$0.1000	$0.40	optional, kit contains 4 black 1/4" #2/56 screws
	Screw #2/56 3/4" Pan Head	Mouser	534-9357	4	$0.1400	$0.56	
	LCD, Lumex 16x2 LCD w/backlight	Mouser	696-LCM-S01602DSFC	1	$13.3600	$13.36	No modification necessary
	LCD, Vishay/Dale 16x2 LCD w/backlight	Mouser	71-L016N2DYYHET	0	$15.6200		No modification necessary
	TOTAL					**$38.58**	
	MIDI Version Only						
R1,R4,R5	Resistor, 220 Carbon 5%	Mouser	291-220-RC	3	$0.0700	$0.21	
R3	Resistor, 270 Carbon 5%	Mouser	291-270-RC	1	$0.0700	$0.07	
D1	Diode, 1N914/1N4148	Mouser	78-1N914	1	$0.0210	$0.02	
U2	Optocoupler, H11L1	Mouser	512-H11L1M	1	$1.2900	$1.29	
U2 socket	IC Socket, 6 pins	Mouser	571-1825093-1	1	$0.4200	$0.42	
MIDI Jacks	Connector, 5 pin DIN	Mouser	16HR655	2	$5.0400	$10.08	MIDI connector nice quality no front panel screws
	TOTAL					**$12.09**	
MIDI Jacks	Connector, 5 pin DIN, Kobiconn panel mount	Mouser	161-0005	2	$0.6800	$1.36	alternate part - inexpensive MIDI connector with front panel screws

MOTM BOM Revision A00							
Reference Designator	**Description**	**Supplier**	**Supplier #**	**Quan.**	**Cost**	**Subtotal**	**Notes**
	LCD Support PCB						
R2	Resistor, 15 Ohm, 1/2 W	Mouser	293-15-RC	1	$0.0800	$0.08	May substitute 18, 22 or 24 ohm, may use 1/4 watt
R6	Resistor, 4.7K Carbon 5%	Mouser	291-4.7K-RC	1	$0.0700	$0.07	
C1,C2	Capacitor 10 uF 25V Electrolytic 5mm	Mouser	140-XRL25V10-RC	2	$0.0600	$0.12	
C3	Capacitor, 0.1 uF, X7R	Mouser	80-C320C104K5R	1	$0.1600	$0.16	
C4,C5	Capacitor, 22 pF ceramic	Mouser	140-50N5-220J	2	$0.0600	$0.12	
U1	IC, LM7805 Regulator	Mouser	511-L7805CV	1	$0.2400	$0.24	
U1 heatsink	Heatsink, AAVID TO-220 TR Hat Section	Mouser	532-507002B00	1	$0.2400	$0.24	
U1 mounting kit	Heatsink, AAVID mounting kit	Mouser	532-4880SG	1	$0.8100	$0.81	requires heatsink grease
U3 socket	IC Socket, 20 pin DIP	Mouser	575-199320	1	$0.7800	$0.78	
J1	Header, 5 pin 0.1" 0.230" pin length	Mouser	571-1031855	1	$0.4600	$0.46	
J1 LCD	Socket, 5 pin 0.1" (1x50 cut to length) .276 height	Mouser	575-093050	1	$6.7700	$6.77	Cut/break to length, one 5 pin segment and two 6 or 7 pin segments
J2	MTA 156 6 pin header	Mouser	571-6404456	1	$0.2000	$0.20	6 pin power connector - see alternate below for 4 pins
(J2)	Mating Connector, 6 pin 0.156" MTA, polarized	Mouser	571-6404266	2	$0.3000	$0.60	Cable connector for MOTM 6 pin power
(J2)	Dust cover for 6 pin 0.156" MTA	Mouser	571-6405516	2	$0.2300	$0.46	Cable Connector for MOTM 6 pin power
(J2)	Mating connector, 6 pin 0.156" MTA, polarized, feed thru	Mouser	571-6405996	1	$0.3000	$0.30	Not needed for PSIM version, use for daisy chaining CVS power
(J2)	Dust cover for 6 pin 0.156" MTA, feed-thru	Mouser	571-6406436	1	$0.1500	$0.15	same as above
J3	Header, 2 pin 0.1"	Mouser	571-6404522	1	$0.2100	$0.21	
(J3)	Shunt, 2 pin, for headers	Mouser	517-952-10	1	$0.1500	$0.15	
J5	MTA 100 6 pin header	Mouser	571-6404546	1	$0.1700	$0.17	
(J5)	Mating connector 6 pin 0.1" MTA header, polarized	Mouser	571-6404416	2	$0.2400	$0.48	Only need one for PSIM, wires solder to PSIM
(J5)	Dust cover for 6 pin 0.1" MTA	Mouser	571-6405506	2	$0.2000	$0.40	same as above
J6	Header, 2x3 0.1", .230" post height	Mouser	571-1033283-3	1	$0.3000	$0.30	
J7	Header, 2x7 0.1", .230" post height	Mouser	571-1032407	1	$1.0500	$1.05	
L1	Ferrite Bead	Mouser	623-2743002112	1	$0.1200	$0.12	
RV1	Potentiometer, Vertical Trimmer, 10K, 10mm	Mouser	531-PTC10H-10K	1	$0.4700	$0.47	
X1	Crystal, 8 MHz	Mouser	520-HCU800-20X	1	$0.4600	$0.46	
	Standoff #2/56 x .375	Mouser	534-1797D	8	$0.8200	$6.56	
	Screw #2/56 1/4" Pan Head	Mouser	534-9355	4	$0.1000	$0.40	optional, kit contains 4 black 1/4" #2/56 screws
	Screw #2/56 3/4" Pan Head	Mouser	534-9357	4	$0.1400	$0.56	
	LCD, Lumex 16x2 LCD w/backlight	Mouser	696-LCM-S01602DSFC	1	$13.3600	$13.36	REQUIRES MODIFICATION TO BOARD, SEE DIRECTIONS
	LCD, Vishay/Dale 16x2 LCD w/backlight	Mouser	71-L016N2DYYHET	0	$15.6200		Alternate LCD, REQUIRES MODIFICATION TO BOARD
	LCD, Seiko 16x2 LCD w/backlight	Mouser	628-L1672B1J	0	$18.9000	$0.00	No longer available from US Distribution, no LCD Support PCB modification necessary
	LCD, Seiko 16x2 LCD w/backlight		M1632	0	$18.9000	$0.00	No longer available from US Distribution, no LCD Support PCB modification necessary
	TOTAL					**$36.25**	
J2	MTA .156 4 pin header	Mouser	571-6404454	1	$0.1600	$0.16	alternate part - 4 pin MOTM/Blacet style power PCB connector
(J2)	MTA-156 receptacle dust cover	Mouser	571-6405514	2	$0.1800	$0.36	alternate part - 4 pin MOTM/Blacet style power cable connector
(J2)	MTA-156 locking receptacle for cable	Mouser	571-6404264	2	$0.3100	$0.62	alternate part - 4 pin MOTM/Blacet style power cable connector dust cover
	MIDI Version Only						
R1,R4,R5	Resistor, 220 Carbon 5%	Mouser	291-220-RC	3	$0.0700	$0.21	
R3	Resistor, 270 Carbon 5%	Mouser	291-270-RC	1	$0.0700	$0.07	
D1	Diode, 1N914/1N4148	Mouser	78-1N914	1	$0.0210	$0.02	
U2	Optocoupler, H11L1	Mouser	512-H11L1M	1	$1.2900	$1.29	
U2 socket	IC Socket, 6 pins	Mouser	571-1825093-1	1	$0.4200	$0.42	
MIDI Jacks	Connector, 5 pin DIN	Mouser	16HR655	2	$5.0400	$10.08	MIDI connector nice quality no front panel screws
	TOTAL					**$12.09**	
MIDI Jacks	Connector, 5 pin DIN, Kobiconn panel mount	Mouser	161-0005	2	$0.6800	$1.36	alternate part - inexpensive MIDI connector with front panel screws

Frac-Rack BOM Revision X00

Reference Designator	Description	Supplier	Supplier #	Quan.	Cost	Subtotal	Notes
	LCD Support PCB						
R2	Resistor, 15 Ohm, 1/2 W	Mouser	293-15-RC	1	$0.0800	$0.08	May substitute 18, 22 or 24 ohm, may use 1/4 watt
R6	Resistor, 4.7K Carbon 5%	Mouser	291-4.7K-RC	1	$0.0700	$0.07	
C1,C2	Capacitor 10 uF 25V Electrolytic 5mm	Mouser	140-XRL25V10-RC	2	$0.0600	$0.12	
C3	Capacitor, 0.1 uF, X7R	Mouser	80-C320C104K5R	1	$0.1600	$0.16	
C4,C5	Capacitor, 22 pF ceramic	Mouser	140-50N5-220J	2	$0.0600	$0.12	
U1	IC, LM7805 Regulator	Mouser	511-L7805CV	1	$0.2400	$0.24	
U1 heatsink	Heatsink, AAVID TO-220 TR Hat Section	Mouser	532-507002B00	1	$0.2400	$0.24	
U1 mounting kit	Heatsink, AAVID mounting kit	Mouser	532-4880SG	1	$0.8100	$0.81	requires heatsink grease
U3 socket	IC Socket, 20 pin DIP	Mouser	575-199320	1	$0.7800	$0.78	
J1	Header, 5 pin 0.1" 0.318" Pin length	Mouser	571-1029765	1	$0.5500	$0.55	
J1 LCD	Socket, 5 pin 0.1" (1x50 cut to length) .276 height	Mouser	575-093050	1	$6.7700	$6.77	Cut/break to length, one 5 pin segment and two 6 or 7 pin segments
J2	MTA .156 4 pin header	Mouser	571-6404454	1	$0.1600	$0.16	4 pin MOTM/Blacet style power PCB connector
(J2)	MTA-156 receptacle dust cover	Mouser	571-6405514	2	$0.1800	$0.36	4 pin MOTM/Blacet style power cable connector
(J2)	MTA-156 locking receptacle for cable	Mouser	571-6404264	2	$0.3100	$0.62	4 pin MOTM/Blacet style power cable connector dust cover
(J2)	Dust cover for 6 pin 0.156" MTA, feed-thru	Mouser	571-6406436	1	$0.1500	$0.15	same as above
J3	Header, 2 pin 0.1"	Mouser	571-6404522	1	$0.2100	$0.21	
(J3)	Shunt, 2 pin, for headers	Mouser	517-952-10	1	$0.1500	$0.15	
J5	MTA 100 6 pin header	Mouser	571-6404546	1	$0.1700	$0.17	
(J5)	Mating connector 6 pin 0.1" MTA header, polarized	Mouser	571-6404416	2	$0.2400	$0.48	Only need one for PSIM, wires solder to PSIM
(J5)	Dust cover for 6 pin 0.1" MTA	Mouser	571-6405506	2	$0.2000	$0.40	same as above
J6	Header, 2x3 0.1", .230" post height	Mouser	571-1033283-3	1	$0.3000	$0.30	
J7	Header, 2x7 0.1", .318" post height	Mouser	571-1029777	1	$1.1100	$1.11	
L1	Ferrite Bead	Mouser	623-2743002112	1	$0.1200	$0.12	
RV1	Potentiometer, Vertical Trimmer, 10K, 10mm	Mouser	531-PTC10H-10K	1	$0.4700	$0.47	
X1	Crystal, 8 MHz	Mouser	520-HCU800-20X	1	$0.4600	$0.46	
	Standoff #2/56 x .375	Mouser	534-1797D	4	$0.8200	$3.28	
	Standoff #2/56 x .250	Mouser	534-1797B	4	$0.7600	$3.04	
	Standoff #2/56 x .187 (alt.)	Mouser	534-1797A	4	$0.7100	$2.84	
	Screw #2/56 1/4" Pan Head	Mouser	534-9355	4	$0.1000	$0.40	optional, kit contains 4 black 1/4" #2/56 screws
	Screw #2/56 3/4" Pan Head	Mouser	534-9357	4	$0.1400	$0.56	
	LCD, Lumex 16x2 LCD w/backlight	Mouser	696-LCM-S01602DSFC	1	$13.3600	$13.36	REQUIRES MODIFICATION TO BOARD, SEE DIRECTIONS
	LCD, Vishay/Dale 16x2 LCD w/backlight	Mouser	71-L016N2DYYHET	0	$15.6200		Alternate LCD, REQUIRES MODIFICATION TO BOARD
	LCD, Seiko 16x2 LCD w/backlight	Mouser	628-L1672B1J	0	$18.9000	$0.00	No longer available from US Distribution, no LCD Support PCB modification necessary
	LCD, Seiko 16x2 LCD w/backlight		M1632	0	$18.9000	$0.00	No longer available from US Distribution, no LCD Support PCB modification necessary
	TOTAL					**$38.58**	
	MIDI Version Only						
R1,R4,R5	Resistor, 220 Carbon 5%	Mouser	291-220-RC	3	$0.0700	$0.21	
R3	Resistor, 270 Carbon 5%	Mouser	291-270-RC	1	$0.0700	$0.07	
D1	Diode, 1N914/1N4148	Mouser	78-1N914	1	$0.0210	$0.02	
U2	Optocoupler, H11L1	Mouser	512-H11L1M	1	$1.2900	$1.29	
U2 socket	IC Socket, 6 pins	Mouser	571-1825093-1	1	$0.4200	$0.42	
MIDI Jacks	Connector, 5 pin DIN	Mouser	16HR655	2	$5.0400	$10.08	MIDI connector nice quality no front panel screws
	TOTAL					**$12.09**	
MIDI Jacks	Connector, 5 pin DIN, Kobiconn panel mount	Mouser	161-0005	2	$0.6800	$1.36	alternate part - inexpensive MIDI connector with front panel screws

MOTM BOM Revision X00

Reference Designator	Description	Supplier	Supplier #	Quan.	Cost	Subtotal	Notes
	LCD Support PCB						
R2	Resistor, 15 Ohm, 1/2 W	Mouser	293-15-RC	1	$0.0800	$0.08	May substitute 18, 22 or 24 ohm, may use 1/4 watt
R6	Resistor, 4.7K Carbon 5%	Mouser	291-4.7K-RC	1	$0.0700	$0.07	
C1,C2	Capacitor 10 uF 25V Electrolytic 5mm	Mouser	140-XRL25V10-RC	2	$0.0600	$0.12	
C3	Capacitor, 0.1 uF, X7R	Mouser	80-C320C104K5R	1	$0.1600	$0.16	
C4,C5	Capacitor, 22 pF ceramic	Mouser	140-50N5-220J	2	$0.0600	$0.12	
U1	IC, LM7805 Regulator	Mouser	511-L7805CV	1	$0.2400	$0.24	
U1 heatsink	Heatsink, AAVID TO-220 TR Hat Section	Mouser	532-507002B00	1	$0.2400	$0.24	
U1 mounting kit	Heatsink, AAVID mounting kit	Mouser	532-4880SG	1	$0.8100	$0.81	requires heatsink grease
U3 socket	IC Socket, 20 pin DIP	Mouser	575-199320	1	$0.7800	$0.78	
J1	Header, 5 pin 0.1" 0.230" pin length	Mouser	571-1031855	1	$0.4600	$0.46	
J1 LCD	Socket, 5 pin 0.1" (1x50 cut to length) .276 height	Mouser	575-093050	1	$6.7700	$6.77	Cut/break to length, one 5 pin segment and two 6 or 7 pin segments
J2	MTA 156 6 pin header	Mouser	571-6404456	1	$0.2000	$0.20	6 pin power connector - see alternate below for 4 pins
(J2)	Mating Connector, 6 pin 0.156" MTA, polarized	Mouser	571-6404266	2	$0.3000	$0.60	Cable connector for MOTM 6 pin power
(J2)	Dust cover for 6 pin 0.156" MTA	Mouser	571-6405516	2	$0.2300	$0.46	Cable Connector for MOTM 6 pin power
(J2)	Mating connector, 6 pin 0.156" MTA, polarized, feed thru	Mouser	571-6405996	1	$0.3000	$0.30	Not needed for PSIM version, use for daisy chaining CVS power
(J2)	Dust cover for 6 pin 0.156" MTA, feed-thru	Mouser	571-6406436	1	$0.1500	$0.15	same as above
J3	Header, 2 pin 0.1"	Mouser	571-6404522	1	$0.2100	$0.21	
(J3)	Shunt, 2 pin, for headers	Mouser	517-952-10	1	$0.1500	$0.15	
J5	MTA 100 6 pin header	Mouser	571-6404546	1	$0.1700	$0.17	
(J5)	Mating connector 6 pin 0.1" MTA header, polarized	Mouser	571-6404416	2	$0.2400	$0.48	Only need one for PSIM, wires solder to PSIM
(J5)	Dust cover for 6 pin 0.1" MTA	Mouser	571-6405506	2	$0.2000	$0.40	same as above
J6	Header, 2x3 0.1", .230" post height	Mouser	571-1033283-3	1	$0.3000	$0.30	
J7	Header, 2x7 0.1", .230" post height	Mouser	571-1032407	1	$1.0500	$1.05	
L1	Ferrite Bead	Mouser	623-2743002112	1	$0.1200	$0.12	
RV1	Potentiometer, Vertical Trimmer, 10K, 10mm	Mouser	531-PTC10H-10K	1	$0.4700	$0.47	
X1	Crystal, 8 MHz	Mouser	520-HCU800-20X	1	$0.4600	$0.46	
	Standoff #2/56 x .375	Mouser	534-1797D	8	$0.8200	$6.56	
	Screw #2/56 1/4" Pan Head	Mouser	534-9355	4	$0.1000	$0.40	optional, kit contains 4 black 1/4" #2/56 screws
	Screw #2/56 3/4" Pan Head	Mouser	534-9357	4	$0.1400	$0.56	
	LCD, Lumex 16x2 LCD w/backlight	Mouser	696-LCM-S01602DSFC	1	$13.3600	$13.36	REQUIRES MODIFICATION TO BOARD, SEE DIRECTIONS
	LCD, Vishay/Dale 16x2 LCD w/backlight	Mouser	71-L016N2DYYHET	0	$15.6200		Alternate LCD, REQUIRES MODIFICATION TO BOARD
	LCD, Seiko 16x2 LCD w/backlight	Mouser	628-L1672B1J	0	$18.9000	$0.00	No longer available from US Distribution, no LCD Support PCB modification necessary
	LCD, Seiko 16x2 LCD w/backlight		M1632	0	$18.9000	$0.00	No longer available from US Distribution, no LCD Support PCB modification necessary
	TOTAL					**$36.25**	
J2	MTA .156 4 pin header	Mouser	571-6404454	1	$0.1600	$0.16	alternate part - 4 pin MOTM/Blacet style power PCB connector
(J2)	MTA-156 receptacle dust cover	Mouser	571-6405514	2	$0.1800	$0.36	alternate part - 4 pin MOTM/Blacet style power cable connector
(J2)	MTA-156 locking receptacle for cable	Mouser	571-6404264	2	$0.3100	$0.62	alternate part - 4 pin MOTM/Blacet style power cable connector dust cover
	MIDI Version Only						
R1,R4,R5	Resistor, 220 Carbon 5%	Mouser	291-220-RC	3	$0.0700	$0.21	
R3	Resistor, 270 Carbon 5%	Mouser	291-270-RC	1	$0.0700	$0.07	
D1	Diode, 1N914/1N4148	Mouser	78-1N914	1	$0.0210	$0.02	
U2	Optocoupler, H11L1	Mouser	512-H11L1M	1	$1.2900	$1.29	
U2 socket	IC Socket, 6 pins	Mouser	571-1825093-1	1	$0.4200	$0.42	
MIDI Jacks	Connector, 5 pin DIN	Mouser	16HR655	2	$5.0400	$10.08	MIDI connector nice quality no front panel screws
	TOTAL					**$12.09**	
MIDI Jacks	Connector, 5 pin DIN, Kobiconn panel mount	Mouser	161-0005	2	$0.6800	$1.36	alternate part - inexpensive MIDI connector with front panel screws

Board Modificiations Revsion X00

The power and ground to the LCD are wired backwards on the LCD Support PCB for certain LCDs. You must correct for this or you will destroy the LCD!!! This applies to the Lumex and Vishay/Dale 16x2 LCDs. Seiko LCDs are wired correctly, but are no longer available from US distributors.
This modification is required for:

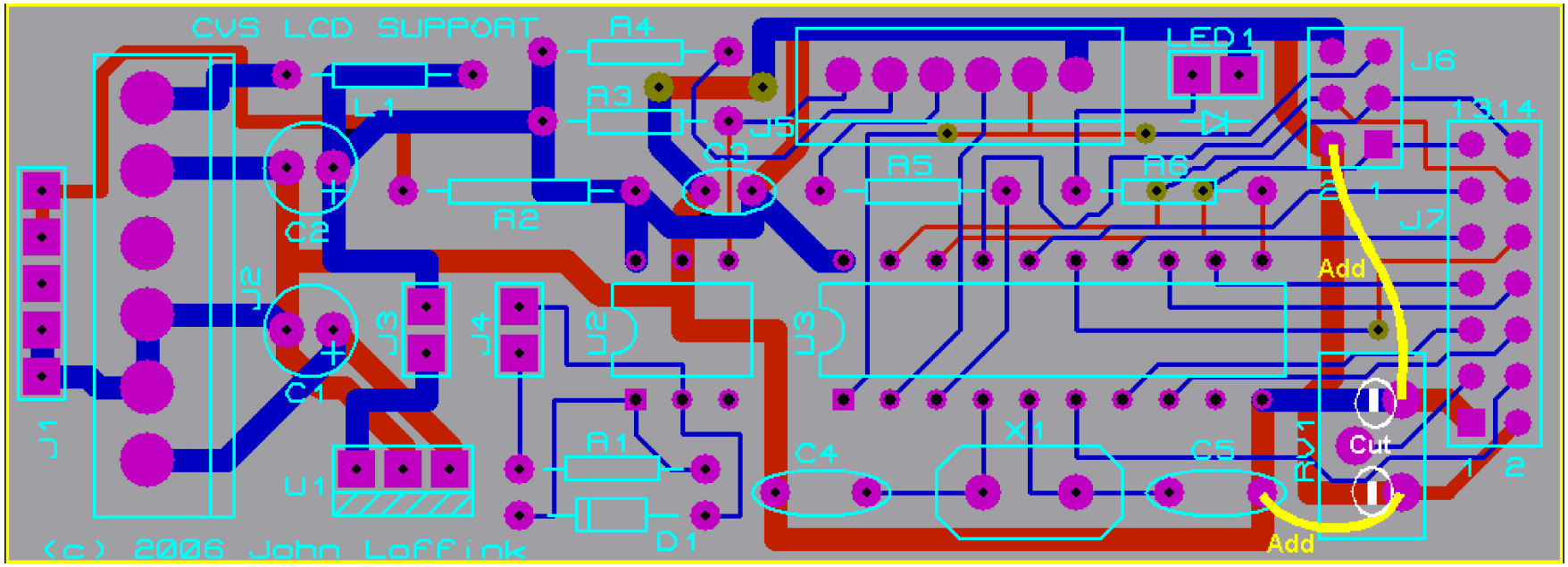
* Lumex LCM-S01602DSF/C (Mouser part number 696-LCM-S01602DSFC)
* Vishay/Dale L016N002DYYHET0000 (Mouser part number 71-L016N2DYYHET)

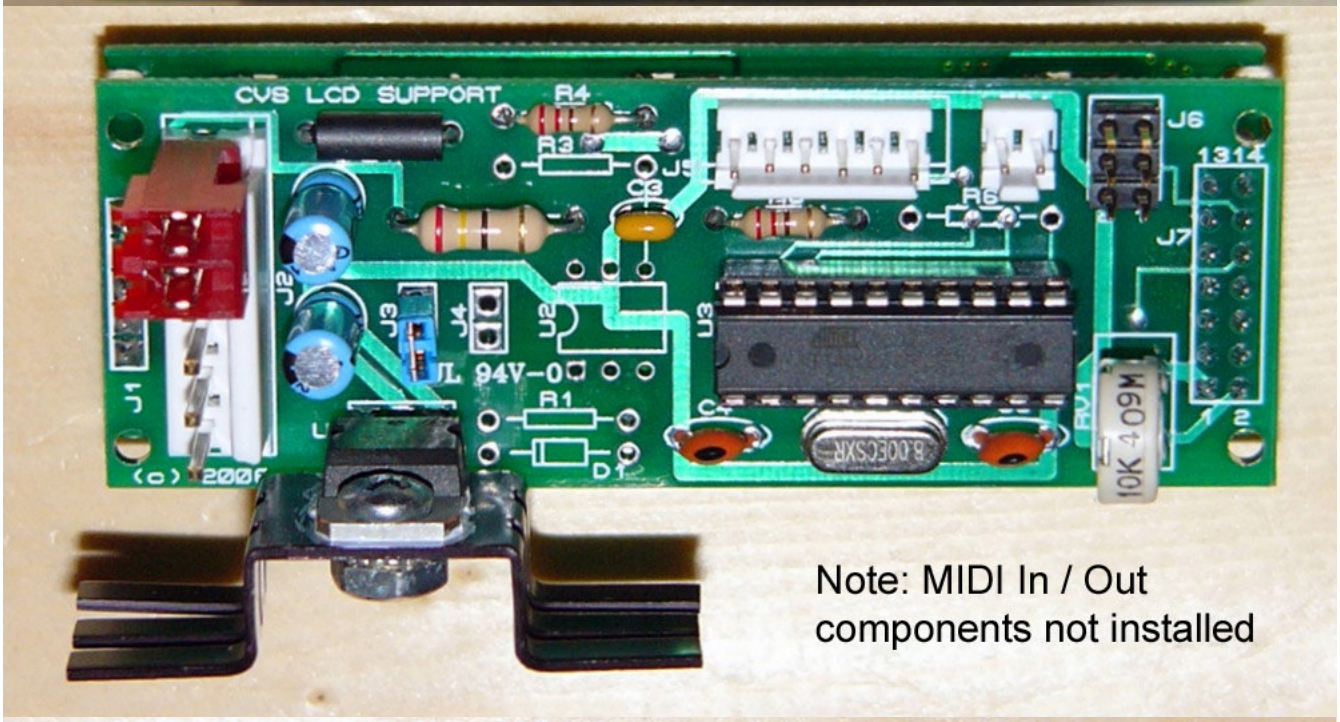
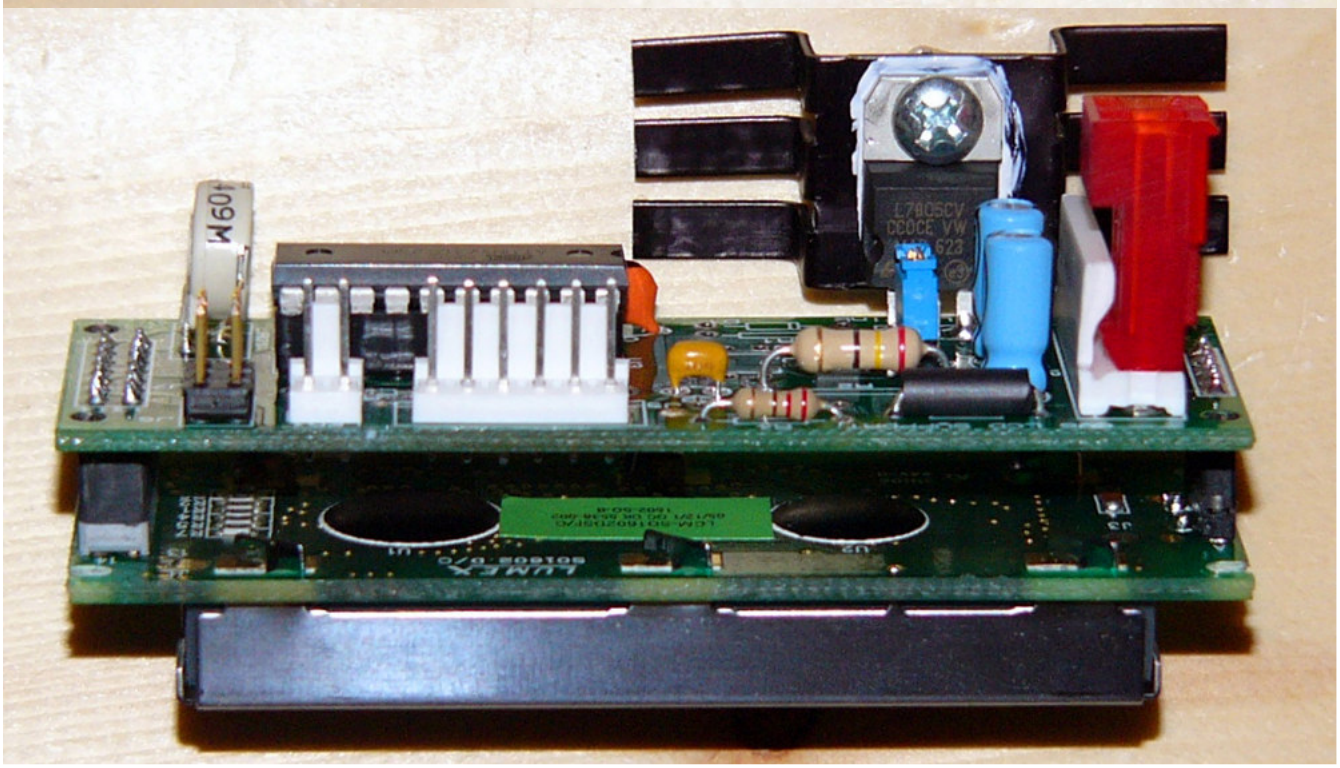
This modification is NOT required for the following Seiko LCDs, which are no longer available through US Distribution. You may be able to find these through Non-US distributors, or through surplus parts distributors. For the Seiko part, simply stack the 2x7 connector between the LCD Support PCB and the LCD. No trace cuts or jumper wires are required.

* Seiko L1672
* Seiko M1632

Option 1: Install two breakaway headers that are 6 pins long into J7, leaving pins 1 and 2 unoccupied. You will need to cut and strip two short wires, and SWAP the connections between the LCD Support PCB and the actual LCD assembly. The two boards will now be permanently attached.

Option 2: Make cuts to the power traces near J7 pins 1 and 2, and then solder the swapped power and ground connections. See the picture below. You will be able to install two 7 pin long headers into J7 for the 2x7 connection.





Note: MIDI In / Out components not installed