ComputerVoltageSource Synthesizer Module

David J. Brown 7/24/2007
Adapted and modified from a design by Grant Richter with contributions by John Loffink and Harry Bissell

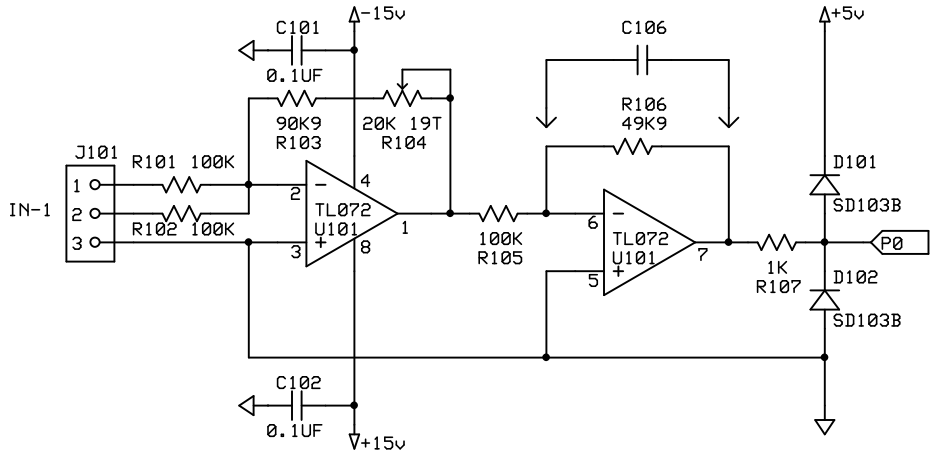
Module Features:

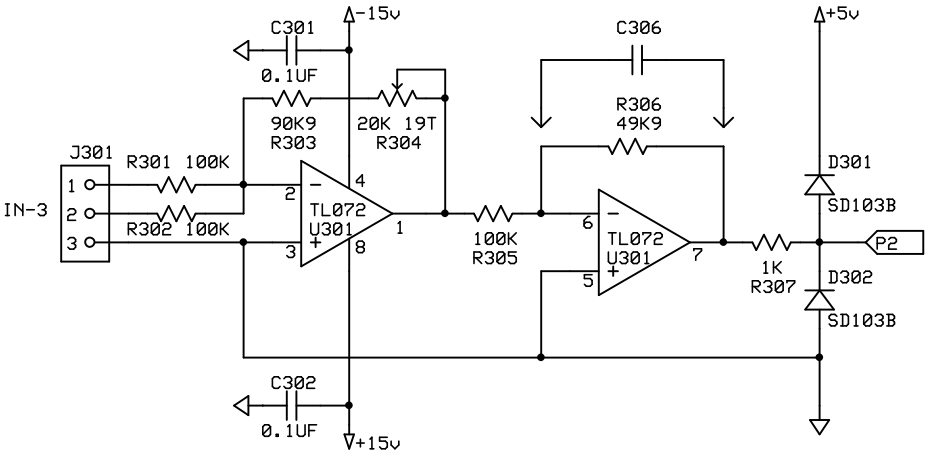
- BasicMicro AtomPro28 processor
  - 2 Kbytes ram
  - 31 Kbytes program flash memory
  - 256 bytes non-volatile eeprom
- Eight 0 to 10 volt analog inputs (each input calibrated to ADC max value 1023)
  - Input attenuator controls normalled to 10 volts
  - Each input is summed with a 0 to 5 volt offset control for +/- 5 volt input levels
- Programmable reference voltages
  - Allow each bank of attenuator and offset controls to be read independently
  - All 16 controls can be used in applications such as a sequencer
- Eight 0 to 10.666 volt analog outputs and indicator LEDs
- Start input, switch, and indicator LED
- Stop input, switch, and indicator LED
- Aux output or input and switch
- Over / under voltage protection on all inputs and outputs
- MIDI input, output, and indicator LED (interrupt 128 byte buffers)
- External I/O connector for additional input and output expandability (100 Kbit I2C interface with power)
- RS-232 computer programming port
- Reset switch
- PSIM software compatible (outputs 5-8 mirror outputs 1-4)
- 2 row x 16 character LCD with eight programmable 5x7 characters
- +15 volts at 130 to 190 mA, depending on the brightness of the LEDs and LCD backlight
- -15 volts at 28 mA

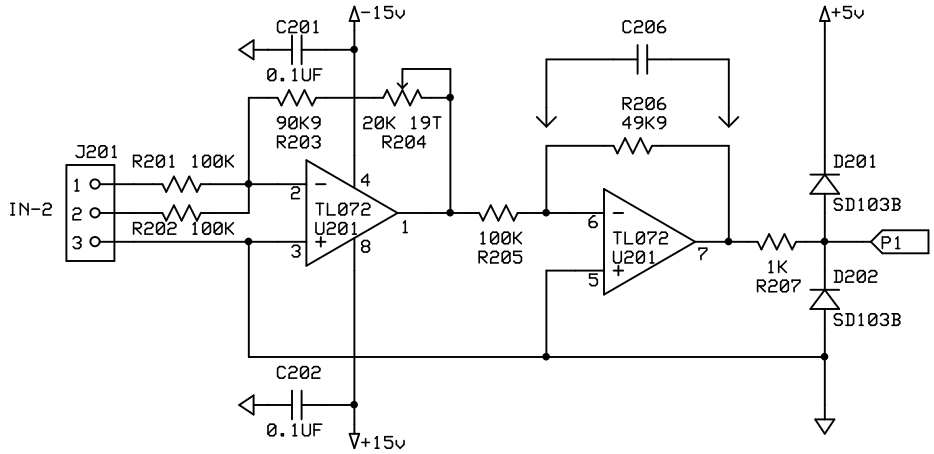
External Controls Module

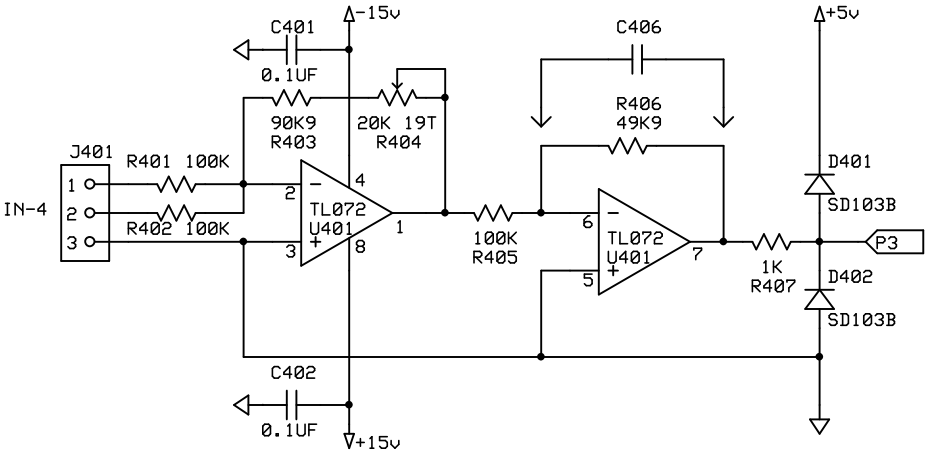
Calibration Notes:

Trim range is 0.467 to 0.537. Adjust while measuring the voltage at the AtomPro28 input pins to compensate for the attenuation from the 1K Rx02 series resistor. Ideal calibration procedure is to set the trim so that a 10.0 volt input equals a value of 1023 and check that that a 5.0 volt input results in a value of 511.









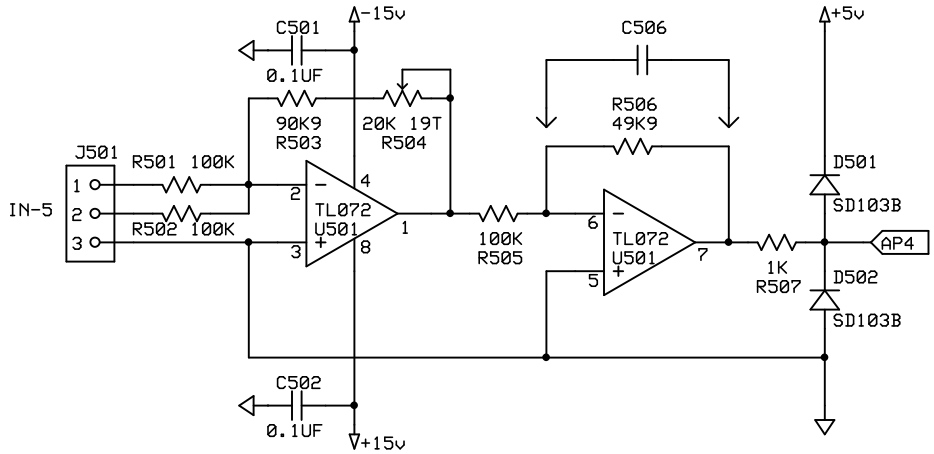
Design Notes:

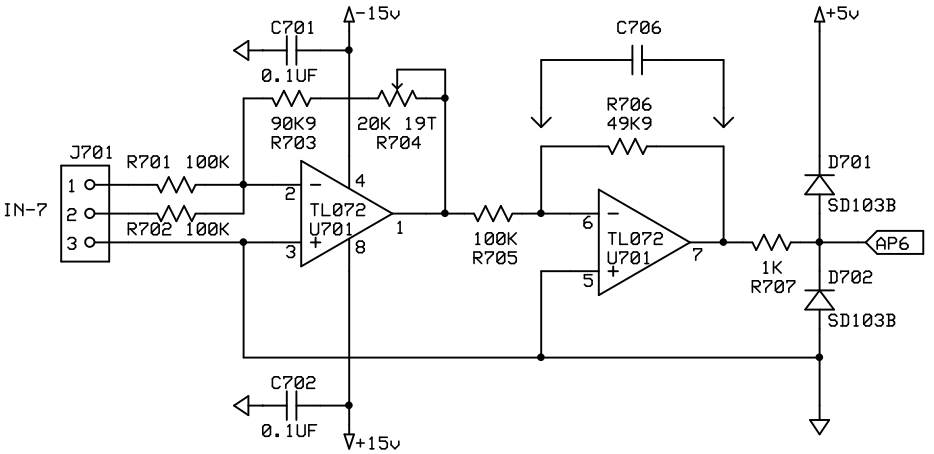
P0-P3 not current limited if pin set to output high and input clamped.

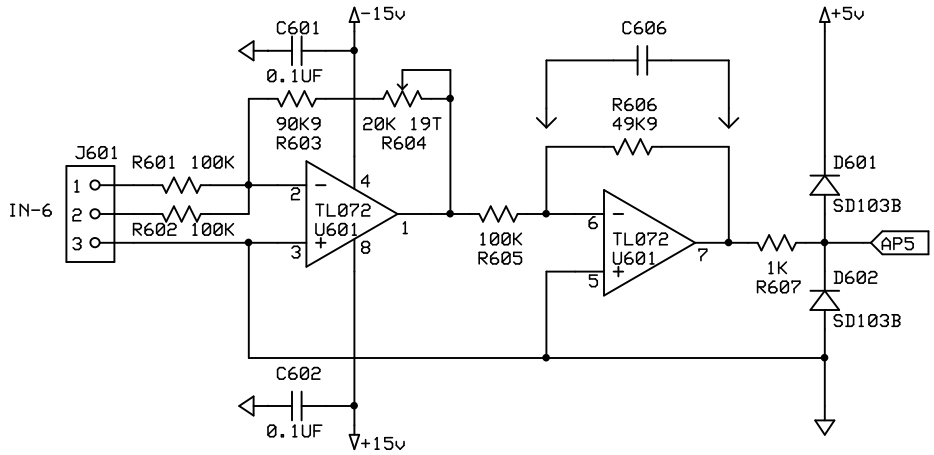
R107,207,307,407 may be changed to 3K to limit current if output high and input 0 to 10 volts.

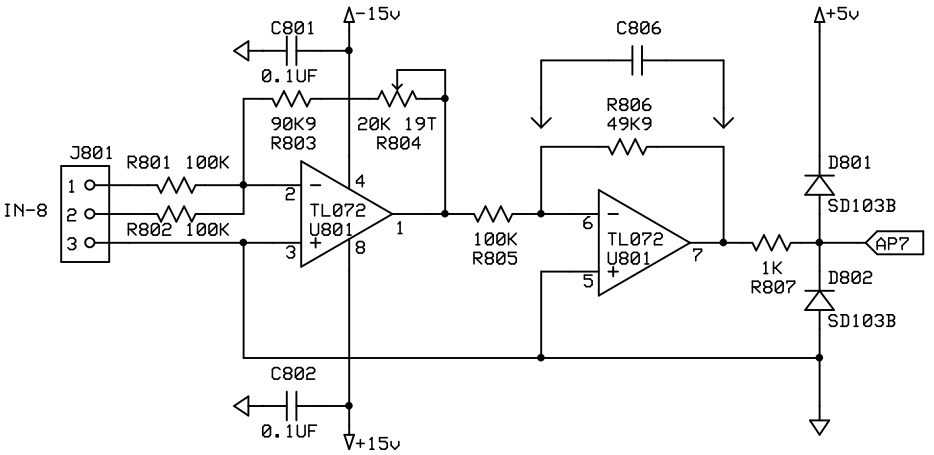
C106, C206, C306, and C406 may be added to reduce input noise. Adding these filters will degrade step response. Not included on PCB.

ComputerVoltageSource		
Main Control Board 1 of 5		
David J. Brown	12/31/2006 Revised 7/20/2007	Analog In 1-4









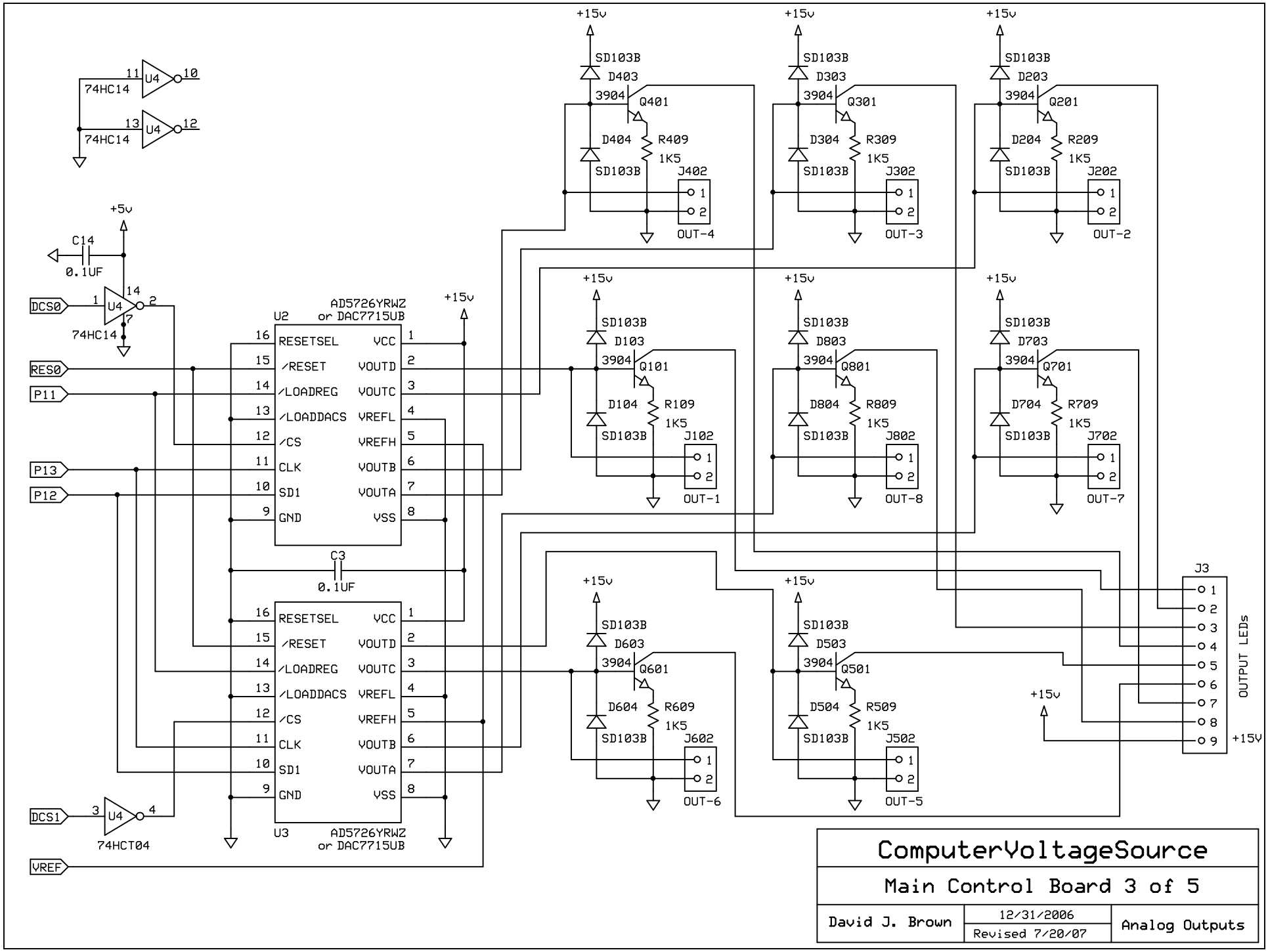
Design Notes:

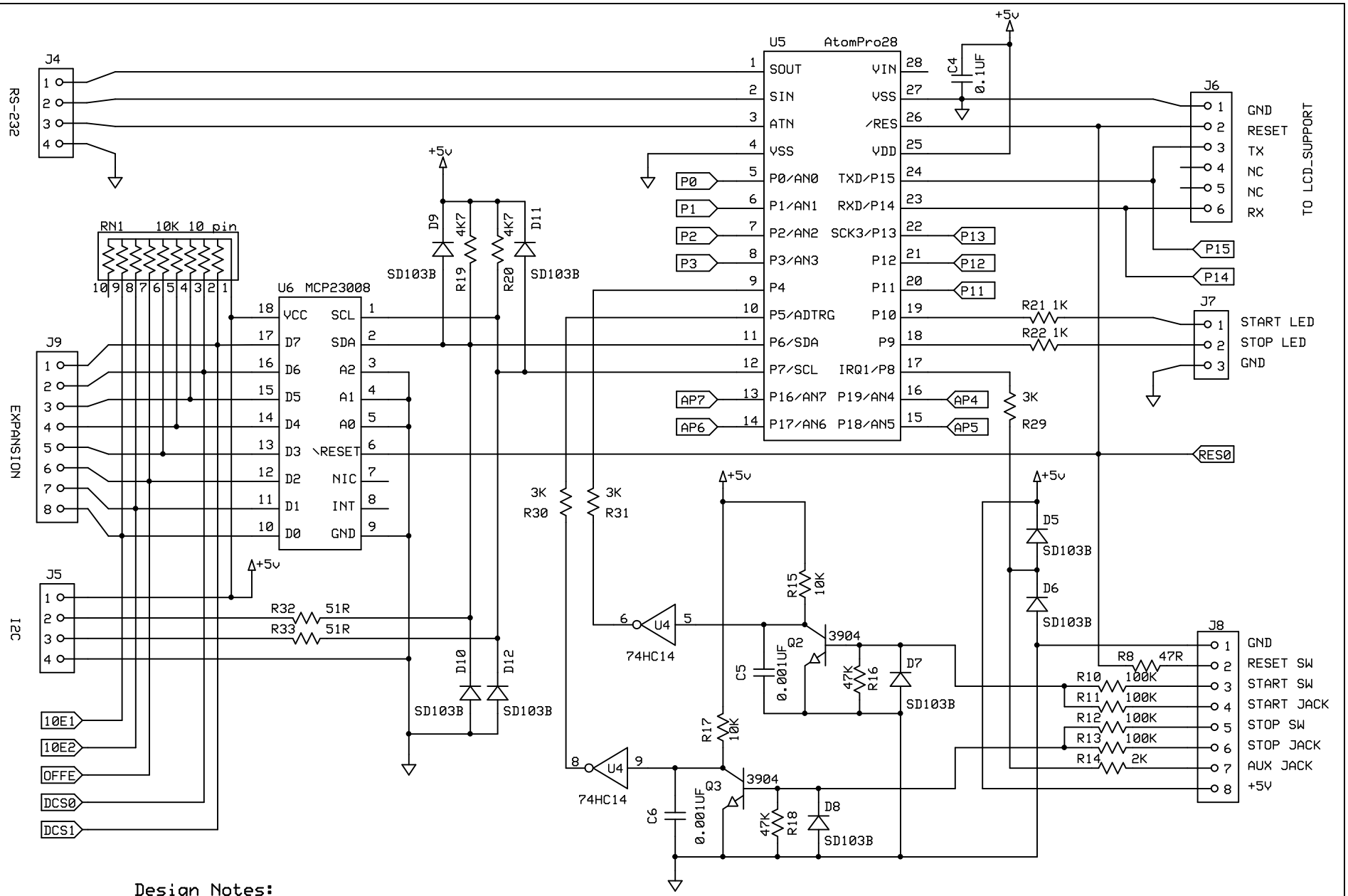
AP4-AP7 not current limited if pin set to output high and input clamped.

R507,607,707,807 may be changed to 3K to limit current if output high and input 0 to 10 volts.

C506, C606, C706, and C806 may be added to reduce input noise. Adding these filters will degrade step response. Not included on PCB.

ComputerVoltageSource		
Main Control Board 2 of 5		
David J. Brown	12/31/2006 Revised 7/20/2007	Analog In 5-8


74HC14
74HC14
+5v
C14
0.1UF
DCS0
74HC14
RES0
P11
P13
P12
DCS1
74HCT04
VREF
U2
AD5726YRWZ
or DAC7715UB
U3
AD5726YRWZ
or DAC7715UB
RESETSEL
/RESET
/LOADREG
/LOADDACS
/CS
CLK
SD1
GND
VCC
VOUTD
VOUTC
VREFL
VREFH
VOUTB
VOUTA
VSS
C3
0.1UF
+15v
SD103B
3904
D403
Q401
D404
R409
1K5
J402
OUT-4
D303
Q301
D304
R309
J302
OUT-3
D203
Q201
D204
R209
J202
OUT-2
D103
Q101
D104
R109
J102
OUT-1
D803
Q801
D804
R809
J802
OUT-8
D703
Q701
D704
R709
J702
OUT-7
D603
Q601
D604
R609
J602
OUT-6
D503
Q501
D504
R509
J502
OUT-5
J3
OUTPUT LEDs
ComputerVoltageSource
Main Control Board 3 of 5
David J. Brown
12/31/2006
Revised 7/20/07
Analog Outputs



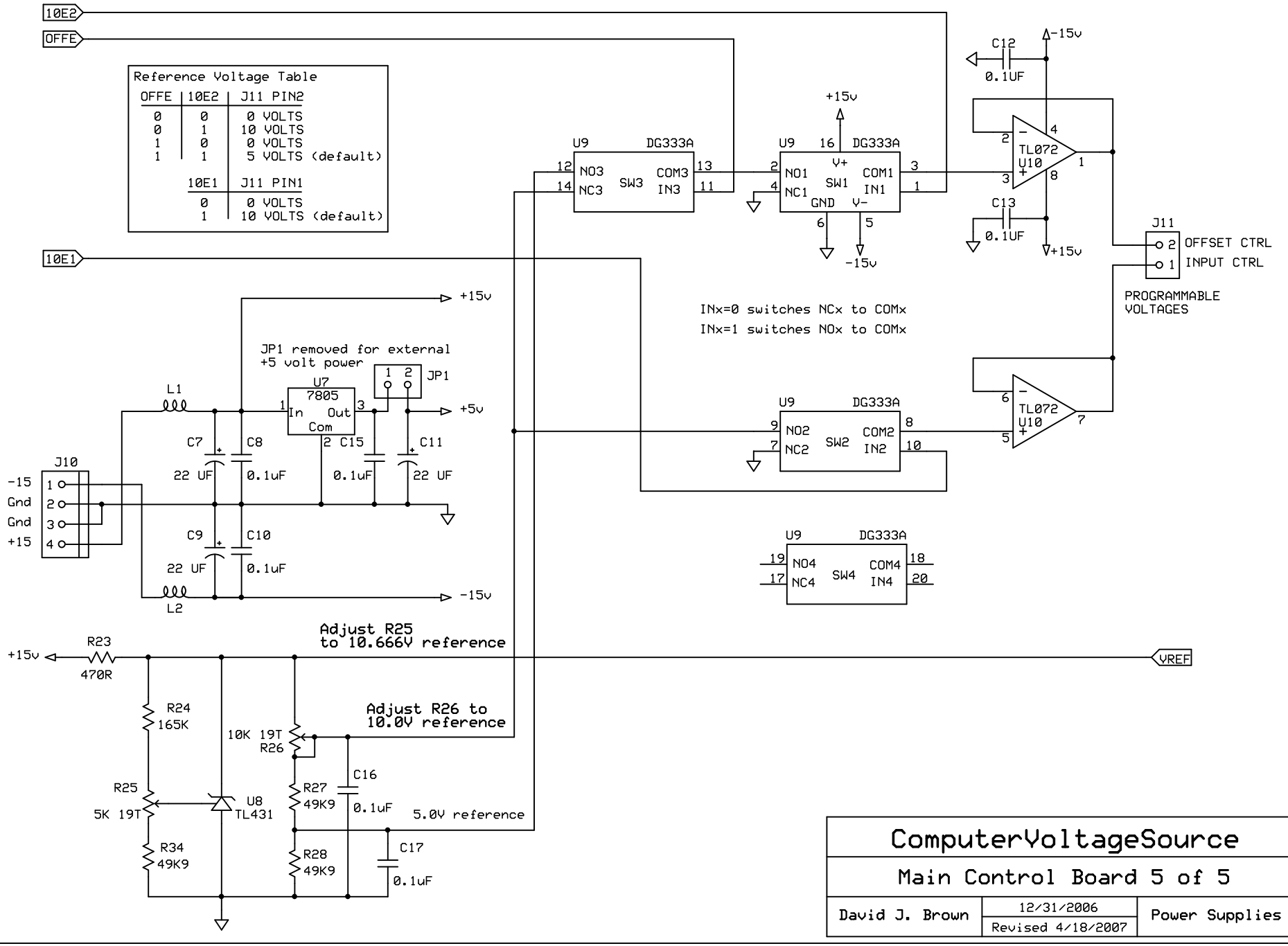
Design Notes:

P14 not current limited if set to output high
R30/31 limits current if set to output high
R14 limits current to 7.5 mA when Aux is -15V
R29 limits current when output high and Aux is negative
R8 limits current since AtomPro28 reset is sourced high (not open drain)

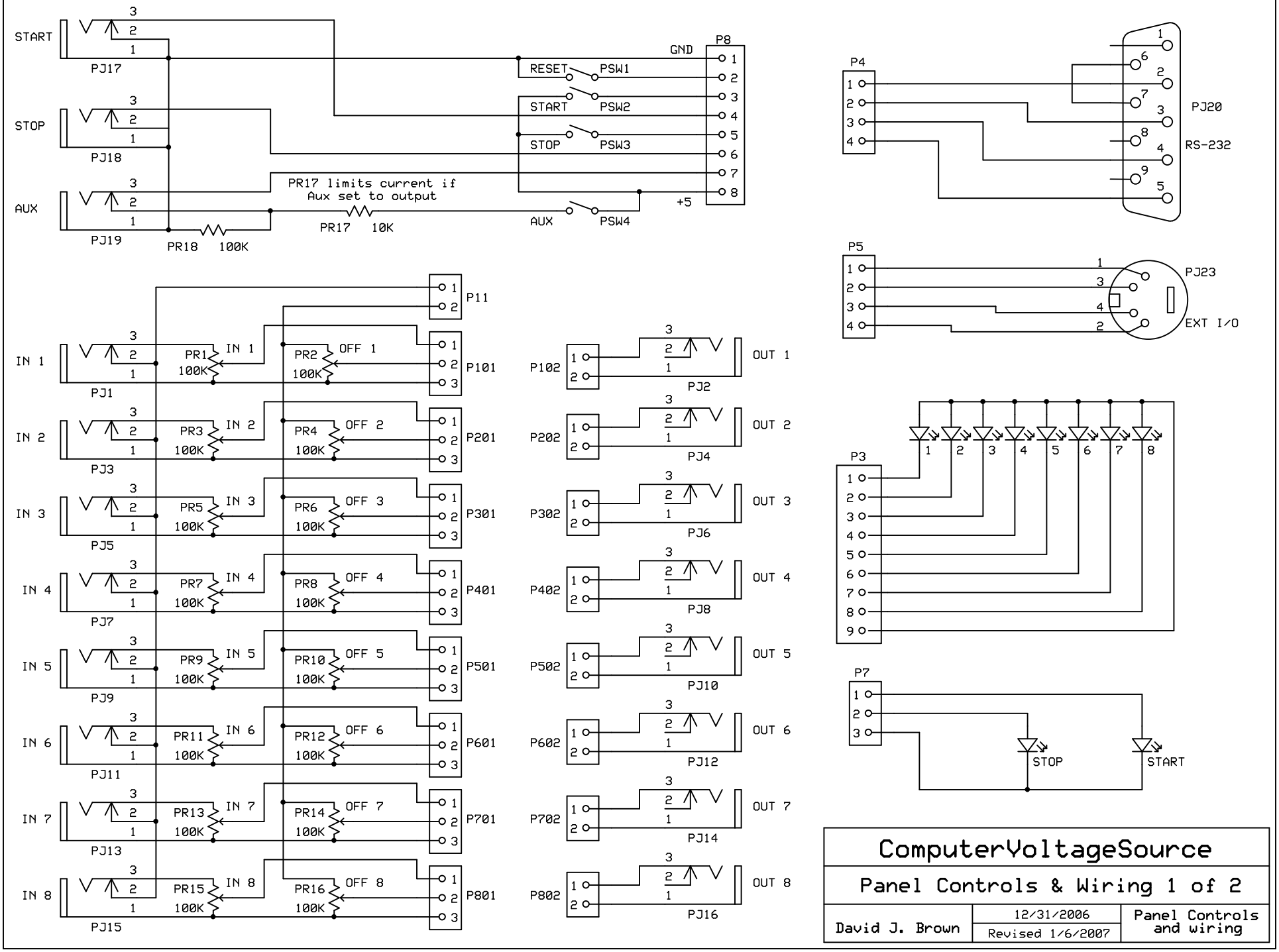
ComputerVoltageSource

Main Control Board 4 of 5

David J. Brown	12/31/2006 Revised 4/18/2007	Processor



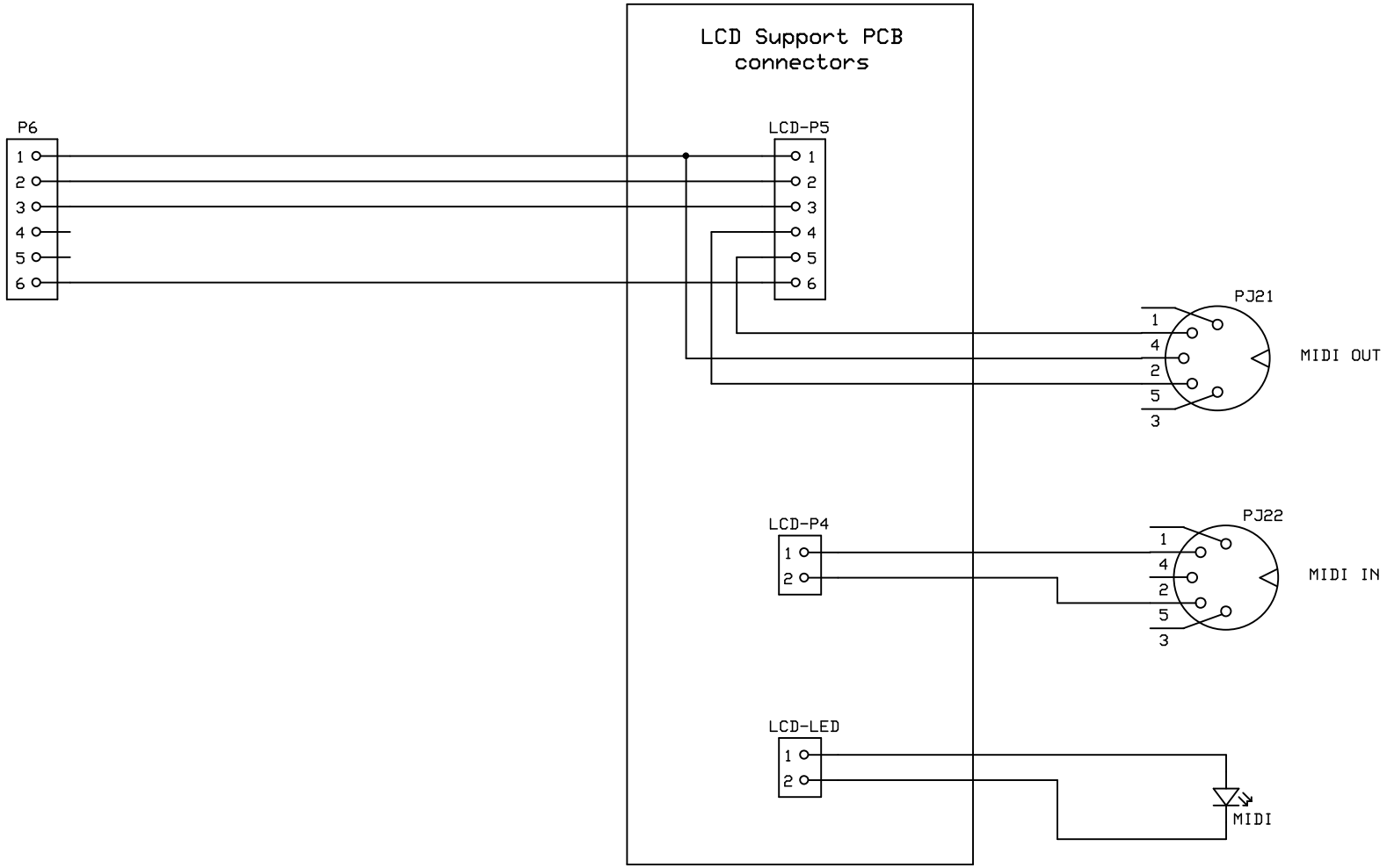
ComputerVoltageSource		
Main Control Board 5 of 5		
David J. Brown	12/31/2006 Revised 4/18/2007	Power Supplies



ComputerVoltageSource

Panel Controls & Wiring 1 of 2

David J. Brown	12/31/2006 Revised 1/6/2007	Panel Controls and wiring



Design Notes:

J6 pinout on ComputerVoltageSource main PCB is reversed to match pinout orientation of J5 on LCD Support PCB

LCD Support PCB should be connected to same power supply as ComputerVoltageSource main PCB to eliminate input over voltage conditions

ComputerVoltageSource		
Panel Controls & Wiring 2 of 2		
David J. Brown	12/31/2006 Revised 1/6/2007	Panel MIDI/LCD and wiring

ComputerVoltageSource Parts List

PCB Components						
Reference	**Description**	**Mouser P/N**	**Qty**	**Cost**	**Total**	**Comment**
C3, C4, C8, C10, C12, C13, C14, C15, C16, C17	0.1 uF 50V	147-72-104-RC	10	$0.16	$1.60	
C5, C6	0.001 uF 50V	147-75-102-RC	2	$0.33	$0.66	
C7, C9, C11	22 uF 35V	140LLRL35V22-RC	3	$0.24	$0.72	
C101, C102, C201, C202, C301, C302,C401, C402	0.1 uF 50V	147-72-104-RC	8	$0.16	$1.28	
C501, C502, C601, C602, C701, C702, C801, C802	0.1 uF 50V	147-72-104-RC	8	$0.16	$1.28	
C106, C206, C306, C406, C506, C606, C706, C806						Reduces input noise but degrades step response; not recommended / not on PCB
D5, D6, D7, D8	SD103B	625-SD103B	3	$0.19	$0.57	
D9,D10,D11,D12	SD103B	625-SD103B	4	$0.19	$0.76	
D101, D102, D103, D104, D201, D202, D203, D204	SD103B	625-SD103B	8	$0.19	$1.52	
D301, D302, D303, D304, D401, D402, D403, D404	SD103B	625-SD103B	8	$0.19	$1.52	
D501, D502, D503, D504, D601, D602, D603, D604	SD103B	625-SD103B	8	$0.19	$1.52	
D701, D702, D703, D704, D801, D802, D803, D804	SD103B	625-SD103B	8	$0.19	$1.52	
J3	9 pin 0.1 MTA	571-6404549	1	$0.49	$0.49	Output LEDs
J4, J5	4 pin 0.1 MTA	571-6404544	2	$0.13	$0.26	RS-232, I2C
J6	6 pin 0.1 MTA	571-6404546	1	$0.18	$0.18	LCD; connector pin 1 reversed to match LCD Support PCB layout
J7	3 pin 0.1 MTA	571-6404543	1	$0.13	$0.13	LEDs
J8	8 pin 0.1 MTA	571-6404548	1	$0.17	$0.17	Digital I/O
J10	4 pin 0.156 MTA	571-6404454	1	$0.16	$0.16	Power
J11	2 pin 0.1 MTA	571-6404542	1	$0.12	$0.12	Reference
J101, J201, J301, J401, J501, J601, J701, J801	3 pin 0.1 square	571-1031853	8	$0.21	$1.68	Inputs; use square pins or wire directly
J102, J202, J302, J402, J502, J602, J702, J802	2 pin 0.1 square	571-1031852	8	$0.18	$1.44	Outputs; use square pins or wire directly
JP1	2 pin square	571-1031852	1	$0.18	$0.18	Omit unless using +5 volt power supply; need to cut trace between pads on top layer
L1, L2	Ferrite bead	623-2743002112LF	2	$0.12	$0.24	Longer ferrite beads
Q2, Q3	3904	512-2N3904TA	2	$0.06	$0.12	
Q101, 201, 301, 401, 501, 601, 701, 801	3904	512-2N3904TA	8	$0.06	$0.48	
R8	47R 1/4W 1%	271-47-RC	1	$0.09	$0.09	Reset current limit
R10, R11, R12, R13	100K 1/4W 1%	271-100K-RC	4	$0.09	$0.36	
R14	2K 1/4W 1%	271-2K-RC	1	$0.09	$0.09	Aux current limit
R15, R17	10K 1/4W 1%	271-10K-RC	2	$0.09	$0.18	
R16, R18	47K 1/4W 1%	271-47K-RC	2	$0.09	$0.18	
R19, R20	4K7 1/4W 1%	271-4.7K-RC	2	$0.09	$0.18	I2C termination
R21, R22	1K 1/4W 1%	271-1K-RC	2	$0.09	$0.18	Start/Stop LED current limit
R23	470R 1/4W 1%	271-470-RC	1	$0.09	$0.09	
R24	165K 1/4W 1%	271-165K-RC	1	$0.09	$0.09	
R25	5K 19 Turn trimmer	72-T93YB-5K	1	$1.20	$1.20	10.666 volt adjust
R26	10K 19 Turn trimmer	72-T93YB-10K	1	$1.20	$1.20	5 volt adjust
R27, R28, R34	49K9 1/4W 1%	271-49.9K-RC	3	$0.09	$0.27	
R29	3K 1/4W 1%	271-3.0K-RC	1	$0.09	$0.09	P8 current limit
R30, R31	3K 1/8W 1%	270-3.0K-RC	2	$0.11	$0.22	P4, P5 current limit; located under U5 socket
R32, R33	51R 1/8W 1%	270-51-RC	2	$0.11	$0.22	I2C currentl limit; can use 1/4 watt and mount radial on PCB
R101, R102, R105, R201, R202, R205	100K 1/4W 1%	271-100K-RC	5	$0.09	$0.45	
R103, R203, R303, R403, R503, R603, R703, R803	90K9 1/4W 1%	271-90.9K-RC	8	$0.09	$0.72	
R104, R204, R304, R404, R504, R604, R704, R804	20K 19 Turn trimmer	72-T93YB-20K	8	$1.20	$9.60	Input trim adjust
R106, R206, R306, R406, R506, R606, R706, R806	49K9 1/4W 1%	271-49.9K-RC	8	$0.09	$0.72	
R107, R207, R307, R407, R507, R607, R707, R807	1K 1/4W 1%	271-1K-RC	8	$0.09	$0.72	
R109, R209, R309, R409, R509, R609, R709, R809	1K5 1/4W 1%	271-1.5K-RC	8	$0.09	$0.72	
R301, R302, R305, R401, R402, R405	100K 1/4W 1%	271-100K-RC	5	$0.09	$0.45	
R501, R502, R505, R601, R602, R605	100K 1/4W 1%	271-100K-RC	5	$0.09	$0.45	
R701, R702, R705, R801, R802, R805	100K 1/4W 1%	271-100K-RC	5	$0.09	$0.45	
RN1	10K 10 pin	652-4310R-1LF-10K	1	$0.57	$0.57	

David J. Brown
Feb 17, 2008

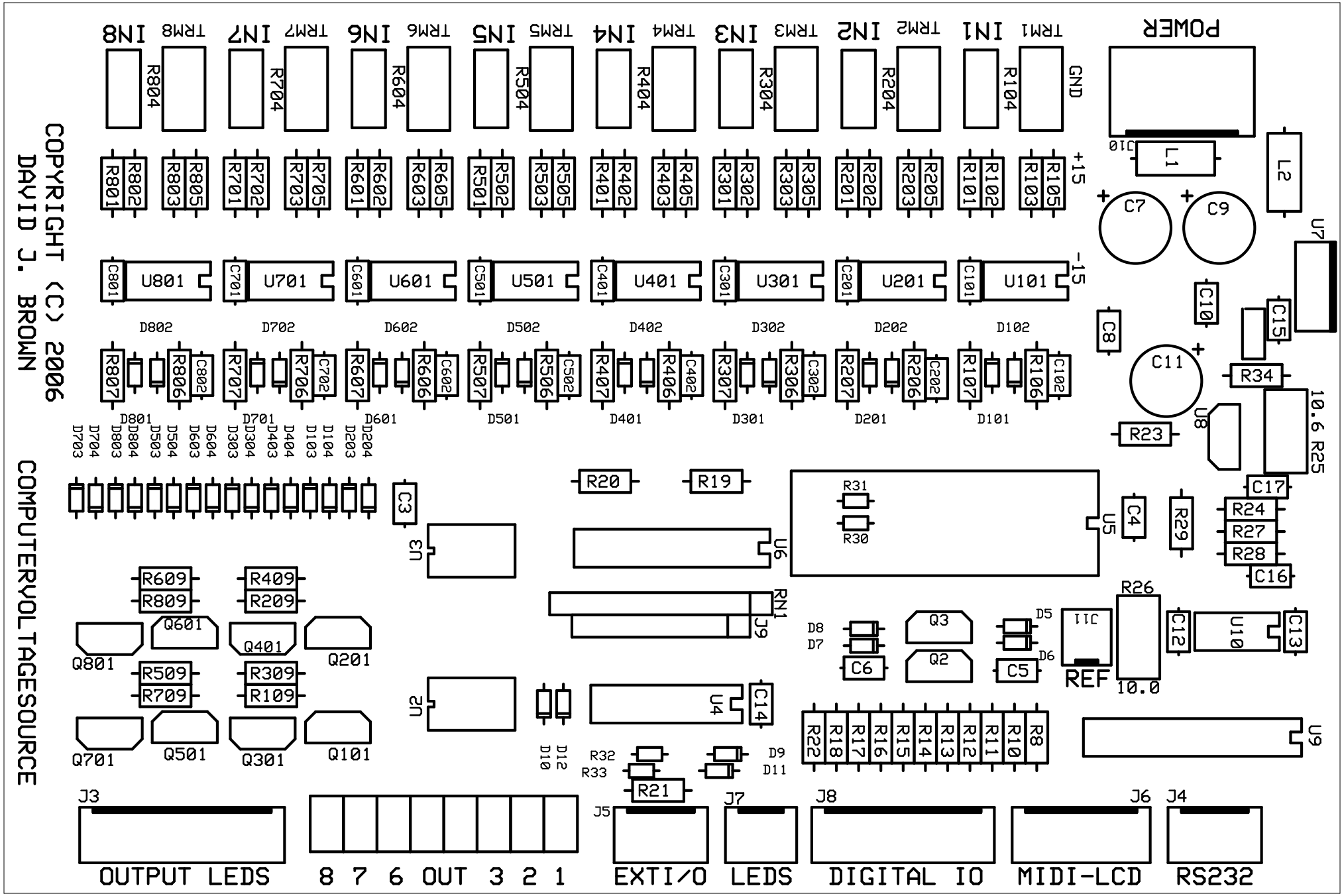
PCB Components

Reference	Description	Mouser P/N	Qty	Cost	Total	Comment
U2, U3	DAC7715UB	DAC7715UB-ND (Digikey)	2	$18.90	$37.80	A lower cost Analog Devices AD5726YRWZ or a DAC7714UB may be used
U4	74HC14	512-MM74HC14N	1	$0.36	$0.36	
U5	AtomPro28	BasicMicro B0204	1	$59.95	$59.95	BasicMicro
U5 addition	28 pin 0.6" socket	517-4828-6000-CP	1	$0.20	$0.20	
U6	MCP23008	579-MCP23008-E/P	1	$1.04	$1.04	
U7	7805	512-KA7805AETU	1	$0.80	$0.80	
U7 addition	AAVID TO-220 heat sink	532-507002B00	1	$0.24	$0.24	Not required
U8	TL431	512-LM431AIZ	1	$0.15	$0.15	
U9	DG333A	781-DG333ADJ-E3	1	$3.97	$3.97	
U10	TL072	595-TL072ACP	1	$0.80	$0.80	
U101, U201, U301, U401, U501, U601, U701, U801	TL072	595-TL072ACP	8	$0.80	$6.40	
					$149.80	

Panel components

Reference	Description	Mouser P/N	Qty	Cost	Total	Comment
J3 mating components	9 pin polarized connector	571-6404419	1	$1.09	$1.09	White 24 AWG
J3 mating components		571-6405509	1	$0.27	$0.27	Dust cover
J4, J5 mating components	4 pin polarized connector	571-6404414	2	$0.14	$0.28	White 24 AWG
J4, J5 mating components		571-6405504	2	$0.16	$0.32	Dust cover
J6 mating components	6 pin polarized connector	571-6404416	1	$0.24	$0.24	White 24 AWG
J6 mating components		571-6405506	1	$0.20	$0.20	Dust cover
J7 mating components	3 pin polarized connector	571-6404413	1	$0.14	$0.14	White 24 AWG
J7 mating components		571-6405503	1	$0.13	$0.13	Dust cover
J8 mating components	8 pin polarized connector	571-6404418	1	$0.33	$0.33	White 24 AWG
J8 mating components		571-6405508	1	$0.22	$0.22	Dust cover
J10 mating components	4 pin polarized connector	571-6404264	2	$0.34	$0.68	Orange 18 AWG
J10 mating components		571-6405514	2	$0.18	$0.36	Dust cover
J11 mating components	2 pin polarized connector	571-6404412	1	$0.11	$0.11	White 24 AWG
J11 mating components		571-6405502	1	$0.12	$0.12	Dust cover
PJ21,PJ22	5 pin DIN	16HR655	2	$5.04	$10.08	High quality version
PJ1, PJ2, ... PJ19	1/4" NC phone jack	502-112A	19	$1.62	$30.78	Panel jacks
PJ23	PS2 4 conductor	161-381/4-E	1	$1.56	$1.56	Ext IO
PSW2, PSW3, PSW4	On-Off-(On)	633-M201902-RO	3	$5.70	$17.10	Start, Stop, Aux switch
PSW1	On-none-(On)	633-M201502-RO	1	$5.60	$5.60	Reset switch
PJ20	DB9 female	152-5109	1	$3.08	$3.08	RS-232
PD1, PD2 … PD8	Amber LED	606-4303F3	8	$0.30	$2.40	Output LEDs; select based on panel design
PD9	Green LED	606-4303F5	1	$0.21	$0.21	Start LED; select based on panel design
PD10	Red LED	606-4303F1	1	$0.21	$0.21	Stop LED; select based on panel design
PD11	Blue LED	606-CMD264UBD	1	$1.50	$1.50	MIDI status LED; select based on panel design
PR1, PR2, … PR16	100K potentiometer	531-PC16SC-100K	16	$2.35	$37.60	Piher medium quality
PR1, PR2, … PR16 addition	3/4" knob	Radioshack 274-415	4	$2.99	$11.96	RadioShack; lower cost than Tyco
PR17	10K 1/4W 1%	291-10K-RC	1	$0.06	$0.06	Aux switch current limit
PR18	100K 1/4W 1%	291-100K-RC	1	$0.06	$0.06	Aux input pull down
					$126.69	

David J. Brown
Feb 17, 2008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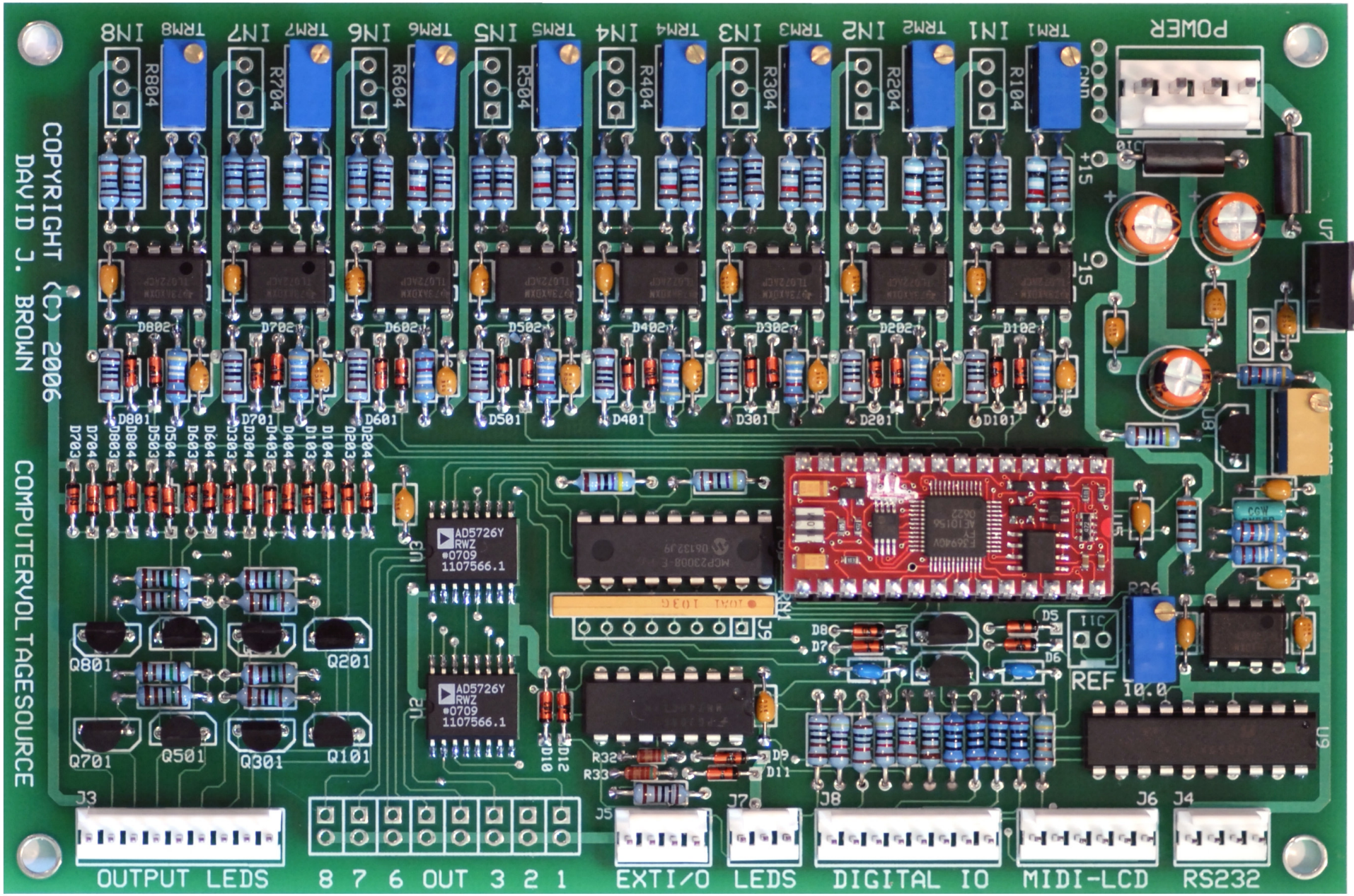
DAVID J. BROWN
COMPUTERVOLTAGESOURCE
POWER
IN1
IN2
IN3
IN4
IN5
IN6
IN7
IN8
GND
+15
-15
REF
10.0
OUTPUT LEDS
8 7 6 OUT 3 2 1
EXTI/O
LEDS
DIGITAL IO
MIDI-LCD
RS232



ComputerVoltageSource Main PCB Version 5/16/07

LAUNCH Groups

Name: CVS FAQ

Table Description: CVS Module and PCB information

Tip	Description	Author
+5 volt operation	JP1 is pre-connected on the top layer of the PCB and does not need to be installed. If a separate +5 volt supply is desired, cut the trace on the top layer between the two pins and connect pin 2 of JP1 to +5 volts.	Dave Brown
ATOMPro Info	You can buy the ATOMPro processor from www.basicmicro.com for $59.95. P/N B0204. The software is BasicATOMPRO Software version 8.0.1.0	Scott Deyo
Additional digital inputs / outputs	There are 3 unused digital inputs / outputs on U6 that connect to pins 3-5 on J9. These have resistor pullups so you can connect three switches to ground for additional inputs. You can also use these for outputs or panel inputs but be sure to add appropriate over / under voltage protection. For additional digital inputs / outputs, an additional MCP23008 can be interfaced directly to J5. You use the I2CIN / I2COUT commands to read / write these bits. There is reference information in the Hardware > I2C Analog-Digital folder.	Dave Brown
AtomPro28 pin 1 orientation	There isn't a marking on the AtomPro28 for pin 1. There is a half circle in copper that marks the top similar to the indentation at the top of an IC. Pin 1 is to the left and pin 28 is to the right of the half circle. The resonator is at the bottom and can be identified as a gray rectangle with two black stripes. If you look carefully you can see 16.0M written on it indicating the frequency. Pin 14 is to the left and pin 15 is to the right of the resonator.	Dave Brown
Eliminating reference voltages	The programmable reference voltages may be eliminated by not installing R26, R27, R28, C12, C13, C16, C17, U9, U10, and J11.	Dave Brown
Fixed reference voltages	Fixed (non-programmable) +10 and +5 reference voltages may be generated by not installing U9 and connecting pin 8 to 9 and pin 3 to 12 on U9.	Dave Brown
Four channel configuration	A four channel version may be built by deleting the additional 4 input and output parts. If the programmable reference voltages are not used, then those parts along with U6 and associated parts may be deleted. RN1 should be installed or a resistor installed between pin 1 and 3 so that pin 1 of U4 will be pulled high to enable the U2 chip select.	Dave Brown
IC orientation	The SMT DACs U2 and U2 are oriented opposite from the DIP parts. All DIP parts have pin 1 towards the top of the PCB. The SMT parts have pin 1 towards the bottom of the PCB. The solder mask shows the correct orientation.	Dave Brown
Input filters	C106, C206, C306, C406, C506, C606, C706, and C806 on the schematic are not recommended for installation and are not included on the PCB. These capacitors reduce input noise but also increase input slew rate and degrade input step response. Optional use depends upon application and performance requirements.	Dave Brown
Input trimmer adjustment	The input trimmers R104, R204, R304, R404, R504, R604, R704 and R804 are adjusted with a calibration program that displays the digital value of the analog inputs. The trimmers are adjusted to a value of 1023 with the 10.0 reference or other precision voltage source connected to the inputs. Note that this adjustment also compensates for the tolerance range of the +5 volt regulator U7 and overall gain will not be exactly 0.5X.	Dave Brown
J6 connection to LCD_ Support	The layout of J6 is reversed to match the layout of J5 on the LCD_Support PCB (pin 1 of J6 is on the opposite end).	Dave Brown
	The 39 over/under voltage protection diodes (D5 - D804) are schottky and chosen for a forward voltage drop of ~0.3 volts to meet the over/under voltage specification of	

	the Renesas H8/3664 processor. Other diodes with similar specifications may be used.	
R25 and R26 adjustment	Adjust R25 to calibrate the 10.666 volts as measured at the end of R23 closest to U8. Then adjust R26 to calibrate the 10.000 volts as measured at pin 9 of U9. Check pin 12 of U9 to be close to 5.0 volts.	Dave Brown
R30 and R31 resistors	R30 and R31 limit current if the AtomPro P4 and P5 are set to outputs. 1/8 watt resistors were used for board space requirements and were placed inside the U5 socket footprint. The socket footprint must allow room for these components. The resistors may also be installed on the bottom side of the PCB or simply replaced with jumper wires.	Dave Brown
R32 and R33 resistors	R32 and R33 limit current for I2C over/under voltage. 1/8 watt resistors were used for board space requirements. 1/4 watt resistors may be used if mounted radially. Values may be changed depending on application.	Dave Brown
Reset current limit	R8 is very important to install. The AtomPro28 has an active power-on-reset circuit and grounding the reset pin shorts the output of this circuit. R8 limits the short circuit current.	Dave Brown
SMT soldering	Here's how I solder the SMT DACs: First, use a very fine point tip (photo in the "Files > Hardware > CVS Module" folder). Then align the DAC on the PCB and use a piece of masking tape to hold it in place. The part needs to be aligned in both directions (horizontal and vertical). Use a magnifying glass to really see where it is placed. Then use fine solder and solder one corner pin. Remove the masking tape and solder the opposite corner pin. There is a bit of compliance in the pins so you can adjust the DAC to align the pin dead center on the pad. Then reflow the first pin and adjust the DAC to align that pin dead center on the pad. Now use the magnifier to check the alignment on all 16 pins. Solder each pin using fine solder. Then recheck each pin with a magnifier to make sure the solder flowed. If you have a bridge you can remove the excess solder with solder wick.	Dave Brown
Transistor orientation	Transistors Q101 – Q801 are not all oriented the same direction. Q301, Q401, Q701, and Q801 are oriented opposite from Q101, Q201, Q501, and Q601.	Dave Brown

ComputerVoltageSource Build Sequence

You can build the ComputerVoltageSource in a four step sequence.

Group A: Power Supplies

1. Install all components on page 5 and RN1 on page 4.

2. Verify +15 volts at J3 pin 9.

3. Verify -15 volts at U10 pin 4.

4. Verify +5 volts at J8 pin 8.

5. Adjust R25 for +10.666 volts at the top of R23, just below U8.

6. Adjust R26 for +10.0 volts at J11 pin 1.

7. Check for approximately +5 volts at J11 pin 2.

8. Recheck R25 for +10.666 volts at the top of R23, just below U8.

9. Recheck R26 for +10.0 volts at J11 pin 1.

Group B: Digital I/O

10. Install all components on page 4 except U6. The default program in the AtomPro28 should blink the Start and Stop LEDs. If not, proceed to step 11.

11. Connect RS-232 to J4. Program the AtomPro28. Make sure the BasicMicro IDE is set to Auto or AtomPro28. You can use the “cvs display inputs (rev0.1).djb.bas”, “cvs test waveforms (rev0.0).djb.bas”, or any PSIM program.

Group C: Analog Outputs

12. Install all components on page 3 and U6 on page 4.

13. Connect the LCD_Support PCB to J6. The ComputerVoltageSource now has full MIDI, LCD Display, and 8 analog output functionality. If you used the “cvs display inputs (rev0.1).djb.bas” or “cvs test waveforms (rev0.0).djb.bas” programs you will see the program name or values displayed on the LCD.

Group D: Analog Inputs

14. Install all components on pages 1 and 2.

15. Program the AtomPro28 with the “cvs display inputs (rev0.1).djb.bas” program. Connect the 10.0 reference voltage source to each input. The display will show the IN1 to IN4 values in the format "I1=XXXX I2=XXXX I3=XXXX I4=XXXX ". Adjust the IN1 to IN4 input trimmers to a value of 1023.

16. Depress the start switch to toggle to IN5 to IN8. Adjust the IN5 to IN8 input trimmers to a value of 1023.

Congratulations. Your ComputerVoltageSource is built and calibrated.

David. J Brown

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