Audio Labs

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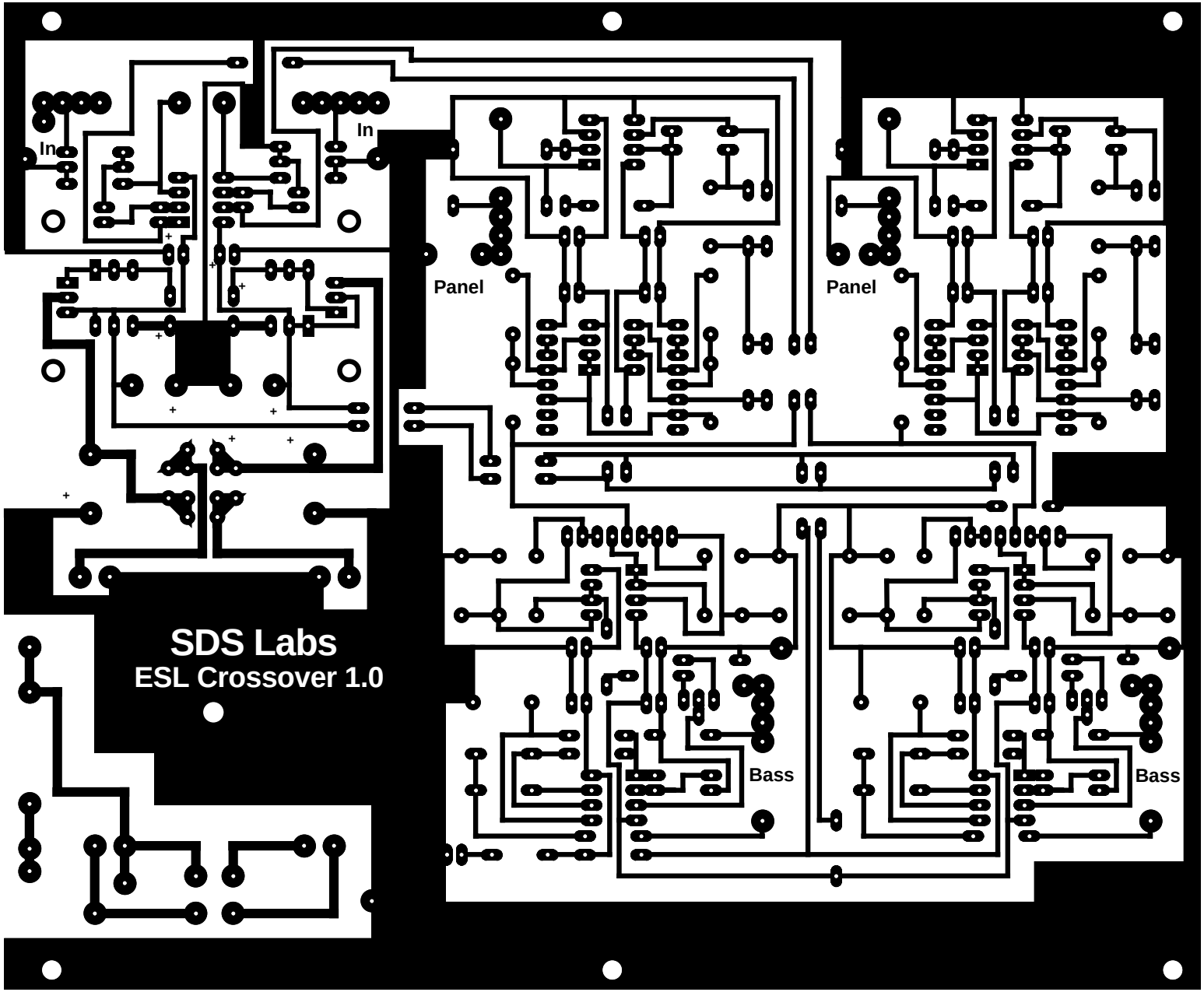
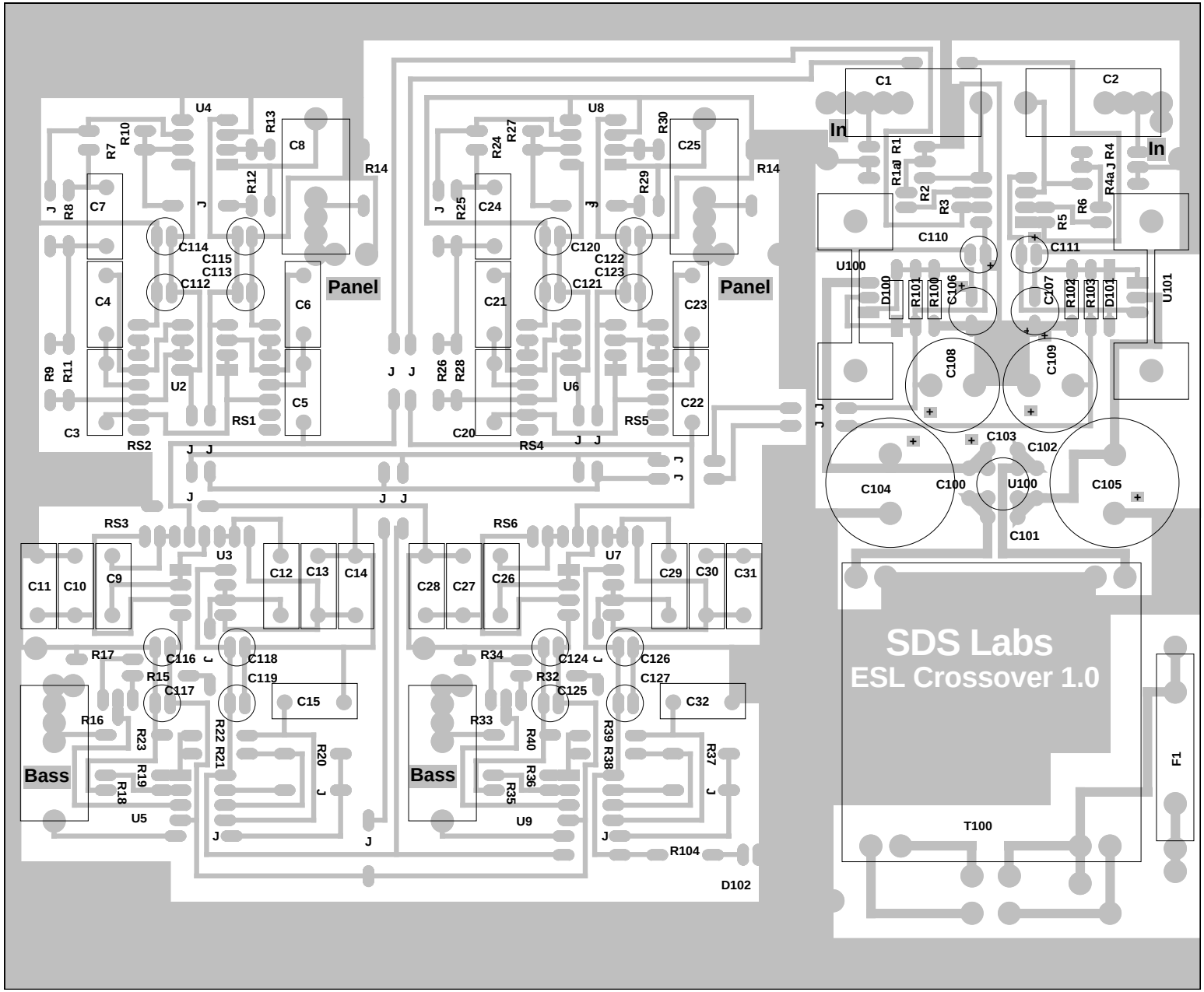
Electrostatic Loudspeaker Active Crossover

Assembled Crossover in Sescom Case

This coponent allows an electrostatic panel and a dynamic low frequency driver to be used together to cover the entire audible spectrum. The device compensates for the pressure rolloff inherent with all dipole drivers. This crossover uses fourth order Linkwitz-Riley crossovers for both high and low pass sections. It uses socketed SIP resistor networks to set the crossover frequency. A simple change of resistor values is accomplished by pulling one set out and pushing the other set in. The panel portion of the crossover has a shelving EQ to compensate for the pressure rolloff. the included schematic has the corner of the shelf at 732 Hz, this is ideal for 20” wide cells. The bass section has an all-pass network in addition to the 24 dB per octave low pass filter. The all-pass netowrk allows a precise time alignment between the bass driver and panel. The layout, schematic and parts list are shown below.


In
In
Panel
Panel
SDS Labs
ESL Crossover 1.0
Bass
Bass


SDS Labs
ESL Crossover 1.0
In
In
Panel
Panel
Bass
Bass
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C20
C21
C22
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C113
C114
C115
C116
C117
C118
C119
C120
C121
C122
C123
C124
C125
C126
C127
D100
D101
D102
F1
R1
R1a
R2
R3
R4
R4a
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
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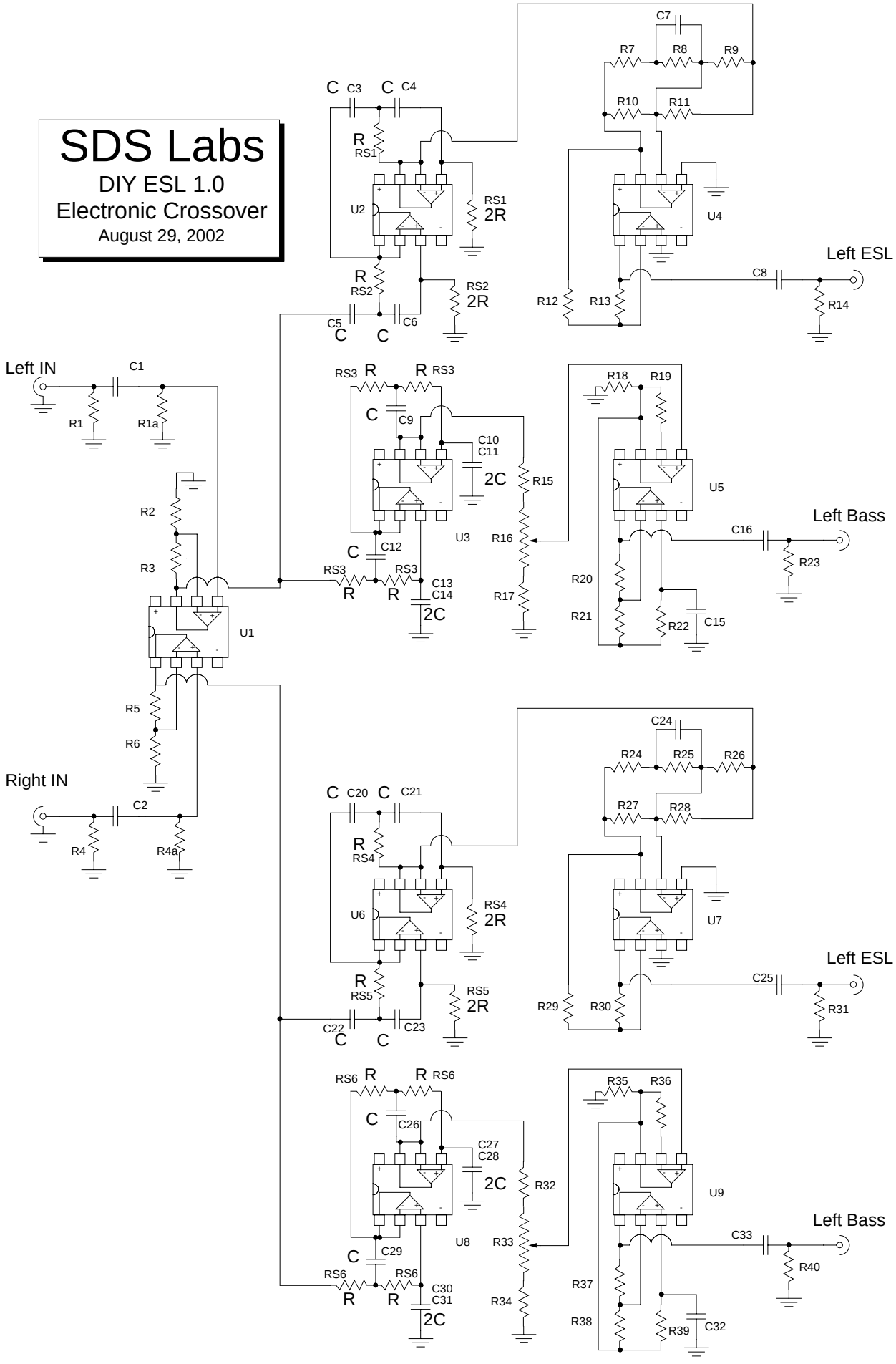
R34
R35
R36
R37
R38
R39
R40
R100
R101
R102
R103
R104
RS1
RS2
RS3
RS4
RS5
RS6
T100
U2
U3
U4
U5
U6
U7
U8
U9
U100
U101
J

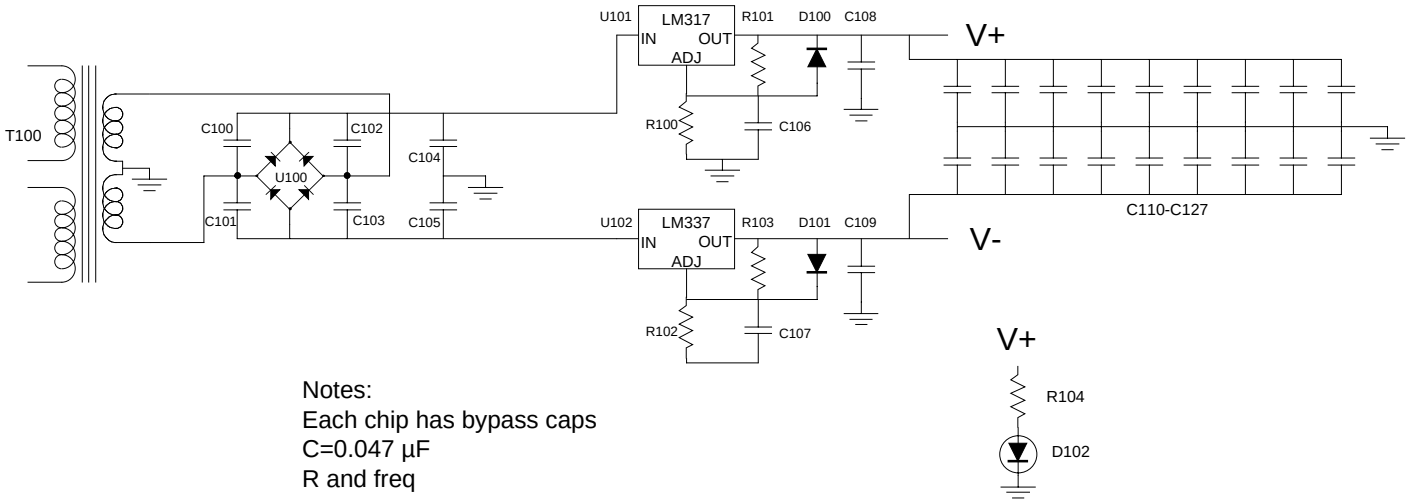
SDS Labs

DIY ESL 1.0

Electronic Crossover

August 29, 2002





Notes:
Each chip has bypass caps
C=0.047 µF
R and freq

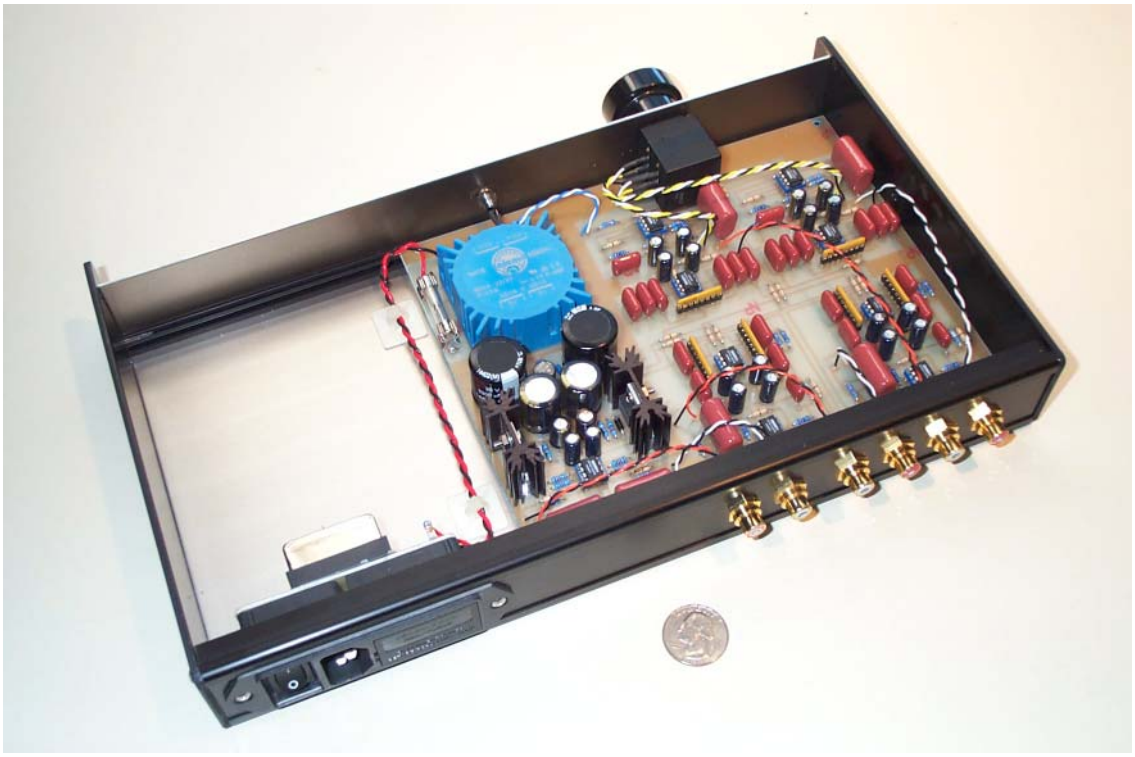
3.9KΩ	614 Hz
4.7 KΩ	509 Hz
5.6 KΩ	427 Hz
6.8 KΩ	351 Hz
8.2 KΩ	291 Hz
10 KΩ	239 Hz
12 KΩ	199 Hz
15 KΩ	160 Hz
18 KΩ	132 Hz
20 KΩ	119 Hz
22 KΩ	109 Hz
27 KΩ	89 Hz
33 KΩ	73 Hz
39 KΩ	61 Hz
47 KΩ	51 hz
56 KΩ	43 Hz

Part #	Description	Digikey #	Page	Price
C1	1.0 µF 250V Polyprop	PF2105-ND	628	$2.94
C2	1.0 µF 250V Polyprop	PF2105-ND	628	$2.94
C3	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C4	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C5	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C6	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C7	0.022 µF 50V Polyprop	P3223-ND	626	$0.57
C8	1.0 µF 250V Polyprop	PF2105-ND	628	$2.94
C9	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C10	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C11	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C12	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C13	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C14	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C15	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C16	1.0 µF 250V Polyprop	PF2105-ND	628	$2.94
C20	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C21	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C22	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C23	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C24	0.022 µF 50V Polyprop	P3223-ND	626	$0.57
C25	1.0 µF 250V Polyprop	PF2105-ND	628	$2.94
C26	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C27	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C28	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C29	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C30	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C31	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C32	0.047 µF 50V Polyprop	P3473-ND	626	$0.55
C33	1.0 µF 250V Polyprop	PF2105-ND	628	$2.94
C100	680 pF 50V Capacitor	P4935-ND	636	$0.46
C101	680 pF 50V Capacitor	P4935-ND	636	$0.46
C102	680 pF 50V Capacitor	P4935-ND	636	$0.46
C103	680 pF 50V Capacitor	P4935-ND	636	$0.46
C104	3300 µF 25V	P7464-ND	594	$3.03
C105	3300 µF 25V	P7464-ND	594	$3.03
C106	220 µF 16V Capacitor	P11199-ND	584	$0.76
C107	220 µF 16V Capacitor	P11199-ND	584	$0.76
C108	2200 µF 16V Capacitor	P10258-ND	585	$1.88
C109	2200 µF 16V Capacitor	P10258-ND	585	$1.88
C110	180 µF 16V Capacitor	P10245-ND	584	$0.49
C111	180 µF 16V Capacitor	P10245-ND	584	$0.49
C112	180 µF 16V Capacitor	P10245-ND	584	$0.49
C113	180 µF 16V Capacitor	P10245-ND	584	$0.49
C114	180 µF 16V Capacitor	P10245-ND	584	$0.49
C115	180 µF 16V Capacitor	P10245-ND	584	$0.49
C116	180 µF 16V Capacitor	P10245-ND	584	$0.49
C117	180 µF 16V Capacitor	P10245-ND	584	$0.49
C118	180 µF 16V Capacitor	P10245-ND	584	$0.49
C119	180 µF 16V Capacitor	P10245-ND	584	$0.49
C120	180 µF 16V Capacitor	P10245-ND	584	$0.49

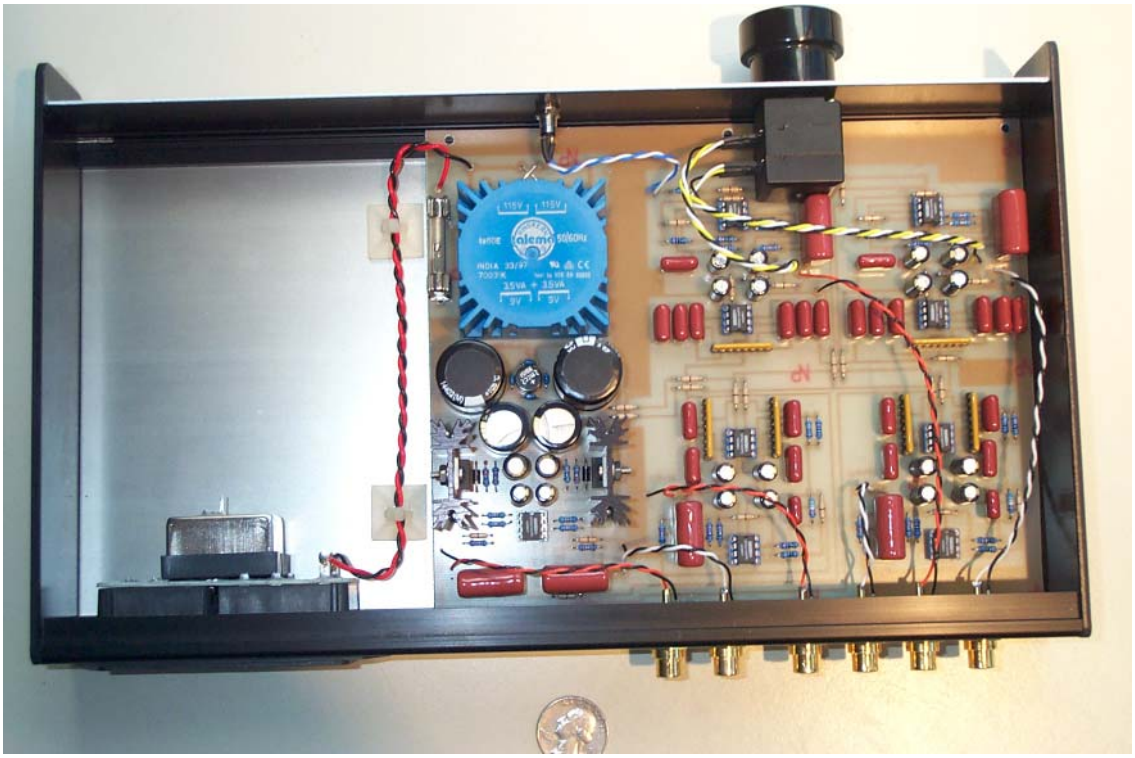
C121	180 µF 16V Capacitor	P10245-ND	584	$0.49
C122	180 µF 16V Capacitor	P10245-ND	584	$0.49
C123	180 µF 16V Capacitor	P10245-ND	584	$0.49
C124	180 µF 16V Capacitor	P10245-ND	584	$0.49
C125	180 µF 16V Capacitor	P10245-ND	584	$0.49
C126	180 µF 16V Capacitor	P10245-ND	584	$0.49
C127	180 µF 16V Capacitor	P10245-ND	584	$0.49
D100	1A Diode	1N4007DICT-ND	495	$0.14
D101	1A Diode	1N4007DICT-ND	495	$0.14
D102	Blue LED	P467-ND	C3	$2.67
R1	221 K 1/4 Watt	221KXBK-ND	674	$0.10
R2	1.21 K 1/4 Watt	1.21KXBK-ND	674	$0.10
R3	5.1 K 1/4 Watt	5.11KXBK-ND	674	$0.10
R4	221 K 1/4 Watt	221KXBK-ND	674	$0.10
R5	5.1 K 1/4 Watt	5.11KXBK-ND	674	$0.10
R6	1.21 K 1/4 Watt	1.21KXBK-ND	674	$0.10
R7	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R8	499 K 1/4 Watt	499KXBK-ND	674	$0.10
R9	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R10	100 K 1/4 Watt	100KXBK-ND	674	$0.10
R11	100 K 1/4 Watt	100KXBK-ND	674	$0.10
R12	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R13	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R14	221 K 1/4 Watt	221KXBK-ND	674	$0.10
R15	100 1/4 Watt	100XBK-ND	674	$0.10
R16	50 K Potentiometer	3299W-503-ND	708	$2.92
R17	49.9 K 1/4 Watt	49.9KXBK-ND	674	$0.10
R18	1.21 K 1/4 Watt	1.21KXBK-ND	674	$0.10
R19	5.1 K 1/4 Watt	5.11KXBK-ND	674	$0.10
R20	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R21	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R22	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R23	221 K 1/4 Watt	221KXBK-ND	674	$0.10
R24	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R25	499 K 1/4 Watt	499KXBK-ND	674	$0.10
R26	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R27	100 K 1/4 Watt	100KXBK-ND	674	$0.10
R28	100 K 1/4 Watt	100KXBK-ND	674	$0.10
R29	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R30	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R31	221 K 1/4 Watt	221KXBK-ND	674	$0.10
R32	100 1/4 Watt	100XBK-ND	674	$0.10
R33	50 K Potentiometer	3299W-503-ND	708	$2.92
R34	49.9 K 1/4 Watt	49.9KXBK-ND	674	$0.10
R35	1.21 K 1/4 Watt	1.21KXBK-ND	674	$0.10
R36	5.1 K 1/4 Watt	5.11KXBK-ND	674	$0.10
R37	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R38	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R39	10.0 K 1/4 Watt	10.0KXBK-ND	674	$0.10
R40	221 K 1/4 Watt	221KXBK-ND	674	$0.10
R100	1.47 K 1/4 Watt	1.47KXBK-ND	674	$0.10
R101	237 1/4 Watt	237XBK-ND	674	$0.10
R102	1.47 K 1/4 Watt	1.47KXBK-ND	674	$0.10
R103	237 1/4 Watt	237XBK-ND	674	$0.10
R104	1.47 K 1/4 Watt	1.47KXBK-ND	674	$0.10

RS1	15 K Resistor Network	4608X-2-153-ND	695	$0.32
RS2	15 K Resistor Network	4608X-2-153-ND	695	$0.32
RS3	15 K Resistor Network	4608X-2-153-ND	695	$0.32
RS4	15 K Resistor Network	4608X-2-153-ND	695	$0.32
RS5	15 K Resistor Network	4608X-2-153-ND	695	$0.32
RS6	15 K Resistor Network	4608X-2-153-ND	695	$0.32
T100	18V 7VA transformer	TE70031-ND	932	$12.87
U1	OPA2134	OPA2134PA-ND	286	$2.63
U2	OPA2134	OPA2134PA-ND	286	$2.63
U3	OPA2134	OPA2134PA-ND	286	$2.63
U4	OPA2134	OPA2134PA-ND	286	$2.63
U5	OPA2134	OPA2134PA-ND	286	$2.63
U6	OPA2134	OPA2134PA-ND	286	$2.63
U7	OPA2134	OPA2134PA-ND	286	$2.63
U8	OPA2134	OPA2134PA-ND	286	$2.63
U9	OPA2134	OPA2134PA-ND	286	$2.63
U100	1.5 Amp Diode Bridge	RB151MS-ND	472	$0.52
U101	Pos. Adjustable Regulator	LN317TNS-ND	363	$0.63
U102	Neg. Adjustable Regulator	LM337TNS-ND	363	$0.94
HS1	Heat Sink	HS231-ND	423	$1.10
HS2	Heat Sink	HS231-ND	423	$1.10
			Total:	$108.72

Resistance	Frequency
3.9 K Ω	614 Hz
4.7 K Ω	509 Hz
5.6 K Ω	427 Hz
6.8 K Ω	351 Hz
8.2 K Ω	291 Hz
10 K Ω	239 Hz
12 K Ω	199 Hz
15 K Ω	160 Hz
18 K Ω	132 Hz
20 K Ω	119 Hz
22 K Ω	109 Hz
27 K Ω	89 Hz
33 K Ω	73 Hz
39 K Ω	61 Hz
47 K Ω	51 Hz
56 K Ω	43Hz



Another View of The Assembled Unit



Yet Another View of The Assembled Unit

Board Etching Tips

The artwork is printed onto transparency film from a laser printer, print it three times. Cut out two of the prints with about a quarter inch of clear space around the circuit board image. Then carefully tape these two copies to the uncut one after carefully aligning the traces of the overlay to the uncut sheet's traces. When finished, there should be three perfectly stacked copies. This increases the contrast of the final image. When a transparency is printed with a laser printer, there are usually holes in the black printed parts. And the blacks aren't all that black when it is held up to the light. Overlaying makes the blacks much more black, and gets rid of the holes. Now the artwork is ready to use. For double sided boards, the two sheets of artwork can be taped securely together on three sides after carefully aligning the traces on each side. this forms an envelope which the circuit board gets slid into. It's helpful to tape the board in place inside the envelope with a single piece of tape. This will prevent the board from shifting when it is flipped over to expose the second side.

This method uses GC positive sensitized boards and developer. The FR-4 fiberglass 1 Oz. grade board works very well (they can be gotten local electronics stores). The board emulsion is sensitive to UV light, A good source of UV to expose the board is a GE sunlamp. The sunlamp is hung so the bottom of the bulb is about 12" above the board. The exposure time is 9 minutes. With a yellow incandescent bug light-bulb on, pull the protective coating off the board and carefully align the artwork on top of the board. Then cover the artwork with a piece of glass to hold the artwork against the board (just like making a contact print in photography). Then turn the sun lamp on for 9 min. If a sunlamp is unavailable, the sun at noontime (on a clear day) can be used exposing the board for about 20 minutes.

The exposed board gets dumped into the developer which has been mixed up beforehand. The developer says to use a 1:9 concentration of developer to water, but a 1:5 mix can be used, which works faster and can yield slightly better results. However the timing is more tricky, so it is not recommended for the first time. Submerge the board into the developer (A photography developer tray works very well), and rock the solution back and forth over the board. The exposed parts with start to dissolve. The emulsion is green and it will wash away exposing the copper underneath. This is the tricky part. The board must be removed when all the emulsion is off the exposed areas. If the board is removed too soon, the emulsion won't be completely dissolved off the exposed areas and it won't etch, if the board is in the developer too long all the emulsion dissolves and all that is left is a bare board. With the 1:9 solution this time window is about a minute, with a 1:5 solution it's about 20 seconds. The board is removed from the developer and washed off with room temperature water, then scrape at a an exposed area and see of there is any emulsion left there. if there is, place the board back in the developer for a few seconds. Repeat this as necessary until the exposed areas clear. With a little practice, it's pretty obvious when it's time to pull the board out. Do all the developing using the yellow bug light. When the board is done, wash it off and let it dry. Be careful of the emulsion, it's easily scratched, especially when fresh from the developer.

Next, drop the board into an etching solution. Ferric Chloride is available from the same electronic outlets where the GC boards and developer are purchased or from Radio Shack. Ferric Chloride is a nasty smelling, iodine looking, serious staining stuff. Pour out the developer from the tray, wash it out and add the etchant. Then put the board into the etchant and rock gently back and forth for about a half hour or so, until all the exposed areas are clear. Then remove the board and wash it clean. The emulsion can then be removed with acetone or alcohol.

Then all the holes need to be drilled in the board. A Dremel moto tool works well for drilling the small holes, a small drill press would also work.