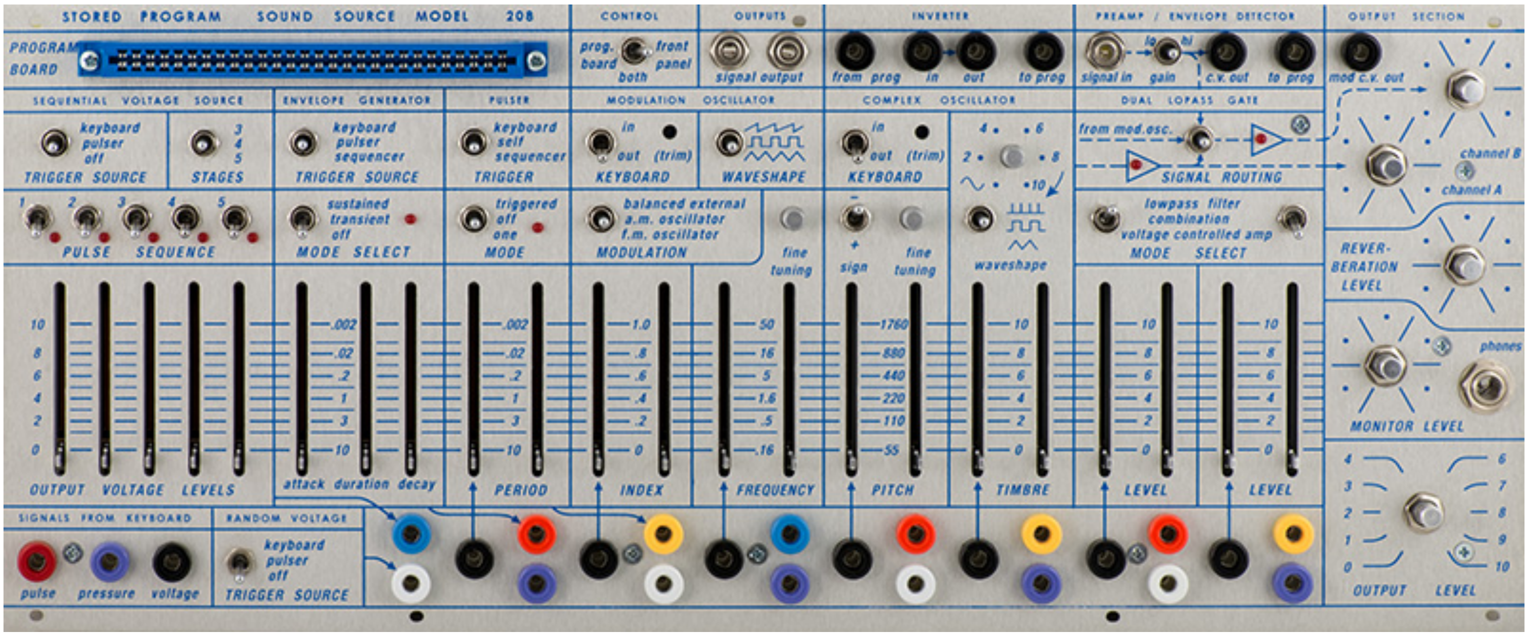
Buchla 208 V2 Stored Program Sound Source Module

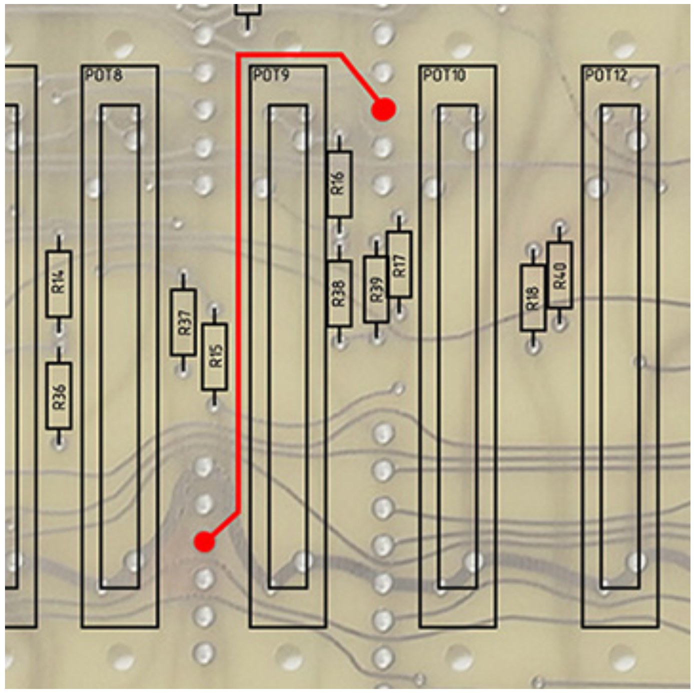
I built a V2 Buchla 208 Stored Program Sound Source module for someone else. They sent me a mostly complete kit of parts (excluding knobs, slider caps and a few miscellaneous components) and I assembled and tested the module. Many of the components are sourced through Mouser but specialized parts, panel, and knobs have specific sourcing and I do not know the details. V2 is designed as per the original Buchla module with a motherboard and 12 plug-in cards. The individual cards makes the PCBs easier to assemble but it takes much longer to build them.. This module took me 27.5 hours to build.



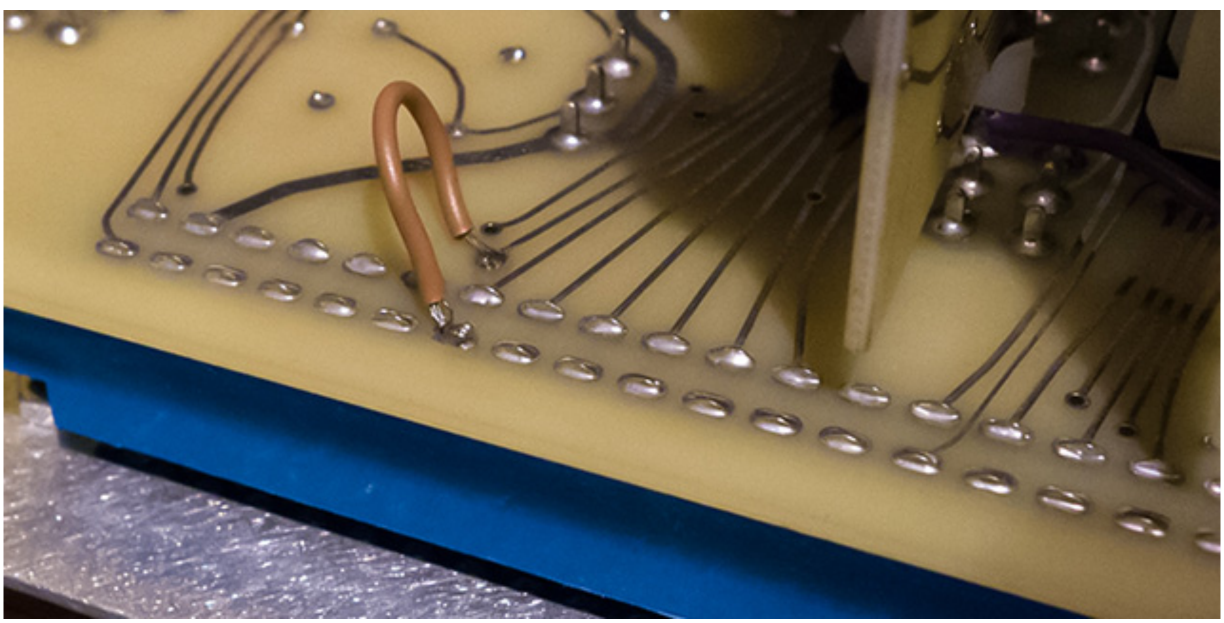
Music Easel Manual 1974	A scan of the manual
Music Easel Manual 1974	A better color scan of the manual contributed by Luther R.

Motherboard Build Tips

According to the forum there are two wires that need to be added to the motherboard. On this version of the PCB the trace between the switches SW1 and SW8 was present but the trace between Molex 4A and Molex 3B was not so I had to add a wire on the front of the motherboard. I've been told the latest version of the motherboard now has this trace.

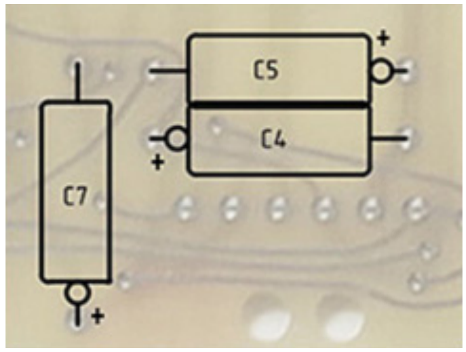


Boops on the Muffwiggler forum found there is a missing trace as the second stage doesn't trigger from the program card. Add a wire from the back from the external pin 7 of the card slot to the via just below it as shown in this photo.



DrKorg on the Muffwiggler forum found that trimmer TR3 CO LOW FREQ TRACKING is connected to pin 11 of card 8 but should connect to pin 12 of card 8. Pin 11 is not in use so you can solder a jumper between pin 11 and pin 12 on card 8.

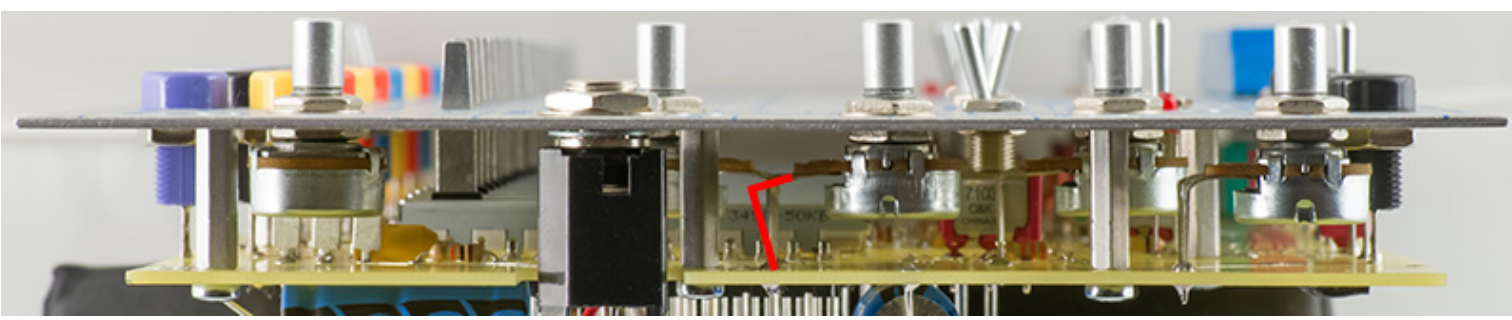
The round circle on the motherboard reference diagram indicates the capacitor + lead.



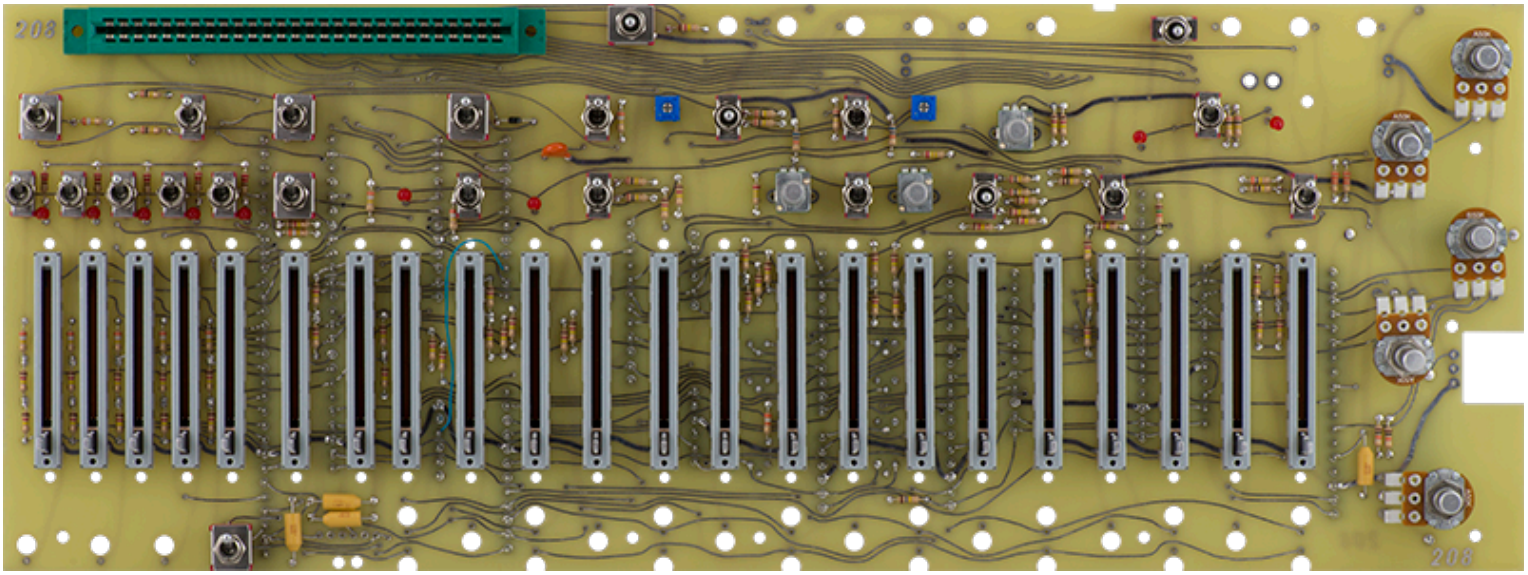
I installed the LEDs and bent the longer pin over 90 degrees to solder it to the shorter pin. These keeps the LEDs captive as I leave them unsoldered until the PCB is mounted on the panel. Then I press them through flush and solder them to a perfect height.

The switches with a nut on top of the panel only extend 16.25mm below the panel while the standoffs are 17mm long and will warp the PCB slightly. While it probably is not an issue I made a cardboard E template that I could slip under the switches and solder them 0.75mm off the PCB. I only soldered one pin then installed the top panel. I backed the nuts up against the rear of the panel and tightened the top nuts flush with the switch barrel. Then I reflowed each pin to relieve the stress and soldered the remaining pins.

The 16mm angled potentiometers have a similar issue. I solder just the center pin so the top is just flush with the PCB. Then I backed the nuts up against the panel rear and tighten the top nuts. Then I reflowed each pin to relieve the stress and soldered the remaining pins. However when I assembled the front panel the 16mm angled potentiometers did not align very well with the front panel so the pins were bent (indicated by the red line in the center of the photo). I worried about stress fracturing the potentiometer phenolic base where the leads crimp to it as I have seen such fractures in my repairs. I rebent the leads carefully to better align with the PCB pads as can be seen in this photo.



This image shows the motherboard front with the potentiometers soldered by only one pin and the LEDs unsoldered. It took 5 hours and 45 minutes to solder the motherboard. I used water washable flux solder and no-clean solder for the potentiometers, switches, and LEDs although I do clean them anyway. I used a more robust EDAC edge connector (Mouser 587-305-056-500-202) for the motherboard and used the blue Jamma 56P-3.96S connector for the front panel.

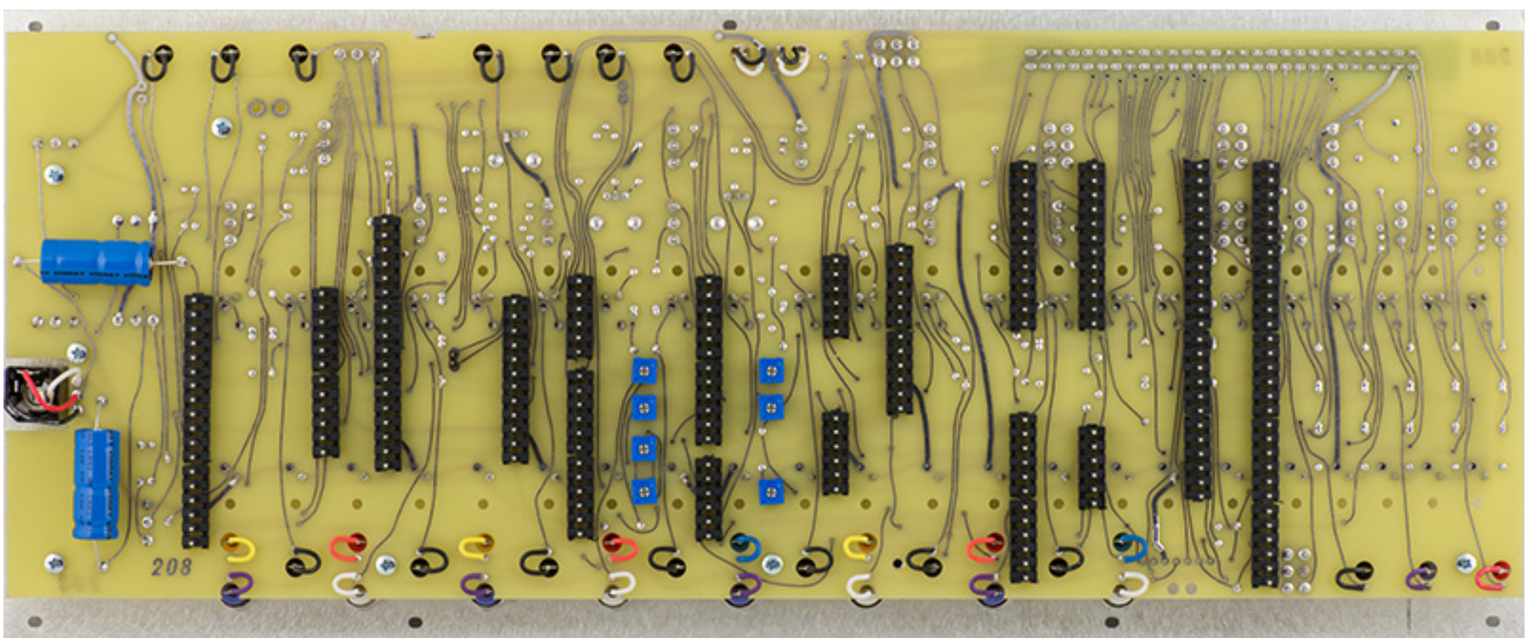


[High resolution motherboard front image]

[Early motherboard schematic] (for 208 V2 motherboard, may be some errors)

[Late motherboard schematic]

I match the wire color to the banana jack. Everything is soldered and cleaned. In total the motherboard and panel took over 9 hours to fully assemble and wire.

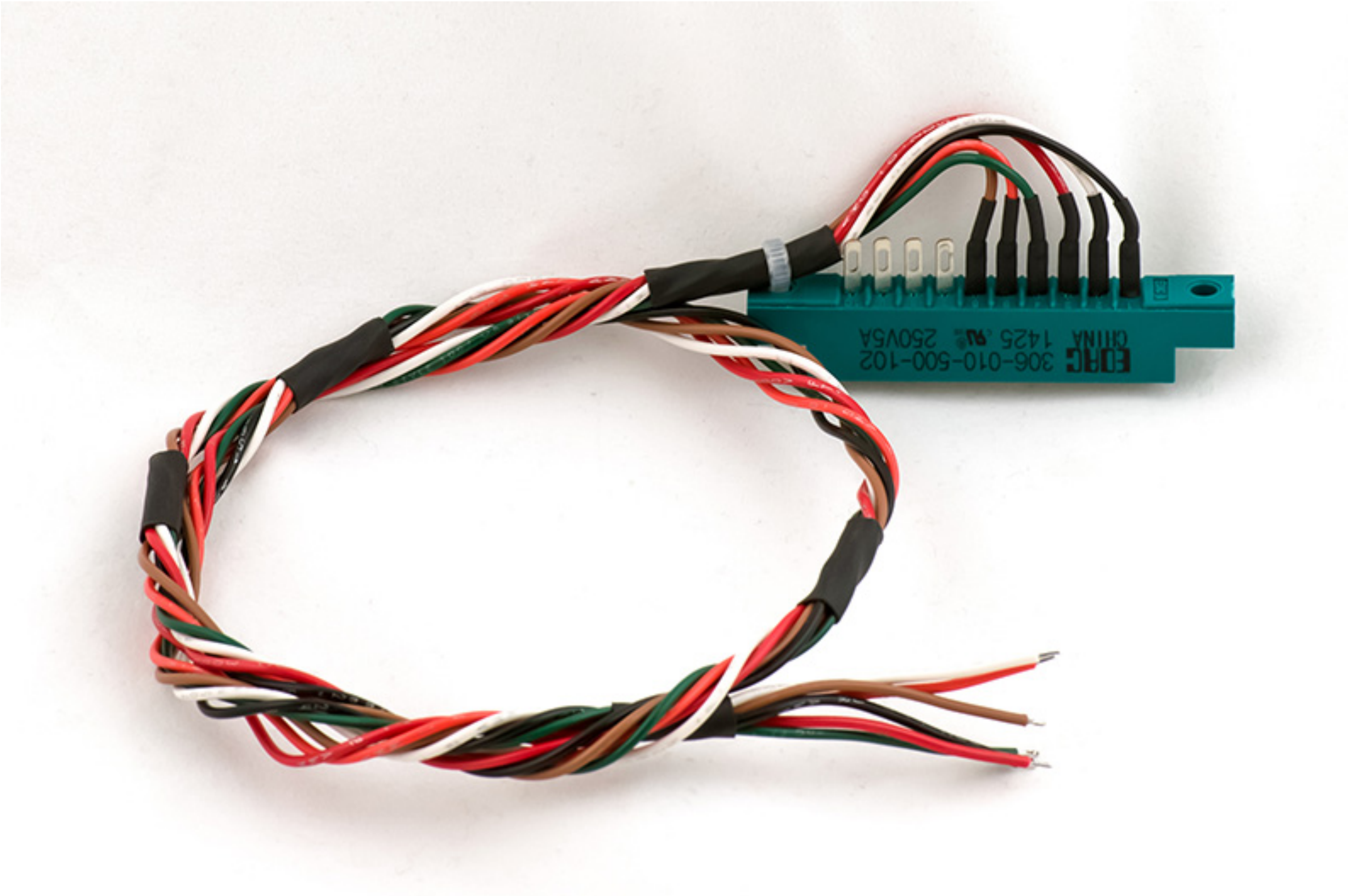


[High resolution motherboard rear image]

I measured the distance between the top of the front panel and the bottom of the EDAC connector and then soldered the program card extender so there would just be a small gap at the bottom of the EDAC connector.

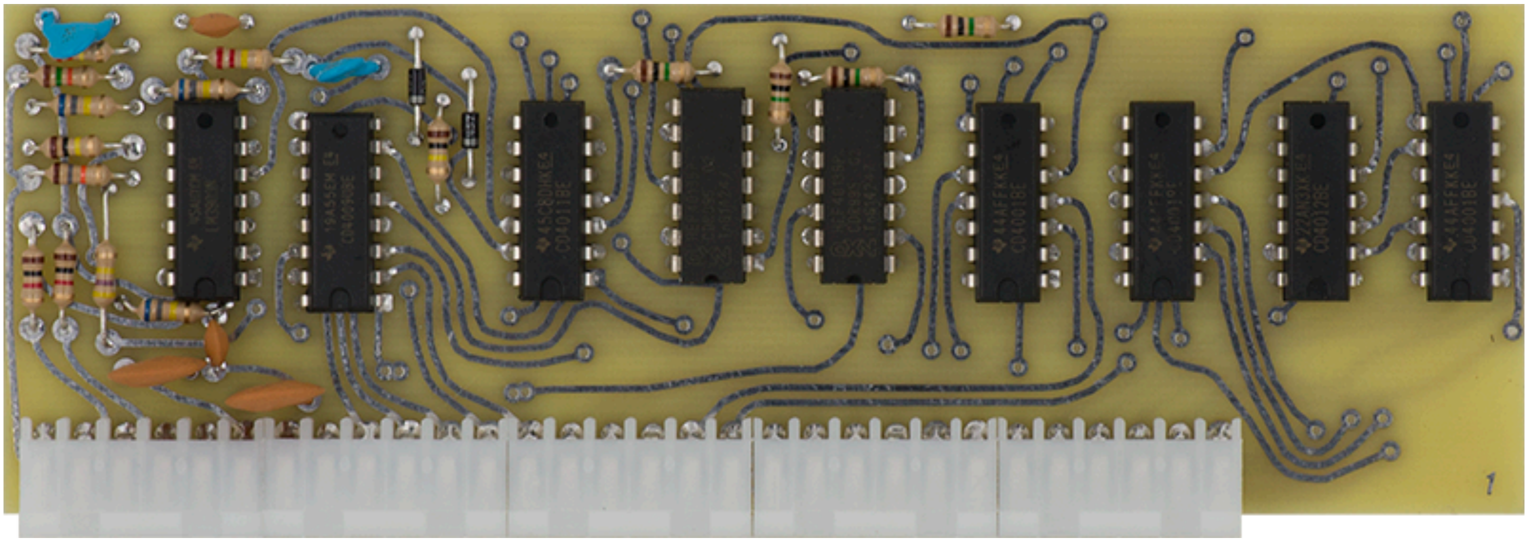
Careful soldering prevents wicking the solder on the pad. This particular connector came with blue tabs on each end that had to be cut off. The bottom of the connector sits lower than the flanges so I put two flat washers between the connector and the panel to fill the gap so the connector is firmly screwed to the panel. Total build time for the panel and motherboard was 9.5 hours.

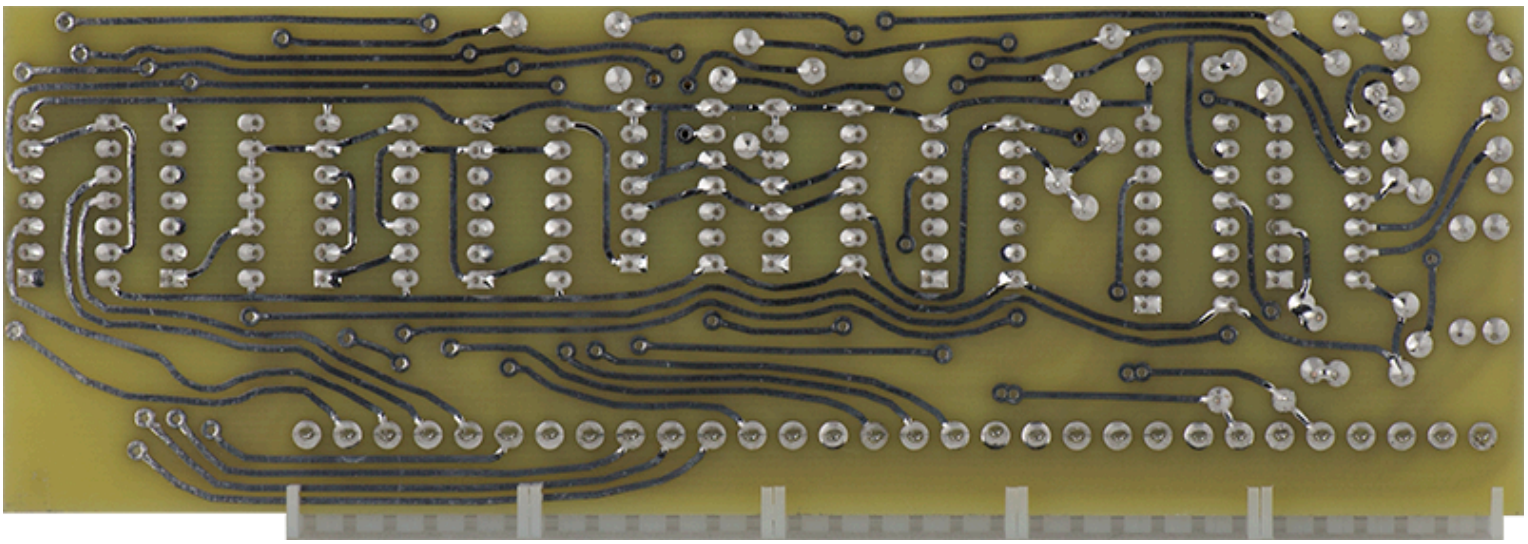
I make the power cables out of 24 AWG stranded wire and use heat shrink to hold the twist. This cable is 18" long.



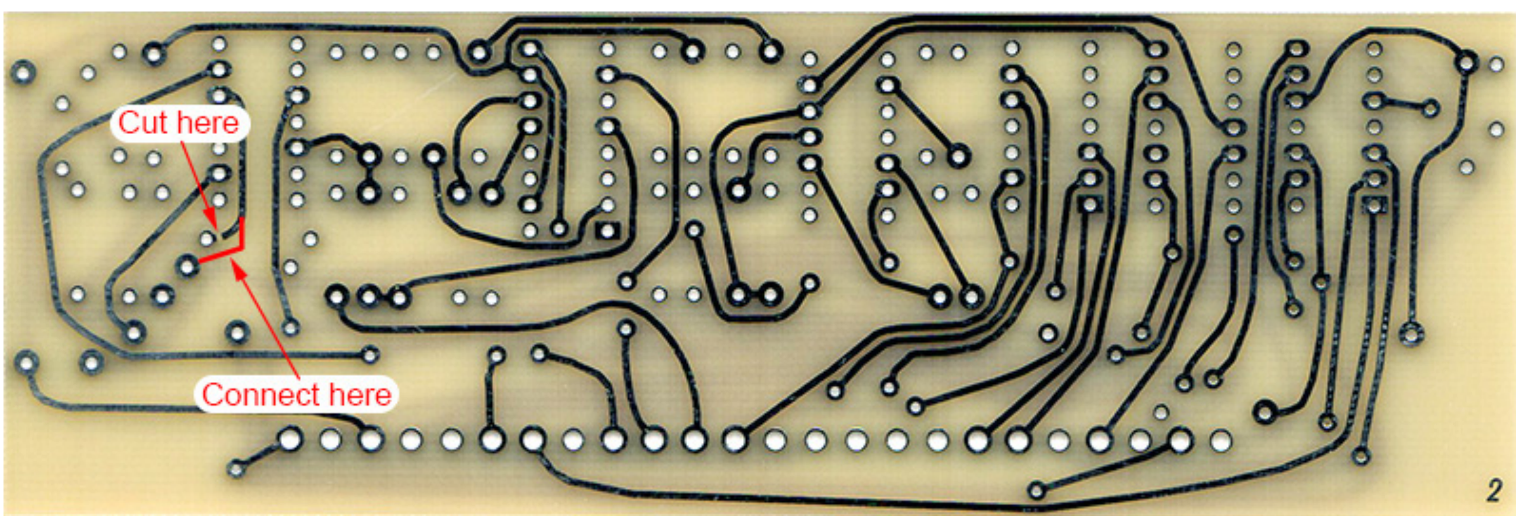
Card Build Tips

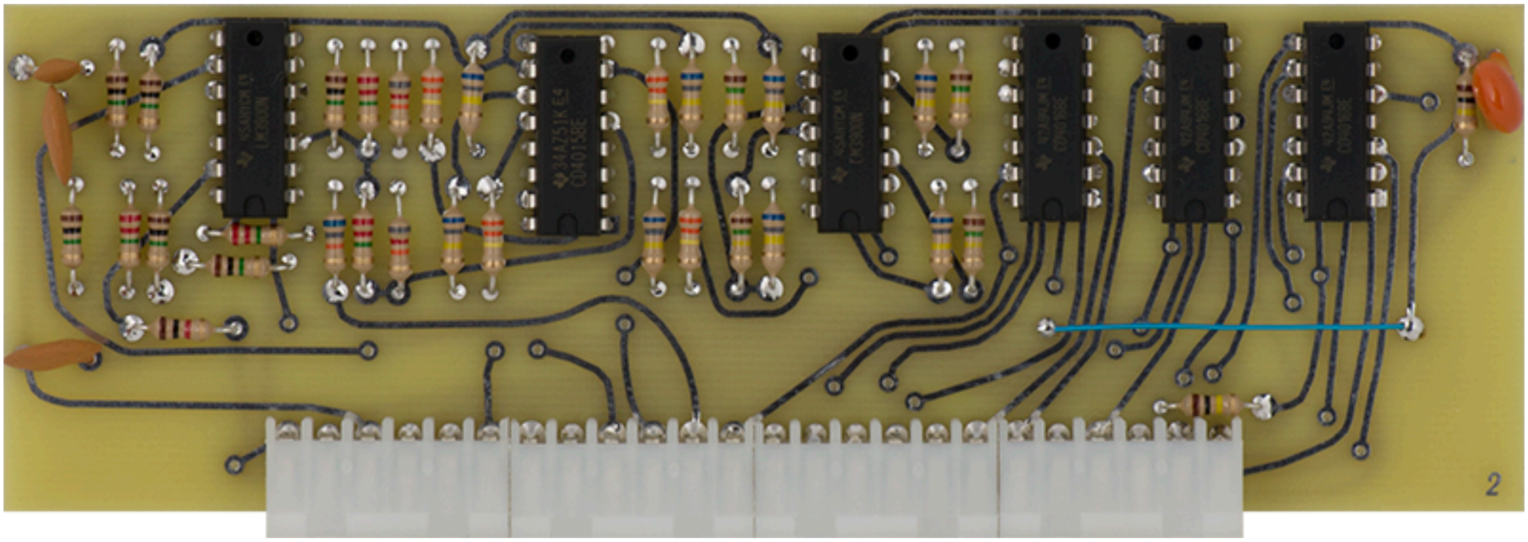
It took about 17.5 hours to build the 12 cards. Some of the simpler cards took 45 minutes while some of the more complex ones took up to 2 hours. Card 1 is the five stage sequencer and is one of the simplest cards to build.

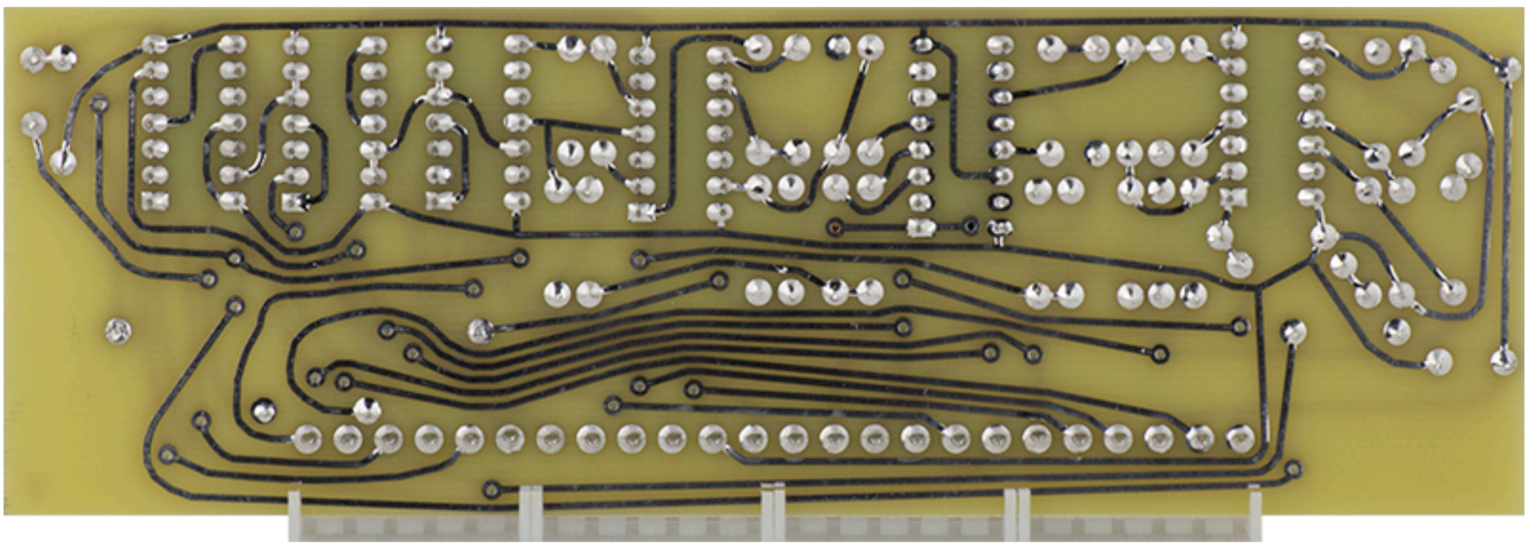




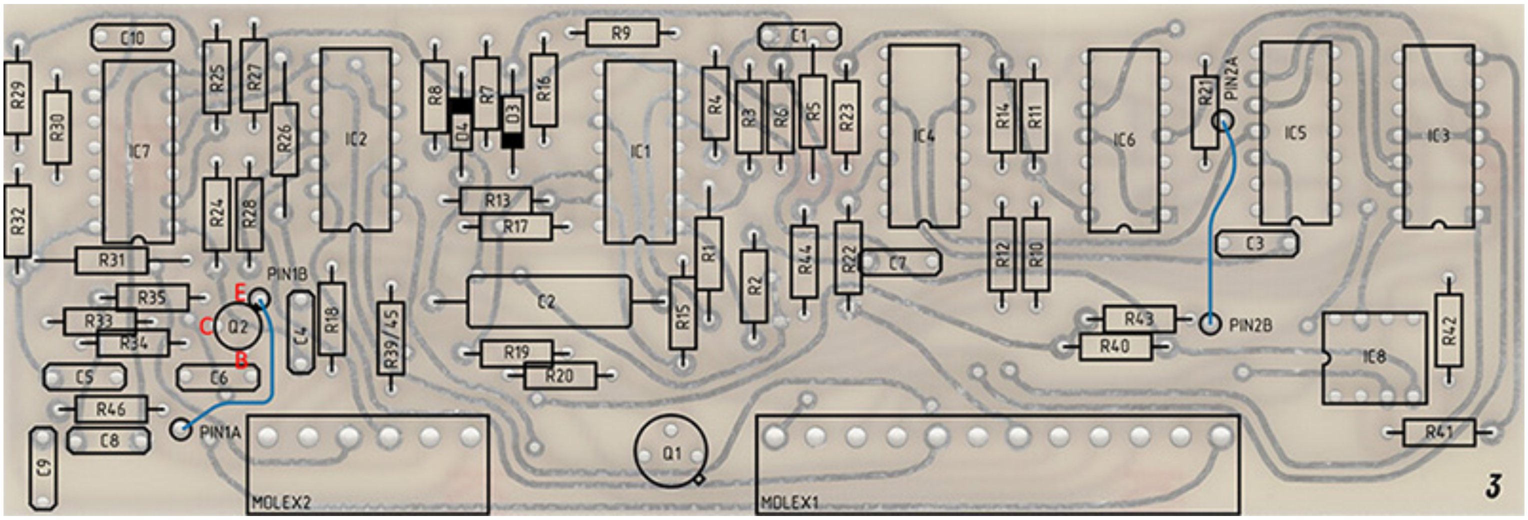
Card 2 is the random voltage source and has one wire. It also requires a cut and jumper modification.



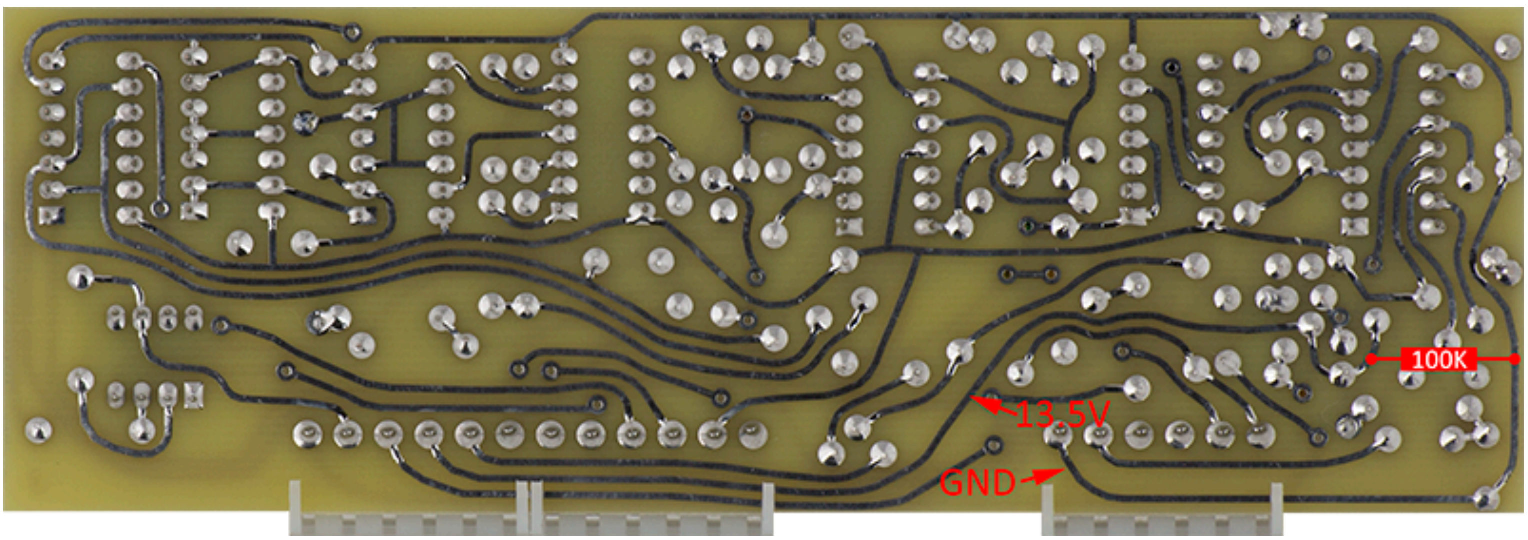


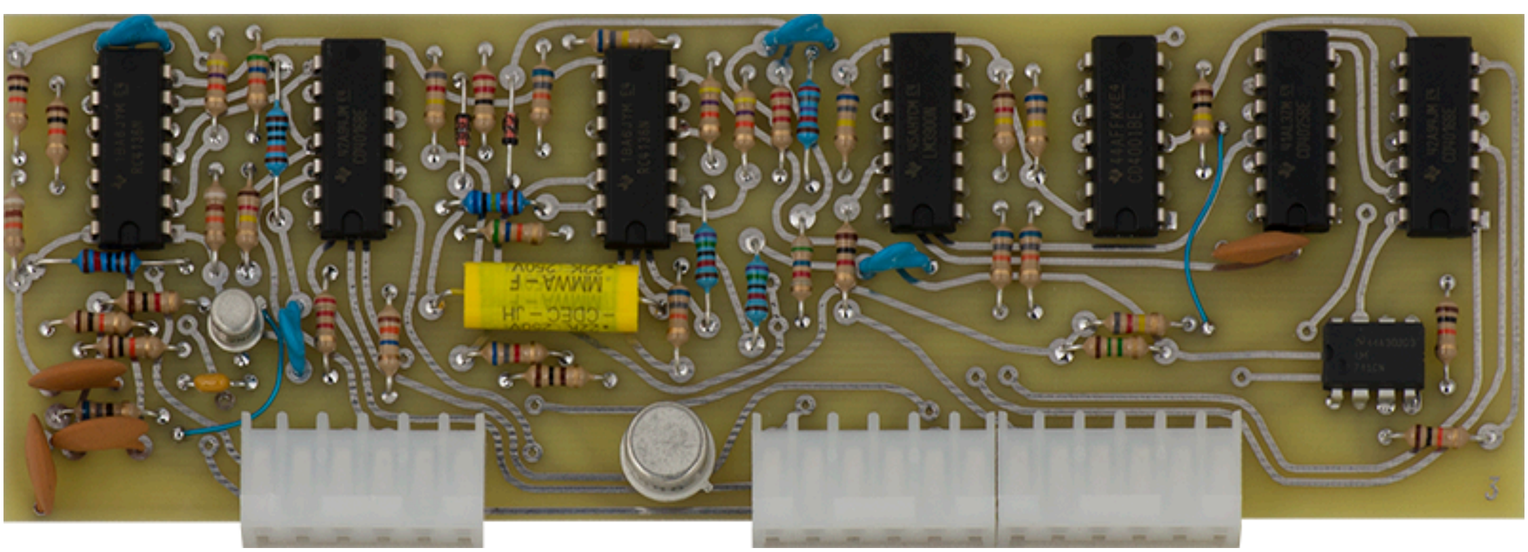


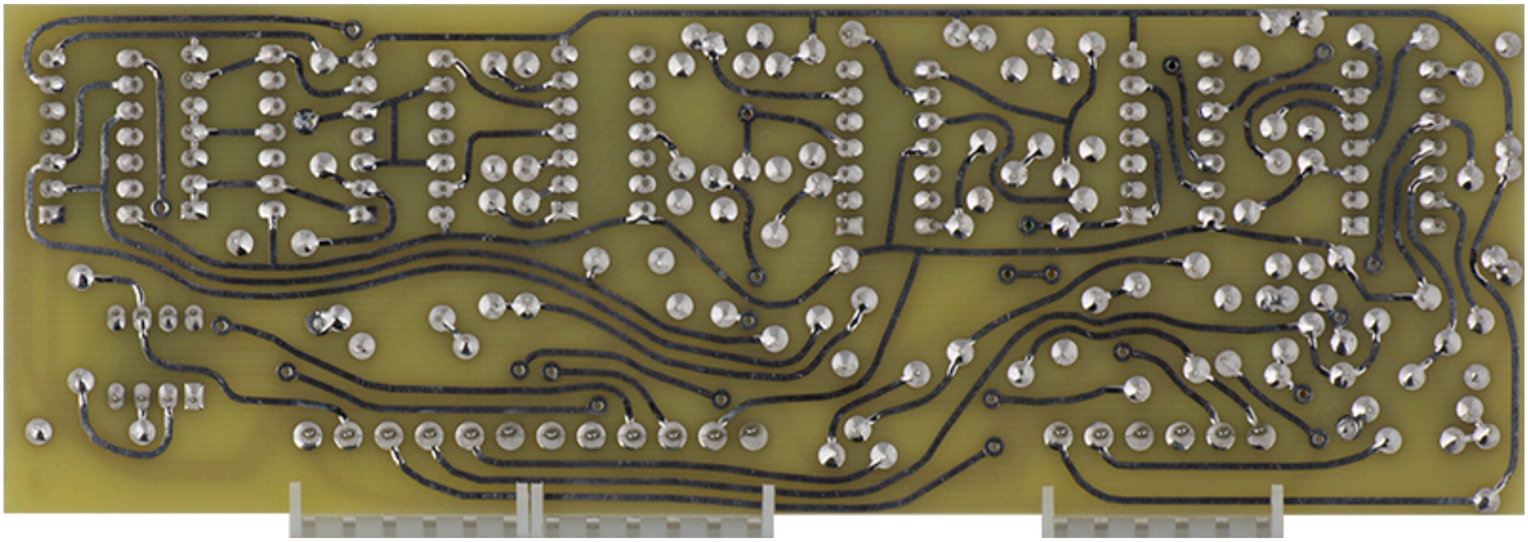
Card 3 is the envelope Generator and has two wires. I have tried to help others through email fix the 13.5V supply that is on this PCB. They tend to run a full volt over at 14.5V. The issue is the Q2 pinout is ECB, not EBC. You have to bend the leads to fit.



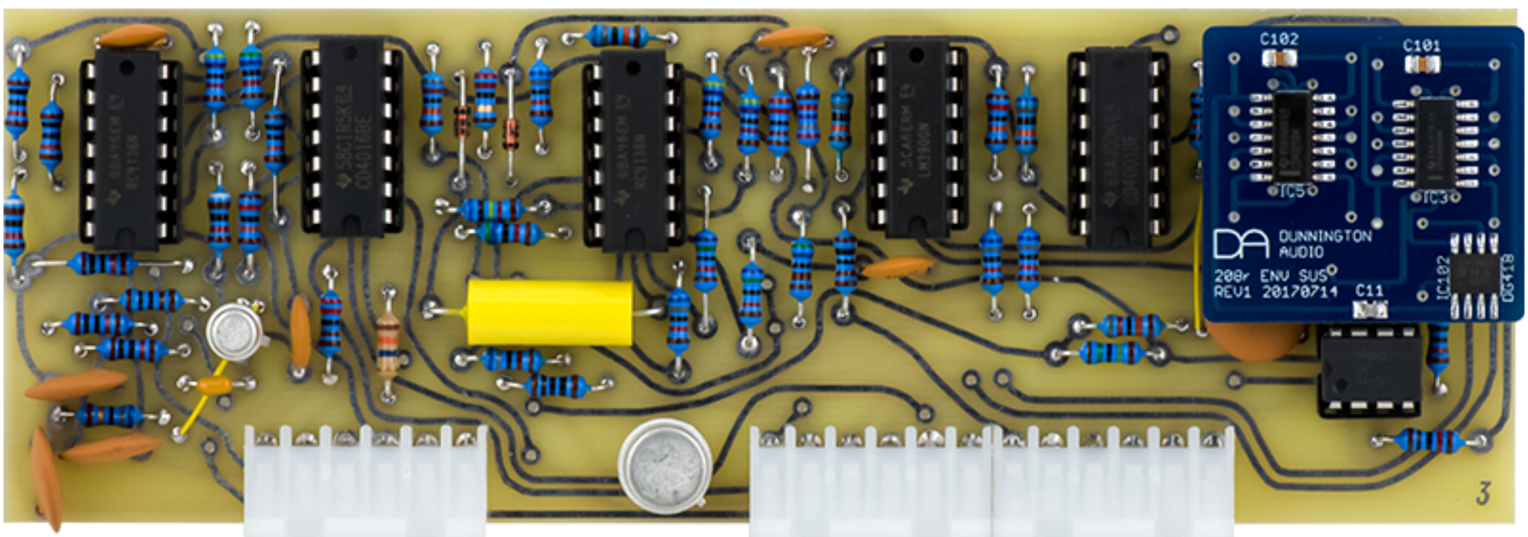
The regulator requires a load and the original schematics had a 100K from edge pin 4 to ground. I added the resistor on the rear.



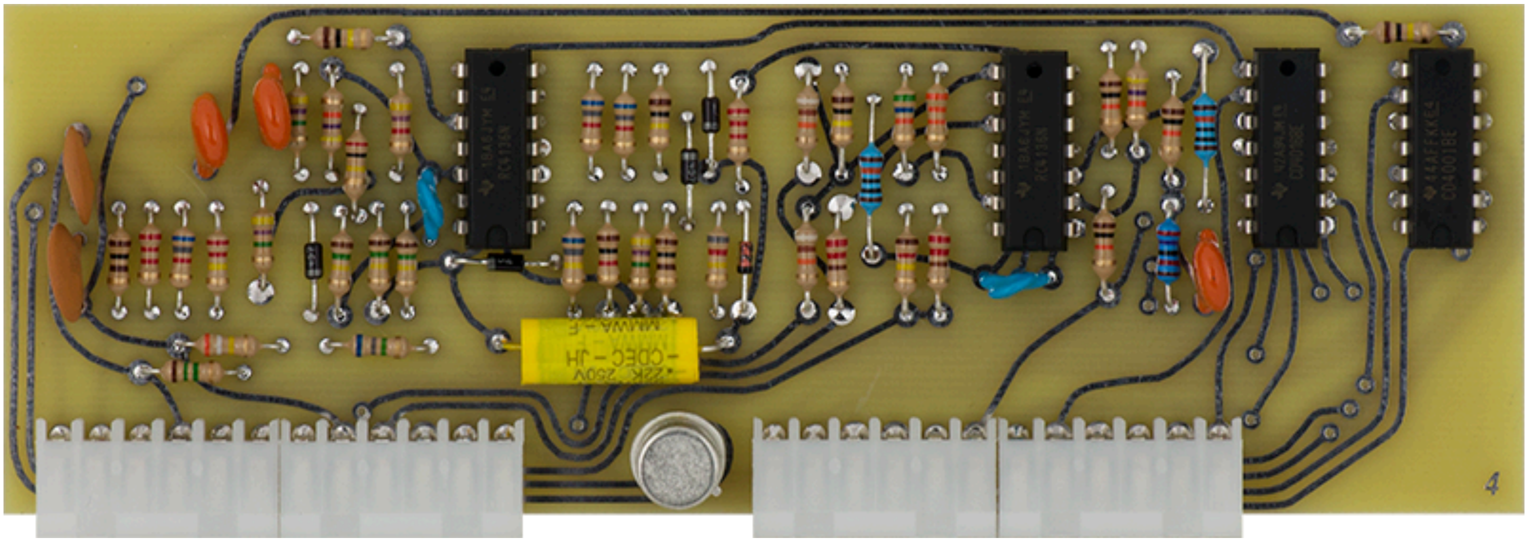


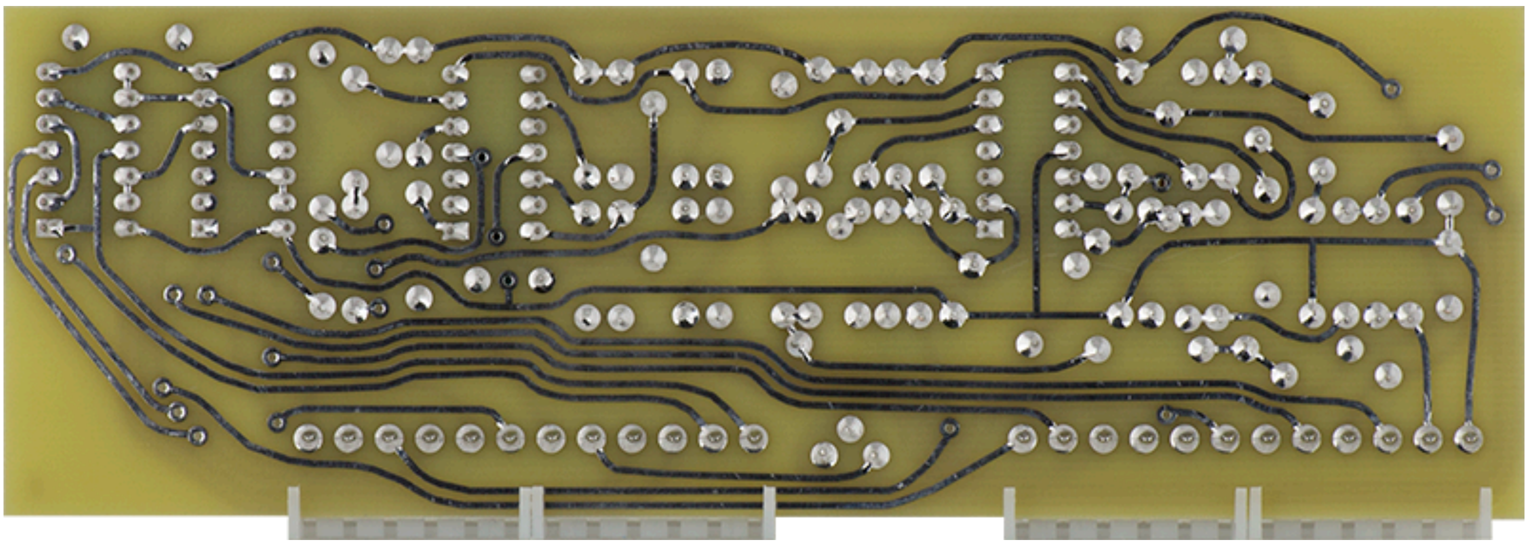


Here is Card 3 with the [Dunnington Audio Music Easel Infinite Sustain module]() installed. I soldered it directly to the PCB.

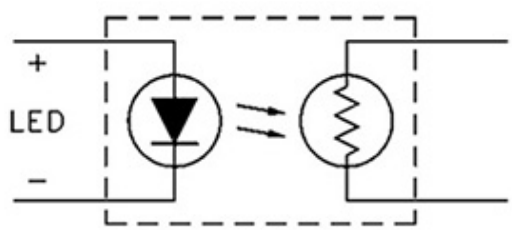


Card 4 is the pulser.

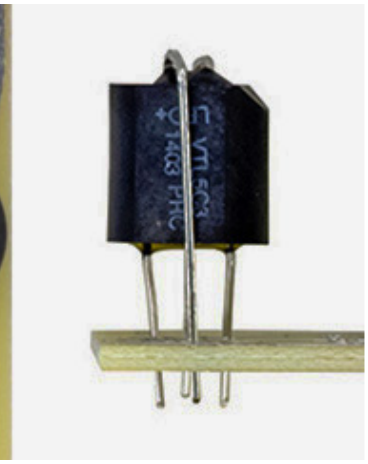




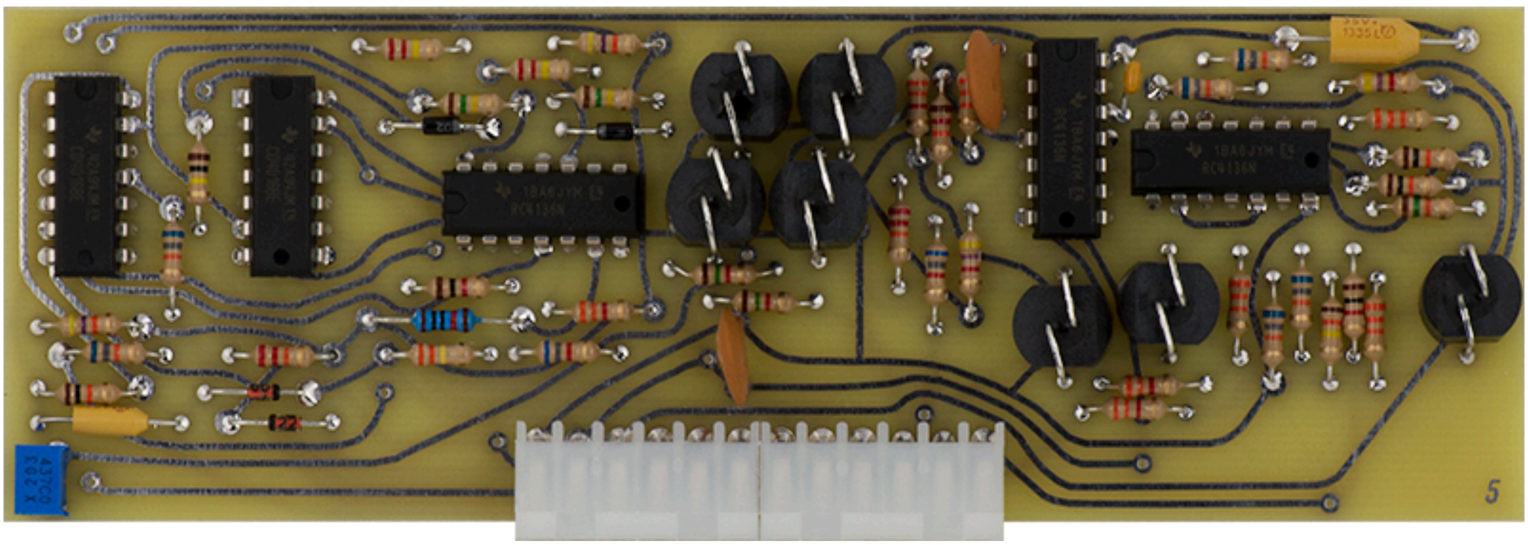
Card 5 is the balanced modulator. The + sign on the vactrol indicates the anode lead to match to the PCB reference diagram.

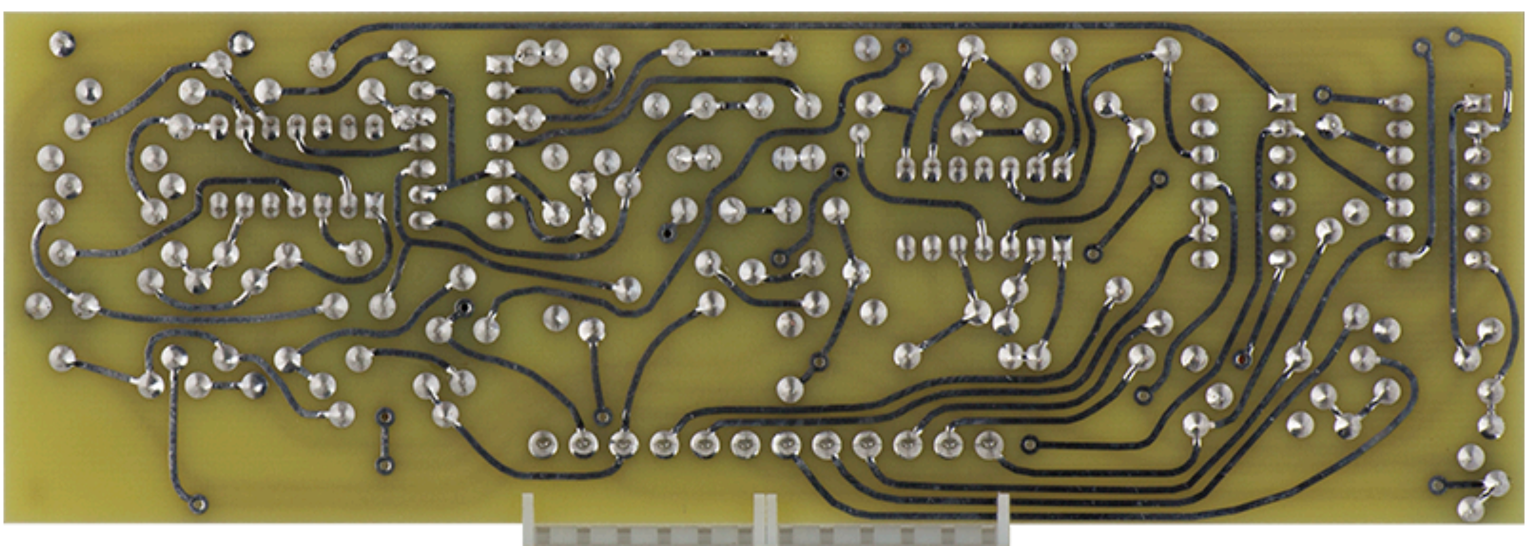


The vactrols on cards 5, 7, and 8 mount with the round resistor leads directly into the PCB and the square LED leads bent over and around into the PCB.

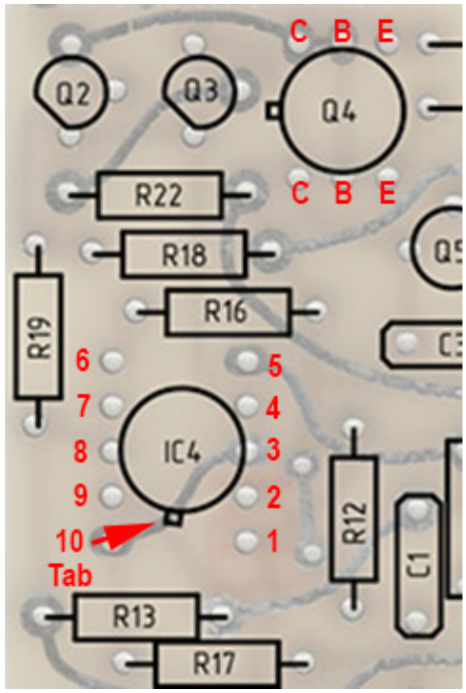
 

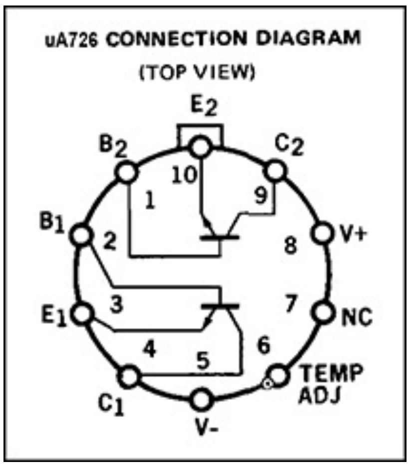
The BOM calls out 1N5228 for D3 and D4 which are 3.9V zener diodes. These should be 1N5236 which are 7.5V and what were used in the original design. This voltage is needed to not exceed the maximum voltage of the CD4016 parts.

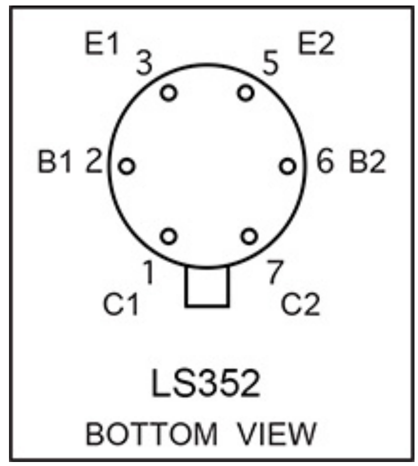


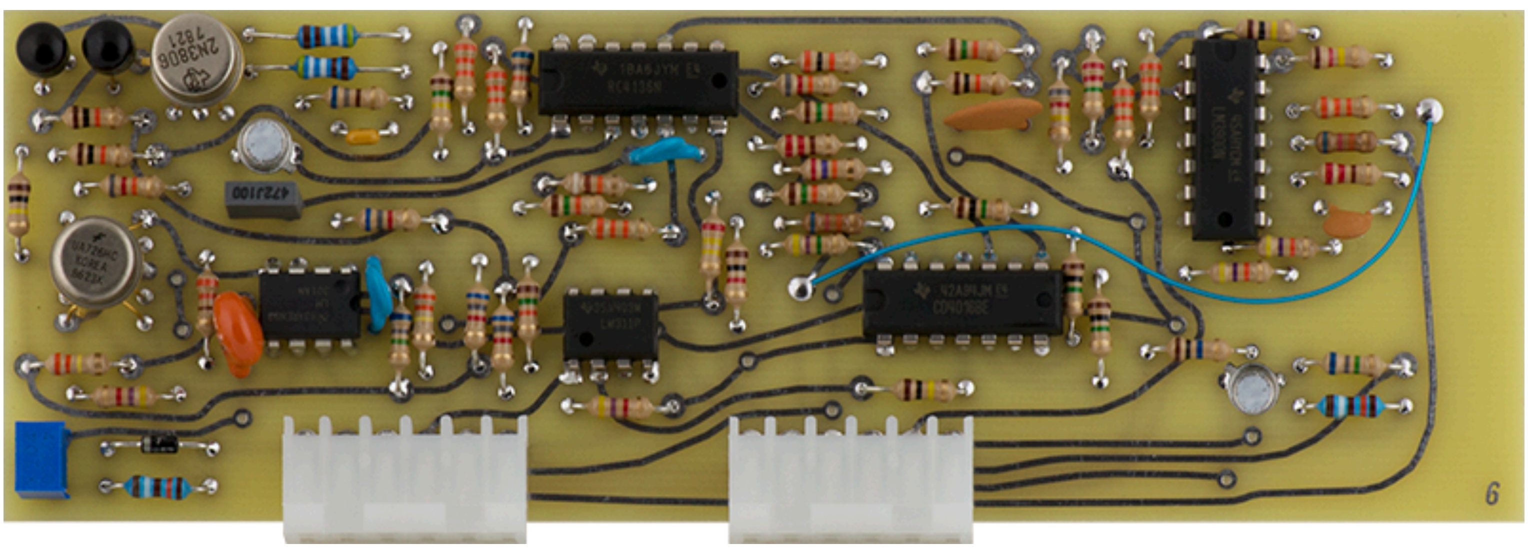


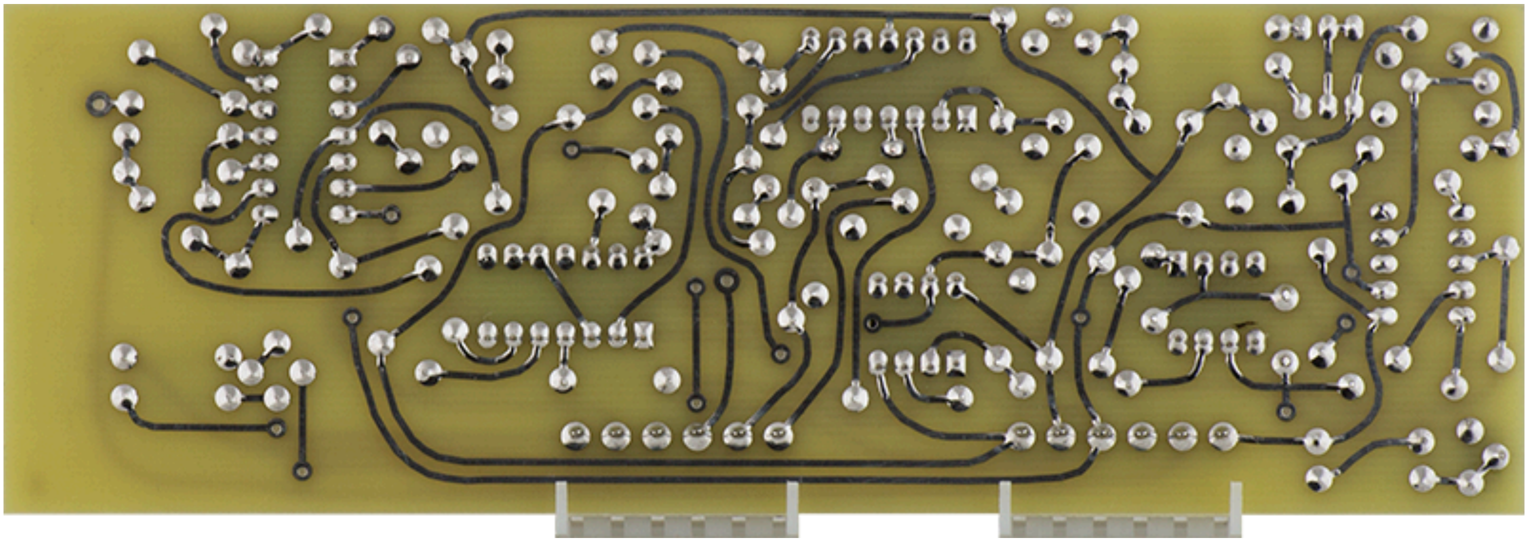
Card 6 is the modulation oscillator. The uA726 tab should point to pin 10, the oval pad on the bottom left. The LS352 tab points to Q3.





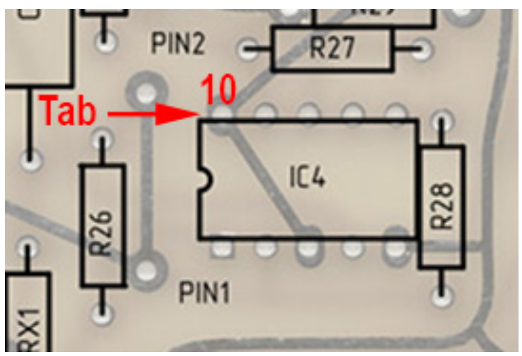


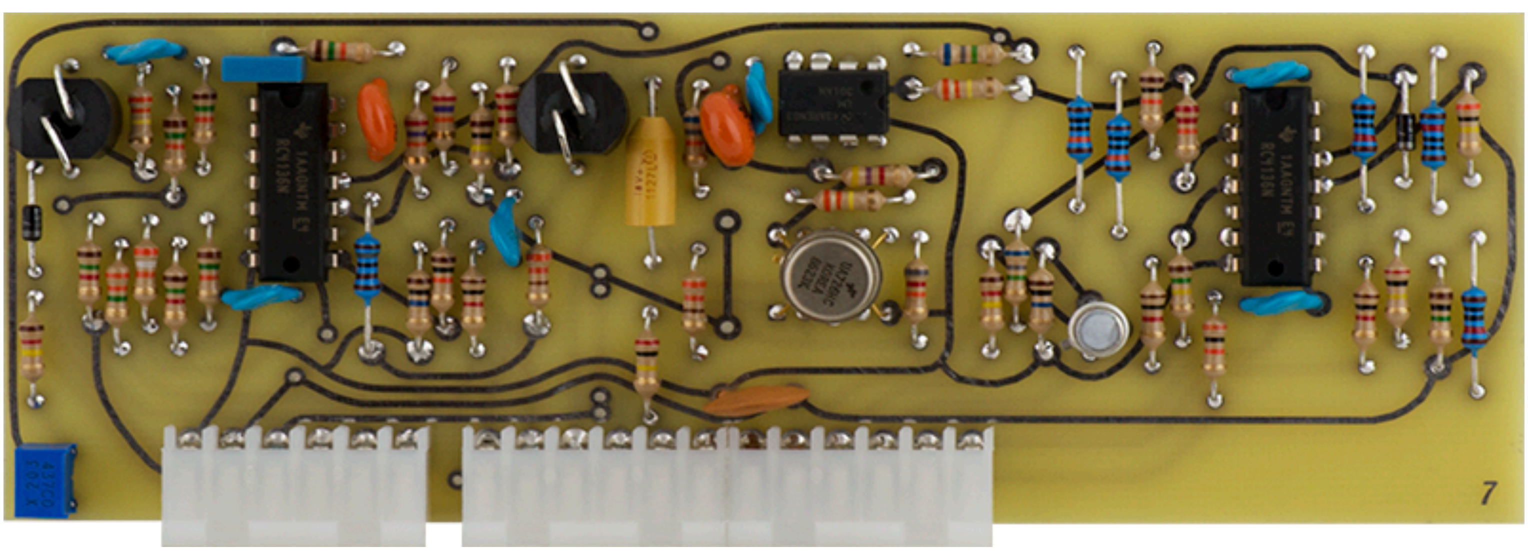


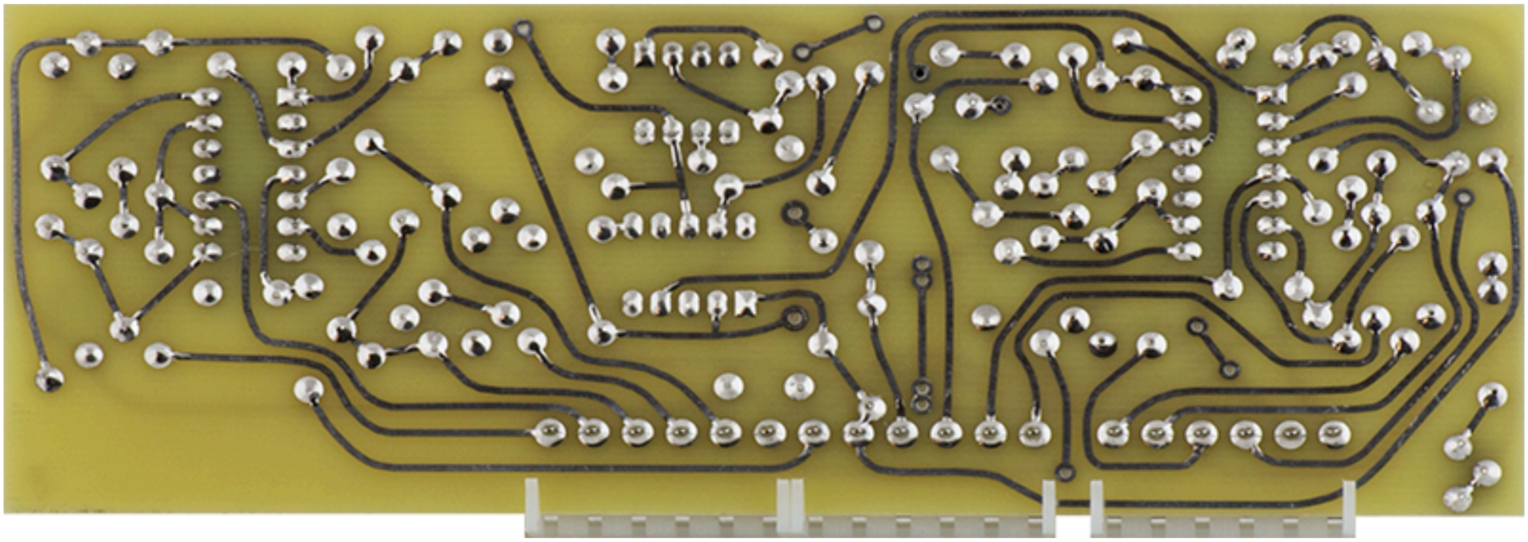


Card 7 is the first of three cards for the complex oscillator. The BOM specifies R3 as 1K8 while the original schematic shows 10K. Increasing R3 to 10K significantly increases the timbre folding. I ended up selecting R3 to be 8K2 for best performance.

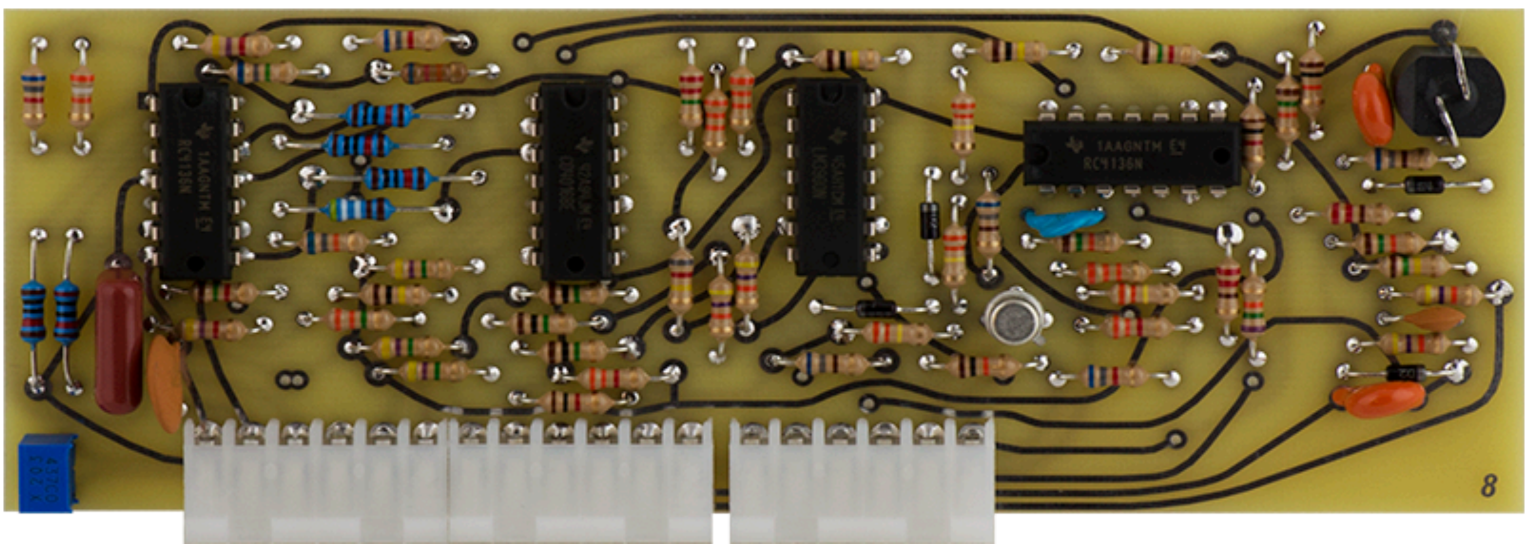
The reference designator for the uA726 shows pin 1 so the tab should point to pin 10 on the upper left.

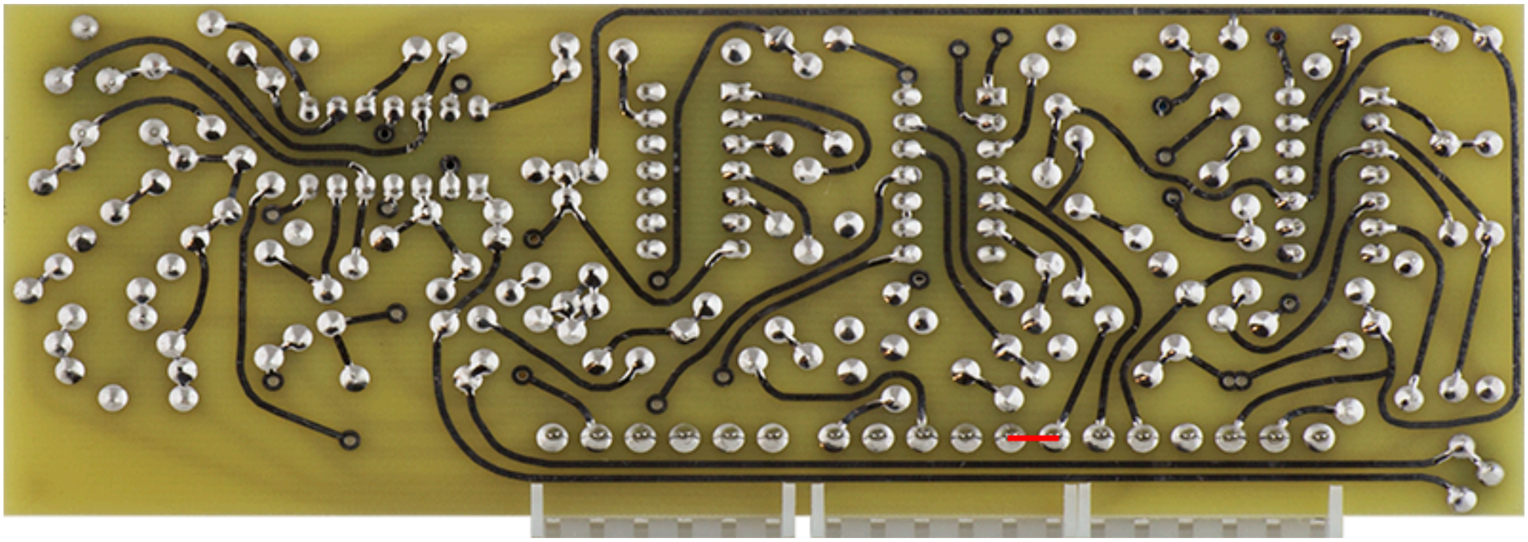




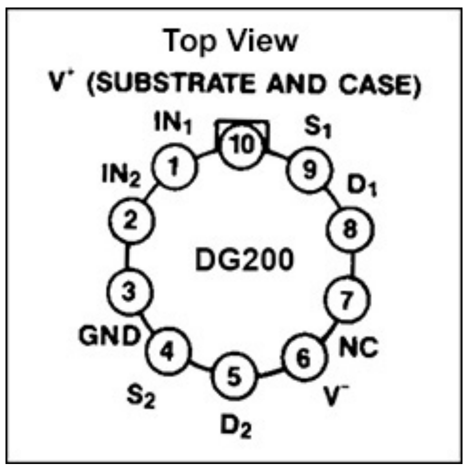


Card 8 is the second of three cards for the complex oscillator. TR3 on the motherboard connects to pin 11 of card 8, not pin 12. Simply short pins 11 and 12 as shown in the photo to fix.

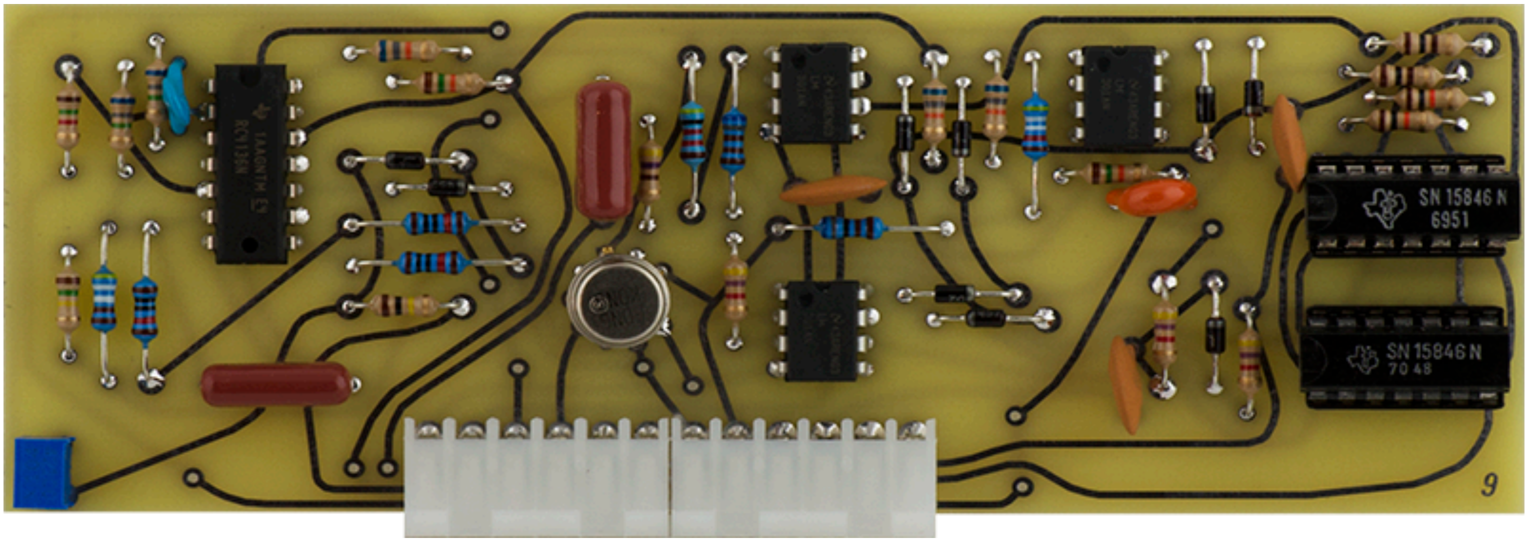


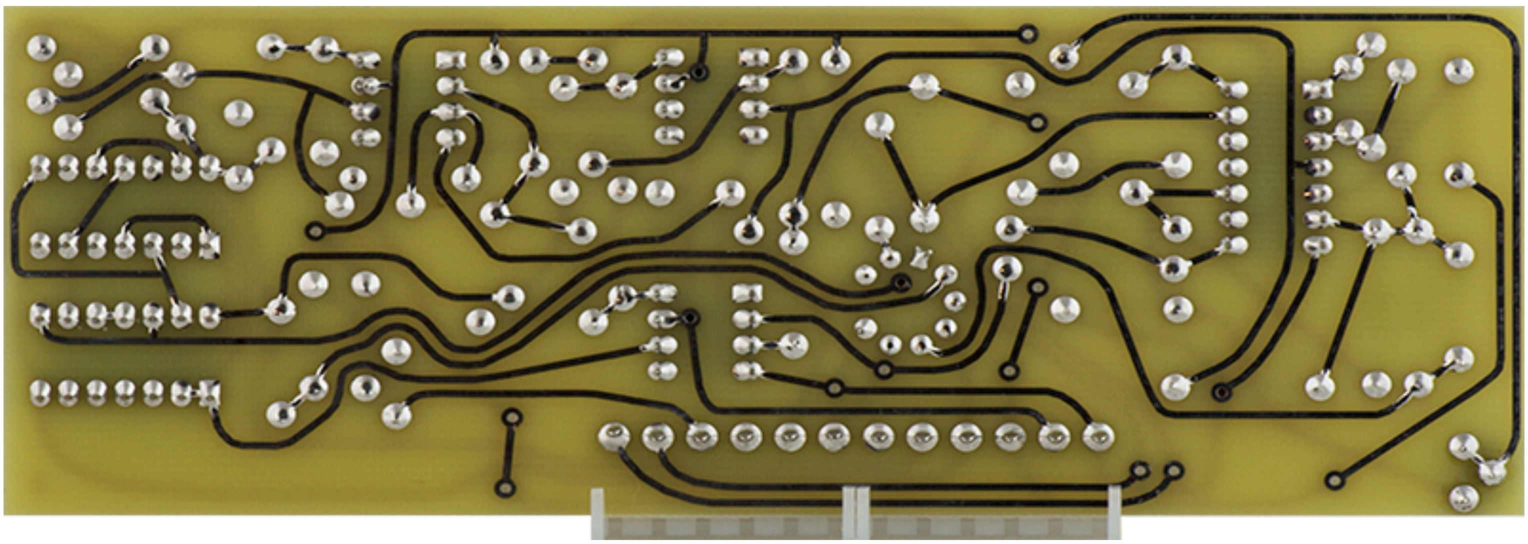


Card 9 is the third of three cards for the complex oscillator. I used sockets for the rare 846 DTL ICs. The tab on the DG200 points to the square pad and pin 7 needs to be cut off to fit the PCB.

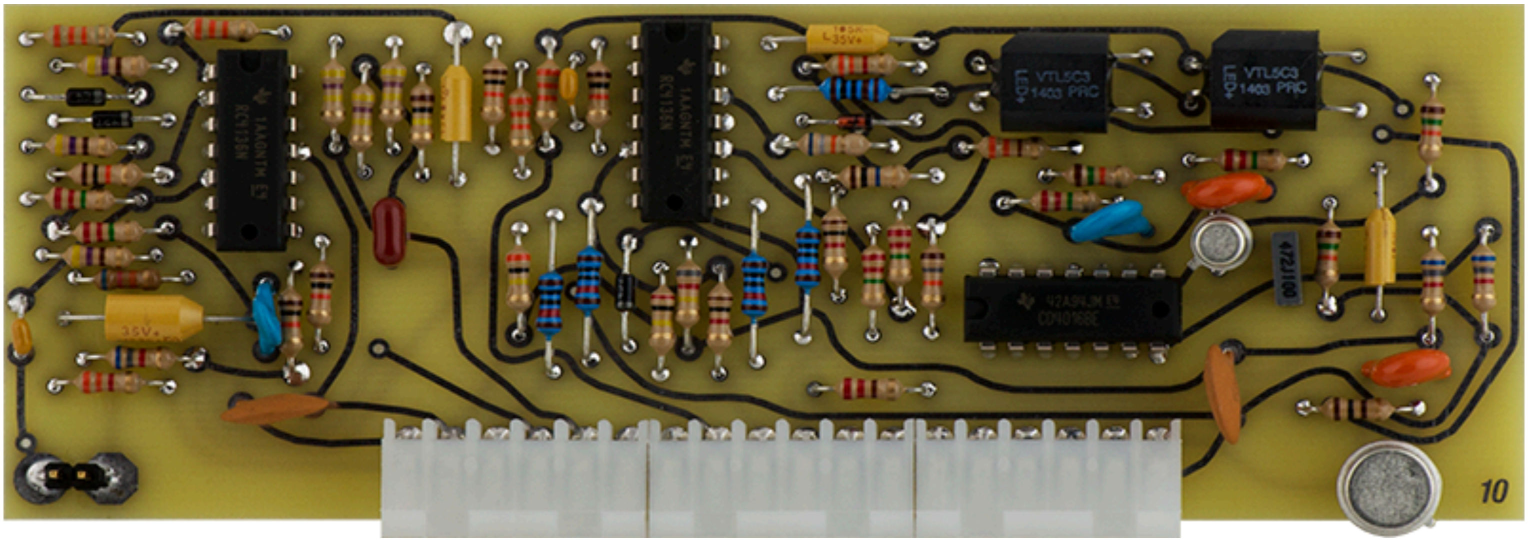


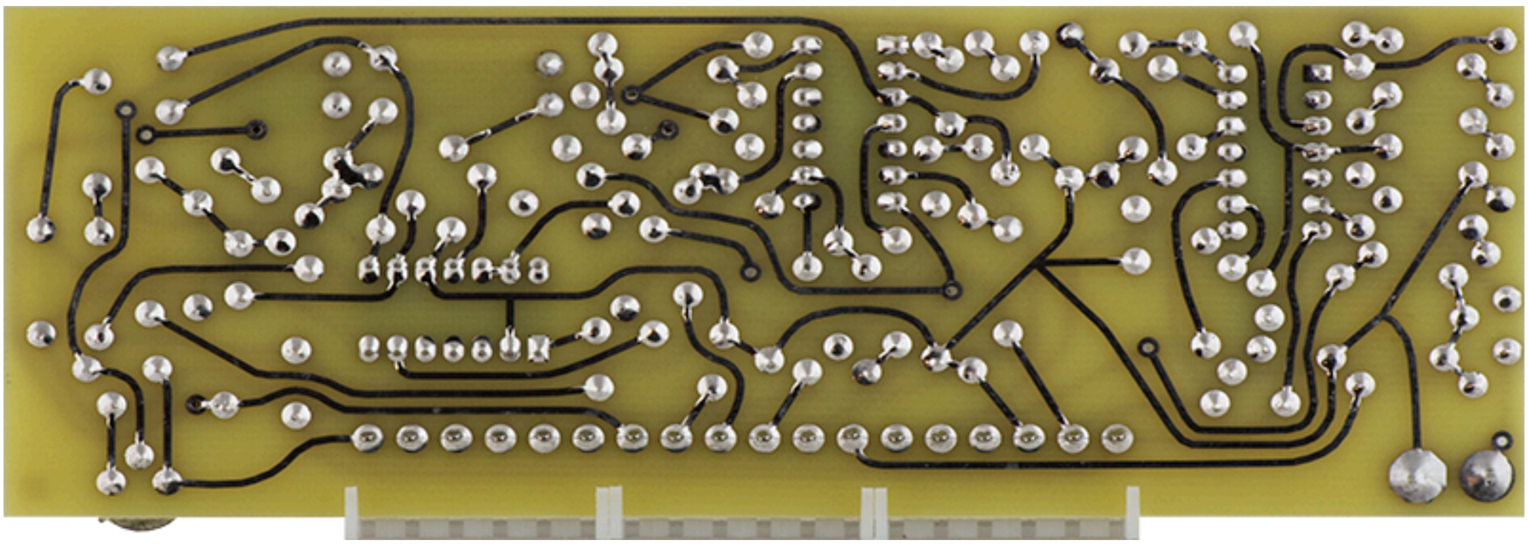
This card is actually a second CO that is used to generate the sine wave and the timbre. It is a separate triangle VCO that tracks the CO on card 8 and is modulated by the triangle output of that VCO when the timbre is increased. The DTL logic gates are driven by comparators and are used to reverse the current of the integrator.



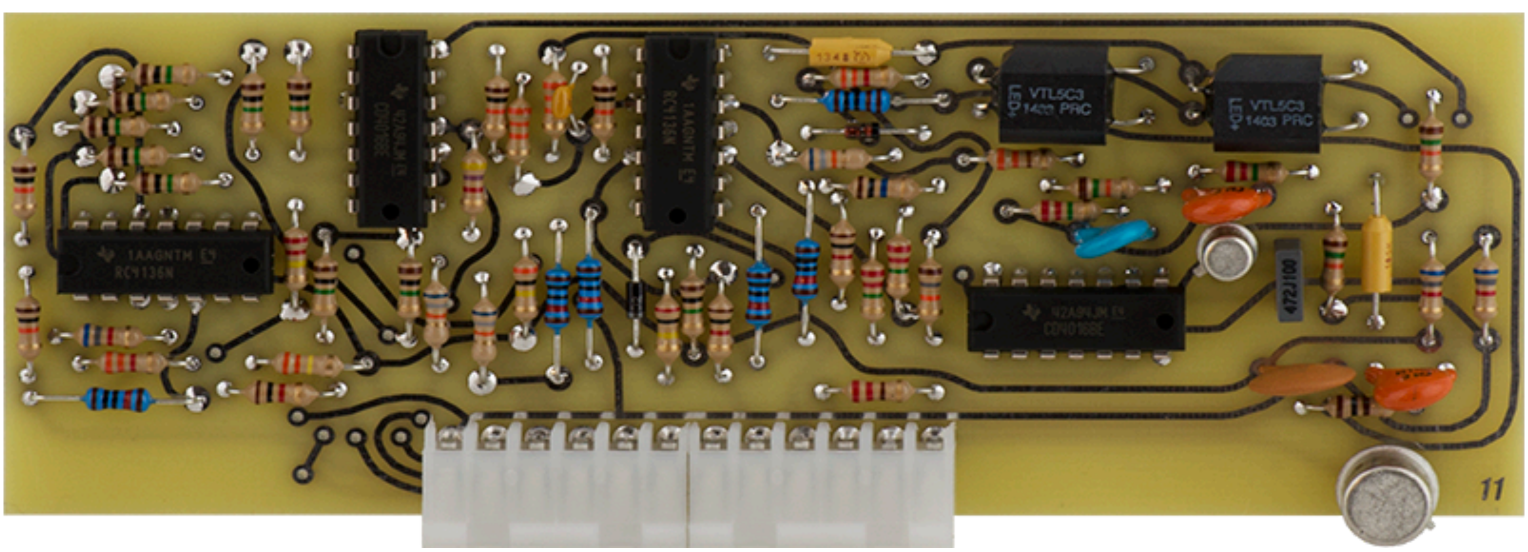


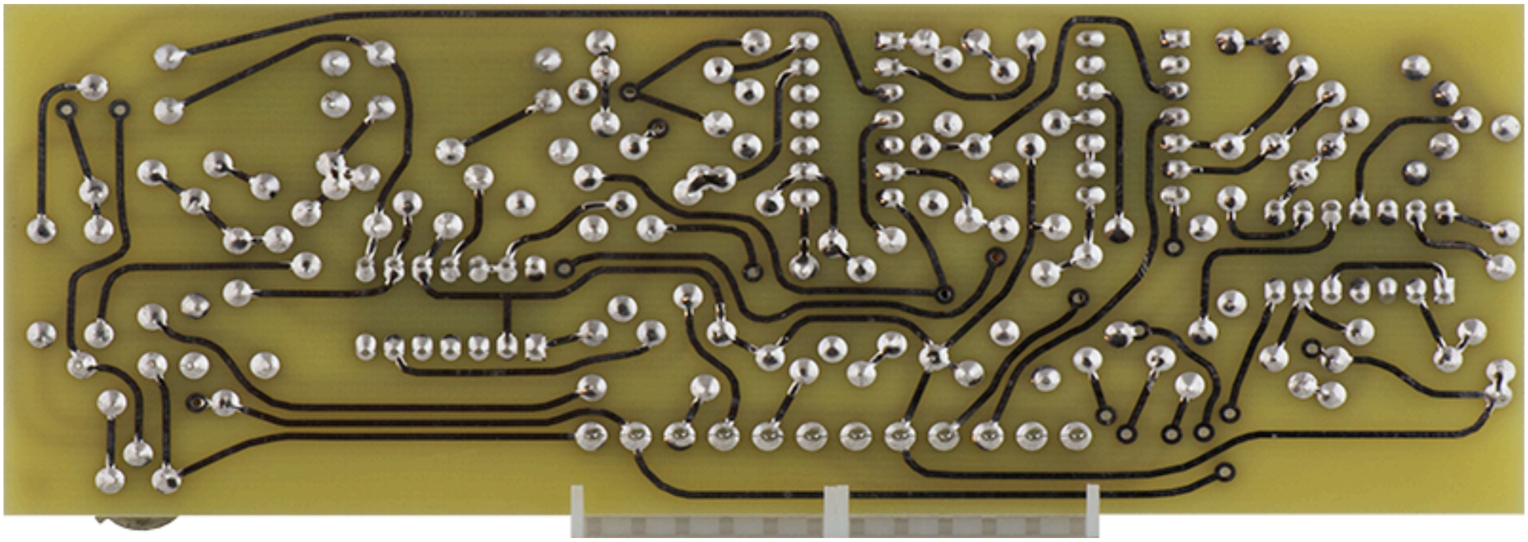
Card 10 is gate 1 and the preamp. I used square pins for the preamp input connector. I used RG174/U coax from the preamp jack to a 2 pin FCI header to mate with the square pins.



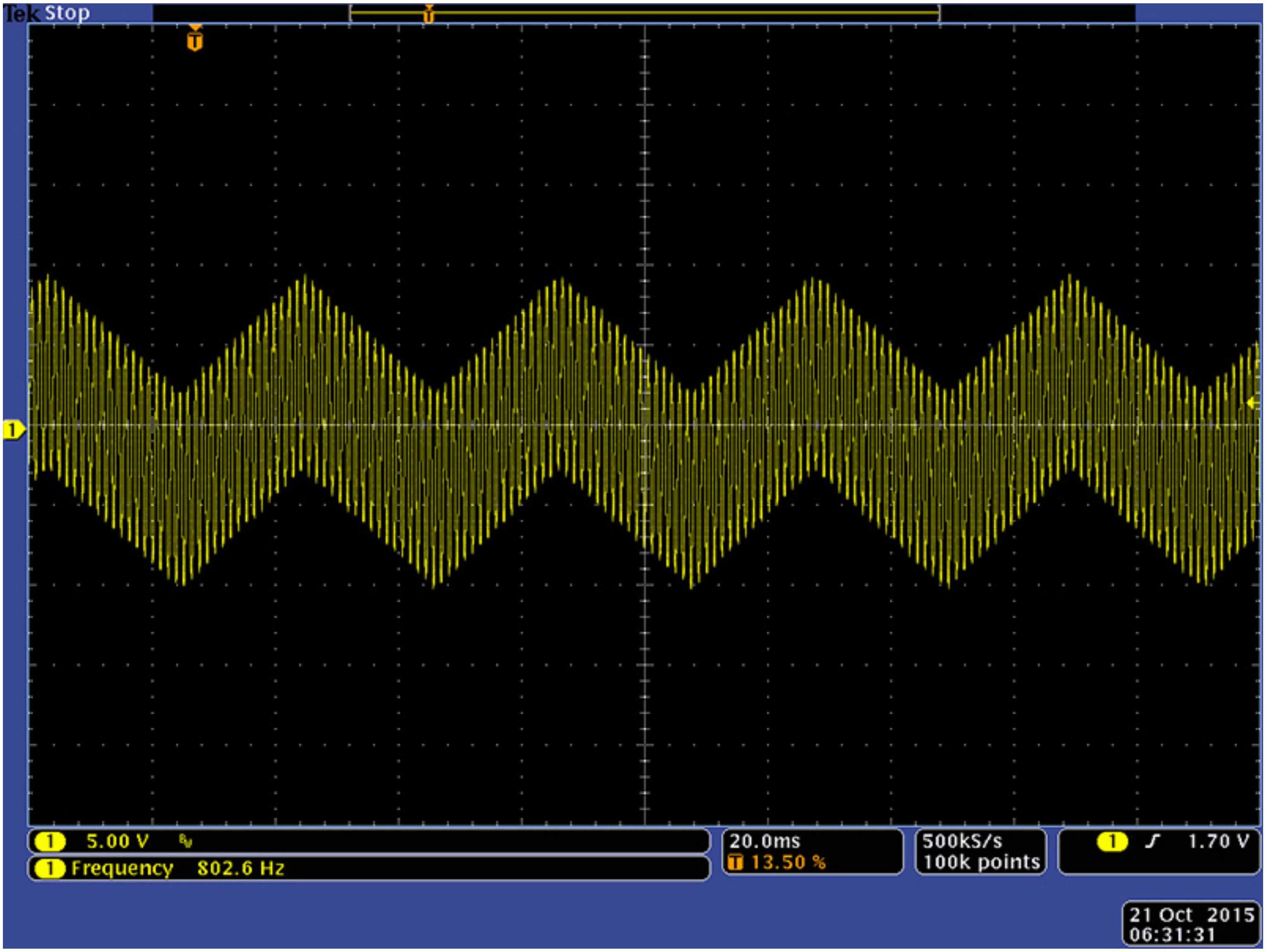


Card 11 is gate 2.

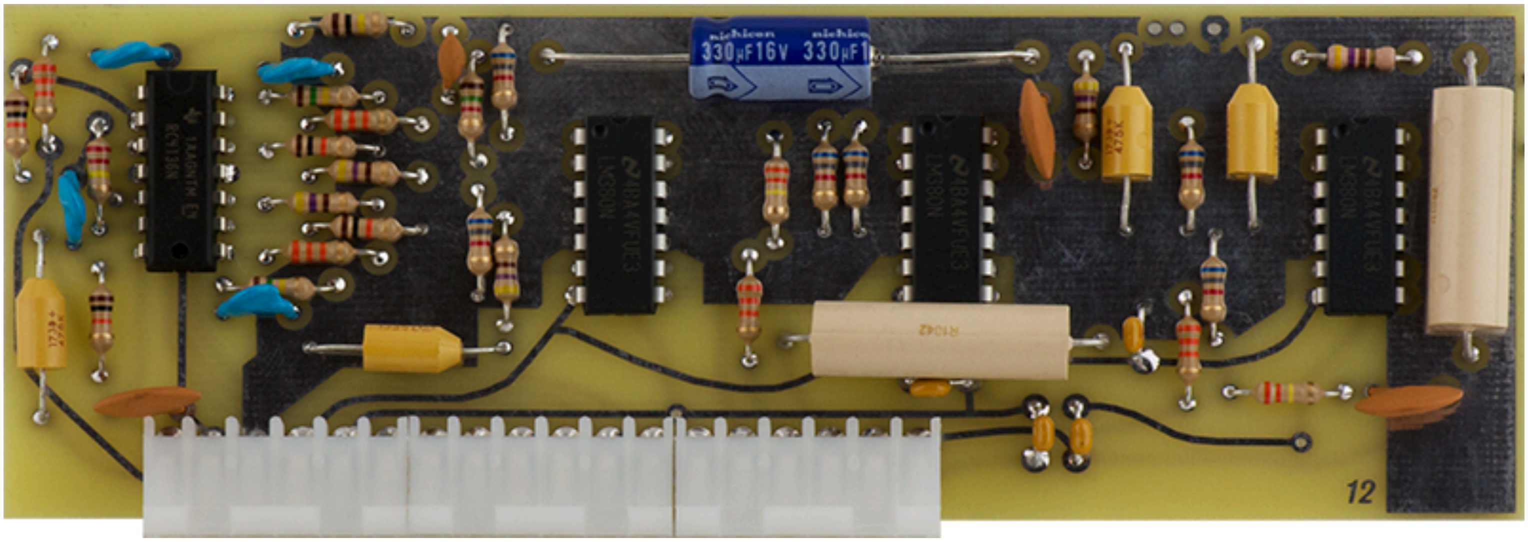


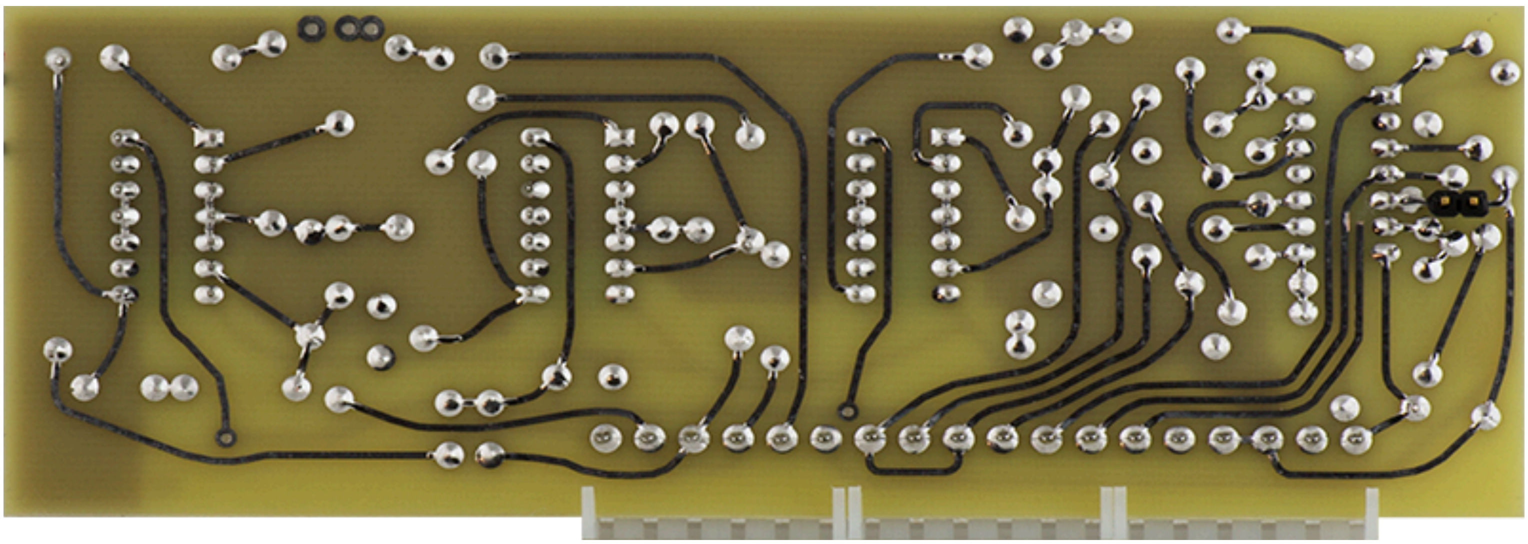


I recently repaired a 208 where the MO was not functional. I was monitoring the MO in the signal output and once I got it working the output was very weak. Looking at it on an oscilloscope the output was highly differentiated. The MO is mixed to the signal output through C4 on Card 11. This is a 1 µF capacitor feeding a 10K potentiometer which is a high pass filter with a lower frequency cutoff of 15 Hz. I increased C4 to 47 µF with a capacitor on the rear of the card where there is more room. This allows lower frequency MO output to be passed through on the signal outputs. This scope image shows the mixing of a low frequency MO triangle with a high frequency CO which is not possible with the original 1µF capacitor.



Card 12 is the reverb driver and output. C2 is a specified as 390 µF which is a value that was available years ago. Today's standard values are 330 µF and 470 µF so I used a 330 µF instead of buying a NOS capacitor.





Card 8 has coax wiring from the Preamp jack and I chose to run the reverb return direct with shielded wire. I cut the trace from pin 5 on IC1 and added square pins on the rear so I could connect with an FCI connector. IC1 pin 5 is the input to the reverb recovery amp and the outside trace (far right on the PCB rear image above) is ground. You can use a 0.100" MTA connector to mate directly with the reverb tank (image below)

Modifications

I started verification first with the pulser and sequencer and immediately ran into a problem. The sequencer would operate correctly in the 3 stage mode but not 4 or 5. Sometimes 4 stages would operate correctly and other times it would also operate as 3. Set to 5 stages it would sometimes operate as 3 and sometimes it would skip stage 4 or stage 4 and 5 would come on simultaneously. I found postings of others with similar problems with a variety of fixes suggested. I found that putting scope probes on various parts would correct the issue. On the Buchla schematics there are 1M resistors in series with the D inputs to the four CD4013 flip-flops. Their purpose is to slow down the D inputs and I suspect modern CD4013s are faster. I suspected a race condition but couldn't find it since putting my scope probe on a number of pins would correct it. Adding a bit of capacitance on various pins would correct it so I decided to add a 51 pF capacitor on the clock from IC1 pin 4 to +15V. Adding the capacitor to Q (quiet ground) also worked but there is only N (noisy ground) on this card which didn't work. I didn't debug it any further since I am building this module for a customer.

On subsequent repair jobs, I have had two 208s that would sequence 2, 4, or 5 steps. They would not operate correctly at 3. If you look at the original Buchla schematics IC8 is used to enable or disable stages 3, 4, or 5 as selected by the logic of IC1. IC1 pins 9 and 10 are logic outputs and should be 01, 10, 11 for the three selections. D1 and D2 OR the two bits for stage three. For some reason, the selection logic is 00, 10, 11 instead. Since these were repairs with an hourly charge rate I did not investigate to root cause. Stage 3 should always operate but it appears this logic was designed for 2, 3, 4, or 5 stages but only 3, 4, and 5 are used. I simply corrected the issue by lifting IC8 pin 9 and connecting it high so stage 3 is always enabled. Note that although the front panel switch does not enable a 2 step sequence the program card can be set for this. This modification eliminates that possibility.

I could not tune the Complex Oscillator. A 1.2V increase in keyboard CV would only increase the pitch by 1.6X, way short of an octave. I decreased Card 7 R14 from 120K to 75K to tune it to 1.2V/Oct. The frequency range was 17 Hz to 2.5 KHz which is 6 octaves but a fairly low frequency. I changed Card 8 C1 and Card 9 C3 from 15 nF to 5.6 nF which shifted the range to 50 Hz to 6 KHz. I personally would like a little more low frequency so would recommend a 7.5 nF Mouser 667-ECW-H8752HV capacitor for a range of 35 Hz to 5 KHz, or C1 to E8, where C4=middle C. The owner was happy with the 17 Hz to 2 KHz range since it matches the slider legend so I left the original capacitors installed.

Likewise the Modulation Oscillator would not tune either so I decreased Card 6 R5 from 190K to 82K to tune it to 1.2V/Oct. I adjusted the MO Offset so 16 Hz mapped to the slider legend with the fine pitch control centered.

On some units I have repaired Timbre would decrease as the CO frequency increased. I lowered R46 on Card 7 which increases the Timbre modulation amplitude. In some cases I dropped this from 15K down to 1K. I assume this is due to variation in VT2. Later I discovered that R3 on Card 7 is 1K8 and the original schematics show it as 10K. I ended up selecting an 8K2 for R3 on my unit. I don't know if this would affect the timbre decrease with increasing frequency.

I cut the run on Card 12 to IC1 pin 5 and ran a coax cable directly from the reverb output to IC5 pin 1. Ground is on a nearby trace..

The pinout for Q2 on card 3is ECB, not EBC as described above. Also add a 100K load resistor as shown above.

Add a wire from the back from the external pin 7 of the card slot to the via just below it as described above.

Cut and jumper the trace on Card 2 as described above.

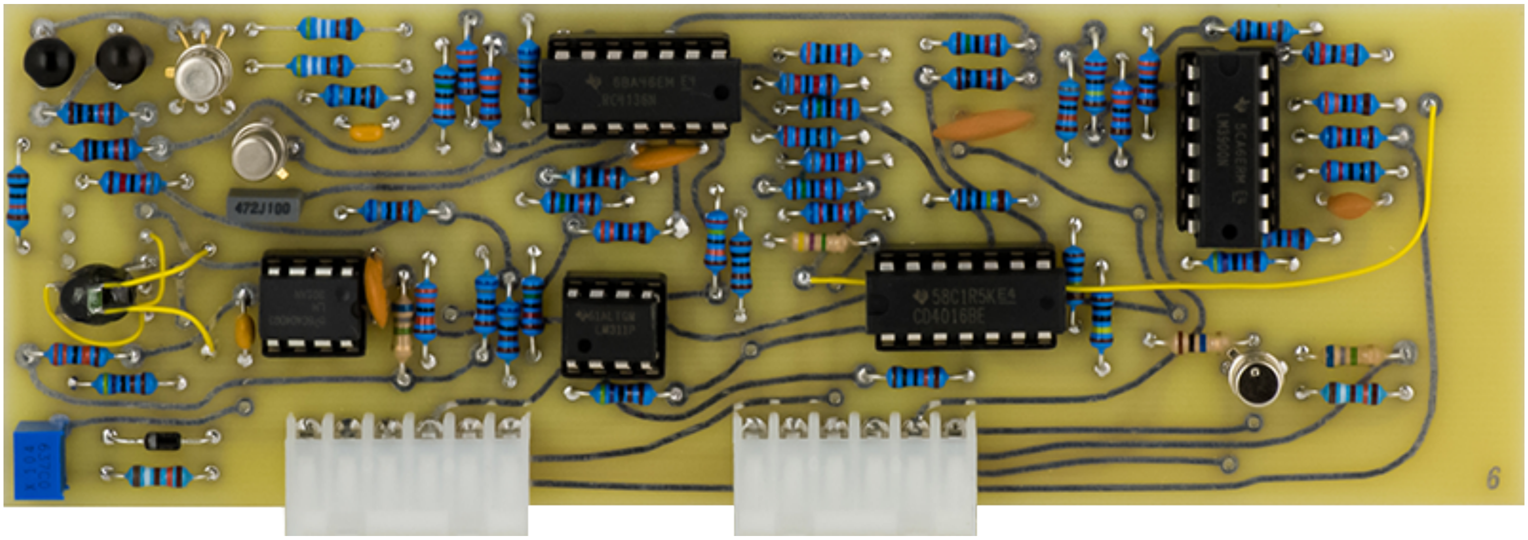
Solder a jumper between pin 11 and pin 12 on card 8 to fix TR3 CO LOW FREQ TRACKING.

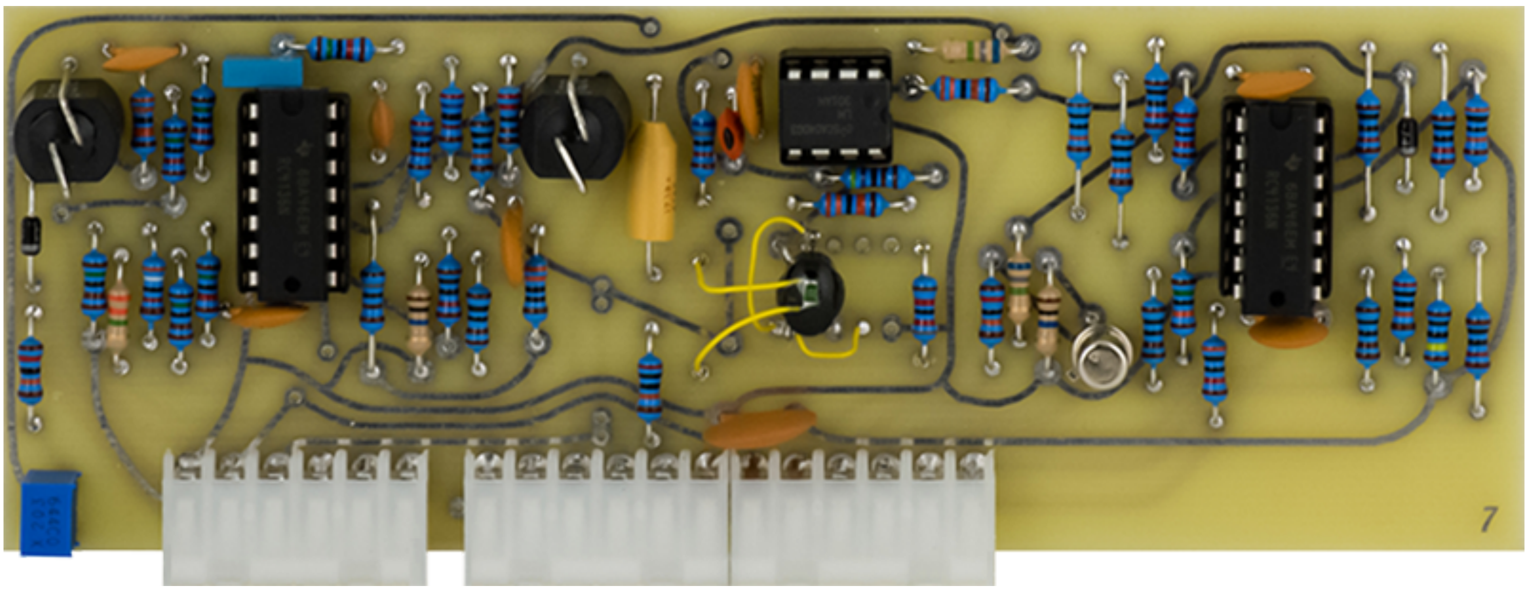
Optionally increase C4 on card 11 to 47 µF for lower frequency MO mix on the signal output.

A 218 will sometimes not trigger the pulser. You can parallel a 240K resistor across R56 on the back of the motherboard to change the pulse in threshold from 10V to 5V. This changes the threshold for the Pulser, Sequencer, and Envelope Generator.

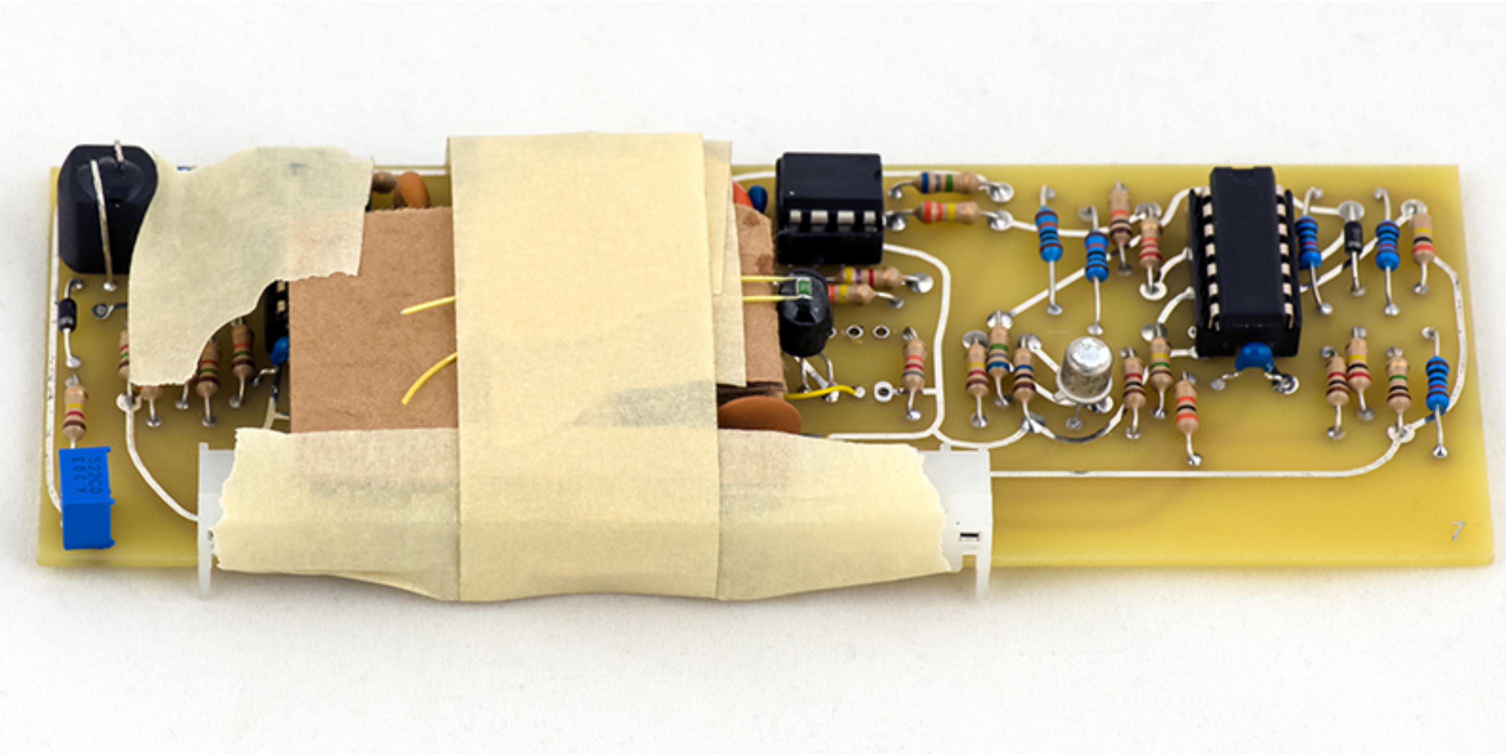
uA726 Modifications

For my personal 208 I chose to not use uA726s even though I have some. Instead I matched NPN transistor pairs on my Tektronix 577 curve tracer and bonded them together with a 3300 PPM/C 330R tempco (R12 on card 6 and R26 on card 7). An easier way to do it is to simply buy tape and reel. Then you can bend the leads a bit, put some epoxy on the faces, and tape them together with the tape and reel.





The tempcos are Panasonic ERAS33J series from Mouser (667-ERA-S33J331V). Their specifications aren't the best as the resistance has a +/-5% value tolerance and the temperature coefficient has a +/-10% tolerance over temperature. I tape cardboard to the PCB and tape the leaded tempco so I can epoxy it to the top of the NPN pair.



I installed the 208 in a boat and powered it up in the garage with an ambient temperature of 62.2°F. I monitored the CO frequency and it stabilized pretty well after 22 minutes so I called this the initial frequency. I monitored the case temperature of the boat and the frequency for the next 2 hours. After one hour I powered down the 208, moved it into my studio, and powered it back up for the last hour. The total drift over a temperature change of 8.8 °F was -5.43 cents. I have no idea how this compares to a non-tempco version or a uA726 version but it is good enough for my studio needs. The gray background cells indicate the warm up time. *If you have measured the temperature stability with a uA726 or a matched pair without a tempco please contact me with your data.*

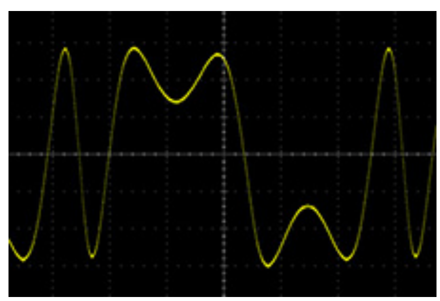
208 Complex Oscillator using 2N3904 matched pairs with 330R Panasonic ERAS33J series tempco

Time in minutes	Ambient temp °F	Boat case temp F	CO Freq Hz	Delta Hz	Delta cents
0	62.2	66.2	1044.5	Turn on	
3	62.2	66.9	1003.8	-40.7	
5	62.2	67.3	1003.3	-0.5	
12	62.2	68.5	997.8	-5.5	
22	62.2	70.8	996.2	22 min warm up	0.00
37	62.2	72.8	995.1	1.1	-1.33
50	62.2	73.0	994.5	1.7	-2.05
62	62.2	74.0	994.1	2.1	-2.53
90	62.2	75.2	993.3	2.9	-3.50
Powered down, moved inside, powered up					

90	71.0	76.0	994.9	1.3	-1.57
110	71.0	77.0	992.8	3.4	-4.10
125	71.0	77.7	992.2	4.0	-4.83
127	71.0	78.2	992.0	4.2	-5.07
142	71.0	78.2	992.0	4.2	-5.07
150	71.0	78.2	991.7	4.5	-5.43

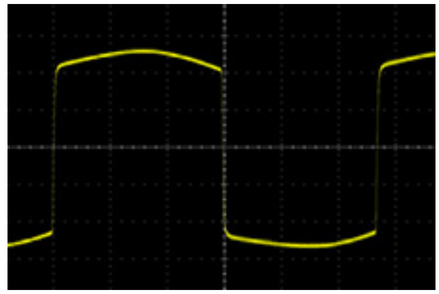
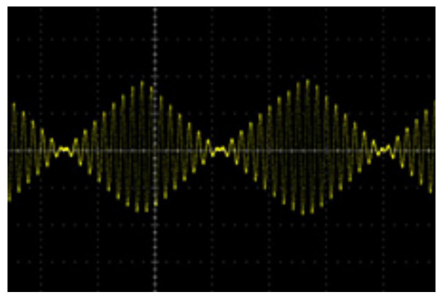
Calibration

Here is my trimmer descriptions and the procedure I used to calibrate the module. Some trimmers had very little effect so I just centered them.

Trimmer	Function	Procedure
MB front TR1	MO Tuning	Set to center and adjust as needed to trim after setting MO Range.
MB front TR2	CO Tuning	Set to center and adjust as needed to trim after setting CO Range.
MB rear TR3	CO LF Lin	I found little tracking effect so set to center. *There is an error on the motherboard. See card 8 description above to correct.*
MB rear TR4	Timbre	Set Timbre to max, Card 9 R5 to center, then view sine wave output on scope and and adjust TR4 for symmetrical folds in waveshape. 
MB rear TR5	CO Offset	Adjusted to 100 Hz with front panel slider at bottom.
MB rear TR6	MO Offset	Adjusted to 16 Hz with front panel slider on 16.

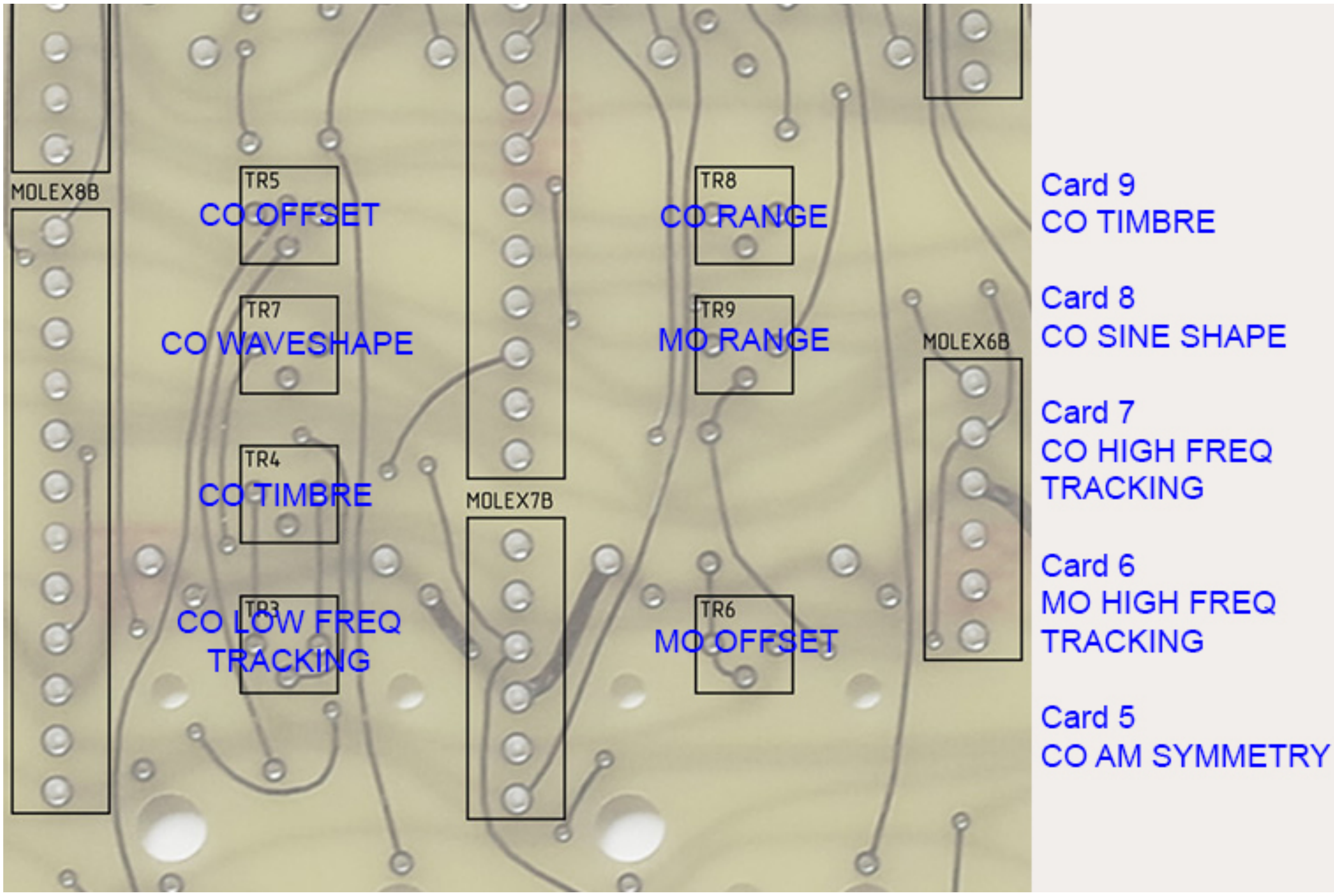
TR7 and Card 9 TR5 require some explanation. There are actually two COs. Card 8 is the main CO but Card 9 is a triangle CO. Timbre is generated by triangle modulating the CO by itself. This is accomplished by using the Card 9 CO, which tracks the Card 8 VCO, to FM modulate the Card 8 VCO. CO Waveshape synchronizes the two COs by adjusting the CV delta between them. This adjustment should be done with the frequency set in the middle of the range.

Set waveshape to square wave and adjust for

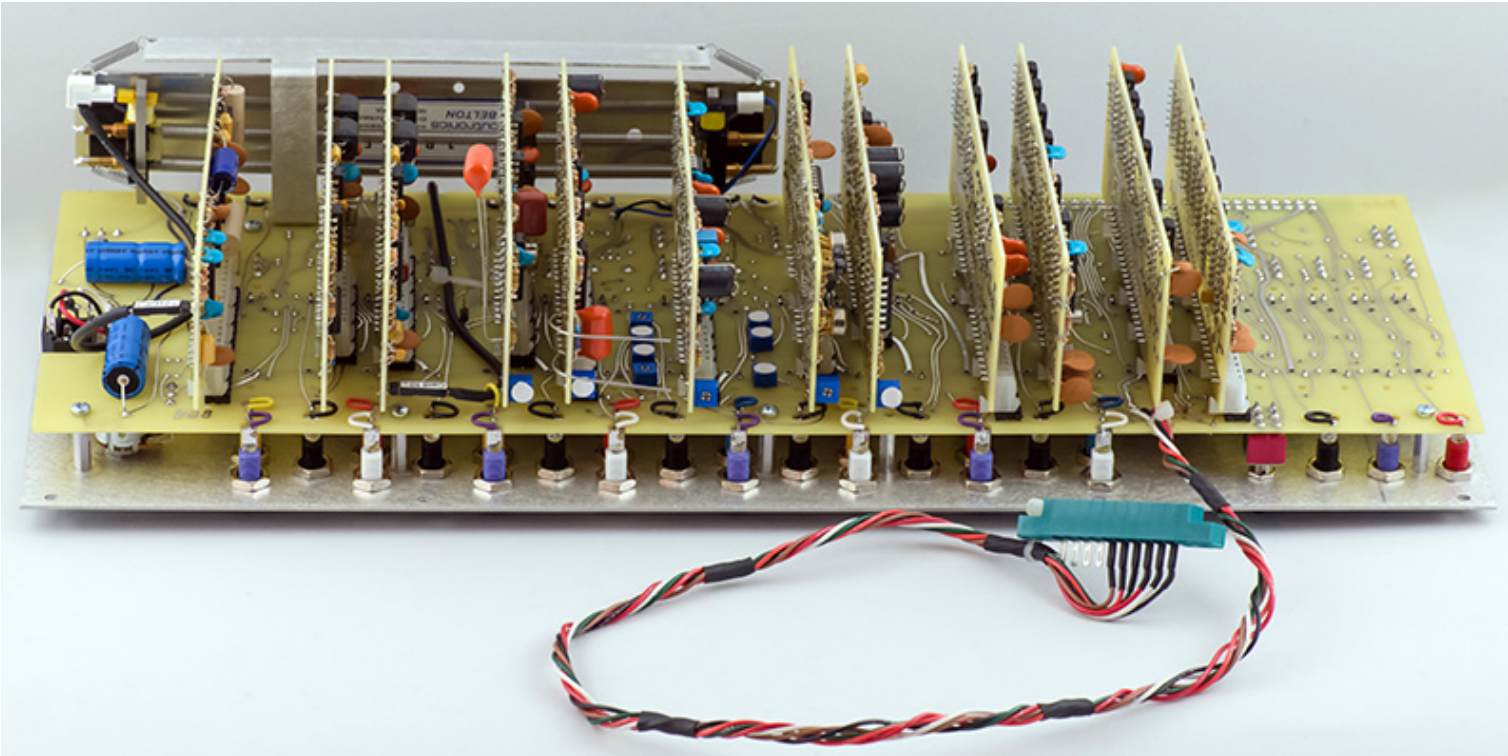
		symmetrical top and bottom.
MB rear TR7	CO Waveshape	
MB rear TR8	CO Range	Set to 1.2V/Octave.
MB rear TR9	MO Range	Set to 1.2V/Octave.
Card 5 R18	CO AM Symmetry	Set MO Index until 100% modulation and adjust for symmetrical AM modulation. I found that it was not symmetrical on all waveforms so set it for the triangle waveform. 
Card 6 R51	MO High Freq Tracking	I found little tracking effect so set to center.
Card 7 R45	CO High Freq Tracking	I found little tracking effect so set to center.
Card 8 R42	CO Sine Shape	Adjust for proper shaped sine wave.

R5 is the low frequency adjustment for the CO on card 9. Sometimes at low frequencies the two COs do not track and it can be heard as instability in frequency.

Card 9 R5	CO Low Freq Track	Adjust for stable oscillation with the frequency control set to minimum. Sometimes it takes some further adjustments to CO Waveshape so recheck and iterate between the two as necessary.



Here is the module nearly done. You can see the two timing capacitors temporarily installed on cards 8 and 9. I haven't yet decided what values to leave in the module. You can also see the white dots over the trimmers I install when complete as it makes it less error prone to adjust the wrong trimmer.



V2.1 Changes

I have not built a V2.1 208 yet so cannot validate this information. However, I believe these are the changes between V2.0 and V2.1

Corrected:

1. Missing trace on motherboard between SW1 and SW8
2. Missing trace on motherboard between Molex 4A and Molex 3B
3. Card 2 trace to R31
4. Card 3 pinout of Q2 and addition of 100K resistor

Not Corrected:

5. Missing trace on motherboard between Program Card pin 7 and via
6. Motherboard trace to Card 8 pin 11 instead of pin 12

back