EFM Mad Mouse Analog CV Synthesizer

V1.0 (c) 1998 1999 EFM

Assembly and Setup Manual

The Mad Mouse is a normalized analog synthesizer designed to work with the PAiA Midi2CV8 midi to control voltage converter. It can be used with any 1 volt per octave controller keyboard, midi interface or sequencer.

I built up two boards before shipping to test the boards as well as the documentation. Both test assemblys worked the first time. However there are two mistakes on the silkscreen. C15 is labeled as C17 and Q8 is labeled as Q6. See the parts layout for corrections. Please send any error reports to me at vco@mindspring.com.

The MM contains two wide range VCOs, one two-pole low-pass resonate VCF, two VCAs, one LFO, two AD envelope generators and it's own on board power supply. It was designed as a small single voice synthesizer to be used by itself or grouped for multi-timbral or poly functions. The PAiA midi2cv8 allows up to four units to be connected to it at once.

I choose very stable well-tested designs for the MM. However there is no temperature compensation. If you have a pair of 1K tempco's use them as R13 and R14 instead of the 1K 1% resistors called for in the parts list.

You may also want to replace the frequency and offset pots with a three turn type. It makes setting the frequency a lot easier. I choose a 220K summing resistor for vco2 offset this value allows almost full frequency range adjustment but makes tuning the VCOs harder in day to day use. Replace the 220K R10 with a 470K for a more manageable range.

Mad Mouse Parts

You will need the following parts to complete the Mad Mouse. I have given the approximate cost from the reference source. Prices may vary from your suppliers.

5% resistors may be used for 1% resistors, match them within 1% with a digital ohm meter.

Part	Source	Needed	Apprx. Cost	Total
1% Resistors				
1K 1/4W 1% Resistor	Mouser	4	.09	.36
5K1 1/4W 1% Resistor	Mouser	2	.09	.18
10K 1/4W 1% Resistor	Mouser	4	.09	.36
100K 1/4W 1% Resistor	Mouser	2	.09	.18
150K 1/4W 1% Resistor	Mouser	2	.09	.18
2M2 1/4W 1% Resistor	Mouser	2	.09	.18
5% Resistors				
100 Ohm 1/4W 5% Resistor	Mouser	1	.07	.07
220 1/4W 5% Resistor	Mouser	9	.07	.63
470 1/4W 5% Resistor	Mouser	3	.07	.21
1K 1/4W 5% Resistor	Mouser	3	.07	.21
2K2 1/4W 5% Resistor	Mouser	3	.07	.21

Item	Source	Qty	Unit	Total
3K3 1/4W 5% Resistor	Mouser	1	.07	.07
4K7 1/4W 5% Resistor	Mouser	2	.07	.14
10K 1/4W 5% Resistor	Mouser	20	.07	1.40
15K 1/4W 5% Resistor	Mouser	2	.07	.14
33K 1/4W 5% Resistor	Mouser	3	.07	.21
47K 1/4W 5% Resistor	Mouser	5	.07	.35
68K 1/4W 5% Resistor	Mouser	1	.07	.07
75K 1/4W 5% Resistor	Mouser	1	.07	.07
100K 1/4W 5% Resistor	Mouser	4	.07	.42
220K 1/4W 5% Resistor	Mouser	1	.07	.07
390K 1/4W 5% Resistor	Mouser	2	.07	.14
1M 1/4W 5% Resistor	Mouser	1	.07	.07

Capacitors

Item	Source	Qty	Unit	Total
100PF Ceramic Capacitor	Mouser #140-CD502P2-101K	2	.08	.16
.002UF Polyester Capacitor	Mouser #140-PM2A202K	2	.12	.24
.01UF Polyester Capacitor	Mouser #140-PM2A103K	3	.13	.39
.01UF Ceramic Capacitor	Mouser #140-CD50Z6-103Z	1	.08	.08
.1UF Ceramic Capacitor	Mouser #140-CD50Z9-104Z	1	.18	.18
1.0UF Polyester Capacitor	Mouser #581-MC105K1H	1	.88	.88
1UF/50V Electrolytic Capacitor	Mouser #140-XRL50V1.0	2	.07	.14
10UF/16V Electrolytic Capacitor	Mouser #140-XRL16V10	4	.07	.28
100UF/25V Electrolytic Capacitor	Mouser #140-XRL25V100	1	.12	.12
470UF/35V Electrolytic Capacitor	Mouser #140-XRL35V470	2	.39	.78

Diodes

Item	Source	Qty	Unit	Total
1N4148 Signal Diode	Mouser #610-1N4148	13	.04	.52
1N4001 Power Diode	Mouser #583-1N4001	2	.05	.10

Trimmers

Item	Source	Qty	Unit	Total
10K PC Mount Trimmer	Mouser #32AA401	4	.26	1.04
50K PC Mount Trimmer	Mouser #32AA405	2	.26	.52
100K PC Mount Trimmer	Mouser #32AA501	1	.26	.26

Transistors

Item	Source	Qty	Unit	Total
2N3904 NPN Transistor	Mouser #610-2N3904	4	.19	.76
2N3906 PNP Transistor	Mouser #610-2N3906	6	.19	1.44

ICs

Item	Source	Qty	Unit	Total
LM556 Dual Timer	Mouser #511-NE556	1	.41	.41

LM7812 +12V Voltage Regulator	Mouser #511-L7812CV	1	.46	.46
LM7912 -12V Voltage Regulator	Mouser #511-L7912CV	1	.53	.53
LM13600 Dual OTA	Mouser #513-NJM13600D	2	.80	1.60
TLO74 Quad opamp	Mouser #511-TLO74CN	3	.60	1.80
Potentiometers				
10K Panel Mount Pot	Mouser #313-1000-10K	3	1.21	3.63
50K Panel Mount Pot	Mouser #313-1000-50K	3	1.21	3.63
100K Panel Mount Pot	Mouser #313-1000-100K	2	1.21	2.82
1M Panel Mount Pot	Mouser #313-1000-1M	5	1.21	6.45
SPDT Panel Mount Toggle Switch	Mouser #10TA830	4	2.09	4.18
Jacks				
3.5mm Phone Jack	Mouser #16PJ011	1	.69	.69
1/4" Phone Jack	Mouser #16PJ022	1	.94	.94
9 Pin D-Sub Receptacle	Mouser #156-1309	1	.66	.66
Panel Mount Red LED	Mouser #35CA001	1	.88	.88
12VAC Transformer 3.5mm Male	Mouser #412-212051	1	5.32	5.32
Knobs	RShack #274-415	13	.50	6.50
Case 8.46 X 5.12 X 2.95	Digikey #HM244-ND	1	12.45	3.69

Assembly

The pc board is a good quality board with silkscreen overlay and solder masking. No preparation is needed on the board. Use a magnifying glass to check your work as you go making sure there are no bridged solder pads.

Wire Jumpers

There are 25 wire jumpers. Install these in the spaces marked for jumpers after installing the resistors. As you install the resistors pile the cutoffs up somewhere and use them as the jumper wires.

Resistors

1% Resistors

We want to build the VCOs as close to identical as possible. This is why we use 1% resistors. 5% resistors may be used for 1% resistors, match them within 1% with a digital ohm meter and install them as pairs one for vco1 and one for vco2. How well your VCOs track depends more on how closely the following 1% resistor pairs are matched than anything else.

1% Resistors	Part	Needed
R4,R5	100K 1/4W 1% Resistor	2
R8,R9	150K 1/4W 1% Resistor	2
R13,R14 - R15,R17	1K 1/4W 1% Resistor	4

R16,R18	5K1 1/4W 1% Resistor	2
R19,R20 –R21,R22	1OK 1/4W 1% Resistor	4
R6,R7	2M2 1/4W 1% Resistor	2

5% Resistors	Part	Needed
R1,R2,R11,R12,R45	47K 1/4W 5% Resistor	5
R3,R34,R35,R39,R40 R46,R47,R60,R61	220 1/4W 5% Resistor	9
R10	220K 1/4W 5% Resistor	1
R23,R24,R28,R30,R31 R36,R37,R38,R41,R42 R44,R48,R50,R53,R55 R59,R62,R64,R66,R68	10K 1/4W 5% Resistor	20
R25	1M 1/4W 5% Resistor	1
R26,R27,R67,R72	100K 1/4W 5% Resistor	4
R29,R52,R63	2K2 1/4W 5% Resistor	3
R32	68K 1/4W 5% Resistor	1
R33	75K 1/4W 5% Resistor	1
R43,R76	4K7 1/4W 5% Resistor	2
R49,R57,R65	33K 1/4W 5% Resistor	3
R54,R56	390K 1/4W 5% Resistor	2
R58,R71	470 1/4W 5% Resistor	3
R69,R74,R75	1K 1/4W 5% Resistor	3
R70	3K3 1/4W 5% Resistor	1
R73	100 Ohm 1/4W 5% Resistor	1
RLA & RLM (Optional VCA/VCMod Linear resistors)	15K 1/4W 5% Resistor	2

NOTE: There is an error on the silkscreen C15 is labeled C17. See the overlay drawing for correct placement.

Capacitors	Part	Needed
C1	1.0UF Mylar Capacitor	1
C2,C3,C19	.01UF Polyester Capacitor	3
C11	.01UF Ceramic Capacitor	1
C4,C5	100PF Ceramic Capacitor	2
C6,C7	.002UF Polyester Capacitor	2
C8,C9,C13,C14	10UF/16V Electrolytic Capacitor	4
C10	.1UF Ceramic Capacitor	1
C12	100UF/16V Electrolytic Capacitor	1
C15,C16	470UF/35V Electrolytic Capacitor	2

C17,C18	1UF/16V Electrolytic Capacitor	2

Diodes	Part	Needed
D1-D13	1N914 or 1N4148 Signal Diode	13
D14,D15	1N4001 Power Diode	2

Trimmers	Part	Needed
TR1	100K PC Mount Trimmer	1
TR2,TR3,TR6,TR7	10K PC Mount Trimmer	4
TR4-TR5	50K PC Mount Trimmer	2

NOTE: There is an error on the silkscreen Q8 is labeled Q6. See the overlay drawing for correct placement.

Transistors	Part	Needed
Q1,Q2,Q5,Q9	2N3904 NPN Transistor	4
Q3,Q4,Q6,Q7,Q8,Q10	2N3906 PNP Transistor	6

ICs

Careful! When installing U1. It is the reverse of the other ICs.

ICs	Part	Needed
U1,U4,U5	TLO74 Quad OpAmp	3
U2,U3	LM13600 Dual OTA	2
U6	LM556 Dual Timer	1
U7	LM7812 +12V Voltage Regulator TO220	1
U8	LM7912 -12V Voltage Regulator TO220	1

This completes the assembly of the PCB.

Wiring

The following parts are mounted on the panel. They are connected to the PCB by "flying" connecting wires from the controls to the board.

Use the supplied punch layout by putting double sided tape on the back of the layout. What we want to do is line up the screw holes in the case lid with the matching holes in the layout. Then press to stick it in place.

Use a punch to mark the holes for drilling, remove the layout and drill the holes.

Deburr the holes with a larger drill bit. Then apply the peel and press panel layout.

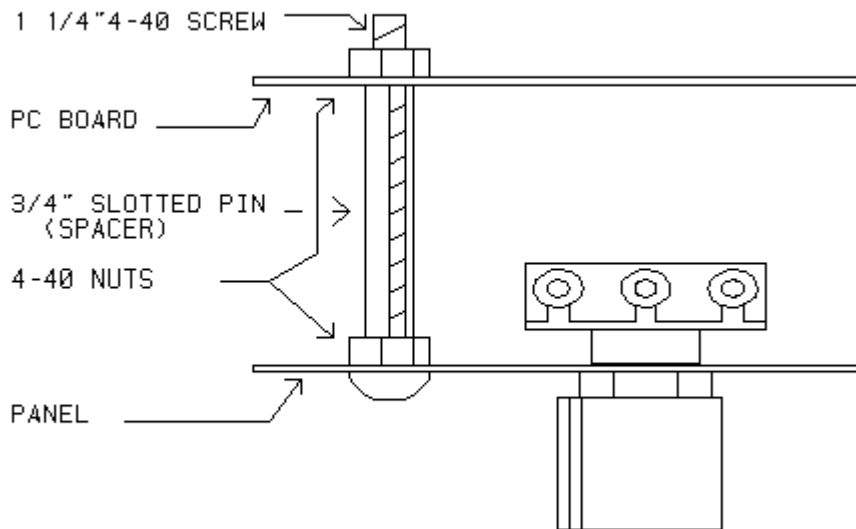Mount the controls then tighten and put the knobs on.

Potentiometers	Part	Needed
P1,P9,P10,P12,P13	1M Panel Mount Pot	5

P2,P3,P5	50K Panel Mount Pot	3
P4,P8	100K Panel Mount Pot	2
P6,P7,P11	10K Panel Mount Pot	3

| Switches	Part	Needed
S1-S4	SPDT Panel Mount Toggle Switch	4

| Jacks	Part	Needed
J1	9 Pin Jack	1
J2	1/4" Phone Jack	1
J3	3.5MM Phone Jack	1

Mount the LED Panel Mount Red LED 1

Follow the wiring diagrams in order; first the top row of controls, then the middle and bottom. Be sure to leave enough slack in the wires to easily place the board back on the spacers over the controls. Secure the board in place with 4-40 nuts.

NOTE: Do not bundle your wires. This looks nice but there is not enough room to do this in the Mad Mouse. Makes trouble shooting harder anyway. Leave enough length on the jack wires to make it to their mounting holes.

M   L   I H

N
+V
-V
O
P
Q
GND
R
S
T
U   W X Y   Z AA BB   CC DD
V

BOTTOM

K J   G F   E D

C
B
A
AC
LED
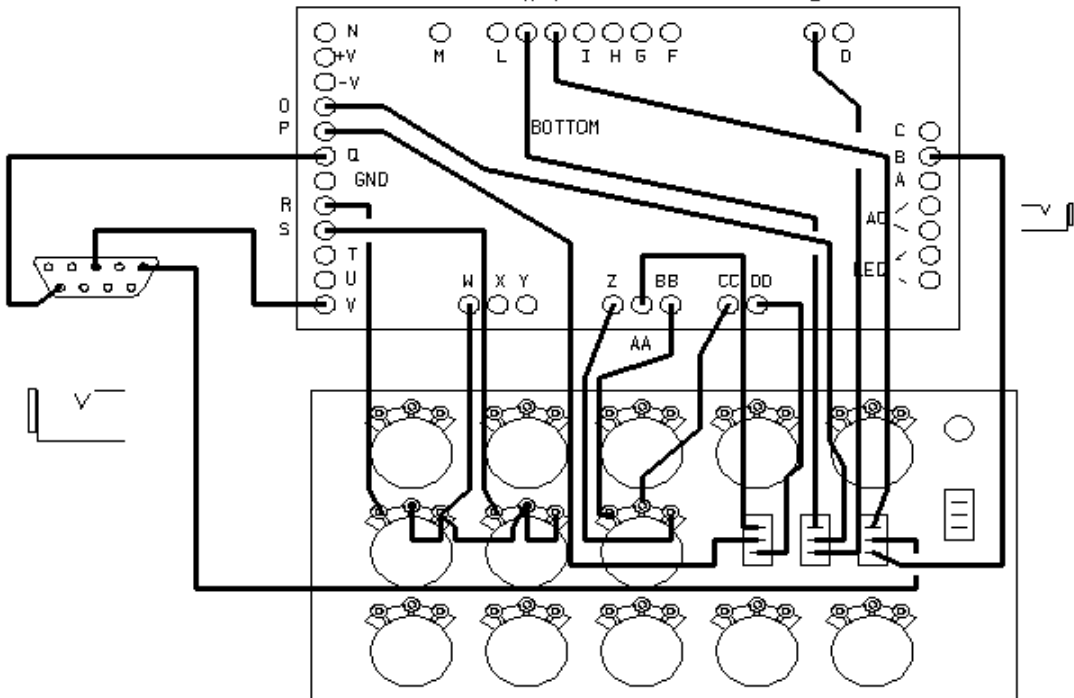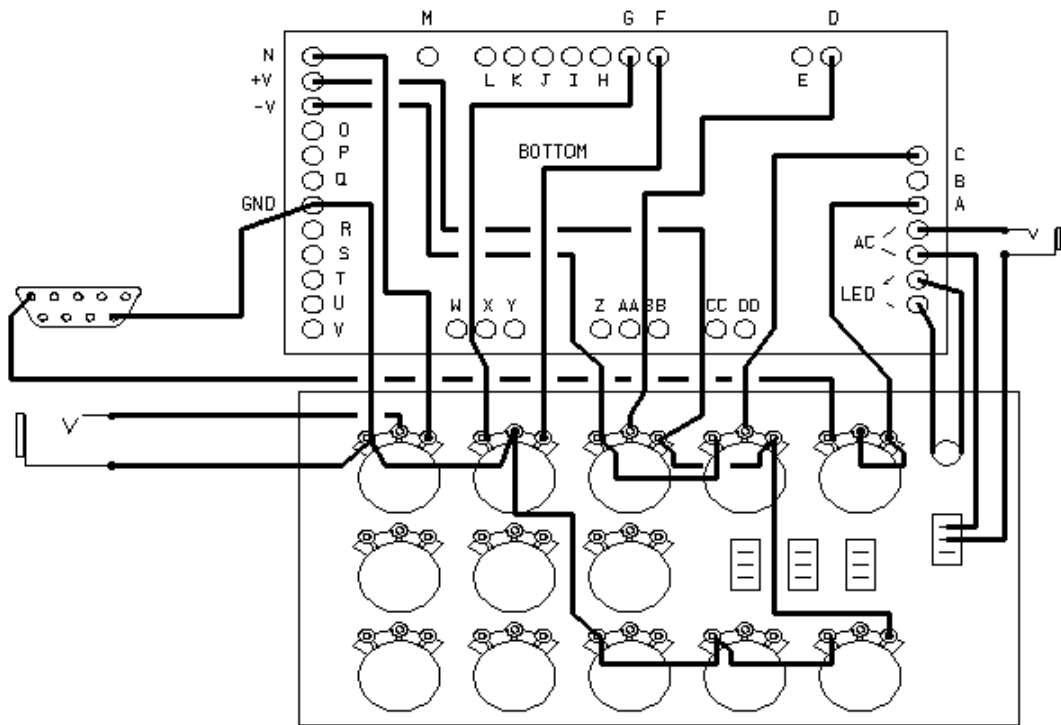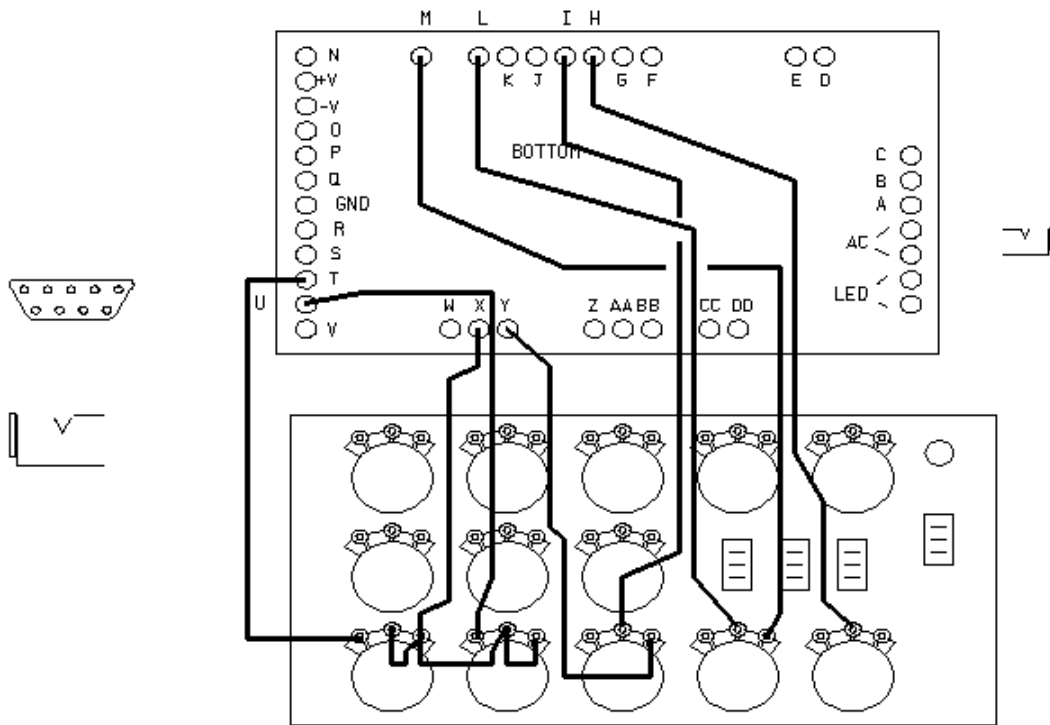
Smoke Test

Make sure the power switch is off and the transformer is unplugged. Plug in the mini power plug and plug the transformer into the wall.

If anything bad is going to happen now is the time. Be ready to turn the power switch off.

Look you're work over well make sure all capacitors, transistors ics and diodes are placed properly.

Turn the unit on. The LED should light up. Nothing should smoke or be hot to the touch.

If there is a problem, turn it off and check your work over again.

The voltage is marked on the pcb next to the power regulator leads. Check for +12 and -12.

If the voltage isn't there, unplug ics until it returns be sure to turn the unit off before removing or plugging in anything. If you get +-12 back you have found a bad ic. Replace it and try again.

If you still can't get +-12 the power rail(s) may be shorted. Find and remove the short.

Setup

To setup the MM you will need a way to send 1V per octave control voltages and gate. You will also need a reference keyboard.

Connect your controller to the MM and set the "Basic Patch" on the Mad Mouse.

Turn all trimmers to 50% on the Mad Mouse.

Connect the output jack to a monitor amp, turn the volume controls about half way up on the Mad Mouse and about 10% on the monitor amp. Turn the VCF cutoff all the way up and turn the Mad Mouse on.

If you have done the heater mod the MM should warm up in about 60 seconds. If not wait about 10 minutes for the MM to stabilize.

Turn the VCO balance control to VCO1. Using a reference keyboard play a C2.

Match a C2 played on the MM to your reference by adjusting TR4. Play a C2 then C3 on the MM. Adjust TR2 until they are one octive apart. You

will have to adjust TR4 and TR2 several times to get it right. Then adjust the high scale trimmer TR6 by playing the C5-C6 octave.
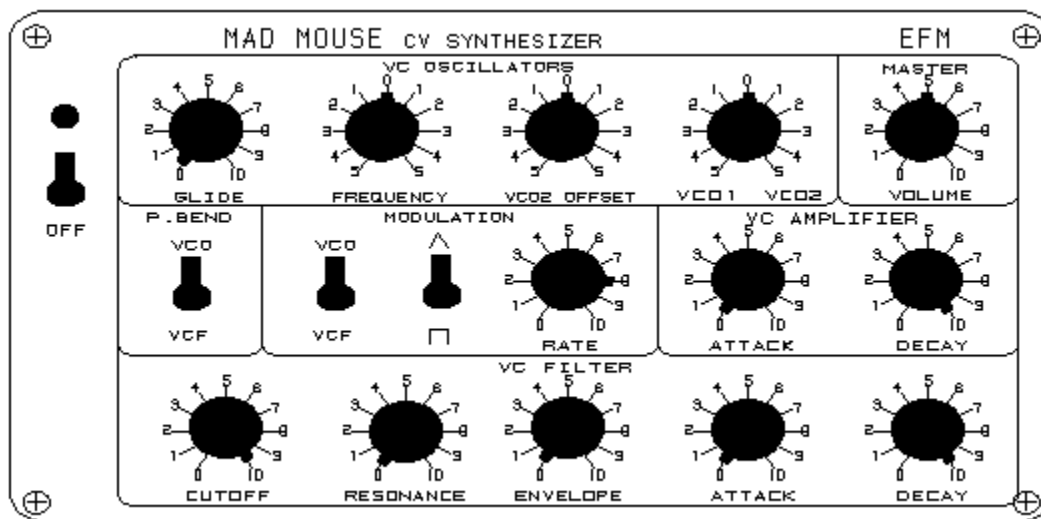
All of these trimmers interact. You will have to play with them to correctly setup your oscillator. For your reference the settings on the test assembly are TR2/TR3 about 4K, TR4/TR5 are very close to 50% and TR6/TR7 about 7.5K.

Once VCO1 is set up, adjust the VCO balance control to 50% and match VCO2 to VCO1. Get as close as you can.

After a burn in period, do this setup again.

Adjust the VCO pitch bend trimmer to allow a 1 note up-down range. This means play a C2 push the bender all the way up and adjust the trimmer so that when the C2 key is played a D2 comes out, push the bender all the way down and it should play a B1 when pressing C2.

That should do it. The Mad Mouse should be ready to go.

If you want the VCA and VCMod to have linear response install a 15K resistor for LRA and LRM.

Start with the basic patch and test all control functions. I hope you enjoy your Mad Mouse.

Mad Mouse Addendum:

The Mad Mouse is a roller coaster I used to ride as a kid. You got in a blind cage and this thing jerked you around like a sack of potatoes. I loved it. Our electronic version has a lot in common with its namesake.

I really wanted the Mad Mouse to cost under $50. If you don't count the cost of the pc board I just made it. When selecting parts for the Mad Mouse I tried to get the best part for the price. For example the trimmers are ($0.26) low cost single turn. Multi -turn cermet trimmers would make the setup and tuning much easier and add stability to the synthesizer but cost ten times ($2.25) as much. My point is, I could have spent a lot of money putting this together but wanted it to be cheep enough for people to experiment with. The trade off is overall heat sensitivity. You will notice when you turn it on after being off for a while that the VCOs will be totally out of adjustment. If you wait about 10 minutes it will warm up and be fine. This is normal for a non-compensated design. The filter is a resonate type and will self oscillate when the resonance is over 50% this is also normal.

If you decide to modify the parts list in favor of higher quality parts, try building it as specified first just to get it working and then modify away.

NOTE:

Use TLO74s only. Do not use TLO84s. They work but for some reason current consumption increases and the regulators run warm.

Heat, The Mad Mouse and Stability:

If the Mad Mouse is built in an enclosed case it is going to drift. It's probably going to drift a little even in open-air installations. The obvious solution is tempco resistors. As soon as I can locate a good source I'll notify all MM owners. I will add a 3046 heater mod to the "Mad Mouse Mod Page" when I get it online but tempco's would be better for the Mouse.

If the heater mod or tempcos are used you can ignore this and install your MM almost anywhere in the case of your choice.

The Case:

I am disgusted! Radio Shack discontinued the case I built the prototype in. After years of this sort of abuse I should know better. There is a similar one available from national parts but it's not the same. The MM PCB grew a little while being manufactured and now it won't fit in the warehouse case! There is a project case #270-1807 available in the RS stores the board almost fits in. If you trim the leading edges a little and cutout a little with a round hobby tool bit it just fits in the box around the mounting post used to secure to top. The real bummer is the board really doesn't fit the case and overall it's bigger that the discontinued part. CRAP! I found an aluminum case like the ones MXR used to put their effects in but the cost is $22. The console case I built the Mini4 in is only $20. I'll keep looking….

The Hammond 1595EKB is available from Digikey #HM244-ND for $12.45. This is a sloping case that I think the MM would fit in with room to do a few mods. I have ordered one and will build one of the test assemblies in it when it comes in.

**Silkscreen Errors**:

I got rushed and just screwed it up.

**Mouser Joins the Conspiracy:**

Mouser has offered to keep a list of the parts for the Mad Mouse on file. By the time you receive this Kim Bates in the Mouser sales department will have the list. So you can just call and ask for parts for the MM-1and she'll know what you are talking about. Pretty good for a company that can't get their computers to add. (It's a joke) I asked for a total one time and was told "sorry sir our computers don't add" I burst out laughing and said between fits "you probably think I'm crazy but trust me on this one, the only thing your computer actually does is add". I know she thought I was insane.
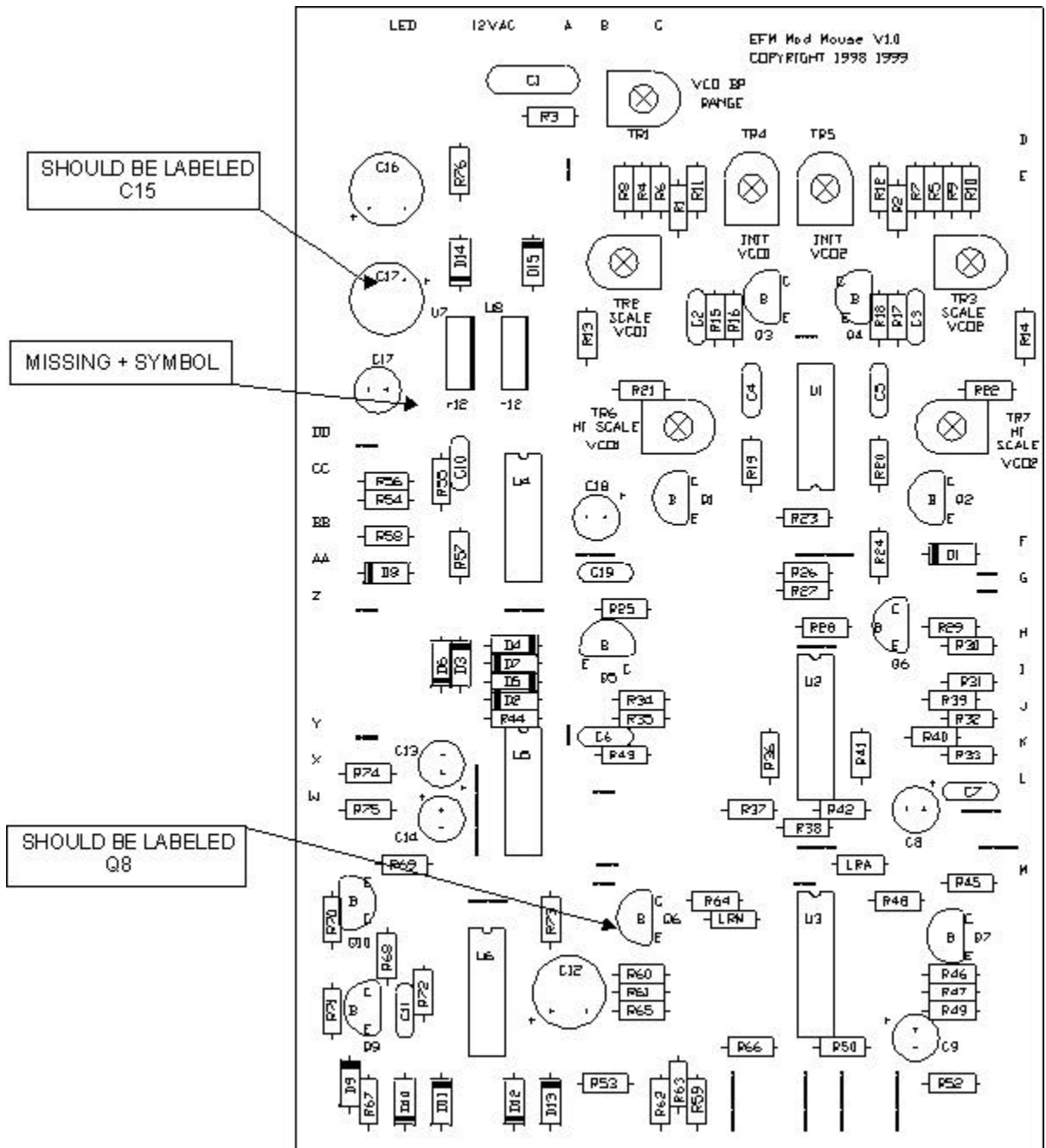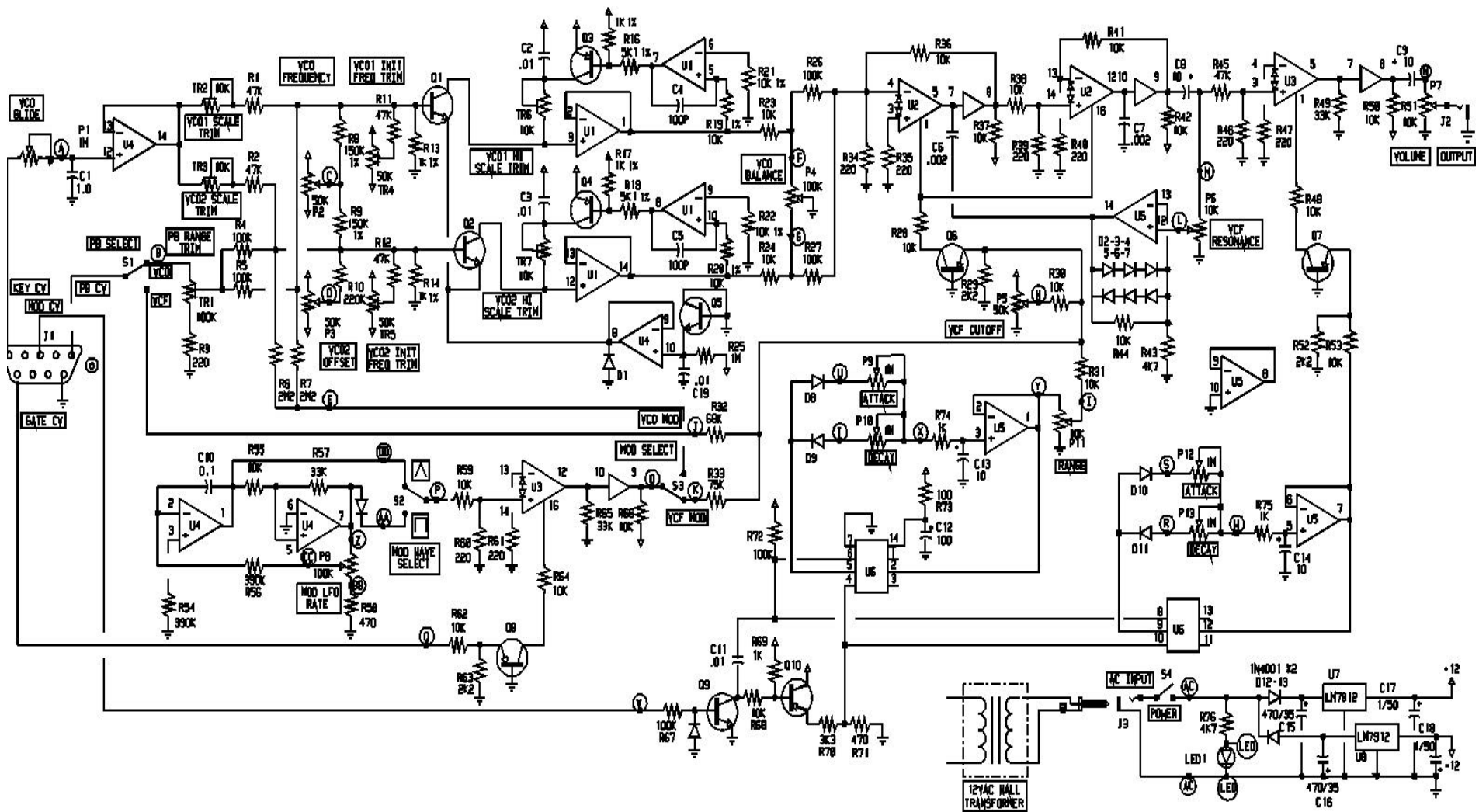
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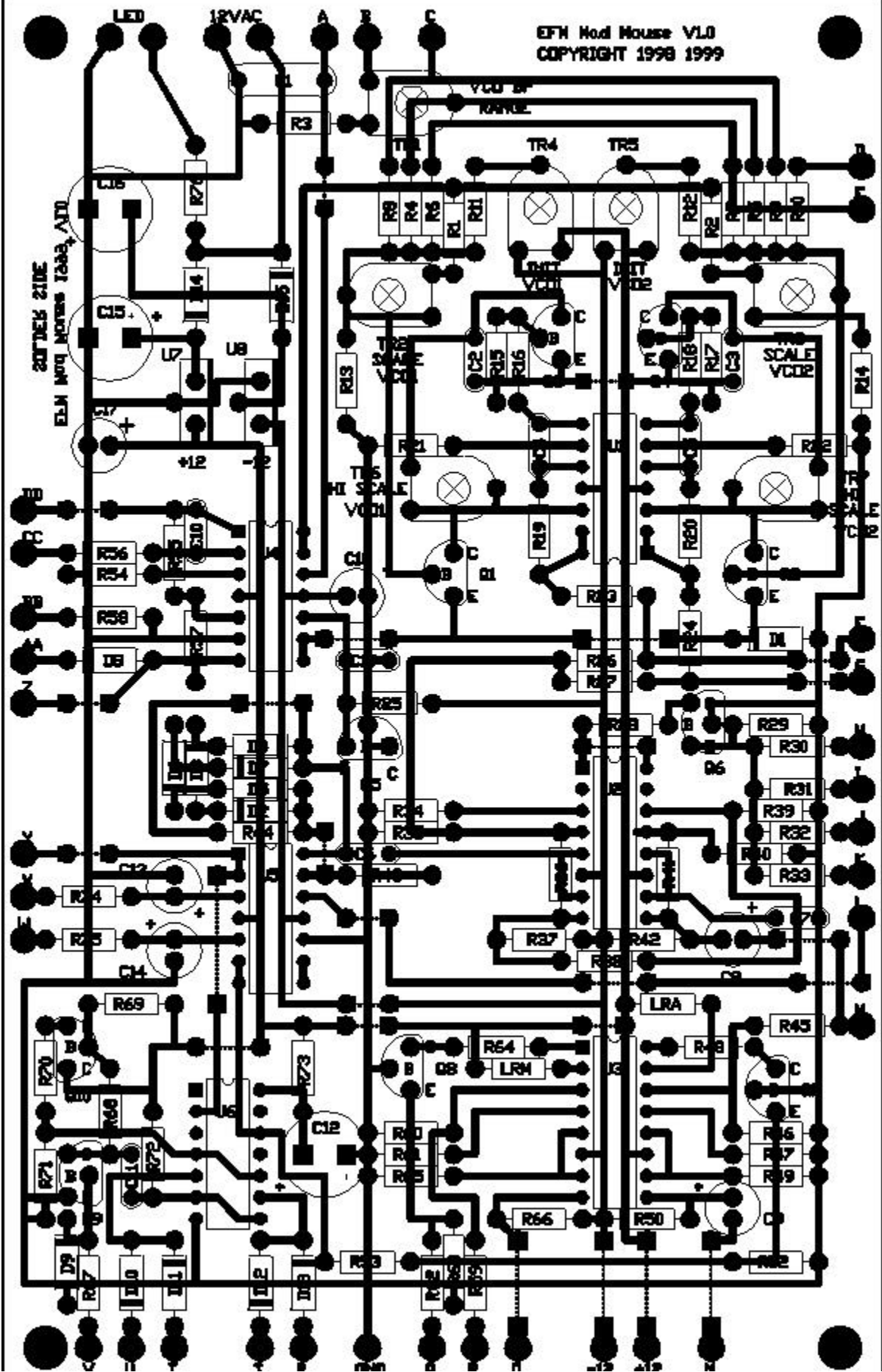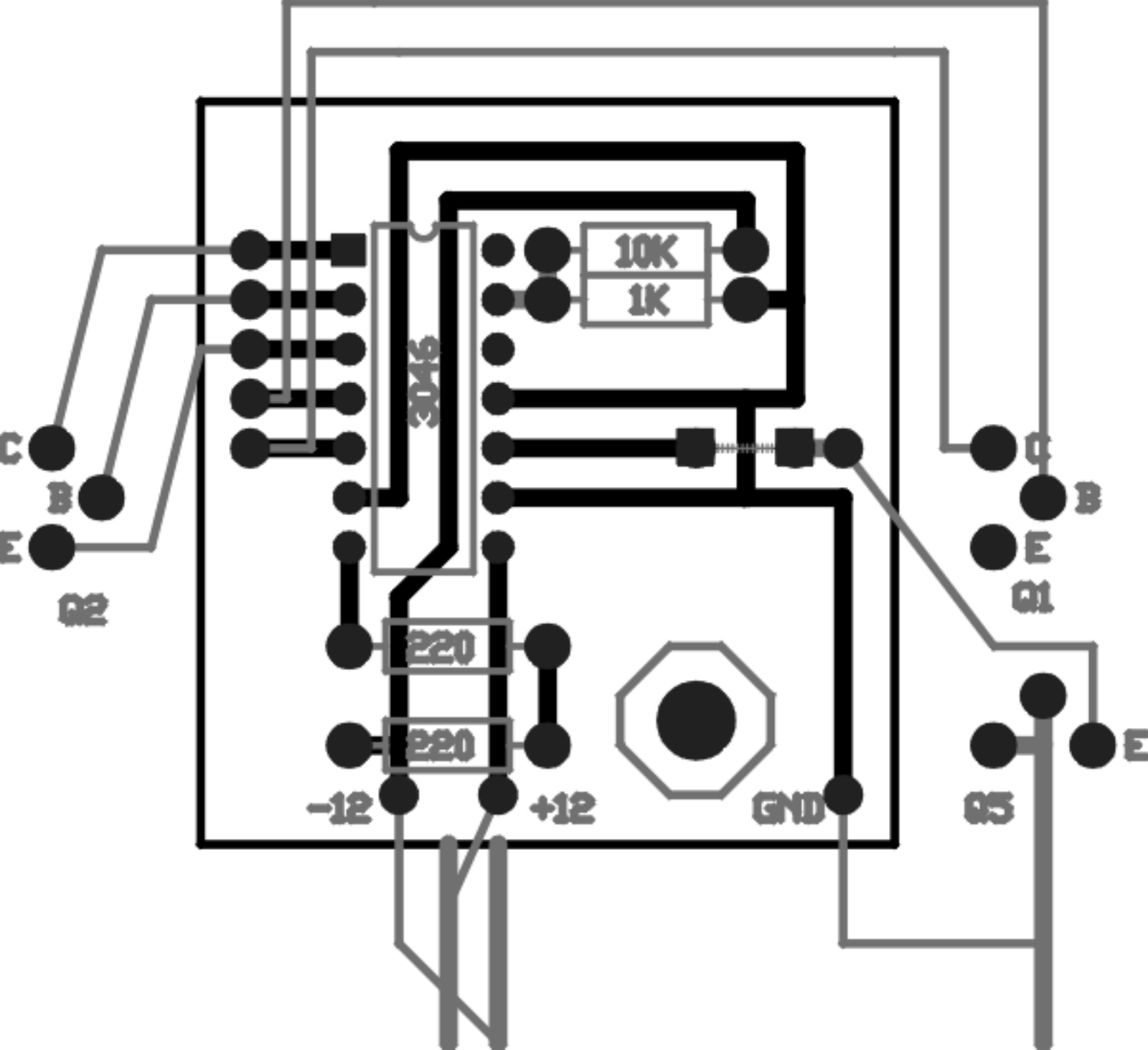
I finally found time to make this mods. When I projected my mm deluxe I ended up with lots of pots and switches for various modulation connecting and levels of modulations, so I thought of making all possible ins and outs of mm, put jacks on them, make few (5) attenuators with jacks for in and wiper out (voltage divider configuration), so I'd have 5 max modulation routing, plus few multiples. Thats the idea, to keep mm small, and just to add "field" with jacks (like on ms 20) and attenuators for modulation.

fig1: Added all ins and outs (jacks), include your mods for fine and coarse freq of each vco, and pw/pwm waveforms selectable (not shown), sync (simplified,you don't need that another res in series with switch), lp/hp switch on vcf, eg1 mode to ADSR (without 4016),eg2 mode to have switchable on/off sustain and release (from multimoog) , lfo1 got level control on panel, manual trig (like gnome), lfo1 range lo/normal speed, vcf switch for eg 1/2, vca sw for eg 1/2. Vco 1+2 cv in controls both vcos. All jacks should be in close position (3.5mm mini jacks) for shorter connections.Couple of multiples (3-4 shorted jacks). Maybe add heated vco version. NOTE: on your schematic vcas for lfo and VCA are mixed pins (on pcb 13600 pin 5 is out for lfo vca not audio VCA but schematic is other way around and so for all pins).

List of jacks:

CV IN

GLIDE CV OUT

VCO 1+2 CV IN

VCO 1 CV1 IN

VCO 1 CV2 IN

VCO 2 CV1 IN

VCO 2 CV2 IN

VCO 1 SAW OUT

VCO 2 SAW OUT

VCO 1 SQUARE OUT

VCO 2 SQUARE OUT

VCO 1 PWM IN

VCO 2 PWM IN

VCF AUDIO IN 1

VCF AUDIO IN 2

VCF OUT

VCF CV IN 1

VCF CV IN 2

VCA AUDIO IN

VCA CV IN

ENV 1 OUT

ENV 2 OUT

GATE IN

NOISE OUT

LFO 1 TRI OUT

LFO 1 SQR OUT

LFO 2 TRI OUT

LFO 2 SQR OUT

S/H IN

S/H CLK IN

S/H OUT

SUB IN

SUB 1 OCT OUT

SUB 2 OCT OUT

SUB 2 OCT PULSE OUT

RING MODULATOR OUT

MULTIPLE A 1-2-3

MULTIPLE B 1-2-3

ATTENUATOR 1 IN

ATTENUATOR 1 OUT

ATTENUATOR 2 IN

ATTENUATOR 2 OUT

ATTENUATOR 3 IN

ATTENUATOR 3 OUT

ATTENUATOR 4 IN

ATTENUATOR 4 OUT

ATTENUATOR 5 IN

ATTENUATOR 5 OUT

I'd add -simple ringmodulator (XOR) from ms20 for square vco outs, -noise (maybe hardwired to pot for mixing with vcos) -s/h from sh09 (not hardwired to anything) -subdivider from sh101, maybe one or for each vco with 3 outputs 1/2 oct below and 2 oct narrow pulse maybe hardwired for mixing with vcos via selector switch for sub oct and level pot -lfo 2 from ms 20 with continuous change of waveforms -maybe env follower and preamp from your maxx2 -some simple HEADPHONE AMP (crucial for fun!) maybe like in ms20 or something -voltage inverter?

Anyway I think that idea with jacks (cheaper than pots/switch combo) and bunch of attenuators for modulation "patch" save space and cost, making mm minimal modular, compact in size.

Marjan