BMC100. Deluxe Decaying Analog Noise
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If you have any questions, or need help trouble shooting, please e-mail
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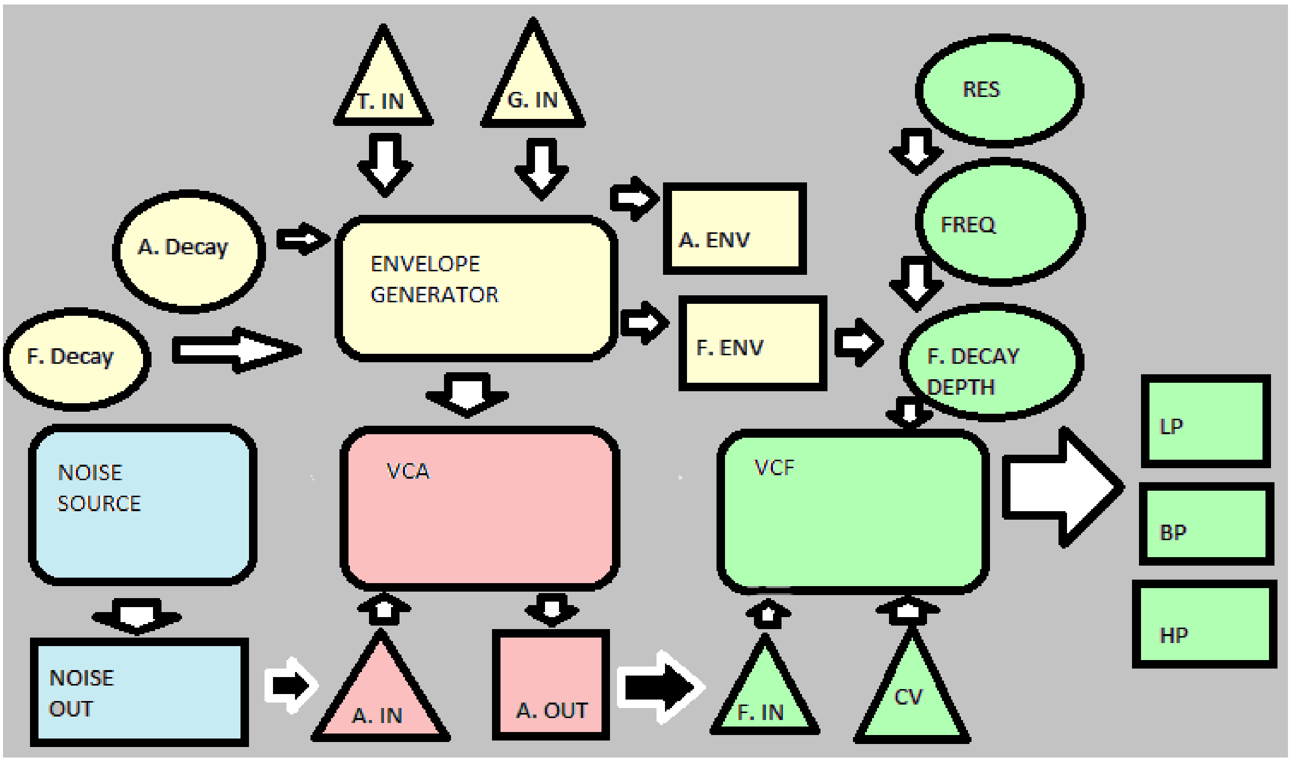
I. Overview/Features

This module is made up of a noise source, envelope generator, VCA and state variable VCF. Together these parts can be used to make percussive sounds, but patch points are available to use the parts individually, the pure noise signal can be patched out, the VCF or VCA can process outside signals or and the envelope generator's output can be patched to other modules.

Below is a diagram of the signal path. Inputs are presented as triangles, outputs as squares and knobs as circles. The white arrows with black outlines are hardwired connections and the black arrows with white outlines are normalized connections that can be broken with patching.



CONTROLS
1.AMP DECAY KNOB – This controls how long the envelope for the VCA takes to decay.
2.FREQ DECAY KNOB – This controls how long the envelope for the VCF takes to decay.
3.FREQ DECAY DEPTH KNOB – This controls how much the frequency depth affects the frequency of the VCF. This is an attenuverter, so pointing the knob straight up makes no signal pass, turning it to the right causes the envelope to increase the frequecny and turning it to the left makes it lower the frequency.
4. FREQ KNOB – This sets the baseline frequency for the VCF. Note that extreme settings of the Freq and Freq Decay Depth knobs can have non-linear results in frequency.
5. RESONANCE KNOB – This sets how resonant the VCF is. This will also affect the amplitude of the VCF.

INPUTS
1.T. In – A trigger input for the envelope generator. Envelopes go high and decays will begin immediately.
2.G. In – A gate input for the envelope generator. The envelopes go high and stay high until the gate input goes low and then begin to decay.
3.VCA IN – Audio input for the VCA. This is normalized to the noise output.
4.CV IN – External frequency CV input for the VCF.
5.VCF IN – Audio input for the VCF. This is normalized to the VCA output.

OUTPUTS

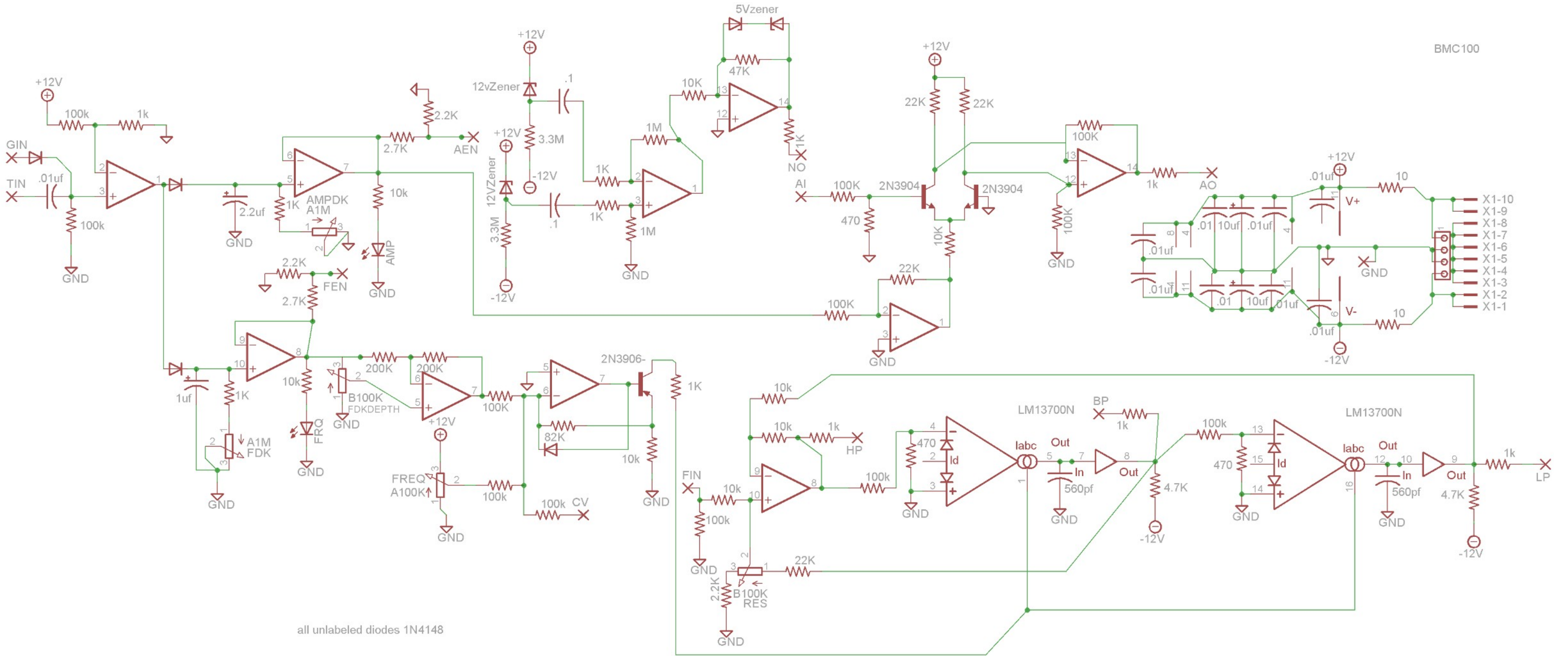
1.A ENV – Output for the envelope signal that's sent to the VCA.
2.F ENV – Output for the envelope signal that's sent to the VCF.
3.NOISE OUT– Noise signal output.
4.VCA OUT – Output for the VCA.
5.LP OUT – Low pass output from the VCF.
6.BP OUT – Band pass output from the VCF.
7.HP OUT – High pass output from the VCF.

SOUND SAMPLES

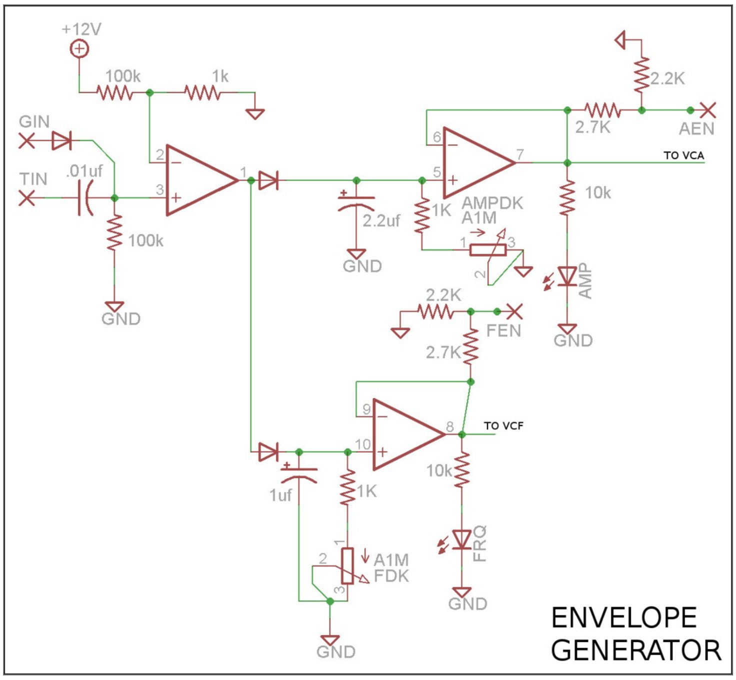
JUST NOISE – The noise source's output directly recorded.
VCA NOISE – The noise through the VCA, playing with the VCA decay knob.
LP NOISE – The noise sent through the VCA and onto the VCF. Low pass output used. Starts with an attempt to synthesize a kick drum.
HP NOISE – Noise sent through the VCA and onto the VCF. High pass output used.
BP NOISE - Noise sent through the VCA and onto the VCF. High pass output used.
LP SQUARE VCO – Signal from a VCO patched into the VCA with the low pass output used.

II. Schematic.

Below is the full schematic for the module. In the next pages the individual sub circuits are reporoduced.

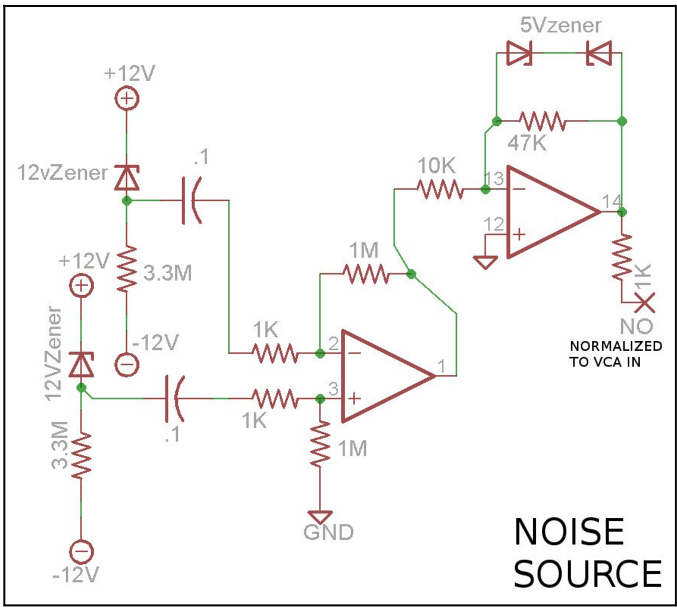


To the right is the envelope generator circuit. The GIN and TIN wirepads are our inputs. Both connect to a 100K resistor to ground at the positive input of an op-amp wired as a comparator. The TIN pad connects through a .01uf capacitor, forming a high pass filter with the 100K resistor. This reduces the input signal to just a short positive spike of voltage at the start of a gate and negative spike at the end. The GIN pad connects through a diode making it so only positive voltages can pass. This allows you to input a bi-polar signal to the GIN jack and still use a unipolar signal on the TIN jack at the same time.



The comparator's threshold is set by a 100K/1K voltage divider between +12V and ground making for .012V threshold. It's output is connected to two diodes, each of which go on to electrolytic capacitors to ground. When the comparator goes high, these diodes conduct and charge these capacitors. The capacitors then discharge through the AMP and FREQ decay pots which are each in series with 1K resistors. The AMP decay circuit uses a 2.2uf cap and FREQ uses a 1uf.

The voltage on these capacitors is buffered by op-amps wired as unity gain buffers. Their outputs are attenuated by 2.7K/2.2K voltage dividers to ground and then sent to the envelope output jacks, as well as being sent on to the next sub circuits.

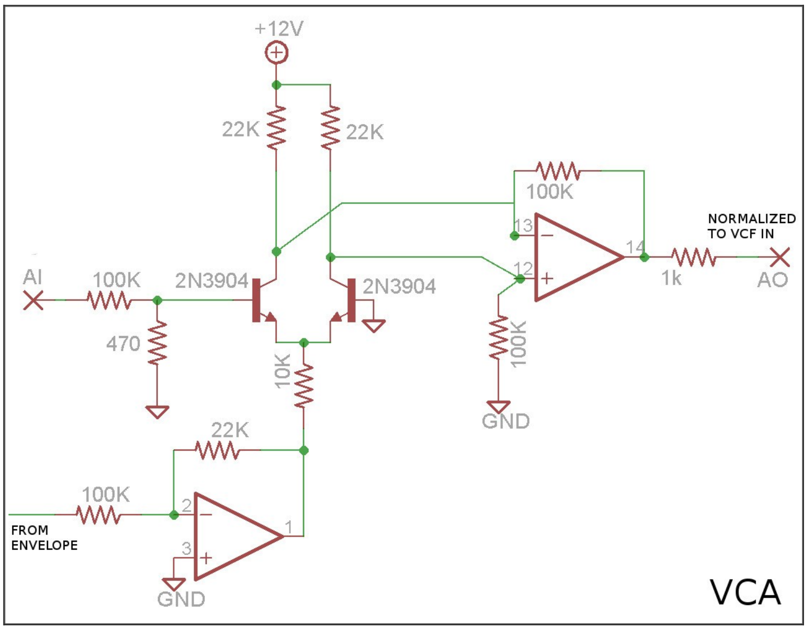


To the left is the noise source circuit. Two zener diodes with a zener voltage of ~12V are used to generate thermal/shot noise. The diodes reference +12V at their cathode and have 3.3M resistors to -12V at their cathodes. The large value of the 3.3M resistor makes it so very small changes in current create larger swings in voltage. These voltage swings are AC coupled by .1uf capacitors onto a differential amplfier composed of 1K input resistors and 1M feedback/ground reference resistors, giving it a gain of ~1000.

The two diodes into a differential amp are used to prevent signal in the power supply from being passed onto the noise output. Because of the high gain, small spikes from the envelope generator turning on or similar large current draws could cause jumps in voltage at the zener that then get passed onto the amplifier. But, the differential amplifier is only passing on the difference between its two signals and canceling out common noise, like these spikes would be since both diodes are referencing the same power supply. Using two diodes also decreases the change of getting zeners that just don't have a great noise sound to them.

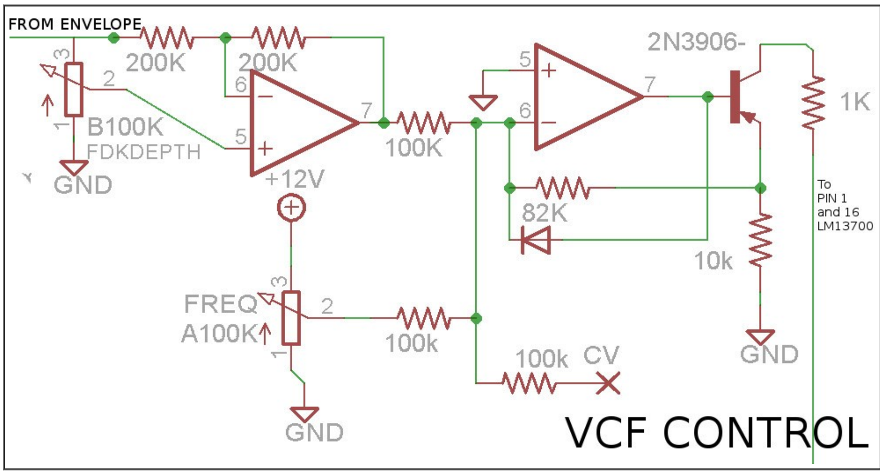
After the differential amplifier, the signal is sent two a 2nd amplifier stage, this one with just a gain of ~5, but with 5V zeners in its feedback path, this limits the output the noise source to just +/-5V. When signals are below +/-5V they must pass through the 47K resistor and only a small amount of negative feedback is applied, but once the signals are larger than +/-5V, the zeners will bypass the resistor and provide direct negative feedback until the signal is reduced to less than +/-5V. The output is sent to the noise out jack through a 1K resistor. The noise out jack is normalized to the VCA input.

To the right is the VCA. The Audio comes in from the AI wirepad and is attenuated by a 100K/470 ohm voltage divider and coupled to the base of a 2N3904 transistor. The emitter is connected to the emitter of a 2nd 2N3904 which has it's base grounded, and the emitters also connect to a 10K resistor. This arrangement is known as emitter coupling, and makes it so the current draw at the collector of the 2nd transistor 180 degrees out of phase with the current draw of the 1st transistor when audio is applied.



This 10K resistor connects to an inverting op-amp with a gain of -0.2. The inverter is fed the envelope signal from the envelope generator. As the voltage becomes more negative from this inverter, it increases the difference in voltage between the base and emitter of the two transistors, which in turn causes them to conduct more current. The collectors of the transistors connect to 12V through a pair of 22K resistors.

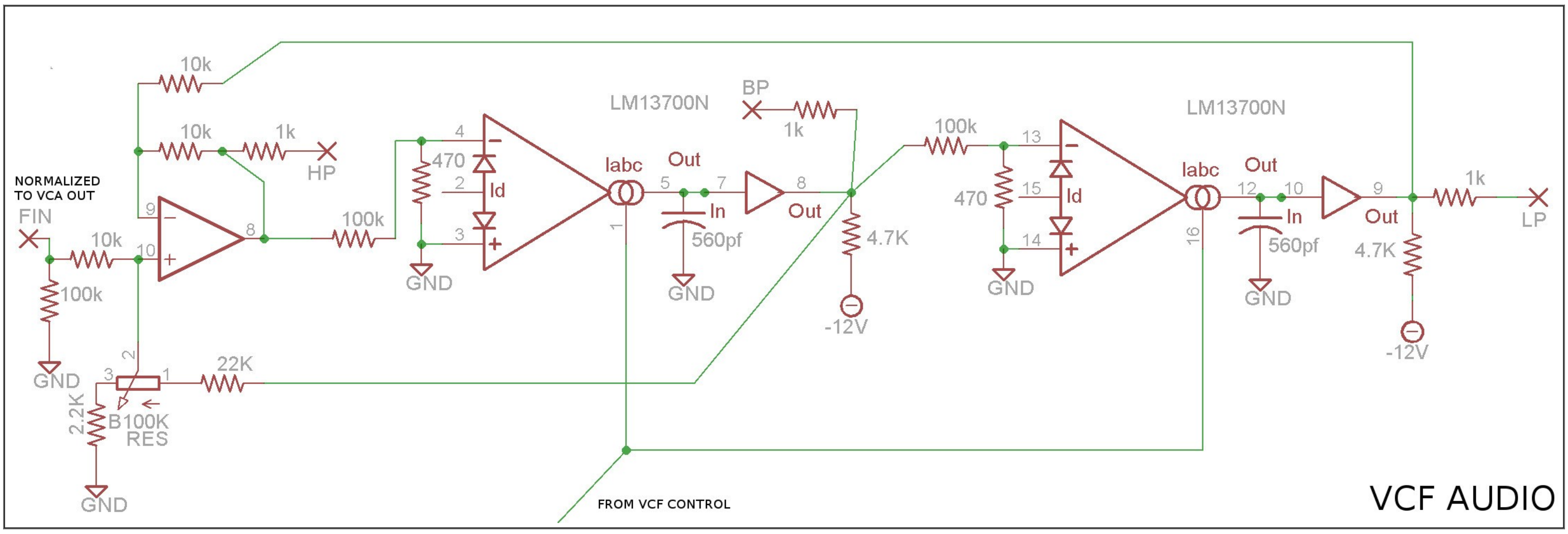
When audio is applied to the circuit, it will contribute to the difference in voltage between base and emitter of the two transistors, multiplied by the increasing negative voltage at the emitters. As more current flows through them, the 22K resistors at the collectors will lower more voltage. The two collectors are sent to a differential amplifier which will amplify the difference between the two collectors. The differential amplifier's output is sent to a jack through a 1K resistor. The jack is normalized to the VCF input.



To the left is the control circuit for the VCF. The signal from the envelope generator comes in from the left goes to a potentiometer used as variable voltage divider and to the inverting input of an op-amp through a 200K resistor. The op-amps's positive input connects to the potentiometer's wiper, so when the wiper connects to ground, the circuit becomes an inverting amplfier stage. When the wiper connects to the input, the circuit becomes a non-inverting amplifier stage. When the wiper is dead center, there will be no output. This arrangement is referred to as an attenuverter.

The output of this gain stage is mixed with the wiper of the Frequency pot and the external CV input by 100K resistors, meeting at the negative input of another op-amp. This op-amp and the 2N3906 transistor work together as a voltage controlled current source for the VCF.

As the voltages increase from the frequency controls, the output of the op-amp becomes more negative, and the op-amp pulls more current out of the base of the 2N3906 which is then sent on to the collector and on to the 13700. A diode from the output of the op-amp to the negative input provides polarity protection. The emitter of the transistor connects to ground through a 10K resistor keeping it slightly more positive than the base, with linearising feedback provided by the 82K resistor to the negative terminal. When the transistor is completely cutoff or saturated, the linearity is lost and frequencies going high when they seem like they should go low or vice versa may occur.



Above is the schematic for the audio section of the VCF. At the bottom we see the connection to the control circuitry which goes to the control pins of the LM13700. On the left we see the FIN wirepad (Filter Input). The signal is given a ground reference through a 100K resistor and then sent to the first op-amp.

The first op-amp is doing a lot. On the positive input terminal the resonance knob's wiper and the input signal are summed together, and at the negative input terminal we have a 10K feedback resistor and another 10K resistor that provides feedback from the low pass output forming a differential amplifier. This difference forms our high-pass output, input minus low frequencies that the low pass input passes equals high frequencies that the high pass input passes on. This output, as well as the other two VCF outputs is sent to it's jack through the usual 1K resistor.

The output of this stage gets sent the inverting input terminal of the LM13700 after being attenuated by a 100K/470ohm voltage divider. The positive terminal is grounded and the output is connected to a 560pf capacitor to ground. This arrangement forms an inverting current controlled low pass filter. As more current is provided to pin 1, the more current gets output and the faster the 560pf cap charges, increasing the frequency response of the filter. The voltage on the capacitor is buffered by the 13700's on chip transistor buffer circuit which gets biased by a 4.7K resistor to -12V and the output of this stage forms our band-pass output.

The band pass output is sent through the resonance pot back to the first op-amp to provide negative feedback. The resonance pot is wired backwards to how most voltage divider pots work, when turning it clockwise, you're actually decreasing the amount of signal passed. The 2.2K resistor controls the maximum amount of resonance and the 22K sets the minimum amount.

The band pass signal then gets sent to another inverting low pass filter stage formed just like the first, to derive our low pass output. The low pass output is then sent back to the first op-amp to provide negative feedback.

III. Construction

A.Parts List

Semiconductors

Name	Quantity	Notes
TL072	1	DIP package
TL074	2	DIP package
LM13700	1	DIP package or SMD depending on PCB
1N4148	4	
5V Zener	2	1N4732 or similar
12V Zener	2	1N4742 or similar
2N3904	2	TO-92
2N3906	1	TO-92
LED	2	3mm

Resistors

Name/Value	Quantity	Notes
10 ohm	2	1/4W Metal film for resistors unless otherwise noted
470 ohm	3	
1K ohm	11	
2.2K	3	
2.7K	2	
4.7K	2	
10K	8	
22K	4	
47K	1	
82K	1	
100K	12	
200K	2	
1M	2	
3.3M	2	
A100K potentiometer	1	16mm PCB mounted pots for all
B100K potentiometer	2	
A1M potentiometer	2	

Capacitors

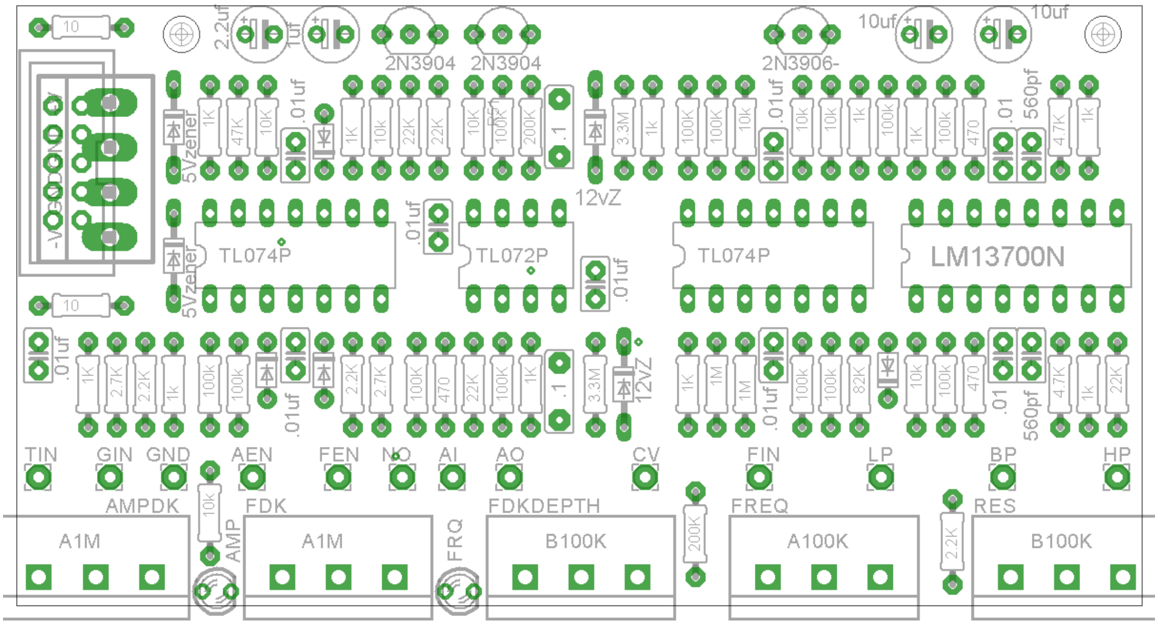
Name/Value	Quantity	Notes
560pf	2	Ceramic disc
.01uf	9	Ceramic disc

.1uf	2	Film box
1uf	1	Electrolytic
2.2uf	1	Electrolytic
10uf	2	Electrolytic

Other

Name/Value	Quantity	Notes
Power connecter	1	
Jack	12	At least 2 should be switching jacks
8 pin DIP socket	1	
14 pin DIP socket	2	
16 pin DIP socket	1	Not needed when using SMD version of 13700

B. The PCB


10
2.2uf
1uf
2N3904
2N3904
2N3906-
10uf
10uf
5Vzener
1K
47K
10K
.01uf
10k
22K
22K
10K
100K
200K
.1
12vZ
3.3M
1k
100K
100K
10k
.01uf
10k
10K
1K
100K
1K
100K
470
.01
560pf
4.7K
1K
TL074P
.01uf
TL072P
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TL074P
LM13700N
10
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100K
100K
.01uf
2.2K
2.7K
100K
470
22K
100K
1K
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3.3M
12VZ
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100K
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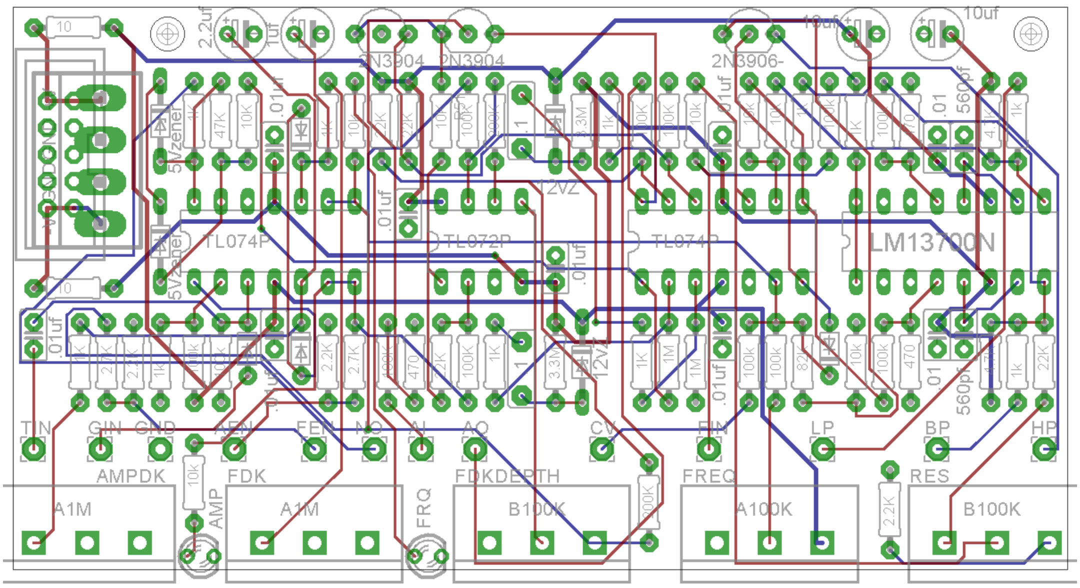
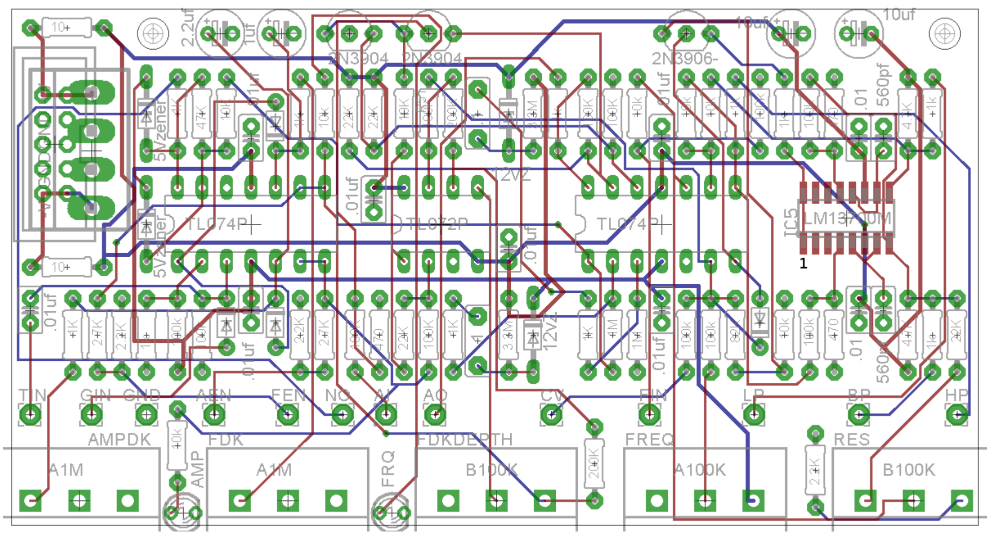
560pf
4.7K
1k
22K
TIN
GIN
GND
AEN
FEN
NO
AI
AO
CV
FIN
LP
BP
HP
AMPDK
10k
FDK
FDKDEPTH
FREQ
RES
A1M
AMP
A1M
FRQ
B100K
200K
A100K
2.2K
B100K



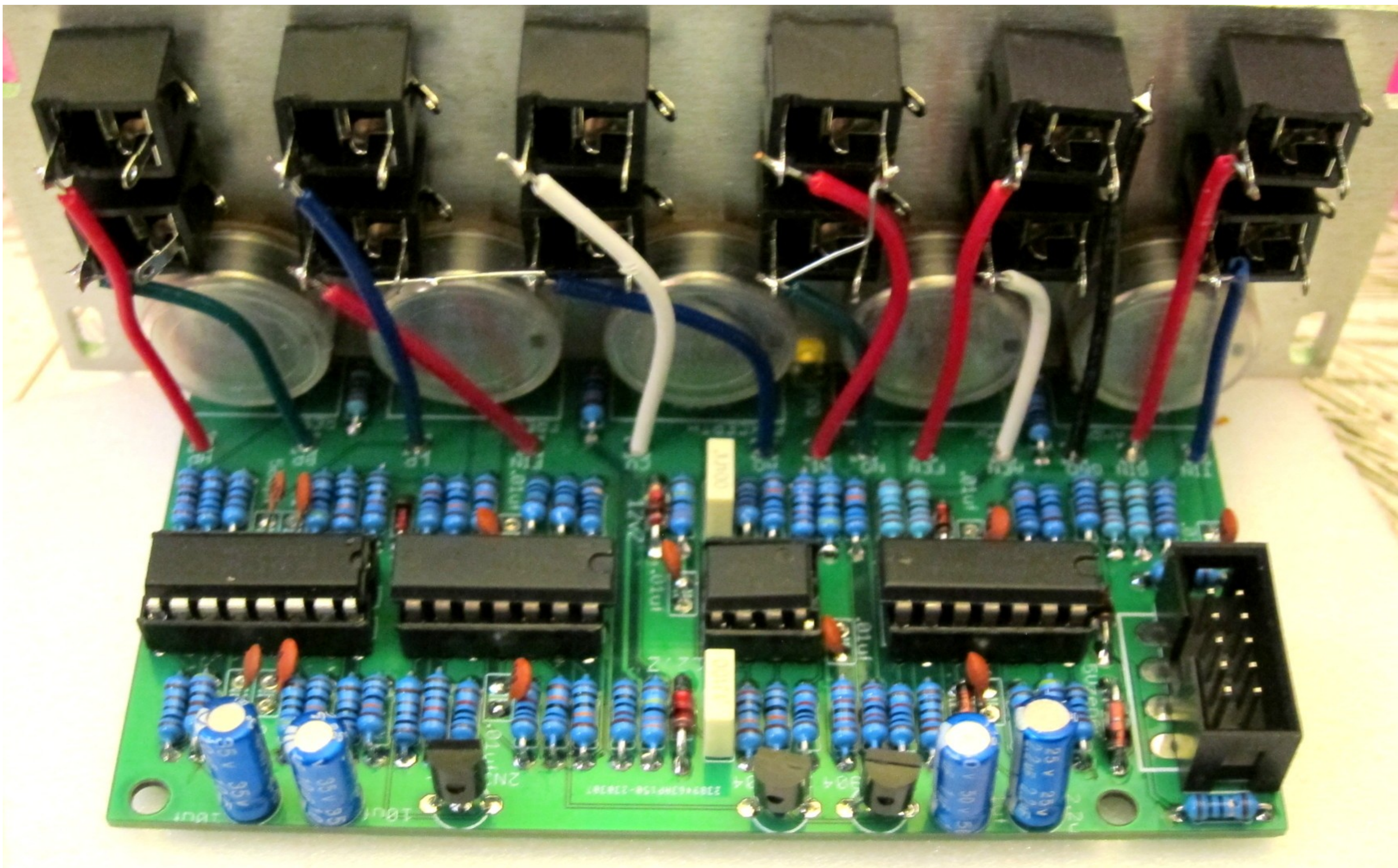


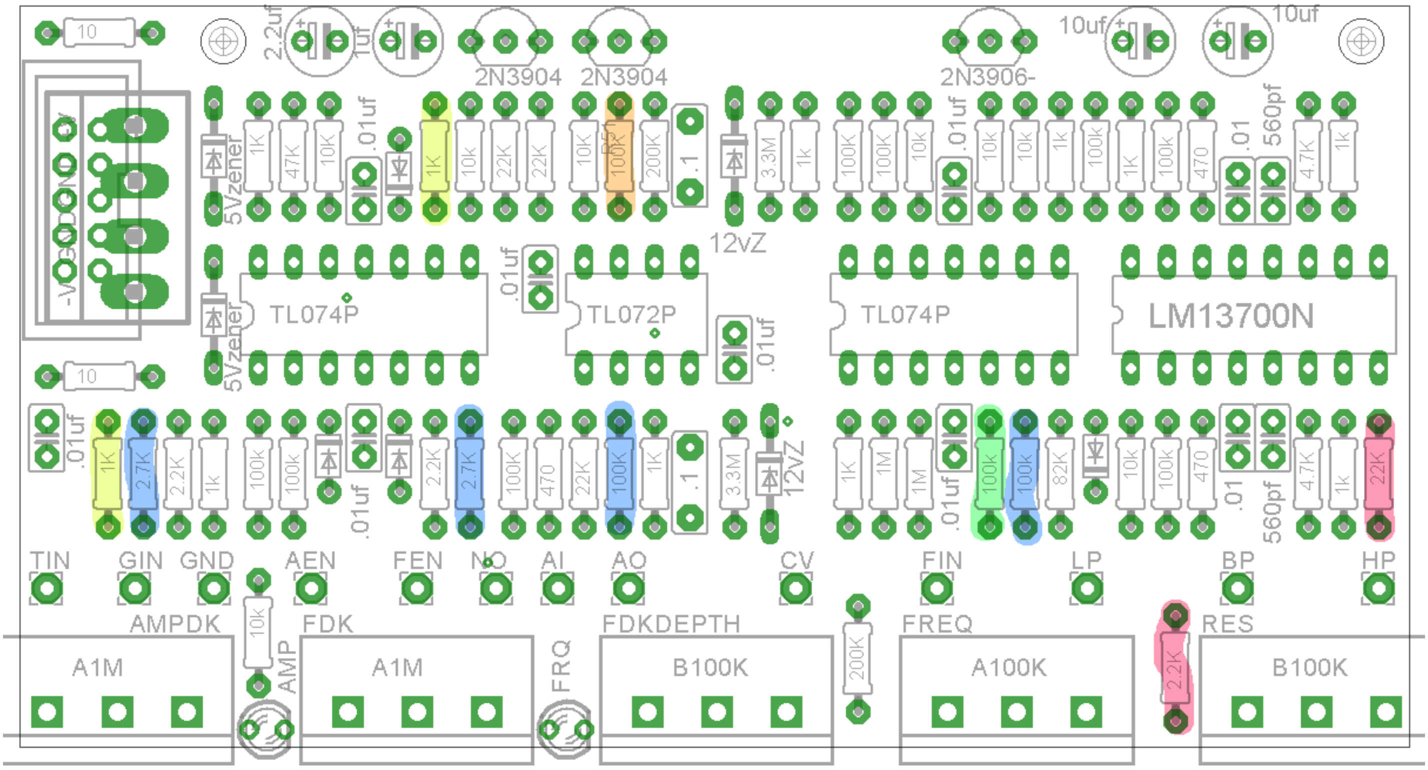
Above are renderings of the PCB with and without traces. The PCB is 100mm x 54mm. On the SMD board, pin 1 of the 13700 is marked with a black "1".

Wirepads should be connected as follows

TIN → tip of trigger input jack
GIN → tip of gate input jack
GND → sleeve of any jack
AEN → tip of Amplitude envelope output jack
FEN → tip of frequency envelope output jack
NO → tip of noise output jack and switch of VCA input jack
AI → tip of VCA input jack
AO → tip of VCA output jack and switch of VCF audio input jack
CV → tip of VCF CV input jack
FIN → tip of VCF audio input jack
LP → tip of Low pass output jack
BP → tip of band pass output jack
HP → tip of high pass output jack

Below is a photo of a completed module to use as a reference





Tweaks/15V builds

1.15V Builds – This module is untested with 15V systems. The resistors I would change are highlighted in blue. The 2.7Ks are used to attenuate the envelope outputs, and can be changed to 3.3K if the envelopes go to too high a voltage. The blue 100K resistor next to the TL072 connects the amplitude envelope to the VCA, it can be increased to 120K if the VCA is staying loud too long or acting odd. The blue 100K next to the TL074 connects the FREQ pot to V+ and can be increased to 120K or 150K to lower the range of the frequency pot.

2.Envelope tweaks – Overall decay maximums can be lowered to give finer control over decay times. The 2.2uf capacitor controls amplitude decay and the 1uf capacitor controls frequency decay. 1uf and 0.47uf caps would make it easier to dial in short decays. The 1K resistors in yellow set the minimum decay times. Increasing the value will increase the minimum. Going too low on the value may cause odd interactions between the two controls.

3.Filter Resonance – The 2.2K and 22K resistors highlighted in red control minimum and maximum filter resonance. Lowering the value of the 2.2K resistor will increase the maximum resonance. Increasing the value of the 22K will increase the minimum resonance.

4.Filter Frequency – The Blue 100K resistor next to the TL074 controls the maximum voltage from the FREQ pot, increasing it's value will tame this pots outptut. The green resistor next to it sets how much the CV input jack affects the frequency, increasing it will give the CV jack less control over the frequency. The orange 100K resistor next to the TL072 sets the maximum voltage that's passed from the FREQ DECAY DEPTH pot, increasing it will tame this knob's output.