The Mutant Vactrol Filter

The Mutant Vactrol filter is a fun little filter. It's definitely got a sound of its own – make that many sounds of its own if one builds the deluxe switchable model of it. I've gotten pure, 'majestic' tones out of it, and I've gotten tones that seem to be intent upon shredding speakers/ears. And, of course, there's an entire range in between those two extremes. Being a Vactrol filter, particularly based off of the VTL5C3/2 optocoupler, it has its own electro-acoustic qualities. The attack can be fairly fast, but never as fast as a filter based off of OTA's, Transistors or Diodes. Instead, one gets a pleasing 'Thwip'. The initial release is even a bit slower, contributing to the effect.

There are actually four variants of the filter – a low pass, a high pass, a band pass and (as mentioned above) the deluxe switchable variant of it, which allows one to have all of the responses in one filter.

Each variant of the filter provides 12 dB and 24 dB tap points. There are two variable signal inputs (more can be added) and three control voltage inputs (again, more of these can be added). One control voltage is a 'Volts per Octave' input, and is unattenuated. The second control voltage input has a level control on the input. On the deluxe version, the third control voltage input is passed through an attenuating inverter circuit so that it both controls the level and phase of the control voltage – rotating CW will increase the signal level; rotating CCW will increase the signal level and flip the phase 180 degrees. Center position is fully attenuated. On the LP, BP and HP versions, this control is a normal attenuator.

An extra switch control is added that allows optional negative half clipping to the internal resonance signal – this allows a smoother resonance control, while unclipped will allow the resonance more free-reign for self-oscillation. The switch adds more timbral/functional variation to the filter.

The Mutant Dissected

The Mutant Vactrol filter is based upon the Sallen-Key structure of the Buchla Low Pass Gate. It is essentially two LPG circuits in series with resonance sourced from the second of the two sections. In place of the usual CV control circuit of the LPG, an expo control circuit has been used instead. The resonance signal is run through a diode/op amp limiter. An additional switch is added, which allows one to clip the lower half of the resonance signal, providing a more controllable, less self-oscillation prone resonance when desired.

The expo control was borrowed from Rene Schmitz's VCO4069 circuit. The resonance limiter was taken from Rene's Late MS-20 Filter design.

This document includes four variations of the Mutant Filter:

The **low pass version** is the unaltered dual series LPG sections, with resonance tapped from the last stage, run through the clipper circuit, inverted and mixed with the input.

Running the two sections in series creates a 24 dB low pass response at the output. The first stage is tapped for a 12 dB response output, but the resonance is still tapped from the 24 dB output of the second section.

The **band pass version** injects the input signal into the first LPG section at a different point, creating a 12 dB high pass response. The second stage is left in the original low pass mode, forming a band pass filter when the two sections are used in series. On this version of the filter, the resonance signal is mixed back into the input non-inverted. The 12 dB band pass response of the first section is available at the tap point between the two sections, however the resonance is derived from the band pass response at the second section.

The **high pass version** injects the input signal into the high pass point of both sections, creating a 24 dB high pass response at the output of the second section. As with the band pass version of the filter, the resonance signal is mixed back into the input non-inverted. The 12 dB band pass response of the first section is available at the tap point between the two sections, however the resonance is derived from the high pass response at the second section.

The **Mutant VCF version** incorporates all three configurations with the addition of a mode select switch and supporting circuitry. It also adds a switch to direct the taps to one output.

Notes

First of all, when I pronounce any response to be '12 dB' and '24 dB', I do so because I know the original LPG is a 12 dB filter. Cascading two 12 dB filters will yield a 24 dB response. I am under the assumption that with this topology, in high pass mode, it is also in 12 dB high pass mode per section.

The resonance from two cascaded low pass sections worked fine when it was inverted. If the first or both sections are made high pass, the resonance worked better non-inverted.

The resonance is mixed at a 1:1 ratio in lowpass mode, and is reduced by half from this level for the HP and BP modes– I found this to be necessary to keep the output of the filter within acceptable limits when high resonance was used. If one wishes to have a less overbearing resonance, then R5 (and/or R8 in the Mutant VCF version) can be increased. I started out with 200K and settled on the 100K/150K combination.

I further provided a switch to allow one to optionally clip the lower half of the resonance signal. This results in a pleasing, more controllable resonance. It's less prone to self oscillation, and sounds less 'trebly' when used. When the resonance is not clipped, the filter can more easily be put into self-oscillation and will provide more 'wild' timbres. The control can be eliminated and the resonance can be either constantly clipped or non-clipped instead. I recommend this control because it gives one access to more 'standard' filter sounds, as well as a wilder resonant sound under certain settings, particularly from the high pass taps .

The LP, BP and HP versions of the filter use an extra op amp section to buffer the resonance signal so that the clipping diode can follow a current limiting 100K resistor. The deluxe, mode switchable version uses this section for the inverting attenuator on CV input 2. Both CV inputs of the LP, HP and BP versions do not have this control (it can be added using an extra op amp – very desirable).

For each section, the high pass response is created by injecting the signal into the normally grounded 1000 pF cap/4.7M resistor pair and grounding the normal low pass input. The high pass response can be quite aggressive with a high resonance setting (read increased volume).

Switching each section from one mode to the other would require a DPDT switch for each section. Switching from low pass to high pass also requires switching the resonance insertion point, which would also be another SPST switch. I did not want to get into a DG/Max type switching IC, nor did I want to get into converting a CD405X type of switch to handle the bipolar signals, so I opted for an unusual mode switching arrangement on the Mutant VCF version. I've never seen it used, so I imagine there's probably some easier way of doing things. As it stands, the parts are easy to come by, and work just fine with my filter.

For the two filter sections, the signal and ground must be swapped around. The resonance must also be switched to the non-inverted input if the mode is anything other than the Low Pass configuration.

For the two filter sections, I split the audio signal into two paths. Each path goes through a 100K resistor to the input of a voltage buffer, formed by a section of a TL072 op amp. When desired, the input of the buffer is grounded using SW1, which is a C&K 7211 DPDT On-On-On switch, while the opposite buffer input is ungrounded. This allows the 'ground' and 'signal' to swap places. I used N channel FETs to swap points A&B, because the ground signal had to be common at two different points. This prevents the resonance and first stage buffers from having a common connection.

I was concerned that this method may dump noise onto the power rails, or require more current than the TL072 was able to accommodate, but I have had no problem using this system. No hot parts, no noise. I increased the size of the power supply filtering caps in anticipation of any sudden voltage needs from the supply.

There is one adjustment to the filter, and that is the V/Oct trimpot. The term 'V/Oct' is used a bit loosely here – Rene's design does a very good job, it's the Vactrol that's the variable here. Still, a very decent tracking response can be had. To tune it, I just set it to a low audio self resonance and key in two notes an octave apart, tweaking the pot until there's an octave of separation in the resonant signal.

Operating the Mutant Vactrol Filter
Each version of the Mutant Vactrol Filter has the following controls and connections:

Frequency – Potentiometer for selecting cut off frequency
Resonance – Potentiometer for setting resonance level
Input Level 1 – Potentiometer for setting input 1 signal level
Input Level 2 – Potentiometer for setting input 2 signal level
CV1 Control – Potentiometer for setting CV 1 level
CV2 Control – (Normal Potentiomenter Control on LP, BP and HP version, Potentiometer for inverting/non-inverting and setting signal level of CV 2 for Deluxe Switched version of the filter).
Res Clip Switch – Switch for selecting clipped or non-clipped resonance.

Signal Input 1 – Audio Input 1 Jack
Signal Input 2 – Audio Input 2 Jack
CV Input 1 – Control Voltage 1 Input Jack
CV Input 2 – Control Voltage 2 Input Jack
V/Oct Input - Unattenuated Input Jack for Filter Tracking Control Voltage

Tap 1 Output – Output Tapped From First Filter Section
Tap 2 Output – Output Tapped From Second Filter Section

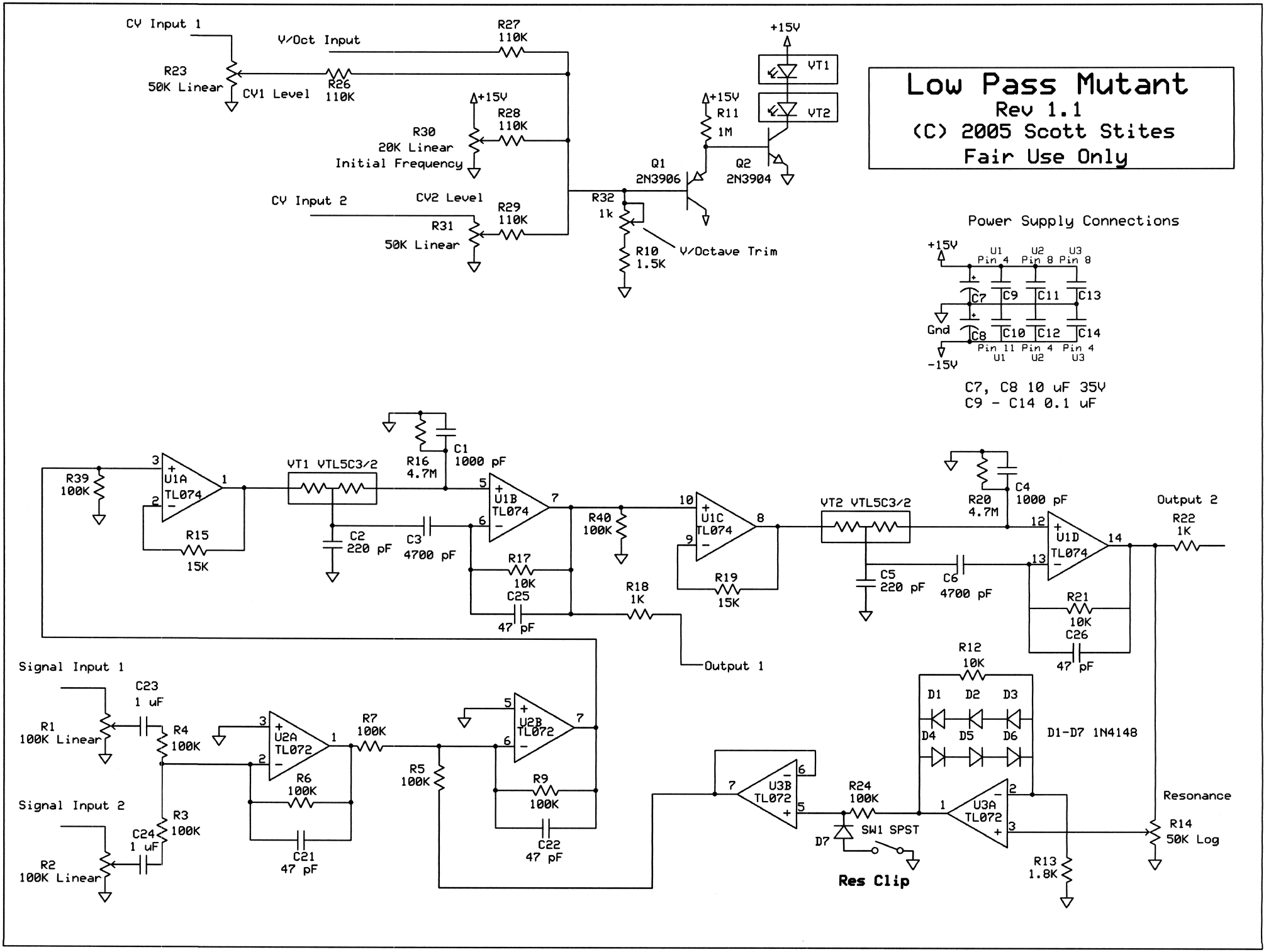
Additional Controls for Mutant Vactrol VCF (Deluxe Version)

Mode Switch – Three position Toggle Switch for Setting Filter Mode
Tap Switch – Two Position Switch for Selecting Tap Output
Tap Out – Signal Either From Tap 1 or Tap 2 as Selected by the Tap Switch

Note that any of the filter variants can have the Tap Switch and single tap output, or the two tap outputs, or a combination of the three. For additional outputs, connect to Pin 7 of U1 through a 1K resistor for each additional Tap 1 output, and pin 14 of U1 through a 1K resistor for each additional Tap 2 output.

On the deluxe version, the various responses are available as follows:

Mode Switch	Tap Switch	Mode
LP	Tap 1	12 dB Low Pass with Resonance Tapped From 24 dB Low Pass Out
LP	Tap 2	24 dB Low Pass
HP/BP	Tap 1	12 dB High Pass with Resonance Tapped From 12 dB Band Pass Out
HP/BP	Tap 2	12 dB Band Pass
HP	Tap 1	12 dB High Pass with Resonance Tapped From 12 dB High Pass Out
HP	Tap 2	24 dB High Pass


Low Pass Mutant
Rev 1.1
(C) 2005 Scott Stites
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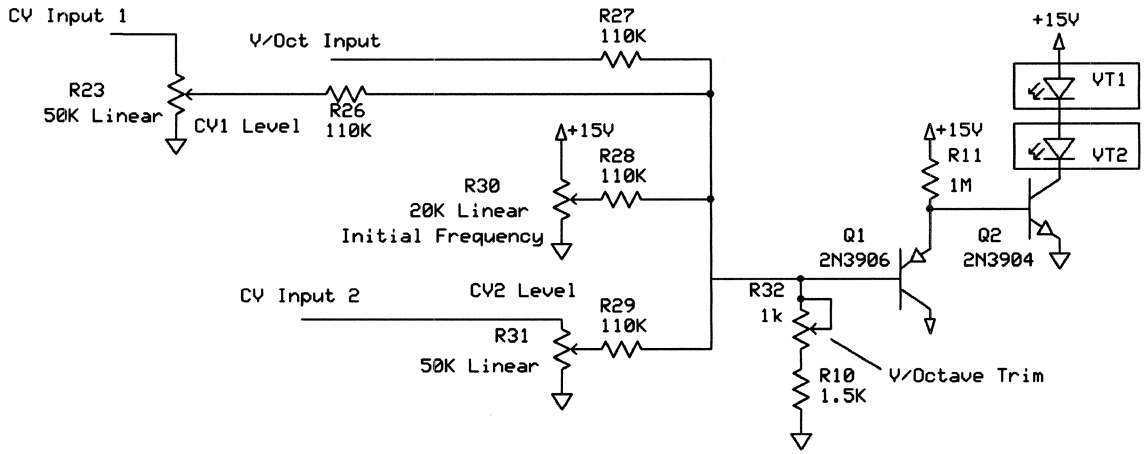
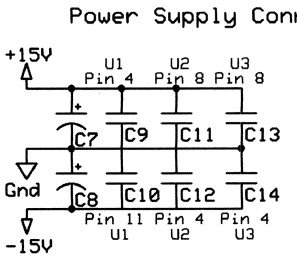
CV Input 1
V/Oct Input
R27
110K
R23
50K Linear
CV1 Level
R26
110K
+15V
VT1
VT2
+15V
R28
110K
R30
20K Linear
Initial Frequency
+15V
R11
1M
Q1
2N3906
Q2
2N3904
CV Input 2
CV2 Level
R29
110K
R31
50K Linear
R32
1k
R10
1.5K
V/Octave Trim
Power Supply Connections
+15V
U1 Pin 4
U2 Pin 8
U3 Pin 8
C7
C9
C11
C13
Gnd
C8
C10
C12
C14
Pin 11 U1
Pin 4 U2
Pin 4 U3
-15V
C7, C8 10 uF 35V
C9 - C14 0.1 uF
R39
100K
U1A
TL074
R15
15K
VT1 VTL5C3/2
R16
4.7M
C1
1000 pF
C2
220 pF
C3
4700 pF
U1B
TL074
R17
10K
C25
47 pF
R40
100K
U1C
TL074
R19
15K
R18
1K
Output 1
VT2 VTL5C3/2
R20
4.7M
C4
1000 pF
C5
220 pF
C6
4700 pF
U1D
TL074
R21
10K
C26
47 pF
Output 2
R22
1K
Signal Input 1
C23
1 uF
R1
100K Linear
R4
100K
U2A
TL072
R6
100K
C21
47 pF
R7
100K
R5
100K
U2B
TL072
R9
100K
C22
47 pF
Signal Input 2
R3
100K
C24
1 uF
R2
100K Linear
U3B
TL072
R24
100K
D7
SW1 SPST
Res Clip
R12
10K
D1
D2
D3
D4
D5
D6
D1-D7 1N4148
U3A
TL072
R13
1.8K
Resonance
R14
50K Log

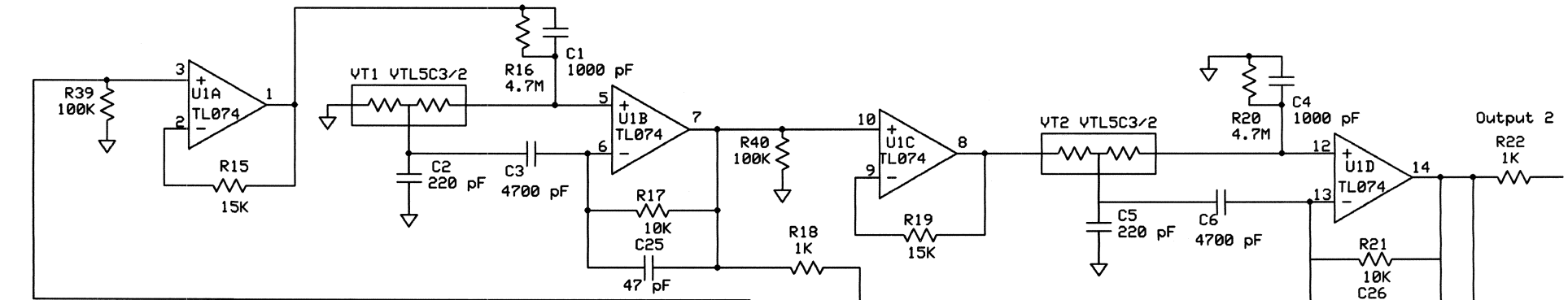
Band Pass Mutant

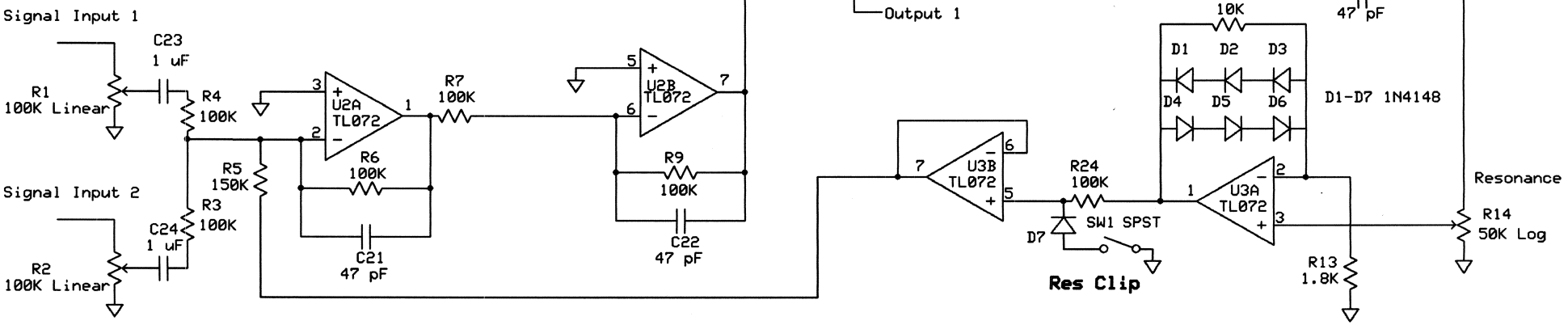
Rev 1.1





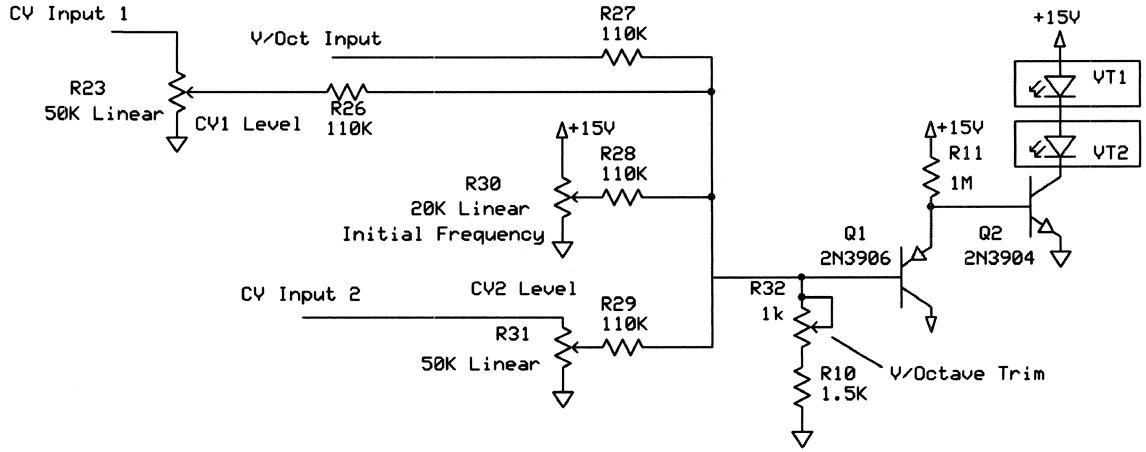
C7, C8 10 uF 35V
C9 - C14 0.1 uF



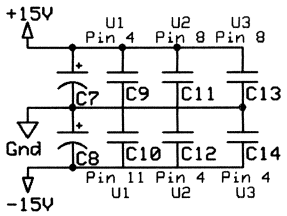


High Pass Mutant

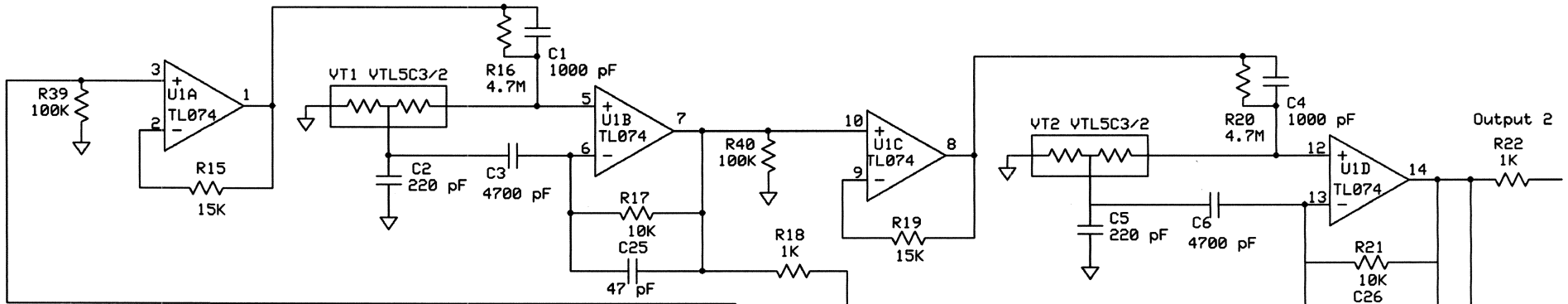
Rev 1.1

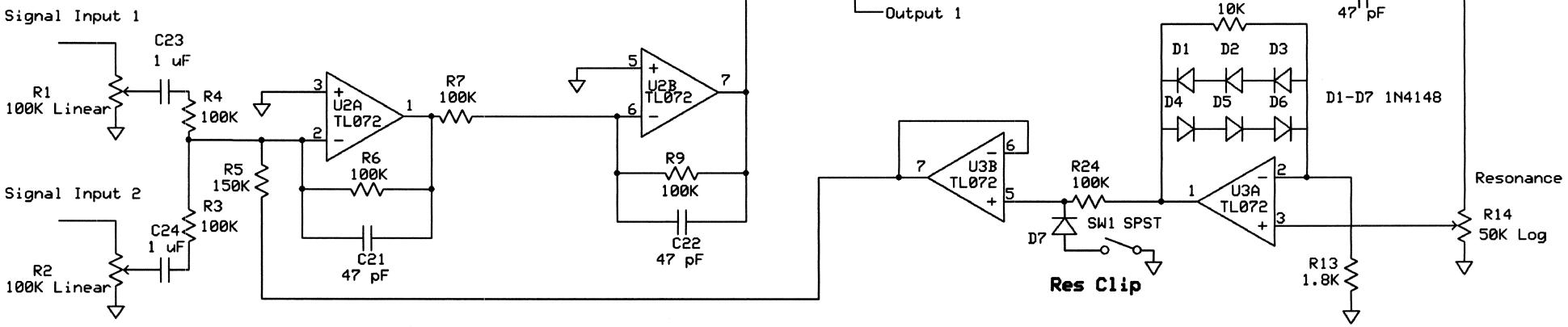


Power Supply Connections



C7, C8 10 uF 35V
C9 - C14 0.1 uF





Mutant Filter LP, BP or HP Parts List

The following parts are used in the LP, BP and HP only versions of the Mutant Filter

Capacitors

C1,C4	1000 pF Polystyrene (2)
C2,C5	220 pF Polystyrene (2)
C3,C6	4700 pF (2)
C7,C8	10 uF 35V Polarized Electrolytic (2)
C9-C14	0.1 uF Ceramic (6)
C21,C22,C25,C26	47 pF Ceramic (4)
C23,C24	1 uF Polyester (2)

Resistors

R3-R7,R9,R24,R39,R40	100K (9)

NOTE: FOR BP OR HP CONFIGURATION, R5 = 150K

R10	1.5K (1)
R11	1M (1)
R12,R17,R21	10K (3)
R13	1.8K (1)
R15,R19	15K (2)
R16,R20	4.7M (2)
R18,R22	1K (2)
R26-R29	110K (4)

Potentiometers

R1,R2	100K Linear (2)
R14	50K Log (1)
R30	20K Linear (1)
R23,R31	50K Linear (2)
R32	1k Trim (1)

Semiconductors

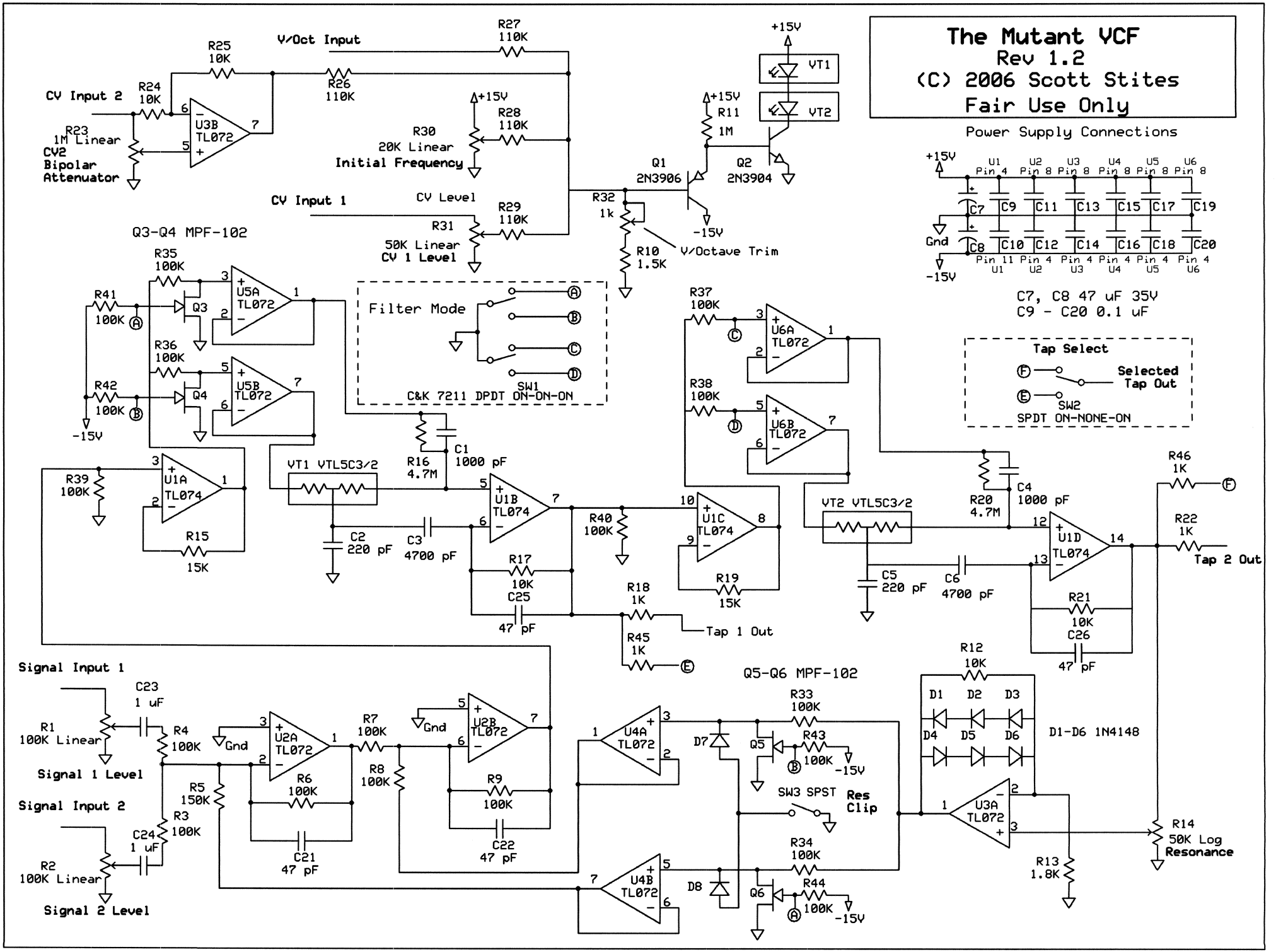
D1-D7	1N4148 (7)
Q1	2N3906 (1)
Q2	2N3904 (1)

Integrated Circuits

U1	TL074 (1)
U2,U3	TL072 (2)

Optocouplers

VT1,VT2	VTL5C3/2 (2)


The Mutant VCF
Rev 1.2
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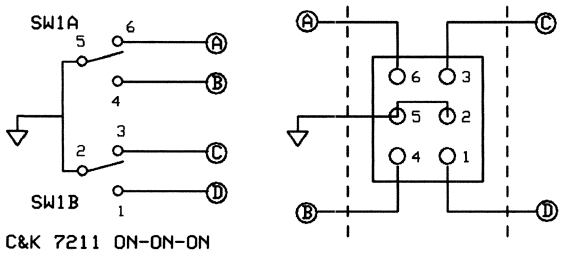
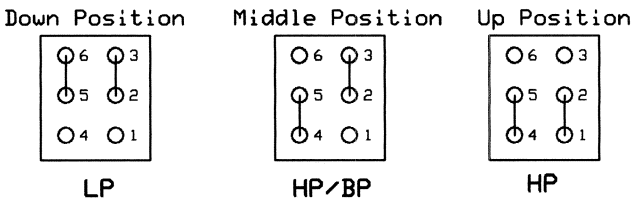
Power Supply Connections
C7, C8 47 uF 35V
C9 - C20 0.1 uF
V/Oct Input
CV Input 2
CV Input 1
CV Level
CV2 Bipolar Attenuator
Initial Frequency
V/Octave Trim
Q3-Q4 MPF-102
Filter Mode
C&K 7211 DPDT ON-ON-ON
Tap Select
Selected Tap Out
SPDT ON-NONE-ON
Tap 1 Out
Tap 2 Out
Q5-Q6 MPF-102
D1-D6 1N4148
Signal Input 1
Signal 1 Level
Signal Input 2
Signal 2 Level
SW3 SPST Res Clip
50K Log Resonance

Mutant Filter Switch Wiring

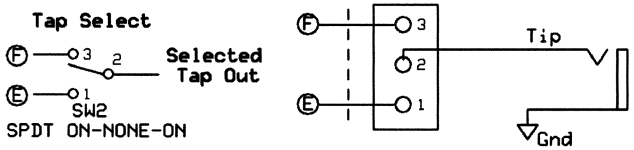
Switch 1 Mode Switch



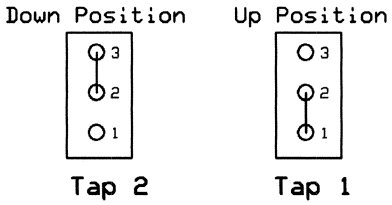
Functional Diagram



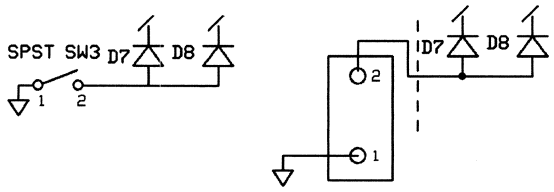
Switch 2 Tap Select Switch



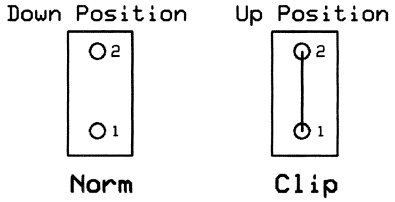
Functional Diagram



Switch 3 Resonance Clip



Functional Diagram



Deluxe Mutant Filter Parts List

The following parts are used in the full blown, mode-switchable Mutant Filter.

Capacitors

C1,C4	1000 pF Polystyrene (2)
C2,C5	220 pF Polystyrene (2)
C3,C6	4700 pF (2)
C7,C8	47 uF 35V Polarized Electrolytic (2)
C9-C20	0.1 uF Ceramic (12)
C21,C22,C25,C26	47 pF Ceramic (4)
C23,C24	1 uF Polyester (2)

Resistors

R3-R9,R33-R44	100K (19)
R10	1.5K (1)
R11	1M (1)
R12,R17,R21,R24,R25	10K (5)
R13	1.8K (1)
R15,R19	15K (2)
R16,R20	4.7M (2)
R18,R22,R45,R46	1K (4)
R26-R29	110K (4)

Potentiometers

R1,R2	100K Linear (2)
R14	50K Log (1)
R23	1M Linear (1)
R30	20K Linear (1)
R31	50K Linear (1)
R32	1k Trim (1)

Switches

SW1	C&K 7211 DPDT ON-ON-ON (1)
SW2	SPDT ON-NONE-ON (1)
SW3	SPST ON-NONE-OFF (1)

Semiconductors

D1-D8	1N4148 (8)
Q1	2N3906 (1)
Q2	2N3904 (1)
Q3-Q6	MPF-102 (4)

Integrated Circuits

U1	TL074 (1)
U2-U6	TL072 (5)

Optocouplers

VT1,VT2	VTL5C3/2 (2)