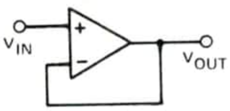
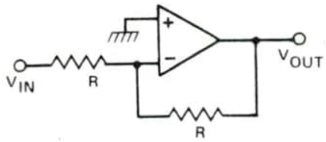
BUILDING BLOCKS

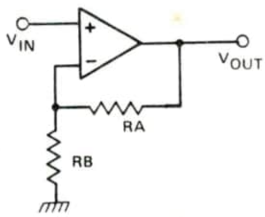
Basic Op-amp Building Blocks



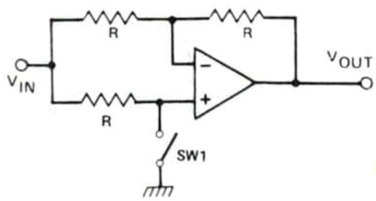
Voltage follower/buffer
Input must have a DC path to ground



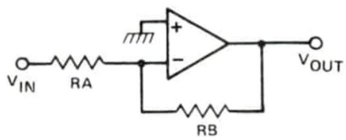
Inverter
Voltage gain = −1
input impedance = R



Non-inverting amplifier
Input must have a DC path to ground
Voltage gain = (RA + RB)/RP



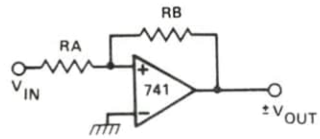
Inverter/non-inverter amplifier
Voltage gain = +1 with SW1 open
Voltage gain = −1 with SW1 closed



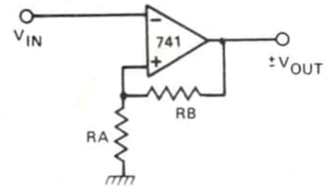
Inverting Amplifier
Voltage gain = −RB/RA
Input impedance = RA

The power supply and compensation are omitted from these diagrams. If internally compensated devices are used no additional compensation is necessary, i.e: 741, TL071, TL072, TL074, etc. If additional compensation is required consult the data sheets on the particular device used.

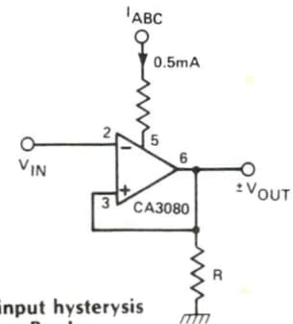
Schmitt Triggers



Non-inverting; input hysterysis levels = ±(RA/RB)) x V_{OUT}



Inverting; input hysterysis levels = ±(RA/(RA + RB)) x V_{OUT}
Note that V_{OUT} depends on the supply voltage and the individual op-amp

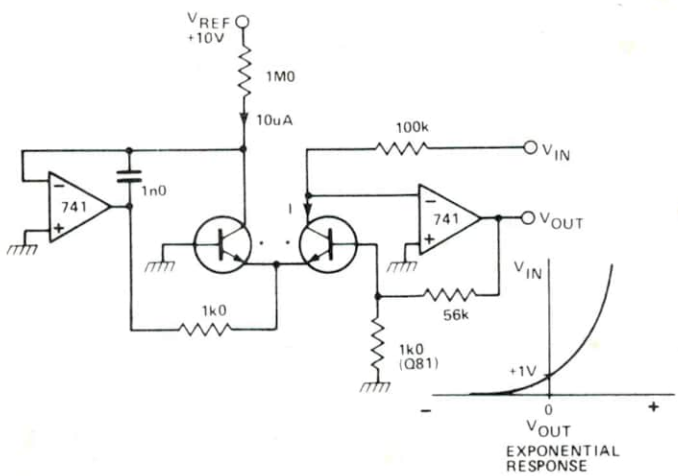


Transconductance type; input hysterysis levels = $\pm V_{OUT}$; V_{OUT} = R x I_{ABC}
R can be replaced by two 1N4148 diodes back-to-back

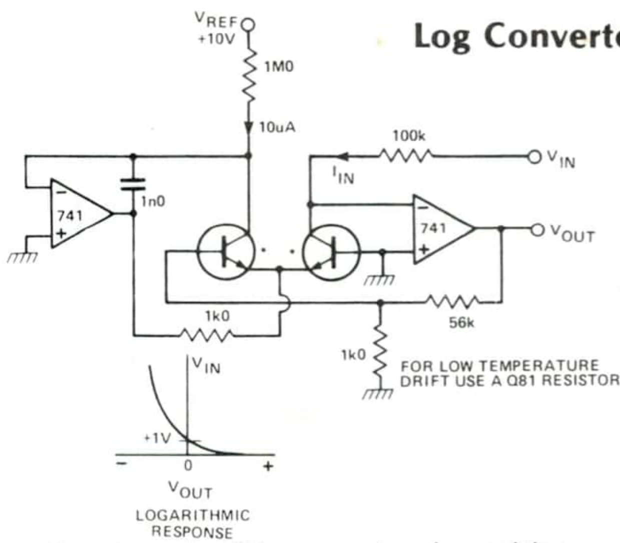
When trying to convert a slowly changing voltage into a step function with a well-defined leading edge a good Schmitt trigger is invaluable. This is a simple but effective trigger capable of good results in the audio passband. Once again, for higher frequency use substitute a faster op-amp for the 741. The Schmitt trigger works by using positive feedback to establish a 'deadband', a range of input voltages within which the output state will not change. The input voltage must exceed the higher limit in order to force the output high. Similarly, the input voltage must be taken below the lower limit to force the output low. The extent of this deadband is given in the equations.

Antilog (Exponential) Converter

V_{OUT} = I x 100k
The current I doubles for every 1 V increase of V_{IN}
When V_{IN} = 0 V, I = 10 uA



Log Converter



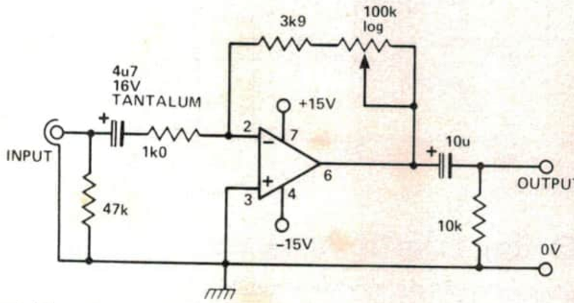
V_{OUT} changes by 1 V for every octave change of the I_{IN} current

*The matched transistors can be two BC212L in thermal contact, or a dual transistor (LM394), or pat of an array (CA3046)

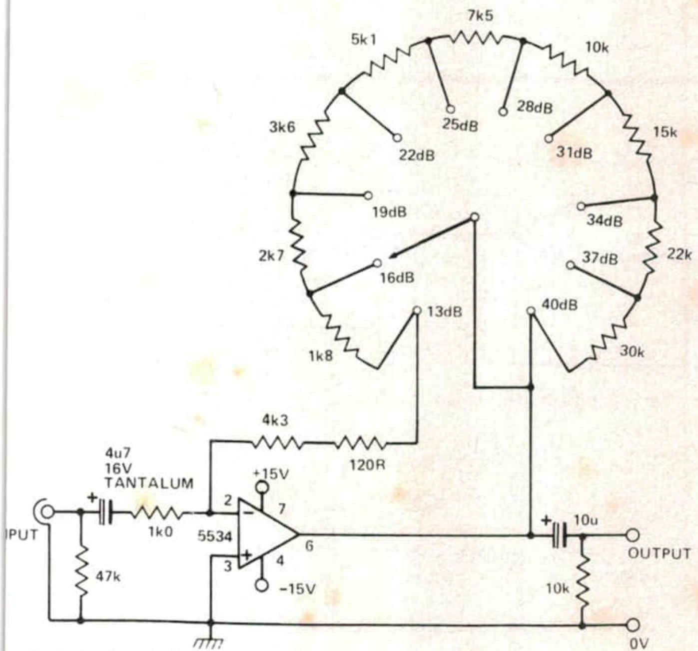
AUDIO

Low Impedance Source Preamp

Very low input noise
Input noise = 4 nV$\sqrt{Hz}$
Equivalent input noise voltage = 0.56 uV$_{RMS}$ (20 kHz bandwidth)
Input impedance = 1k0 (suitable for microphone)



Variable gain; x 3.9 to x 100 (12 dB to 40 dB)

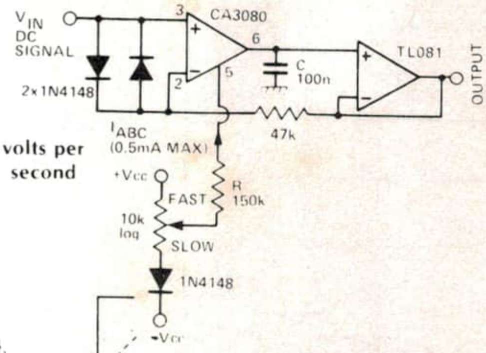


Switched gain; 3 dB steps

The NE5534N is a very low-noise op-amp specifically intended for audio applications. The device boasts one of the lowest noise figures of all op-amps combined with good slew rate and large signal bandwidth figures.

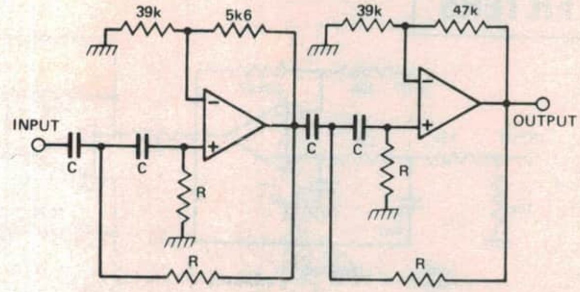
The lowest-noise devices have the designation NE5534AN. Suitable supply decoupling is essential if best results are to be obtained.

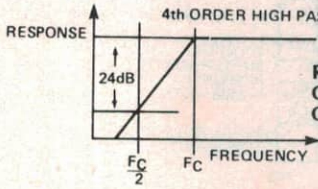
Slew Limiter



Slewrate = $\frac{I_{ABC}}{C}$ volts per second

Rumble Filter





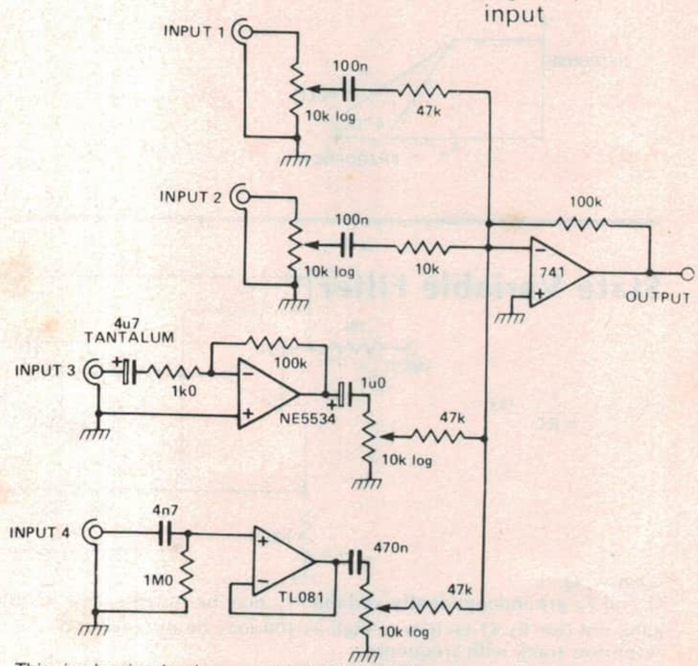
Roll-off slope = 24dB/octave
Overall voltage gain = x 2.6 (8.3 dB)
Op-amps are 741's or RC4558

F_C	C	R
25 Hz	100n	62k
50 Hz	100n	30k
100 Hz	100n	15k
200 Hz	100n	7k5

(5% tolerance)

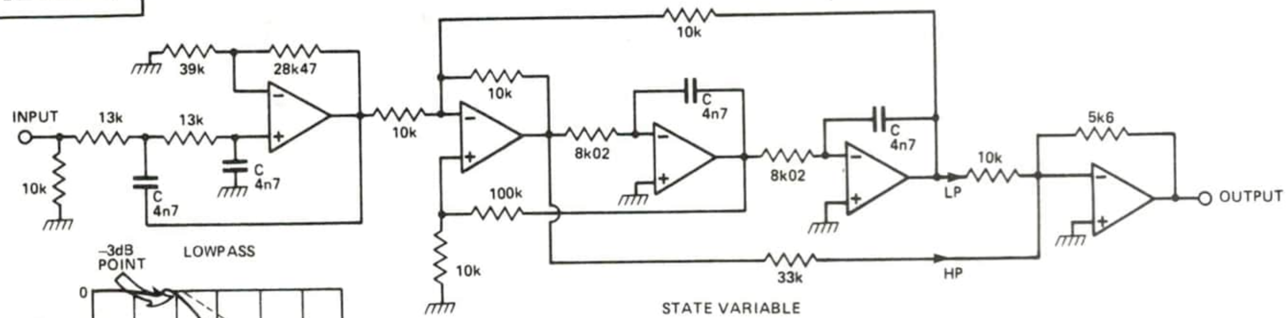
Simple Mixer

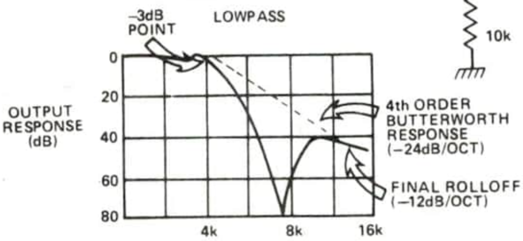
INPUT	MAX GAIN	INPUT IMPEDANCE	SOURCE
1	+6 dB	10k	line level
2	+20 dB	5 to 10k	line level
3	+46 dB	1k0	low impedance microphone
4	+6 dB	1M0	high impedance input



This simple mixer has been provided with four different types of input circuit. Any combination of these could however be used. Once again, the 741 limits the high frequency response and slew rate capabilities. To improve performance substitute the 741 for a faster device such as an NE5534N or TL071, etc.

FILTERS





4th Order Elliptic lowpass

Cutoff frequency is 4 kHz. To change cutoff frequency, scale capacitor C (four off)

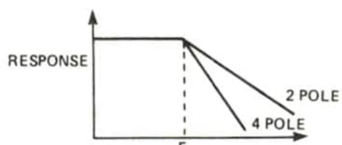
Lowpass Active Filters

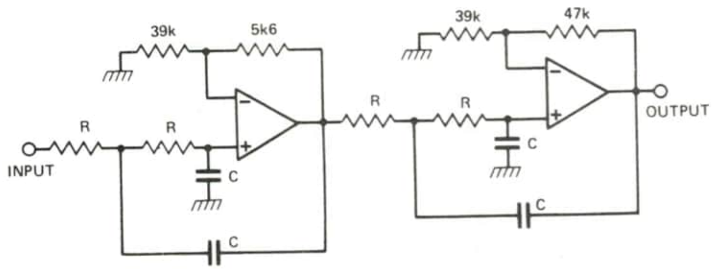
Inputs must have a DC path to ground

$$F_c = \frac{1}{2\pi RC}$$

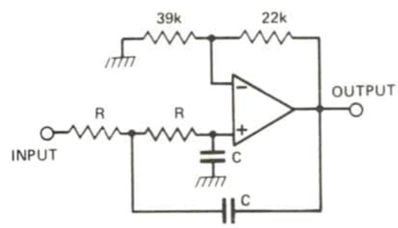
2 pole roll-off = −12 dB/octave
4 pole roll-off = −24 dB/octave

R	C	F_C
107k	15n	100 Hz
10k7	15n	1 kHz
10k7	1n5	10 kHz





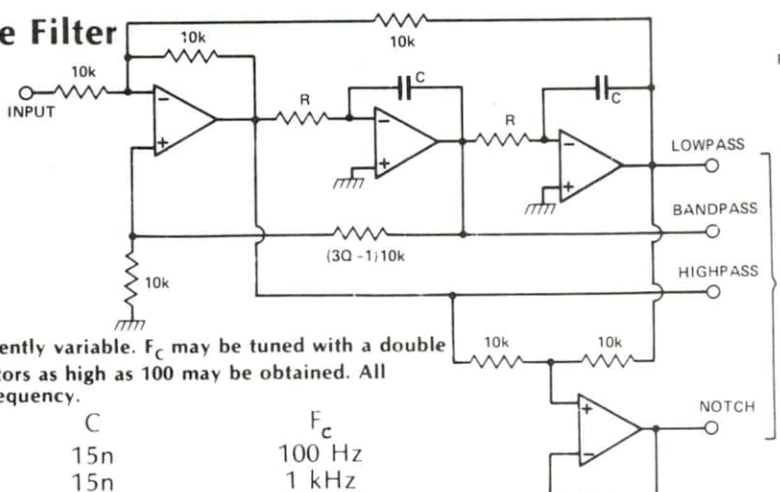
4 pole Butterworth

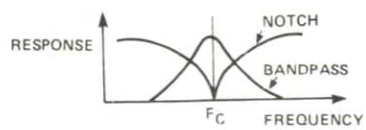


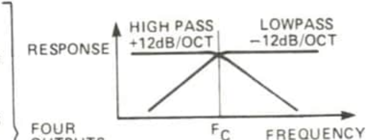
2 pole Butterworth

State Variable Filter

$$F_c = \frac{1}{2\pi RC} \text{ Hz}$$





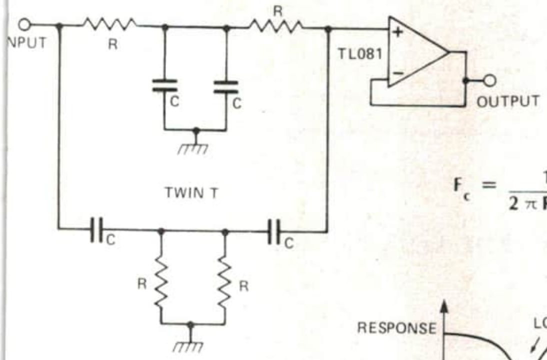


Gain = Q
Q and F_C are independently variable. F_C may be tuned with a double gang pot (for R). Q factors as high as 100 may be obtained. All responses track with frequency.

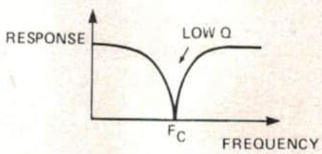
R	C	F_c
107k	15n	100 Hz
10k7	15n	1 kHz
10k7	1n5	10kHz

Active Notch Filter

The two R's in parallel represent R/2
The two C's in parallel represent 2C
For 50 Hz, R = 680k, C = 4n7 (a hum remover)

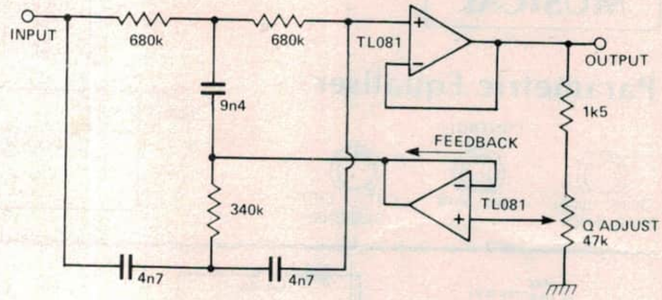


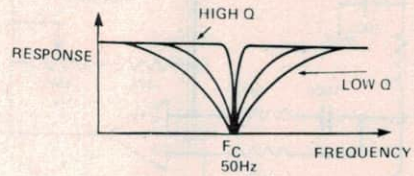
$$F_c = \frac{1}{2\pi RC}$$



A basic Twin-Tee notch. Rejection depends on component matching, so for best results use high-stability components.

50 Hz Notch, Variable Q

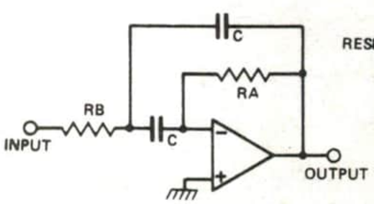


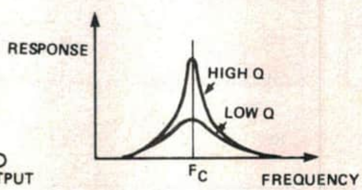


This is a modified version of the basic Twin-Tee notch filter. The Q can be adjusted by controlling the amount of feedback with the 47k potentiometer. The rejection offered by the circuit is determined by the matching of the passive components, but even with ordinary components a figure of 30 dB to 40 dB should be obtained.

Bandpass Active Filter

$F_C = 1/2\pi C\sqrt{RA + RB}$
$Q = 1/2\sqrt{RA/RB}$
Gain $= 2Q^2$





F_C = 1kHz, C = 15n

RA	RB	Q	GAIN
10k6	10k6	0.5	x 0.5
21k2	5k3	1.0	x 2.0
42k4	2k65	2.0	x 8.0
84k8	1k32	4.0	x 32.0

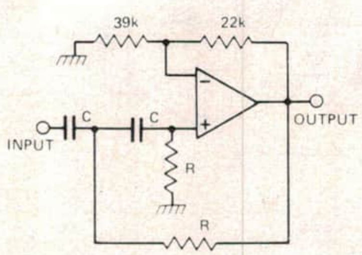
This is probably the most common bandpass filter. The circuit is really only useful for the relatively low Q shown. For a higher Q one of the more complex bandpass circuits should be used, such as the state variable filter.

Highpass Active Filters

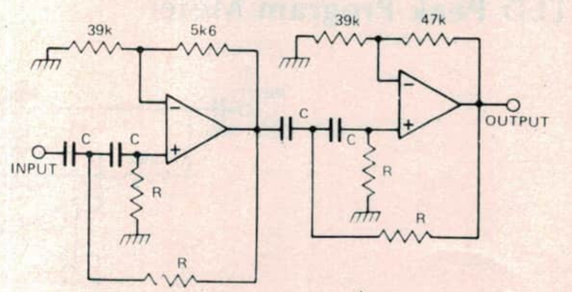
$$F_c = \frac{1}{2\pi RC}\ \text{Hz}$$

2 pole roll-off = +12 dB/octave
4 pole roll-off = +24 dB/octave

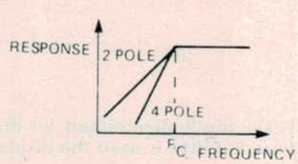
R	C	F_c
107k	15n	100 Hz
10k7	15n	1 kHz
10k7	1n5	10 kHz



2 pole Butterworth



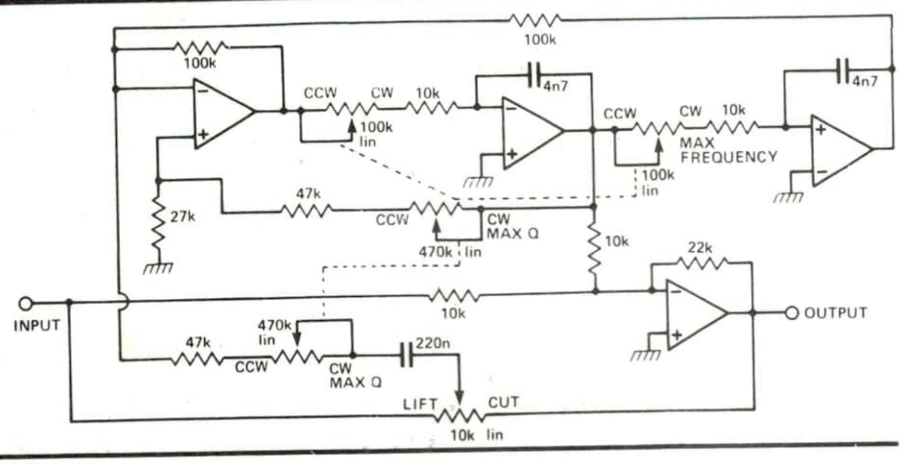
4 pole Butterworth



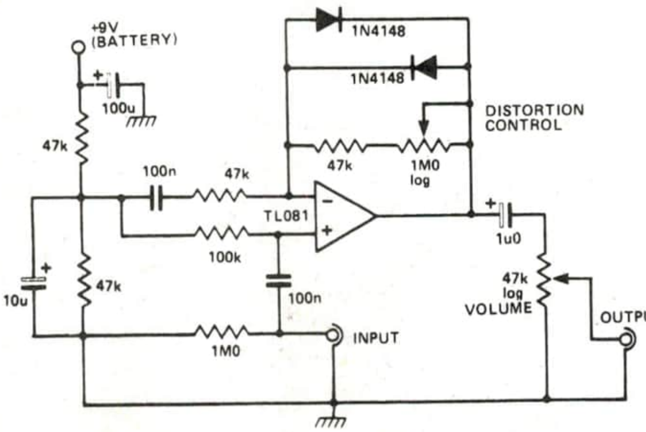
OP-AMP COOKBOOK

MUSICAL

Parametric Equaliser

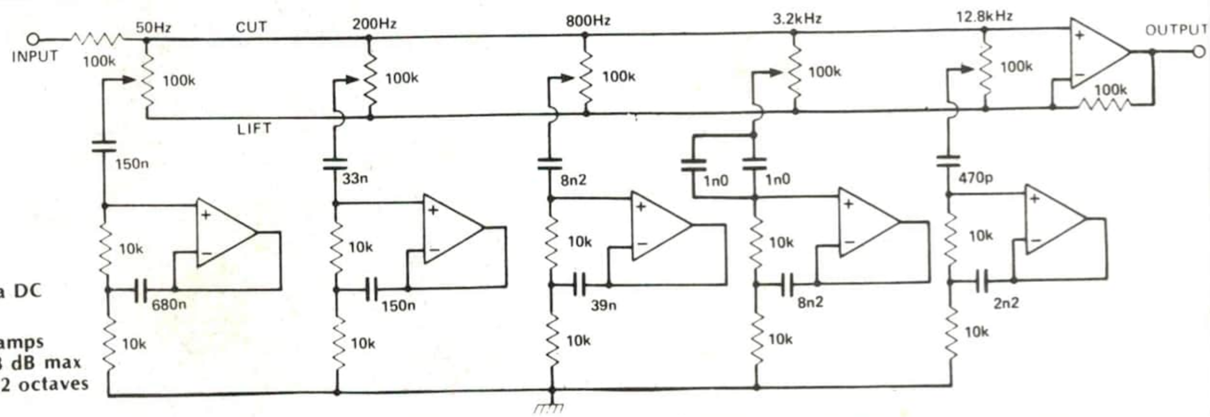


Fuzz Unit For Guitar



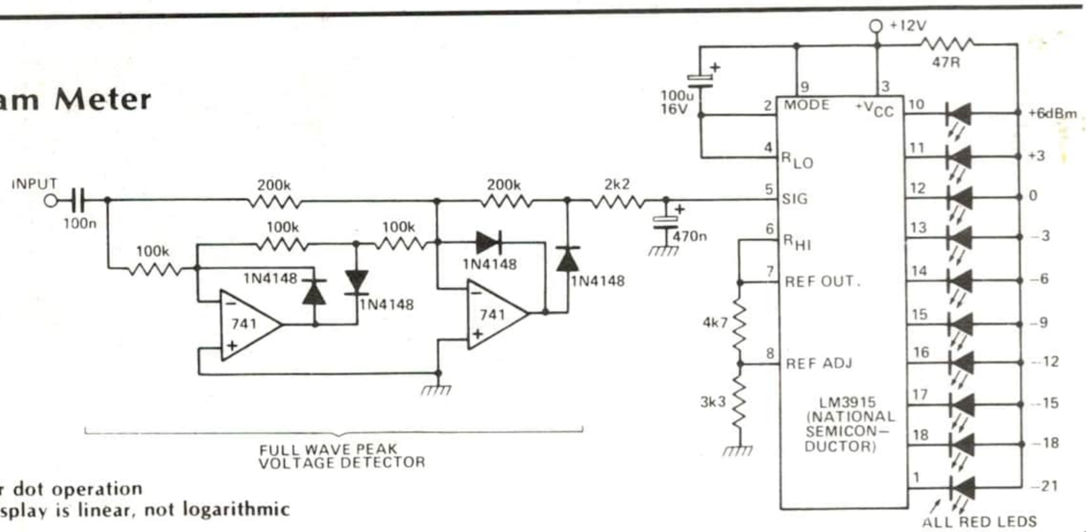
The battery can be switched on via the jack socket (a stereo jack can be used).

Graphic Equaliser



Input must have a DC path to ground
Use 741's for op-amps
Cut and lift = 13 dB max
Filter spacing = 2 octaves

LED Peak Program Meter



Leave pin 9 open circuit for dot operation
If an LM3914 is used the display is linear, not logarithmic