



VOLTAGE CONTROLLED FILTER CIRCUIT

DESCRIPTION

The SSM 2040* is a four section filter whose cutoff frequency can be exponentially voltage controlled over a 10,000 to 1 range. This flexible building-block can be used in virtually any active filter design including lowpass, highpass, bandpass and notch. Rolloff characteristics can be selected to be Butterworth, Bessel, Chevyshev, Cauer or any other filter type.

Applications include tracking filters, organs, music synthesizers, music phase shifters and sound effects generation.

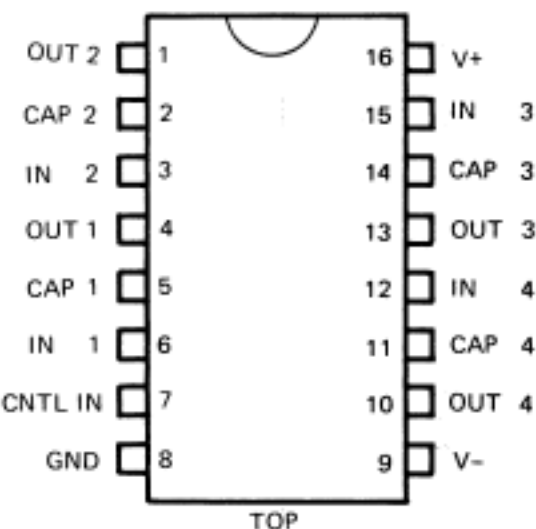
FEATURES

- +/- 15V Supplies
- Exponential Frequency Control Response
- 4 Filter Sections in One Package
- Low Noise
- Low Distortion
- Guaranteed Control Rejection Characteristics
- 10,000:1 Sweep Range

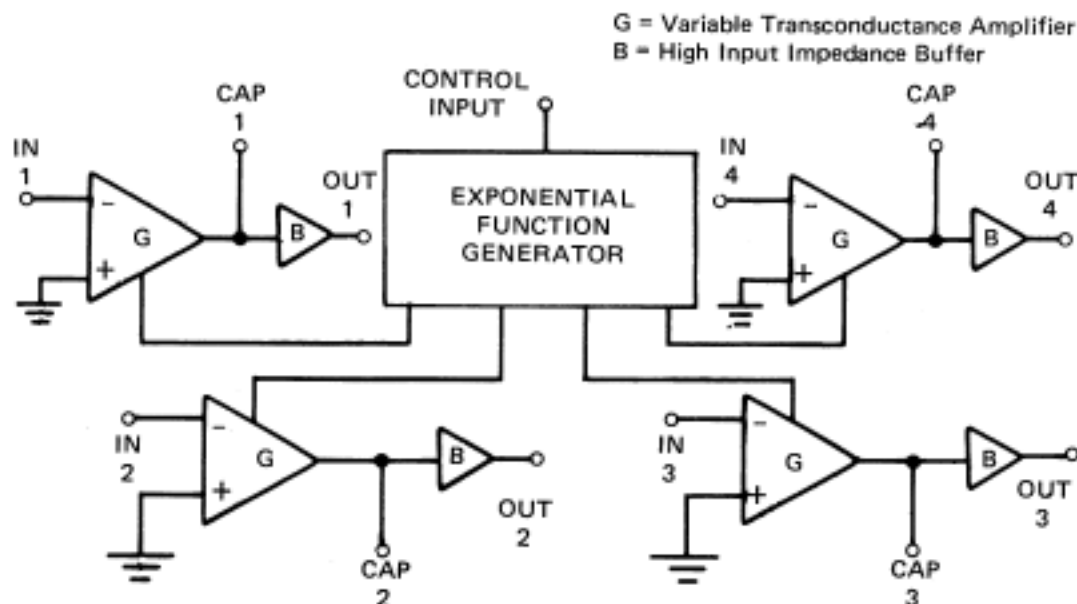
APPLICATIONS

- Voltage Controlled Filters:
 - Lowpass
 - Bandpass
 - Highpass
 - Allpass
 - Notch
- Parametric Equalizers
- Music Synthesizers
- Music Phase Shifters
- Tracking Filters
- Low Distortion Sine VCO's

*Covered by U.S. Patent Number 3,969,882.



Pin Diagram



Block Diagram

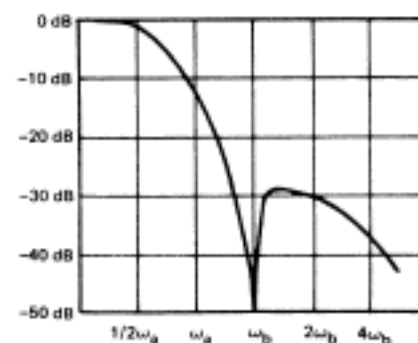
SPECIFICATIONS:

$V_S = +/-15V, T_A = 25^\circ C$

SPECIFICATION	CONDITIONS	MIN	TYP	MAX	UNIT
Functional Range		10,000:1			
Input Offset, each cell			2	5	mV
Δ Input Offset, 4 cells in series	$V_{cntl} = 0 \text{ mV}, -90 \text{ mV}$		0.6	3	mV
	$V_{cntl} = 0 \text{ mV}, +90 \text{ mV}$		0.6	3	mV
Transconductance	$V_{cntl} = 0$	1/10K	1/5K	1/3K	mhos
Equiv. Input Noise, each cell	20 Hz-20 KHz, $V_{cntl} = -90 \text{ mV}$		0.5		$\mu\text{V RMS}$
Distortion (THD), $E_{in} = 30 \text{ mVpp}$	$F = 1 \text{ KHz}, V_{cntl} = -90 \text{ mV}$		0.1		%
Tempco of Transconductance	$V_{cntl} = 0$		+0.5		$\%/^\circ\text{C}$
Control Sensitivity			-18		mV/oct
Tempco of Control Sensitivity			0.33		$\%/^\circ\text{C}$
Power Supply Current	$V_{cntl} = 0$	2	4	7	mA
Buffer Slew Rate			2		V/usec
Buffer Output Sink Current		425	560	750	μA

ABSOLUTE MAXIMUM RATINGS:

Any Pin to V-	36V
Current at any pin	20mA
Operating Temperature	0-70° C
Storage Temperature	-55-125° C
Power Dissipation	625 mW



CAUER FILTER RESPONSE - $\omega_b = 2\omega_a$

APPLICATIONS FIGURES:

Filter Type	Figure	Gain (K)	ω_o	$d=1/Q$	XFER char. ($S=j\omega/\omega_o$)
Lowpass - Real Pole	1	$-R2/R1$	$200G/R2C$	2	$-K/(S+1)$
Highpass - Real Pole	2	1	$200G/RC$	2	$S/(S+1)$
Allpass	3	1	$200G/RC$	2	$(S-1)/(S+1)$
Sallen & Key Lowpass	4	$R2/R1$	$200G/R2C$	$2-(R4/R3)$	$K/(S^2+dS+1)$
Sallen & Key Highpass	5	1	$200G/R1C$	$2-(R3/R2)$	$S^2/(S^2+dS+1)$
Sallen & Key Bandpass	6	$-R2/R1$	$200G/R2C$	$2-(R2/R3)$	$-KS/(S^2+dS+1)$
State Variable LP	7	$-R2/R1$	$200G/R3C$	*	$-K/(S^2+dS+1)$
State Variable BP	7	$R2/R1$	$200G/R3C$	*	$KS/(S^2+dS+1)$
State Variable HP	7	$-R2/R1$	$200G/R3C$	*	$-KS^2/(S^2+dS+1)$
Cauer (Elliptical)	8	$R2/R1$	$\omega_a = 200G/C1R2$ $\omega_b = 200G/C2R2$		$K(Sb^2+1)/((Sa+1)^2 (Sb+1)^2)$

*= $R5 (2R1+R2)/(R1(R4+R5))$; R4 parallel R5=R1 parallel R2/2

G = Variable Transconductance Amplifier

B = High Input Impedance Buffer.

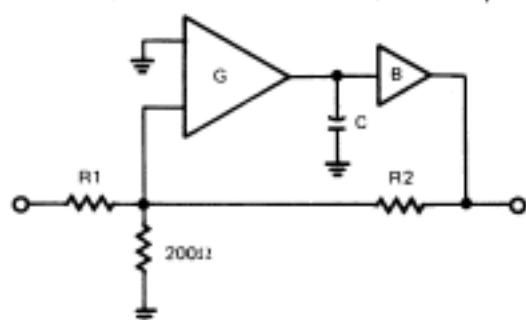


Figure 1—Lowpass Real Pole

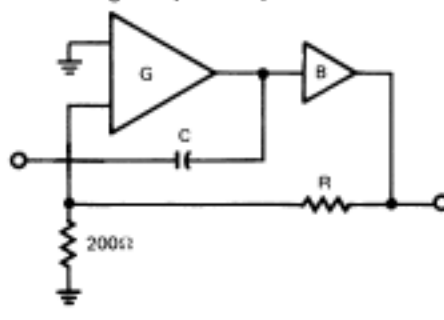


Figure 2—Highpass Real Pole

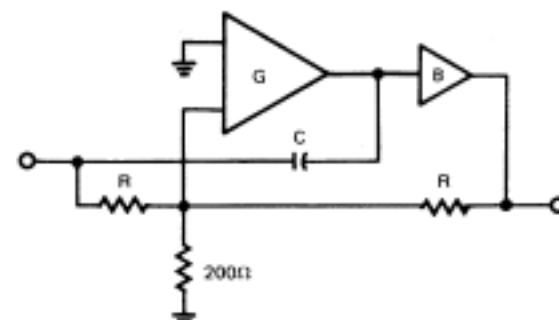


Figure 3—Allpass (Phase-shift)

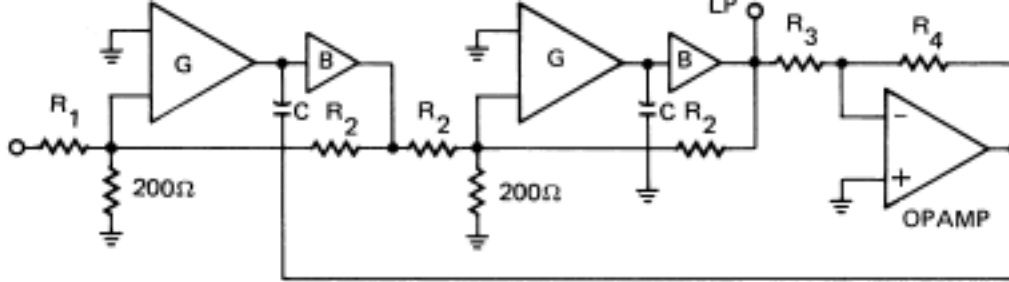


Figure 4—Sallen & Key Lowpass

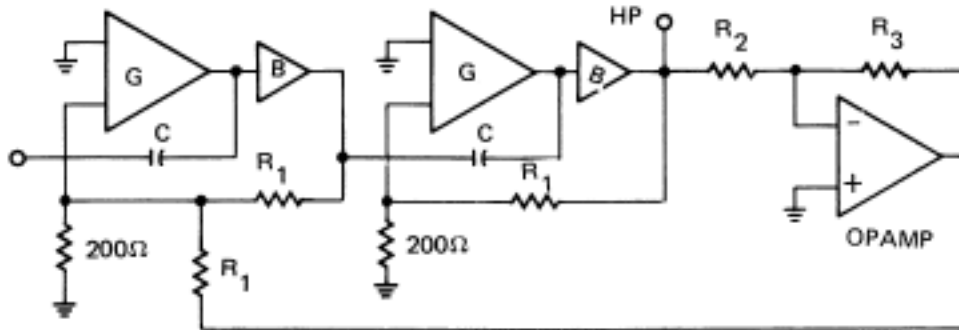


Figure 5—Sallen & Key Highpass

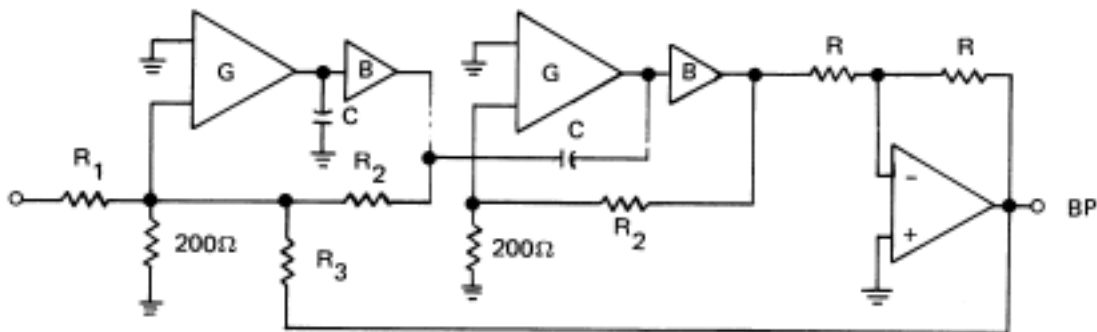


Figure 6—Sallen & Key Bandpass

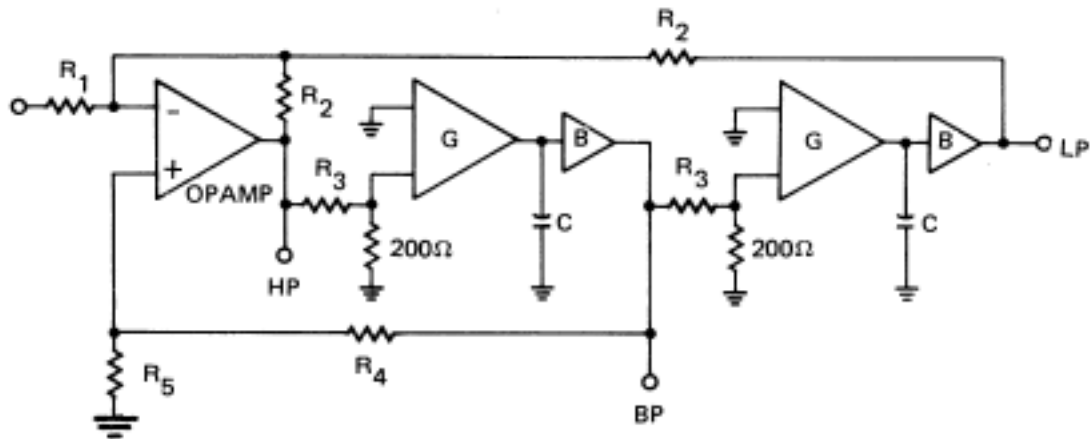


Figure 7—State Variable Filter

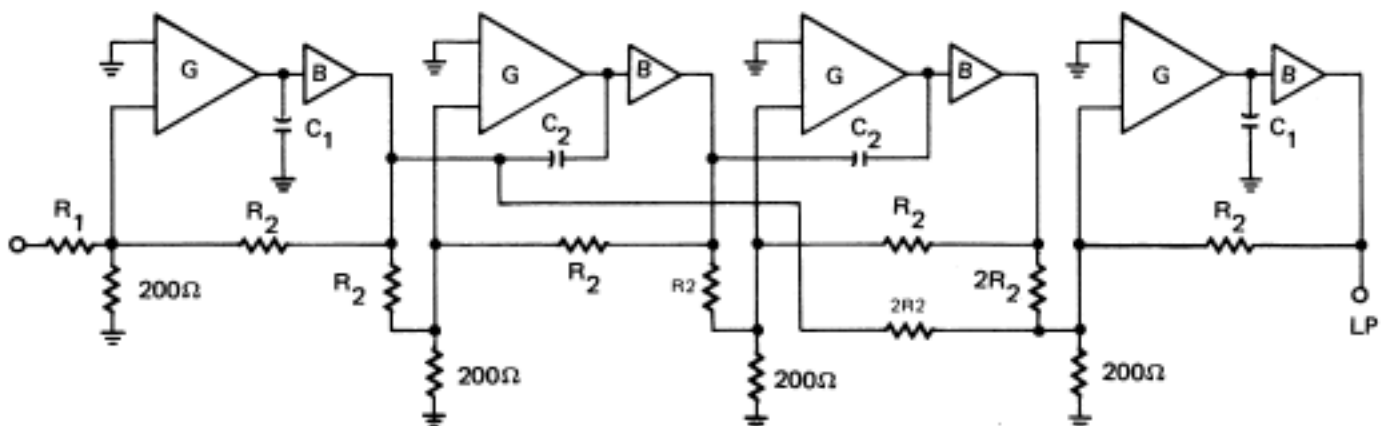


Figure 8—Cauer (Elliptical) Filter

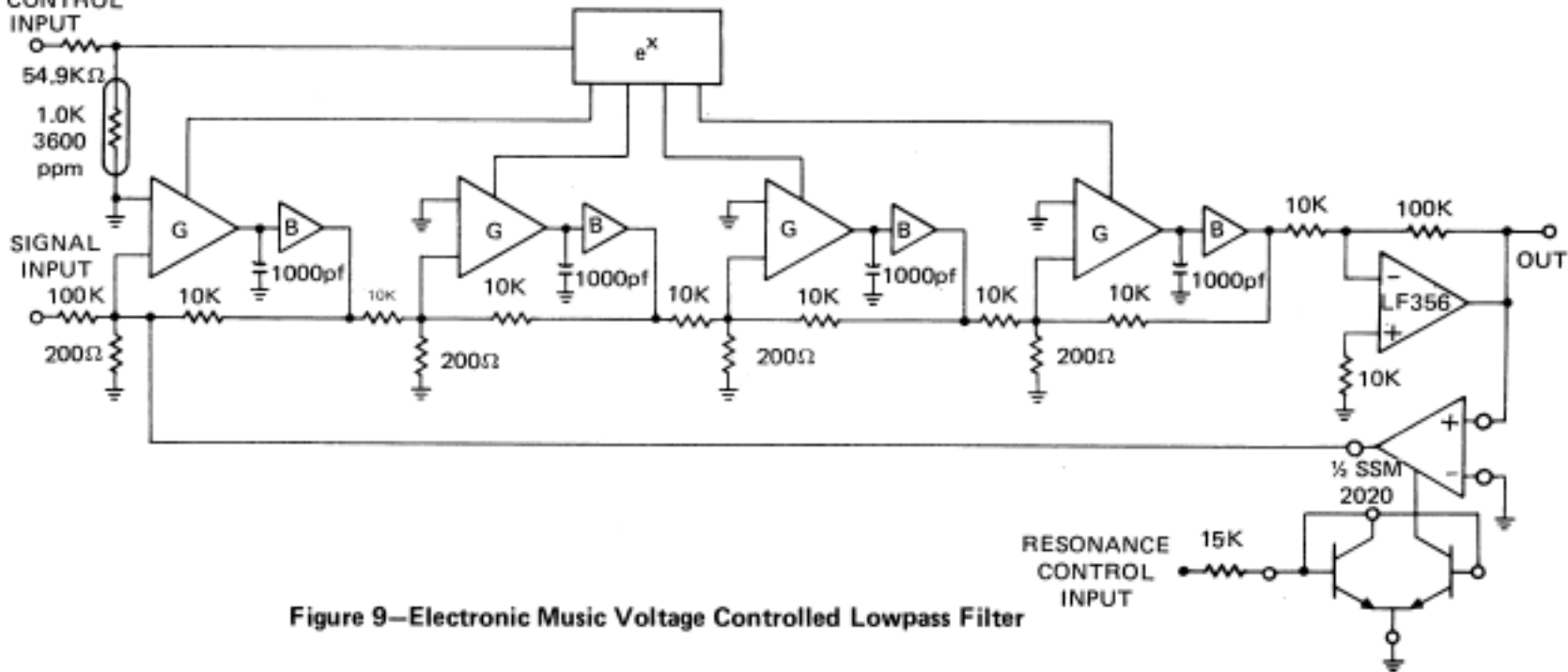
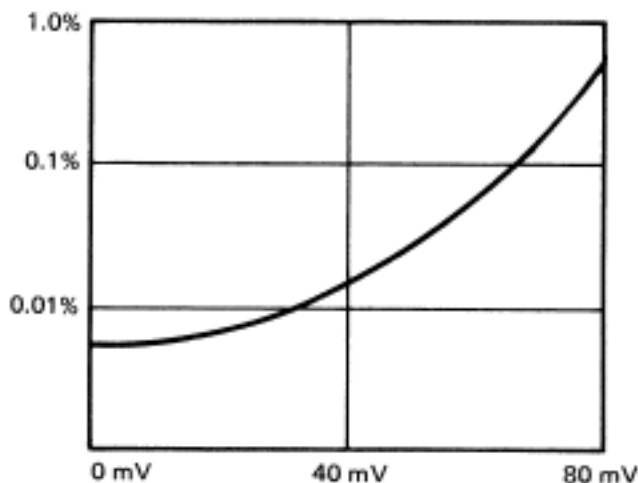
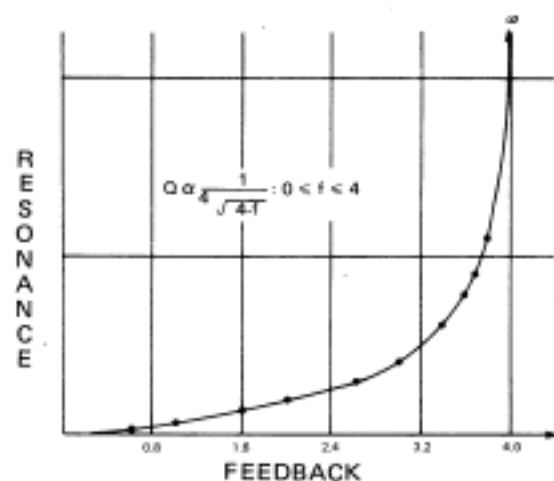


Figure 9—Electronic Music Voltage Controlled Lowpass Filter

Figure 9 is a voltage controlled lowpass filter with voltage controlled resonance for electronic music applications. The frequency control input sensitivity is 1 volt/octave, temperature compensated. At high resonance settings the filter will oscillate with a pure sine wave. The output signal level is 10V p/p max.



THD vs. INPUT SIGNAL LEVEL



Resonance as a Function of Feedback for Figure 9

DESIGN HINTS:

1. The output pins (OUT1-OUT4) are only capable of swinging +/- 1V, and sinking 500 μ A DC. Hence a 10K feedback resistor & load will give good performance.
2. Control input sensitivity tempco is best cancelled by a +3300 ppm resistor (Tel Labs Q81 or equiv.) as shown in Figure 9.
3. C values should be kept above 1000 pF to insure stability at all control settings.
4. The 200 ohm attenuating resistor is chosen for optimal control rejection. Other values can be used with some degradation of this parameter.
5. The outputs are not short-circuit protected. Care should be taken to avoid shorting any OUT, CAP or IN pin to either supply.

