Solid State Micro Technology for Music

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.
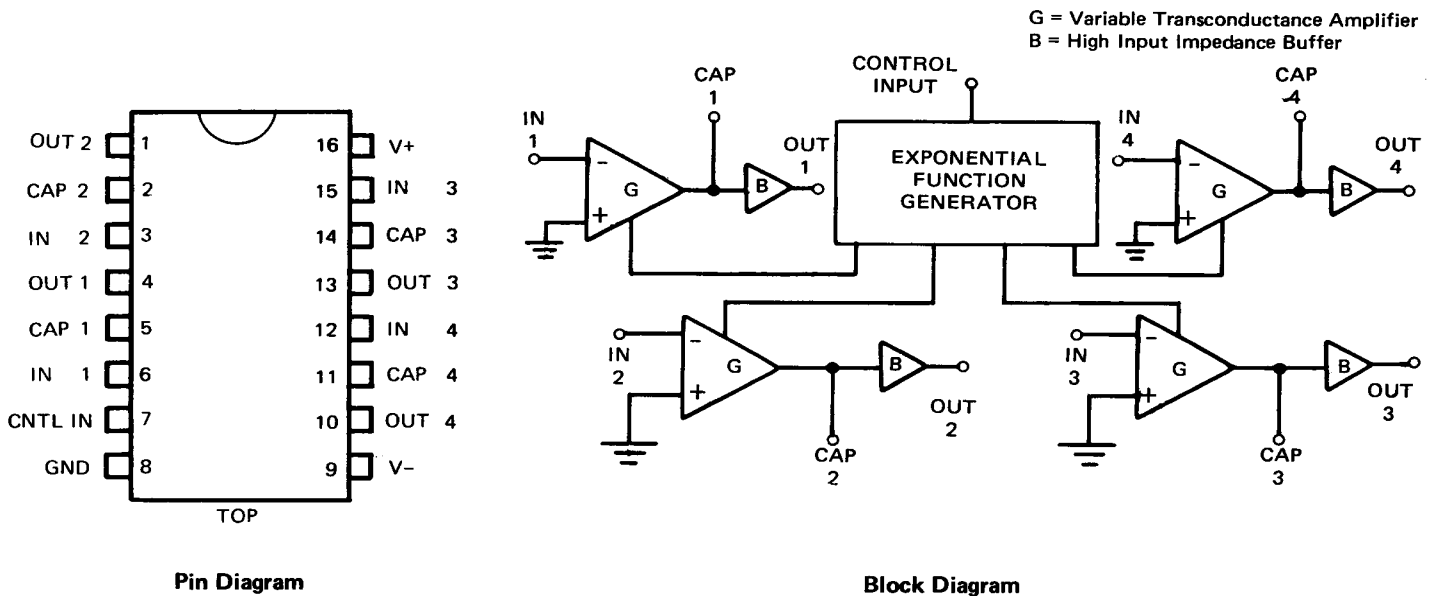
FEATURES

- +/- 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

*Covered by U.S. Patent Number 3,969,682.

APPLICATIONS

- Voltage Controlled Filters:
  Lowpass   Biquad
  Bandpass   State Variable
  Highpass   Sallen & Key
  Allpass   Cauer
  Notch
- Parametric Equalizers
- Music Synthesizers
- Music Phase Shifters
- Tracking Filters
- Low Distortion Sine VCO's

G = Variable Transconductance Amplifier
B = High Input Impedance Buffer

Pin Diagram

Block Diagram

SPECIFICATIONS:

$V_S = +/-15V, T_A = 25°C$

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	Vcntl= 0 mV, -90 mV		0.6	3	mV
	Vcntl= 0 mV, +90 mV		0.6	3	mV
Transconductance	Vcntl= 0	1/10K	1/5K	1/3K	mhos
Equiv. Input Noise, each cell	20 Hz-20 KHz, Vcntl=-90 mV		0.5		uV RMS
Distortion (THD), Ein=30 mVpp	F=1 KHz, Vcntl=-90 mV		0.1		%
Tempco of Transconductance	Vcntl=0		+0.5		%/°C
Control Sensitivity			-18		mV/oct
Tempco of Control Sensitivity			0.33		%/°C
Power Supply Current	Vcntl=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
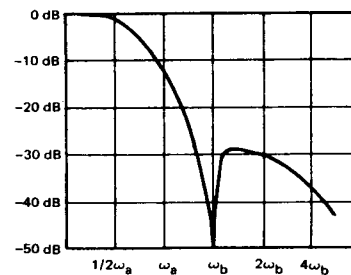
CAUER FILTER RESPONSE — $\omega_b = 2\omega_a$

APPLICATIONS FIGURES:

Filter Type	Figure	Gain (K)	ω_o	d=1/Q	XFER char. (S=jω/ω_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	ω_a=200G/C1R2		
			ω_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

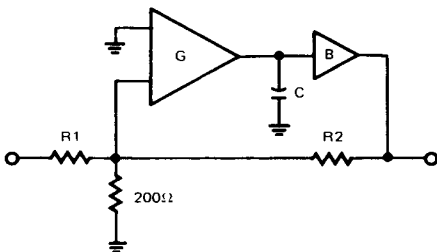G = Variable Transconductance Amplifier   B = High Input Impedance Buffer.
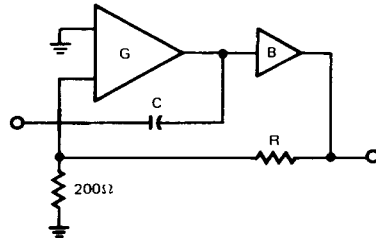

Figure 1—Lowpass Real Pole
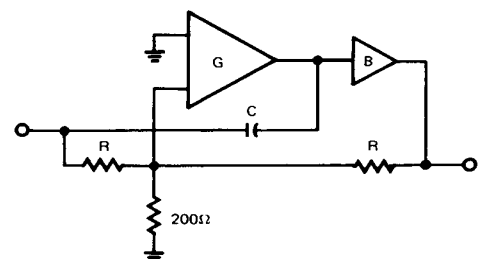

Figure 2—Highpass Real Pole
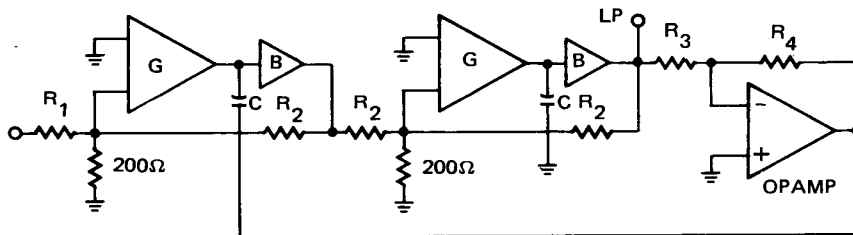

Figure 3—Allpass (Phase-shift)

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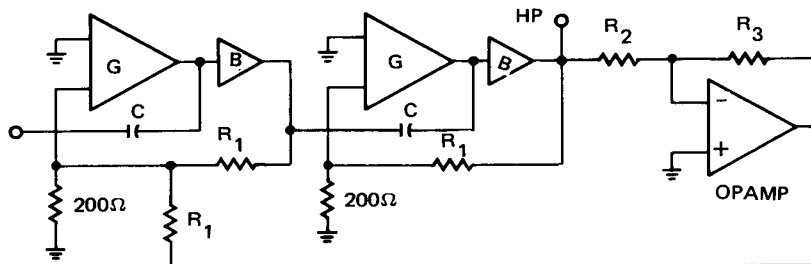**Figure 4—Sallen & Key Lowpass**

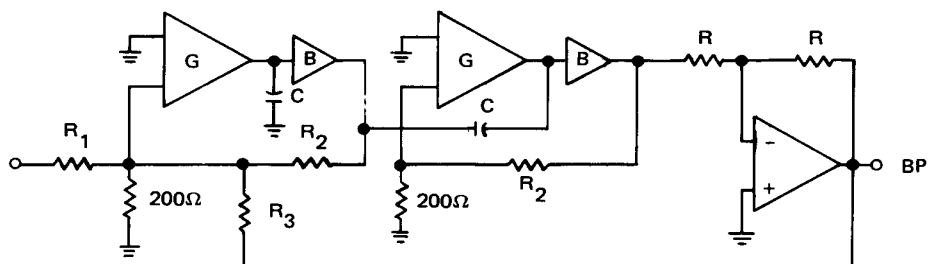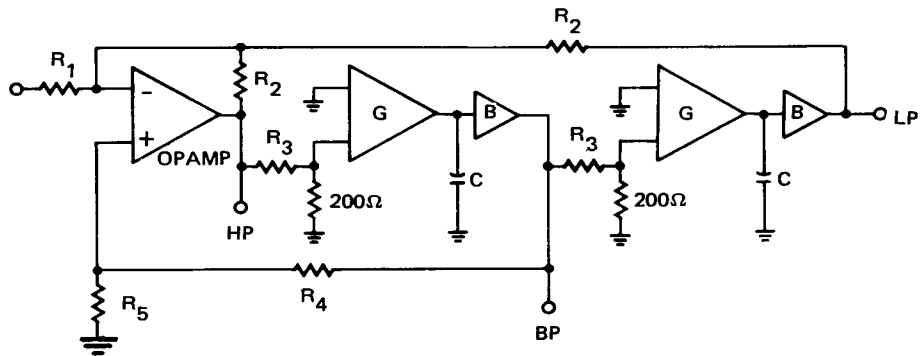**Figure 5—Sallen & Key Highpass**

Figure 6—Sallen & Key Bandpass

Figure 7—State Variable Filter
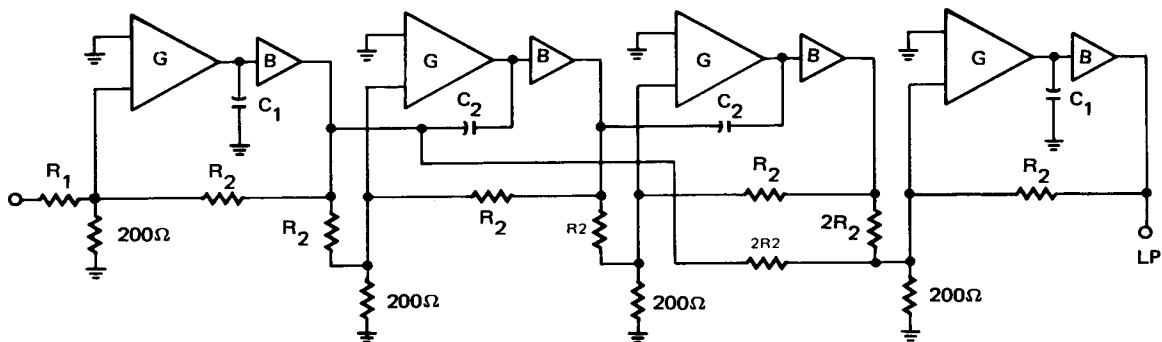
Figure 8—Cauer (Elliptical) Filter

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CONTROL INPUT

54.9KΩ

1.0K
3600 ppm

e^x

SIGNAL INPUT

100K

G B 1000pf

10K

200Ω

10K

G B 1000pf

10K

10K

200Ω

G B 1000pf

10K

10K

200Ω

G B 1000pf

10K

10K

200Ω

10K 100K

LF356

10K

OUT

½ SSM 2020
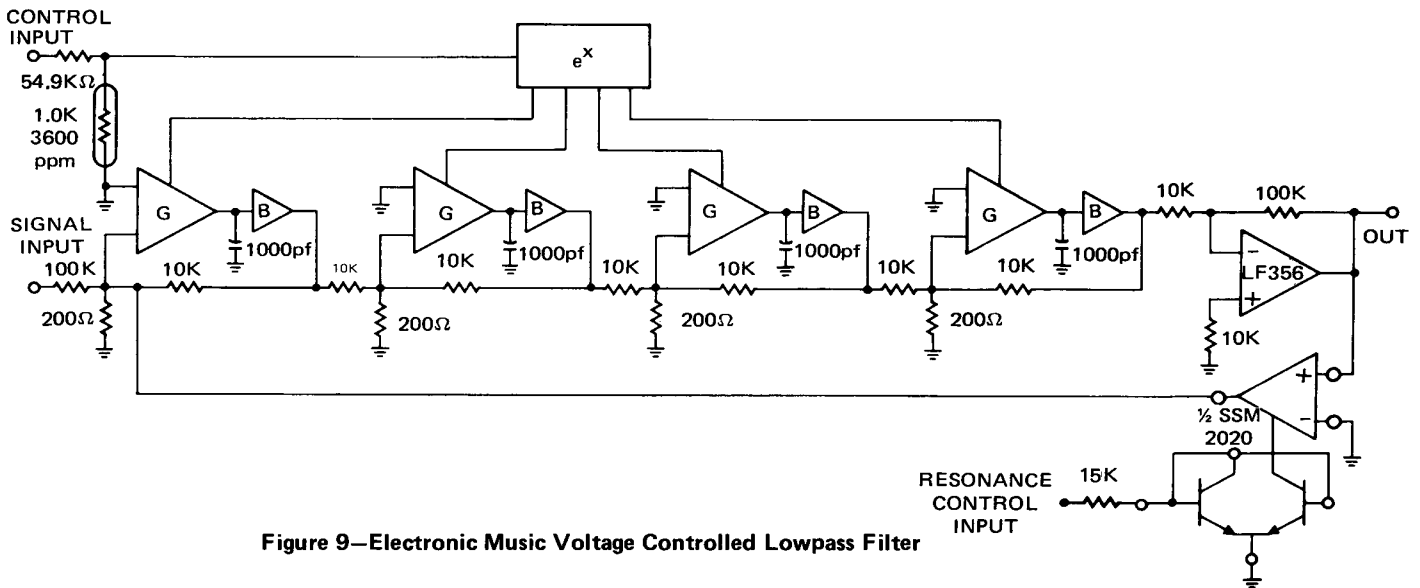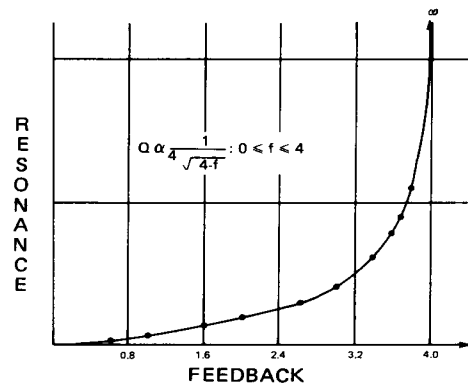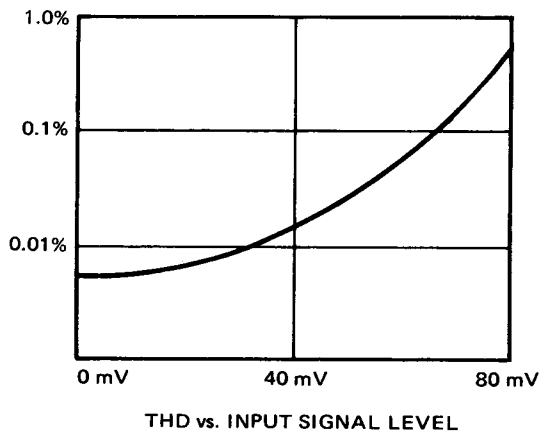
RESONANCE CONTROL INPUT

15K

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

$$Q \alpha \sqrt[4]{\frac{1}{\sqrt{4-f}}} : 0 \leqslant f \leqslant 4$$

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 μA 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.

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