Solid State Music **SSM 2040**

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.

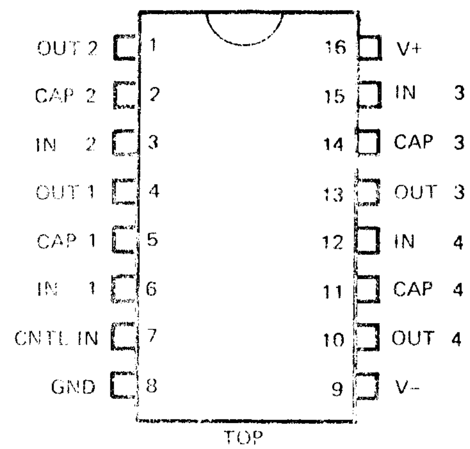
Applications include tracking filters, organs, music synthesizers, music phase shifters and sound effects generation.

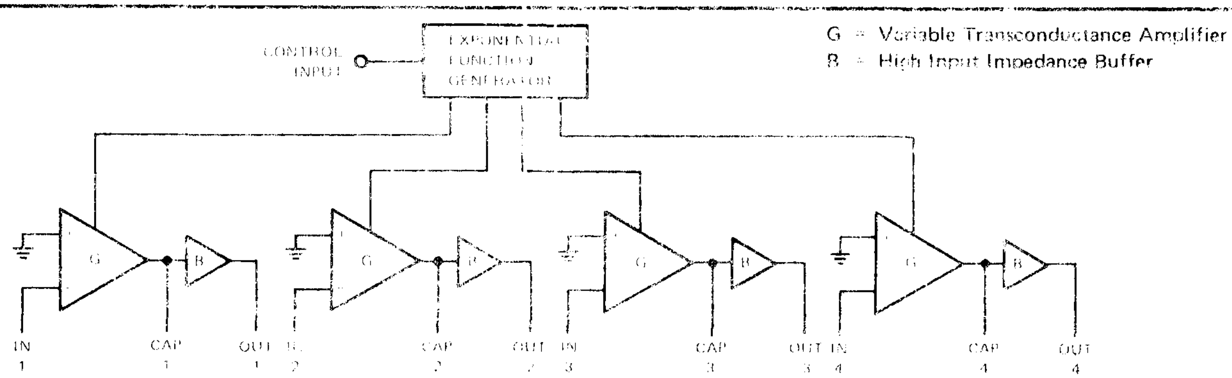
FEATURES

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

APPLICATIONS

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





Functional Block Diagram

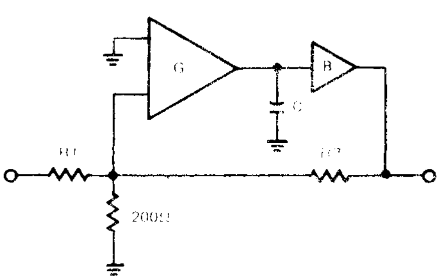


Figure 1. Lowpass Real Pole

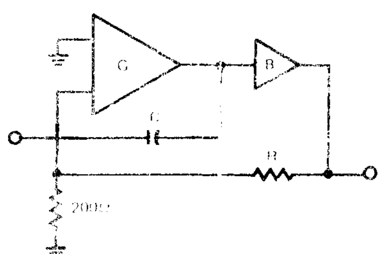


Figure 2. Highpass Real Pole

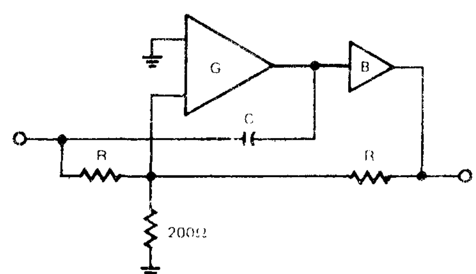


Figure 3. Allpass (Phase-shift)

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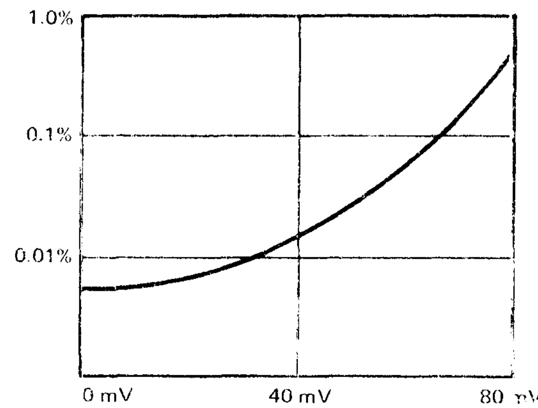
Data Sheet

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

DESIGN HINTS:

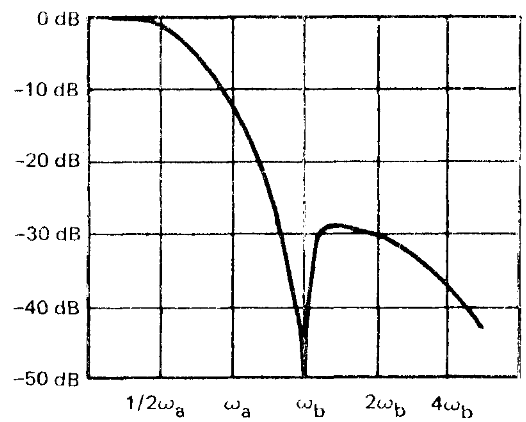
1. The output pins (OUT1-OUT4) are only capable of swinging +/- 1V, and sinking 500 μA DC. Hence a 10K feedback resistor & load will give good performance.
2. Control input sensitivity tempco is cancelled best by a +3300 ppm resistor (Tel Labs Q81 or equiv.) as shown in Figure 9.
3. C values should be 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.



THD vs. INPUT SIGNAL LEVEL

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	625mW



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

APPLICATIONS FIGURES:

Filter Type	Fig.	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	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

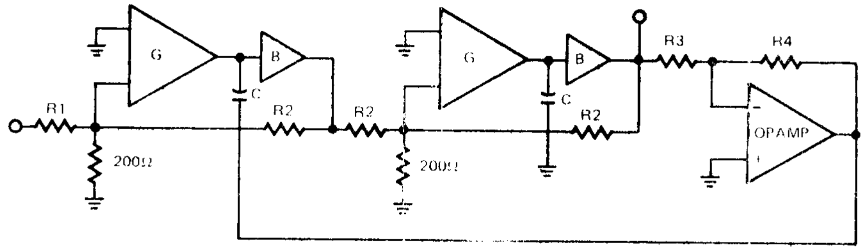


Figure 4. Sallen & Key Lowpass

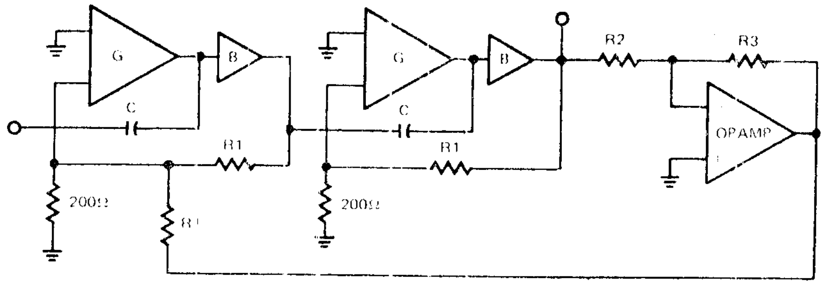


Figure 5. Sallen & Key Highpass

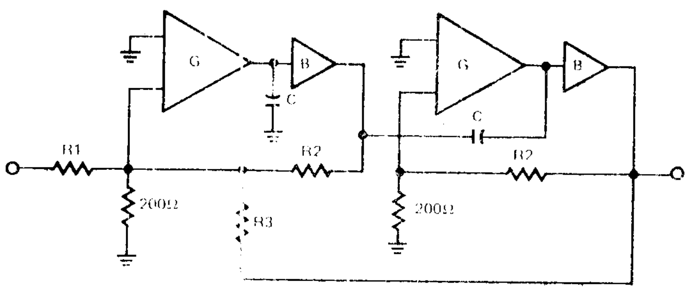


Figure 6. Sallen & Key Bandpass

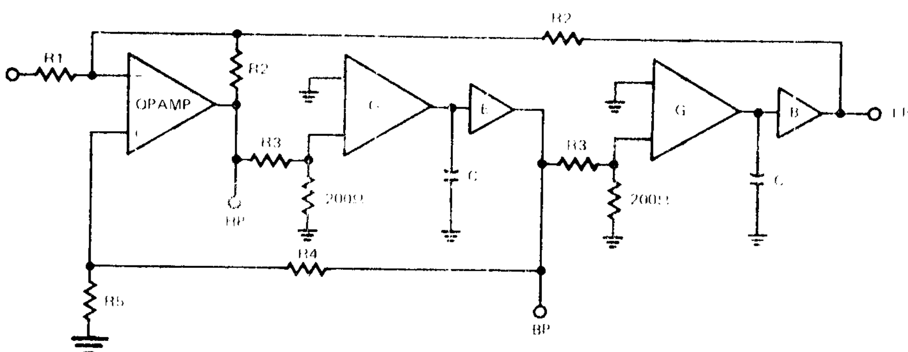


Figure 7. State Variable Filter

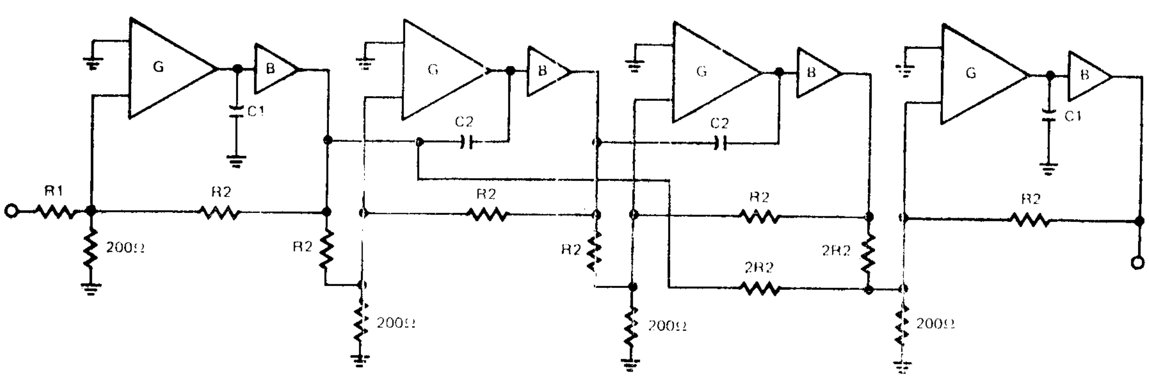


Figure 8. Cauer (Elliptical) Filter

Figure 9 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 signal level is 10V p/p max.

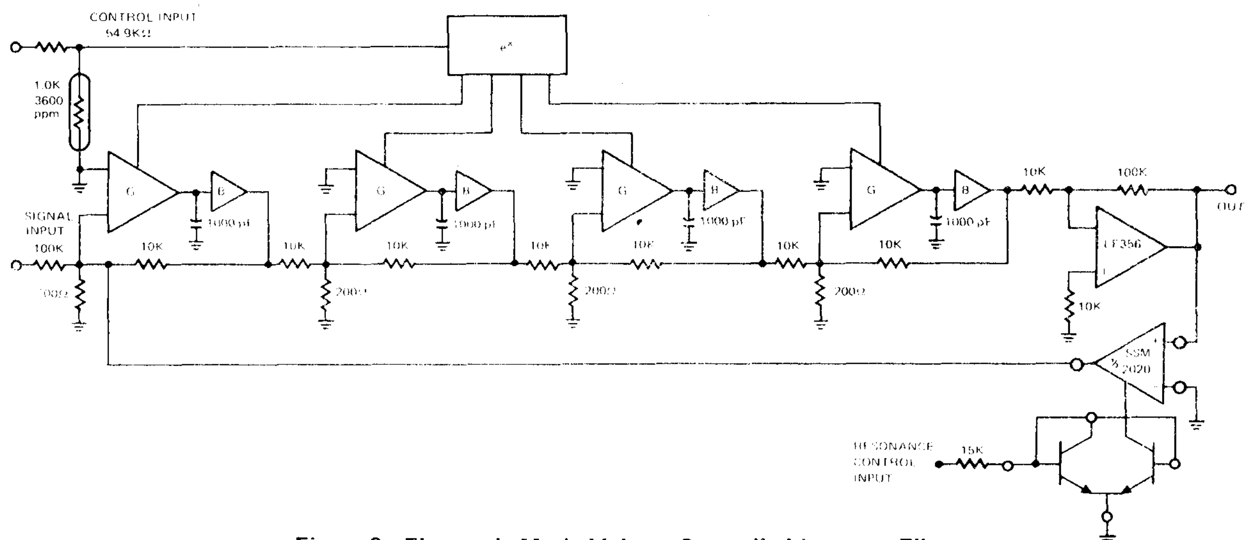


Figure 9. Electronic Music Voltage Controlled Lowpass Filter

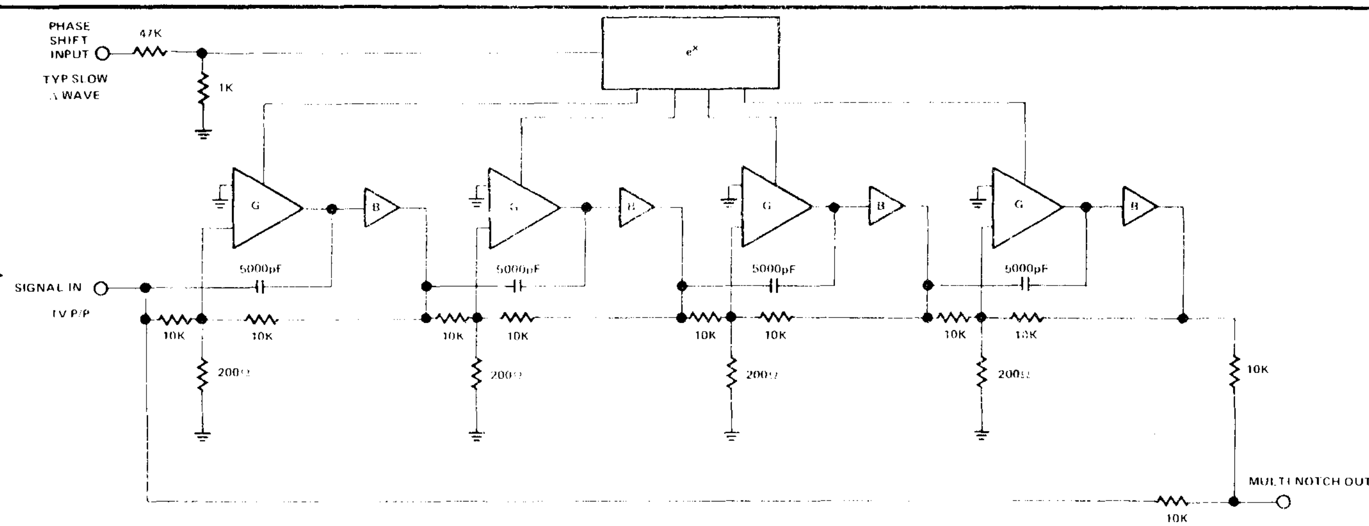


Figure 10. Electronic Music Multiple Notch ("Phase Shifter") Filter

Figure 10 is a filter producing two deep nothes in the transfer response, giving the electronic music 'phase-shifter' effect. Using additional cascaded stages gives greater effect.

VALUES FOR STANDARD FILTERS:

Order	Butterworth		Thompson-Butterworth		Bessel		Min		Chebyshev 1 dB		Chebyshev 2 dB		Chebyshev 3 dB	
	ω_o	d	ω_o	d	ω_o	d	ω_o	d	ω_o	d	ω_o	d	ω_o	d
2	1.000	1.414	1.128	1.564	1.274	1.732	0.929	1.216	0.863	1.045	0.852	0.895	0.841	0.767
3	1.000	1.000	1.206	1.203	1.454	1.447	0.954	0.704	0.911	0.496	0.913	0.402	0.916	0.326
	1.000	–	1.152	–	1.328	–	0.672	–	0.452	–	0.322	–	0.299	–
4	1.000	1.848	1.198	1.881	1.436	1.916	0.709	1.534	0.502	1.275	0.466	1.088	0.443	0.929
	1.000	0.765	1.269	0.949	1.610	1.241	0.971	0.463	0.943	0.281	0.946	0.224	0.950	0.179
5	1.000	1.618	1.270	1.695	1.613	1.775	0.796	1.074	0.634	0.714	0.624	0.578	0.614	0.468
	1.000	0.618	1.348	0.821	1.819	1.091	0.980	0.334	0.961	0.180	0.964	0.142	0.967	0.113
	1.000	–	1.248	–	1.557	–	0.529	–	0.280	–	0.223	–	0.178	–
6	1.000	1.932	1.268	1.945	1.609	1.959	0.589	1.593	0.347	1.314	0.321	0.121	0.298	0.958
	1.000	1.414	1.301	1.521	1.694	1.636	0.856	0.802	0.733	0.455	0.727	0.363	0.722	0.289
	1.000	0.518	1.382	0.711	1.910	0.977	0.988	0.254	0.977	0.125	0.976	0.099	0.975	0.0782