Eμ SYSTEMS

3046 SCOTT BOULEVARD
SANTA CLARA, CALIFORNIA 95050
PHONE (408) 241-0788

Prices on the SSM I.C.'s are as follows:

2010 VCA	$12.50	each
2020 DVCA	7.50	
2030 VCO	10.00	
2040 VCF	10.00	
2050 TG	7.50	

We can also supply Q81 Tempco resistors at a cost of $3.50 each.

Please add $2.00 for shipping. California residents BE SURE to add sales tax. Purchasers outside of the U.S. will be responsible for Custom's charges.

Thank you for your interest in our products.

SSM 2020 DUAL LINEAR-ANTILOG VOLTAGE CONTROLLED AMPLIFIER

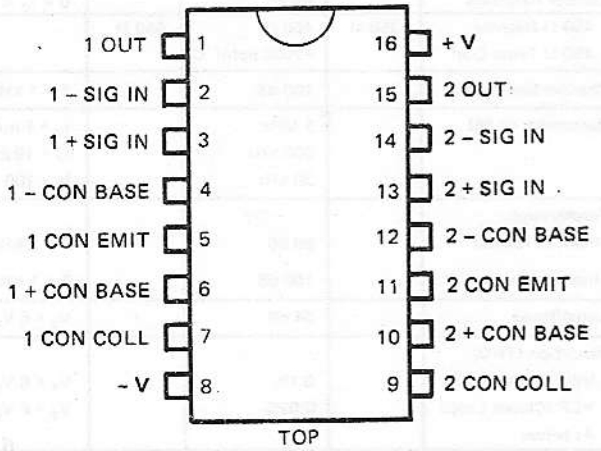
The SSM 2020 is a dual two quadrant multiplier designed to be used with op amps in a wide variety of precision audio-frequency applications including AGC circuits, Dividers and as a Biquad tuning element. Each channel has separate control and differential signal inputs and a current output. The device offers an exceptionally flexible control circuit for each channel which allows simultaneous linear and exponential voltage control of gain or either polarity of current control. Both channels are fully temperature compensated and have 84dB signal to noise ratios at less than 0.1% distortion.

FEATURES

- Max Supplies ±18V
- Dual Design (Independent Control Selection)
- 2% Channel Gain Matching
- 100dB Control Range
- Simultaneous Linear and Exponential Gain Control
- Differential Signal Inputs
- Current Output
- 84dB Signal to Noise
- 0.1% Distortion
- Fully Temperature Compensated

APPLICATIONS

- 2 and 4 Quadrant Multipliers
- Dividers
- AGC Circuits
- Voltage Controlled Filters
- Voltage Controlled Quadrature Oscillators
- Volume Controls
- Equalizers
- Compandors
- Antilog Amplifiers
- Voltage Controlled Current Sources

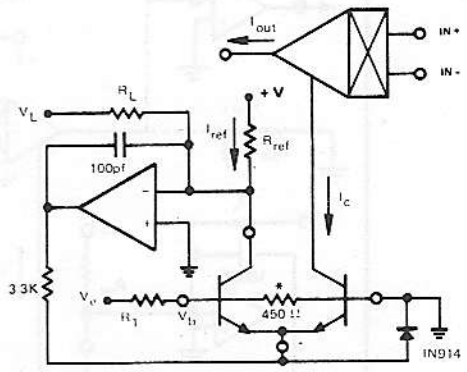


1) $I_{out} = g_m (V_+ - V_-)$

2) $I_{out} = \frac{I_c (V_+ - V_-)}{14 \text{ volts}}$

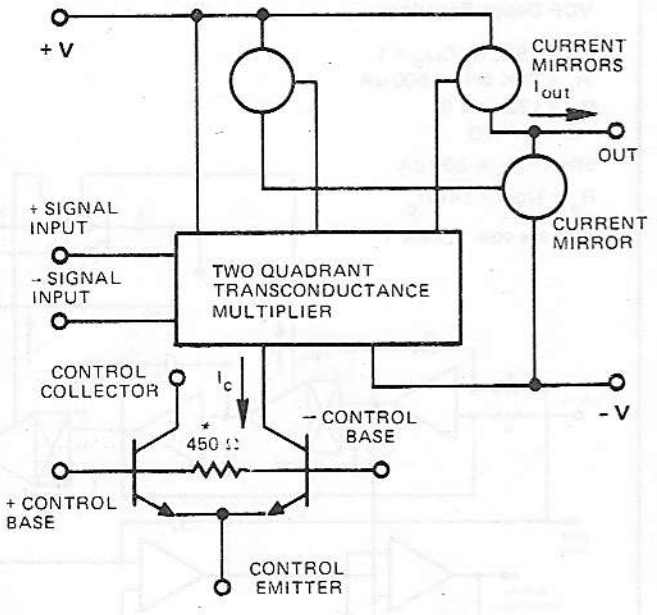
3) $I_c = e^{-V_b q/KT} (+ V/R_{ref} + V_L/R_L)$

where $V_b = \frac{V_c \ 450\Omega}{R_1 + 450\,\Omega}$



Basic Control Circuit

*NOTE: THE 450 Ω RESISTORS ARE INTERNAL TO THE I.C. AND COMPENSATE FOR THE T FACTOR IN THE EXPONENT.



Block Diagram (One Side)

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May 1978

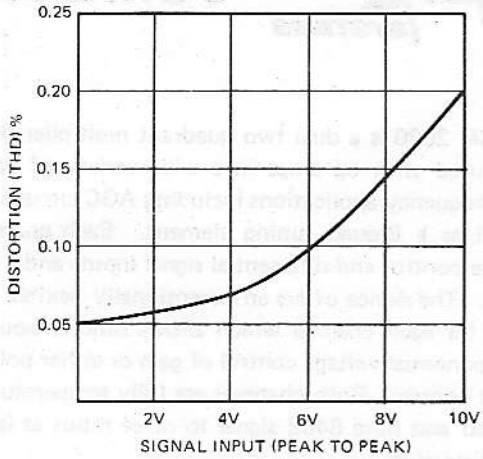
Operating Temperature −25°C to +75°C

Storage Temperature −55°C to 125°C

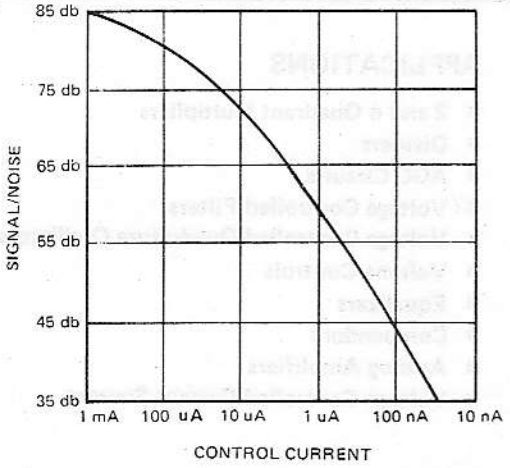
Specifications @ V_S = ±15V, $I_{c1} = I_{c2}$ = 500 μA and T_A = 25°C, unless otherwise specified.

Parameters	Min	Typ	Max	Conditions
Signal Input Bias I_b		500 nA	2.2 μA	V_{ee} + 3V ≤ V_+, V_- ≤ V_{cc} −3V
Supply Voltage V_s	±6	±15	±18	
Supply Current I_s		6 mA	8 mA	I_{c1} = I_{c2} = 1 mA
Control Current			1 mA	
Tranconductance gm	1/12 kΩ	1/14 kΩ	1/16 kΩ	$I_{c1} = I_{c2}$ = 1 mA
gm match		±2%	±5%	
gm Temco		100 ppm/°C		
Control Circuit V_{os}		1 mV	3 mV	
Output Offset I_o/I_c		±2%	±10%	$V_+ = V_-$ = GND (untrimmed)
Control Rejection		60 dB		0 ≤ I_c ≤ 1 mA (trimmed)
450 Ω Resistor	350 Ω	450 Ω	550 Ω	
450 Ω Temp Coef		+2000 ppm/°C		
Channel Separation		100 dB		F = 1 kHz
Bandwidth (3 dB)		1 MHz		I_c = 1 mA *
		300 kHz		I_c = 10 μA
		30 kHz		I_c = 100 nA
Feedthrough:				
−Input to Output		90 dB		F = 1 kHz, I_c = 0
+Input to Output		100 dB		F = 1 kHz, I_c = 0
Signal/Noise		84 dB		V_s = 6 V_{pp}, I_c = 1 mA
Distortion (THD)				
VCA (Open Loop)		0.1%		V_s = 6 V_{pp}, I_c = 1 mA
VCF (Closed Loop)		0.02%		V_s = 6 V_{pp}, I_c = 1 mA
As below				

* Output at Virtual GND



Distortion vs Signal Input



Signal Noise vs Control Current (6 Vpp in)

VCF Design Equations

$R = 15K, R_a C\omega_o = 1$

$R_a = 28K @ I_c = 500$ uA

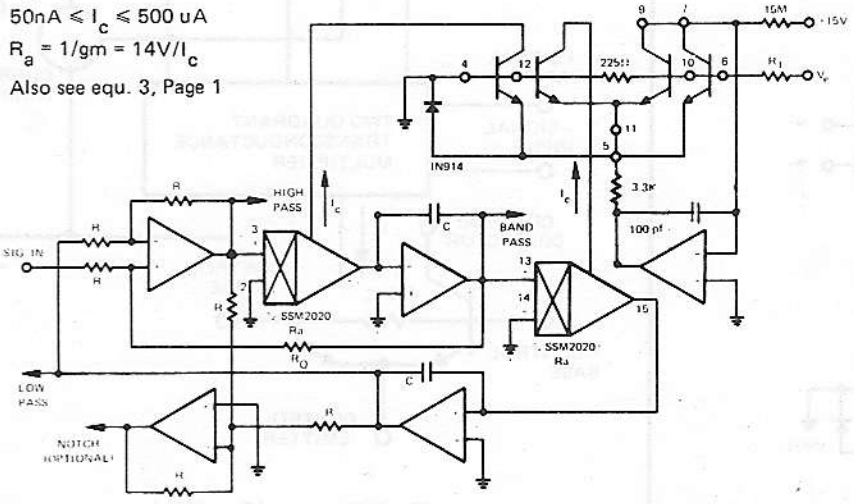
$R_Q = (2Q - 1) R$

$A = 2 - 1/Q$

$50nA \leq I_c \leq 500$ uA

$R_a = 1/gm = 14V/I_c$

Also see equ. 3, Page 1



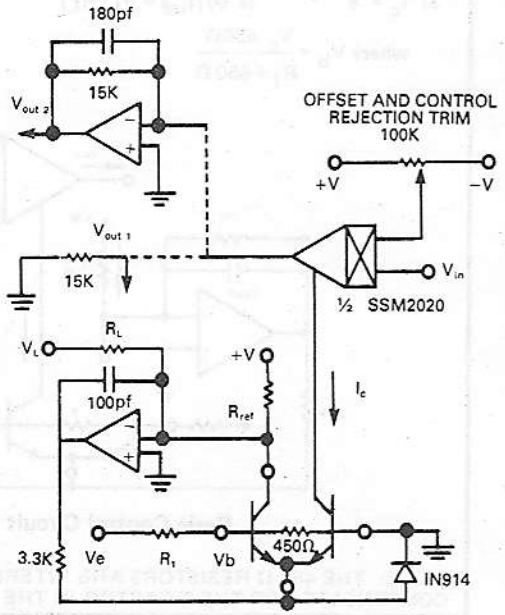
Voltage Controlled Filter (10,000 to 1 Sweep)

VCA Design Equations

$V_{out} = I_c V_{in}$ 15K/14Volts

$I_c = e^{-Vb\,q/KT} (V_+/R_{ref} + V_L/R_L)$

$Vb = Ve\ 450\Omega/(R_1 + 450\Omega)$



Voltage Controlled Amplifier

SSM 2030 VOLTAGE CONTROLLED OSCILLATOR

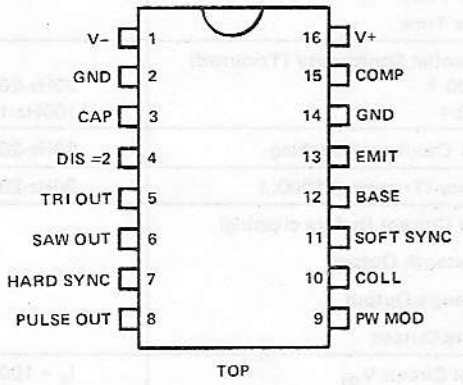
The SSM2030 is a precision voltage controlled oscillator designed specifically to meet the waveform and accuracy requirements of electronic music systems. It has both exponential and proportional linear sweep inputs which can control frequency over a 1,000,000 to 1 range with the same capacitor.. Sweep accuracy is better than 0.25% over a 1,000 to 1 range and 0.1% over 100 to 1. The device has simultaneous sawtooth, triangle and pulse outputs. An internal comparator provides control of pulse output duty cycle from 0 to 100%. Hard and soft sync inputs make possible a rich variety of modulation and harmonic locking effects.

FEATURES

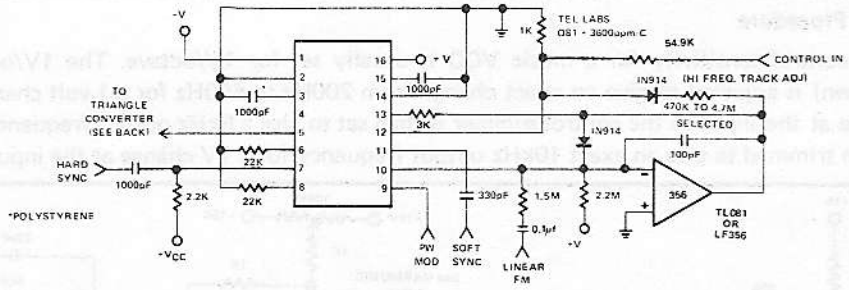
- Simultaneous Exponential and Proportional Linear Sweep Inputs
- High Sweep Accuracy (0.25% 1000 to 1)
- 1,000,000 to 1 Sweep Range
- 200 kHz Max Operating Frequency
- Simultaneous Sawtooth, Triangle and Pulse Outputs
- Pulse Duty Cycle Voltage Control Range (0 to 100%)
- All Outputs Short Circuit Protected
- Hard and Soft Sync Inputs
- Max Supplies ±18V

APPLICATIONS

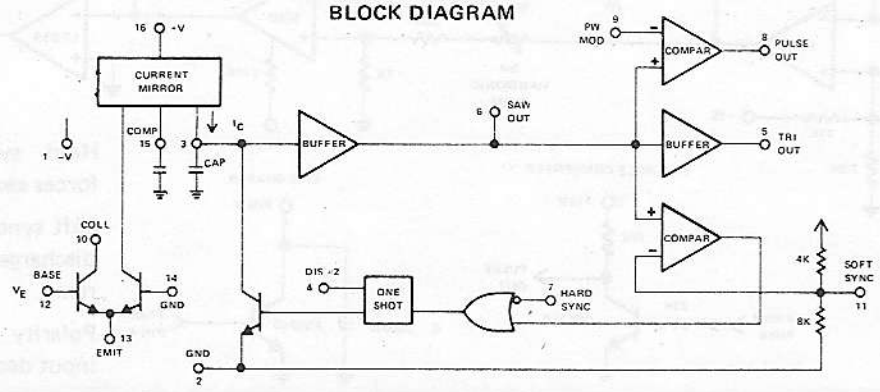
- Music Synthesizers
- Electronic Organs
- Electronics Games
- Waveform Generation
- V to F and F to V Conversion
- Modulation Control Circuits
- Wide Range Phase-Locked Loops
- Frequency Multiplication and Division



BASIC CONNECTION



BLOCK DIAGRAM



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SSM 2030

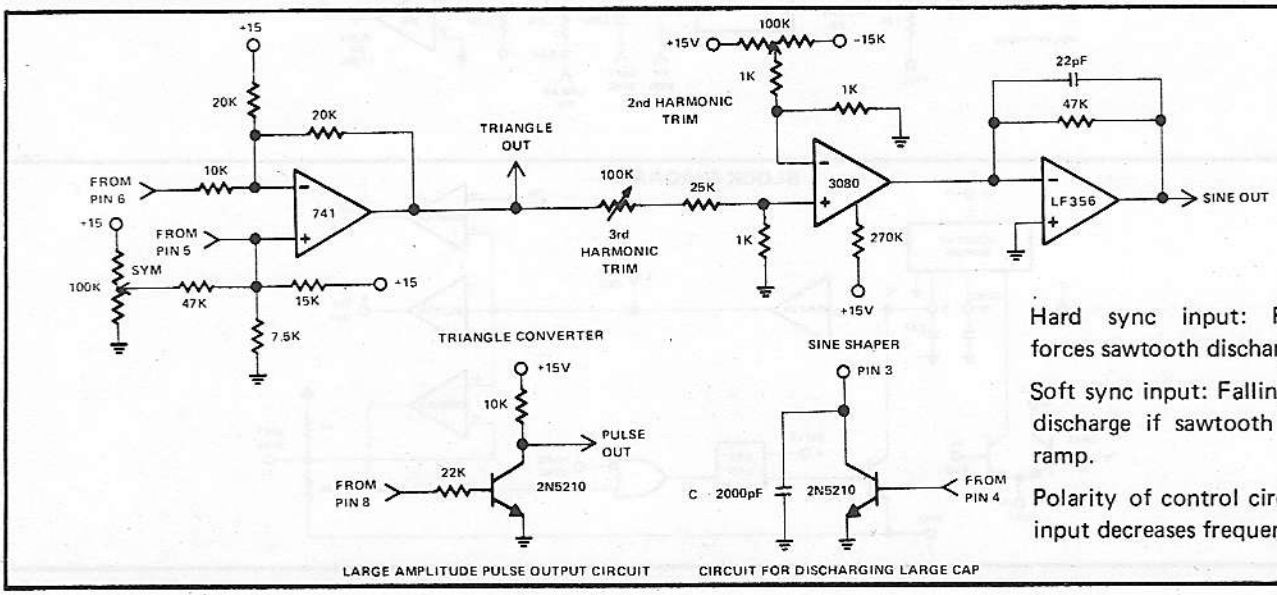
SPECIFICATIONS @ V_S = ±15V AND T_A = 25°C

Operating Temperature –25°C to +75°C
Storage Temperature –55°C to +125°C

Parameter	Conditions	Min	Typ	Max
V_S		±9V	±15V	±18V
Supply Current	I_C = 1 mA	8 mA	12 mA	16 mA
Buffer Leakage	I_C = 0		100 pA	1nA
Sweep Range	C = 1000pF	10^6:1	10^7:1	–
Operating Frequency	C = 1000pF	0.02 Hz	–	200 kHz
Sawtooth Amplitude		9.5 Vpp	10 Vpp	10.5 Vpp
Pulse Amplitude		7.0 Vpp	7.5 Vpp	8.0 Vpp
Sawtooth Fall Time Buffer Output Buffer Input		 – –	 500 nsec 200 nsec	 – –
Pulse Output Fall Time Rise Time		 – –	 200 nsec 200 nsec	 – –
Exponential Conformity (Trimmed) 1000:1 100:1	 20Hz-20kHz, C = 1000pF 100Hz-10kHz, C = 1000pF	 – –	 0.25% 0.1%	 – –
1000:1 Oscillator Matching	20Hz-20kHz, C = 1000pF	–	0.1%	–
Linearity (Trimmed) 1000:1	20Hz-20kHz, C = 1000pF, V_e = GND	–	0.05%	–
Output Current (before clipping) Sawtooth Output Triangle Output Pulse Output		 1.8 mA 1.8 mA 3.5 mA	 2.4 mA 2.4 mA 4.6 mA	 3.4 mA 3.4 mA 6.5 mA
Control Circuit V_{OS}	I_e = 100 μA	–	1 mV	3 mV
Power Supply Sensitivity		–	0.5%/V	1%/V
Pulse Mod Input Bias		–	1 μA	2.5 μA
Temperature Stability	V_e = GND	–	50ppm/°C	

VCO Adjustment Procedure

The exponential control sensitivity for a music VCO is usually set for 1V/octave. The 1V/octave trim on the control summer (not shown) is adjusted to give an exact change from 200Hz to 400Hz for a 1 volt change at the control summer input. The voltage at the input to the control summer is then set to give a 5kHz output frequency. The hi frequency track adjustment is then trimmed to give an exact 10kHz output frequency for a 1V change at the input.



LARGE AMPLITUDE PULSE OUTPUT CIRCUIT CIRCUIT FOR DISCHARGING LARGE CAP

Hard sync input: Falling edge forces sawtooth discharge.

Soft sync input: Falling edge forces discharge if sawtooth near top of ramp.

Polarity of control circuit: Positive input decreases frequency.

SSM 2040 VOLTAGE CONTROLLED FILTER CIRCUIT

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.

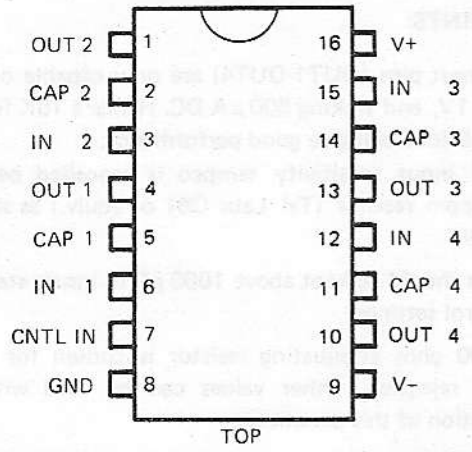
Applications include tracking filters, organs, music synthesizers, music phase shifters and sound effects generation.

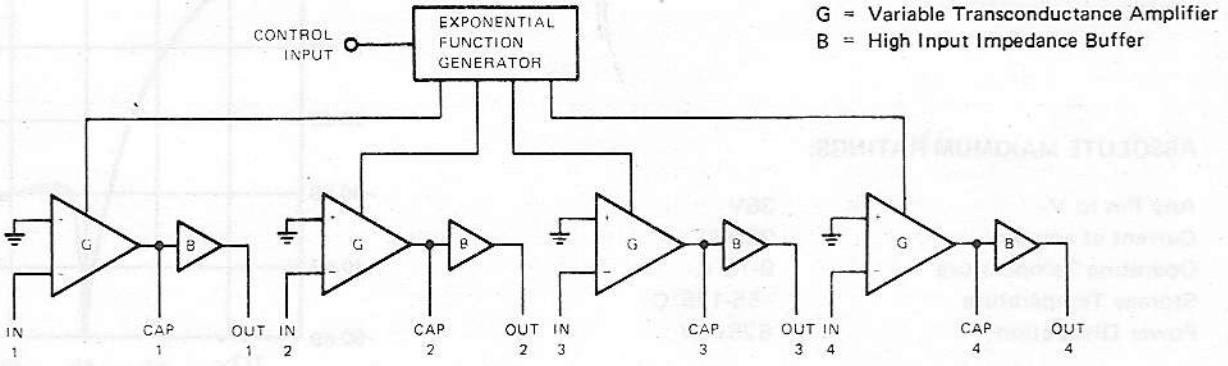
FEATURES

- +/- 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

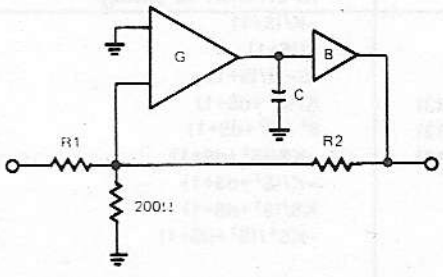


Figure 1. Lowpass Real Pole

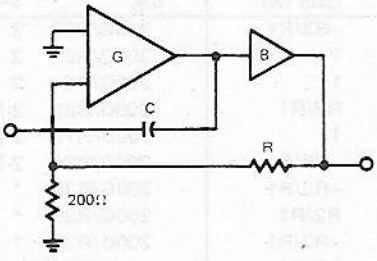


Figure 2. Highpass Real Pole

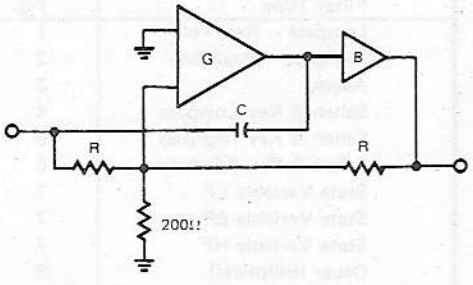


Figure 3. Allpass (Phase-shift)

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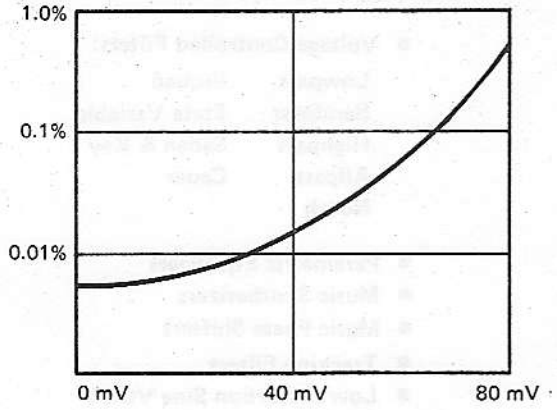
SPECIFICATIONS: V_S = +/-15V, T_A = 25°C

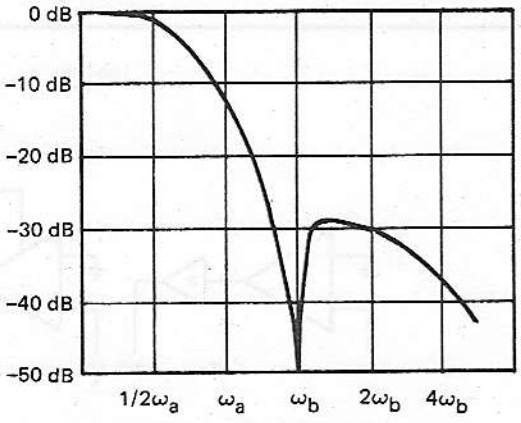
Specification	Conditions	Min	Typ	Max	Unit
Functional Range		10,000:1			
Input Offset, each cell			2	5	mV
Δ Input Offset, 4 cells in series	Vcntl= 0 mV, -90 mV		0.6	3	mV
	Vcntl= 0 mV, +90 mV		0.6	3	mV
Transconductance	Vcntl= 0	1/10K	1/5K	1/3K	mhos
Equiv. Input Noise, each cell	20 Hz-20 KHz, Vcntl=-90 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



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

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

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

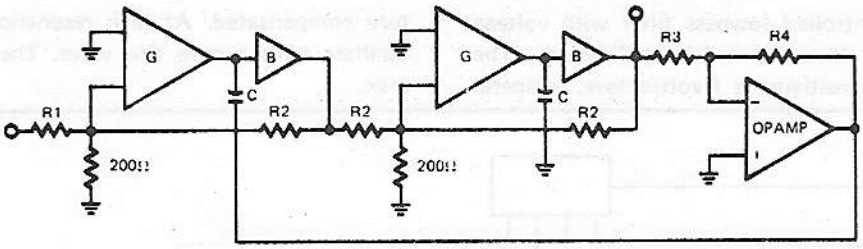


Figure 4. Sallen & Key Lowpass

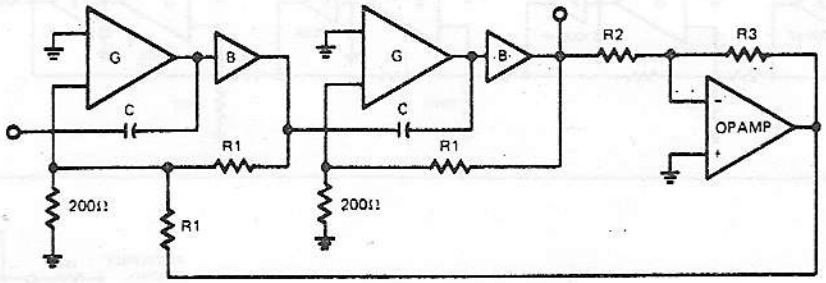


Figure 5. Sallen & Key Highpass

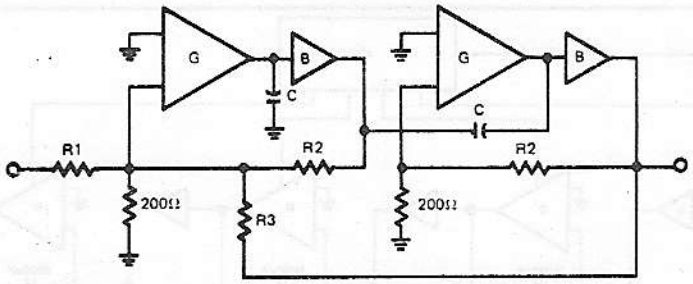


Figure 6. Sallen & Key Bandpass

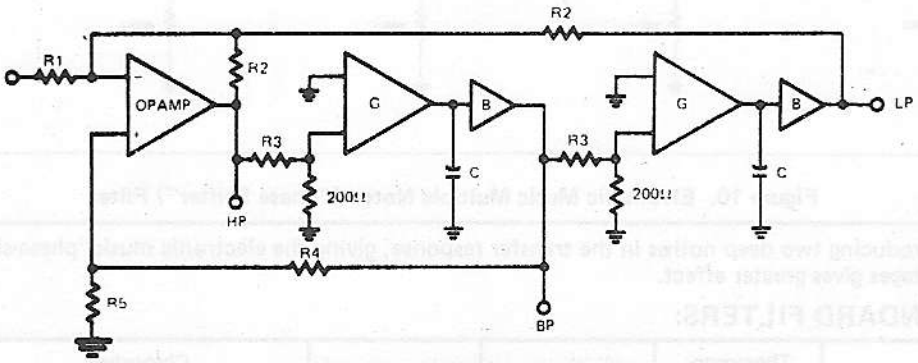


Figure 7. State Variable Filter

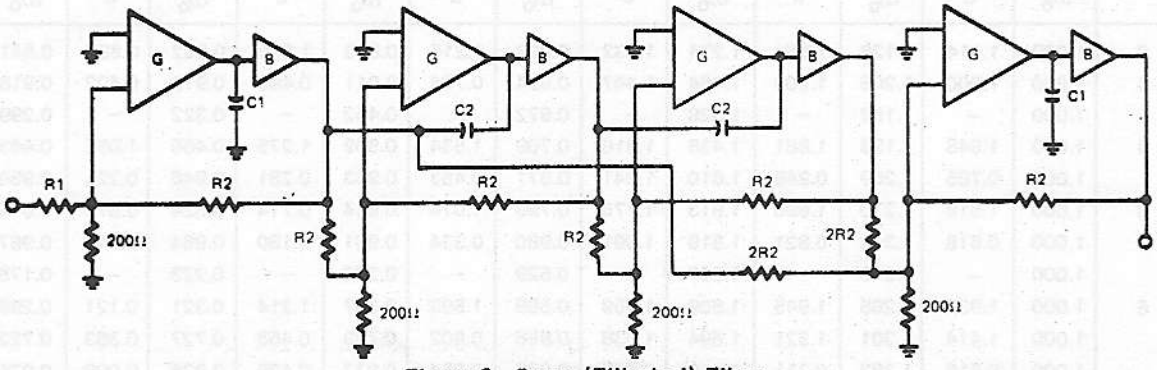


Figure 8. Cauer (Elliptical) Filter

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.

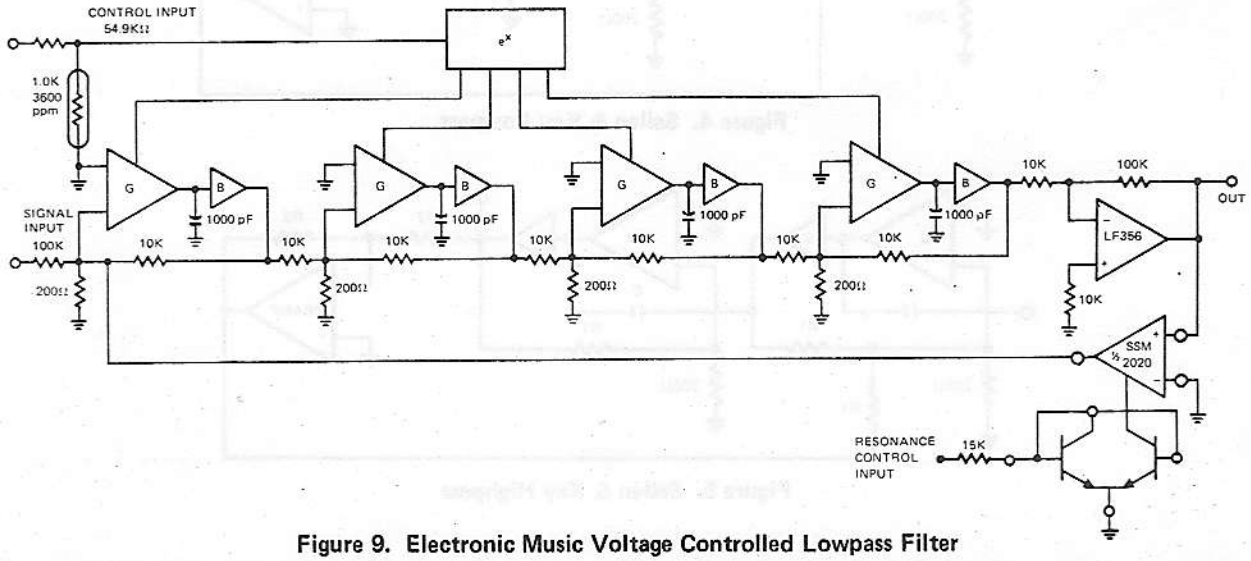


Figure 9. Electronic Music Voltage Controlled Lowpass Filter

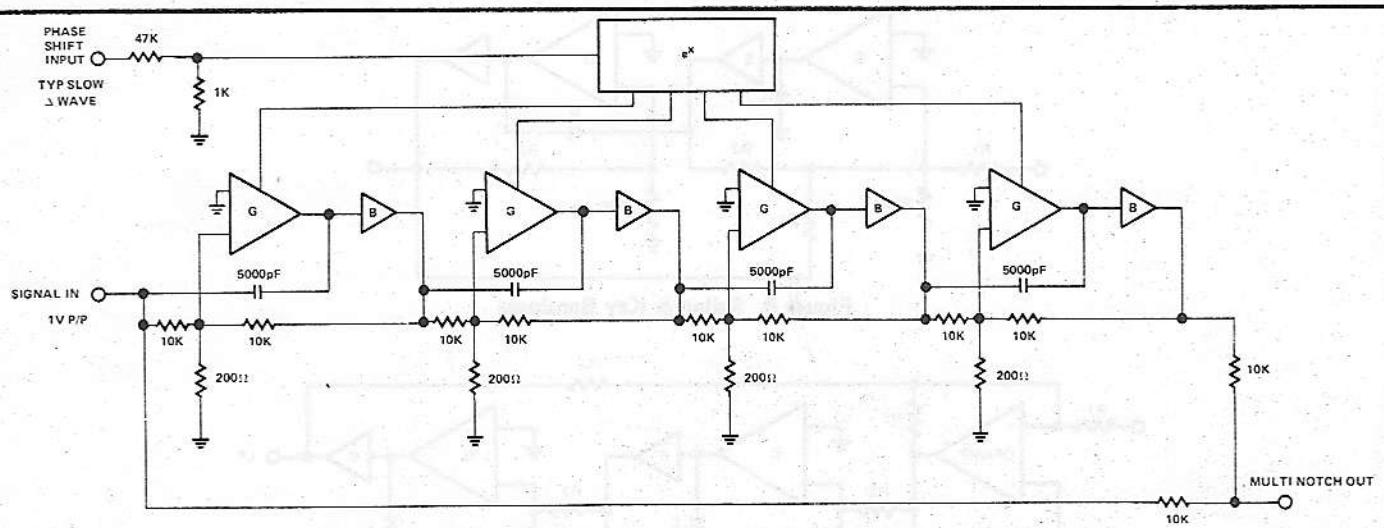


Figure 10. Electronic Music Multiple Notch ("Phase Shifter") Filter

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

SSM 2050 VOLTAGE CONTROLLED TRANSIENT GENERATOR

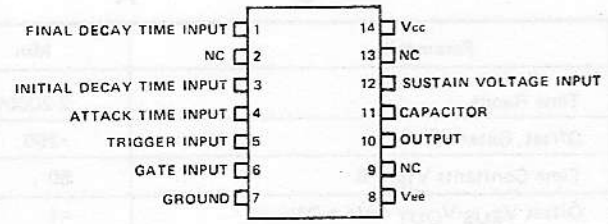
The SSM 2050 is a self-contained ADSR type electronic music transient generator. Attack, initial decay and final decay timers can be exponentially voltage controlled over a 10,000 to 1 range from 1 msec to more than 10 sec. The sustain level is linearly voltage controllable from 0 to 100%. The device has independant gate and trigger inputs for maximum flexibility and much effort has been taken to minimize the external parts count.

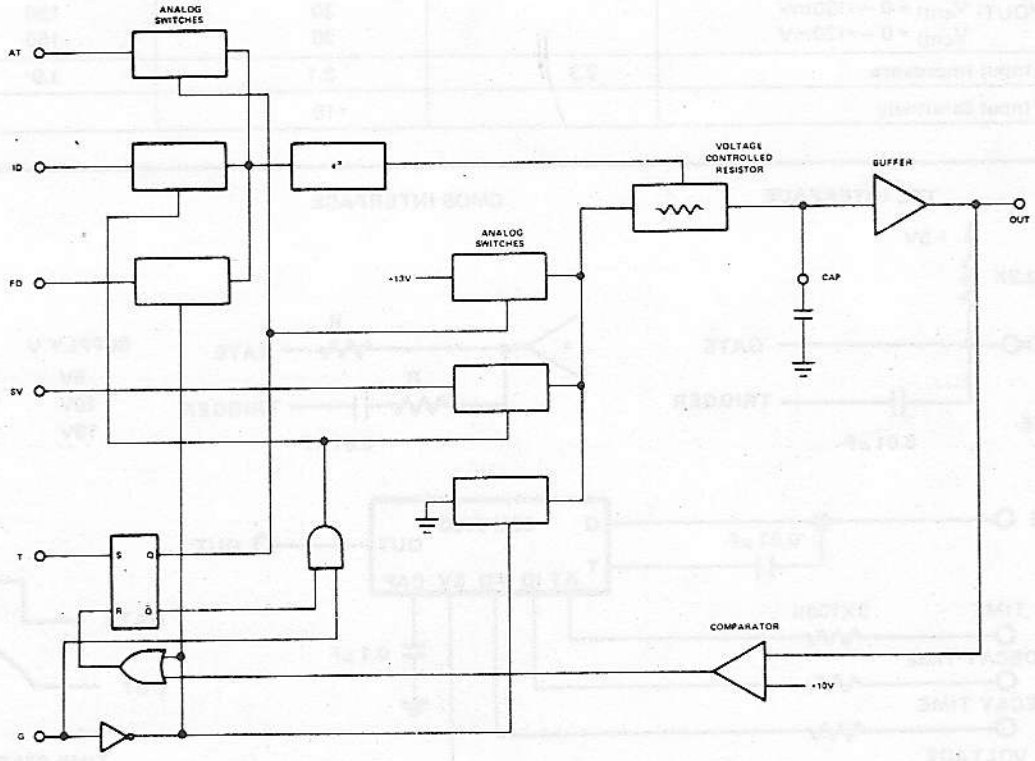
FEATURES:

- +/- 15V Supplies
- Exponential Time Control Response
- Minimum External Component Count
- Guaranteed Control Rejection Characteristics
- 10,000:1 Time Control Range
- Full ADSR Response
- Independent Gate & Trigger

APPLICATIONS

- Music Synthesizers
- Organs
- Rhythm Synthesizers
- Sound Effects Generators
- Electronic Games





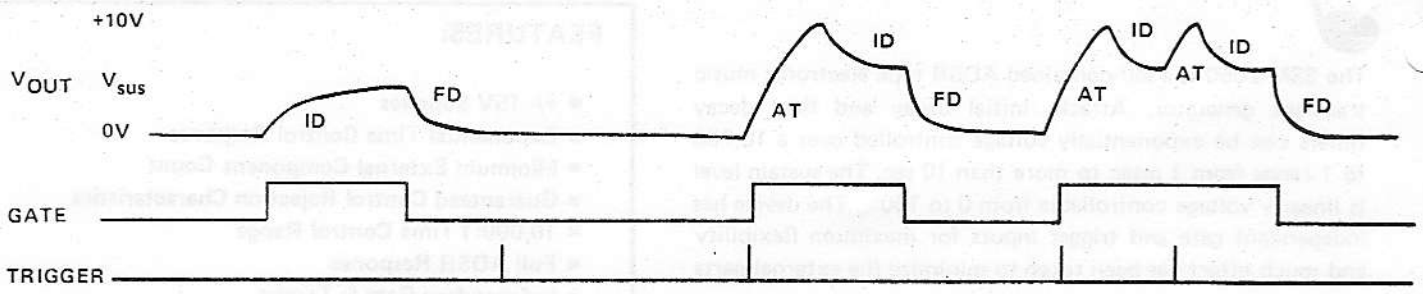
FUNCTIONAL BLOCK DIAGRAM

3046 Scott Blvd., Santa Clara, CA 95050, (408) 241-0788

May 1978

SSM 2050

GATE & TRIGGER FUNCTION



AT, ID, FD indicate times controlled by Attack, Initial Decay and Final Decay Time Control Inputs respectively. (A positive voltage reduces the time constant.) All are nominally exponential approaches to +13V, Sustain Voltage and Ground respectively.

SPECIFICATIONS: V_S = +/-15V, T_A = 25°C, CAP = 0.1 μF

Parameter	Min	Typ	Max	Unit
Time Range	2-20000	1-100000		msec
Offset, Gate=off	±250	±50		mV
Time Constants V_{IN} = 0	50	100	200	msec
Offset V_{SUS}-V_{OUT} Gate = ON	-1	0	+1	V
Gate & Trig On Voltage Current V_{IN} = 1.5V		1.0 500	1.5 750	V μA
Output Noise		0.5		mV RMS
V_{attack}	10	10.5	11	V
Final Decay Control Rejection V_{OUT}; V_{cntl} = 0 — -120mV V_{cntl} = 0 — +120mV		 30 30	 150 150	 mV mV
Control Input Impedance	2.3	3.1	3.9	kohm
Control Input Sensitivity		+18		mV/octave