



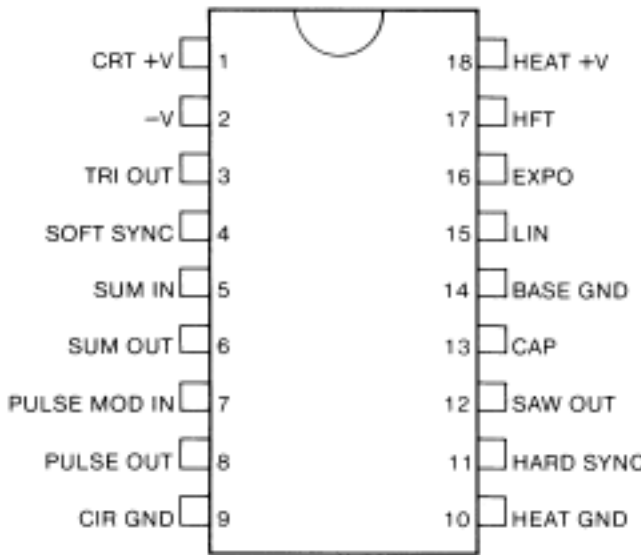
VOLTAGE CONTROLLED OSCILLATOR*

DESCRIPTION

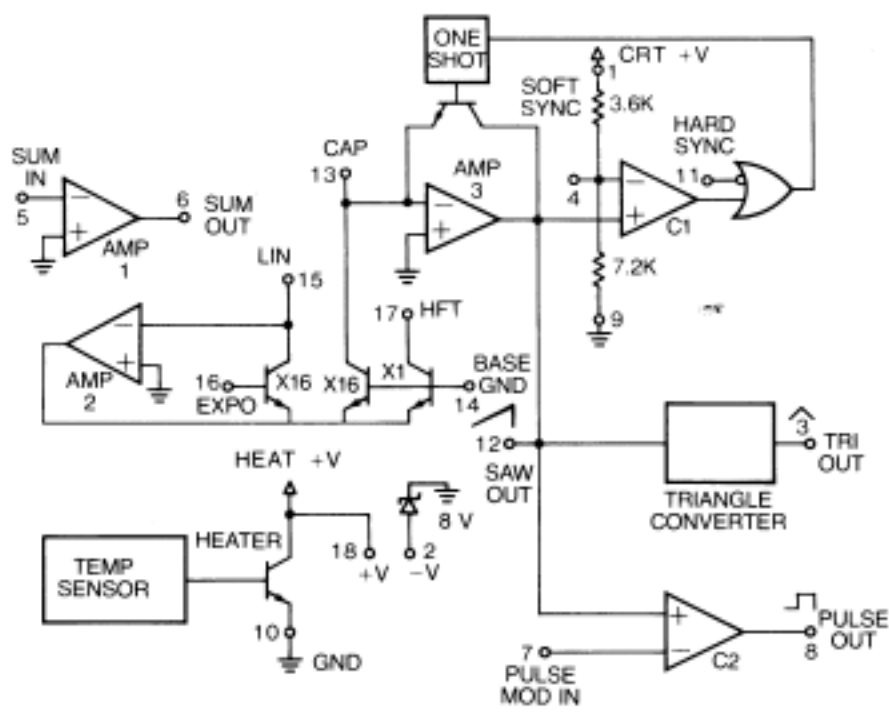
The SSM 2033 is a precision voltage controlled oscillator designed specifically for tone generation in electronic music. It has sawtooth, triangle, and variable width pulse outputs. Simultaneous exponential and proportional linear sweep inputs can control operating frequency over a 500,000-to-1 range. On-chip low input bias summer and control op amps have been provided. The pulse comparator, which has built-in hysteresis for clean switching, can control pulse width duty cycle from 0 to 100%. Hard and soft sync inputs make possible a rich variety of modulation and harmonic locking effects. In addition, the operating temperature of the chip is regulated making external temperature compensation unnecessary. Only one trim (volts/octave) is required for normal operation.

FEATURES

- Full on-chip temperature compensation.
- 500,000-to-1 sweep range.
- Simultaneous sawtooth, triangle, and variable width pulse outputs.
- Simultaneous exponential and proportional linear sweep inputs.
- On-chip summer and control op amps.
- Excellent exponential conformity.
- All outputs are short circuit protected.
- Hard and soft sync inputs.
- Pulse duty cycle voltage controllable from 0 to 100%
- Pulse comparator has built-in hysteresis.
- 100 nsec sawtooth discharge time.
- Only volts/octave trim required for normal operation.



PIN OUT (TOP VIEW)



BLOCK DIAGRAM

SPECIFICATIONS*

OPERATING TEMPERATURE

STORAGE TEMPERATURE

25°C

-10°C to +55°C

-55°C to +125°C

+V = +15V, -V = INTERNAL REFERENCE

PARAMETER	MIN	TYP	MAX	UNITS	CONDITIONS
Positive Supply Current	8.0	10.5	13.3	mA	
Max Heater Current	30.0	37	45	mA	
Positive Supply Voltage Range	9.0	15	18	V	
Negative Supply Voltage Range ⁽¹⁾	-4.5	-15	-18	V	
Sweep Range	250K:1	1M:1			
Integrator Input Bias Current	-	0.3	1	nA	
Control Circuit Offset	-5.0	0	+5	mV	
Max Operating Frequency	27	33	44	kHz	C = 1000 pf
Max Charging Current	270	330	440	μA	
Exponential Scale Error	-	0.05	0.2	%	-90 mV ≤ V _e ≤ +90 mV
Sawtooth Peak Level	9.75	10.0	10.25	V	
Sawtooth Discharge Level	-	200	350	mV	
Sawtooth Discharge Time	-	100	-	nsec	
Sawtooth Output Short Circuit Current	5.6	7.5	9.4	mA	
Triangle Peak Level	4.75	5.0	5.25	V	
Triangle Trough Level	-250	0	+250	mV	
Triangle Output Short Circuit Current	8	11	14	mA	V _{pin 3} = GND
Pulse Upper Level	5.8	6.5	7.2	V	
Pulse Lower Level	-100	0	+100	mV	Pin 8 has 15K to GND
Pulse Fall Time	-	1	-	μsec	
Pulse Rise Time	-	3	-	μsec	@ 50HZ
Pulse Modulation Input Bias Current	0.75	2.0	6.0	μA	V _{pin 7} > V _{pin 12}
Control and Summer Op Amps					
Input Offset Voltage	-5	-	+5	mV	
Input Offset Voltage Drift	-	0.2	-	μV/C°	0°C ≤ T ≤ 45°C
Input Bias Current	-	40	250	nA	
Input Bias Current Drift	-	50	-	pA/C°	
Frequency Drift With Temperature					0°C < T < 45°C
Basic Loop	-20	-	+20	ppm/C°	V _e = GND
With Exponential Converter ⁽²⁾	-100	-	+100	ppm/C°	V _e = ±26 mV

*Final specifications may be subject to change.

Notes: (1) Series current limiting resistor required for negative supplies greater than -6V.

(2) Uncompensated drift under the same conditions is 3300 ppm/C° @ 25°C.

The schematic above show the typical connection of the SSM 2033 as an electronic music VCO. The control circuit section is redrawn for easy reference (figure 1). Any number of input voltages can be summed by amplifier A₁ which drives the exponential input attenuator to pin 16. Amplifier A₂ forces the current in Q₁ to be equal to the sum of the reference current, established by R₁, and the linear FM voltage. The current in the output transistor Q₂ is:

$$I_o = (V_+/R_1 + V_L/R_2) e^{-V_e q/kT} \quad \frac{kT}{q} = 28.3 \text{ mV @ } 55^\circ\text{C}$$

Propagation delay and discharge time can cause a deviation from true exponentiality at frequencies above 5kHz. To correct for this effect, transistor Q₃ provides feedback to the exponential control input. At low frequencies (currents), Q₃ will have a negligible effect on the voltage at the base of Q₁. At high frequencies (currents), Q₃ will correct for the tendency of the oscillator to track flat. Since 5kHz is about the upper limit for most musical applications, pin 17 can be grounded and R₃ and R₄ replaced with a 1K 1% resistor. For accurate operation above 5kHz, R₃ R₄ are chosen to give a true last octave.

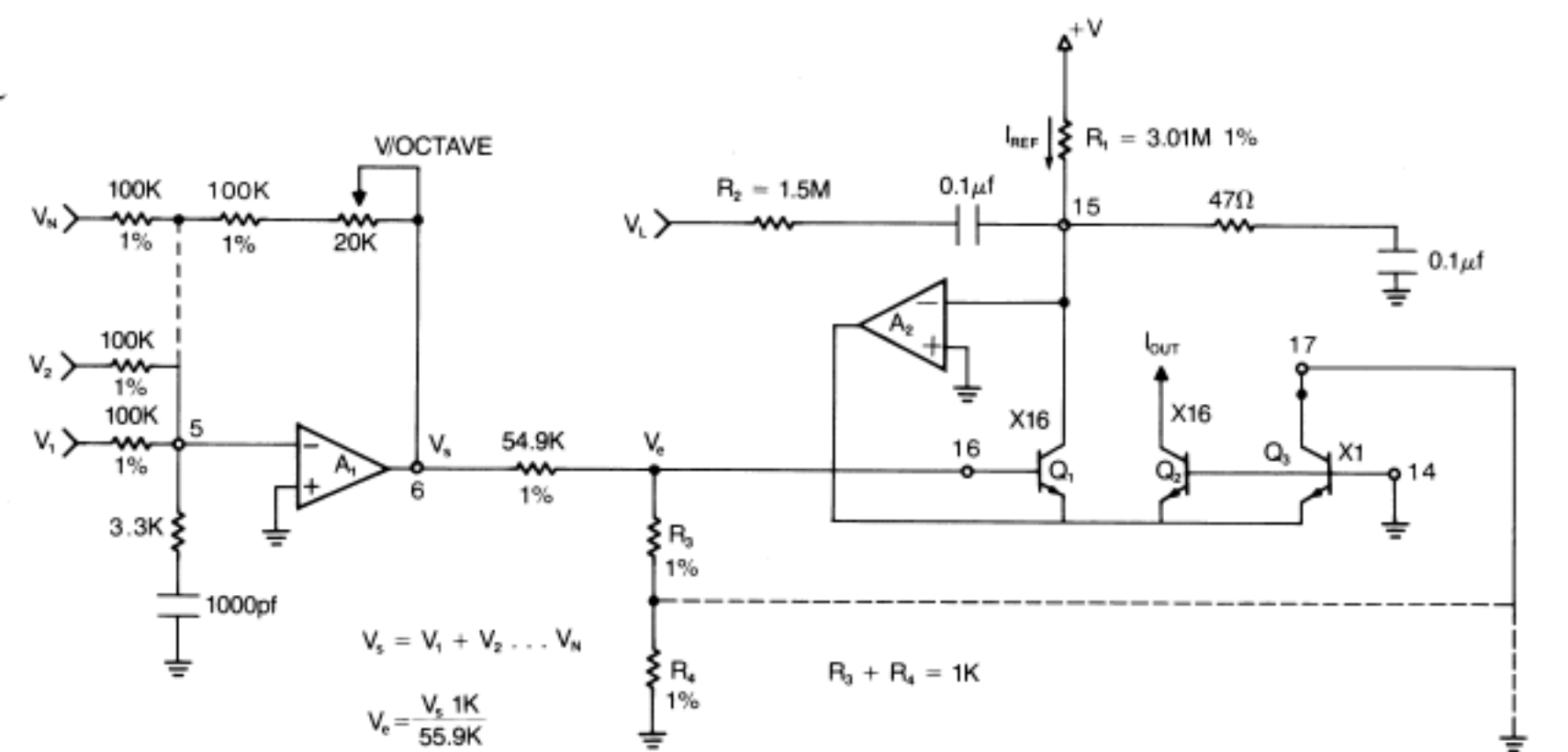
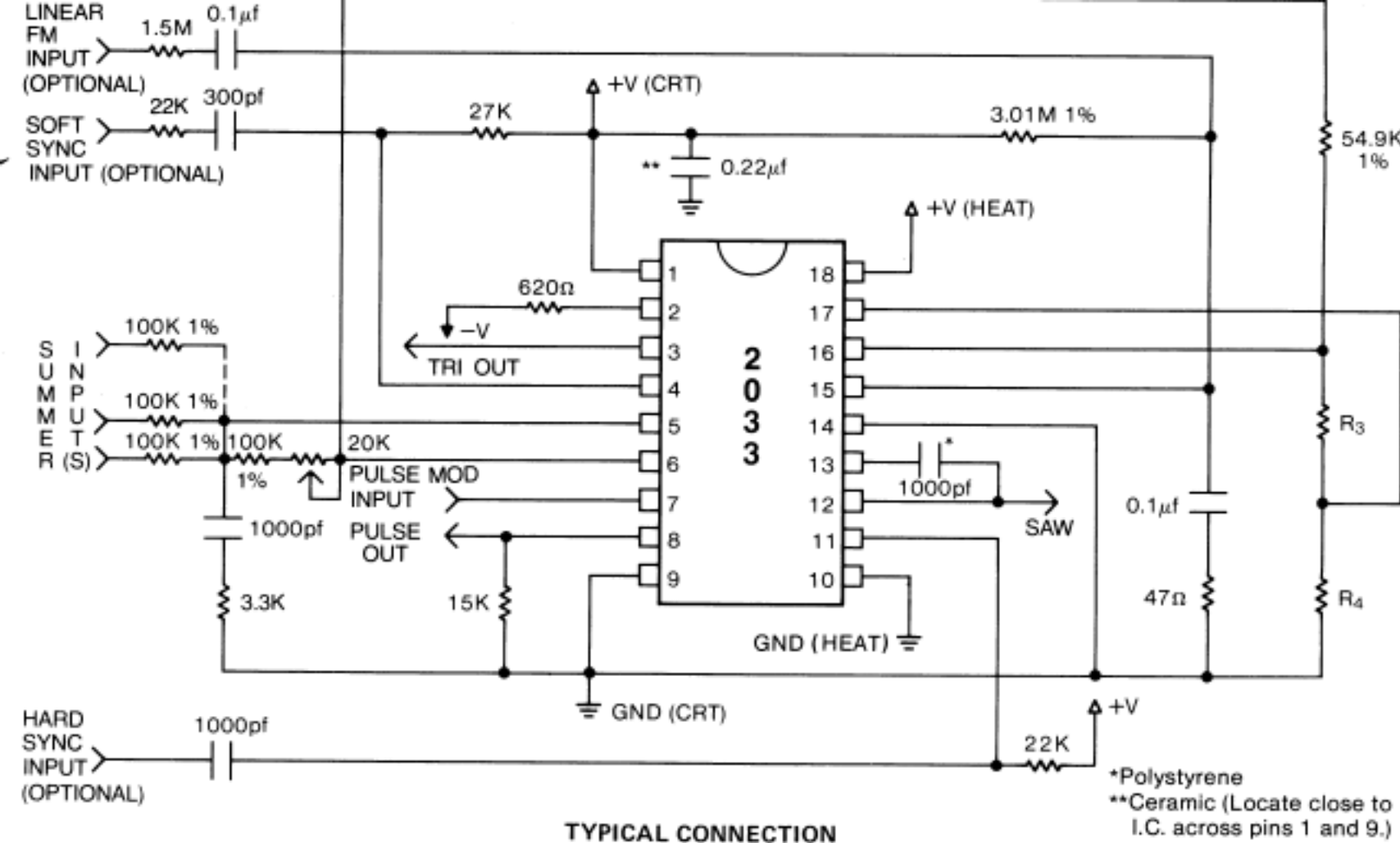


FIGURE 1 – CONTROL CIRCUIT

The SSM 2033 has an on-chip temperature sensor and heater which regulates the chip temperature to 55°C. The kT/q term in the exponent of the equation above is now a fixed value independent of ambient temperature. Operating temperature is reached 30 to 40 seconds after device power-up. Current drawn by the heater will decrease as ambient temperature rises. The temperature stabilization also insures that errors caused by offset drift with temperature in the summer and control op amps will be extremely small. (SEE NOTE LAST PAGE.)

The output current of the control circuit is fed to an integrating amplifier which creates the sawtooth waveform. The instantaneous sawtooth output is compared to a reference voltage that is two-thirds of the positive supply. Sawtooth discharge is accomplished by a capacitorless one-shot which delivers a pulse to the discharge transistor when triggered by comparator C_1 .

The triangle converter and pulse width comparator shape the sawtooth to provide the other two waveform outputs. The $27K$ resistor between the positive supply and the soft sync pin centers the sawtooth for proper triangle conversion. Comparator C_2 compares the pulse width modulation input voltage to the instantaneous sawtooth output to create a pulse that can have a duty cycle between 0 and 100%. The control range on the PWM input is between 0 and 10 V. C_2 has about 180 mV of built-in hysteresis to give fast clean transitions on both the rising and falling edges of the output.

The hard and soft sync features provide additional means for timbre modulation and additive synthesis. The hard sync input senses a falling edge, such as another 2033's sawtooth discharge, and forces an immediate discharge of the synced 2033. The resulting waveform has a complex harmonic structure whose pitch is that of the incoming oscillator (figure 2). The soft sync input also accepts a falling edge but it will force discharge only if the synced 2033 is within $240K/(R_3 + 2.4K)$ % of discharge. This enables one to phase-lock two oscillators to frequencies that are exact small integer ratios of one another (figure 3). By mixing the waveforms of the two oscillators, complex additive synthesis can be performed.

NOTE: The time required for the 2033(s) to become temperature stabilized after system turn on can be eliminated by wiring the power supply so that the oscillators operate as long as the system is pugged in. This is similar to the "instant on" feature in tube T.V. sets.

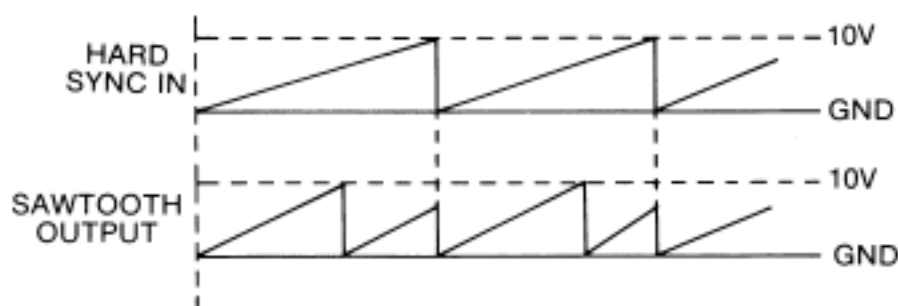
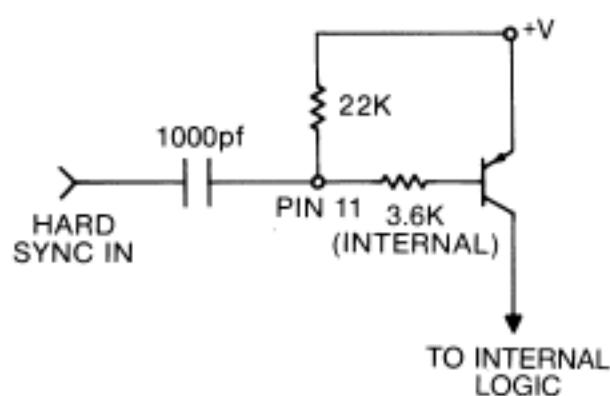


FIGURE 2— HARD SYNC

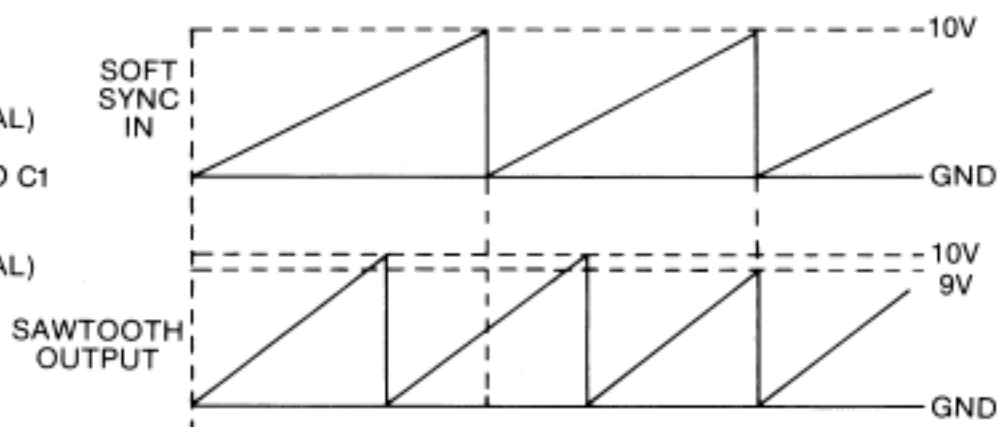
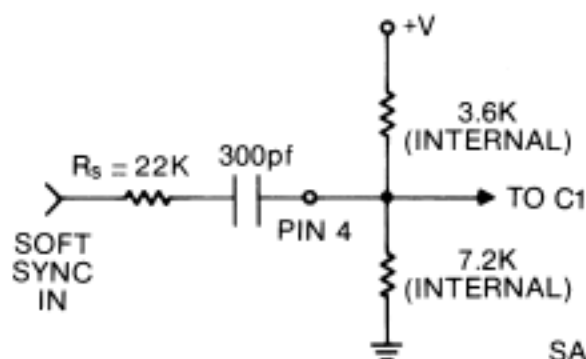


FIGURE 3— SOFT SYNC

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