SSM 2030 VOLTAGE CONTROLLED OSCILLATOR

The SSM 2030 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 synchronisation inputs make possible a rich variety of modulation and harmonic locking effects.

KEY FEATURES:

- **Simultaneous exponential and proportional linear sweep inputs**
- **High sweep accuracy over audio range**
- **1,000,000 to 1 sweep range**
- **200kHz max. operating frequency**
- **Simultaneous sawtooth, triangle and pulse outputs**
- **Pulse duty cycle voltage control (0 to 100%)**
- **Hard and soft synchronisation inputs**
- **Power supply up to ±18V**

APPLICATIONS:

- **Music synthesisers**
- **Electronic organs**
- **Electronic games**
- **Waveform generation**
- **V to F and F to V conversion**
- **Modulation control circuits**
- **Wide range phase-locked loops**
- **Frequency multiplication and division**

DEVICE DESCRIPTION AND APPLICATION

The 2030 from Solid State Micro Technology is the first VCO in integrated circuit form to address the needs of electronic music systems. The device (Figure 1) consists of a pair of matched logging transistors, a precision current mirror, a fast ultra-low leakage buffer, waveshaping circuits for pulse and triangle outputs, a fast comparator and a discharge circuit which includes a capacitorless one-shot. In addition, provision has been made to allow linear FM and synchronising the oscillator to the output of another.

The frequency control circuit shown in Figure 3 is similar to many modular designs now in use. A low input bias op amp is used to force the current in Q1 to be equal to the reference current established by R1 and the linear FM voltage (if any). The current in the output transistor Q2 is:

$$I_o = (V+/R1 + V_L/R2)e^{V_b q/KT}$$

As can be seen the term in the exponent is temperature dependent. This problem can be addressed by making V_b temperature dependent.

$$\frac{d}{dT}\frac{KT}{q} = 3300\text{ppm}/^\circ\text{C @ } 25^\circ\text{C} \qquad V_b = \frac{V_e R3}{R3+R4} \qquad R3 = 1K; \; R4 = 54k9$$

Since R4 is large compared to R3 one can use a Tel Lab Q81 resistor (temp. coeff. 3500ppm/°C) to give V_b the necessary temperature dependence. Best results are obtained with the Q81 thermally coupled to the package.

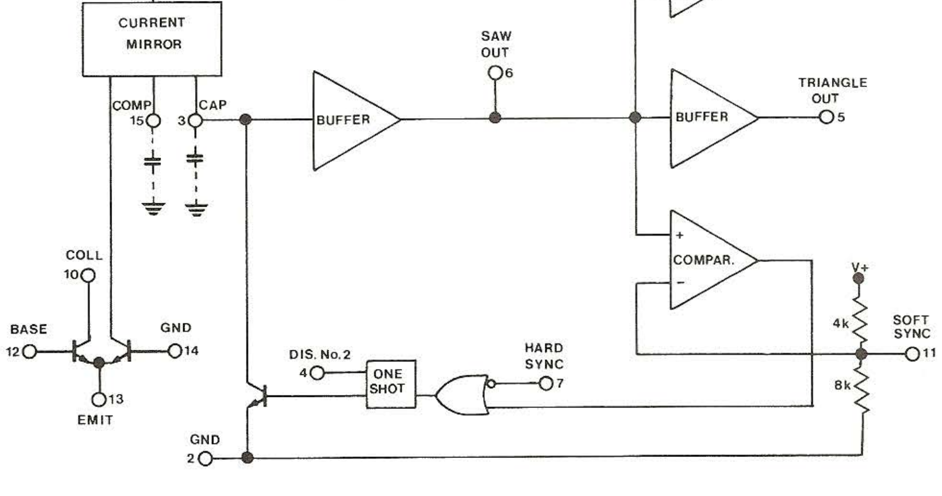


Figure 1 Functional Block Diagram

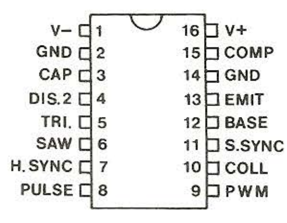


Figure 2 Pin Configuration

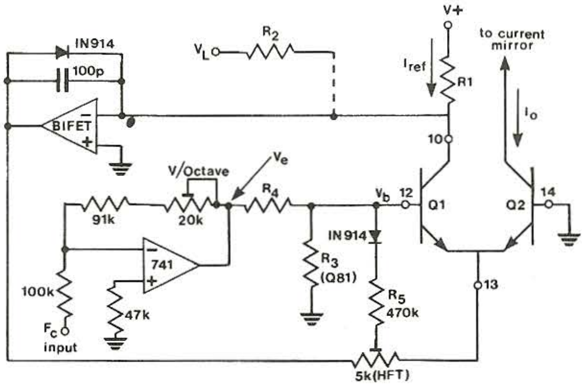


Figure 3 Control Circuit

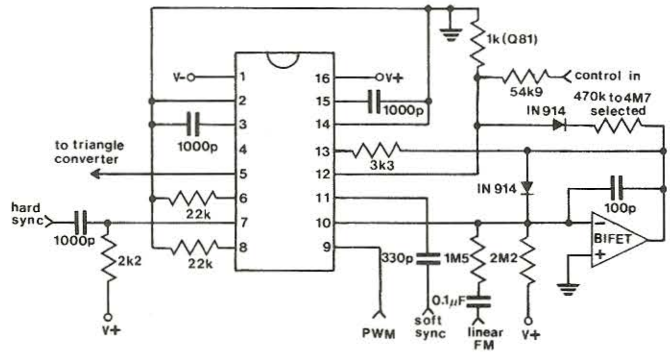


Figure 4 Basic Connection

Two other sources of error exist which can affect sweep accuracy: the input bias current of the buffer at the low end (the 2030 spec. is I_b less than 1nA); and the bulk emitter resistance of the logging transistors at the high end. In Figure 3, the diode-R5 network compensates for this latter effect by providing extra base drive at high current to the sweep circuit. The integrating capacitor must have good temperature stability (e.g. polystyrene type.)

For proper operation the Volt/octave trimmer is adjusted to give a true octave at 200Hz to 400Hz. The HFT preset potentiometer is then trimmed for a true octave at 4000Hz to 8000Hz. Using this procedure one can get better than 0.25% absolute sweep accuracy from 20Hz to 10kHz with 0.1% in the critical range between 100Hz to 8000Hz. Since the small remaining errors tend to be similar from oscillator, matching between oscillators is even better than the absolute frequency accuracy — an important benefit in designing polyphonic systems.

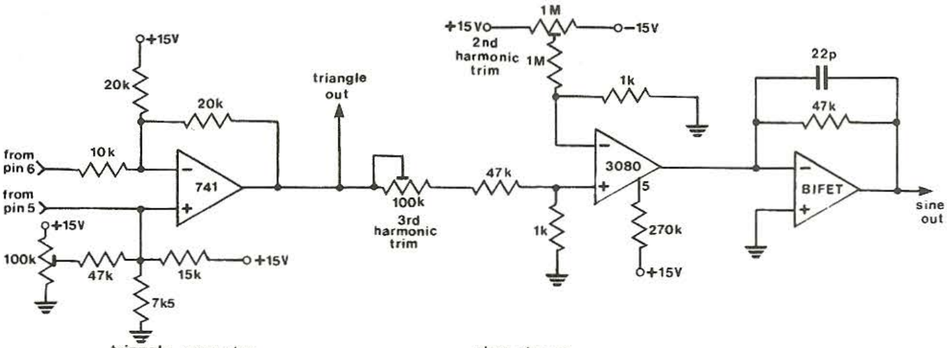
Within the chip, the exponential current is mirrored and direct integration yields a sawtooth whose discharge results from the comparator triggering the one-shot. The sawtooth waveform is 0-10V. The sawtooth and "triangle" output pins are both emitter followers from the internal sawtooth. The triangle waveshaping circuit (Figure 5) uses the sawtooth output and an emitter follower from the same point which is biased to give half a sawtooth. The subtraction performed by the 741 of the sawtooth from this waveform yields a triangle output of ±5V. A true 741 type op amp must be used as its lower slew rate ignores the fast negative going discharge ramp which would otherwise cause a glitch in the output. Any sine shaping circuit may be used, if required, and that shown in Figure 5 uses few components and produces a ±5V sine wave with about 2% THD when trimmed.

The variable width pulse output is derived by internally comparing the sawtooth to the pulse width input. The PWM pin is thus a voltage input with a fixed 10%/V sensitivity (100% at 0V decreasing to 0% at 10V.) The output is –0.5V low and 7V high.

The circuit shown in Figure 4 provides linear frequency modulation with a 10%/V sensitivity for the components used. Although it is shown AC coupled so as to avoid errors from any DC drift it may be DC coupled if required.

The auxiliary discharge output (Pin 4) can be used to drive a large geometry transistor for discharging capacitors from 2nF to 10nF in low frequency oscillators used for modulation purposes (Figure 6).

The hard sync input senses a falling edge, such as another 2030's sawtooth discharge, and forces an immediate discharge of the synchronised 2030 (Figure7). Oscillators set to integral ratios (slave faster than master) will lock with coherent waveforms but when set to ratios of numbers unusual waveforms result. The hard sync facility can produce pleasant timbral effects when the slave VCO is modulated and the master held constant. The soft sync input also accepts a falling edge but it will only force discharge if the synchronised 2030 is within ($240k/R_s$+2k4) % of discharge and this percentage is normally kept between 5 and 10 so as to synchronise oscillators to ratios without producing odd waveforms (Figure 8).



triangle converter

sine shaper

Figure 5

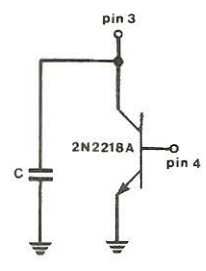


Figure 6

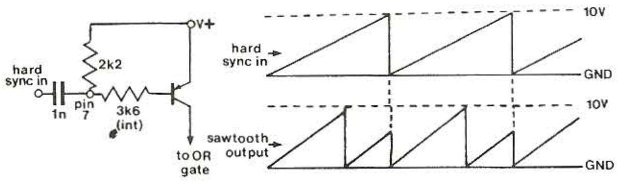


Figure 7 Hard Synchronisation

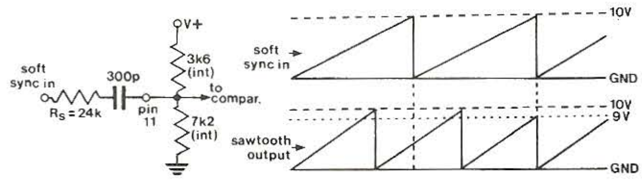


Figure 8 Soft Synchronisation

SPECIFICATIONS: V_S ±15V, T_A = 25°C, CAP = 1nF

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	1 nA
Sweep Range		10^6: 1	10^7: 1	–
Operating Frequency		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 100Hz-10kHz	 – –	 0.25% 0.1%	 – –
1000: 1 Oscillator Matching	20Hz-20kHz	–	0.1%	–
Linearity (Trimmed) 1000: 1	20Hz-20kHz, 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 uA
Temperature Stability	V_e = GND	–	50ppm/°C	

REFERENCES: Application Note and Data Sheet published by **Solid State Micro Technology, Santa Clara, U.S.A.**

Published by: **DIGISOUND LIMITED**
13 THE BROOKLANDS, WREA GREEN, PRESTON, LANCS. PR4 2NQ. Tel. 0772 683138

August 1979