PRODUCT SPECIFICATIONS **LINEAR INTEGRATED CIRCUITS**

Raytheon

Voltage-Controlled Oscillator

XR-2207

Features

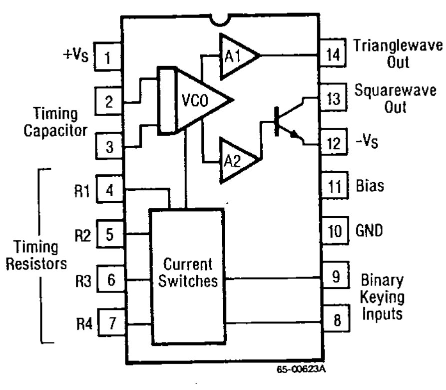
- Excellent temperature stability — 20ppm/°C
- Linear frequency sweep
- Adjustable duty cycle — 0.1% to 99.9%
- Two or four level FSK capability
- Wide sweep range — 1000:1 min
- Logic compatible input and output levels
- Wide supply voltage range — ±4V to ±13V
- Low supply sensitivity — 0.15%/V
- Wide frequency range — 0.01Hz to 1MHz
- Simultaneous triangle and squarewave outputs

Applications

- FSK generation
- Voltage and current-to-frequency conversion
- Stable phase-locked loop
- Waveform generation triangle, sawtooth, pulse, squarewave
- FM and sweep generation

Connection Information

14-Lead
Dual In-Line Package
(Top View)



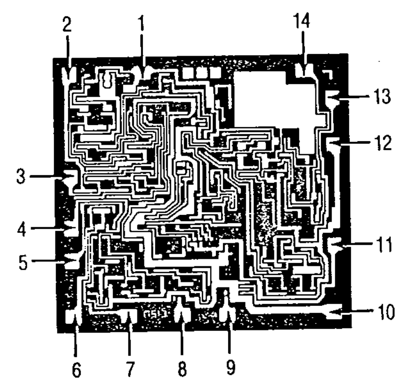
Description

The XR-2207 is a monolithic voltage-controlled oscillator (VCO) integrated circuit featuring excellent frequency stability and a wide tuning range. The circuit provides simultaneous triangle and squarewave outputs over a frequency range of 0.01Hz to 1MHz. It is ideally suited for FM, FSK, and sweep or tone generation, as well as for phase-locked loop applications.

As shown in the Schematic Diagram, the circuit is comprised of four functional blocks: a variable-frequency oscillator which generates the basic periodic waveforms; four current switches actuated by binary keying inputs; and buffer amplifiers for both the triangle and squarewave outputs. The internal switches transfer the oscillator current to any of four external timing resistors to produce four discrete frequencies which are selected according to the binary logic levels at the keying terminals (pins 8 and 9).

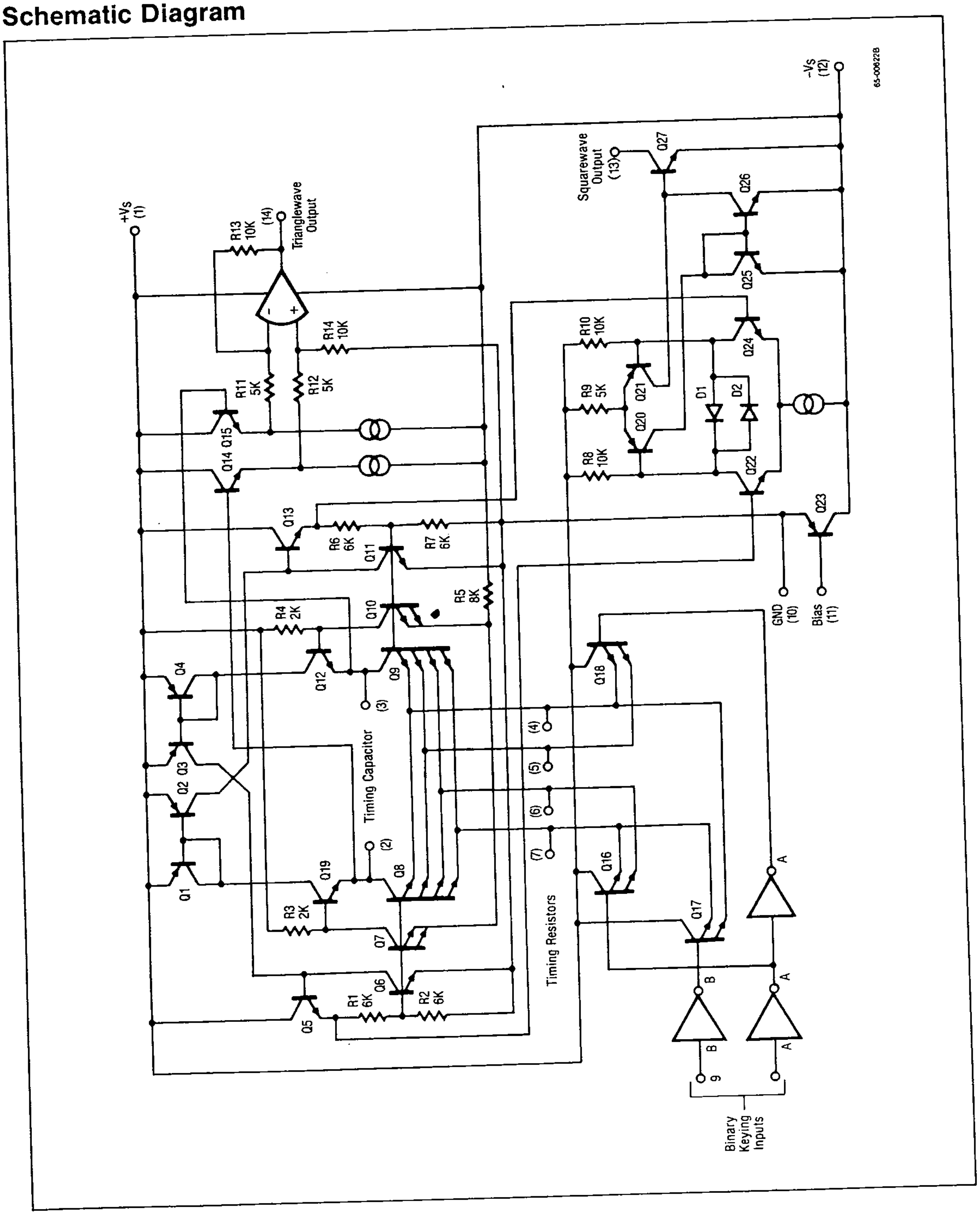
The XR-2207 has a typical drift specification of 20ppm/°C. The oscillator frequency can be linearly swept over a 1000:1 range with an external control voltage; and the duty cycle of both the triangle and the squarewave outputs can be varied from 0.1% to 99.9% to generate stable pulse and sawtooth waveforms.

Mask Pattern



Die Size: 85 x 80 mils
Min. Pad Dimensions: 4 x 4 mils

Schematic Diagram



XR-2207

Voltage-Controlled Oscillator

Absolute Maximum Ratings

Supply Voltage .... +26V
Storage Temperature
Range .... -65°C to +150°C

Thermal Characteristics

	14-Lead Plastic DIP	14-Lead Ceramic DIP
Max. Junction Temp.	125°C	175°C
Max. P_D T_A < 50°C	468mW	1042mW
Therm. Res. θ_{JC}	—	60°C/W
Therm. Res. θ_{JA}	160°C/W	120°C/W
For T_A > 50°C Derate at	6.25mW per °C	8.33mW per °C

Ordering Information

Part Number	Package	Operating Temperature Range
XR-2207CN	Ceramic	0°C to +75°C
XR-2207CP	Plastic	0°C to +75°C
XR-2207N	Ceramic	-40°C to +85°C
XR-2207P	Plastic	-40°C to +85°C
XR-2207M	Ceramic	-55°C to +125°C
XR-2207M/883C*	Ceramic	-55°C to +125°C

*MIL-STD-883, Level C Processing

Electrical Characteristics

(Test Circuit of Figure 1, V_S = ±6V, T_A = +25°C = 5000pF, R1 = R2 = R3 = R4 = 20kΩ, R_L = 4.7kΩ, Binary inputs grounded, S1 and S2 closed unless otherwise specified)

Parameters	Test Conditions	XR-2207			XR-2207C			Units
		Min	Typ	Max	Min	Typ	Max	
General Characteristics								
Supply Voltage Single Supply Split Supplies	See Typical Performance Characteristics	+8.0 ±4	+12 ±6	+26 ±13	+8.0 ±4	+12 ±6	+26 ±13	V
Supply Current Single Supply	Measured at pin 1, S1 open (See Fig. 2)		5.0	7.0		5.0	8.0	mA
Split Supplies Positive	Measured at pin 1, S1 open (See Fig. 1)		5.0	7.0		5.0	8.0	mA
Negative	Measured at pin 12, S1, S2 open		4.0	6.0		4.0	7.0	mA
Binary Keying Inputs								
Switching Threshold	Measured at pins 8 and 9. Refer to pin 10	1.4	2.2	2.8	1.4	2.2	2.8	V
Input Resistance			5.0			5.0		kΩ

XR-2207 Voltage-Controlled Oscillator

Electrical Characteristics (Continued)

Parameters	Test Conditions	XR-2207 Min	XR-2207 Typ	XR-2207 Max	XR-2207C Min	XR-2207C Typ	XR-2207C Max	Units
Oscillator Section — Frequency Characteristics								
Upper Frequency Limit	C = 500pF, R3 = 2kΩ	0.5	1.0		0.5	1.0		MHz
Lower Practical Frequency	C = 50μF, R3 = 2Ω		0.01			0.01		Hz
Frequency Accuracy			±1.0	±3.0		±1.0	±5.0	% of f_0
Frequency Matching			0.5			0.5		% of f_0
Frequency Stability Vs. Temperature	0°C < T_A < +75°C		20	50		30		ppm/°C
Vs. Supply Voltage			0.15			0.15		%/V
Sweep Range	R3 = 1.5kΩ for f_H R3 = 2MΩ for f_L	1000:1	3000:1			1000:1		f_H/f_L
Sweep Linearity 10:1 Sweep	C = 5000pF f_H = 10kHz, f_L = 1kHz		1.0	2.0		1.5		%
1000:1 Sweep	f_H = 100kHz, f_L = 100Hz		5.0			5.0		%
FM Distortion	±10% FM Deviation		0.1			0.1		%
Recommended Range of Timing Resistors	See Characteristic Curves	1.5		2000	1.5		2000	kΩ
Impedance at Timing Pins	Measured at pins 4, 5, 6 or 7		75			75		Ω
DC Level at Timing Terminals			10			10		mV
Output Characteristics								
Triangle Output Amplitude	Measured at pin 14	4	6		4	6		V_{p-p}
Impedance			10			10		Ω
DC Level	Referenced to pin 10		+100			+100		mV
Linearity	from 10% to 90% of swing		0.1			0.1		%
Squarewave Output Amplitude	Measured at pin 13, S2 Closed	11	12		11	12		V_{p-p}
Saturation Voltage	Referenced to pin 12		0.2	0.4		0.2	0.4	V
Rise Time	$C_L \leq 10pF$		200			200		nS
Fall Time	$C_L \leq 10pF$		20			20		nS

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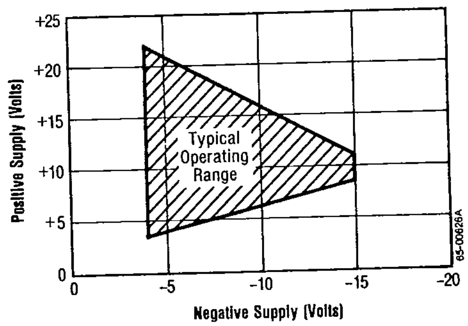
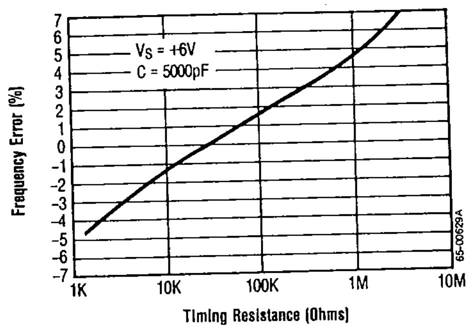
Typical Performance Characteristics

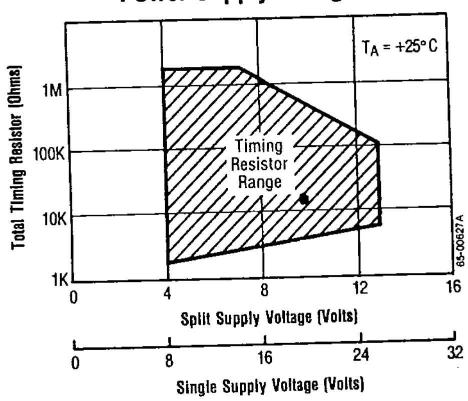
Typical Operating Range for Split Supply Voltage



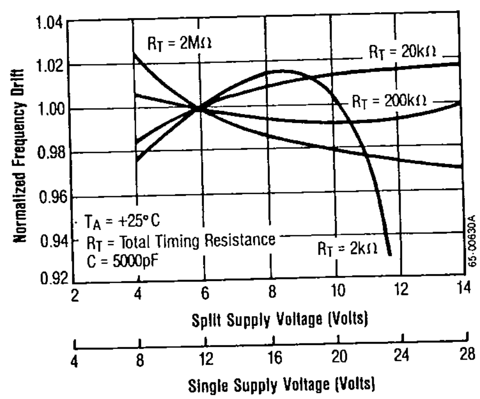
Frequency Accuracy vs. Timing Resistance



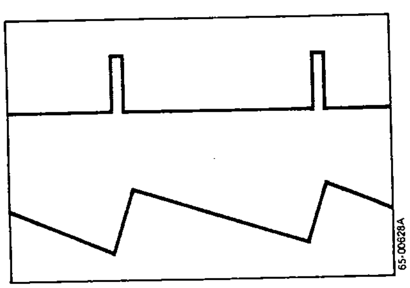
Recommended Timing Resistor Value vs. Power Supply Voltage*



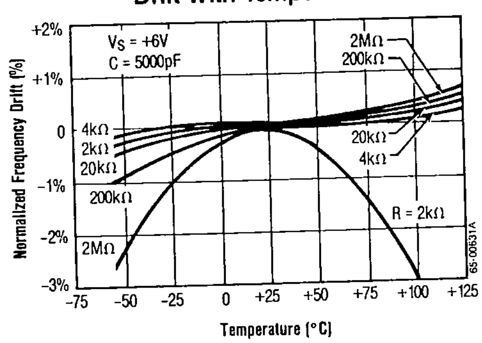
Frequency Drift vs. Supply Voltage



Pulse and Sawtooth Outputs



Normalized Frequency Drift With Temperature



* R_T = Parallel Combination of Activated Timing Resistors

Description of Circuit Controls

Timing Capacitor (pins 2 and 3)
The oscillator frequency is inversely proportional to the timing capacitor, C. The minimum capacitance value is limited by stray capacitances and the maximum value by physical size and leakage current considerations. Recommended values range from 100pF to 100μF. The capacitor should be non-polarized.

Timing Resistors (pins 4, 5, 6, and 7)
The timing resistors determine the total timing current, I_T, available to charge the timing capacitor. Values for timing resistors can range from 1.5kΩ to 2MΩ; however, for optimum temperature and power supply stability, recommended values are 4kΩ to 200kΩ. To avoid parasitic pick up, timing resistor leads should be kept as short as possible. For noisy environments, unused or deactivated timing terminals should be bypassed to ground through 0.1μF capacitors. Otherwise, they may be left open.

Supply Voltage (pins 1 and 12)
The XR-2207 is designed to operate over a power supply range of ±4V to ±13V for split supplies, or 8V to 26V for single supplies. At high supply voltages, the frequency sweep range is reduced. Performance is optimum for ±6V, or 12V single supply operation.

Binary Keying Inputs (pins 8 and 9)
The internal impedance at these pins is approximately 5kΩ. Keying levels are <1.4V for "zero" and >3V for "one" logic levels referenced to the DC voltage at pin 10.

Bias for Single Supply (pin 11)
For single supply operations, pin 11 should be externally biased to a potential between $+V_S/3V$ and $+V_S/2V$ (see Figure 1). The bias current at pin 11 is nominally 5% of the total oscillation timing current I_T.

Ground (pin 10)
For split supply operation, this pin serves as circuit ground. For single supply operation, pin 10 should be AC grounded through a 1μF bypass capacitor. During split supply operation, a ground current of 2 I_T flows out of this terminal, where I_T is the total timing current.

Squarewave Output (pin 13)
The squarewave output at pin 13 is an "open-collector" stage capable of sinking up to 20mA of load current. R_L serves as a pull-up load resistor for this output. Recommended values for R_L range from 1kΩ to 10kΩ.

Triangle Output (pin 14)
The output at pin 14 is a triangle wave with a peak swing of approximately one-half of the total supply voltage. Pin 14 has a very low output impedance of 10Ω and is internally protected against short circuits.

Note: Triangle waveform linearity is sensitive to parasitic coupling between the square and the triangle-wave outputs (pins 13 and 14). In board layout or circuit wiring care should be taken to minimize stray wiring capacitance between these pins.

Operating Instructions

Precautions
The following precautions should be observed when operating the XR-2207 family of integrated circuits:

1. Pulling excessive current from the timing terminals will adversely effect the temperature stability of the circuit. To minimize this disturbance, it is recommended that the total current drawn from pins 4, 5, 6, and 7 be limited to <6mA. In addition, permanent damage to the device may occur if the total timing current exceeds 10mA.
2. Terminals 2, 3, 4, 5, 6, and 7 have very low internal impedance and should, therefore, be protected from accidental shorting to ground or the supply voltages.
3. The keying logic pulse amplitude should not exceed the supply voltage.

Split Supply Operation
Figure 1 is the recommended circuit connection for split supply operation. The frequency of operation is determined by the timing capacitor, C, and the activated timing resistors (R1 through R4). The timing resistors are activated by the logic signals at the binary keying inputs (pins 8 and 9), as shown in Table 1. If a single timing resistor is activated, the frequency is 1/RC.

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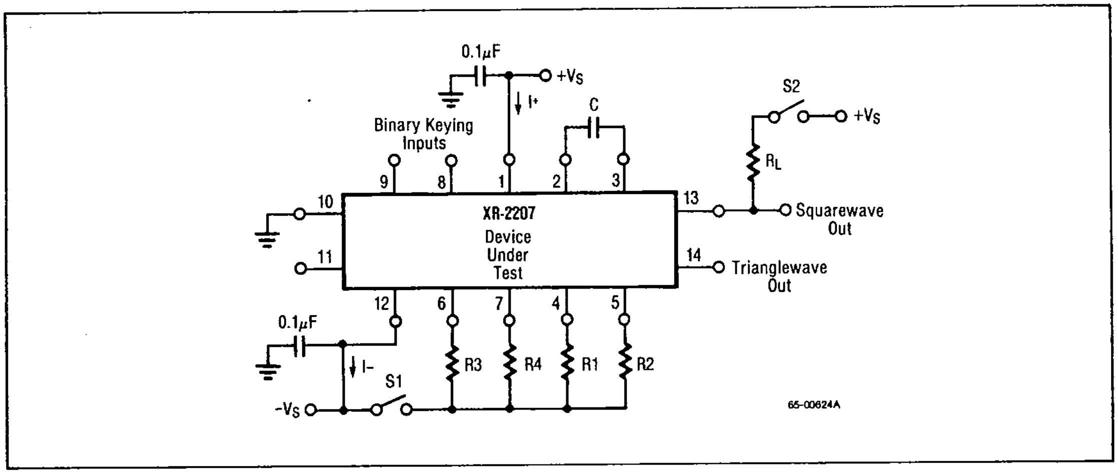

Figure 1. Test Circuit for Split Supply Operation

Table 1. Logic Table for Binary Keying Controls

Logic Level 8	Logic Level 9	Selected Timing Pins	Frequency	Definitions
0	0	6	f_1	$f_1 = 1/R3C$, $\Delta f_1 = 1/R4C$
0	1	6 and 7	$f_1 + \Delta f_1$	$f_2 = 1/R2C$, $\Delta f_2 = 1/R1C$
1	0	5	f_2	Logic Levels: 0 = Ground
1	1	4 and 5	$f_2 + \Delta f_2$	Logic Levels: 1 = >3V

Note: For single-supply operation, logic levels are referenced to voltage at pin 10.

Otherwise, the frequency is either 1/(R1||R2)C or 1/(R1||R4)C.

The squarewave output is obtained at pin 13 and has a peak-to-peak voltage swing equal to the supply voltages. This output is an "open-collector" type and requires an external pull-up load resistor (nominally 5kΩ) to the positive supply. The triangle waveform obtained at pin 14 is centered about ground and has a peak amplitude of $+V_S/2$.

The circuit operates with supply voltages ranging from ±4V to ±13V. Minimum drift occurs with ±6V supplies.

Single Supply Operation

The circuit should be interconnected as shown in Figure 2 for single supply operation. Pin 12 should be grounded, and pin 11 biased from $+V_S$ through a resistive divider to a value of bias voltage between $+V_S/3$ and $+V_S/2$. Pin 10 is bypassed to ground through a 0.1μF capacitor.

For single supply operation, the DC voltage at pin 10 and the timing terminals (pins 4 through 7) are equal and approximately 0.6V above V_B, the bias voltage at pin 11. The logic levels at the binary keying terminals are referenced to the voltage at pin 10.

On-Off Keying

The XR-2207 can be keyed on and off by simply activating an open circuited timing pin. Under certain conditions, the circuit may exhibit very low frequency (<1Hz) residual oscillation in the "off" state due to internal bias current. If this effect is undesirable, it can be eliminated by connecting a 10MΩ resistor from 3 to $+V_S$.

Frequency Control (Sweep and FM)

The frequency of operation is controlled by varying the total timing current, I_T, drawn from the activated timing pins 4, 5, 6, or 7. The timing current can be modulated by applying a control voltage, V_C, to the activated timing pin through a series resistor R_C as shown in Figure 3.

For split supply operation, a *negative* control voltage, V_C, applied to the circuit of Figure 3 causes the total timing current, I_T, and the frequency, to increase.

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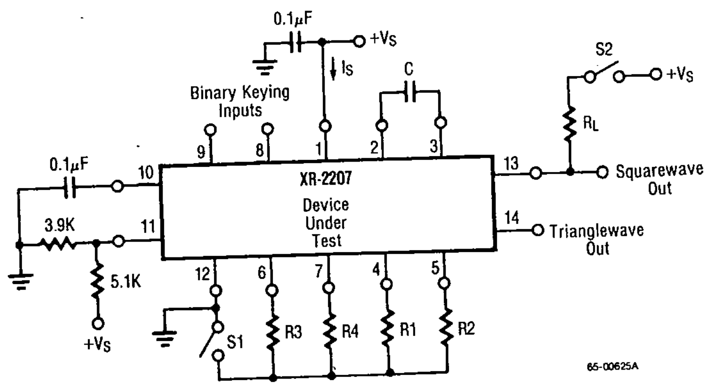

Figure 2. Test Circuit for Single Supply Operation

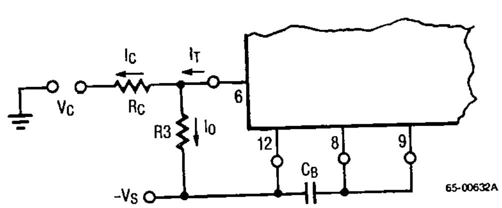

Figure 3. Frequency Sweep Operation

As an example, in the circuit of Figure 3, the binary keying inputs are grounded. Therefore, only timing pin 6 is activated.

The frequency of operation is determined by:

$$f = \frac{1}{R3C_B}\left[1 - \frac{V_C R3}{(R_C)(-V_S)}\right] \text{Hz}$$

Pulse and Sawtooth Operation

The duty cycle of the output waveforms can be controlled by frequency shift keying at the end of every half cycle of oscillator output. This is accomplished by connecting one or both of the binary keying inputs (pins 8 or 9) to the square-wave output at pin 13. The output waveforms can then be converted to positive or negative pulses and sawtooth waveforms.

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T-50-15

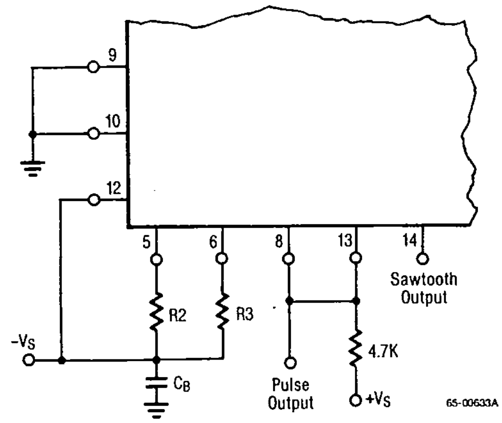

Figure 4. Pulse and Sawtooth Generation

Figure 4 is the recommended circuit connection for duty cycle control. Pin 8 is shorted to pin 13 so that the circuit switches between the "0,0" and the "1,0" logic states given in Table 1. Timing pin 5 is activated when the output is "high", and pin 6 is activated when the squarewave output goes to a "low" state.

The duty cycle of the output waveforms is given as:

$$\text{Duty Cycle} = \frac{R2}{R2 + R3}$$

and can be varied from 0.1% to 99.9% by proper choice of timing resistors. The frequency of oscillation, f, is given as:

$$f = \frac{2}{C}\left[\frac{1}{R2 + R3}\right]$$

The frequency can be modulated or swept without changing the duty cycle by connecting R2 and R3 to a common control voltage V_C instead of to $-V_S$. The sawtooth and the pulse output waveforms are shown in the Typical Performance Characteristics Graphs.