Micropower Dual Timer

GENERAL DESCRIPTION

The XR-L556 dual timer contains two independent micropower timer sections on a monolithic chip. It is a direct replacement for the conventional 556-type dual timers, for applications requiring very low power dissipation. Each section of the XR-L556 dual timer is equivalent to Exar's XR-L555 micropower timer. The circuit dissipates only 1/15th of the stand-by power of conventional dual timers and can operate down to 2.5 volts without sacrificing such key features as timing accuracy and stability. At 5 volt operation, typical power dissipation of the dual-timer circuit is less than 2 mW; and it can operate in excess of 500 hours with only two 300 mA-Hr NiCd batteries.

The two timer sections of the circuit have separate controls and outputs, but share common supply and ground terminals. Each output can source up to 100 mA of output current or drive TTL circuits.

FEATURES

Replaces two XR-L555 Micropower Timers
Pin Compatible with Standard 556-Type Dual Timer
Less than 1 mW Power Dissipation per Section (V_{CC} = 5V)
Timing from Microseconds to Minutes
Over 500-Hour Operation with 2 NiCd Batteries Low Voltage Operation (V_{CC} = 2.5V)
Operates in Both Monostable and Astable Modes
CMOS TTL and DTL Compatible Outputs
Introduces No Switching Transients

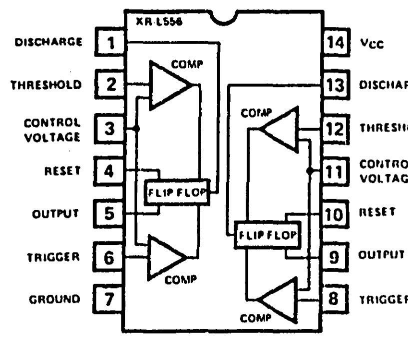
APPLICATIONS

Battery Operated Timing
Micropower Clock Generator
Pulse Shaping and Detection
Micropower PLL Design
Power-On Reset Controller
Micropower Oscillator
Sequential Timing
Pulse-Width Modulation
Appliance Timing
Remote-Control Sequencer

ABSOLUTE MAXIMUM RATINGS

Power Supply	18V
Power Dissipation	
Ceramic Dual-In-Line	750 mW
Derate above T_A = 25°C	6 mW/°C
Plastic Dual-In-Line	625 mW
Derate above T_A = 25°C	5 mW/°C
Storage Temperature Range	−65°C to +150°C

FUNCTIONAL BLOCK DIAGRAM



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ORDERING INFORMATION

Part Number	Package	Operating Temperature
XR-L556 M	Ceramic	−55°C to +125°C
XR-L556 CN	Ceramic	0°C to +70°C
XR-L556 CP	Plastic	0°C to +70°C

SYSTEM DESCRIPTION

The XR-L556 is a micropower version of the industry standard XR-556 timing circuit, capable of both monostable and astable operation with timing intervals ranging from low microseconds up through several hours. Timing is independent of supply voltage, which may range from 2.5 V to 15 V. The output stage can source 100 mA. Each timer section is fully independent and similar to the XR-L555.

In the monostable (one shot) mode, timing is determined by one resistor and capacitor. Astable operation (oscillation) requires an additional resistor, which controls duty cycle. An internal resistive divider provides a reference voltage of 2/3 V_{CC}, which produces a timing interval of 1.1 RC. As the reference is related to V_{CC}, the interval is independent of supply voltage; however, for maximum accuracy, the user should ensure V_{CC} does not vary during timing.

The output of the XR-L556 is high during the timing interval. It is triggered and reset on falling waveforms. The control voltage inputs (Pins 3 and 11) may serve as pulse width modulation points.

XR-L556

ELELTRICAL CHARACTERISTICS

Test Conditions: (T_A = 25°DC, V_{CC} = +5V, unless otherwise specified)

PARAMETERS	XR-L556M MIN	XR-L556M TYP	XR-L556M MAX	XR-L556C MIN	XR-L556C TYP	XR-L556C MAX	UNITS	CONDITION
Supply Voltage	2.5		15	2.7		15	V	
Supply Current (Each Timer Section)		150	300		200	500	µA	Low State Output V_{CC} = 5V, R_L = ∞
Total Supply Current (Both Timer Sections)		300	600		400	1000	µA	
Timing Error								R_A, R_B = 1 KΩ to 100 KΩ
Initial Accuracy		0.5			1.0		%	C = 0.1 µF
Drift with Temperature		50	200		50		ppm/°C	0°C ≤ T_A ≤ 70°C
Drift with Supply Voltage		0.5			0.5		%/V	Monostable Operation
Threshold Voltage		2/3			2/3		X V_{CC}	
Trigger Voltage	1.45	1.67	1.9		1.67		V	V_{CC} = 5V
	4.8	5.0	5.2		5.0		V	V_{CC} = 15V
Trigger Current		20			20		nA	
Reset Voltage	0.4	0.7	1.0	0.4	0.7	1.0	V	
Reset Cureerent		10			10		µA	
Threshold Current		10	50		20	100	nA	
Control Voltage Level	2.90	3.33	3.80	2.60	3.33	4.00	V	V_{CC} = 5V
	9.6	10.0	10.4	9.0	10.0	11.0	V	V_{CC} = 15V
Output Voltage Drop (Low)		0.1	0.3		0.15	0.35	V	I_{sink} = 1.5 mA
Output Voltage Drop (High)								I_{source} = 10mA
	3.0	3.3		2.75	3.3		V	V_{CC} = 5V
	13	13.3		12.75	13.3		V	V_{CC} = 15V
								I_{source} = 100 mA
		12.5			12.5		V	V_{CC} = 15V
Rise Time of Output		200			200		nsec	
Fall Time of Output		100			100		nsec	
Discharge Transistor Leakage		0.1			0.1		µA	

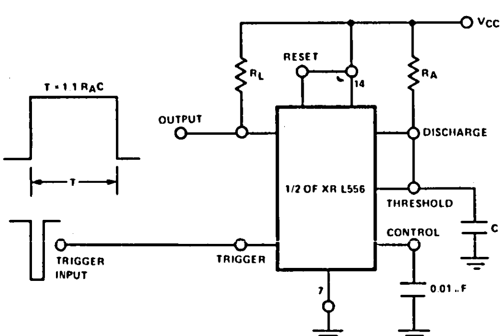


Figure 1. Monostable (One-Shot) Circuit

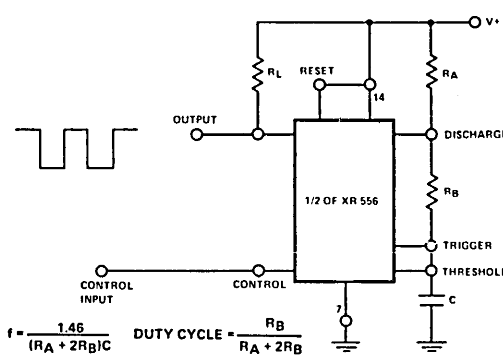


Figure 2. Astable (Free-Running) Circuit

CHARACTERISTIC CURVES

GENERAL CHARACTERISTICS

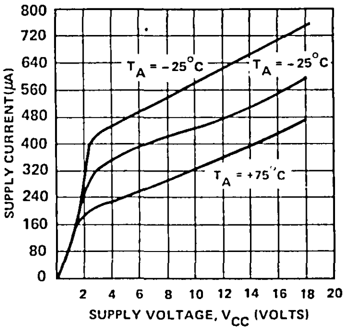


Figure 3. Total Supply Current as a Function of Supply Voltage

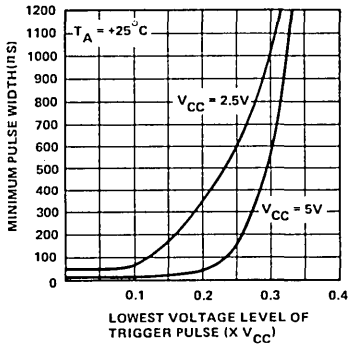


Figure 4. Minimum Pulse-Width Required for Triggering

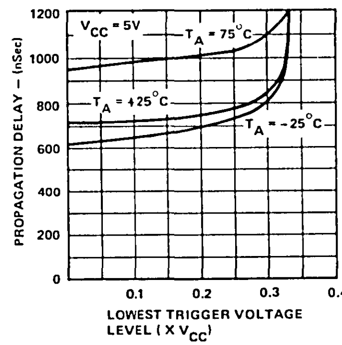


Figure 5. Propagation Delay as a Function of Voltage Level of Trigger Pulse

MONOSTABLE OPERATION

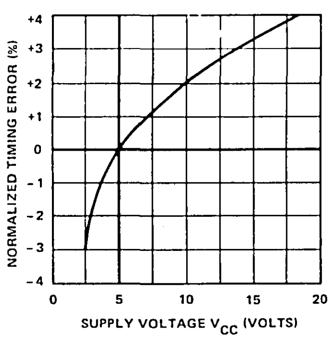


Figure 6. Typical Timing Accuracy as a Function of Supply Voltage

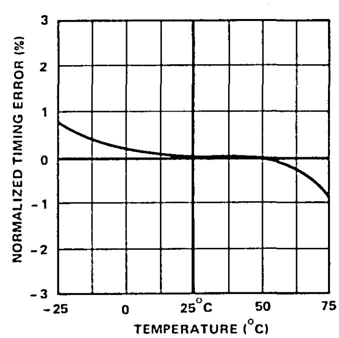


Figure 7. Typical Timing Accuracy as a Function of Temperature
($V_{CC} = 5V$, $R_A = 100K\Omega$, $C = 0.01\mu F$)

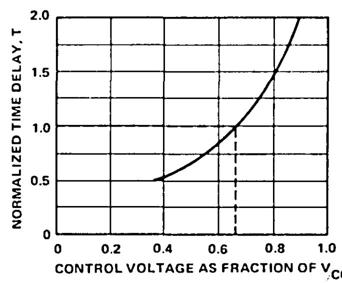


Figure 8. Normalized Time Delay as a Function of Control Voltage

ASTABLE OPERATION

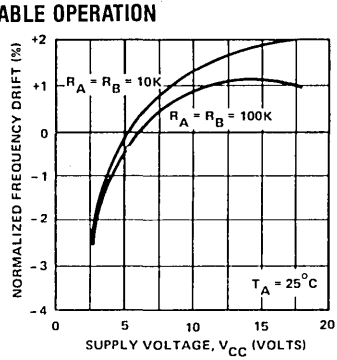


Figure 9. Typical Frequency Stability as a Function of Supply Voltage

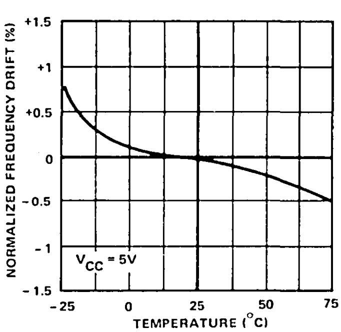


Figure 10. Typical Frequency Stability as a Function of Temperature
($R_A = R_B = 10K\Omega$, $C = 0.1\mu F$)

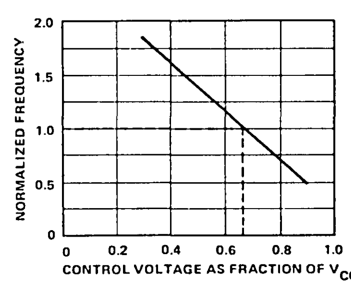


Figure 11. Normalized Frequency of Oscillation as a Function of Control Voltage

XR-L556

FEATURES OF XR-L556

The XR-L556 micropower dual timer is, in most instances, a direct pin-for-pin replacement for the conventional 556-type dual timer. However, compared to conventional 556-timer, it offers the following important performance features:

Reduced Power Dissipation: The current drain is 1/15th of the conventional 556-type dual timer.

No Supply Current Transients: The conventional 556-timer can produce 300 to 400 mA of supply current spikes during switching of either one of its timer sections. The XR-L556 is virtually transient-free as shown in Figure 12.

Low-Voltage Operation: The XR-L556 operates down to 2.7 volts of supply voltage, vs. 4.5V minimum operating voltage needed for conventional 556-timer. Thus, the XR-L556 can operate safely and reliably with two 1.5V NiCd batteries.

Proven Bipolar Technology: The XR-L556 is fabricated using conventional bipolar process technology. Thus, it is immune to electrostatic burn-out problems associated with low-power timers using CMOS technology.

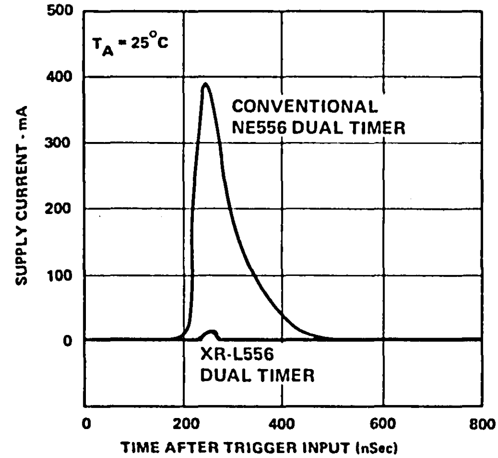


Figure 12. Comparison of Supply Current Transient of Conventional NE556 Dual Timer with XR-L556 Micropower Dual Timer

PRINCIPLES OF OPERATION

MONOSTABLE (ONE-SHOT) OPERATION

The circuit connection for monostable, or one-shot operation is one of the timer sections of the XR-L556 is shown in Figure 1. The internal flip-flop is triggered by lowering the trigger level to less than 1/3 of V_{CC}. The circuit triggers on a negative-going slope. Upon triggering, the flip-flop is set, which releases the short circuit across the capacitor and also moves the output level toward V_{CC}. The voltage across the capacitor, therefore, starts increasing exponentially with a time constant $\tau = R_A C$. A comparator is referenced to 2/3 V_{CC} with the use of three equal internal resistors. When the voltage across the capacity reaches this level, the flip-flop is reset, the capacitor is discharged rapidly, the output level moves toward ground and the timing cycle is completed. The duration of the timing period, T, during which the output logic level is at a "high" state is given by the equation:

$$T = 1.1\, R_A C$$

This time delay varies linearly with the choice of R_A and C as shown by the timing curves of Figure 13. For proper operation of the circuit, the trigger pulse-width *must be* less than the timing period.

Once the circuit is triggered it is immune to additional trigger inputs until the present period has been completed. The timing-cycle can be interrupted by using the reset control. When the reset control is "low", the internal discharge transistor is turned "on" and prevents the capacitor from charging. As long as the reset voltage is applied, the digital output level will remain unchanged i.e. "low". The reset pin should be connected to $+V_{CC}$ when not used to avoid the possibility of false triggering.

ASTABLE (SELF-TRIGGERING) OPERATION

For astable (or self-triggering) operation, the correct circuit connection is shown in Figure 2. The external capacitor charges to 2/3 V_{CC} through the series combination of R_A and R_B, and discharges to 1/3 V_{CC} through R_B. In this manner, the capacitor voltage oscillates between 1/3 V_{CC} and 2/3 V_{CC}, with an exponential waveform. The output level at pin 5 (or 9) is high during the charging cycle, and goes low during the discharge cycle. The charge and the discharge times are independent of supply voltage. The oscillations can be keyed "on" and "off" using the reset controls (pin 4 or 10).

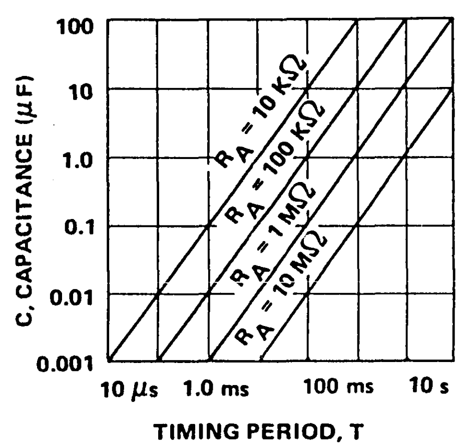


Figure 13. Timing Period, T, as a Function of External R-C Network

The charge time (output high) is given by:

$$t_1 = 0.695\,(R_A + R_B)C$$

The discharge time (output low) by:

$$t_2 = 0.695\,(R_B)C$$

Thus the total period is given by:

$$T = t_1 + t_2 = 0.695\,((R_A + 1R_B)C$$

The frequency of oscillation is then:

$$f = \frac{1}{T} = \frac{1.44}{(R_A + 2R_B)C} \text{ and}$$

may be easily found as shown in Figure 14.

The duty cycle D, is given by:

$$D = \frac{R_B}{R_A + 2R_B}$$

APPLICATIONS INFORMATION

INDEPENDENT TIME DELAYS

Each timer section of the XR-L556 can operate as an independent timer to generate a time delay, T, set by the respective external timing components. Figure 15 is a circuit connection where each section is used separately in the monostable mode to produce respective time delays of T_1 and T_2, where:

$$T_1 = 1.1\,R_1C_1 \text{ and } T_2 = 1.1\,R_2C_2$$

SEQUENTIAL TIMING (DELAYED ONE-SHOT)

In this application, the output of one timer section (Timer 1) is capacitively coupled to the trigger terminal of the second, as shown in Figure 16. When Timer 1 is triggered at pin 6, its output at pin 5 goes "high" for a time duration $T_1 = 1.1\,R_1C_1$. At the end of this timing cycle, pin 5 goes "low" and triggers Timer 2 through the capacitive coupling, C_C, between pins 5 thru 8. Then, the output at pin 9 goes "high" for a time duration

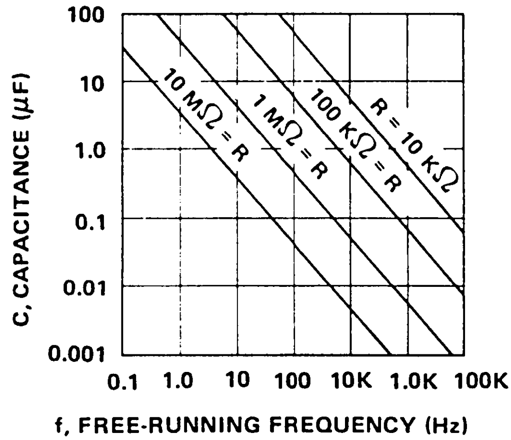


Figure 14. Free Running Frequency as a Functionof External Timing Components (Note: $R = R_A + 2R_B$)

$T_2 = 1.1\,R_2C_2$. In this manner, the unit behaves as a "delayed one-shot" where the output of Timer 2 is delayed from the initial trigger at pin 6 by a time delay of T_1

KEYED OSCILLATOR

One of the timer sections of the XR-L556 can be operated in its free-running mode, and the other timer section can be used to key it "on" and "off". A recommended circuit connection is shown in Figure 17. Timer 2 is used as the oscillator section, and its frequency is set by the resistors R_A, R_B and the capacitor C_2. Timer 1 is operated as a monostable circuit, and its output is connected to the reset terminal (pin 10 of Timer 2).

When the circuit is at rest, the logic level at the output of Timer 1 is "low"; and the oscillations of Timer 2 are inhibited. Upon application of a trigger signal to Timer 1, the logic level at pin 1 goes "high" and the oscillator section (Timer 2) is keyed "on". Thus, the output of Timer 2 appears as a tone burst whose frequency is set by R_A, R_B and C_2, and whose duration is set by R_1 and C_1 of Figure 17.

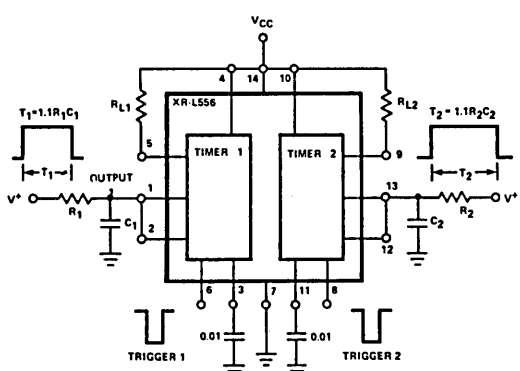


Figure 15. Generation of Two Independent Time Delays

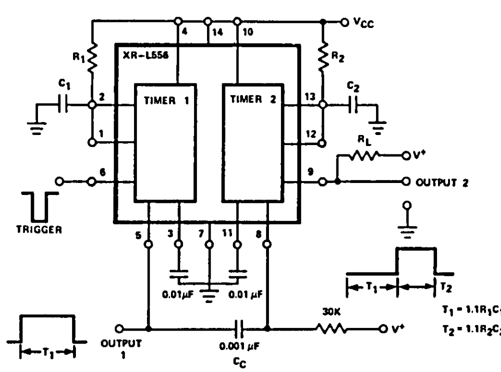


Figure 16. Sequential Timing

XR-L556

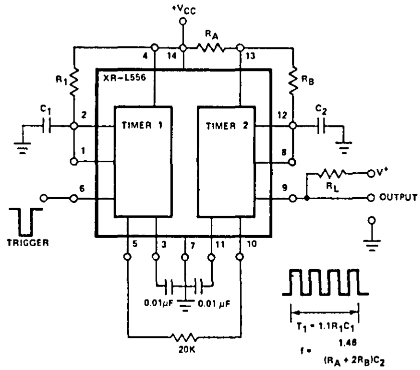


Figure 17. Keyed Oscillator

FREQUENCY DIVIDER AND PULSE SHAPER

If the frequency of the input is known, each timer section of the XR-L556 can be used as a frequency divider by adjusting the length of its timing cycle. If the timing interval T_1 (= 1.1 R_1C_1) is larger than the period of the input pulse trigger, then only those input pulses which are spaced more than 1.1 R_1C_1 will actually trigger the circuit.

The output frequency is equal to (1/N) times the input frequency. The division factor N is in the range:

$$\frac{T}{T_P} - 1 < N < \frac{T}{T_P}$$

where T_P is the period of the input pulse signal.

Since the two timer sections of the XR-L556 are electrically independent, each can be used as a frequency divider. Thus, if the trigger terminals of both timer sections are connected to a common input, the XR-L556 can produce two independent outputs at frequencies f_1 and f_2:

$$f_1 = f_2/N_1 \text{ and } f_2 = f_2 = f_S/N_2$$

Where N_1 and N_2 are the division factors for respective timer sections, set by external resistors and capacitors at pins (1, 2) and (12, 13).

Frequency division can be performed by 1/2 of the XR-L556. The remaining timer section can be used as a "pulse-shaper" to adjust the duty cycle of the output waveform. As seen in Figure 18, Timer 1 is used as the frequency divider section and Timer 2 is used as the pulse shaper.

The output of Timer 1 (pin 5) triggers Timer 2, which produces an output pulse whose frequency is the same as the output frequency of Timer 1, and whose duty cycle is controlled by the timing resistor and capacitor of Timer 2. The duty cycle of the output of Timer 2 (pin 9) can be adjusted from 1% to 99% by varying the value of R_2.

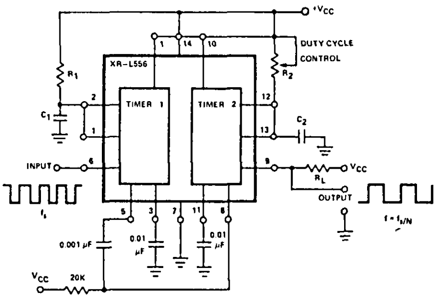


Figure 18. Frequency Divider and Pulse-Shaper

MICROPOWER OSCILLATOR WITH INDEPENDENT FREQUENCY AND DUTY CYCLE ADJUSTMENT

If Timer 1 is operated in its astable mode and Timer 2 is operated in its monostable mode, as shown in Figure 19, then an oscillator with fixed frequency and variable duty cycle results.

Timer 1 generates a basic periodic waveform that is then used to trigger Timer 2. If the time delay, T_2, of Timer 2 is chosen to be less than the period of oscillations of Timer 1, then the output at pin 9 has the same frequency as Timer 1, but has its duty cycle determined by the timing cycle of Timer 2. The output duty cycle can be adjusted over a wide range (from 1% to 99%) by adjusting R_2.

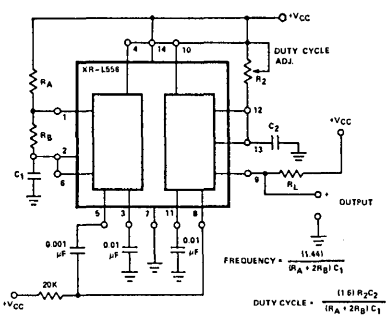
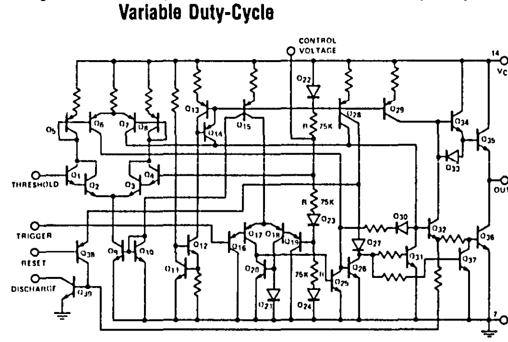


Figure 19. Micropower Oscillator with Fixed Frequency and Variable Duty-Cycle



EQUIVALENT SCHEMATIC DIAGRAM