



NATL SEMICOND (LINEAR)

T-51-19

LM555/LM555C Timer

General Description

The LM555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For astable operation as an oscillator, the free running frequency and duty cycle are accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output circuit can source or sink up to 200 mA or drive TTL circuits.

Features

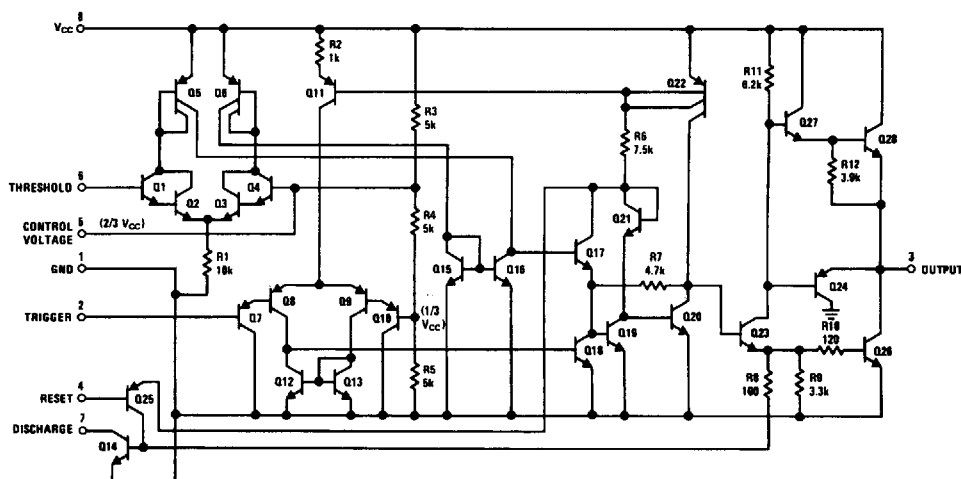
- Direct replacement for SE555/NE555
- Timing from microseconds through hours
- Operates in both astable and monostable modes

- Adjustable duty cycle
- Output can source or sink 200 mA
- Output and supply TTL compatible
- Temperature stability better than 0.005% per °C
- Normally on and normally off output

Applications

- Precision timing
- Pulse generation
- Sequential timing
- Time delay generation
- Pulse width modulation
- Pulse position modulation
- Linear ramp generator

Schematic Diagram



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Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage +18V

Power Dissipation (Note 1)

LM555H, LM555CH 760 mW

LM555, LM555CN 1180 mW

Operating Temperature Ranges

LM555C 0°C to +70°C

LM555 -55°C to +125°C

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Storage Temperature Range -65°C to +150°C

Soldering Information

Dual-In-Line Package

Soldering (10 Seconds) 260°C

Small Outline Package

Vapor Phase (60 Seconds) 215°C

Infrared (15 Seconds) 220°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

Electrical Characteristics ($T_A = 25^\circ\text{C}$, $V_{CC} = +5\text{V}$ to $+15\text{V}$, unless otherwise specified)

Parameter	Conditions	Limits						Units
		LM555			LM555C			
		Min	Typ	Max	Min	Typ	Max	
Supply Voltage		4.5		18	4.5		16	V
Supply Current	$V_{CC} = 5V, R_L = \infty$ $V_{CC} = 15V, R_L = \infty$ (Low State) (Note 2)		3 10	5 12		3 10	6 15	mA mA
Timing Error, Monostable	$R_A = 1k$ to $100k\Omega$, $C = 0.1\mu F$, (Note 3)		0.5			1		%
Initial Accuracy		30			50		ppm/°C	
Drift with Temperature								
Accuracy over Temperature			1.5			1.5		%
Drift with Supply			0.05			0.1		%/V
Timing Error, Astable	$R_A, R_B = 1k$ to $100k\Omega$, $C = 0.1\mu F$, (Note 3)		1.5			2.25		%
Initial Accuracy		90			150		ppm/°C	
Drift with Temperature								
Accuracy over Temperature			2.5			3.0		%
Drift with Supply			0.15			0.30		%/V
Threshold Voltage			0.667			0.667		$\times V_{CC}$
Trigger Voltage	$V_{CC} = 15V$ $V_{CC} = 5V$	4.8 1.45	5 1.67	5.2 1.9		5 1.67		V V
Trigger Current			0.01	0.5		0.5	0.9	μA
Reset Voltage		0.4	0.5	1	0.4	0.5	1	V
Reset Current			0.1	0.4		0.1	0.4	mA
Threshold Current	(Note 4)		0.1	0.25		0.1	0.25	μA
Control Voltage Level	$V_{CC} = 15V$ $V_{CC} = 5V$	9.6 2.9	10 3.33	10.4 3.8	9 2.6	10 3.33	11 4	V V
Pin 7 Leakage Output High			1	100		1	100	nA
Pin 7 Sat (Note 5)								
Output Low	$V_{CC} = 15V, I_L = 15mA$		150			180		mV
Output Low	$V_{CC} = 4.5V, I_L = 4.5mA$		70	100		80	200	mV

NATL SEMICON (LINEAR)

Electrical Characteristics $T_A = 25^\circ\text{C}$, $V_{CC} = +5\text{V}$ to $+15\text{V}$, (unless otherwise specified) (Continued)

Parameter	Conditions	Limits						Units
		LM555			LM555C			
		Min	Typ	Max	Min	Typ	Max	
Output Voltage Drop (Low)	V _{CC} = 15V							
	I _{SINK} = 10 mA		0.1	0.15		0.1	0.25	V
	I _{SINK} = 50 mA		0.4	0.5		0.4	0.75	V
	I _{SINK} = 100 mA		2	2.2		2	2.5	V
	I _{SINK} = 200 mA		2.5			2.5		V
	V _{CC} = 5V							
	I _{SINK} = 8 mA		0.1	0.25				V
	I _{SINK} = 5 mA					0.25	0.35	V
Output Voltage Drop (High)	I _{SOURCE} = 200 mA, V _{CC} = 15V		12.5			12.5		V
	I _{SOURCE} = 100 mA, V _{CC} = 15V	13	13.3		12.75	13.3		V
	V _{CC} = 5V	3	3.3		2.75	3.3		V
Rise Time of Output			100			100		ns
Fall Time of Output			100			100		ns

Note 1: For operating at elevated temperatures the device must be derated above 25°C based on a $+150^\circ\text{C}$ maximum junction temperature and a thermal resistance of $164^\circ\text{C}/\text{w}$ (TO-8), $106^\circ\text{C}/\text{w}$ (DIP) and $170^\circ\text{C}/\text{w}$ (SO-8) junction to ambient.

Note 2: Supply current when output high typically 1 mA less at $V_{CC} = 5\text{V}$.

Note 3: Tested at $V_{CC} = 5\text{V}$ and $V_{CC} = 15\text{V}$.

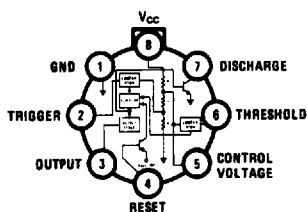
Note 4: This will determine the maximum value of $R_A + R_B$ for 15V operation. The maximum total ($R_A + R_B$) is $20\text{ M}\Omega$.

Note 5: No protection against excessive pin 7 current is necessary providing the package dissipation rating will not be exceeded.

Note 6: Refer to RETS55X drawing of military LM555H and LM555J versions for specifications.

Connection Diagrams

Metal Can Package

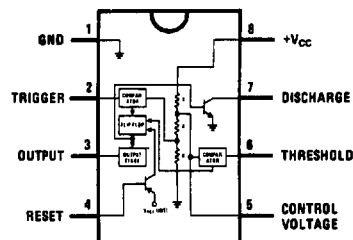


Top View

Order Number LM555H or LM555CH
See NS Package Number H08C

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Dual-In-Line and Small Outline Packages



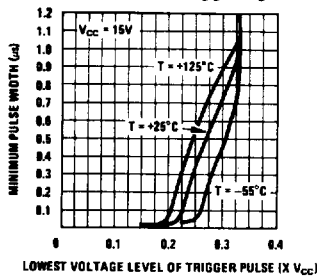
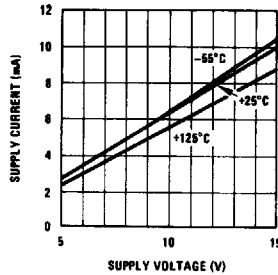
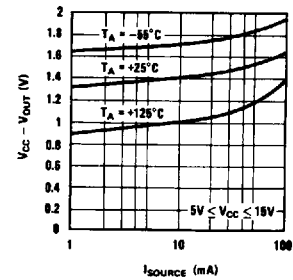
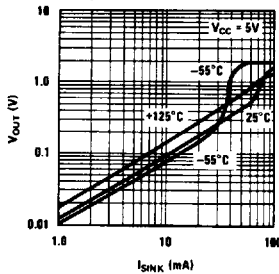
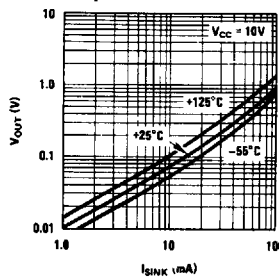
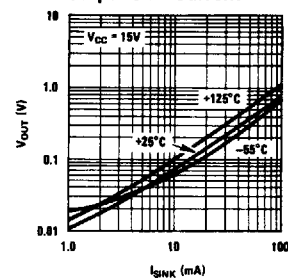
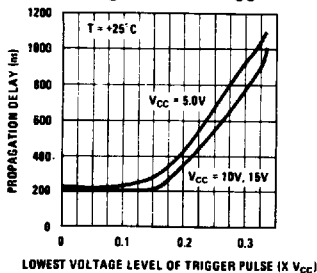
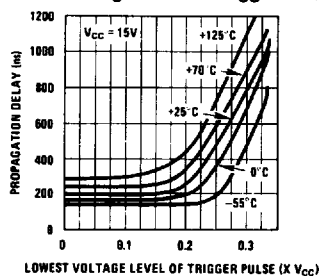
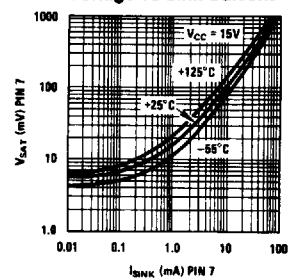
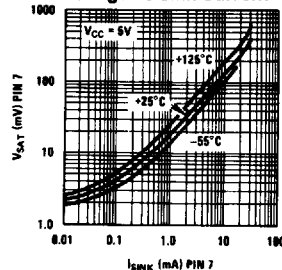
Top View

Order Number LM555J, LM555CJ,
LM555CM or LM555CN
See NS Package Number J08A, M08A or N08E

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Typical Performance Characteristics

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Minimum Pulse Width
Required for TriggeringSupply Current vs
Supply VoltageHigh Output Voltage vs
Output Source CurrentLow Output Voltage vs
Output Sink CurrentLow Output Voltage vs
Output Sink CurrentLow Output Voltage vs
Output Sink CurrentOutput Propagation Delay vs
Voltage Level of Trigger PulseOutput Propagation Delay vs
Voltage Level of Trigger PulseDischarge Transistor (Pin 7)
Voltage vs Sink CurrentDischarge Transistor (Pin 7)
Voltage vs Sink Current

Applications Information

MONOSTABLE OPERATION

In this mode of operation, the timer functions as a one-shot (Figure 1). The external capacitor is initially held discharged by a transistor inside the timer. Upon application of a negative trigger pulse of less than $1/3 V_{CC}$ to pin 2, the flip-flop is set which both releases the short circuit across the capacitor and drives the output high.

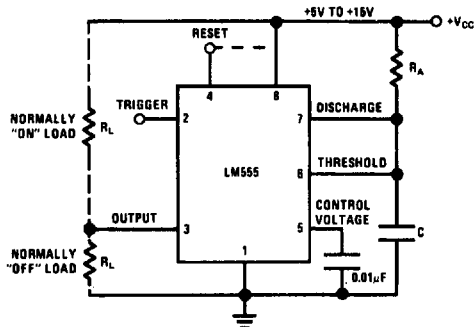
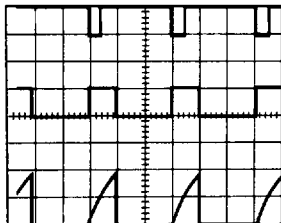


FIGURE 1. Monostable

The voltage across the capacitor then increases exponentially for a period of $t = 1.1 R_A C$, at the end of which time the voltage equals $2/3 V_{CC}$. The comparator then resets the flip-flop which in turn discharges the capacitor and drives the output to its low state. Figure 2 shows the waveforms generated in this mode of operation. Since the charge and the threshold level of the comparator are both directly proportional to supply voltage, the timing interval is independent of supply.



$V_{CC} = 5V$
TIME = 0.1 ms/DIV.
 $R_A = 9.1 k\Omega$
 $C = 0.01 \mu F$

Top Trace: Input 5V/Div.
Middle Trace: Output 5V/Div.
Bottom Trace: Capacitor Voltage 2V/Div.

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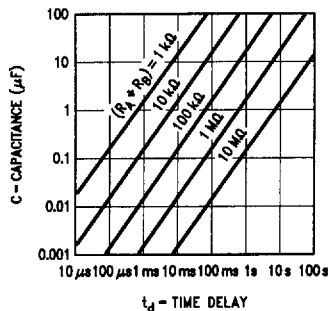
FIGURE 2. Monostable Waveforms

During the timing cycle when the output is high, the further application of a trigger pulse will not effect the circuit so long as the trigger input is returned high at least $10 \mu s$ before the end of the timing interval. However the circuit can be reset during this time by the application of a negative pulse to the reset terminal (pin 4). The output will then remain in the low state until a trigger pulse is again applied.

When the reset function is not in use, it is recommended that it be connected to V_{CC} to avoid any possibility of false triggering.

Figure 3 is a nomograph for easy determination of $R_A C$ values for various time delays.

NOTE: In monostable operation, the trigger should be driven high before the end of timing cycle.

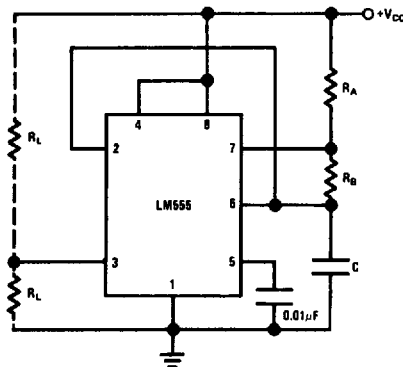


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FIGURE 3. Time Delay

ASTABLE OPERATION

If the circuit is connected as shown in Figure 4 (pins 2 and 6 connected) it will trigger itself and free run as a multivibrator. The external capacitor charges through $R_A + R_B$ and discharges through R_B . Thus the duty cycle may be precisely set by the ratio of these two resistors.



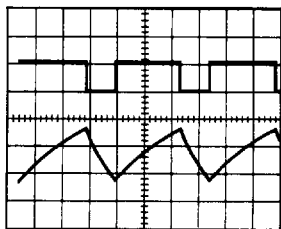
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FIGURE 4. Astable

In this mode of operation, the capacitor charges and discharges between $1/3 V_{CC}$ and $2/3 V_{CC}$. As in the triggered mode, the charge and discharge times, and therefore the frequency are independent of the supply voltage.

Applications Information (Continued)

Figure 5 shows the waveforms generated in this mode of operation.



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$V_{CC} = 5V$
 TIME = 20 μs /Div.
 $R_A = 3.9 k\Omega$
 $R_B = 3 k\Omega$
 $C = 0.01 \mu F$

Top Trace: Output 5V/Div.
 Bottom Trace: Capacitor Voltage 1V/Div.

FIGURE 5. Astable Waveforms

The charge time (output high) is given by:

$$t_1 = 0.693 (R_A + R_B) C$$

And the discharge time (output low) by:

$$t_2 = 0.693 (R_B) C$$

Thus the total period is:

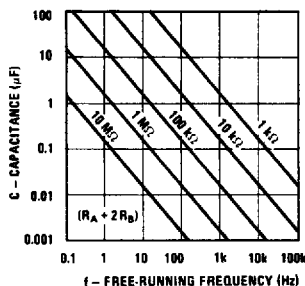
$$T = t_1 + t_2 = 0.693 (R_A + 2R_B) C$$

The frequency of oscillation is:

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

Figure 6 may be used for quick determination of these RC values.

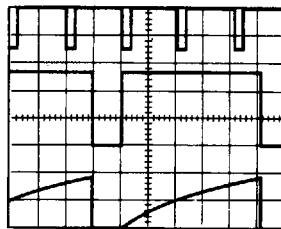
The duty cycle is: $D = \frac{R_B}{R_A + 2R_B}$



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FIGURE 6. Free Running Frequency**FREQUENCY DIVIDER**

The monostable circuit of Figure 1 can be used as a frequency divider by adjusting the length of the timing cycle. Figure 7 shows the waveforms generated in a divide by three circuit.

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$V_{CC} = 5V$
 TIME = 20 μs /Div.
 $R_A = 9.1 k\Omega$
 $C = 0.01 \mu F$

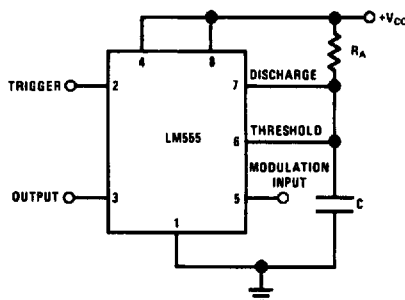
Top Trace: Input 4V/Div.

Middle Trace: Output 2V/Div.

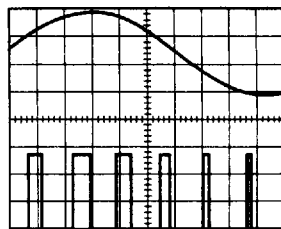
Bottom Trace: Capacitor 2V/Div.

FIGURE 7. Frequency Divider**PULSE WIDTH MODULATOR**

When the timer is connected in the monostable mode and triggered with a continuous pulse train, the output pulse width can be modulated by a signal applied to pin 5. Figure 8 shows the circuit, and in Figure 9 are some waveform examples.



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FIGURE 8. Pulse Width Modulator

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$V_{CC} = 5V$
 TIME = 0.2 ms/Div.
 $R_A = 9.1 k\Omega$
 $C = 0.01 \mu F$

Top Trace: Modulation 1V/Div.

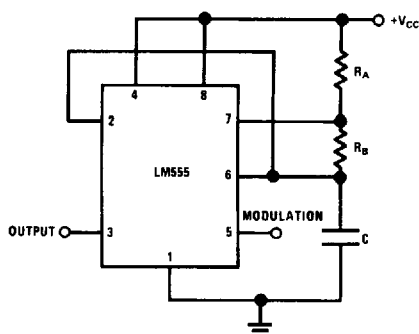
Bottom Trace: Output Voltage 2V/Div.

FIGURE 9. Pulse Width Modulator**PULSE POSITION MODULATOR**

This application uses the timer connected for astable operation, as in Figure 10, with a modulating signal again applied to the control voltage terminal. The pulse position varies with the modulating signal, since the threshold voltage and hence the time delay is varied. Figure 11 shows the waveforms generated for a triangle wave modulation signal.

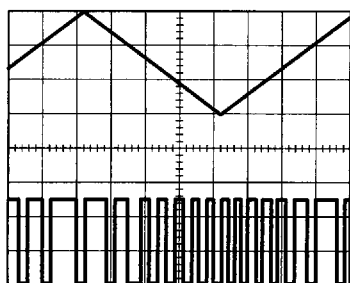
Applications Information (Continued)

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FIGURE 10. Pulse Position Modulator



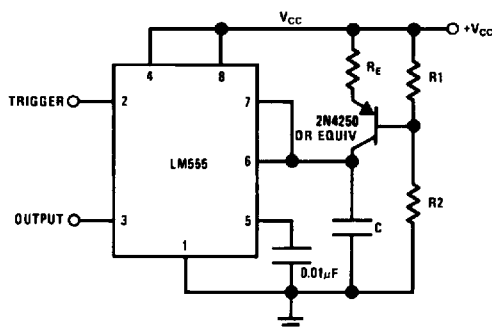
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$V_{CC} = 5V$
 TIME = 0.1 ms/DIV.
 $R_A = 3.9 k\Omega$
 $R_B = 3 k\Omega$
 $C = 0.01 \mu F$

FIGURE 11. Pulse Position Modulator

LINEAR RAMP

When the pullup resistor, R_A , in the monostable circuit is replaced by a constant current source, a linear ramp is generated. Figure 12 shows a circuit configuration that will perform this function.



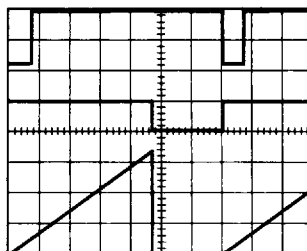
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FIGURE 12

Figure 13 shows waveforms generated by the linear ramp. The time interval is given by:

$$T = \frac{2/3 V_{CC} R_E (R_1 + R_2) C}{R_1 V_{CC} - V_{BE} (R_1 + R_2)}$$

$$V_{BE} \approx 0.6V$$



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$V_{CC} = 5V$
 TIME = 20 μs /DIV.
 $R_1 = 47 k\Omega$
 $R_2 = 100 k\Omega$
 $R_E = 2.7 k\Omega$
 $C = 0.01 \mu F$

FIGURE 13. Linear Ramp

50% DUTY CYCLE OSCILLATOR

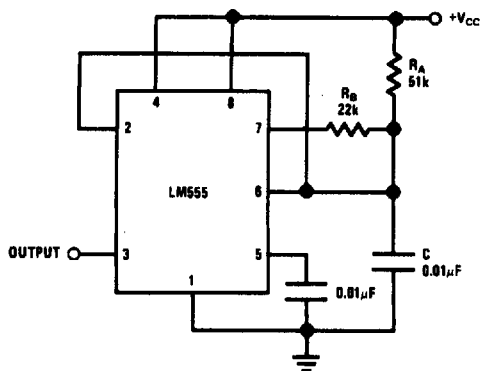
For a 50% duty cycle, the resistors R_A and R_B may be connected as in Figure 14. The time period for the out-

Applications Information (Continued)

put high is the same as previous, $t_1 = 0.693 R_A C$. For the output low it is $t_2 =$

$$\left[(R_A R_B) / (R_A + R_B) \right] C \ln \left[\frac{R_B - 2R_A}{2R_B - R_A} \right]$$

Thus the frequency of oscillation is $f = \frac{1}{t_1 + t_2}$



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FIGURE 14. 50% Duty Cycle Oscillator**NATL SEMICON (LINEAR)**

Note that this circuit will not oscillate if R_B is greater than $1/2 R_A$ because the junction of R_A and R_B cannot bring pin 2 down to $1/3 V_{CC}$ and trigger the lower comparator.

ADDITIONAL INFORMATION

Adequate power supply bypassing is necessary to protect associated circuitry. Minimum recommended is $0.1 \mu F$ in parallel with $1 \mu F$ electrolytic.

Lower comparator storage time can be as long as $10 \mu s$ when pin 2 is driven fully to ground for triggering. This limits the monostable pulse width to $10 \mu s$ minimum.

Delay time reset to output is $0.47 \mu s$ typical. Minimum reset pulse width must be $0.3 \mu s$, typical.

Pin 7 current switches within $30 ns$ of the output (pin 3) voltage.