LM55/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
### 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
- **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

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conditions</th>
<th>Limits</th>
<th>Units</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>LM555</td>
<td>Typ</td>
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<tr>
<td>Supply Voltage</td>
<td>(V_{CC} = 5V, R_L \to \infty), (V_{CC} = 15V, R_L \to \infty) (Low State) (Note 2)</td>
<td>4.5</td>
<td>18</td>
</tr>
<tr>
<td>Supply Current</td>
<td>(V_{CC} = 5V), (R_L)</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>(V_{CC} = 15V), (R_L)</td>
<td>10</td>
<td>12</td>
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<tr>
<td>Timing Error, Monostable</td>
<td>Initial Accuracy: (R_A = 1k) to 100 kΩ, (C = 0.1 \mu F), (Note 3)</td>
<td>0.5</td>
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<tr>
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<td>Drift with Temperature: (R_A = 1k) to 100 kΩ, (C = 0.1 \mu F), (Note 3)</td>
<td>30</td>
<td>50</td>
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<tr>
<td></td>
<td>Accuracy over Temperature: (R_A = 1k) to 100 kΩ, (C = 0.1 \mu F), (Note 3)</td>
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<tr>
<td>Timing Error, Astable</td>
<td>Initial Accuracy: (R_A, R_B = 1k) to 100 kΩ, (C = 0.1 \mu F), (Note 3)</td>
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<td>Drift with Temperature: (R_A, R_B = 1k) to 100 kΩ, (C = 0.1 \mu F), (Note 3)</td>
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<td>150</td>
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<td>Accuracy over Temperature: (R_A = 1k) to 100 kΩ, (C = 0.1 \mu F), (Note 3)</td>
<td>2.5</td>
<td></td>
</tr>
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<td></td>
<td>Drift with Supply: (R_A = 1k) to 100 kΩ, (C = 0.1 \mu F), (Note 3)</td>
<td>2.5</td>
<td></td>
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<tr>
<td>Threshold Voltage</td>
<td>(V_{CC} = 5V)</td>
<td>0.667</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(V_{CC} = 15V)</td>
<td>0.667</td>
<td></td>
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<tr>
<td>Trigger Voltage</td>
<td>(V_{CC} = 15V)</td>
<td>4.8</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>(V_{CC} = 5V)</td>
<td>1.45</td>
<td>1.67</td>
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<tr>
<td>Trigger Current</td>
<td>(V_{CC} = 15V)</td>
<td>0.01</td>
<td>0.5</td>
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<tr>
<td></td>
<td>(V_{CC} = 5V)</td>
<td>1.45</td>
<td>1.67</td>
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<tr>
<td>Reset Voltage</td>
<td>(V_{CC} = 15V)</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>(V_{CC} = 5V)</td>
<td>1.45</td>
<td>1.67</td>
</tr>
<tr>
<td>Reset Current</td>
<td>(V_{CC} = 15V)</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>(V_{CC} = 5V)</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Threshold Current</td>
<td>(V_{CC} = 15V)</td>
<td>0.1</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>(V_{CC} = 5V)</td>
<td>0.1</td>
<td>0.25</td>
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<tr>
<td>Control Voltage Level</td>
<td>(V_{CC} = 15V)</td>
<td>9.6</td>
<td>10</td>
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<tr>
<td></td>
<td>(V_{CC} = 5V)</td>
<td>2.9</td>
<td>3.33</td>
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<tr>
<td>Pin 7 Leakage Output High</td>
<td>(V_{CC} = 15V, I_{L7} = 15 mA)</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>(V_{CC} = 4.5V, I_{L7} = 4.5 mA)</td>
<td>70</td>
<td>100</td>
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<tr>
<td>Pin 7 Sat (Note 5)</td>
<td>(V_{CC} = 15V, I_{P7} = 15 mA)</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Output Low</td>
<td>(V_{CC} = 4.5V, I_{P7} = 4.5 mA)</td>
<td>70</td>
<td>100</td>
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### Electrical Characteristics  \( T_A = 25^\circ C, V_{CC} = +5\text{V to } +15\text{V} \), (unless otherwise specified) (Continued)

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Limits</th>
<th>Units</th>
</tr>
</thead>
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<tr>
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<td>LM555</td>
<td>LM555C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min</td>
<td>Typ</td>
</tr>
<tr>
<td>Output Voltage Drop (Low)</td>
<td>( V_{CC} = 15\text{V} )</td>
<td>0.1</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>( I_{SINK} = 10 \text{mA} )</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>( I_{SINK} = 50 \text{mA} )</td>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>( I_{SINK} = 100 \text{mA} )</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( I_{SINK} = 200 \text{mA} )</td>
<td>0.1</td>
<td>0.25</td>
</tr>
<tr>
<td>Output Voltage Drop (High)</td>
<td>( I_{SOURCE} = 200 \text{mA}, V_{CC} = 15\text{V} )</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( I_{SOURCE} = 100 \text{mA}, V_{CC} = 15\text{V} )</td>
<td>13</td>
<td>13.3</td>
</tr>
<tr>
<td></td>
<td>( V_{CC} = 8\text{V} )</td>
<td>3</td>
<td>3.3</td>
</tr>
<tr>
<td>Rise Time of Output</td>
<td></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Fall Time of Output</td>
<td></td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**Note 1:** For operating at elevated temperatures the device must be derated above 25°C based on a +150°C maximum junction temperature and a thermal resistance of 164°C/w (TO-5), 106°C/w (DIP) and 170°C/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 MΩ.

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

**Note 6:** Refer to RET555X drawing of military LM555H and LM555J versions for specifications.

### Connection Diagrams

#### Metal Can Package

**TL/H/7851–2**

Order Number LM555H or LM555CH
See NS Package Number H08C

#### Dual-In-Line and Small Outline Packages

**TL/H/7851–3**

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

Minimum Pulse Width Required for Triggering

Supply Current vs Supply Voltage

High Output Voltage vs Output Source Current

Low Output Voltage vs Output Sink Current

Low Output Voltage vs Output Sink Current

Low Output Voltage vs Voltage Level of Trigger Pulse

Output Propagation Delay vs Voltage Level of Trigger Pulse

Discharge Transistor (Pin 7) Voltage vs Sink Current

Discharge Transistor (Pin 7) Voltage vs Sink Current

TL/H/7851–4
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.

The voltage across the capacitor then increases exponentially for a period of \( t = 1.1 \times R \times C \), 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.

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 \( R, C \) values for various time delays.

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

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.

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.

![Figure 5](image1.png)

**FIGURE 5. Astable Waveforms**

The charge time (output high) is given by:

\[ t_1 = 0.693 \left( R_A + R_B \right) C \]

And the discharge time (output low) by:

\[ t_2 = 0.693 \left( R_B \right) C \]

Thus the total period is:

\[ T = t_1 + t_2 = 0.693 \left( R_A + 2R_B \right) C \]

The frequency of oscillation is:

\[ f = \frac{1}{T} = \frac{1.44}{\left( R_A + 2R_B \right) C} \]

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

The duty cycle is:

\[ D = \frac{R_B}{R_A + 2R_B} \]

**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.

![Figure 6](image2.png)

**FIGURE 6. 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.

![Figure 8](image3.png)

**FIGURE 8. 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.

![Figure 10](image4.png)

**FIGURE 9. Pulse Width Modulator**

**FIGURE 10. Pulsetrigger Modulator**
Applications Information (Continued)

**FIGURE 10. Pulse Position Modulator**

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.

**LINEAR RAMP**

$V_{CC} = 5V$

Top Trace: Modulation Input 1V/Div.

TIME $= 0.1$ ms/Div.

Bottom Trace: Output 2V/Div.

$R_A = 3.9 \text{ k}\Omega$

$R_B = 3 \text{ k}\Omega$

$C = 0.01 \mu\text{F}$

**FIGURE 11. Pulse Position Modulator**

$V_{CC} = 5V$

Top Trace: Input 3V/Div.

TIME $= 20 \mu$s/Div.

$R_1 = 47 \text{ k}\Omega$

$R_2 = 100 \text{ k}\Omega$

$R_E = 2.7 \text{ k}\Omega$

$C = 0.01 \mu\text{F}$

**FIGURE 12**

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

$$T = \frac{2}{3} \frac{V_{CC} R_C}{R_1 + R_2} C$$

$$= \frac{V_{CC}}{R_1 V_{BE} + V_{BE}} (R_1 + R_2)$$

$V_{BE} \approx 0.6V$

**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)

Note that this circuit will not oscillate if $R_B$ is greater than $1/2 \times R_A$ because the junction of $R_A$ and $R_B$ cannot bring pin 2 down to $1/3 \times V_{CC}$ 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 $30 \text{ ns}$ of the output (pin 3) voltage.

FIGURE 14. 50% Duty Cycle Oscillator

Physical Dimensions inches (millimeters)
Physical Dimensions inches (millimeters) (Continued)

Ceramic Dual-In-Line Package (J)
Order Number LM555J or LM555CJ
NS Package Number J08A

Small Outline Package (M)
Order Number LM555CM
NS Package Number M08A
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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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**Physical Dimensions** inches (millimeters) (Continued)

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