

General-purpose single bipolar timers

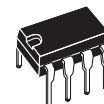
Features

- Low turn-off time
- Maximum operating frequency greater than 500 kHz
- Timing from microseconds to hours
- Operates in both astable and monostable modes
- Output can source or sink up to 200 mA
- Adjustable duty cycle
- TTL compatible
- Temperature stability of 0.005% per °C

Description

The NE555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor.

The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200 mA.

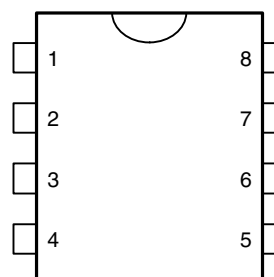


N
DIP8
(Plastic package)



D
SO8
(Plastic micropackage)

Pin connections (top view)



- | | |
|-------------|---------------------|
| 1 - GND | 5 - Control voltage |
| 2 - Trigger | 6 - Threshold |
| 3 - Output | 7 - Discharge |
| 4 - Reset | 8 - V _{CC} |

1 Schematic diagrams

Figure 1. Block diagram

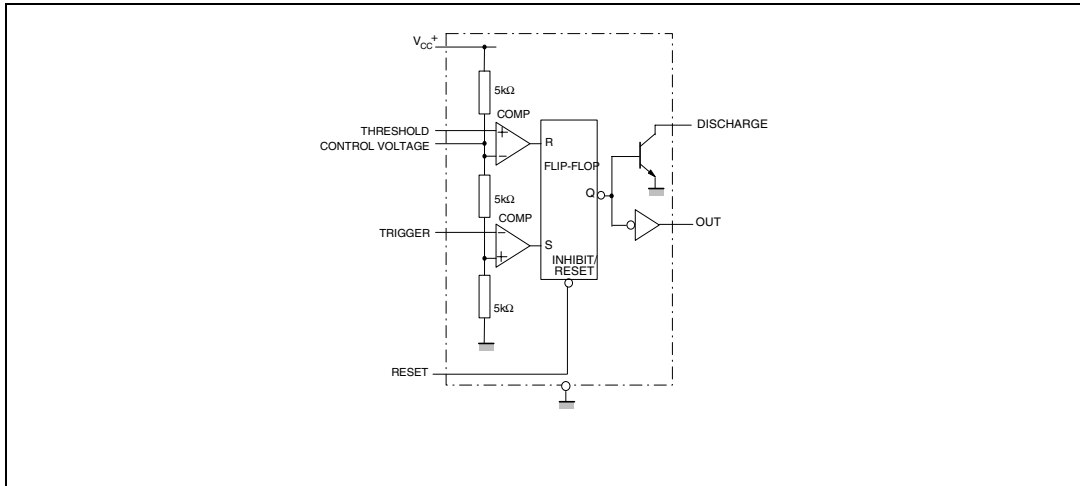
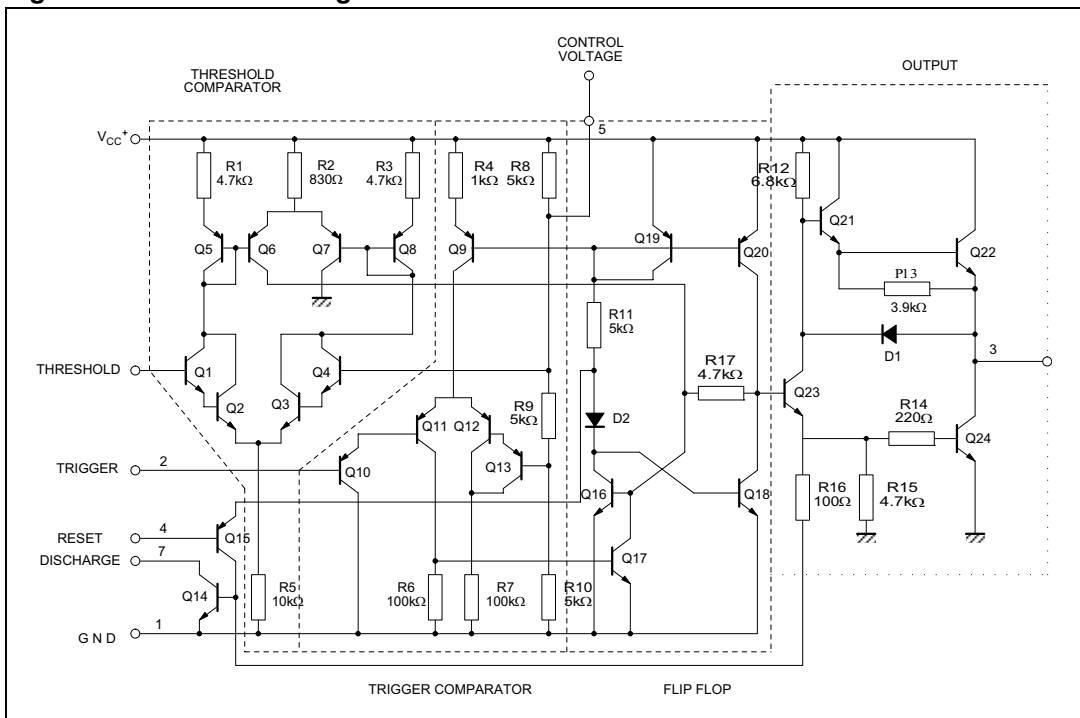


Figure 2. Schematic diagram



2 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings

| Symbol | Parameter | Value | Unit |
|------------|---|------------|-----------------------------|
| V_{CC} | Supply voltage | 18 | V |
| I_{OUT} | Output current (sink & source) | ± 225 | mA |
| R_{thja} | Thermal resistance junction to ambient ⁽¹⁾ | | $^{\circ}\text{C}/\text{W}$ |
| | DIP8 SO-8 | 85 125 | |
| R_{thjc} | Thermal resistance junction to case ⁽¹⁾ | | $^{\circ}\text{C}/\text{W}$ |
| | DIP8 SO-8 | 41 40 | |
| ESD | Human body model (HBM) ⁽²⁾ | 1000 | V |
| | Machine model (MM) ⁽³⁾ | 100 | |
| | Charged device model (CDM) ⁽⁴⁾ | 1500 | |
| | Latch-up immunity | 200 | mA |
| T_{LEAD} | Lead temperature (soldering 10 seconds) | 260 | $^{\circ}\text{C}$ |
| T_j | Junction temperature | 150 | $^{\circ}\text{C}$ |
| T_{stg} | Storage temperature range | -65 to 150 | $^{\circ}\text{C}$ |

- Short-circuits can cause excessive heating. These values are typical.
- Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5k Ω resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
- Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.
- Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins.

Table 2. Operating conditions

| Symbol | Parameter | Value | Unit |
|---|--------------------------------------|--------------------------|--------------------|
| V_{CC} | Supply voltage | | V |
| | NE555 | 4.5 to 16 | |
| | SA555 SE555 | 4.5 to 16 4.5 to 18 | |
| V_{th} , V_{trig} , V_{cl} , V_{reset} | Maximum input voltage | V_{CC} | V |
| I_{OUT} | Output current (sink and source) | ± 200 | mA |
| T_{oper} | Operating free air temperature range | | $^{\circ}\text{C}$ |
| | NE555 | 0 to 70 | |
| | SA555 SE555 | -40 to 105 -55 to 125 | |

3 Electrical characteristics

Table 3. $T_{amb} = +25^{\circ}C$, $V_{CC} = +5V$ to $+15V$ (unless otherwise specified)

| Symbol | Parameter | SE555 | | | NE555 - SA555 | | | Unit |
|---------------------|--|-------|------|------|---------------|------|------|------------------------------|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| I_{CC} | Supply current ($R_L = \infty$) | | | | | | | mA |
| | Low state $V_{CC} = +5V$ | | 3 | 5 | | 3 | 6 | |
| | $V_{CC} = +15V$ | | 10 | 12 | | 10 | 15 | |
| | High state $V_{CC} = +5V$ | | 2 | | | 2 | | |
| | Timing error (monostable) ($R_A = 2k\Omega$ to $100k\Omega$, $C = 0.1\mu F$) | | | | | | | % ppm/ $^{\circ}C$ %/V |
| | Initial accuracy ⁽¹⁾ | | 0.5 | 2 | | 1 | 3 | |
| | Drift with temperature | | 30 | 100 | | 50 | | |
| | Drift with supply voltage | | 0.05 | 0.2 | | 0.1 | 0.5 | |
| | Timing error (astable) ($R_A, R_B = 1k\Omega$ to $100k\Omega$, $C = 0.1\mu F$, $V_{CC} = +15V$) | | | | | | | % ppm/ $^{\circ}C$ %/V |
| | Initial accuracy ⁽¹⁾ | | 1.5 | | | 2.25 | | |
| | Drift with temperature | | 90 | | | 150 | | |
| | Drift with supply voltage | | 0.15 | | | 0.3 | | |
| V_{CL} | Control voltage level | | | | | | | V |
| | $V_{CC} = +15V$ | 9.6 | 10 | 10.4 | 9 | 10 | 11 | |
| | $V_{CC} = +5V$ | 2.9 | 3.33 | 3.8 | 2.6 | 3.33 | 4 | |
| V_{th} | Threshold voltage | | | | | | | V |
| | $V_{CC} = +15V$ | 9.4 | 10 | 10.6 | 8.8 | 10 | 11.2 | |
| | $V_{CC} = +5V$ | 2.7 | 3.33 | 4 | 2.4 | 3.33 | 4.2 | |
| I_{th} | Threshold current ⁽²⁾ | | 0.1 | 0.25 | | 0.1 | 0.25 | μA |
| V_{trig} | Trigger voltage | | | | | | | V |
| | $V_{CC} = +15V$ | 4.8 | 5 | 5.2 | 4.5 | 5 | 5.6 | |
| | $V_{CC} = +5V$ | 1.45 | 1.67 | 1.9 | 1.1 | 1.67 | 2.2 | |
| I_{trig} | Trigger current ($V_{trig} = 0V$) | | 0.5 | 0.9 | | 0.5 | 2.0 | μA |
| V_{reset} | Reset voltage ⁽³⁾ | 0.4 | 0.7 | 1 | 0.4 | 0.7 | 1 | V |
| I_{reset} | Reset current | | | | | | | mA |
| | $V_{reset} = +0.4V$ | | 0.1 | 0.4 | | 0.1 | 0.4 | |
| | $V_{reset} = 0V$ | | 0.4 | 1 | | 0.4 | 1.5 | |
| V_{OL} | Low level output voltage | | | | | | | V |
| | $V_{CC} = +15V$ $I_{O(sink)} = 10mA$ | | 0.1 | 0.15 | | 0.1 | 0.25 | |
| | $I_{O(sink)} = 50mA$ | | 0.4 | 0.5 | | 0.4 | 0.75 | |
| | $I_{O(sink)} = 100mA$ | | 2 | 2.2 | | 2 | 2.5 | |
| | $I_{O(sink)} = 200mA$ | | 2.5 | | | 2.5 | | |
| | $V_{CC} = +5V$ $I_{O(sink)} = 8mA$ | | 0.1 | 0.25 | | 0.3 | 0.4 | |
| $I_{O(sink)} = 5mA$ | | 0.05 | 0.2 | | 0.25 | 0.35 | | |
| V_{OH} | High level output voltage | | | | | | | V |
| | $V_{CC} = +15V$ $I_{O(sink)} = 200mA$ | | 13 | 12.5 | | 12.5 | | |
| | $I_{O(sink)} = 100mA$ | | 3 | 13.3 | | 13.3 | | |
| | $V_{CC} = +5V$ $I_{O(sink)} = 100mA$ | | 3 | 3.3 | | 3.3 | 2.75 | |

Table 3. $T_{amb} = +25^{\circ}C$, $V_{CC} = +5V$ to $+15V$ (unless otherwise specified) (continued)

| Symbol | Parameter | SE555 | | | NE555 - SA555 | | | Unit |
|----------------|--|-------|------------|------------|---------------|------------|------------|---------|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| $I_{dis(off)}$ | Discharge pin leakage current (output high) $V_{dis} = 10V$ | | 20 | 100 | | 20 | 100 | nA |
| $V_{dis(sat)}$ | Discharge pin saturation voltage (output low) ⁽⁴⁾ $V_{CC} = +15V$, $I_{dis} = 15mA$ $V_{CC} = +5V$, $I_{dis} = 4.5mA$ | | 180 80 | 480 200 | | 180 80 | 480 200 | mV |
| t_r t_f | Output rise time Output fall time | | 100 100 | 200 200 | | 100 100 | 300 300 | ns |
| t_{off} | Turn off time ⁽⁵⁾ ($V_{reset} = V_{CC}$) | | 0.5 | | | 0.5 | | μs |

1. Tested at $V_{CC} = +5V$ and $V_{CC} = +15V$.
2. This will determine the maximum value of $R_A + R_B$ for 15 V operation. The maximum total ($R_A + R_B$) is 20 M Ω for +15 V operation and 3.5 M Ω for +5 V operation.
3. Specified with trigger input high.
4. No protection against excessive pin 7 current is necessary, providing the package dissipation rating is not exceeded.
5. Time measured from a positive pulse (from 0 V to $0.8 \times V_{CC}$) on the Threshold pin to the transition from high to low on the output pin. Trigger is tied to threshold.

Figure 3. Minimum pulse width required for triggering

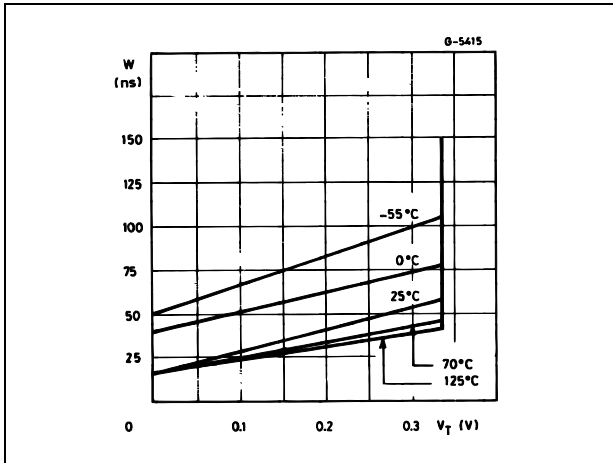


Figure 4. Supply current versus supply voltage

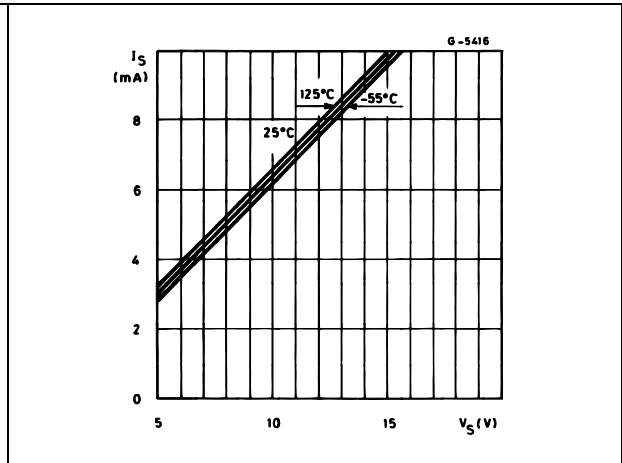


Figure 5. Delay time versus temperature

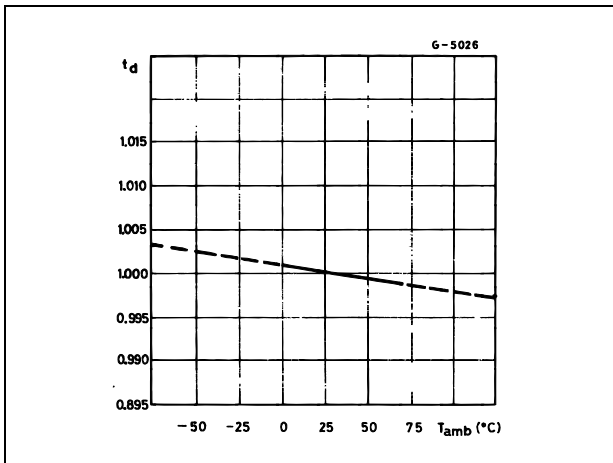


Figure 6. Low output voltage versus output sink current

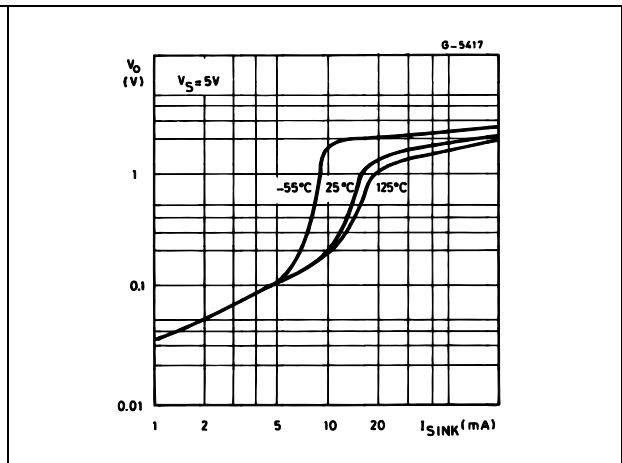


Figure 7. Low output voltage versus output sink current

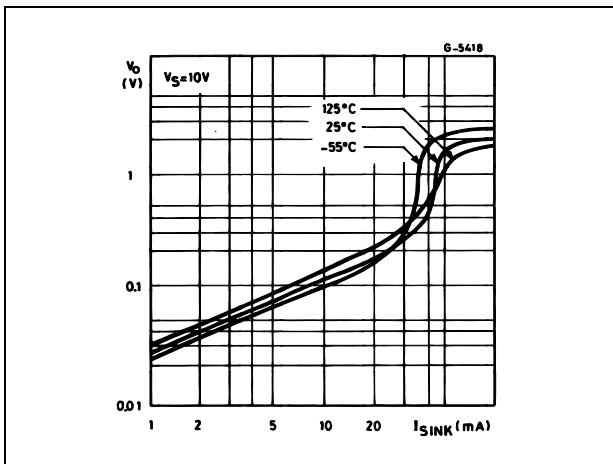


Figure 8. Low output voltage versus output sink current

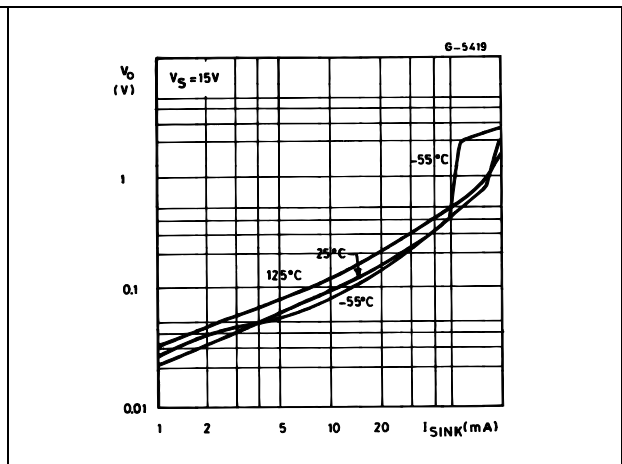


Figure 9. High output voltage drop versus output

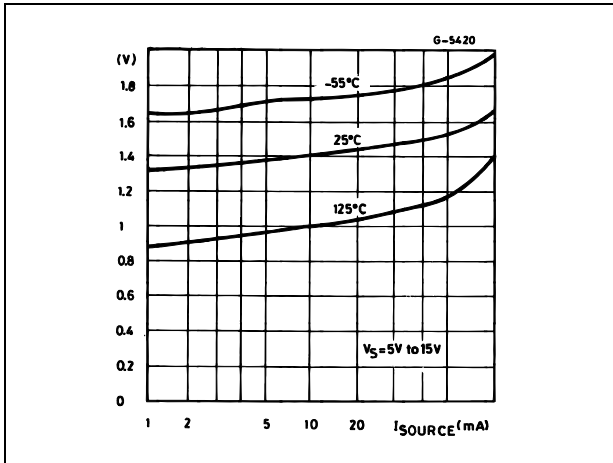


Figure 10. Delay time versus supply voltage

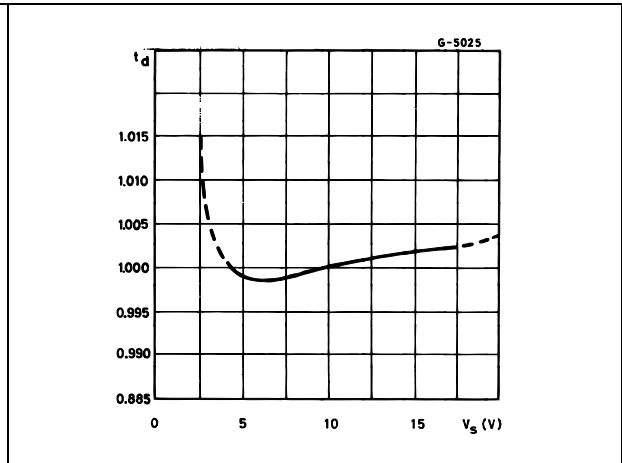
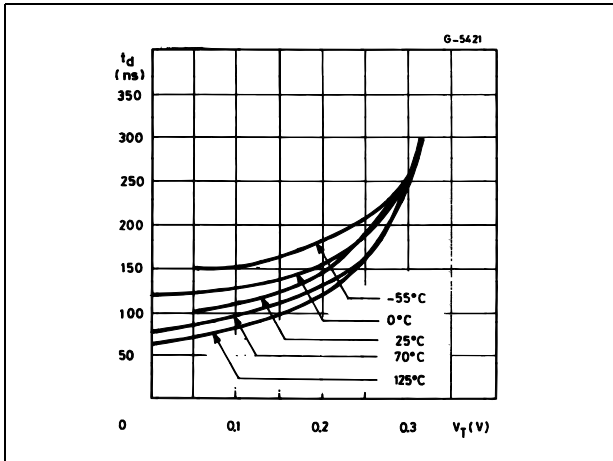


Figure 11. Propagation delay versus voltage level of trigger value

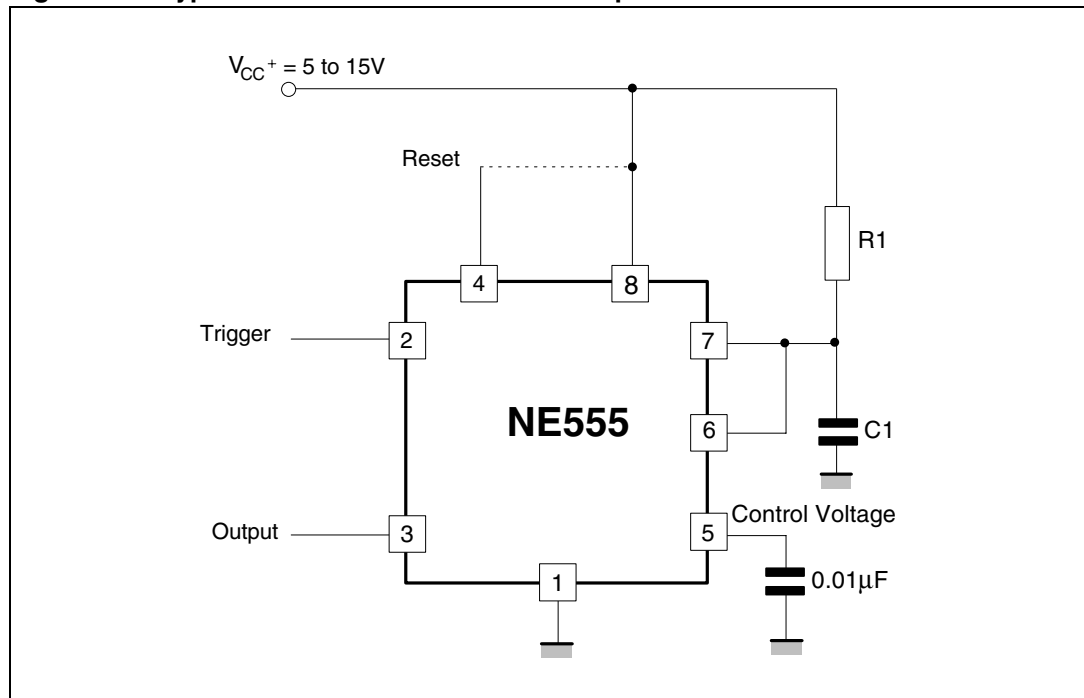


4 Application information

4.1 Monostable operation

In the monostable mode, the timer generates a single pulse. As shown in [Figure 12](#), the external capacitor is initially held discharged by a transistor inside the timer.

Figure 12. Typical schematics in monostable operation



The circuit triggers on a negative-going input signal when the level reaches $1/3 V_{CC}$. Once triggered, the circuit remains in this state until the set time has elapsed, even if it is triggered again during this interval. The duration of the output HIGH state is given by $t = 1.1 R_1 C_1$ and is easily determined by [Figure 14](#).

Note that because the charge rate and the threshold level of the comparator are both directly proportional to supply voltage, the timing interval is independent of supply. Applying a negative pulse simultaneously to the reset terminal (pin 4) and the trigger terminal (pin 2) during the timing cycle discharges the external capacitor and causes the cycle to start over. The timing cycle now starts on the positive edge of the reset pulse. During the time the reset pulse is applied, the output is driven to its LOW state.

When a negative trigger pulse is applied to pin 2, the flip-flop is set, releasing the short-circuit across the external capacitor and driving the output HIGH. The voltage across the capacitor increases exponentially with the time constant $t = R_1 C_1$. When the voltage across the capacitor equals $2/3 V_{CC}$, the comparator resets the flip-flop which then discharges the capacitor rapidly and drives the output to its LOW state.

[Figure 13](#) shows the actual waveforms generated in this mode of operation.

When Reset is not used, it should be tied high to avoid any possibility of unwanted triggering.

Figure 13. Waveforms in monostable operation

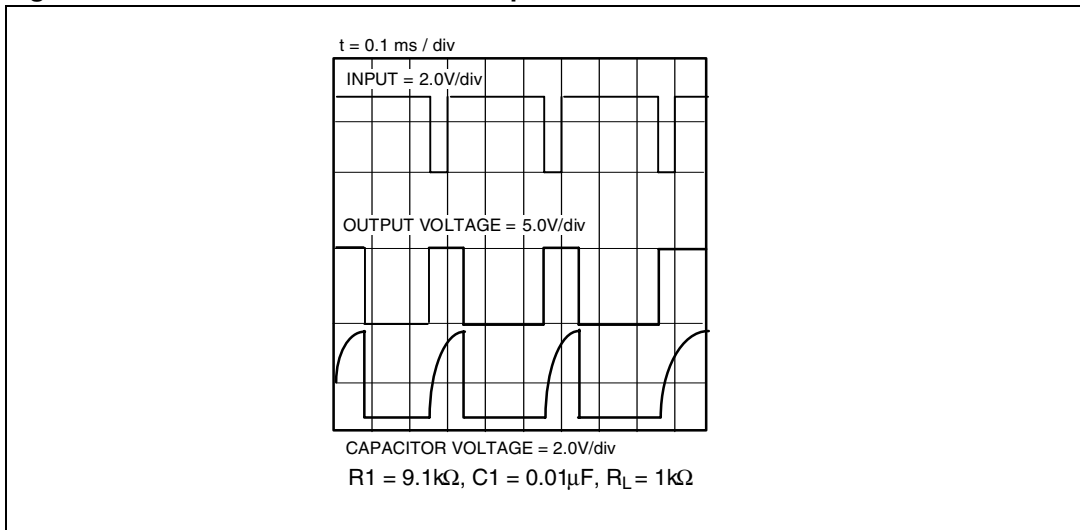
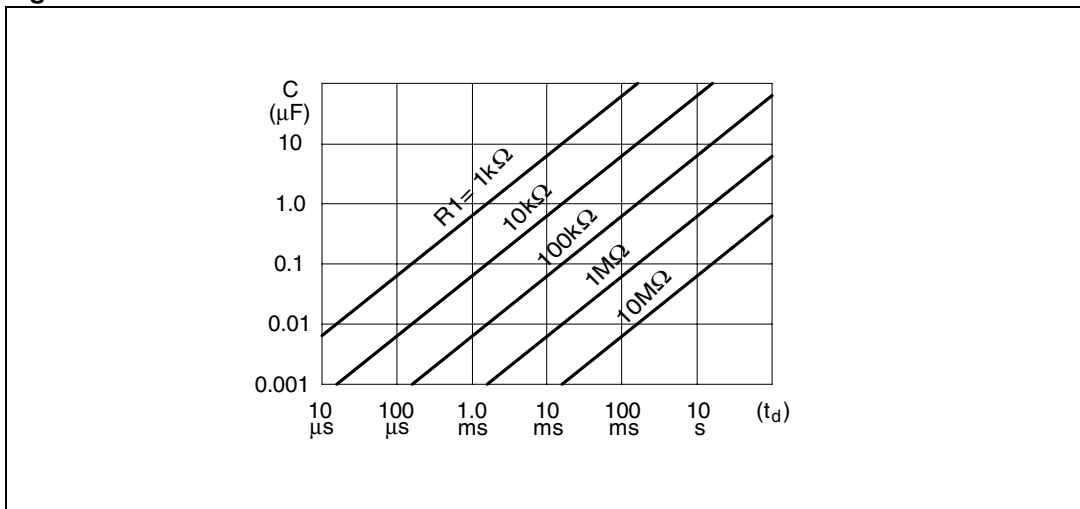


Figure 14. Pulse duration versus R1C1



4.2 Astable operation

When the circuit is connected as shown in [Figure 15](#) (pins 2 and 6 connected) it triggers itself and free runs as a multi-vibrator. The external capacitor charges through R_1 and R_2 and discharges through R_2 only. Thus the duty cycle can be set accurately by adjusting the ratio of these two resistors.

In the astable mode of operation, C_1 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, frequency are independent of the supply voltage.

Figure 15. Typical schematics in astable operation

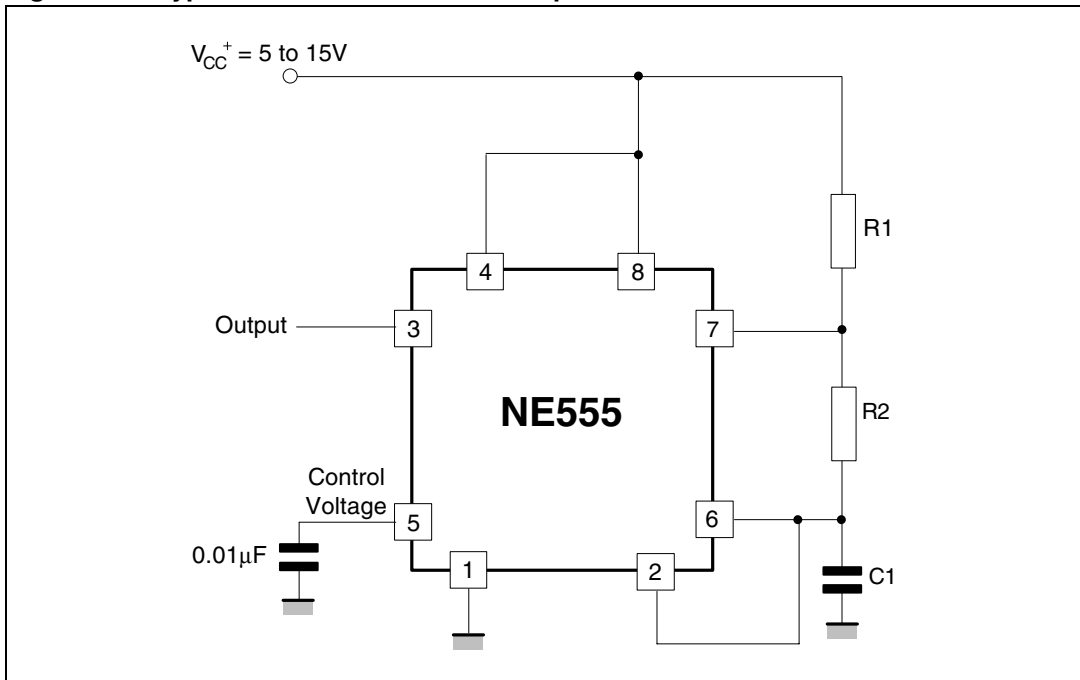


Figure 16 shows the actual waveforms generated in this mode of operation.

The charge time (output HIGH) is given by:

$$t_1 = 0.693 (R_1 + R_2) C_1$$

and the discharge time (output LOW) by:

$$t_2 = 0.693 (R_2) C_1$$

Thus the total period T is given by:

$$T = t_1 + t_2 = 0.693 (R_1 + 2R_2) C_1$$

The frequency of oscillation is then:

$$f = \frac{1}{T} = \frac{1.44}{(R_1 + 2R_2)C_1}$$

It can easily be found from Figure 17.

The duty cycle is given by:

$$D = \frac{R_2}{R_1 + 2R_2}$$

Figure 16. Waveforms in astable operation

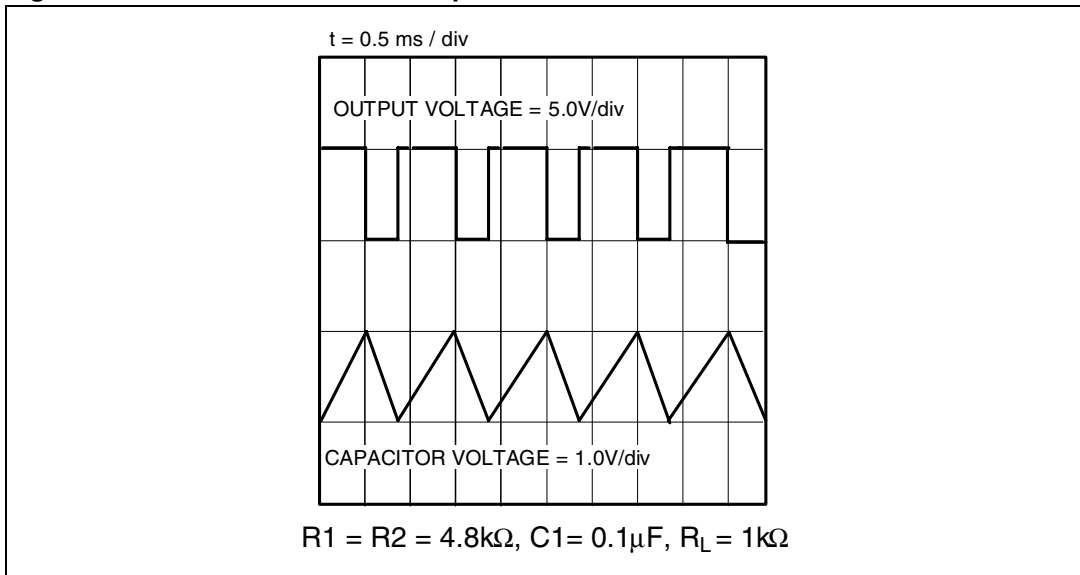
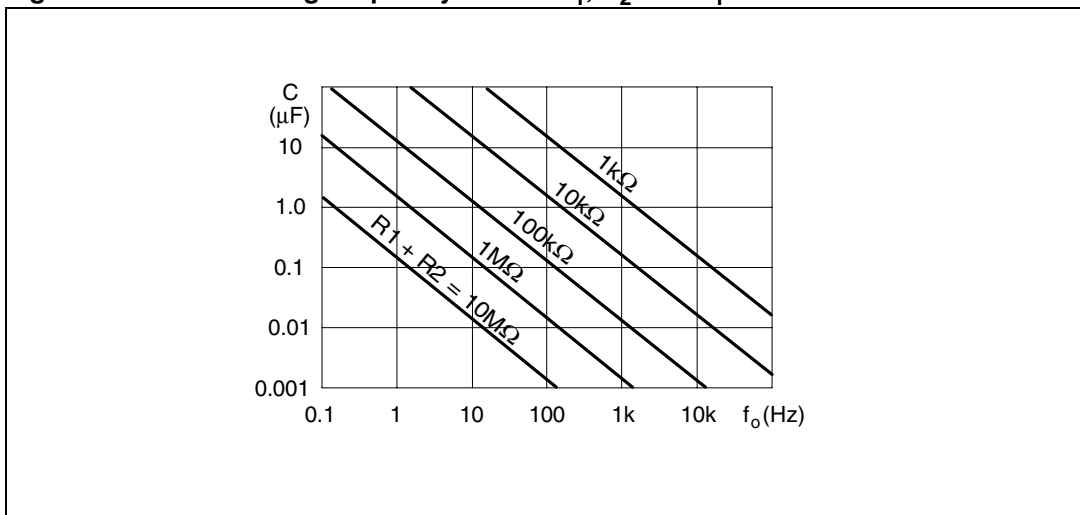


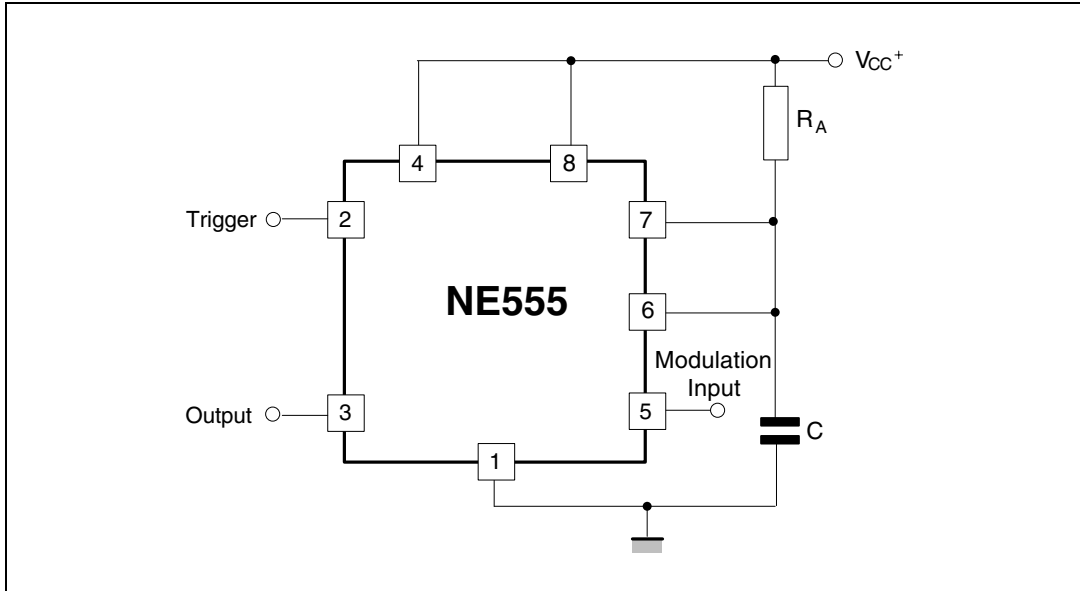
Figure 17. Free running frequency versus R₁, R₂ and C₁



4.3 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 18* shows the circuit.

Figure 18. Pulse width modulator



4.4 Linear ramp

When the pull-up resistor, R_A , in the monostable circuit is replaced by a constant current source, a linear ramp is generated. *Figure 19* shows a circuit configuration that will perform this function.

Figure 19. Linear ramp

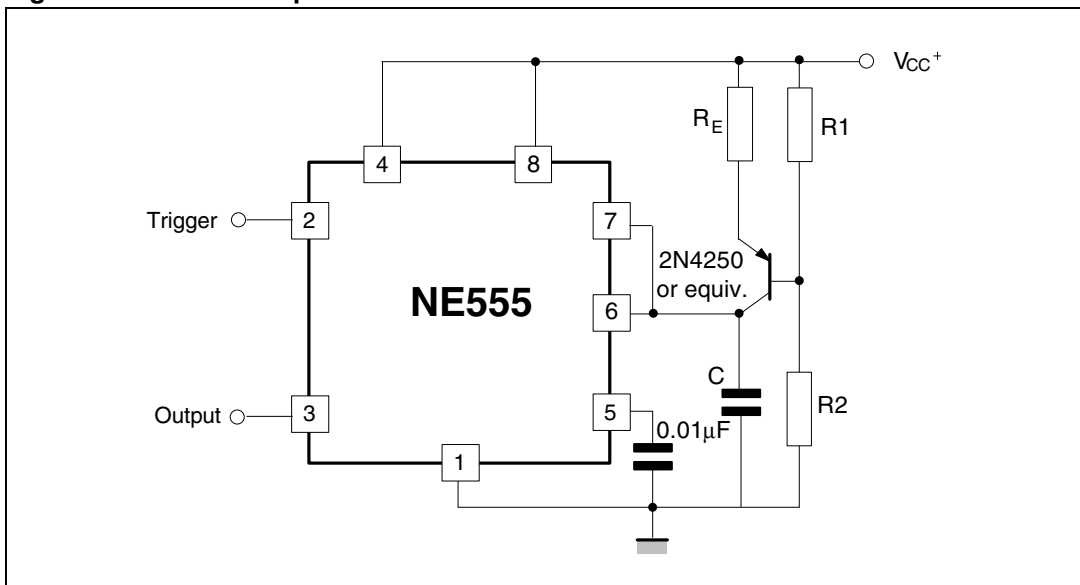
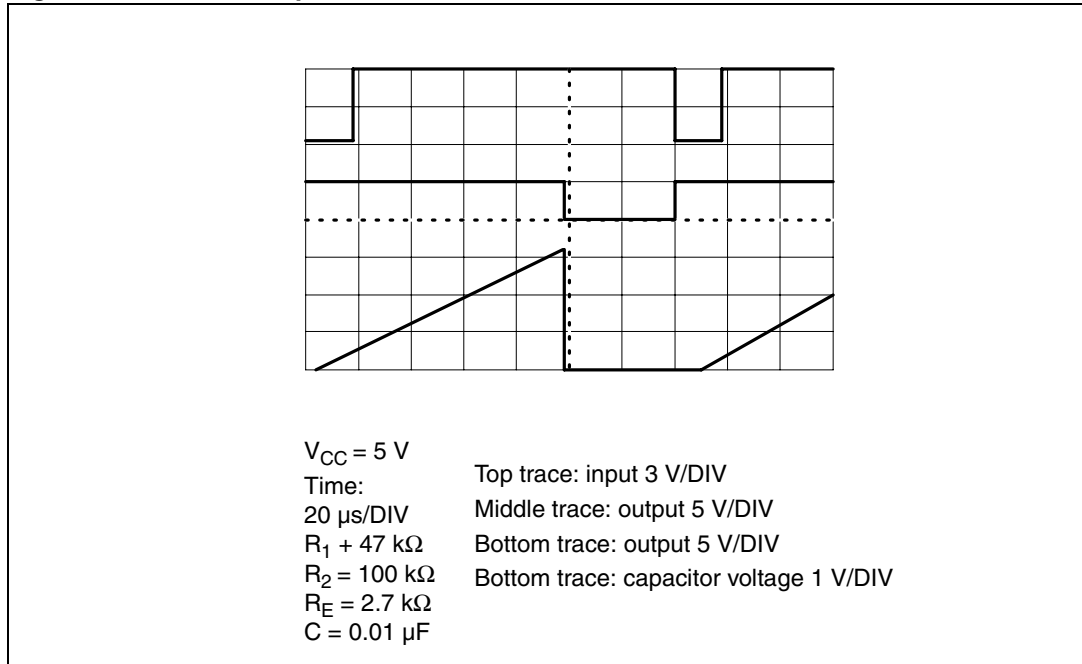


Figure 20 shows the waveforms generator by the linear ramp.

The time interval is given by:

$$T = \frac{(2/3 V_{CC} R_E (R_1+R_2) C}{R_1 V_{CC} - V_{BE} (R_1+R_2)} \quad V_{BE} = 0.6V$$

Figure 20. Linear ramp



4.5 50% duty cycle oscillator

For a 50% duty cycle, the resistors R_A and R_B can be connected as in Figure 21. The time period for the output high is the same as for astable operation (see Section 4.2 on page 9):

$$t_1 = 0.693 R_A C$$

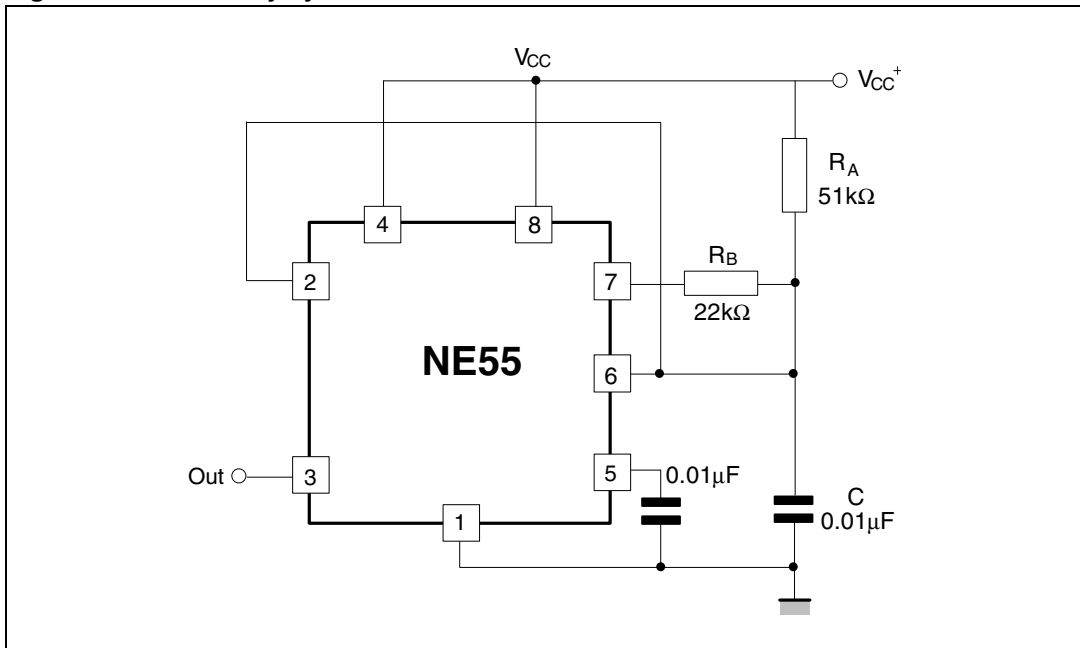
For the output low it is

$$t_2 = [(R_1 R_B)/(R_A+R_B)].C.Ln \left[\frac{R_B - 2R_A}{2R_B - R_A} \right]$$

Thus the frequency of oscillation is:

$$f = \frac{1}{t_1 + t_2}$$

Figure 21. 50% duty cycle oscillator



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.

4.6 Additional information

Adequate power supply bypassing is necessary to protect associated circuitry. The minimum recommended is 0.1 μF in parallel with 1 μF electrolytic.

5 Package information

In order to meet environmental requirements, STMicroelectronics offers these devices in ECOPACK[®] packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an STMicroelectronics trademark. ECOPACK specifications are available at: www.st.com.

5.1 DIP8 package information

Figure 22. DIP8 package mechanical drawing

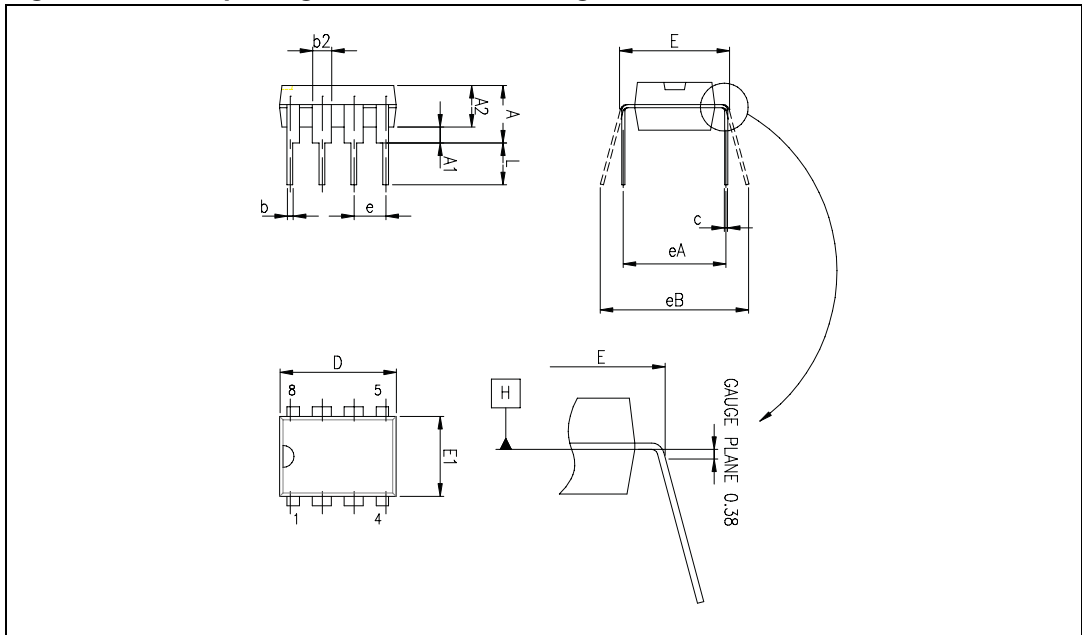


Table 4. DIP8 package mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|-------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 5.33 | | | 0.210 |
| A1 | 0.38 | | | 0.015 | | |
| A2 | 2.92 | 3.30 | 4.95 | 0.115 | 0.130 | 0.195 |
| b | 0.36 | 0.46 | 0.56 | 0.014 | 0.018 | 0.022 |
| b2 | 1.14 | 1.52 | 1.78 | 0.045 | 0.060 | 0.070 |
| c | 0.20 | 0.25 | 0.36 | 0.008 | 0.010 | 0.014 |
| D | 9.02 | 9.27 | 10.16 | 0.355 | 0.365 | 0.400 |
| E | 7.62 | 7.87 | 8.26 | 0.300 | 0.310 | 0.325 |
| E1 | 6.10 | 6.35 | 7.11 | 0.240 | 0.250 | 0.280 |
| e | | 2.54 | | | 0.100 | |
| eA | | 7.62 | | | 0.300 | |
| eB | | | 10.92 | | | 0.430 |
| L | 2.92 | 3.30 | 3.81 | 0.115 | 0.130 | 0.150 |

5.2 SO-8 package information

Figure 23. SO-8 package mechanical drawing

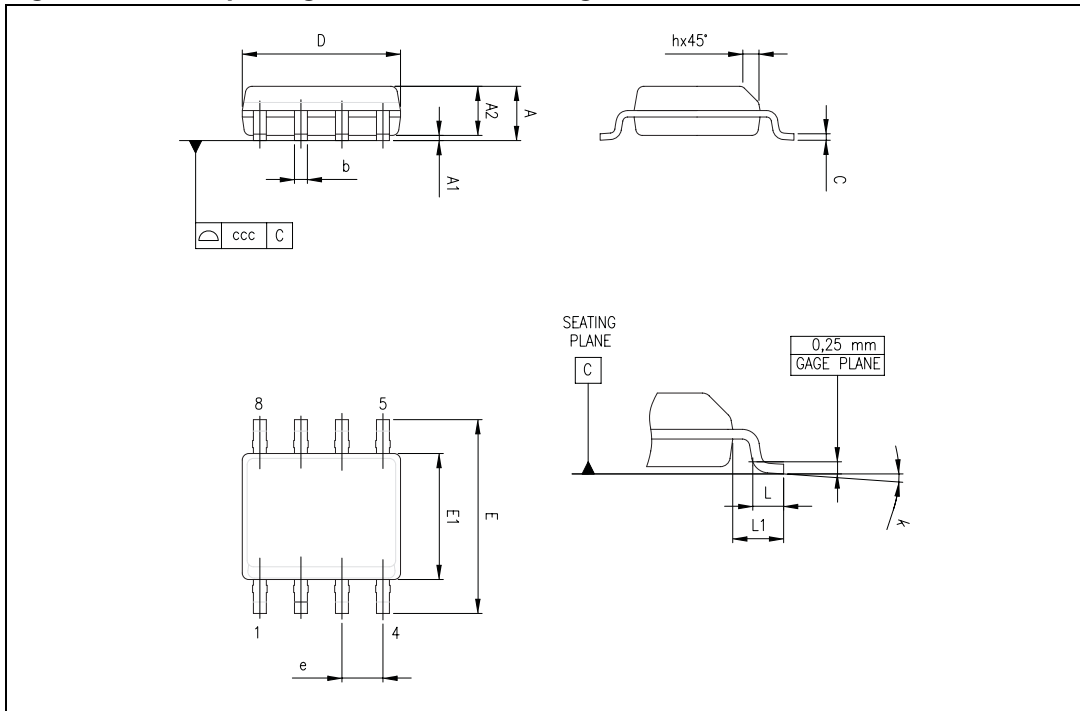


Table 5. SO-8 package mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.75 | | | 0.069 |
| A1 | 0.10 | | 0.25 | 0.004 | | 0.010 |
| A2 | 1.25 | | | 0.049 | | |
| b | 0.28 | | 0.48 | 0.011 | | 0.019 |
| c | 0.17 | | 0.23 | 0.007 | | 0.010 |
| D | 4.80 | 4.90 | 5.00 | 0.189 | 0.193 | 0.197 |
| E | 5.80 | 6.00 | 6.20 | 0.228 | 0.236 | 0.244 |
| E1 | 3.80 | 3.90 | 4.00 | 0.150 | 0.154 | 0.157 |
| e | | 1.27 | | | 0.050 | |
| h | 0.25 | | 0.50 | 0.010 | | 0.020 |
| L | 0.40 | | 1.27 | 0.016 | | 0.050 |
| L1 | | 1.04 | | | 0.040 | |
| k | 0 | | 8° | 1° | | 8° |
| ccc | | | 0.10 | | | 0.004 |

6 Ordering information

Table 6. Order codes

| Part number | Temperature range | Package | Packing | Marking |
|-------------|-------------------|---------|---------------------|---------|
| NE555N | 0°C, +70°C | DIP8 | Tube | NE555N |
| NE555D/DT | | SO-8 | Tube or tape & reel | NE555 |
| SA555N | -40°C, +105°C | DIP8 | Tube | SA555N |
| SA555D/DT | | SO-8 | Tube or tape & reel | SA555 |
| SE555N | -55°C, + 125°C | DIP8 | Tube | SE555N |
| SE555D/DT | | SO-8 | Tube or tape & reel | SE555 |

7 Revision history

Table 7. Document revision history

| Date | Revision | Changes |
|-------------|----------|--|
| 01-Jun-2003 | 1 | Initial release. |
| 2004-2006 | 2-3 | Internal revisions |
| 15-Mar-2007 | 4 | Expanded order code table. Template update. |
| 06-Nov-2008 | 5 | Added I _{OUT} value in Table 1: Absolute maximum ratings and Table 2: Operating conditions . Added ESD tolerance, latch-up tolerance, R _{thja} and R _{thjc} in Table 1: Absolute maximum ratings . |

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