Engineer's Mini-Notebook

555 Timer IC Circuits

Forrest M. Mims III
555/556 Pin Outlines

The 556 contains two 555 timers.

<table>
<thead>
<tr>
<th>Function</th>
<th>555</th>
<th>555 (1)</th>
<th>555 (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground</td>
<td>1</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Trigger</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Output</td>
<td>3</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Reset</td>
<td>4</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Control V</td>
<td>5</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Threshold</td>
<td>6</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Discharge</td>
<td>7</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Vcc</td>
<td>8</td>
<td>14</td>
<td>14</td>
</tr>
</tbody>
</table>

555 Specifications

- Supply Voltage (Vcc): 4.5 to 15 V
- Supply Current (Vcc = +15V): 3 to 6 mA
- Output Current (Maximum): 200 mA
- Power Dissipation: 600 mW
- Operating Temperature: 0 to 70°C

Values shown apply to NE555.
PLEASE READ THIS FIRST...

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DESIGNS, TECHNICAL ADVICE, TROUBLESHOOTING
ADVICE, ETC.). BUT THOUGH WE CANNOT
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WILL BE HAPPY TO RECEIVE ANY COMMENTS,
IMPRESSIONS, SUGGESTIONS AND INFORMATION
ABOUT SUSPECTED ERRORS IN THIS BOOK.

THANKS IN ADVANCE TO THOSE OF YOU
WHO WRITE! BUT PLEASE REMEMBER WE
WILL BE UNABLE TO RESPOND PERSONALLY.

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INTRODUCTION

THE 555 TIMER IS ONE OF THE MOST POPULAR AND VERSATILE INTEGRATED CIRCUITS EVER PRODUCED. IT INCLUDES 23 TRANSISTORS, 2 DIODES AND 16 RESISTORS ON A SILICON CHIP INSTALLED IN AN 8-PIN MINI-DUAL-IN-LINE PACKAGE (DIP). THE 555 IS A 14-PIN DIP THAT COMBINES TWO 555'S ON A SINGLE CHIP. ALLOCATED ARE ULTRA-LOW POWER VERSIONS OF THE 555. THE 555 HAS TWO PRINCIPLE OPERATING MODES:

MONOSTABLE MODE - IN THIS MODE THE 555 FUNCTIONS AS A "ONE-SHOT" APPLICATION. INCLUDES A TIMERS, MESSING PULSE DETECTION, BOUNCEFREE SWITCHES, TOUCH SWITCHES, ETC.

ASTABLE MODE - THE 555 CAN OPERATE AS AN OSCILLATOR. USES INCLUDE LED AND LAMP FLASHERS, PULSE GENERATION, LOGIC CLOCKS, TONE GENERATION, SECURITY ALARMS, ETC.

CIRCUIT ASSEMBLY TIPS

BUILD TEST VERSIONS OF CIRCUITS ON PLASTIC SOLDERLESS BREADBOARD BEFORE MAKING THEM PERMANENT. IN MONOSTABLE CIRCUITS WHERE FALSE TRIGGERING MIGHT CAUSE PROBLEMS, TIE PIN 8 TO GROUND VIA A 0.1 MF CAPACITOR. IF POWER LEADS ARE LONG OR IF A CIRCUIT SEEMS TO MALFUNCTION, PLACE A 0.1 MF CAPACITOR ACROSS PINS 8 AND 1. A 1 MF CAPACITOR MAY ALSO BE NECESSARY. BE SURE TO EXPERIMENT WITH VALUES OF TIMING RESISTORS AND CAPACITORS. THE BASIC CIRCUITS ON PP 6-7 EXPLAIN THE ROLE THESE COMPONENTS PLAY. REMEMBER THAT THE 555 REPLACES TWO 555's. LOW-POWER VERSIONS OF THE 555 MAY REQUIRE SOME REVISIONS TO STANDARD 555 CIRCUITS.

FOR MORE TIPS, SEE THE LABORATORY SHACK BOOK "GETTING STARTED IN ELECTRONICS".
BASIC MONOSTABLE CIRCUIT

Vcc (+5 to +15V)

MAKE RESET AND TRIGGER INPUT MOMENTARILY LOW TO RESET
RESET TIMING CYCLE. OTHERWISE KEEP RESET AT Vcc.

C1

R1

TRIGGER
PULSE IN

C2

MONOSTABLE PULSE OUT

t = R1 * C1
(\text{t is independent of Vcc})

A negative trigger pulse at pin 2 turns off a transistor that otherwise shorts C1 to ground. The output then goes high as C1 charges through R1. When the charge on C1 is 2/3 Vcc, the 555 discharges C1 to ground, the output then goes low.

C1 (\mu F)

10
1
0.1
0.01
0.001

10 100 100 1000 1 10 100 100 1000

ms sec  \mu sec  ns sec  \mu sec  sec  sec

TIME DELAY (t)

BASIC ASTABLE CIRCUIT

Vcc (+5 to +15V)

RC

R2

C1

CHARGE ON C1
\text{t1} = \frac{1}{491(R1+R2)C1}
\text{t2} = \frac{1}{491(R2)C1}

FREQUENCY = \frac{1}{(R1+2R2)C1}

Here, pins 2 and 6 are connected so the circuit will trigger itself each timing cycle, thereby functioning as an oscillator. C1 charges through R1 and R2 but discharges through R2. The charge on C1 ranges from 1/3 Vcc to 2/3 Vcc. The oscillation frequency is independent of Vcc.
BOUNCEFREE SWITCH

CLOSING S1 MOMENTARILY BEGINS A TIMING CYCLE. THE RELAY IS ACTUATED DURING THE ENTIRE CYCLE. R1 AND C1 CONTROL TIME DELAY. C2 PREVENTS FALSE TRIGGERING. D2 ABSORBS VOLTAGE GENERATED BY RELAY COIL WHEN RELAY IS SWITCHED OFF. USE CAUTION WHEN CONNECTING LINE-POWERED DEVICES TO RELAY CONNECTIONS.

TYPICAL DELAYS (SECONDS)

<table>
<thead>
<tr>
<th>R1</th>
<th>C1 = 10uF</th>
<th>C1 = 100uF</th>
</tr>
</thead>
<tbody>
<tr>
<td>100K</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>220K</td>
<td>3</td>
<td>31</td>
</tr>
<tr>
<td>470K</td>
<td>6</td>
<td>70</td>
</tr>
<tr>
<td>1M</td>
<td>15</td>
<td>175</td>
</tr>
</tbody>
</table>
**Cascaded Timer**

Both timers are connected in their one-shot mode. Grounding the trigger input starts timer 1 which then starts timer 2.

**Intervalometer**

Timer 1 is connected as a stable oscillator which oscillates at a frequency determined by R1 and C1. Timer 2 is a one-shot that drives a relay via D1. Timer 1 triggers timer 2 once per cycle for 3 to 5 seconds.
MISSING PULSE DETECTOR

INCOMING PULSES CONTINUALLY RESET THE TIMING CYCLE. A MISSING PULSE ALLOWS THE TIMING CYCLE TO BE COMPLETED, CHANGING THE OUTPUT STATE.

EVENT FAILURE ALARM

WHEN POWER IS APPLIED, C1 BEGINS TO CHARGE THROUGH R2. UNLESS S1 IS CLOSED BEFORE THE 555 TIMING CYCLE IS COMPLETED, THE BUZZER WILL SOUND. S1 CAN BE ANY EXTERNAL SWITCH.

CHARGE ON C1
FREQUENCY DIVIDER

This circuit also squares slowly rising input pulses.

For typical input and output waveforms shown, output frequency ≈ \( \frac{1}{4} \) input frequency.

IN THIS CIRCUIT THE 555 IS CONNECTED AS A MONOSTABLE MULTIVIBRATOR. ONCE A TIMING CYCLE IS INITIATED, BY AN INPUT PULSE, SUBSEQUENT INPUT PULSES HAVE NO EFFECT UNTIL CYCLE IS COMPLETED. SHOWN BELOW ARE TYPICAL INPUT AND OUTPUT WAVEFORMS (C1 = 0.1 µF, R1 VARIED IN VALUE).

\[
\begin{align*}
\text{IN} & \quad \text{IN/1} & \quad \text{IN/R} & \quad \text{IN/5} & \quad \text{IN/10} \\
\end{align*}
\]

VOLTAGE-CONTROLLED OSCILLATOR

The 555 oscillates at a frequency determined by R2 and C1. A voltage applied to the input changes the oscillation frequency of the 555. As the input voltage increases, the oscillation frequency decreases. For more volume, omit R1 and connect speaker to ground through 4.7 µF capacitor.

\[
\begin{align*}
\text{INPUT VOLTAGE} & \quad \text{SPEAKER}
\end{align*}
\]

\[
\begin{align*}
\text{TONE FREQUENCY}
\end{align*}
\]
PULSE GENERATOR

+5 to +15V

R1 1M
R2 1K
C1 (0.02 - 1µF)

555

GND

USE FREQUENCY TABLE TO SELECT R1 AND C1. OK TO CONNECT PIN 3 TO FREQUENCY METER ON FACING PAGE.

USE AS DIGITAL LOGIC CLOCK PULSE GENERATOR, SIGNAL GENERATOR, ETC.

FREQUENCY TABLE (Frequencies in Hz)

<table>
<thead>
<tr>
<th>C1 (µF)</th>
<th>R1=10K</th>
<th>R1=100K</th>
<th>R1=1M</th>
</tr>
</thead>
<tbody>
<tr>
<td>.0022</td>
<td>12.170</td>
<td>5.240</td>
<td>510</td>
</tr>
<tr>
<td>.0033</td>
<td>30.490</td>
<td>3.740</td>
<td>371</td>
</tr>
<tr>
<td>.0047</td>
<td>21.532</td>
<td>2.430</td>
<td>241</td>
</tr>
<tr>
<td>.0068</td>
<td>16.300</td>
<td>1.987</td>
<td>197</td>
</tr>
<tr>
<td>.01</td>
<td>11.942</td>
<td>1.414</td>
<td>140</td>
</tr>
<tr>
<td>.015</td>
<td>7.210</td>
<td>0.876</td>
<td>87</td>
</tr>
<tr>
<td>.022</td>
<td>4.959</td>
<td>0.501</td>
<td>50</td>
</tr>
<tr>
<td>.033</td>
<td>3.730</td>
<td>0.428</td>
<td>42</td>
</tr>
<tr>
<td>.047</td>
<td>2.351</td>
<td>0.285</td>
<td>28</td>
</tr>
<tr>
<td>.1</td>
<td>1.757</td>
<td>0.210</td>
<td>21</td>
</tr>
<tr>
<td>.15</td>
<td>1.139</td>
<td>0.138</td>
<td>14</td>
</tr>
<tr>
<td>.22</td>
<td>0.804</td>
<td>0.097</td>
<td>10</td>
</tr>
</tbody>
</table>

FREQUENCY METER

+5 to +15V

R1 4.7K
R2 4.7K
C1 .01µF
C2 .1µF
C5 .01-2µF
R5 10K
R6 100K

OK TO ADD AMPLIFIER

M1

CALIBRATE METER

NOTE NON-LINEAR RESPONSE AT 1kHz.

METER (0-1mA) 5

R3=10K

C3=1µF

R5=2.2K

C3=1µF

FREQUENCY (kHz)

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This circuit will function with either or both output devices. The speaker
provides more volume, but uses more current. Use R3 to reduce volume.
Here are typical frequencies for various settings of R1:

**Oscillator (C1=.01 μF) Metronome (C1=1 μF)**

<table>
<thead>
<tr>
<th>R1</th>
<th>Frequency (Hz)</th>
<th>R1</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1M</td>
<td>17</td>
<td>1M</td>
<td>1.2</td>
</tr>
<tr>
<td>470K</td>
<td>40</td>
<td>480K</td>
<td>1.8</td>
</tr>
<tr>
<td>220k</td>
<td>85</td>
<td>470K</td>
<td>2.9</td>
</tr>
<tr>
<td>100K</td>
<td>577</td>
<td>210K</td>
<td>4.1</td>
</tr>
<tr>
<td>47K</td>
<td>4.10</td>
<td>100K</td>
<td>9.4</td>
</tr>
<tr>
<td>22K</td>
<td>4.38</td>
<td>838</td>
<td>4.4</td>
</tr>
<tr>
<td>10K</td>
<td>1570</td>
<td>10K</td>
<td>4.7</td>
</tr>
<tr>
<td>47K</td>
<td>4.63</td>
<td>2.346</td>
<td>6.0</td>
</tr>
<tr>
<td>22K</td>
<td>4606</td>
<td>6283</td>
<td>18</td>
</tr>
</tbody>
</table>

Note: Your values may vary.

Piezo gives intense sound.
GATED OSCILLATOR

IN  Q1  +5 TO +15V  0
R1  Q1
R2  1M
C1  .01 µF
S.W. SPKR

555

Q1 - POWER MOSFET
(RADIO SHACK 276-2075 OR SIMILAR)

CHIRP GENERATOR

+9V
R1M
R2
R3  10K
C1  .01 µF
C2  4.7 µF
C3  4.7 µF

Q1  2N3904
PZEO BUZZER

R1  10K
R4

THIS CIRCUIT WILL ALLOW YOU TO SWITCH THE TONE GENERATED BY THE 555 BY MEANS OF AN EXTERNAL LOGIC SIGNAL. THE TRIANGULAR SYMBOL IS ANY EXTERNAL LOGIC GATE. OR TO SWITCH THE TONE ON AND OFF BY CONNECTING GATE OF Q1 TO +V OR GROUND THROUGH 1M RESISTOR. R1 AND C1 CONTROL TONE FREQUENCY. Q1 CAN BE CONNECTED AS A SWITCHABLE GATE ELSEWHERE IN CIRCUIT.

IN  TONE  CAUTION: Q1 CAN BE DESTROYED BY STATIC ELECTRICITY! DO NOT TOUCH EXPOSED LEADS.
    LOW  OFF
    HIGH  ON
    FOLLOW HANDLING PRECAUTIONS ON PACKAGE.

THIS CIRCUIT APPLIES BRIEF PULSES OF CURRENT TO A PIEZO BUZZER (RADIO SHACK 275-065 OR SIMILAR). THIS CAUSES THE BUZZER TOemit ATTEMPT-GETTING CHIRPS. THE CIRCUIT MAKES A WARNING DEVICE.

R1 CONTROLS RATE OF CHIRPS. USE 100K FIXED RESISTOR FOR ABOUT 2-3 CHIRPS PER SECOND. C3 CONTROLS DURATION OF CHIRPS. FOR LONG DURATION PULSES (WHICH BECOME TONE BURSTS) INCREASE C3 TO 0.22 µF OR MORE. REDUCE VOLUME BY INSERTING 100 - 10,000 Ω RESISTOR BETWEEN PIN 9 AND PIEZO BUZZER. TRY USING C45 PHOTORESISTOR FOR R1.
STEPPED-TONE GENERATOR

+5 to 15V

R1 500K
R2 1K
R3 500K
R4 5K
+ C3 10μF

C1 0.1μF
C2 0.1μF

FREQUENCY FALLS AS R2 REDUCED. THIS CIRCUIT PRODUCES SOUNDS RESEMBLING PLUCKED VIOLIN STRINGS TO DRUM AS R1 AND R3 ARE ADJUSTED. FREQUENCY OF STEPPED OUTPUT DECREASES IN PROGRESSIVELY SMALLER INCREMENTS AS R3 IS REDUCED IN VALUE. GRAPH SHOWN HERE IS TYPICAL FOR VALUES SHOWN. OK TO CHANGE C1, C2 AND R1.

FREQUENCY OUT

0.5 kHz 1 kHz 1.5 kHz 2 kHz

3-STAGE TONE GENERATOR

+9V

R1 2.2K
R2 100K
R3
R4 5K
R5 5K

C1 3.3μF
C2 1μF

R6 270

8 Ω SPKR

EXPERIMENT WITH VALUES OF R1, C1, R4 AND C2.

S1 (CENTER OFF):
1 - TONE BURST
2 - STEADY TONE
3 - TWO-TONE

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TONE BURST GENERATOR

When S1 is closed, the speaker emits a tone whose frequency is determined by R1 and C1. When S1 is opened, the tone continues for several seconds. The time required for C2 to discharge through R4 increases C2 to increase burst duration.

CLOSE S1
OPEN S1
TONE ON
TONE OFF

SOUND EFFECTS GENERATOR

The first 555 oscillates at a frequency determined by R1 and C1. Its output charges C2 through R3.

The second 555 oscillates at a frequency determined by R7, C3, and the voltage at pin 5 (i.e., the charge on C2). Experiment with the settings of R1 and R7 and the values of R3 and C2 to obtain wobble effects.

CHARGE ON C2
 SPEAKER TONE FREQUENCY
LED FLASHER

THIS CIRCUIT WILL DRIVE BOTH VISIBLE LIGHT AND INFRARED-EMITTING DIODES. USE RED, GREEN OR YELLOW LED TO MAKE A VISIBLE LIGHT FLASHER. USE NEAR-INFRARED EMITTER TO MAKE POWERFUL TRANSMITTER. CONNECT SOLAR CELL, PHOTODIODE OR PHOTOTRANSISTOR TO AMPLIFIER TO RECEIVE SIGNAL.

R1 RATE (Hz)

100K 0.2 CONNECT PIEZO BUZZER ACROSS LED FOR LIGHT/SOUND DARKROOM TIMER.
47K 0.6
22K 1.1 REDUCE C1 FOR FASTER PULSE RATES.
10K 2.1 ESPECIALLY WHEN INFRARED EMITTER IS USED. SEE "GETTING STARTED IN ELECTRONICS" (RADIO SHACK, pp.64-69).
4.7K 3.6
2.2K 6.1
1.0K 8.3

POWER FET LAMP DIMMER

SOME VERSIONS MAY OPERATE WHEN 555 IS Powered BY 6V.

R1 100
R2 1K OR SK
R3 1K
R4 10K

C1 C047µF

Q1 2N2222

Q1* SEE BELOW.

THIS CIRCUIT IS A LINEAR LAMP DIMMER. IN OPERATION, THE 555 SWITCHES Q1 ON AND OFF AT A RATE DETERMINED BY R1+R2 AND C1. WHEN Q1 IS ON, L1 IS ALSO ON. THE SWITCHING RATE IS SO FAST L1 APPEARS TO GLOW CONTINUOUSLY. INCREASING THE SWITCHING RATE INCREASES THE APPARENT BRIGHTNESS OF L1.

Q1 MUST BE PROPERLY RATED. FOR EXAMPLE, A 555 6-VOLT FLASHLIGHT LAMP CONSUMES 0.5 AMPERE OR 3 WATTS. THEREFORE, USE AN IRF510 OR SIMILAR POWER FET. ATTACH A TO-220 HEATSINK TO DISSIPATE EXCESS HEAT.

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**LIGHT/DARK DETECTOR**

When S1 is in position "L," the speaker emits a tone. When light strikes the photoresistor, when S1 is in position "D," the speaker emits a tone. When the photoresistor is not illuminated.

SI position:

- Light
- Dark
- Tone on
- Tone off

---

**INFRARED SECURITY ALARM**

Alarm sounds when the insert is moved from between LED (infrared emitter) and Q3. Monitor doors, etc.
ANALOG LIGHTWAVE TRANSMITTER

This circuit pulses an infrared-emitting diode at a frequency determined by R1 and C1. The receiver on the facing page receives and amplifies the infrared signal. It then converts the signal's frequency into a current which is displayed on a 0-1 mA meter. Use lenses to increase range. For full details, see "The Forrest Mims Circuit Scrapbook" (McGraw-Hill, 1983).

TEST RECEIVER CIRCUIT GAVE NON-LINEAR RESPONSE WHEN TRANSMITTER FREQUENCY EXCEEDED 5.13 KHz.

CALIBRATE RECEIVER METER WITH R9.

ANALOG LIGHTWAVE RECEIVER

This circuit receives PFM signals from the transmitter on facing page.

CONNECT C2 DIRECTLY ACROSS PIN 3 B.F. OF THE 1456.
DC-DC CONVERTER

CAUTION: HIGH VOLTAGE!

R1 4.7K
R2 1K
C1 .01uF
C2 .1uF 250V
C3 1M
D1 1N4004
T1 555

+5V to -9V (VIN)

120V WINDING
6.3V WINDING

T1: MINIATURE 6.3V 120V POWER TRANSFORMER
(RADIO SHACK 273-1384 OR SIMILAR).

THIS CIRCUIT APPLIES A PULSATING CURRENT
TO A TRANSFORMER WINDING. THE INPUT
VOLTAGE IS THEN BOOSTED BY THE
TRANSFORMER'S SECOND WINDING. USE TO
POWER NEON LAMPS, PLASMA DISPLAYS, ETC.
CAUTION: DO NOT TOUCH OUTPUT LEADRI! (R3 BLEEDS
CHARGE FROM C2 WHEN VIN IS REMOVED.)

RESISTOR COLOR CODE

BLACK 0 0 X 1
BROWN 1 1 X 10
RED 2 2 X 100
ORANGE 3 3 X 1,000
YELLOW 4 4 X 10,000
GREEN 5 5 X 100,000
BLUE 6 6 X 1,000,000
VIOLET 7 7 X 10,000,000
GRAY 8 8 X 100,000,000
WHITE 9 9

FOURTH BAND INDICATES TOLERANCE (ACCURACY):
GOLD = ±5% SILVER = ±10% NONE = ±20%

OHM'S LAW: V = IR R = V/I
I = V/R P = VI = I^2R

ABBREVIATIONS

A = AMPERE R = RESISTANCE
F = FARAD V (OR E) = VOLT
I = CURRENT W = WATT
P = POWER Ω = OHM

M (MEG-) = 1,000,000
K (Kilo-) = 1,000
m (MILLI-) = .001
μ (MICRO-) = 0.000 001
n (NANO-) = 0.000 000 001
p (PICO-) = 0.000 000 000 001