Engineer's Mini-Notebook
555 Timer IC Circuits

Forrest M. Mims III
<table>
<thead>
<tr>
<th><strong>555 SPECIFICATIONS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>555 (A)</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td><strong>555 (B)</strong></td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

**Supplies Voltage (Vcc)**
- 4.5 to 15 V

**Input Current (max)**
- 3 mA

**Operating Temperature (°C)**
- 0° to 70°C

**555/556 PINOUTS**

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**555 ENGINEER'S MINI-CIRCUITTS**

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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 13 transistors, 2 diodes and 14 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. Also available 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. Applications include timers, missing pulse detection, bounce-free switches, touch switches, etc.

Astable Mode - The 555 can operate as an oscillator. Uses include LED lamp flashers, pulse generation, logic clocks, tone generation, security alarms, etc.

CIRCUIT ASSEMBLY TIPS

Build test versions of circuits on plastic solderless breadboards before making them permanent. In monostable circuits where false triggering might cause problems, tie pin 5 to ground via a 0.1 μF capacitor. If power leads are long or if a circuit seems to malfunction, place a 0.1 μF capacitor across pins 2 and 6. A 1 μF 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 Radio Shack book "Getting Started in Electronics."
BASIC MONOSTABLE CIRCUIT

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.

\[ t = R1 \times C1 \]  
(t is independent of Vcc)

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 \( 2/3 \times Vcc \) to \( 1/3 \times Vcc \). The oscillation frequency is independent of Vcc.

BASIC ASTABLE CIRCUIT

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 \( 2/3 \times Vcc \) to \( 1/3 \times Vcc \). The oscillation frequency is independent of Vcc.

\[ t1 = 0.693 (R1 + R2) C1 \]
\[ t2 = 0.693 (R2) C1 \]

Frequency = \[ \frac{1.44}{(R1 + 2R2)C1} \]
BOUNCEFREE SWITCH

+5 TO +15V

R1 100K

C1 0.1µF

C2 0.01µF

555

CLOSE S1

OPEN R3

S1 100K

C1 (µF) 1

C2 (µF) 0.01

DELAY (SEC) 10

OUTPUT PULSE

DELAY

CLOSE

OPEN S3

S3

TOUCH-ACTIVATED SWITCH

+5 TO +15V

R1 100K

C1 0.1µF

C2 0.01µF

555

DELAY

OUTPUT PULSE

TOUCH

RELEASE

MAY ALSO WORK WHEN ONLY PIN 2 IS TOUCHED.

RELAY PLUS RELAY

+12V

D1 1N914

D2 1N914

R2 10K

R1 1M

C1 10µF

C2 0.1µF

S1

RELAY

(5 TO 9 V, 150 TO 500 mA)

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 = 10µF</th>
<th>C1 = 100µF</th>
</tr>
</thead>
<tbody>
<tr>
<td>100K</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>220K</td>
<td>3</td>
<td>33</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>
CASCAD ED 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 an astable oscillator which oscillates at a frequency determined by R1 and C1. Timer 2 is a one-shot that drives a relay via DI. Timer 1 triggers timer 2 once per cycle for 3 to 5 seconds.

OUT 1
OUT 2
**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.
**FREQUENCY DIVIDER**

This circuit also squares slowly rising input pulses.

For typical input and output waveforms shown, output frequency = 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).

**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 SPEKR to ground through 4.7 μF capacitor.

![Diagram of circuit diagram]
PULSE GENERATOR

+5 TO +15V

R1 1M
R2 1K

C1 (0.027, 1 µF)

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>0.027</td>
<td>12.4 K</td>
<td>5.2 K</td>
<td>5.2 K</td>
</tr>
<tr>
<td>0.033</td>
<td>30.2 K</td>
<td>12.0 K</td>
<td>12.0 K</td>
</tr>
<tr>
<td>0.047</td>
<td>21.5 K</td>
<td>8.7 K</td>
<td>8.7 K</td>
</tr>
<tr>
<td>0.068</td>
<td>19.3 K</td>
<td>7.6 K</td>
<td>7.6 K</td>
</tr>
<tr>
<td>0.1</td>
<td>11.4 K</td>
<td>4.6 K</td>
<td>4.6 K</td>
</tr>
<tr>
<td>0.15</td>
<td>7.2 K</td>
<td>3.1 K</td>
<td>3.1 K</td>
</tr>
<tr>
<td>0.22</td>
<td>4.8 K</td>
<td>2.1 K</td>
<td>2.1 K</td>
</tr>
<tr>
<td>0.33</td>
<td>3.3 K</td>
<td>1.4 K</td>
<td>1.4 K</td>
</tr>
<tr>
<td>0.47</td>
<td>2.5 K</td>
<td>1.1 K</td>
<td>1.1 K</td>
</tr>
<tr>
<td>0.68</td>
<td>1.8 K</td>
<td>0.8 K</td>
<td>0.8 K</td>
</tr>
<tr>
<td>1.5</td>
<td>1.5 K</td>
<td>0.6 K</td>
<td>0.6 K</td>
</tr>
<tr>
<td>2.2</td>
<td>1.1 K</td>
<td>0.5 K</td>
<td>0.5 K</td>
</tr>
</tbody>
</table>

FREQUENCY METER

+5 TO +15V

R1 4.7K
R2 4.7K
R3 10K
R4 4.7K
R5 10K

C1 0.1 µF
C2 4.7K
C3 1.0 µF
C5 0.1 µF

OK TO ADD AMPLIFIER

CALIBRATE METER < 100A

THIS ULTRA-SIMPLE CIRCUIT MEASURES AUDIO FREQUENCY SIGNALS. INPUT SIGNAL SHOULD RANGE FROM 2.5 TO 5 VOLTS. FOR TESTING, CONNECT PULSE GENERATOR ON FACING PAGE DIRECTLY TO PIN 2 (Omit C1). R3 AND C5 DETERMINE FREQUENCY RANGE.

NOTE NON-LINEAR RESPONSE AT 1 KHz.

METER (0-1mA)

R3=10K
R4=10K
C3=1µF
C5=0.1µF

FREQUENCY (KHz)
**AUDIO OSCILLATOR / METRONOME**

![Circuit Diagram]

**TOY ORGAN**

![Circuit Diagram]

This circuit will function with either or both output devices. The speaker gives more volume, but uses more current. Use R3 to reduce volume.

Here are typical frequencies for various settings of R1:

### Oscillator (C1=0.01 μF) Metronome (C1=1 μF)

<table>
<thead>
<tr>
<th>R1 (Ohm)</th>
<th>Frequency (Hz)</th>
<th>R1 (Ohm)</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 M</td>
<td>17</td>
<td>1 M</td>
<td>1.2</td>
</tr>
<tr>
<td>470 K</td>
<td>40</td>
<td>470 K</td>
<td>1.8</td>
</tr>
<tr>
<td>220 K</td>
<td>85</td>
<td>470 K</td>
<td>2.9</td>
</tr>
<tr>
<td>100 K</td>
<td>177</td>
<td>220 K</td>
<td>4.1</td>
</tr>
<tr>
<td>47 K</td>
<td>410</td>
<td>100 K</td>
<td>9.4</td>
</tr>
<tr>
<td>22 K</td>
<td>838</td>
<td>47 K</td>
<td>18.7</td>
</tr>
<tr>
<td>10 K</td>
<td>1.87</td>
<td>22 K</td>
<td>2.34</td>
</tr>
<tr>
<td>4.7 K</td>
<td>2.74</td>
<td>10 K</td>
<td>4.60</td>
</tr>
<tr>
<td>1 K</td>
<td>6.28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Your values may vary.

Piezo gives intense sound.

---

**TABLE GIVES FREQUENCIES WHEN R1=100 K.**

- **C1 (μF)**: Frequency (Hz)
  - 0.22: 52
  - 0.15: 76
  - 0.047: 230
  - 0.033: 340
  - 0.021: 490
  - 0.015: 710
  - 0.01: 1,173
  - 0.0068: 1,970
  - 0.0047: 2,240
  - 0.0023: 3,152

OK to add **0022**: 4,471

Additional **0015**: 6,336

Capacitors **0012**: 8,237
GATED OSCILLATOR

IN

Q1

Any

R1

LOGIC

GATE

1M

R2

1K

C1

0.01 μF

C2

4.7 μF

B3

SPKR

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.

CHIRP GENERATOR

Q1

POWER

MOSFET

(RADIO SHACK

276-2073

OR SIMILAR)

+9V

R1

1M

R2

1K

556

R3

10K

Q1

2N3304

R4

10K

C1

0.01 μF

C2

0.01 μF

C3

0.01 μF

piezo buzzer

This circuit applies brief pulses of current to a piezo buzzer (Radio Shack 276-065 or similar). This causes the buzzer to emit attention-getting chirps. The circuit makes a good warning device.

R1 controls rate of chirps. Use 1M fixed resistor for about 2-3 chirps per second. C3 controls duration of chirps. For longer 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 C15 phototransistor for R1.
STEPPED-TONE GENERATOR

+5 to 15V

R1 500k
R2 1k
R3 500k
C1 .01µF

C3 10µF

R4 5k

FREQUENCY FALLS AS R2 REDUCED
FREQUENCY OUTPUT DECREASES IN PROGRESSIVELY SMALLER INCREMENTS AS R3 IS REDUCED

THIS CIRCUIT PRODUCES SOUNDS RESEMBLING PLUCKED VIOLIN STRINGS OR DRUM AS R1 AND R3 ARE ADJUSTED. FREQUENCY OF STEPPED OUTPUT DECREASES IN PROGRESSIVELY SMALLER INCREMENTS AS R3 IS REDUCED.

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

22

3-STATE TONE GENERATOR

+9V

R1 2.2k
R2 100k
C5 1µF
R4 5k
R5 5k

C3 10µF
C2 1µF
R6 270

S1 6
7
8
9
12
13

FREQUENCY OUT

.5kHz 1kHz 1.5kHz 2kHz

EXPERIMENT WITH VALUES OF R1, C1, R4 AND C2.
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 C1). Experiment with the settings of R1 and R7 and the values of R3 and C2 to obtain wave 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 a powerful transmitter. Connect solar cell, photodiode or phototransistor to amplifier to receive signal.

<table>
<thead>
<tr>
<th>R1 Rate (Hz)</th>
<th>Connect Piezo buzzer across LED for light/sound darkroom timer.</th>
<th>Reduce C1 for faster pulse rates, especially when infrared emitter is used. See &quot;getting started in electronics&quot; (Radio Shack, pp.64-69).</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 k</td>
<td>0.2</td>
<td>4.7 k 3.6 4.1 1.0 k 8.3</td>
</tr>
</tbody>
</table>

**Power FET Lamp Dimmer**

Some versions may operate when 555 is powered by 14V. 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 7815 5-volt flashlight lamp consumes 0.5 ampere or 3 watts. Therefore, use an IRF510 or similar power FET. Attach a TO-220 heat sink to dissipate excess heat.
**Light/Dark Detector**

- **R1**: 47K
- **R2**: 1K
- **R3**: 10K
- **C1**: 0.047
- **C2**: 4.7µF

OK to alter R1 & C1 to change the frequency of the tone.

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.

**S1 Position:**
- **Light**
- **Dark**
- **Tone On**
- **Tone Off**

---

**Infrared Security Alarm**

- **555**
- **C1**: 4.7µF
- **R2**: 1K
- **R1**: 47K
- **+5V to 15V**

Attach insert to door, window, etc.

Opaque insert

Shield & from external light.

Q1 (NPN)

RS 1M

C3 0.1µF

Alarm sounds when the insert is moved from between LED (infrared emitter) and Q1. Monitor doors, etc.

**Piezo Buzzer**
ANALOG LIGHTWAVE TRANSMITTER

R1 CAN BE ANY SENSOR HAVING VARIABLE RESISTANCE. WHEN R1 IS A CADMIUM SULFIDE (CdS) PHOTORESISTOR, THE FREQUENCY OF THE SIGNAL RISES WITH LIGHT LEVEL.

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).

CALIBRATE RECEIVER METER WITH R9.

TRANSMITTER FREQUENCY (KHz)

1 2 3 4 5 6 7 8 9 10 11 12

1 2 3 4 5 6 7 8 9 10 11 12

ANALOG LIGHTWAVE RECEIVER

THIS CIRCUIT RECEIVES PFM SIGNALS FROM THE TRANSMITTER ON THE FACING PAGE.

CONNECT C2 DIRECTLY ACROSS PINS B & E OF THE 1458.

CALIBRATE
DC-DC CONVERTER

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 (ACURACY):
GOLD = ±5%  SILVER = ±10%  NONE = ±20%

OHM'S LAW: V = IR  R = V/I
I = V/R  P = VI = I²R

ABBREVIATIONS
A = AMPERE  R = RESISTANCE
F = FARAD  V (OR E) = VOLT
I = CURRENT  W = WATT
P = POWER  Ω = OHM
M (MEG-) = X 1,000,000
K (KILO-) = X 1,000
m (MILLI-) = .001
μ (MICRO-) = .000 001
n (NANO-) = .000 000 001
p (PICO-) = .000 000 000 001