555 timer IC

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The **555 timer IC** is an integrated circuit (chip) used in a variety of timer, pulse generation, and oscillator applications. The 555 can be used to provide time delays, as an oscillator, and as a flip-flop element. Derivatives provide two or four timing circuits in one package.

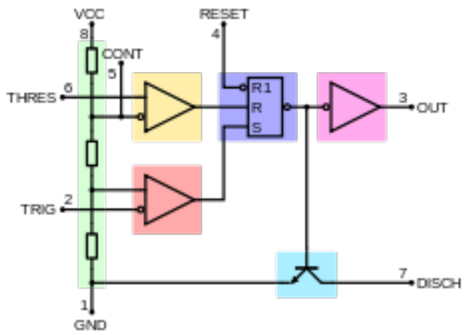
Introduced in 1972[1] by Signetics,[2] the 555 is still in widespread use due to its low price, ease of use, and stability. It is now made by many companies in the original bipolar and in low-power CMOS. As of 2003, it was estimated that 1 billion units were manufactured every year.[3] The 555 is the most popular integrated circuit ever manufactured.[4][5]

555 timer IC

NE555 from Signetics in 8-pin DIP package

Type	Active, Integrated circuit
Invented	Hans Camenzind
First production	1971
Pin configuration	GND, TRIG, OUT, RESET, CTRL, THR, DIS, VCC

Electronic symbol



Internal block diagram

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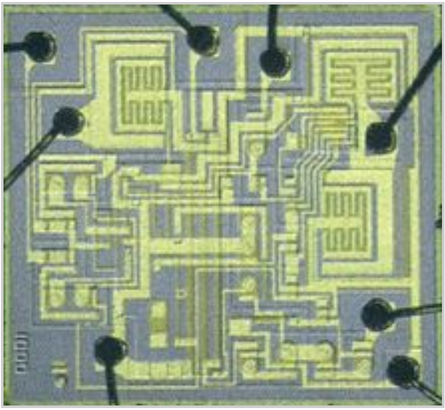
History

The IC was designed in 1971 by Hans R. Camenzind under contract to Signetics (later acquired by Philips Semiconductors, and now NXP).



Die of the first 555 chip (1971)

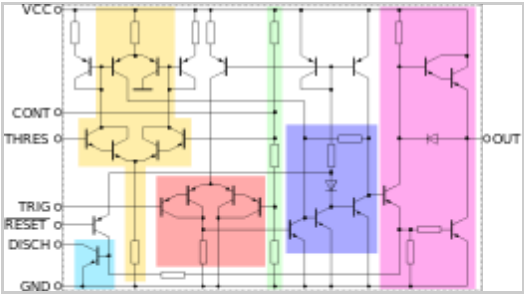
In 1962, Camenzind joined PR Mallory's Laboratory for Physical Science in Burlington, Massachusetts.[3] He designed a pulse-width modulation (PWM) amplifier for audio applications,[6] but it was not successful in the market because there was no power transistor included. He became interested in tuners such as a gyrator and a phase-locked loop (PLL). He was hired by Signetics to develop a PLL IC in 1968. He designed an oscillator for PLLs such that the frequency did not depend on the power supply voltage or temperature. However, Signetics laid off half of its employees, and the development was frozen due to a recession.[7]

Camenzind proposed the development of a universal circuit based on the oscillator for PLLs, and asked that he would develop it alone, borrowing their equipment instead of having his pay cut in half. Other engineers argued the product could be built from existing parts, but the marketing manager bought the idea. Among 5xx numbers that were assigned for analogue ICs, the special number "555" was chosen.[3][7]

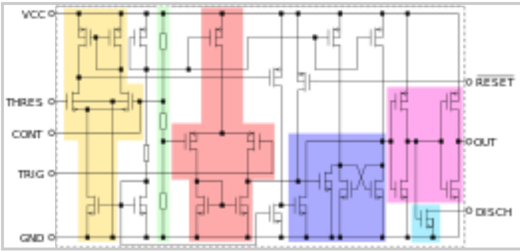
Camenzind also taught circuit design at his nearby university in the morning, and went to the Northeastern University to get the master's degree at night. The first design was reviewed in the summer of 1971. There was no problem, so it had gone to the layout design. A few days later, he got the idea of using a direct resistance instead of a constant current source, and found that it worked. The change decreased the required 9 pins to 8, so the IC could be fit in an 8-pin package instead of a 14-pin package. This design passed the second design review, and the prototype was completed in October 1971. Its 9-pin copy had been already released by another company founded by an engineer who attended the first review and retired from Signetics, but they withdrew it soon after the 555 was released. The 555 timer was manufactured by 12 companies in 1972 and it became the best selling product.[7]

Design

Depending on the manufacturer, the standard 555 package includes 25 transistors, 2 diodes and 15 resistors on a silicon chip installed in an 8-pin mini dual-in-line package (DIP-8).[8] Variants available include the 556 (a 14-pin DIP combining two 555s on one chip), and the two 558 & 559s (both a 16-pin DIP combining four slightly modified 555s with DIS & THR connected internally, and TR is falling edge sensitive instead of level sensitive).



Internal schematic (bipolar version)



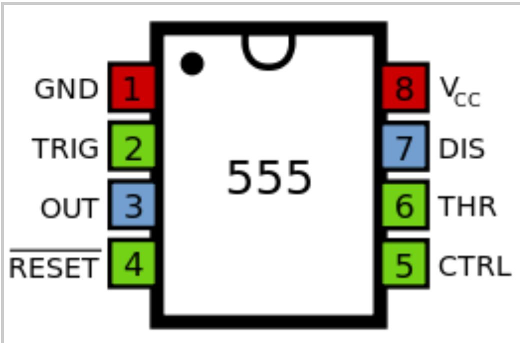
Internal schematic (CMOS version)

The **NE555** parts were commercial temperature range, 0 °C to +70 °C, and the **SE555** part number designated the military temperature range, −55 °C to +125 °C. These were available in both high-reliability metal can (T package) and inexpensive epoxy plastic (V package) packages. Thus the full part numbers were NE555V, NE555T, SE555V, and SE555T. It has been hypothesized that the 555 got its name from the three 5 kΩ resistors used within,[9] but Hans Camenzind has stated that the number was arbitrary.[3]

Low-power versions of the 555 are also available, such as the 7555 and CMOS TLC555.[10] The 7555 is designed to cause less supply noise than the classic 555 and the manufacturer claims that it usually does not require a "control" capacitor and in many cases does not require a decoupling capacitor on the power supply. Those parts should generally be included, however, because noise produced by the timer or variation in power supply voltage might interfere with other parts of a circuit or influence its threshold voltages.

Pins

The connection of the pins for a DIP package is as follows:



Pinout diagram

Pin	Name	Purpose
1	GND	Ground reference voltage, low level (0 V)
2	TRIG	The OUT pin goes high and a timing interval starts when this input falls below 1/2 of CTRL voltage (which is typically 1/3 V_{CC}, CTRL being 2/3 V_{CC} by default if CTRL is left open). More simply we can say that OUT will be high as long as the trigger is kept at low voltage. Output of the timer totally depends upon the amplitude of the external trigger voltage applied to this pin.
3	OUT	This output is driven to approximately 1.7 V below $+V_{CC}$, or to GND.
4	$\overline{\text{RESET}}$	A timing interval may be reset by driving this input to GND, but the timing does not begin again until RESET rises above approximately 0.7 volts. Overrides TRIG which overrides THR.
5	CTRL	Provides "control" access to the internal voltage divider (by default, 2/3 V_{CC}).
6	THR	The timing (OUT high) interval ends when the voltage at THR ("threshold") is greater than that at CTRL (2/3 V_{CC} if CTRL is open).
7	DIS	Open collector output which may discharge a capacitor between intervals. In phase with output.
8	V_{CC}	Positive supply voltage, which is usually between 3 and 15 V depending on the variation.

Pin 5 is also sometimes called the CONTROL VOLTAGE pin. By applying a voltage to the CONTROL VOLTAGE input one can alter the timing characteristics of the device. In most applications, the CONTROL VOLTAGE input is not used. It is usual to connect a 10 nF capacitor between pin 5 and 0 V to prevent interference. The CONTROL VOLTAGE input can be used to build an astable multivibrator with a frequency-modulated output.

Modes

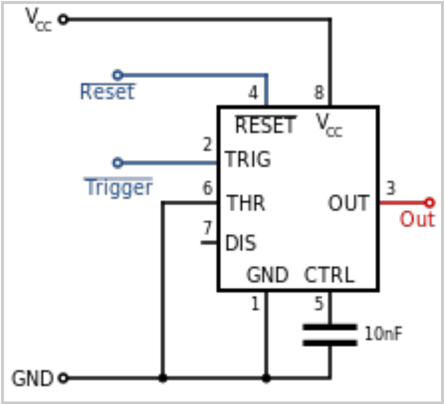
The IC 555 has three operating modes:

1. **Bistable** mode or Schmitt trigger – the 555 can operate as a flip-flop, if the DIS pin is not connected and no capacitor is used. Uses include bounce-free latched switches.
2. **Monostable** mode – in this mode, the 555 functions as a "one-shot" pulse generator. Applications include timers, missing pulse detection, bounce-free switches, touch switches, frequency divider, capacitance measurement, pulse-width modulation (PWM) and so on.
3. **Astable** (free-running) mode – the 555 can operate as an electronic oscillator. Uses include LED and lamp flashers, pulse generation, logic clocks, tone generation, security alarms, pulse position modulation and so on. The 555 can be used as a simple ADC, converting an analog value to a pulse length (e.g., selecting a thermistor as timing resistor allows the use

of the 555 in a temperature sensor and the period of the output pulse is determined by the temperature). The use of a microprocessor-based circuit can then convert the pulse period to temperature, linearize it and even provide calibration means.

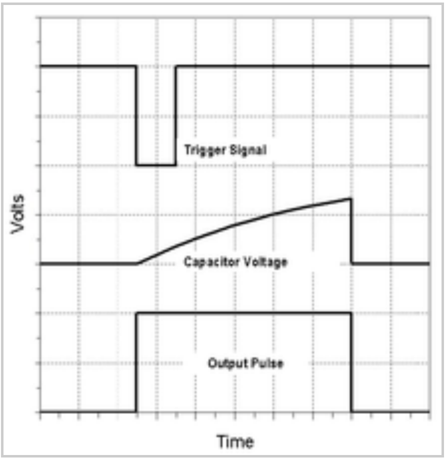
Bistable

In bistable (also called Schmitt trigger) mode, the 555 timer acts as a basic flip-flop. The trigger and reset inputs (pins 2 and 4 respectively on a 555) are held high via pull-up resistors while the threshold input (pin 6) is simply floating. Thus configured, pulling the trigger momentarily to ground acts as a 'set' and transitions the output pin (pin 3) to Vcc (high state). Pulling the reset input to ground acts as a 'reset' and transitions the output pin to ground (low state). No timing capacitors are required in a bistable configuration. Pin 5 (control voltage) is connected to ground via a small-value capacitor (usually 0.01 to 0.1 µF). Pin 7 (discharge) is left floating.[11]

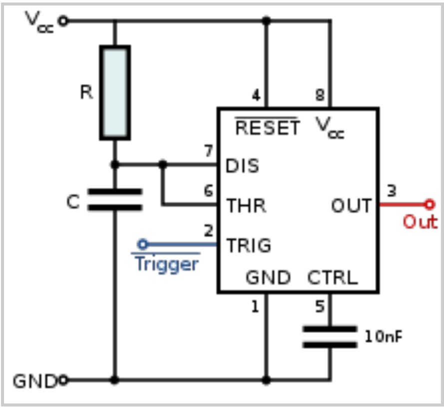


Schematic of a 555 in bistable mode

Monostable



The output pulse ends when the voltage on the capacitor equals 2/3 of the supply voltage. The output pulse width can be lengthened or shortened to the need of the specific application by adjusting the values of R and C.[12]



Schematic of a 555 in monostable mode

The output pulse width of time *t*, which is the time it takes to charge C to 2/3 of the supply voltage, is given by

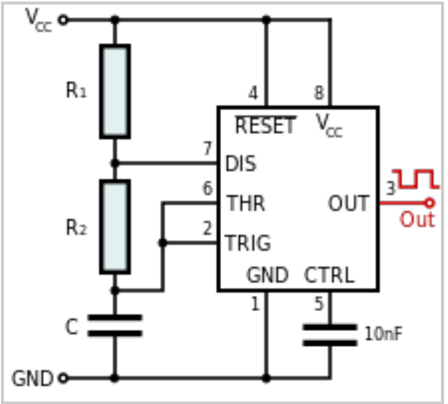
$$t = \ln(3) \cdot RC \approx 1.1RC$$

where t is in seconds, R is in ohms (resistance) and C is in farads (capacitance).

While using the timer IC in monostable mode, the main disadvantage is that the time span between any two triggering pulses must be greater than the RC time constant.[13] Conversely, ignoring closely spaced pulses is done by setting the RC time constant to be larger than the span between spurious triggers. (Example: ignoring switch contact bouncing.)

Astable

In astable mode, the 555 timer puts out a continuous stream of rectangular pulses having a specified frequency. Resistor R_1 is connected between V_{CC} and the discharge pin (pin 7) and another resistor (R_2) is connected between the discharge pin (pin 7), and the trigger (pin 2) and threshold (pin 6) pins that share a common node. Hence the capacitor is charged through R_1 and R_2, and discharged only through R_2, since pin 7 has low impedance to ground during output low intervals of the cycle, therefore discharging the capacitor.



Schematic of a 555 in astable mode

In the astable mode, the frequency of the pulse stream depends on the values of R_1, R_2 and C:

$$f = \frac{1}{\ln(2) \cdot C \cdot (R_1 + 2R_2)}$$ [14]

The high time from each pulse is given by:

$$\text{high} = \ln(2) \cdot C \cdot (R_1 + R_2)$$

and the low time from each pulse is given by:

$$\text{low} = \ln(2) \cdot C \cdot R_2$$

where R_1 and R_2 are the values of the resistors in ohms and C is the value of the capacitor in farads.

The power capability of R_1 must be greater than $\frac{V_{cc}^2}{R_1}$.

Particularly with bipolar 555s, low values of R_1 must be avoided so that the output stays saturated near zero volts during discharge, as assumed by the above equation. Otherwise the output low time will be greater than calculated above. The first cycle will take appreciably longer than the calculated time, as the capacitor must charge from 0V to 2/3 of V_{CC} from power-up, but only from 1/3 of V_{CC} to 2/3 of V_{CC} on subsequent cycles.

To have an output high time shorter than the low time (i.e., a duty cycle less than 50%) a small diode (that is fast enough for the application) can be placed in parallel with R_2, with the cathode on the capacitor side. This bypasses R_2 during the high part of the cycle so that the high interval depends only on R_1 and C, with an adjustment based the voltage drop across the diode. The voltage drop across the diode slows charging on the capacitor so that the high time is a longer than the expected and often-cited ln(2)*R_1C = 0.693 R_1C. The low time will be the same as above, 0.693 R_2C. With the bypass diode, the high time is

$$\mathrm{high} = R_1 \cdot C \cdot \ln\left(\frac{2V_{\mathrm{cc}} - 3V_{\mathrm{diode}}}{V_{\mathrm{cc}} - 3V_{\mathrm{diode}}}\right)$$

where V_{diode} is when the diode's "on" current is 1/2 of V_{cc}/R_1 which can be determined from its datasheet or by testing. As an extreme example, when V_{cc}= 5 and V_{diode}= 0.7, high time = 1.00 R_1C which is 45% longer than the "expected" 0.693 R_1C. At the other extreme, when V_{cc}= 15 and V_{diode}= 0.3, the high time = 0.725 R_1C which is closer to the expected 0.693 R_1C. The equation reduces to the expected 0.693 R_1C if V_{diode}= 0.

The operation of RESET in this mode is not well-defined. Some manufacturers' parts will hold the output state to what it was when RESET is taken low, others will send the output either high or low.

The astable configuration, with two resistors, cannot produce a 50% duty cycle. To produce a 50% duty cycle, eliminate R1, disconnect pin 7 and connect the supply end of R2 to pin 3, the output pin. This circuit is similar to using an inverter gate as an oscillator, but with fewer components than the astable configuration, and a much higher power output than a TTL or CMOS gate. The duty cycle for either the 555 or inverter-gate timer will not be precisely 50% and will change based off any load that the output is also driving while high (longer duty cycles for greater loads) due to the fact the timing network is supplied from the devices output pin, which has different internal resistances depending on whether it is in the high or low state (high side drivers tend to be more resistive).

Specifications

These specifications apply to the NE555. Other 555 timers can have different specifications depending on the grade (military, medical, etc.).

Supply voltage (V_{CC})	4.5 to 15 V
Supply current (V_{CC} = +5 V)	3 to 6 mA
Supply current (V_{CC} = +15 V)	10 to 15 mA
Output current (maximum)	200 mA
Maximum Power dissipation	600 mW
Power consumption (minimum operating)	30 mW@5V, 225 mW@15V
Operating temperature	0 to 75 °C

Packages

In 1972, Signetics originally released the 555 timer in 8-pin DIP and 8-pin TO-5 metal can packages, and the 556 timer was released in 14-pin DIP package.[2]

Currently, the 555 is available in through-hole packages as DIP-8 and SIP-8 (both 2.54mm pitch),[15] and surface-mount packages as SO-8 (1.27mm pitch), SSOP-8 / TSSOP-8 / VSSOP-8 (0.65mm pitch), BGA (0.5mm pitch).[16] The Microchip/Micrel MIC1555 is a 555 CMOS timer with 3 fewer pins available in SOT23-5 (0.95mm pitch) surface mount package.[17]

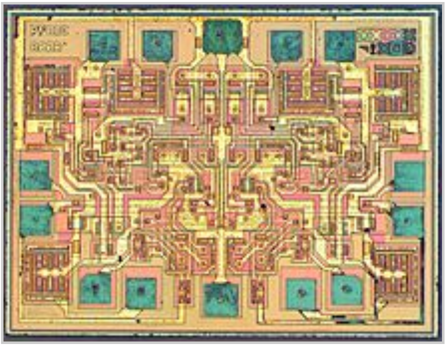
Derivatives

Many pin-compatible variants, including CMOS versions, have been built by various companies. Bigger packages also exist with two or four timers on the same chip. The 555 is also known under the following type numbers:

Manufacturer	Model	Remark
Custom Silicon Solutions[18]	CSS555/CSS555C	CMOS from 1.2 V, IDD < 5 μA
CEMI	ULY7855	
ECG Philips	ECG955M	
Exar	XR-555	
Fairchild Semiconductor	NE555/KA555	
GoldStar	GSC555	CMOS
Harris	HA555	
Hitachi	HA17555	
IK Semicon	ILC555	CMOS from 2 V
Intersil	SE555/NE555	
Intersil	ICM7555	CMOS
Lithic Systems	LC555	
Maxim	ICM7555	CMOS from 2 V
Motorola	MC1455/MC1555	
National Semiconductor	LM1455/LM555/LM555C	
National Semiconductor	LMC555	CMOS from 1.5 V
NTE Sylvania	NTE955M	
Raytheon	RM555/RC555	
RCA	CA555/CA555C	
STMicroelectronics	NE555N/ K3T647	
STMicroelectronics	TS555	CMOS from 2 V
Texas Instruments	SN52555/SN72555	
Texas Instruments	TLC555	CMOS from 2 V
USSR	K1006ВИ1	
X-REL Semiconductor	XTR655	Operation from -60°C to 250+°C
Zetex	ZSCT1555 (discontinued (http://www.diodes.com/_files/datasheets/ZSCT1555.pdf))	down to 0.9 V
NXP Semiconductors	ICM7555	CMOS
HFO / East Germany	B555	

556 dual timer

The dual version is called 556. It features two complete 555s in a 14 pin DIL package.



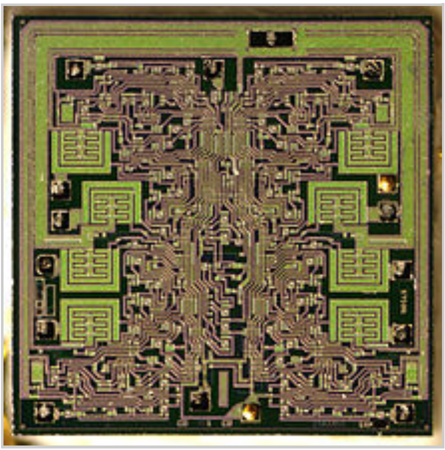
Die of a 556 dual timer manufactured by STMicroelectronics.

558 quad timer

The quad version is called 558 and has 16 pins. To fit four 555s into a 16 pin package the power, control voltage, and reset lines are shared by all four modules. Each module's discharge and threshold circuits are wired together internally.

Example applications

Joystick interface circuit using the 558 quad timer



Die of a 558 quad timer.

The Apple II microcomputer used a quad timer 558 in monostable (or "one-shot") mode to interface up to four "game paddles" or two joysticks to the host computer. It also used a single 555 for flashing the display cursor.

A similar circuit was used in the IBM PC.[19] In the joystick interface circuit of the IBM PC, the capacitor of the RC network (see Monostable Mode above) was generally a 10 nF capacitor. The resistor of the RC network consisted of the potentiometer inside the joystick along with an external resistor of 2.2 kΩ.[20] The joystick potentiometer acted as a variable resistor. By moving the joystick, the resistance of the joystick increased from a small value up to about 100 kΩ. The joystick operated at 5 V.[21]

Software running in the host computer started the process of determining the joystick position by writing to a special address (ISA bus I/O address 201h).[21][22] This would result in a trigger signal to the quad timer, which would cause the capacitor of the RC network to begin charging and cause the quad timer to output a pulse. The width of the pulse was determined by how long it took the capacitor to charge up to 2/3 of 5 V (or about 3.33 V), which was in turn determined by the joystick position.[21][23] The software then measured the pulse width to determine the joystick position. A wide pulse represented the full-right joystick position, for example, while a narrow pulse represented the full-left joystick position.[21]

See also

- Counter (digital)
- Operational amplifier

- List of LM-series integrated circuits
- List of linear integrated circuits
- 4000 series, List of 4000 series integrated circuits
- 7400 series, List of 7400 series integrated circuits

References

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Further reading

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- *Timer, Op Amp, and Optoelectronic Circuits and Projects*; Forrest Mims III; Master Publishing; 128 pages; 2004; ISBN 978-0-945053-29-3.
- *Engineer's Mini-Notebook – 555 Timer IC Circuits*; Forrest Mims III; Radio Shack; 33 pages; 1989; ASIN B000MN54A6.
- *IC Timer Cookbook*; 2nd Ed; Walter G Jung; Sams Publishing; 384 pages; 1983; ISBN 978-0-672-21932-0.
- *555 Timer Applications Sourcebook with Experiments*; Howard M Berlin; Sams Publishing; 158 pages; 1979; ISBN 978-0-672-21538-4.
- *IC 555 Projects*; E.A. Parr; Bernard Babani Publishing; 144 pages; 1978; ISBN 978-0-85934-047-2.
- *Analog Applications Manual* (https://archive.org/details/bitsavers_signeticsdcsAnalogApplications_33415016); Signetics; 418 pages; 1979. Chapter 6 Timers is 22 pages.

External links

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- 555 Timer Circuits – the Astable, Monostable and Bistable (http://www.eleinmec.com/article.asp?1)
- Simple 555 timer circuits (http://www.electroniq.net/555-timer-circuits)
- Java simulation of 555 oscillator circuit (http://www.falstad.com/circuit/e-555square.html)
- NE555 Frequency and duty cycle calculator (http://www.daycounter.com/Calculators/NE555-Calculator.phtml) for astable multivibrators
- Using NE555 as a Temperature DSP (http://www.globu.net/pp/english/pp/ne555.htm)
- 555 Timer Tutorial by Tony van Roon (http://www.sentex.ca/~mec1995/gadgets/555/555.html)
- Common Mistakes When Using a 555 Timer (http://www.555-timer-circuits.com/common-mistakes.html)
- 555 and 556 Timer Circuits (http://www.kpsec.freeuk.com/555timer.htm)
- 555 using areas and examples circuits (http://elektronikhobi.net/555-entegresinin-ozellikleri-ve-kullanim-alanlari/)
- Working with 555 Timer Circuits (http://www.engineersgarage.com/555-timer-circuits) Engineers Garage
- Analysis and synthesis of a 555 astable multivibrator circuit - online calculator (http://ekalk.info/555a_en.html)
- Online simulations of a 555 astable multivibrator circuit - online simulator (http://www.cirvirlab.com/simulation/ne555_astable_multivibrator_online.php)

Datasheets / Databooks

- NE555, Single Bipolar Timer, Texas Instruments (http://focus.ti.com/lit/ds/symlink/ne555.pdf)
- NE556, Dual Bipolar Timer, Texas Instruments (http://focus.ti.com/lit/ds/symlink/na556.pdf)
- NE558, Quad Bipolar Timer, NXP (http://www.nxp.com/documents/data_sheet/NE558_3.pdf)

- LMC555, Single CMOS Timer, Texas Instruments (http://www.ti.com/lit/gpn/lmc555) (operates down to 1.5 Volt at 50 uAmp)
- ICM755x, Single / Dual CMOS Timer, Intersil (http://www.intersil.com/data/fn/fn2867.pdf) (operates down to 2.0 Volt at 60 uAmp)
- ZSCT1555, Single CMOS Timer, Diodes Inc (http://www.diodes.com/datasheets/ZSCT1555.pdf) (operates down to 0.9 Volt at 74 uAmp)
- TS300x, Single CMOS Timers, Touchstone (http://touchstonesemi.com/products/timers) (operates down to 0.9 Volt at 1.0 uAmp)
- XTR65x, HiRel HiTemp Timer, X-REL (http://www.x-relsemi.com/EN/Documentation/Datasheet/DS-00100-11-XTR650-HIGH-TEMPERATURE%20VERSATILE%20TIMER.pdf) (operates from -60°C to 230°C)

Categories: Oscillators | Linear integrated circuits
