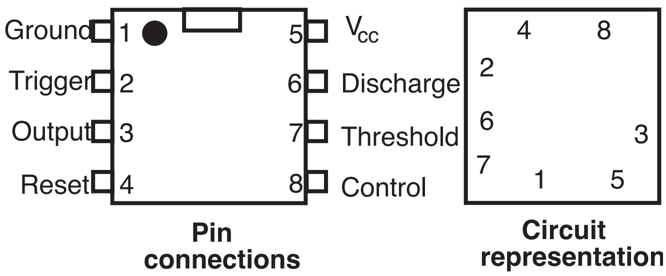
THE 555 TIMER

Many electronic systems require a timer to control their operation. The popular 555 timer IC can be used to produce two types of timed output.

The first type of output produced is a single pulse of a fixed period of time. A circuit that produces this type of output is called a **monostable.**

The second type of output produced is a continuous chain of on/off pulses. A circuit that produces this type of output is referred to as a square wave oscillator or **astable.**

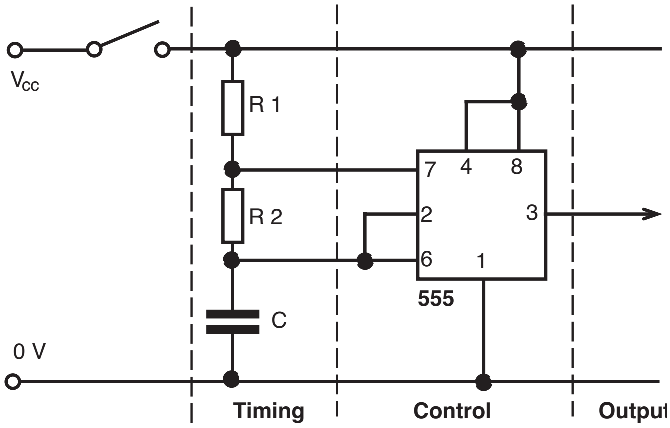
The 555 timer is mounted on an eight pin DIL package. On a circuit diagram the timer is represented by a square box with the pin numbers arranged around the perimeter. The position of these numbers can be changed to suit a particular circuit layout.



The 555 timer uses a mixture of linear (or analogue) and digital IC technology. It can work off supply voltages in the range 4.5 to 16V and the output can source or sink up to 200 mA. A low power version of the 555 timer is available in the CMO5 7555 IC which is pin compatible with the 555 IC. The 7555 is particularly useful in battery powered projects as it only requires a fraction of the current drawn by a 555 IC

ASTABLE TIMER

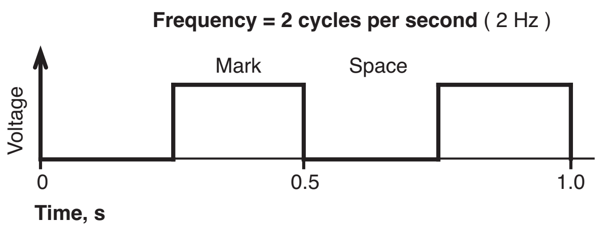
An astable has no stable output state. The output will continually switch between OV ('low') and a voltage just below the supply voltage, ('high') producing a 'square wave' output. The frequency of the output is determined by three external components, a capacitor and two resistors. Astables can either be free running or triggered. Free running astable timers produce an output immediately the power is applied. The circuit diagram for a free running 555 astable is shown below.



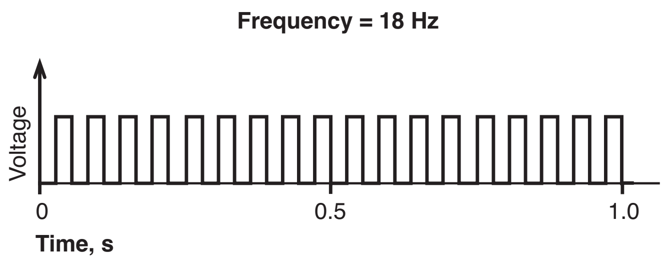
Note: A triggered astable timer would have pin 4 held at OV if no output was required. For the output to be active pin 4 would be taken high. An output waveform would be provided as long as pin 4 is held high.

The following diagrams show two typical output waveforms for an astable.

1. A low frequency output.

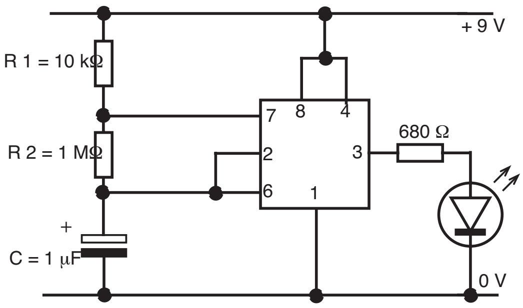


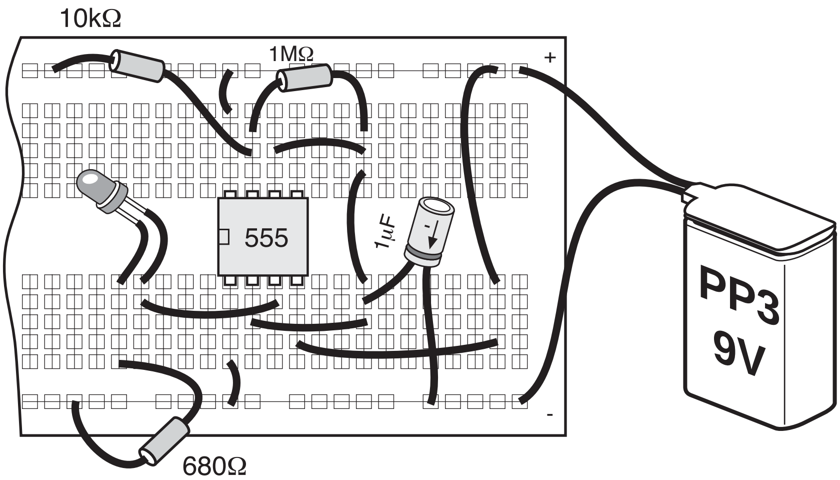
2. A higher frequency output.



INVESTIGATION

Set up the following circuit on breadboard.





Switch on the power and describe what you observe.

Measure the time for 20 flashes of the LED (i.e. 20 cycles) and enter the result in the table below:

Capacitor	Time for 20 Cycles	Time for one cycle (Period)
1μF 0.47μF		

Replace the 1μF capacitor with a 0.47μF capacitor and repeat the investigation.

Calculate the period of each signal by dividing the time for 20 cycles by 20.

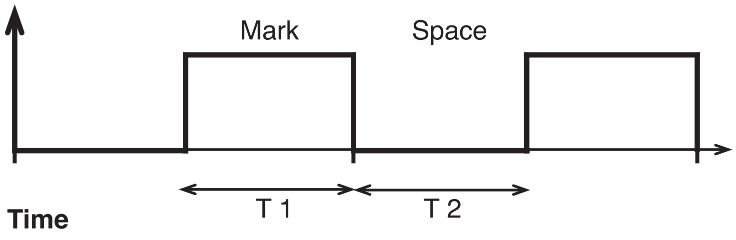
Use your results to complete the following.

Decreasing the value of capacitance in an astable circuit ______ the period of the output signal.

Note that Frequency (Hz) = 1/Period (sec).

TO CALCULATE THE FREQUENCY OF A 555 ASTABLE

Consider the following waveform.



The theoretical values for the **MARK** and **SPACE** are

Mark T_1 = 0.7 (R1 + R2). C

Space T_2 = 0.7 R2 C

and the frequency of oscillation

$$f = \frac{1}{T_1 + T_2} = \frac{1.44}{(R_1 + 2R_2).C}$$

Where R is measured in ohms and C is measured in farads.

Note
The mark-to-space ratio of the output waveform can be altered by varying either R_1 or R_2. As can be seen from the timing equations the mark will always be greater than the space. An approximately square waveform may be obtained (i.e. mark = space) if R_2 is much larger than R_1.

Example. Calculate the frequency of oscillation of a 555 astable having R1 = 1kΩ; R2 = 10kΩ ; C = 0.22μF.

$$f = \frac{1.44}{(R_1 + 2R_2) \times C} = \frac{1.44}{(1+20) \times 10^3 \times 0.22 \times 10^{-6}}$$

$$= \frac{1.44}{21 \times 0.22 \times 10^{-3}}$$

$$f = \frac{1.44}{4.62 \times 10^{-3}} = \frac{1.44 \times 1000}{4.62}$$

= **312 Hz**

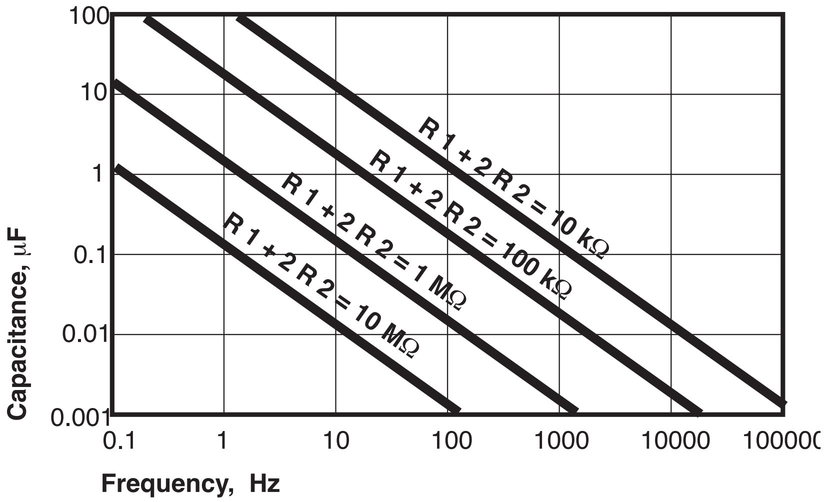
TO DESIGN AN ASTABLE TO PRODUCE A CERTAIN FREQUENCY

Designing an astable for a given frequency is quite difficult as there are three unknowns in the equation

$$f = \frac{1.44}{(R_1 + 2R_2)C}$$

There are numerous combinations of R1, R2 and C that will produce a given frequency.

The following graph can be used to help us choose component values.

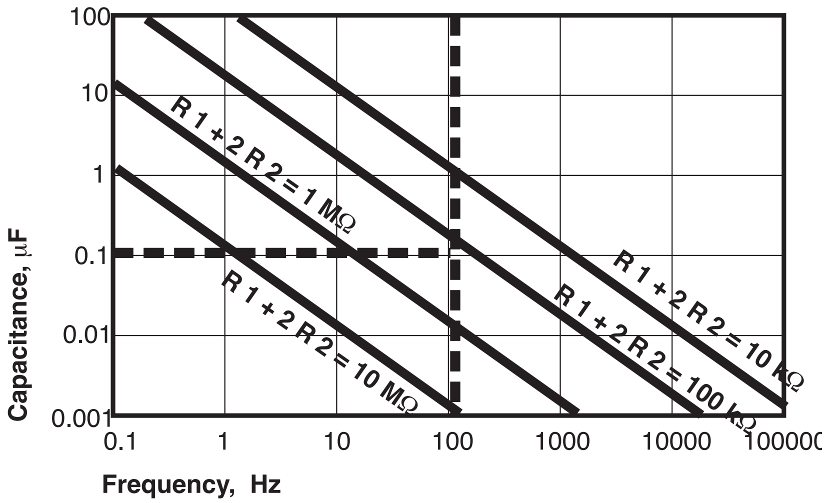


EXAMPLE
Design a 555 astable to produce a frequency of 100Hz.
You may assume that R1 = 1kΩ

If you look along the vertical line at f = 100 Hz. you will see that it crosses each of the diagonal lines labelled $R_1 + 2R_2$.

Choose any convenient one of these say $R_1 + 2R_2 = 100k\Omega$.

You will see the dotted line drawn horizontally from this point gives a capacitance of approximately 0.1μF.



	C = 0.1μF	
and	$R_1 + 2R_2$	= 100kΩ
i.e.	$1k\Omega + 2R_2$	= 100kΩ
	$2R_2$	= 99kΩ
	R_2	= 49.5kΩ

If the frequency is only required to be approximately 100 Hz choose a 47kΩ resistor for R_1.

If the frequency has to be exactly 100Hz then use a 47kΩ pot in series with a 10kΩ fixed resistor for R_1.

The frequency can then be adjusted accurately by using a frequency counter or an oscilloscope.

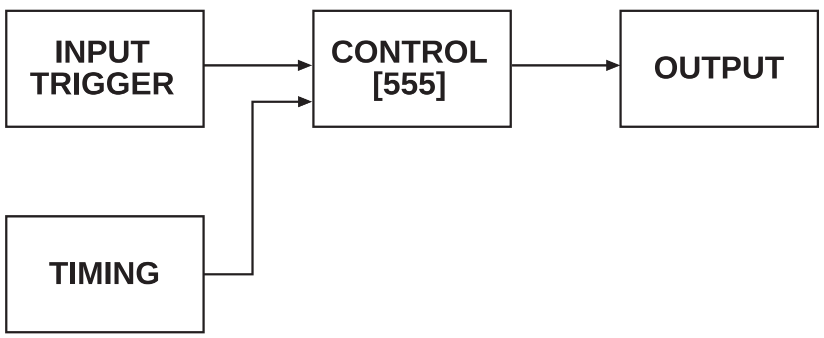
MONOSTABLE TIMER

A monostable has only one stable output state. Normally it is in this stable state with the output at OV. It can be triggered into the other state for a predetermined length of time. The length of time for which the output is in this 'temporary' state is determined by two external components, a resistor and a capacitor. In the 'temporary' state the output voltage is approximately equal to the supply voltage.

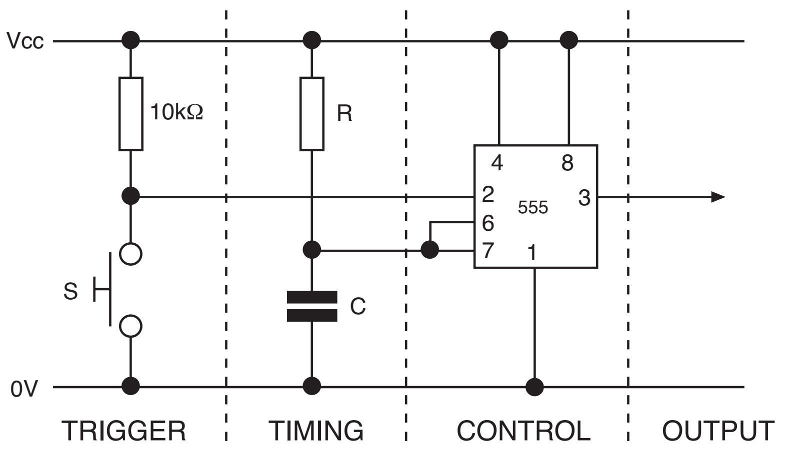
There are several different types of circuits that can produce a monostable output. One such circuit is based on the 555 timer.

Both a block diagram and a circuit diagram for 555 monostable are shown below.

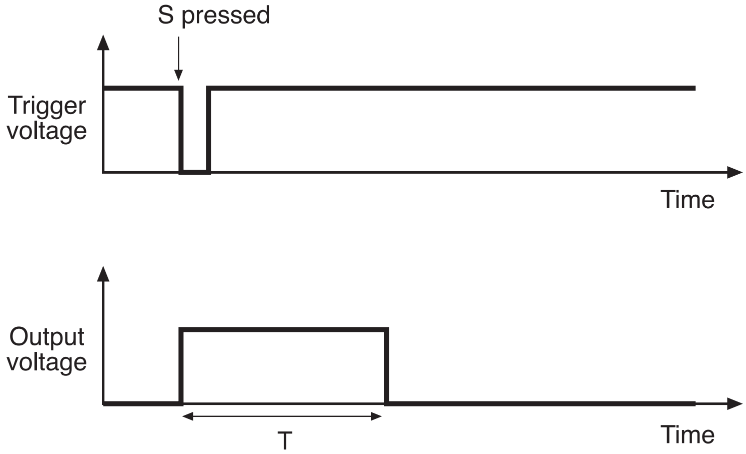
Block diagram for a monostable timer



Circuit diagram for monostable timer



The output is normally in a low state. When switch S is pressed momentarily, it causes the voltage at pin 2 to fall from a value equal to the supply voltage to OV. The monostable output is triggered high by the falling edge of the trigger pulse produced at pin 2.

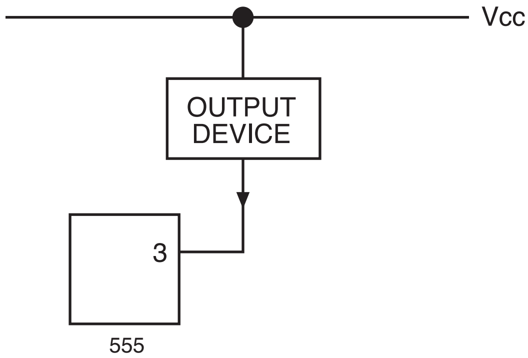


The period T is dependent on the values of resistance R and capacitance C used and can be calculated from tables, charts or by using a formula. The period can be made variable by replacing the fixed resistor R with a variable resistor in series with a 1kΩ fixed resistor. The 1kΩ fixed resistor is required to limit the current flowing into pin 7 when the variable resistor is set to zero.

In fact a wide range of "timings" may be obtained by using a 1MΩ variable resistor and one of three capacitor values (10μF, 100μF, 1000μF), as shown in the table below:

Required Timing Period	Capacitor
1 to 11 seconds	10μF
10 to 110 seconds	100μF
100 to 1100 seconds	1000μF

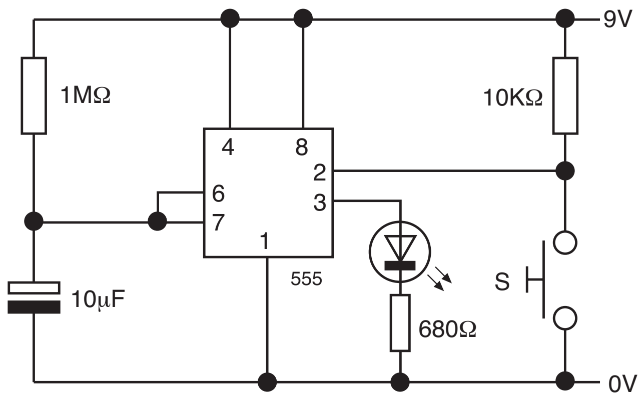
We sometimes require a monostable output that switches an output device off for a predetermined time. This can easily be achieved by connecting the output device between the positive supply and the 555 output.

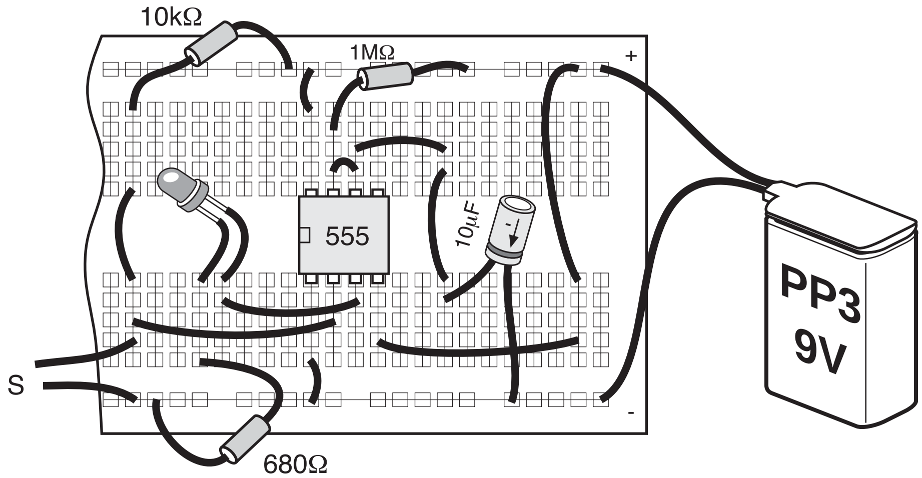


In the stable state pin 3 is low, the 555 timer sinks current and the output device is on. When the monostable is triggered the output device goes off for a predetermined length of time. Typical applications of this type of timer circuit may be an electronic egg timer or photographic timer, or any system in which we need to be warned that a certain time has elapsed.

INVESTIGATION 2

Set up the following circuit on breadboard





Momentarily touch the wires labelled S on the breadboard layout diagram. The LED should light up for a certain length of time and then go off.

Measure the time period for which the LED is ON.

Replace the 1MΩ resistor with a 100kΩ resistor and measure the new time period.

Replace the 10μf capacitor with a 47μf capacitor and repeat once more.

Use your results to complete the following:
Increasing the value of resistance ________ the time period
Increasing the value of capacitance ________ the time period.

TO CALCULATE THE TIME DELAY OF A 555 MONOSTABLE

The formula for the time delay T is:

$$T = 1.1 \times R \times C$$

When R is in ohms C is in farads and T is in seconds.

Example
Calculate the time delay produced by a 555 Monstable having
R = 100kΩ, C = 2200μf

$$\begin{aligned} T &= 1.1 \times R \times C \\ &= 1.1 \times 100 \times 10^{3} \times 2200 \times 10^{-6} \\ &= 1.1 \times 10 \times 22 \\ &= 242 \text{ seconds.} \end{aligned}$$

Use the formula to check the results you obtained in Investigation 2.