DESIGNING AND MAKING AN ELECTRONIC TIMER

WHAT YOU WILL LEARN

After completing this project, you should understand:

- What an electronic timer is and how it is used.
- How to design an electronic timer system using a block diagram.
- What an integrated circuit (IC) is.
- How a 555 IC is used as an electronic timer.
- How to change the time period of a 555 IC using resistors and capacitors.
- How to select the correct resistors and capacitors using formulae and tables.

After completing this project, you should be able to:

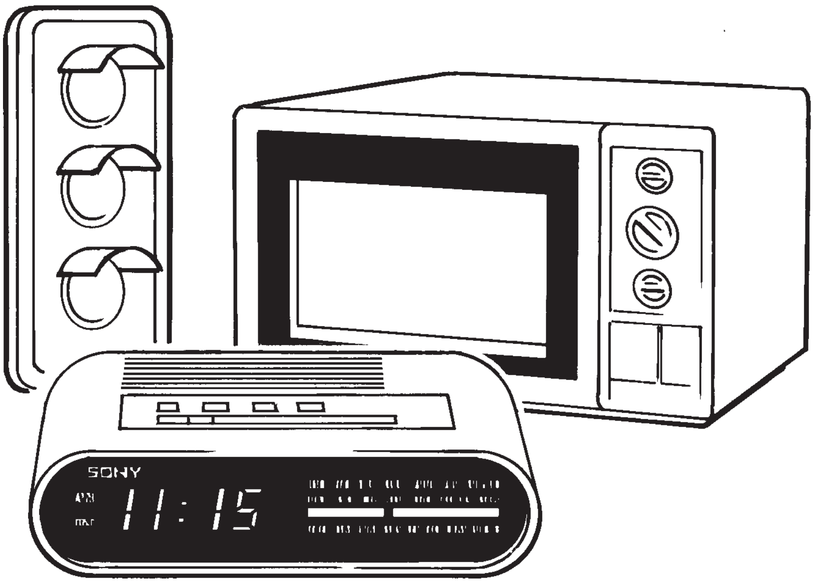
- Use the following components in electronic circuits:

  555 IC
  Light emitting diode (LED)
  Resistor
  Capacitor.

- Select components using formulae and tables to make a circuit work in a desired way.

DESIGNING AND MAKING AN ELECTRONIC TIMER

A timer is a system that controls **when** something should happen or for **how long** it should happen. Timers are very common in electronic control systems. At the heart of a digital radio/alarm clock is a timer that controls when the radio or alarm should come on. Most modern cookers, and all micro-wave ovens, have a timer to control how long food is cooked for. Traffic light systems, and pelican crossings, need timers as part of their control systems to make them function efficiently. Many of the stages in automated production lines are controlled by timers.



The similarity in all of these different examples is that the timer makes something happen when it is supposed to happen and for a set amount of time.

DESIGNING AN ELECTRONIC SYSTEM

Electronic systems can be represented using block diagrams. There are three basic building blocks and each block is used to represent a stage in the system. The three blocks are:

Input Block - Enters information into the system. E.g., a switch which might be turned 'on' or 'off'.

Process Block - Uses information from the input to control the output. E.g., an electronic component such as a transistor.

Output Block - Makes things happen. E.g., a bulb lighting up or a motor turning on.

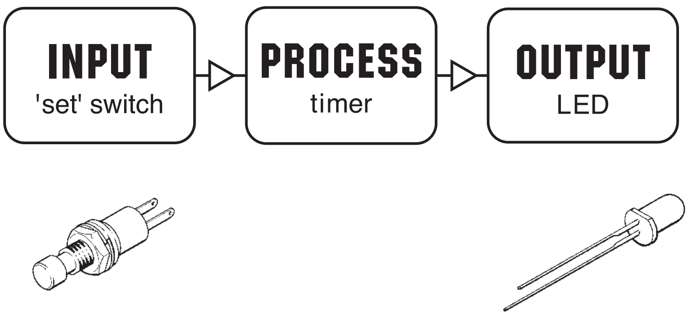
YOUR TASK

DESIGN BRIEF

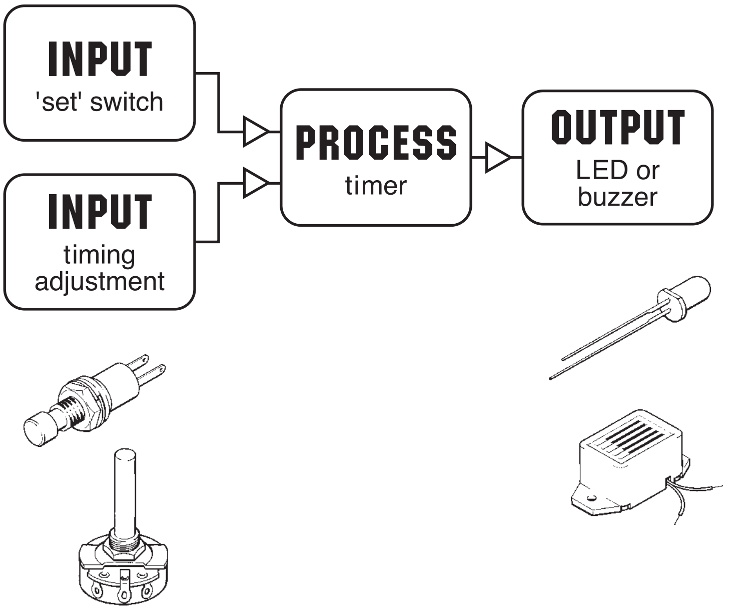
There is often a need to time a process such as photographic development or playing a game. Design and make an electronic timing system that could be used by somebody for timing intervals between 0 and 10 minutes.

DESIGNING YOUR SYSTEM

The timer has to be set by a user so there is a need for some kind of switch in the input block. The timer part of the system would be the process block. Some kind of output block would be needed to indicate the start and end of the time period.



The operator pushes the switch which sets the timer going and lights up the LED. When the time period is over, the LED goes out. Although this basic system will work, the design brief asks for a timing system that can "indicate times varying between 0 and 10 minutes in length". This means that you need to add something more to the system. The user not only has to push the switch to set the timer going, but also has to set how long the timer operates for. The system therefore needs another input block.



The user sets how long the timer operates for and then pushes the switch. This starts the timer, lighting up the LED until the end of the time period.

DESCRIBING YOUR TASK

DESIGN SPECIFICATION

First, you need to describe in detail what the product will be like, what it will do and who will use it. This is called a **design specification** and will guide your design work and help you to judge how well the outcome works.

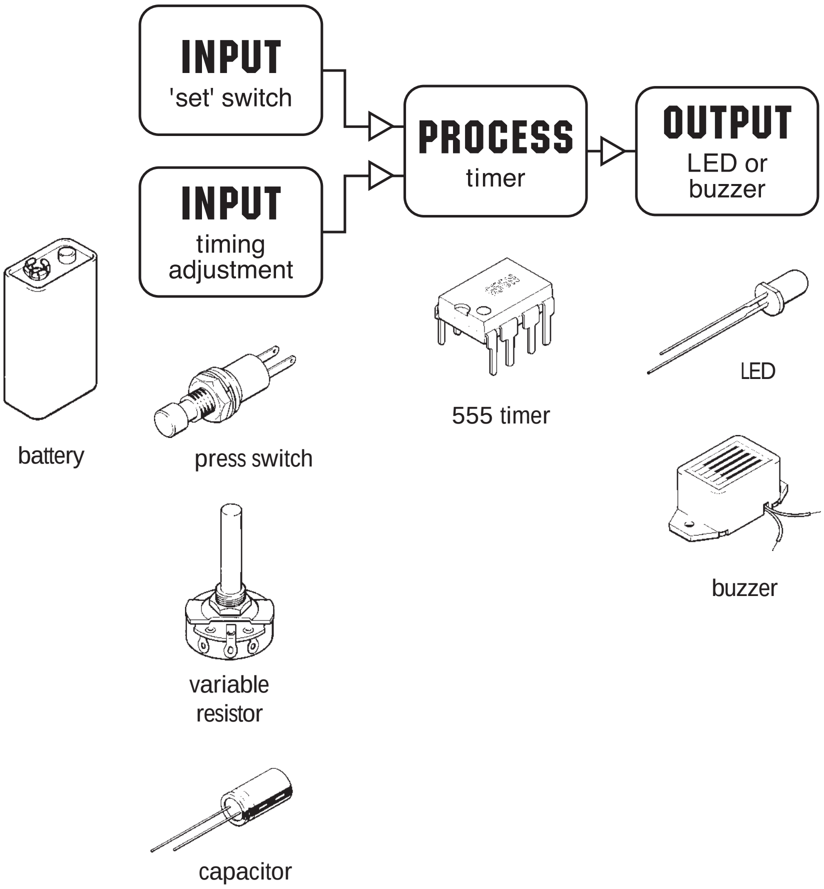
Here are some questions to help you with your design specification:

- *What is the timer for?*
- *What is the maximum interval it must time?*
- *Who will use it?*
- *What size should it be?*
- *What should it cost?*

MATERIALS AND COMPONENTS AVAILABLE

DESIGNING AND MANUFACTURING CONSTRAINTS

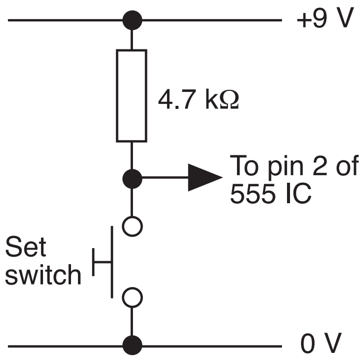
Before you can go ahead with designing and making the timing system, you need some more information. You need to know what power supply to use, what components are available to make up each system block and how they are used.



INPUT BLOCK

SYSTEM INPUT POSSIBILITIES

The input block that sets the timer going is called a trigger. To trigger the timer you need to make pin 2 go from +9 V to 0 V. This is done by using a switch connected like this.



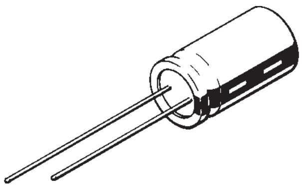
TIME PERIOD

The time period (how long the timer is on) is set by a capacitor and a resistor connected in series.

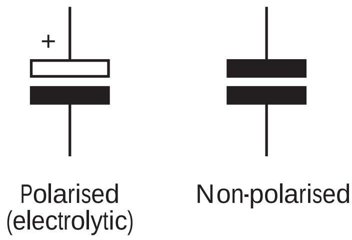
A capacitor is a device that charges up when connected to a power supply and stores electrical charge. The larger the capacitor, the longer it takes to charge. The size of a capacitor is measured in farads. Most capacitors are only a fraction of one farad so they are measured in microfarads (μF):

1 μF = 0.000001 farads

The capacitor you will be using is 1000 μF. It looks like this:



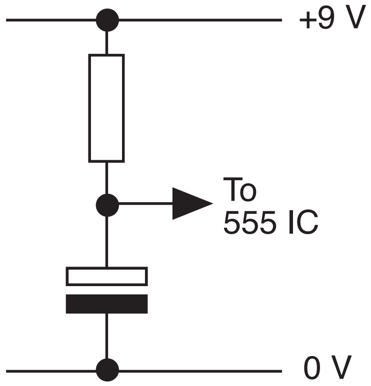
Note that the negative facing leg is clearly indicated. This means that this capacitor must be connected correctly into the circuit. This is because it is an *electrolytic* capacitor. Not all capacitors are like this. Most capacitors don't have positive and negative connections and can be connected in any direction. Notice the difference in the two circuit symbols:



When using capacitors, it is always important to check whether they are polarised.

The time taken to charge the capacitor also depends on the size of the resistance between it and the supply. The larger the resistance, the longer the capacitor takes to charge.

The capacitor and resistor are connected in series like this:



It is possible to calculate the time period of the 555. This is given by the formula:

1.1 × capacitance × resistance

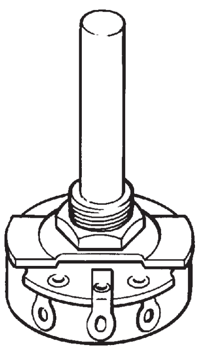
In the case of a 1000 μF capacitor and a 1 kΩ resistor

Time period $= 1.1 \times C \times R$
$= 1.1 \times 1000\ \mu F \times 1\ k\Omega$
$= 1.1 \times 0.001\ F \times 1000\ \Omega$
$= 1.1$ *seconds*

(Remember to convert to the base units of farads and ohms.)

The design brief requires a timing system that can "indicate times varying between 0 and 10 minutes in length".

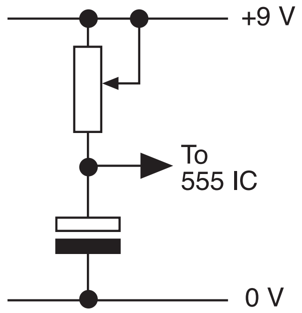
This means you need to be able to change the value of one of the components to vary the time period. The easiest way to do this is to use a variable resistor.



Variable resistor

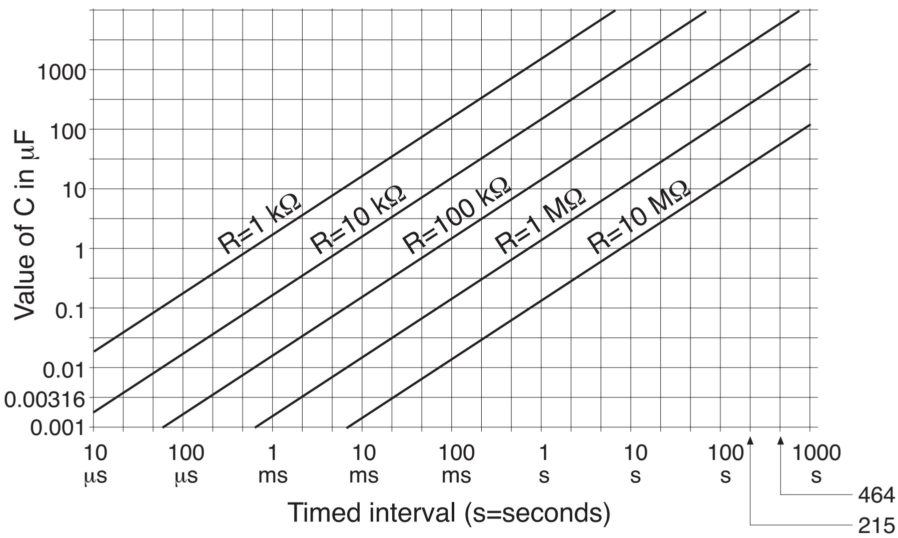
When you turn the shaft of the variable resistor, you change its resistance. By changing the resistance, you can change the time period.

The modified input circuit would look like this:



There is one last decision to make. Variable resistors come in different values. The quantity written on the resistor is the maximum value of resistance. Turning the shaft of the variable resistor varies its resistance from zero to the maximum value. You need to calculate the value of resistance to give you a time period of 10 minutes.

To calculate the time period, you can either use the equation (time period = C × R) or a table. Engineers often use graphs to look up values. They are a quick way of finding things out without having to do calculations. Using this graph, you can see what time period you would get using different combinations of resistors and capacitors. This graph will give you only approximate values.



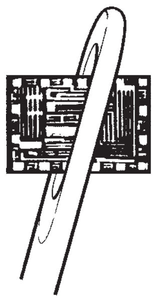
Look up the vertical scale to find 1000 µF. Draw a pencil line horizontally across from this point. Where the pencil line crosses the ‘resistor lines’, you can draw a vertical line to find the time period. (You need a maximum time period of 10 minutes.)

PROCESS BLOCK

SYSTEM PROCESSING POSSIBILITIES

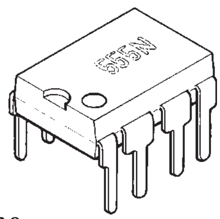
The process block contains the timing circuit. It is possible to make a timing circuit using normal electronic components. It is more usual however, certainly in real control systems, to use an integrated circuit (IC) to do this.

An integrated circuit is a tiny chip of semi-conducting material, usually silicon, that has a whole circuit produced on it. This is why they are also known as a silicon 'chips' or 'micro-chips'. The chip is normally no bigger than 0.2 mm^2, small enough to pass through the eye of a needle!

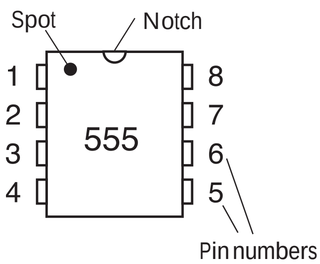


To make them easier to handle and use, they are fitted into larger plastic cases with connecting leads. ICs have revolutionised the electronics industry by enabling engineers to design and make electronic products that are much smaller and that consume far less power. Whereas the first computers would take up a whole floor of an office block, the same machine could now be made to fit in your pocket. ICs are an example of a very high technology product, yet they are also very cheap to buy. The majority of ICs cost less than £1.

There are many different types of IC designed to do different jobs. You will be using a 555 timer.



The IC has eight connecting pins numbered from 1 to 8. To find out which pin is which, you need to look carefully at the case. On one end is a notch and to the left of the notch is a spot. The pin next to the spot is pin 1. The pins then count around in an anti-clockwise direction from pin 1.



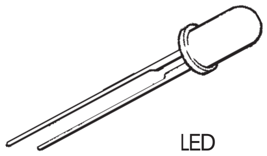
When engineers design electronic control systems that use ICs, they do not need to know much about what happens inside the chip. Instead they need to know what each pin on the IC does (e.g. is it a power supply connection, an input, an output etc.).

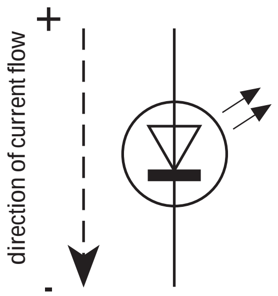
The 555 IC needs only a few external components to work as a timer. These components set it going and control how long it works. You know from the block diagram that these are the input components.

OUTPUT BLOCK

Light Emitting Diode (LED)
There are some important things to remember when using LEDs.

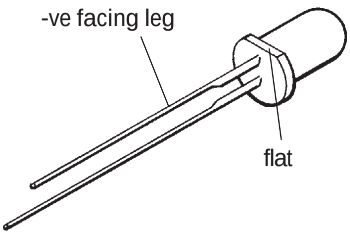
i) An LED only lights up when current flows through it in the correct direction. For this to happen, it must be connected the right way around in the circuit.



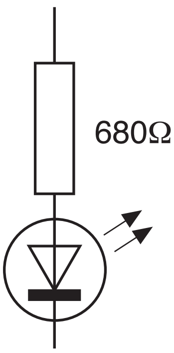


Circuit symbol for LED

To find out which leg is which, you have to look carefully at the LED. On one side of the circular case there is a flat surface. The leg next to this flat is the negative connection.



ii) LEDs must always be used with a series resistor. The resistor prevents too much current flowing through the LED which would damage it. You will need to use a 680 Ω resistor.



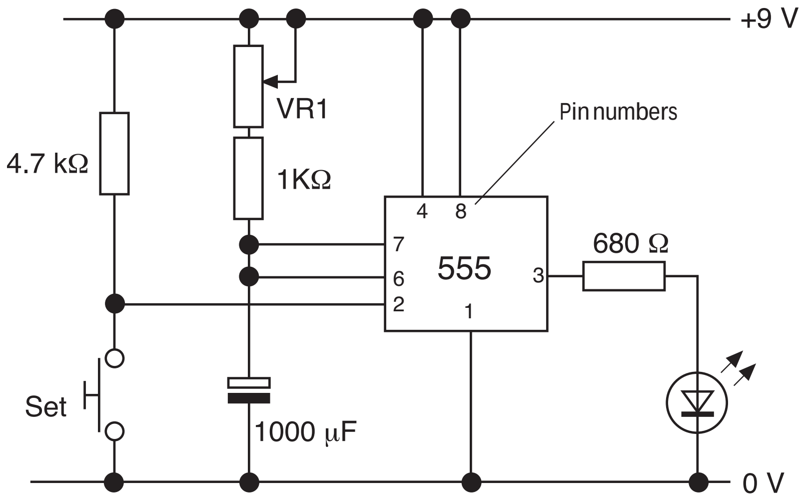
SYSTEM OUTPUT POSSIBILITIES

NOTE

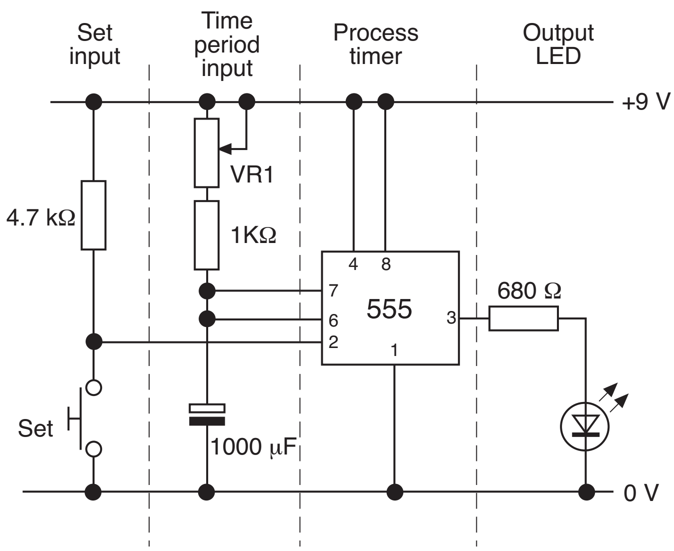
For more information, see Technology Study File 9 (Investigating the LED)

PUTTING IT ALL TOGETHER

The circuit diagram for a timer with an LED output is shown below. You will have found out the value for VR1, the variable resistor.



The circuit diagram for the timer is shown below divided into inputs, process and output. It may help you to understand which components are doing what.



You will need to make a printed circuit board (PCB) on which to mount the components.

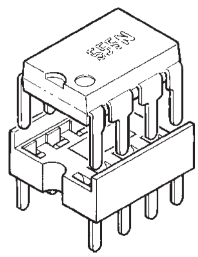
➤ SYSTEM SYNTHESIS

➤ NOTE

See Study File 1a, Crocodile Clips.

➤ NOTE

Integrated circuits are delicate devices so they need to be handled with care. In particular, all ICs can be damaged by static discharge. (Tests by National Semiconductors showed that 80% of all of their production line failures were attributed to static electricity.) Don't remove them from their packaging until you are ready to use them and don't handle them unnecessarily. When you use them to build circuits, you must mount them in a holder. The holder is soldered onto the PCB and the chip simply plugs into it. This means that the chip does not have to be soldered which could damage it. It can also be replaced easily should it be defective.



I.C and holder

➤ NOTE

To find out about this, see Technology Study File 2 (Making a PCB).

TESTING

SYSTEM DIAGNOSTICS

When you have built the circuit, you will need to test it to see if it works correctly. Press the set switch and see if the LED lights up. It should go off again after a period of time. Check that, by varying the resistor, you can vary the time period.
If the circuit does not work, follow this simple fault finding procedure, to find out why:

1. Check that the PCB layout is correct and that no tracks are bridged or broken. Repair if necessary.

NOTE

See Technology Study File 2 (Making a PCB)

2. Check that all soldered joints are good.

3. Check that all components are connected correctly. Pay particular attention to the chip. It is quite easy to plug it in the wrong way around.

4. If all this fails, try a new 555 IC.

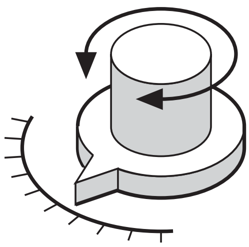
CALIBRATING

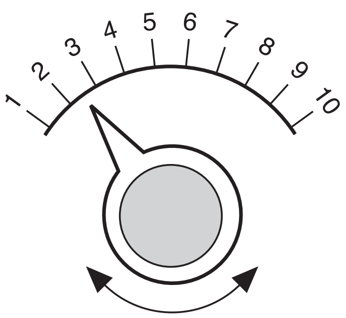
NOTE

See Technology Study File 10 (Maths Help)

If somebody is going to use the timing system, they need to know where to set the variable resistor to get the timer to run for the period they want. This means you have to design and make some kind of *gauge* or *scale* and a pointer.

You then need to put marks on the scale that correspond to the different time periods. One mark for each whole minute should be sufficient. This process of marking a gauge to set up the timer is known as calibrating.





EVALUATING THE TIMER

EVALUATION

There are a number of things you need to consider when evaluating your timing system:

1. How well does it work?

Is it accurate - does it give the same time period every time?

2. Will it work in the situation for which it was designed?

How easy is it to change the time period from one value to another one accurately?

3. Was trial and error the best way to calibrate the timer?

Can you think of another way to do it?