DESIGNING AND MAKING A MOISTURE SENSOR

WHAT YOU WILL LEARN

After completing this project, you should understand:

- What a sensor is and how it is used.
- How to design an electronic system using a block diagram.
- How to use a transistor as an electronic switch.
- How a moisture sensor works.
- How to manufacture a moisture sensor.

After completing this project you should be able to:

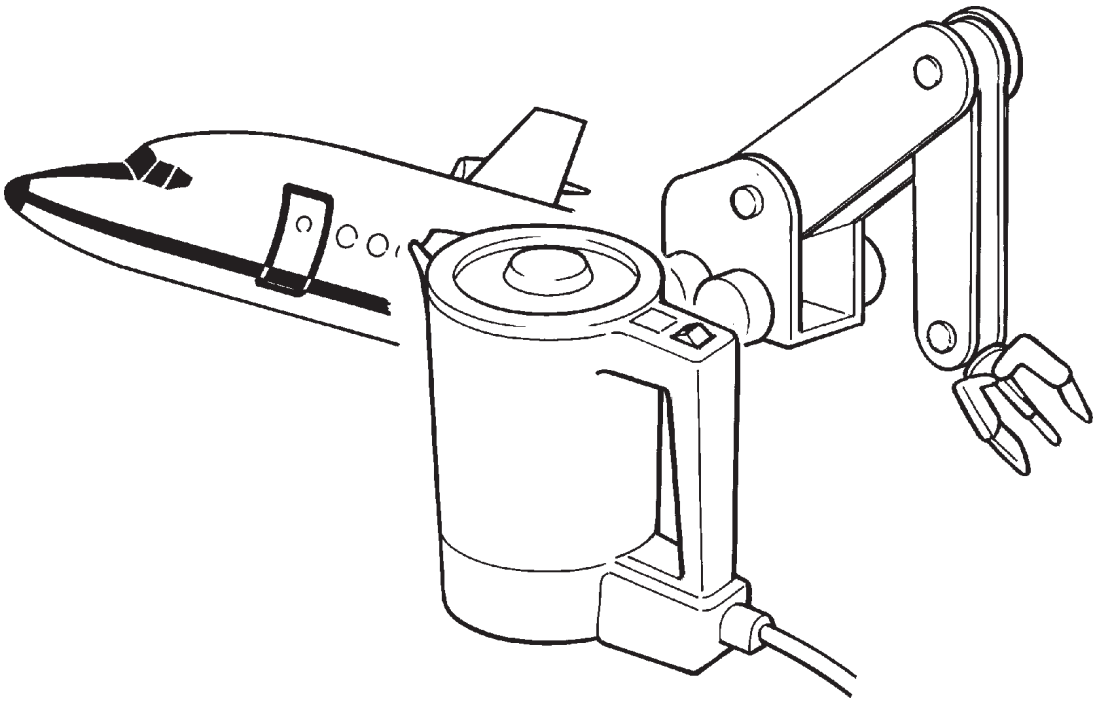
- Use the following components:

  Transistor
  Light emitting diode (LED)
  Buzzer
  Resistor
  Moisture sensor.

- Build a circuit that uses a moisture sensor.

ELECTRONIC SYSTEMS

Electronic systems are all around us silently performing useful tasks. These tasks can be as simple as turning a kettle off when it has boiled, or as complex as controlling an industrial robot or a modern jet aircraft.



For electronic systems to work effectively, it is often necessary for them to *sense* changes in the outside world. (Just as a human being senses sound, light and heat.)

Electronic systems use information gathered by *sensors* to monitor things that change (e.g. the **temperature** of the water in an electric kettle, the **position** of a robot arm). The system uses this information to make something else happen when the conditions are correct. For example the kettle switches off when the water is boiling or the robot arm picks up an object when it reaches the correct position.

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 control 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

Design and make an electronic system that can sense a change in moisture level and indicate when this happens. The system must satisfy a need that has been identified and investigated by you.

You need to design a system that can sense a change in moisture level and indicate when this happens. The block diagram for a control system that could do this would look like this:

The moisture sensor senses a change in moisture level. It passes this 'information' to the process block. The process block switches on the output block. The output block indicates that the moisture level has changed.

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.

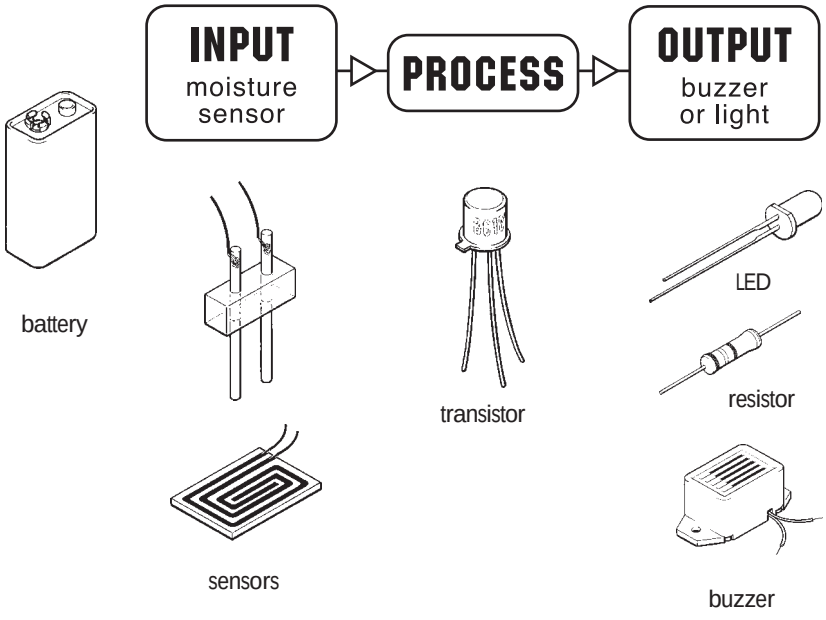
Here are some questions to help you with your design specification:

- *What is the moisture sensor for?*
- *Who will use it?*
- *What size should it be?*
- *What should it cost?*
- *What battery will it use?*

MATERIALS AND COMPONENTS AVAILABLE

DESIGNING AND MANUFACTURING CONSTRAINTS

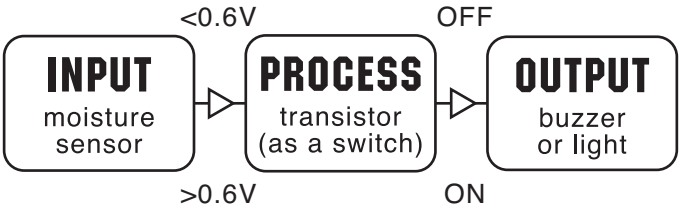
Before you can go ahead and make an electronic circuit you need more information. You need to know what power supply to use, what components are available and how to use them.



INPUT BLOCK

SYSTEM INPUT POSSIBILITIES

The input block contains the sensor. This senses when moisture is present and passes the information to the process block. The process block is a transistor that is being used as an electronic switch. For the transistor to switch the output on or off, it needs a voltage that is greater than 0.6 V. This means that the 'information' the input block passes to the process block is a voltage that varies between two levels - less than 0.6 V for off and greater than 0.6 V for on.

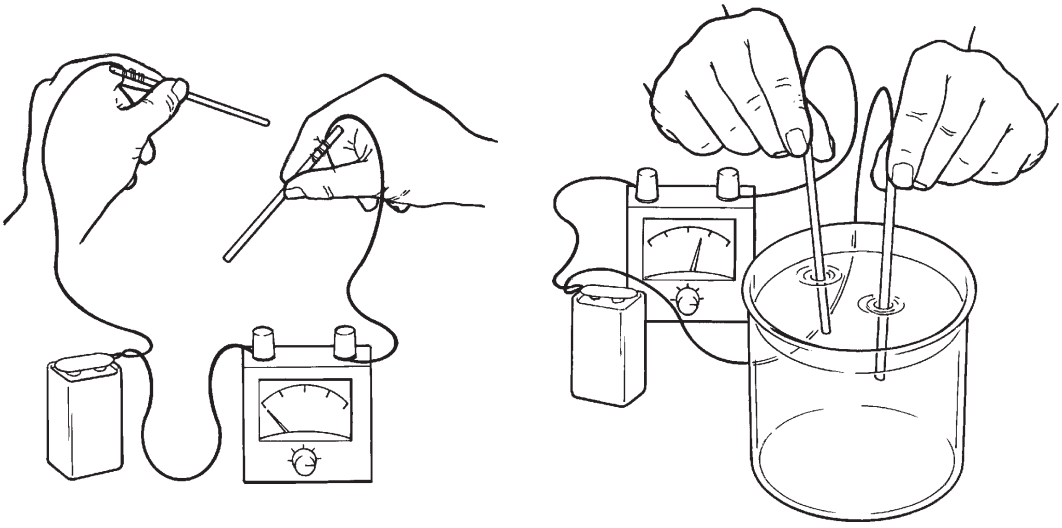


INVESTIGATING THE SENSOR

Key Point - The input block provides a voltage that is either greater than, or less than, 0.6 V depending on whether it is wet or dry.

There are some ready-made components available that sense moisture and provide a voltage change of 0.6 V. However, you can design and make your own. When you are designing the sensor, you need to know that water is a good conductor of electricity and air is a bad conductor of electricity. If two metal rods are connected to the terminals of a battery and held apart in the air, no current flows between them.

If the two rods are placed in a container full of tap water, the water completes the circuit and a current flows between them. The water acts in the same way as a resistor.

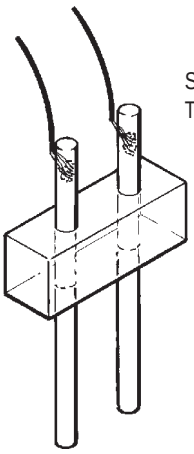


Using this knowledge, you can now begin to design a moisture sensor. It is at this point that you have to start making design decisions of your own.

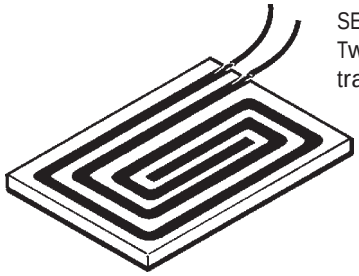
Two copper rods held apart by a piece of drilled acrylic would be fine for testing the water level in a bath, or fish tank etc., or for inserting into the soil in a plant pot to see if the plant needs watering.

But would this design be suitable for use where the moisture is in small droplets (e.g. rain) or where it has to be used in sensitive environments (e.g. sensing baby's bed wetting)?

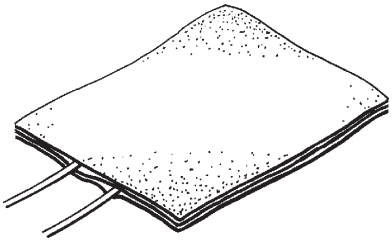
The similarity between these moisture sensors is that they all have two metal objects close to one another. It is the method of construction that varies.



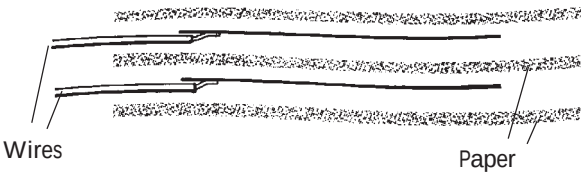
SENSOR 1
Two rods



SENSOR 2
Two copper tracks on PCB



SENSOR 3
Wires are sandwiched between paper sheets which are then glued together. For greater sensitivity, the paper can be soaked in salt solution and dried prior to gluing.



CONNECTING THE SENSOR

The way you connect the sensor depends on when you want the control system to switch on the output component. For example, do you want the output component (buzzer or LED) to come on when the moisture sensor senses that something is dry or when something is wet?

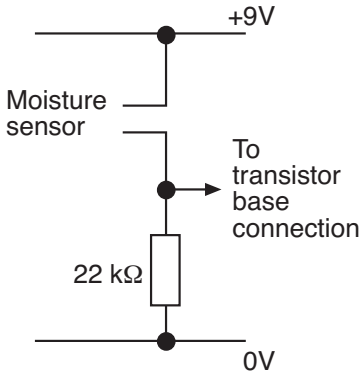
This depends on the type of system you are designing. A soil tester needs to indicate when the soil is dry (sensor dry). A bath level indicator needs to indicate when the bath is full (sensor wet).

The input block is made from two components, your moisture sensor and a resistor. They are connected in series between the power supply lines. The output voltage fed to the transistor process block is taken from the point where the two components connect and the negative supply line. There are two alternative connections:

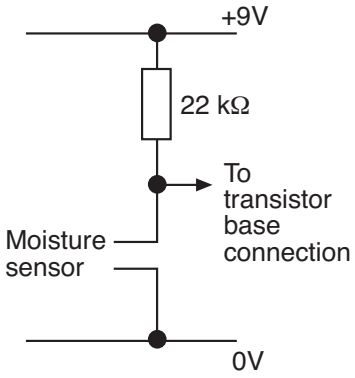
NOTE

To find out more about the input circuit (resistors connected in series), see Technology Study File 6 (Investigating the Potential Divider)

*This one gives you an output voltage that **rises** when the sensor gets wet.*



*This one gives you an output voltage that **falls** when the sensor gets wet.*



You will need to build one of these input circuits and measure the output voltage to find out how you are going to connect your sensor. Use a 22 kΩ resistor and make sure that you have got the meter set to the correct range (d.c. 0-10 V).

NOTE

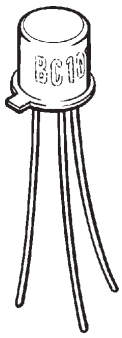
To find out about meters see Technology Study File 4 (Multimeters)

Measure the voltage with the sensor dry and with the sensor wet and note your results. Check to see whether these are the voltages you need when the sensor is dry and wet. If the voltages are not correct, build the other input circuit and test the output voltage.

PROCESS BLOCK

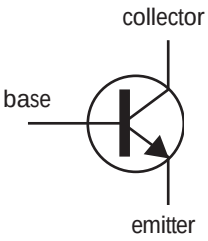
SYSTEM PROCESSING POSSIBILITIES

The component used in the process block is a transistor. There are many different types of transistor designed for different purposes. You will use a BC108 transistor that looks like this.



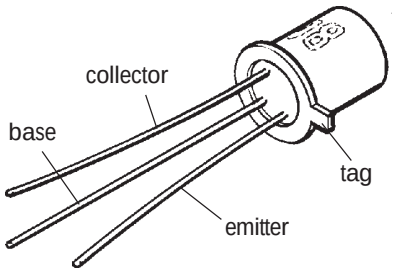
BC108 transistor

The three legs of the transistor have names. These are shown on the transistor's circuit symbol.



Transistor circuit symbol

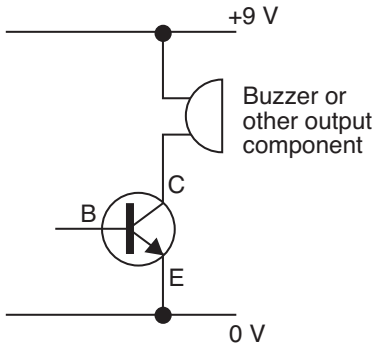
To find out which leg is which on a BC108, you must look at it very closely. The tag indicates the position of the emitter. Next to the emitter is the base and then the collector.



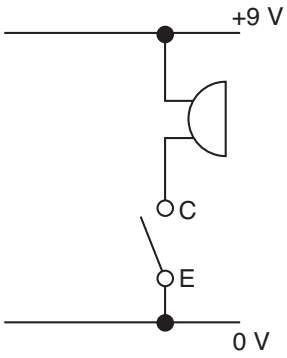
You will use the transistor as an electronic switch. Connect it like this.

NOTE

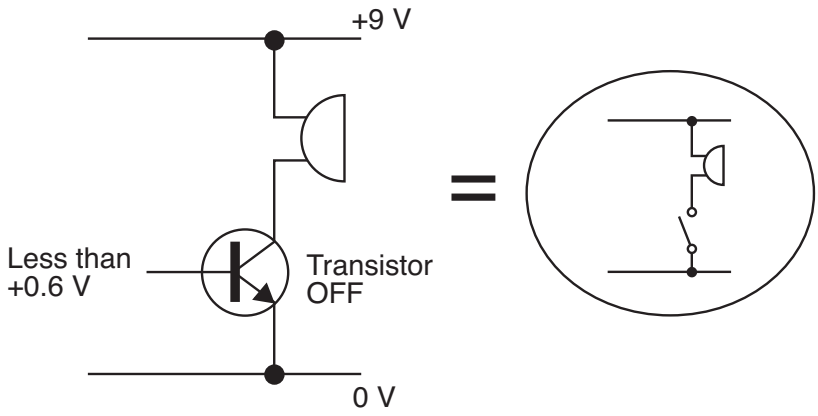
The transistor is first presented as a simple electronic ON/OFF switch. Further information is then provided.



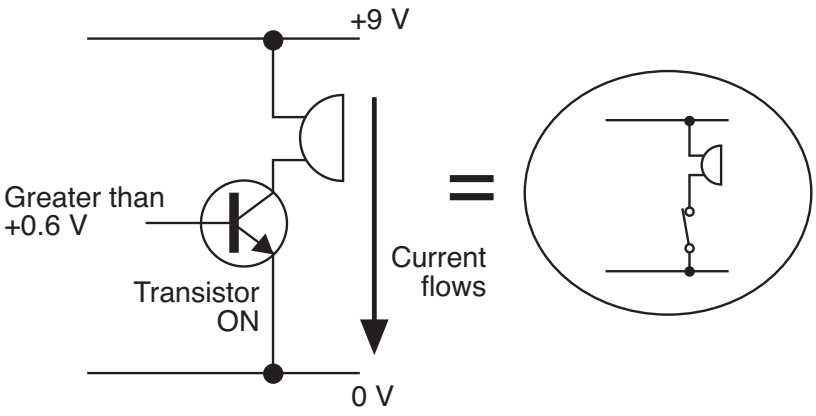
The transistor switches the output component (buzzer) on or off. You could think of the transistor as a normal switch controlled by the base connection.



The transistor works when you connect a positive voltage to the base. If the positive voltage is less than 0.6 V, the transistor switches off. No current flows through the buzzer and it will not buzz.



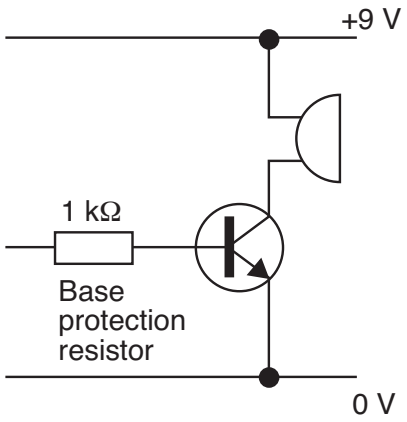
If the voltage is greater than 0.6 V, the transistor switches on. This allows current to flow through the buzzer and it buzzes.



When the transistor is used as an electronic switch, you must always use a base protection resistor to protect the transistor. This prevents too much current flowing through the transistor, which could damage it. You need to use a 1kΩ resistor for this.

NOTE

For more information see Technology Study File 7 (Investigating the Bipolar Transistor)

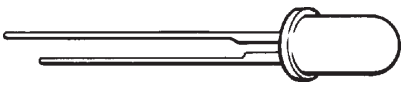


OUTPUT BLOCK

SYSTEM OUTPUT POSSIBILITIES

There are two types of output component available to you.

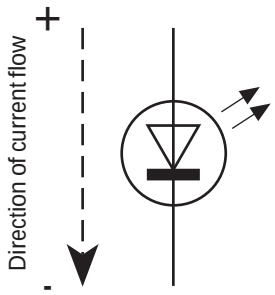
1. Light Emitting Diode (LED)
The LED is a small electronic light used as an indicator in many electronic products.



You have probably seen examples of LEDs in computers, videos, stereo systems, games consoles, microwaves etc.

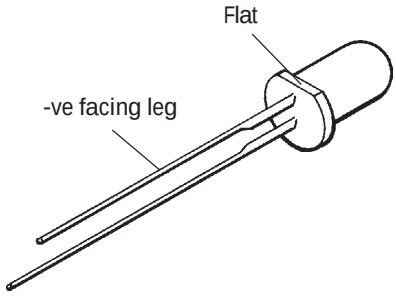
There are some important things to remember when using LEDs.

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 round in the circuit.



Circuit symbol for LED

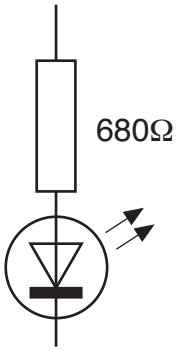
To find out which leg is which you have to look carefully at the LED. One side of the circular case is flat. The leg next to the flat side is the negative connection.



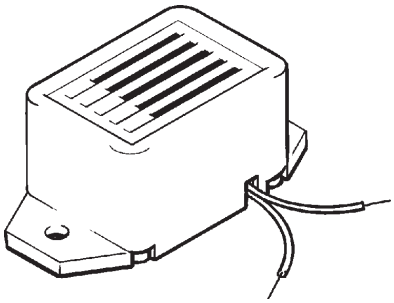
ii) Always use a resistor in series with an LED. The resistor limits the current flowing through the LED which would otherwise damage it. You will need to use a 680 Ω resistor.

NOTE

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



2. Buzzer
The buzzer makes a loud buzzing sound when current flows through it.



There are some important things to remember when using them.

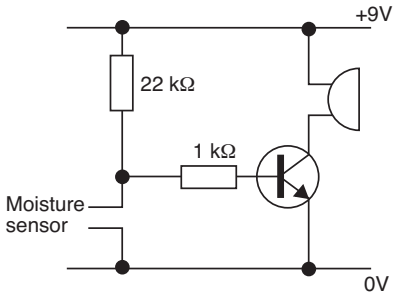
i) Different buzzers use different supply voltages. Choose a buzzer that matches the supply voltage you are using, i.e. 9 V.

ii) Buzzers normally need to be connected the right way round in a circuit if they are going to work. They normally have one red lead and one black lead. Connect the red lead to the positive part of the circuit and the black lead to the negative part of the circuit.

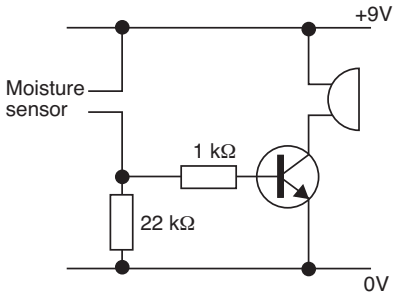
PUTTING IT ALL TOGETHER

SYSTEM SYNTHESIS

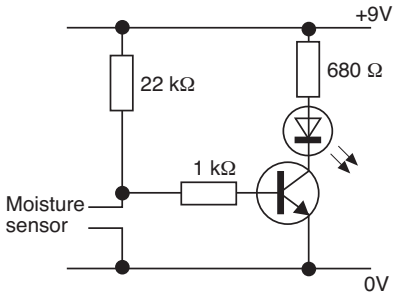
Once you have found out how to connect your sensor, you can draw the circuit diagram. There are four possible circuits. The one you use will depend on whether you want an LED or a buzzer as the output component and whether you want this component to operate when the sensor is wet or dry.



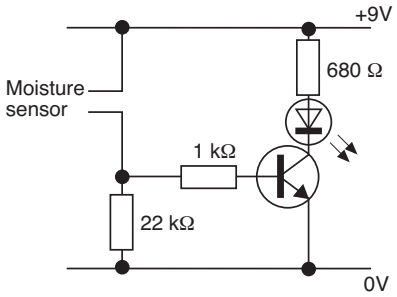
Buzzer on when sensor dry



Buzzer on when sensor wet



LED on when sensor dry



LED on when sensor wet

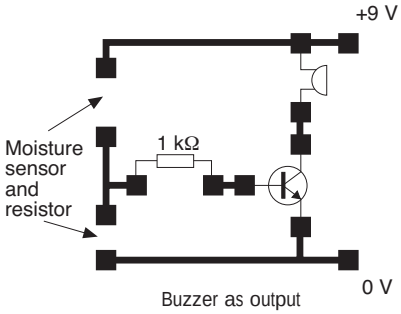
NOTE

See Study File 1a, Crocodile Clips.

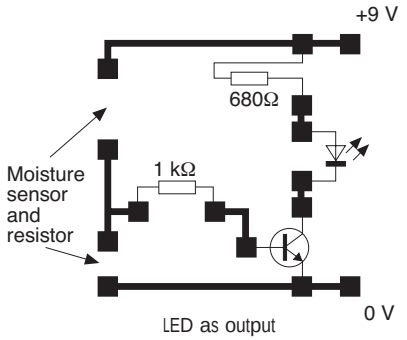
You need to make a printed circuit board (PCB) on which to mount the components. A possible PCB layout is shown here with components in position.

NOTE

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



Buzzer as output



LED as output

TESTING

SYSTEM DIAGNOSTICS

When you have built the circuit, you will need to test it. If the circuit does not work, try following this simple fault finding procedure:

- Check the PCB layout is correct and that no tracks are bridged or broken. Repair if necessary.
- Check that all soldered joints are good.
- Check that all components are connected correctly. Pay particular attention to the transistor as mistakes are easily made.
- Check that the input voltage to the transistor is still changing when the sensor is dry or wet by connecting a voltmeter across the bottom component in the input circuit (< 0.6 V transistor off, > 0.6 V transistor on). If the voltage does not change in the correct range, try changing the value of the 22 kΩ resistor.

NOTE

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

EVALUATING THE SENSOR

EVALUATION

There are a number of things to consider when evaluating your moisture sensor:

- How well does it work? - Is it sensitive, robust, reliable?
- Will it work in the situation for which it was designed?
- Did you choose the best materials and methods of manufacture?