Teacher Resource Guide

for FK908 *(Soil Moisture Indicator)*

During the construction of this kit, the students will be exposed to the following learning elements:

Description	Activity
Heat transfer (by conduction)	Soldering
Energy transference	Electricity to Light (LED)
Transfer of Energy through an electrical circuit	Entire KIT! Also… "Electrical Conductivity" of soil will change with increasing moisture…. This is used to Drive more LED's with increasing conductivity.

The kit comes with:

- Solder included
- A circuit Diagram
- Instruction sheet (which is aimed at experienced users)
- 9V Battery snap

Extra resources recommended to be used with the kit:

- A copy of the locally written "Student Instruction Sheet" (provided as a soft copy with class sets, and included below).
- A copy of the locally written guide "Towards Better Soldering" (provided as a soft copy with class sets).
- 9V DC battery
- Soldering Iron
- Soldering Iron Stand with a damp cloth or sponge
- Diagonal Pliers ("Side-cutters")
- Solder sucker or Solder wick (for removing unwanted solder)

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Extension activities for this kit:

1) Change the distance between the Probes when they are inserted into the soil.
   a. This will show up as different behaviour of the indicator LED's.
   b. Particularly useful in soils which have a naturally high Electrical Conductivity.
      i. Start with probes approx 1cm apart.
      ii. Trial the difference in behaviour with probes set 5cm, 10cm and even further apart.
   c. If students are finding that the indicator LEDs all behave "in unison" , it is highly likely that they have very damp soil already. Separateing the probes may be a quick and handy way to overcome this.

2) Use "insulated" probes and only expose the ends to the soil. Then insert them to different depths of the soil to indicate the depth to which any applied irrigation has penetrated into the soil. (See notes & picture 5 & 6 at end of this document).

3) Practice different soldering techniques, to study affect of heat flow by conduction.

4) Change the Brightness of the LEDs by changing R3, R4, R5 or R6
   a. Do not use a value less than 180 Ohms! The LED will suffer a short life if you do!
   b. Increase the value of R3,R4, R54 or R6 which will make the LEDs appear duller.

Student Sheet with notes inserted:

Below is a copy of the student notes, with some comments and suggestions for teachers. Our comments are inserted in RED font.

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What it does:

This circuit responds to the amount of moisture in an area of soil. The more moisture present in the soil, the more lights will illuminate.

What we are making:

The finished circuit will have two wires (which make the "Probe") that will be placed into the desired test area of soil. The circuit board will also have four light emitting diodes (LED's) which will indicate the amount of moisture present in the test area.

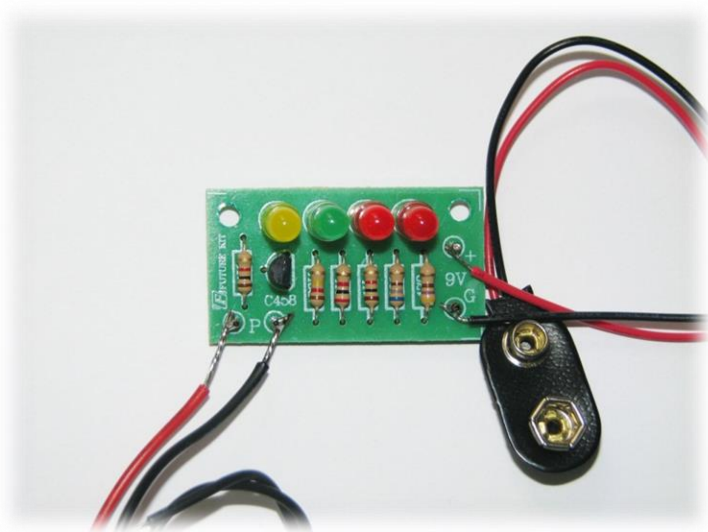

Fig 1: Finished Product

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Technical Specs:

- Power supply: 9VDC
- Consumption: 20mA max.
- Amount of moisture: 4 levels
- PCB dimensions: 41 x 22mm

How it works:

Current from the battery will flow through the first resistor (R1), the Probe (P) and then into the soil being tested. If there is moisture present the current will continue to flow through the circuit and light up the first LED. The higher the amount of moisture the more current will be able to flow through the soil, which will then turn the Transistor (TR1) on harder, resulting in more LED's illuminating.

Circuit Diagram:

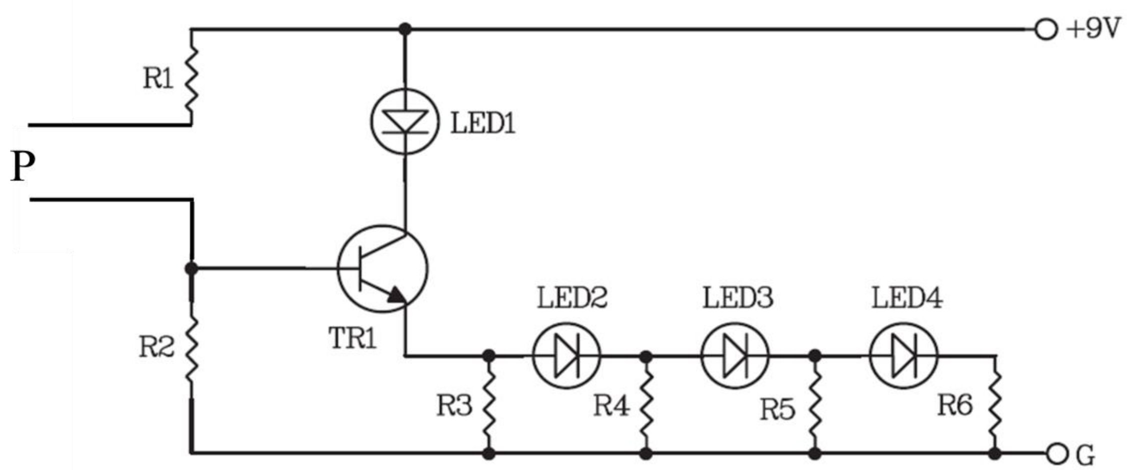

Fig 2: Circuit Diagram

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How to build it:

Step 1. Installing the resistors.

RESISTORS

R1,R4	1k Ω	-brown-black-red-gold
R2	120k Ω	-brown-red-yellow-gold
R3	2k Ω	-red-black-red-gold
R5	680 Ω	-blue-gray-brown-gold
R6	470 Ω	-yellow-violet-brown-gold

Fig 3.1 Resistor Values

By referring to *Fig 3.1* determine the value of each resistor and place them in their correct positions as indicated on the printed circuit board (PCB). Do this by carefully bending their wires down to form a 'U' shape and poke through the holes in the PCB as shown in *Fig3.2*. Once they are in the correct positions solder them into place and trim the excess wire.

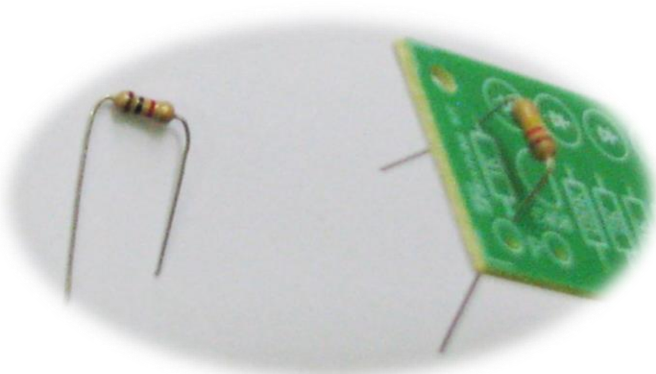

Fig 3.2 Installing Resistors

Step 2. Installing the transistor.

Carefully bend the middle leg of the transistor slightly forward and the two outer legs out and carefully manipulate them as you place them through the holes and onto the PCB as shown in *Fig3.3*. Pull the legs through until the transistor is sitting about 10mm off the PCB. Once in the correct position solder it into place and trim the excess wire.

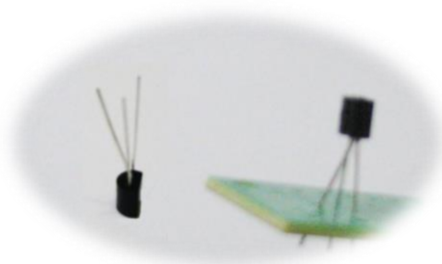

Fig 3.3 Installing the Transistor

Step 3. Installing the LED's.

Place the LED's on the PCB in the order of color shown in *Fig 3.4*. Take care with the polarity of the LED's, they must be installed facing the correct way. Ensure the longer leg of each LED is placed at the back of the triangle in the diode symbol which is shown on the PCB (see *Fig 3.4*). Once in the correct order, solder them in place and trim the excess wire.

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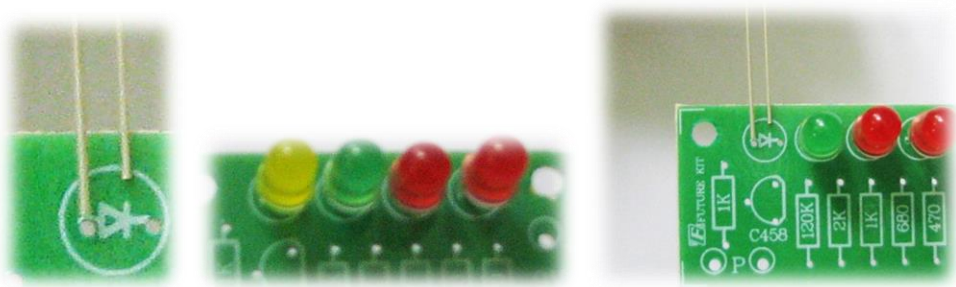

Fig 3.4 Installing the Coloured LEDs

Step 4. Connecting wires and Battery snap.

One by one, place the four poles into their positions on the PCB and solder into place. Once they are set, 'tin' each pole with solder. *(For more information on "tinning", please refer to our separate document "Towards Better Soldering").* The battery snap can be soldered into place by 'tinning' the leads and ensuring the black wire is attached to the 'ground' (G) or negative (-) pole and the red wire to the positive (+). Finally the two remaining wires can be tinned and then soldered to the two remaining poles. (See *Fig 4* for attaching the wires).

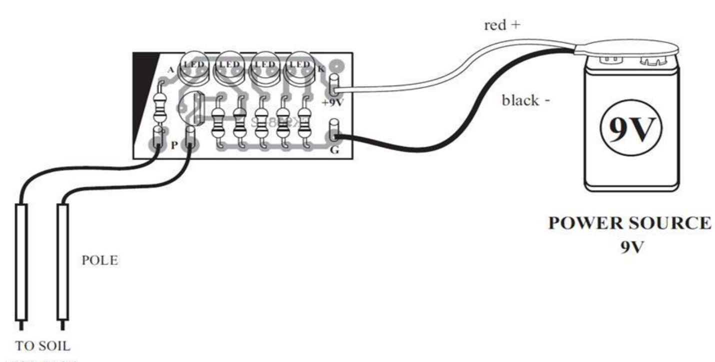

Fig 4 Attaching the wires

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Comments to teachers:

1) We strongly recommend students should strip and "tin" the ends of the wires which will be used as probes.

2) It is quite conceivable that the probe tips may disintegrate and be "lost" within a few months if they are placed into acidic, damp soils. Encourage students to keep a spare set if they wish to use this kit for an extended period of time.

3) An extension activity may be to discuss why the probes may corrode, and what could be done to minimize this?
   Answers include:
   a. Chemcial reactions between the probe materials and the contents to the soils. (Both acid and alkaline soils will have a corrosive impact on the probes).
   b. The design of the circuit uses a Direct Current ("DC") voltage across the probes.... Hence a small amount of electricity will be continually flowing in the one direction. Most professional indicator systems use an Alternating Current ("AC") signal which has the electricity flowing backwards and forwards, and so reduces the rate of corrosion.
   c. Turn the battery off when it is not being used. This will slow the corrosion due to electrical conduction.

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Testing:

Ensure the two test wires are separated and attach the battery to the battery snap. Place the two wires into a damp medium (examples may be: a cup of water, or damp soil, or a wet sponge).

As you move the wires further apart, less LED's should light up.

EXTENSION ACTIVITIES: USING LONGER PROBES

Use probes which are covered in a good insulator, and only expose a small amount of conductor at their tips.

See picture 5 for some alternative wires which we have used.

Picture 5: Two commonly available wires we have used for longer probes.

Strip the probe "tip" and then "tin" it with solder. (Refer picture 6).

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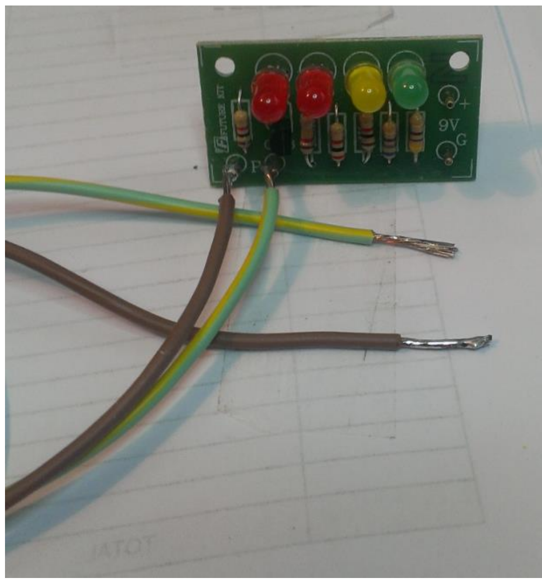

Wire tips have been "tinned" with solder.

Picture 6: Showing the wire tips to be used as probes.

Encourage students to experiment with how far below the soil surface they place these longer probe tips.

Q1: How could two or more of these kits be used to measure the rate at which water penetrates into the soil?

Ans: Set up kit #1 with probes at the surface of your test soil (dry).

Set up kit #2 with probes at a known distance below the surface (Typically 20cm or 30 cm).

Take care to ensure the probes are set at the same distance apart for both kits.

Observe the difference in the indicators.
Measure (time) how long before deeper indicator is showing the same as the surface indicator.

Question 2: Is it better to irrigate soil with one large event or several smaller watering events? Which gives the best penetration and usage of the water ?

Activity: up a series of tests and trial different scenarios:

Answer Guideline:

Professional irrigators will tell you that the following advantages and disadvantages will occur:

- For a single, large watering event, the water will penetrate faster. HOWEVER there is a very strong risk that the water will keep sinking into the soil and so a larger percentage of it will be lost and unused by the plants you are trying to help.

- For multiple smaller events, the water will likely take longer to penetrate down into the soil, but in doing so it is usual that a a higher percentage of water will be available to the roots of your target plants. (This behaviour often resembles natural rainfall affects , compared to the "Flood" style of water delivery.