Electricity & Magnetism

Field effect transistor electroscope

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Background

The MPF102 is an N-channel transistor and is turned off when the movable negative electrons are pushed out of the silicon turning it into an insulator.

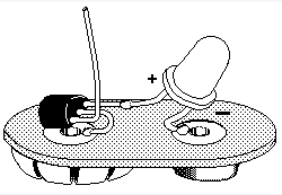
N5460 is a P-channel transistor which will do the reverse.

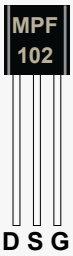
You will need...

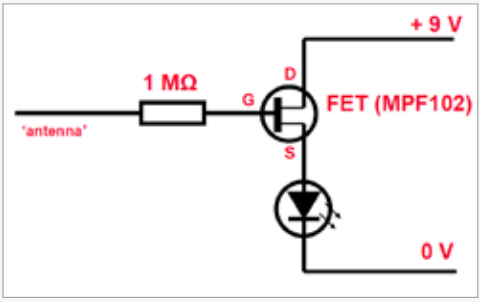
- ✓ MPF102 Field Effect Transistor (F.E.T) (Can be bought online on Amazon)
- ✓ 9-volt battery & 9-volt battery clip
- ✓ red/blue light emitting diode (L.E.D)
- ✓ wire for antenna
- ✓ wire clippers,
- ✓ soldering iron & solder
- ✓ balloon
- ✓ materials to test for static electricity.

Follow these steps

1. Bend the gate wire of the F.E.T upwards. This acts as the antenna so leave it unconnected.
2. Connect the middle wire, the Source, to the red positive lead on the 9-volt battery clip.
3. Connect the remaining wire, the Drain, to the positive leg of the L.E.D (longer leg).
4. Connect the negative leg of the L.E.D (shorter leg) to the black negative lead of the 9-volt battery clip.
5. Check your circuit is correct and then connect the battery clip to the top of the 9-volt battery. The red L.E.D should light up.
6. To test the circuit rub a balloon on your hair and bring it close to the gate wire. The L.E.D should go dark but will light up again when you remove the balloon.
7. If it doesn't work the humidity may be too high. You can check this using a balloon and rubbing it on your hair. If the hairs on your arm aren't attracted to the balloon then humidity is too high.
8. A wire (0.5m) can be soldered to the gate leg to act as an antenna, increasing the sensitivity to up to nearly 6m!
9. If the L.E.D does not light up touch the gate wire with your finger to reset







(FET electroscope continued)

So what happened?

When there is no Gate voltage (V_G = 0), and a small voltage (V_{DS}) applied between the Drain and the Source, maximum saturation current (I_{DSS}) will flow through the channel from the Drain to the Source restricted only by the small depletion region around the junctions.

If a small negative voltage ($-V_{GS}$) is now applied to the Gate the size of the depletion region begins to increase reducing the overall effective area of the channel and thus reducing the current flowing through it. So by applying a reverse bias voltage increases the width of the depletion region which in turn reduces the conduction of the channel.

Since the PN-junction is reverse biased, little current will flow into the gate connection. As the Gate voltage ($-V_{GS}$) is made more negative, the width of the channel decreases until no more current flows between the Drain and the Source and the FET is said to be “pinched-off”.

What next?

1. Brush your hair with a comb; if it is a very dry day you will see the L.E.D flicker on and off. Bring the comb towards the gate and the L.E.D will go dark, indicating excess negative charge.
2. Rub your feet on a carpet while holding the electroscope and see the L.E.D flicker on and off.
3. Jump up and down on the carpet and see the L.E.D turn on and off.
4. Turn on a Van de Graaff generator and see the electroscope detect the electric field.
5. Hold the electroscope near the aluminium pie pan when you touch your finger of the tinfoil ball and see what happens to the L.E.D.
6. Using a digital hygrometer compare the distance versus humidity with the electroscope and draw a scatter plot and calculate the correlation coefficient.
7. Change the antenna length and compare to the distance and again plot a scatter plot and calculate the correlation coefficient.