DIY

Do It Yourself

# Mand Labs

step by step

Electronic Series, KIT-1

Experiment 56:

# Temperature Sensor

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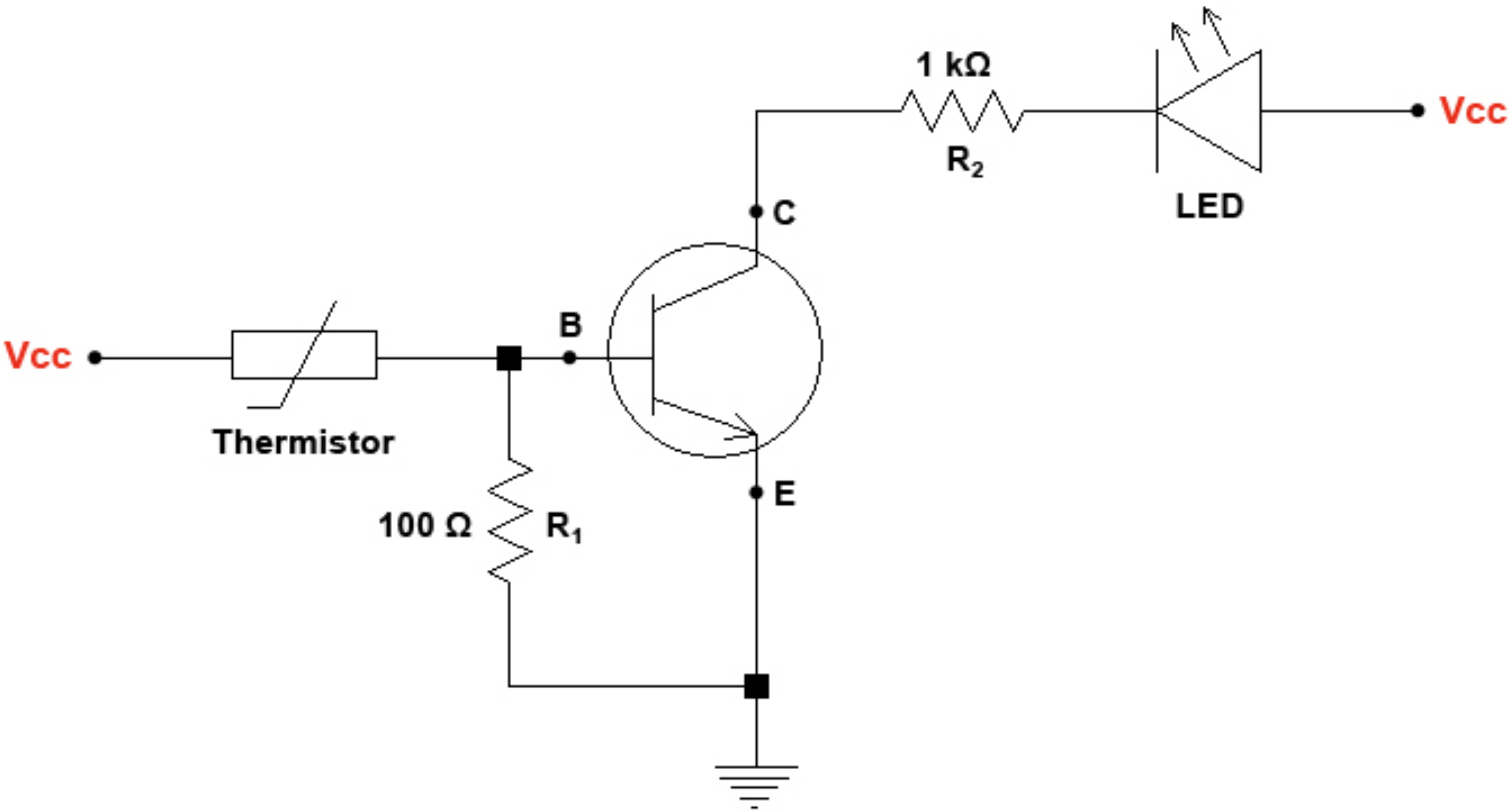
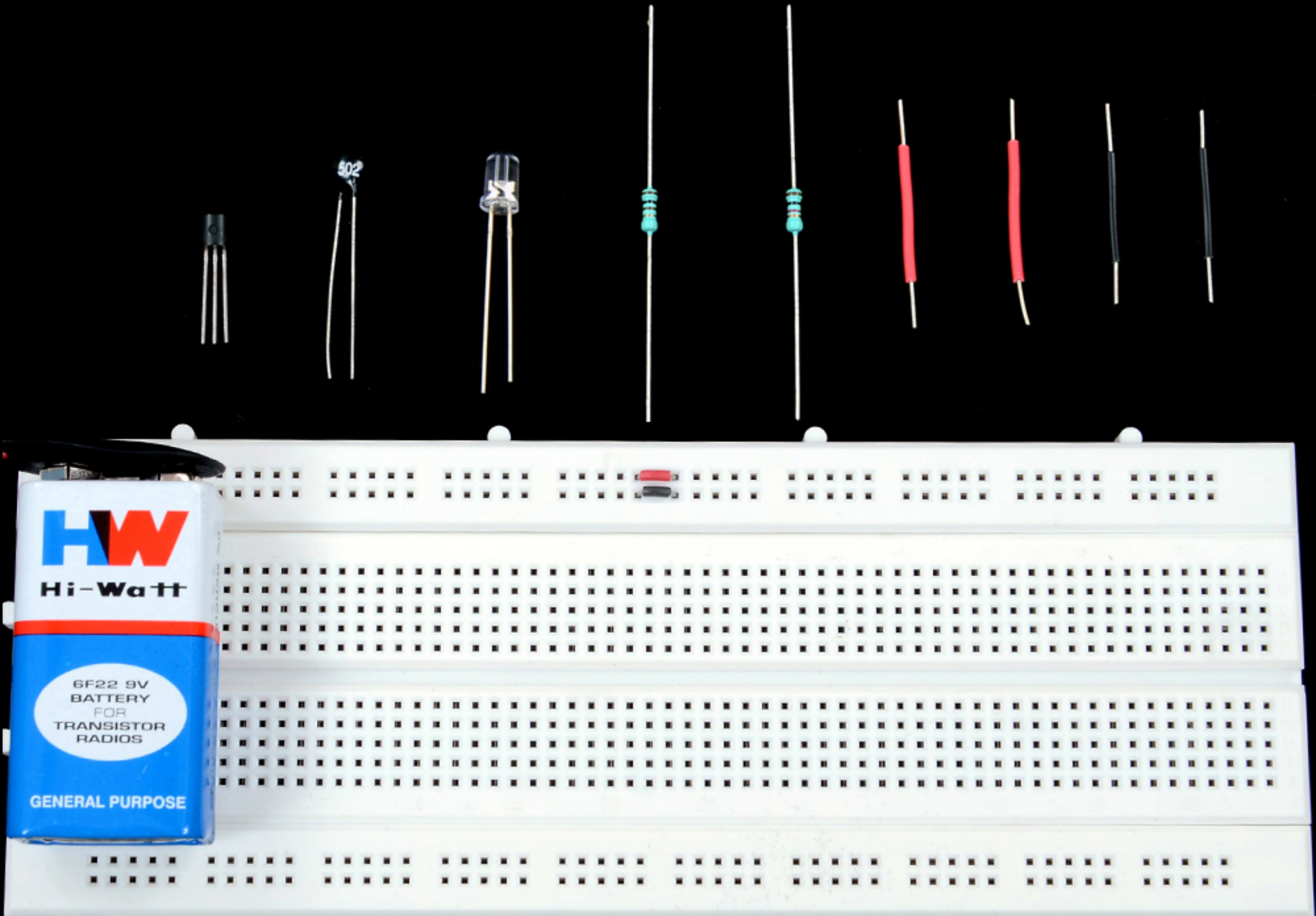
## Circuit Diagram



# Materials Required

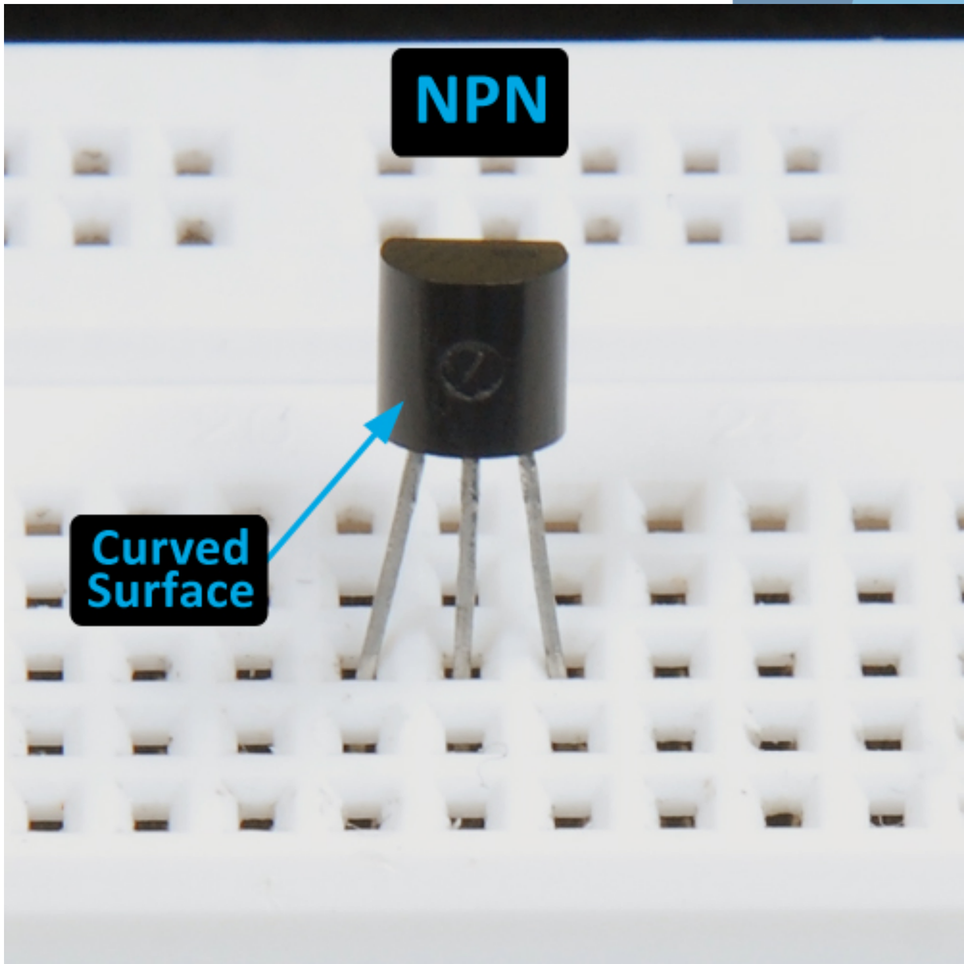
i. Breadboard - 1
ii. Transistor: BC547 - 1
iii. Thermistor (Temperature Sensor) - 1
iv. LED - 1
v. Resistor: 100 Ω - 1, 1 kΩ - 1
Colour Code: 100 Ω - Brown Black Brown Gold
1 kΩ - Brown Black Red Gold
vi. 9 V Battery - 1
vii. Connecting Wire Pieces


502
HW
Hi-Watt
6F22 9V
BATTERY
FOR
TRANSISTOR
RADIOS
GENERAL PURPOSE

# Points to Remember

An NPN transistor has three legs, namely, Emitter (E), Base(B) and Collector (C). 547-B is an NPN transistor.

‘To identify the legs, we will keep the transistor  such that the curved surface faces us. Starting from the left side, the first leg is the emitter, the second is the base and the third is the collector.’

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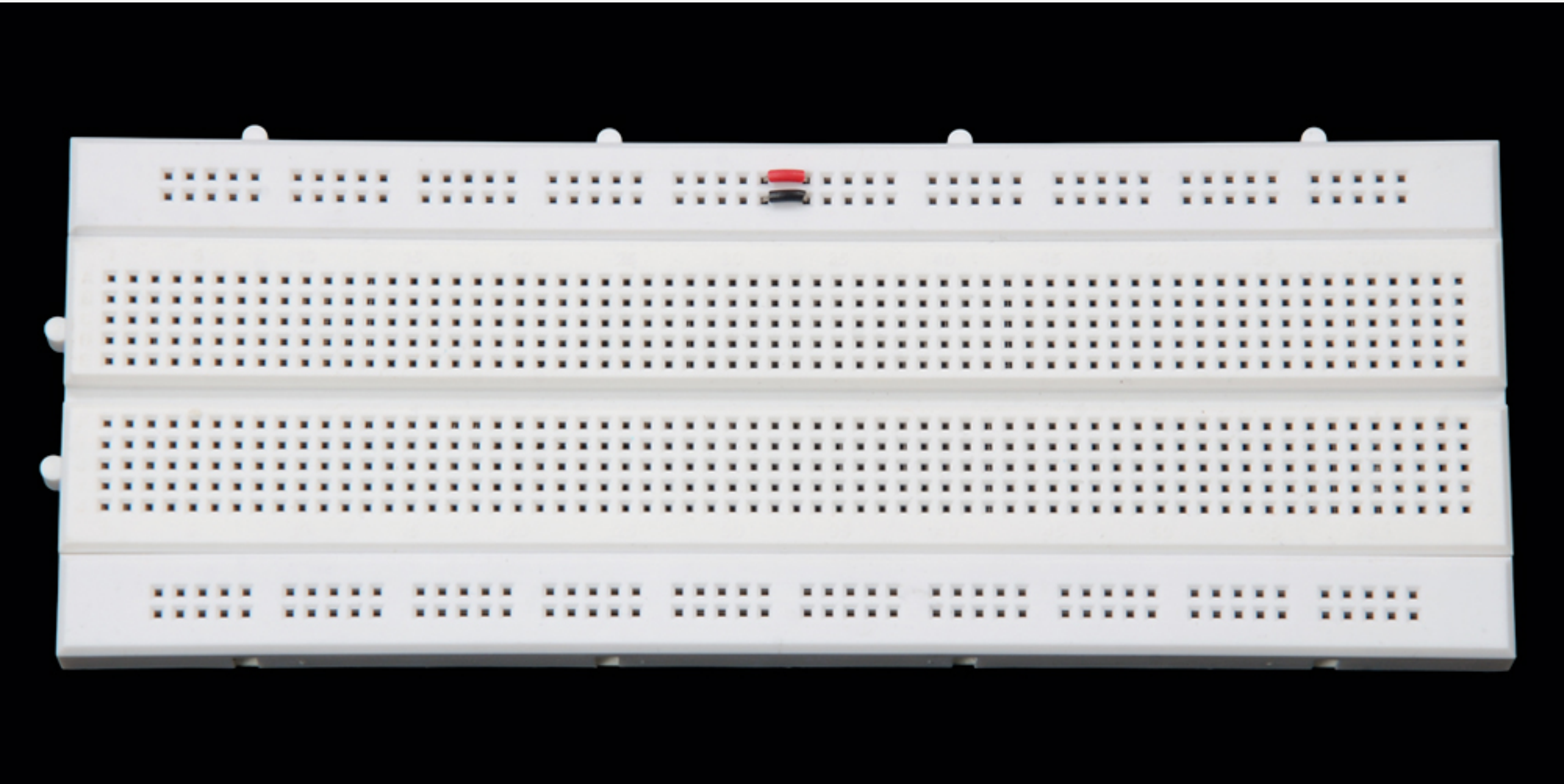
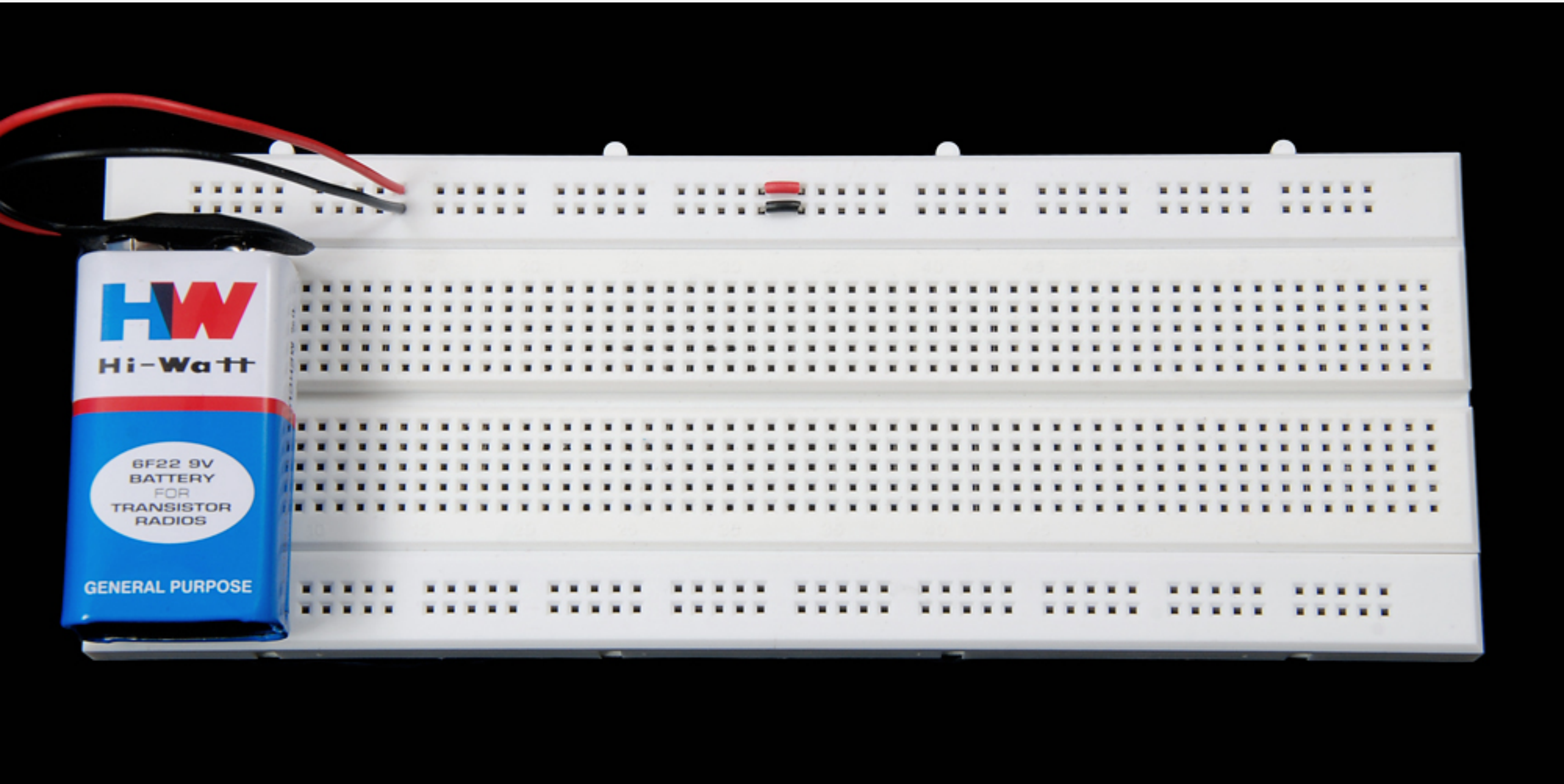
# Step No. 1

Take a breadboard and connect its two halves as shown in figure below.



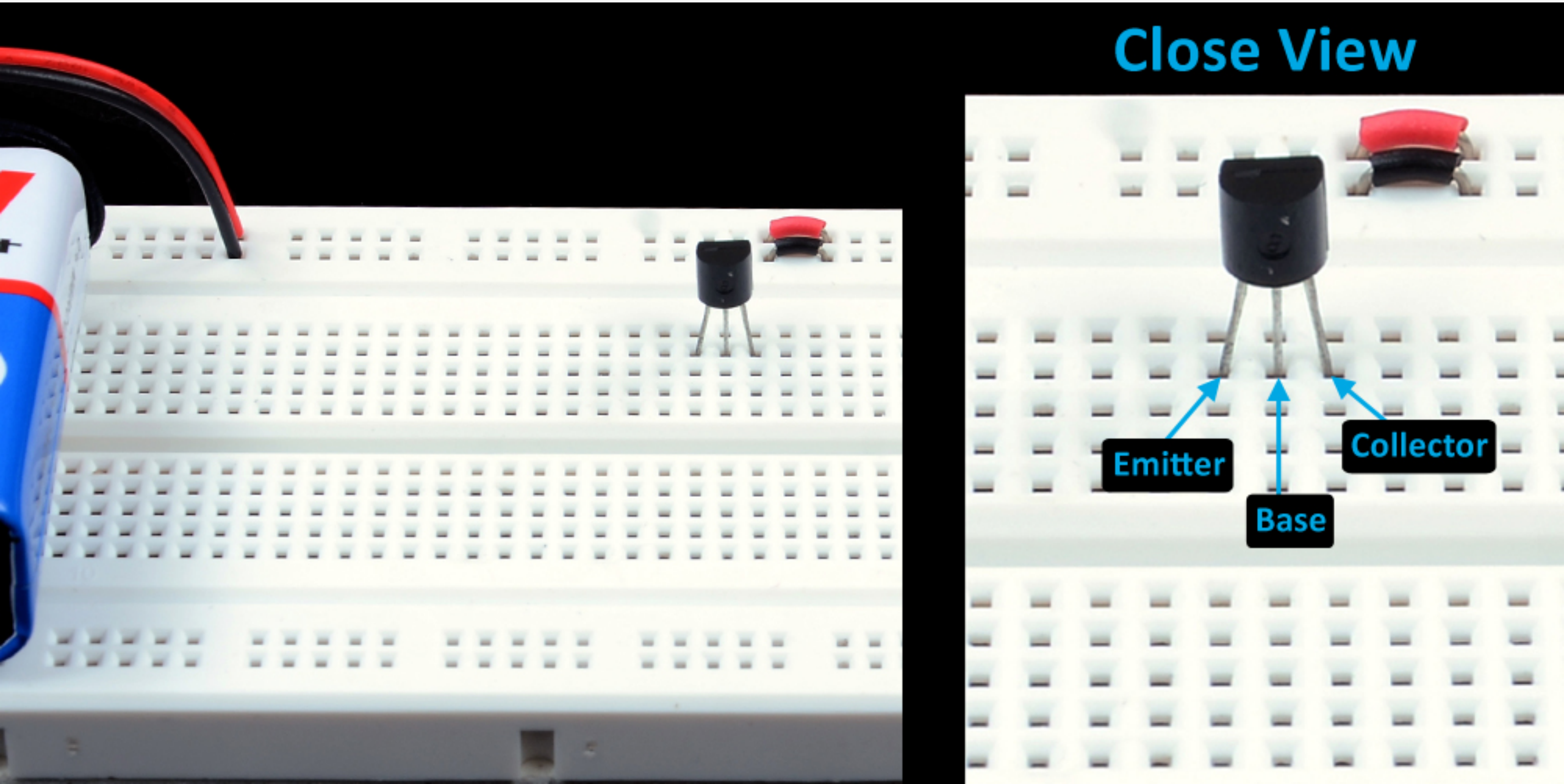
# Step No. 2

Connect a 9 V battery on the breadboard.



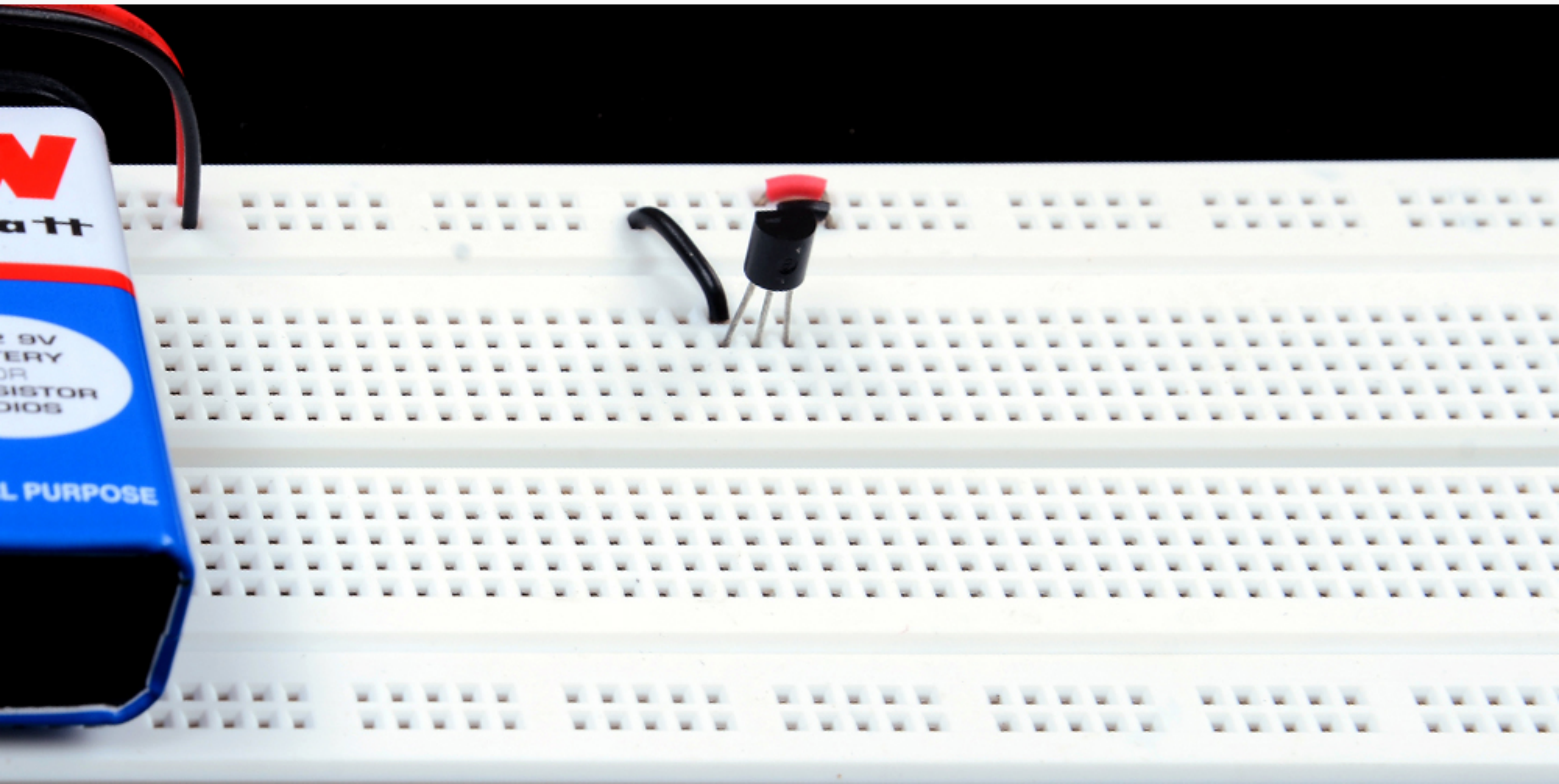
# Step No. 3

Connect an NPN transistor on the breadboard with its three legs (Emitter, Base, Collector) inserted in three different columns of the breadboard. **Remember that the curved surface of the transistor should face you.**



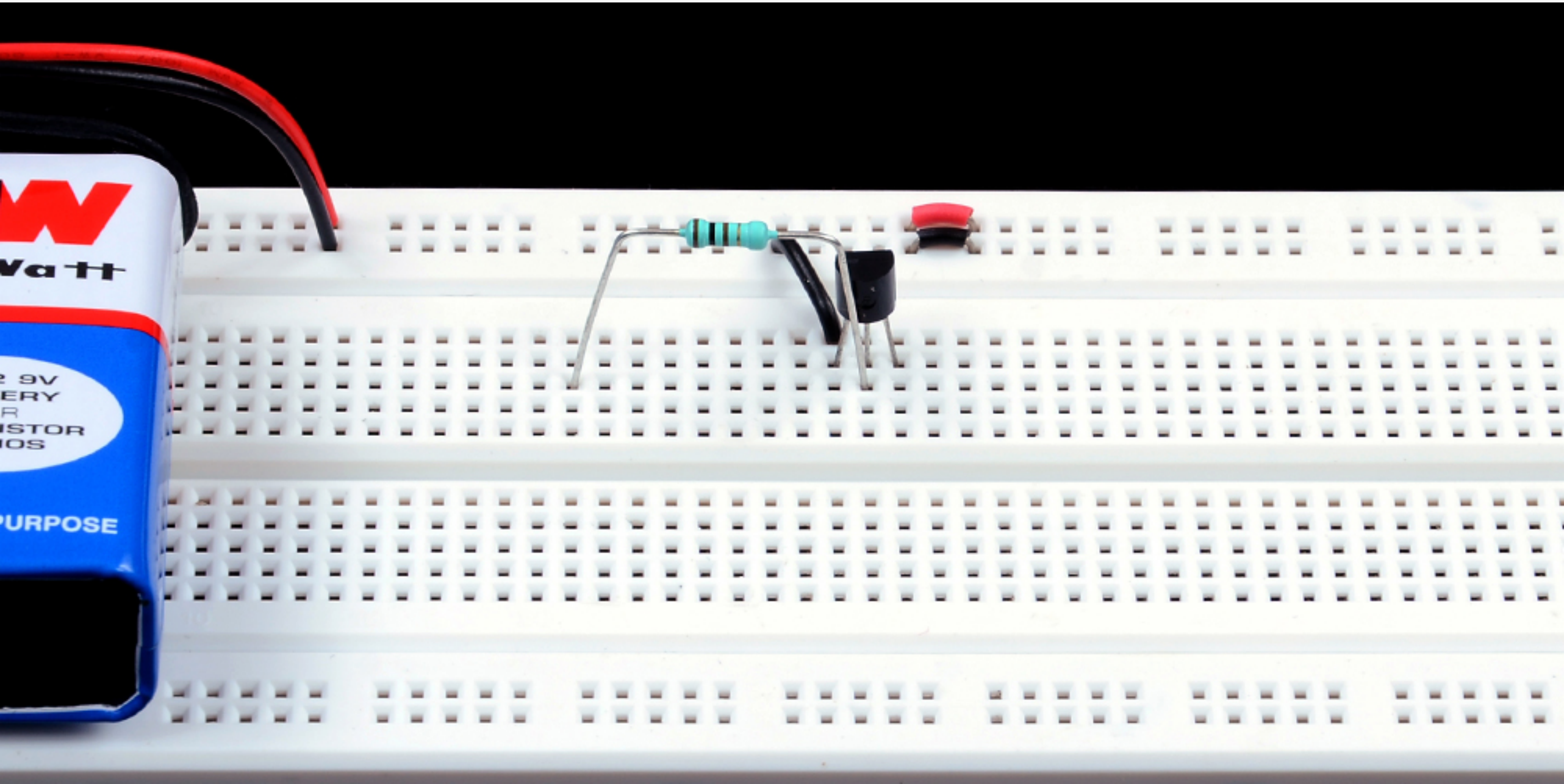
# Step No. 4

Connect the emitter of the transistor to ground.



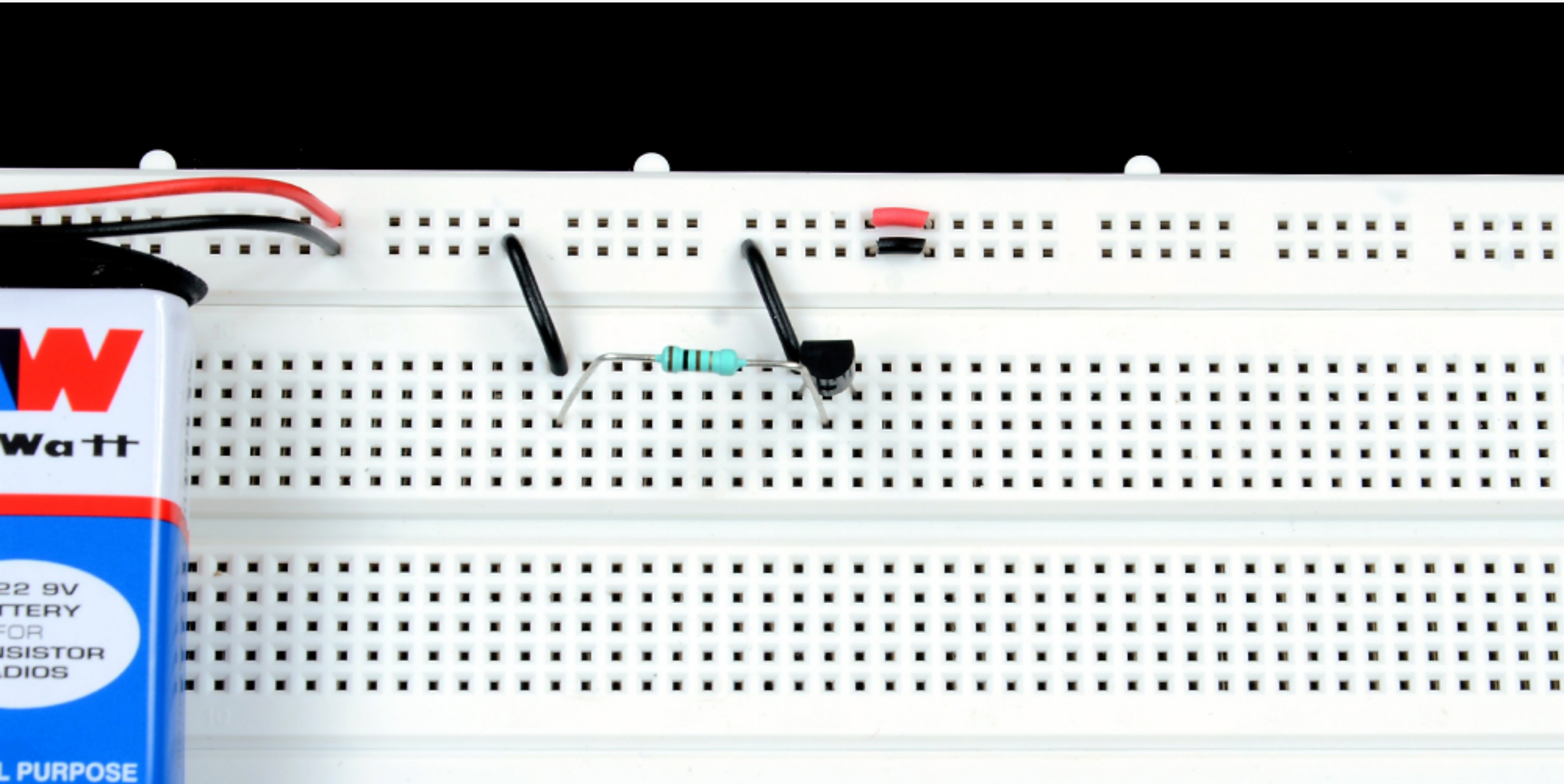
# Step No. 5

Connect one leg of a 100 Ω resistor to the base of the transistor, and its other leg to any different column of the breadboard.



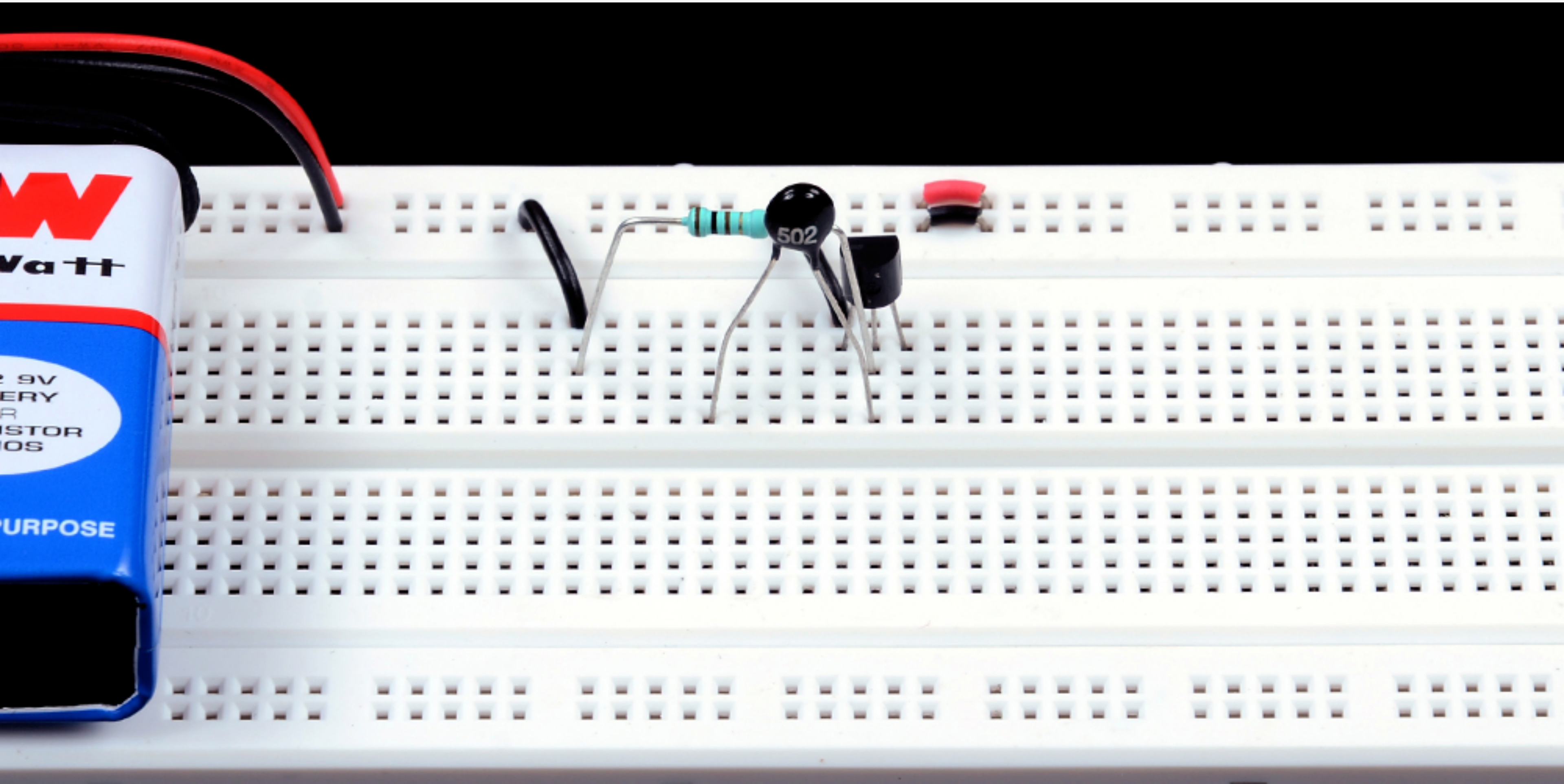
# Step No. 6

Connect the other leg of the resistor to ground.



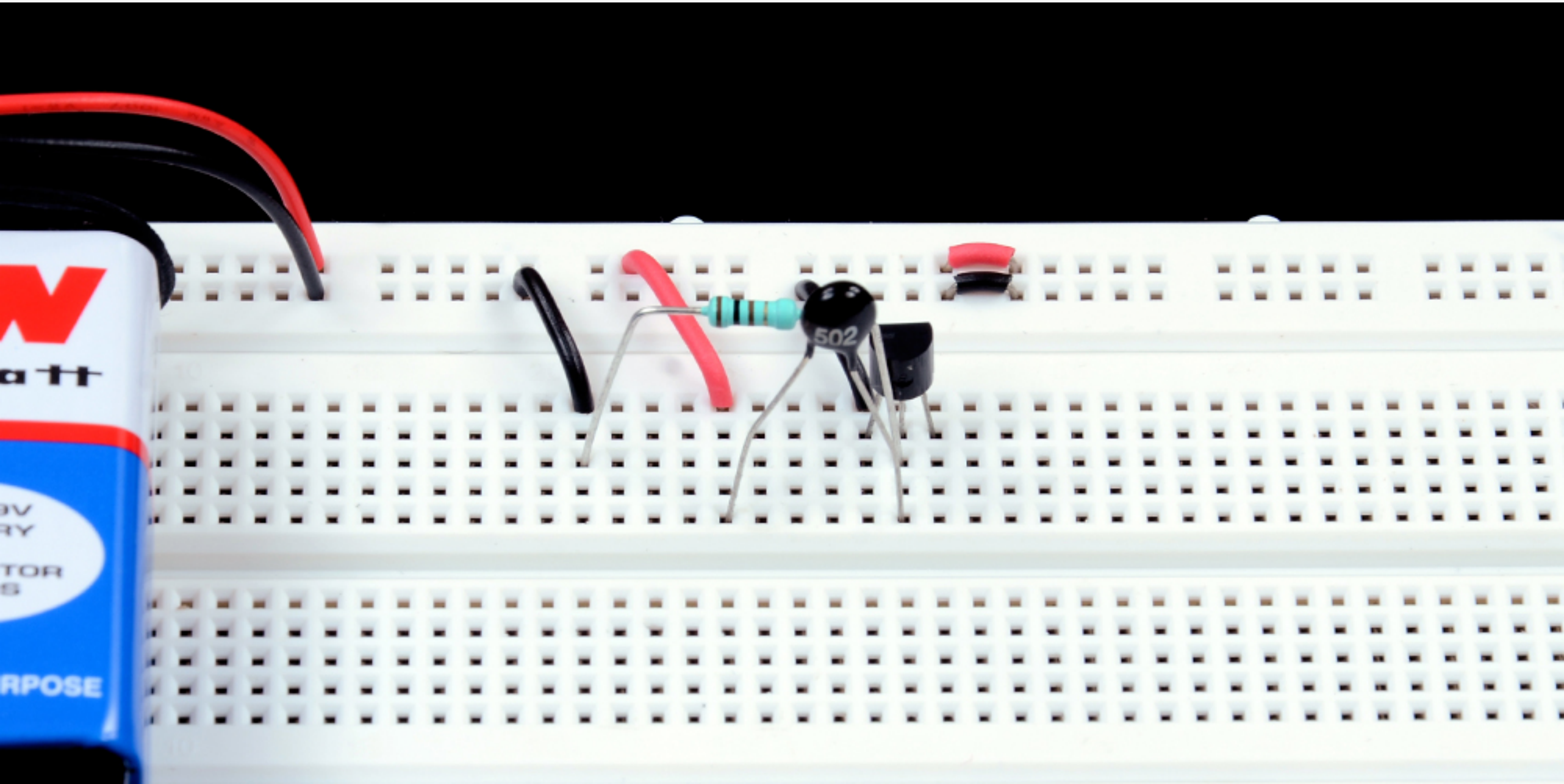
# Step No. 7

Take a thermistor (temperature sensor, 502). First connect its one leg to the base of the transistor. Then connect its other leg to any different column of the breadboard.



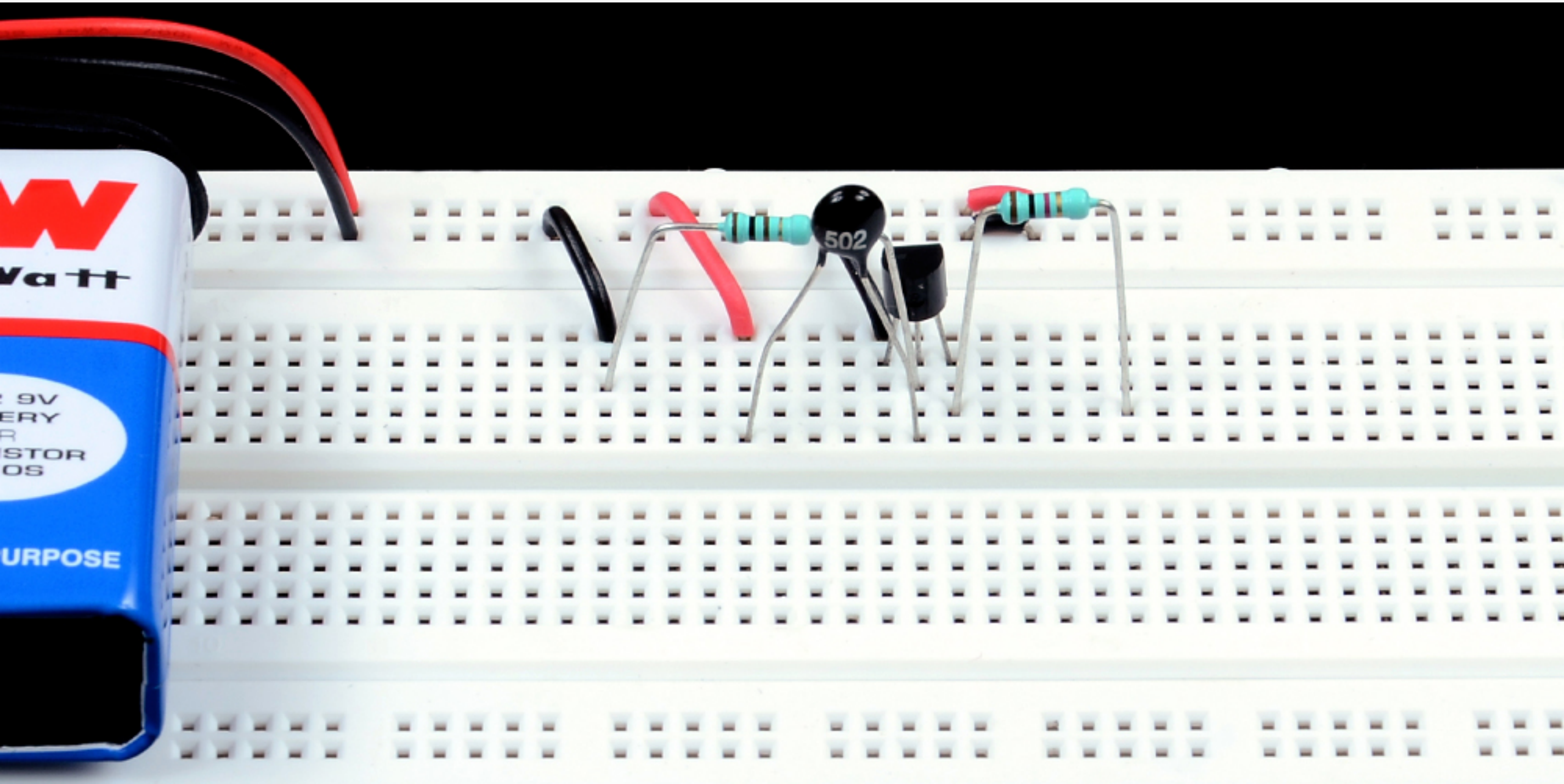
# Step No. 8

Connect the other leg of the thermistor to Vcc.



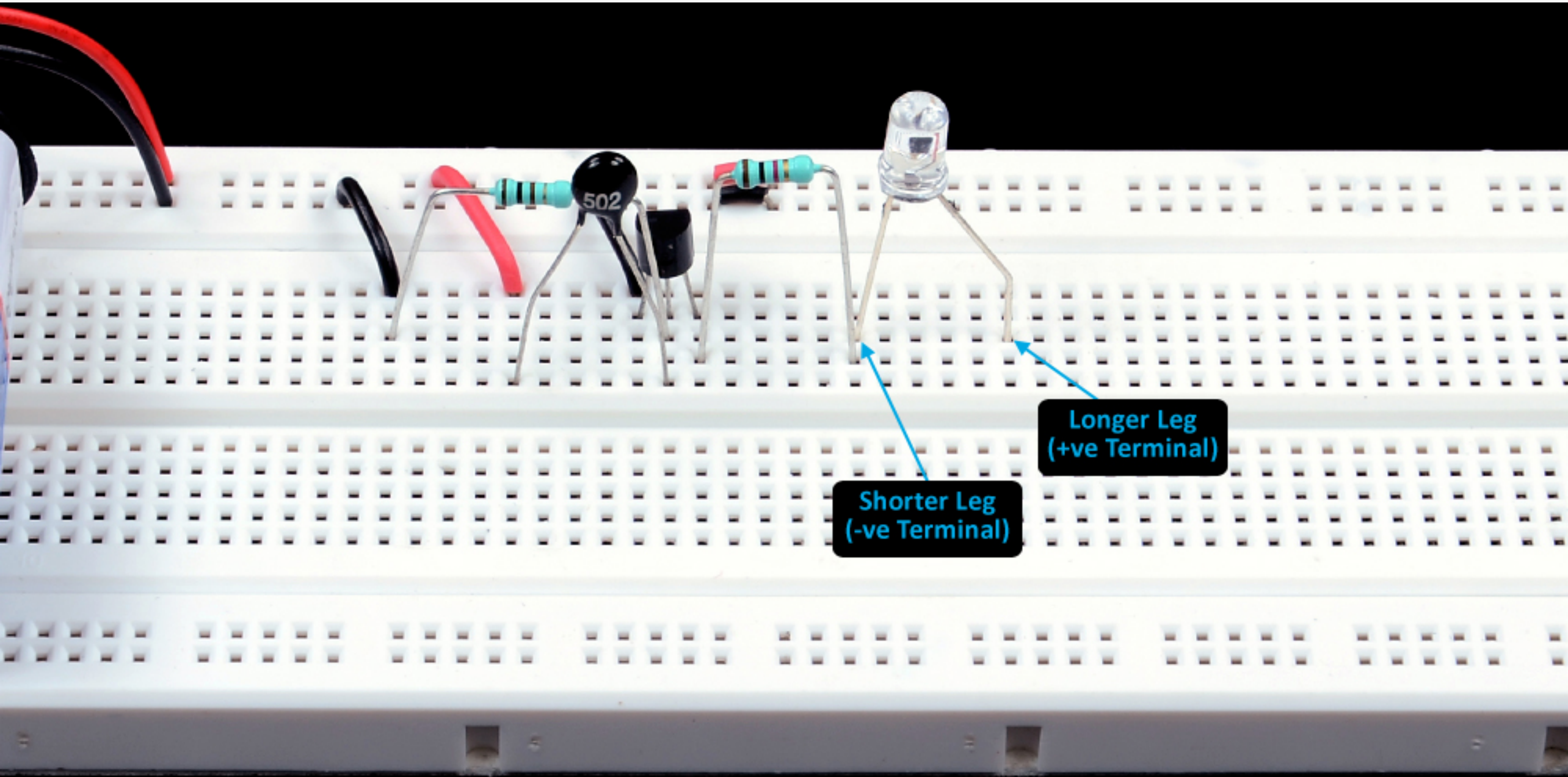
# Step No. 9

Connect one leg of a 1 kΩ resistor to the collector of the transistor, and its other leg to any different column of the breadboard.



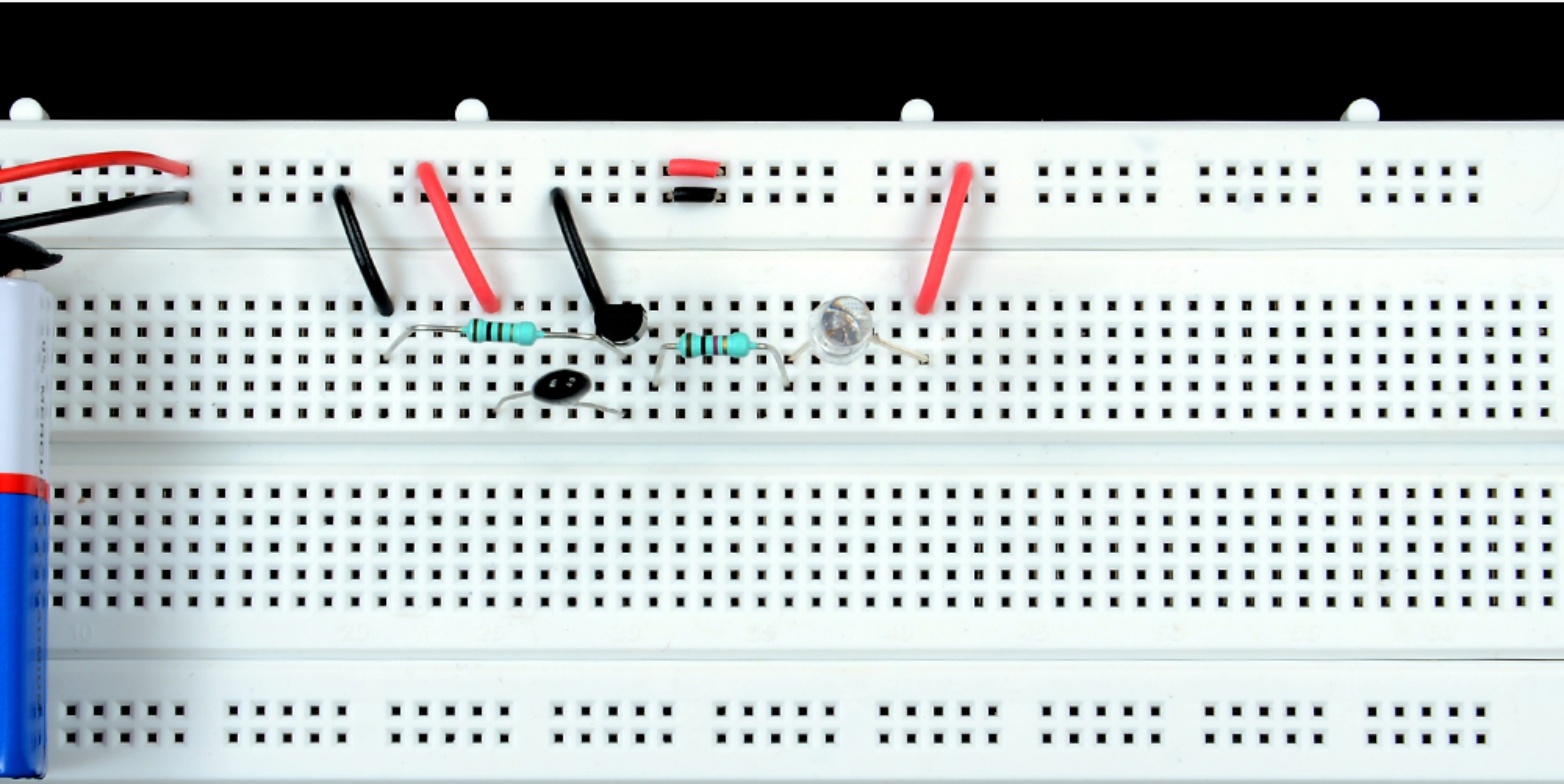
# Step No. 10

Take an LED. Connect its negative terminal to the right leg of 1 kΩ resistor.



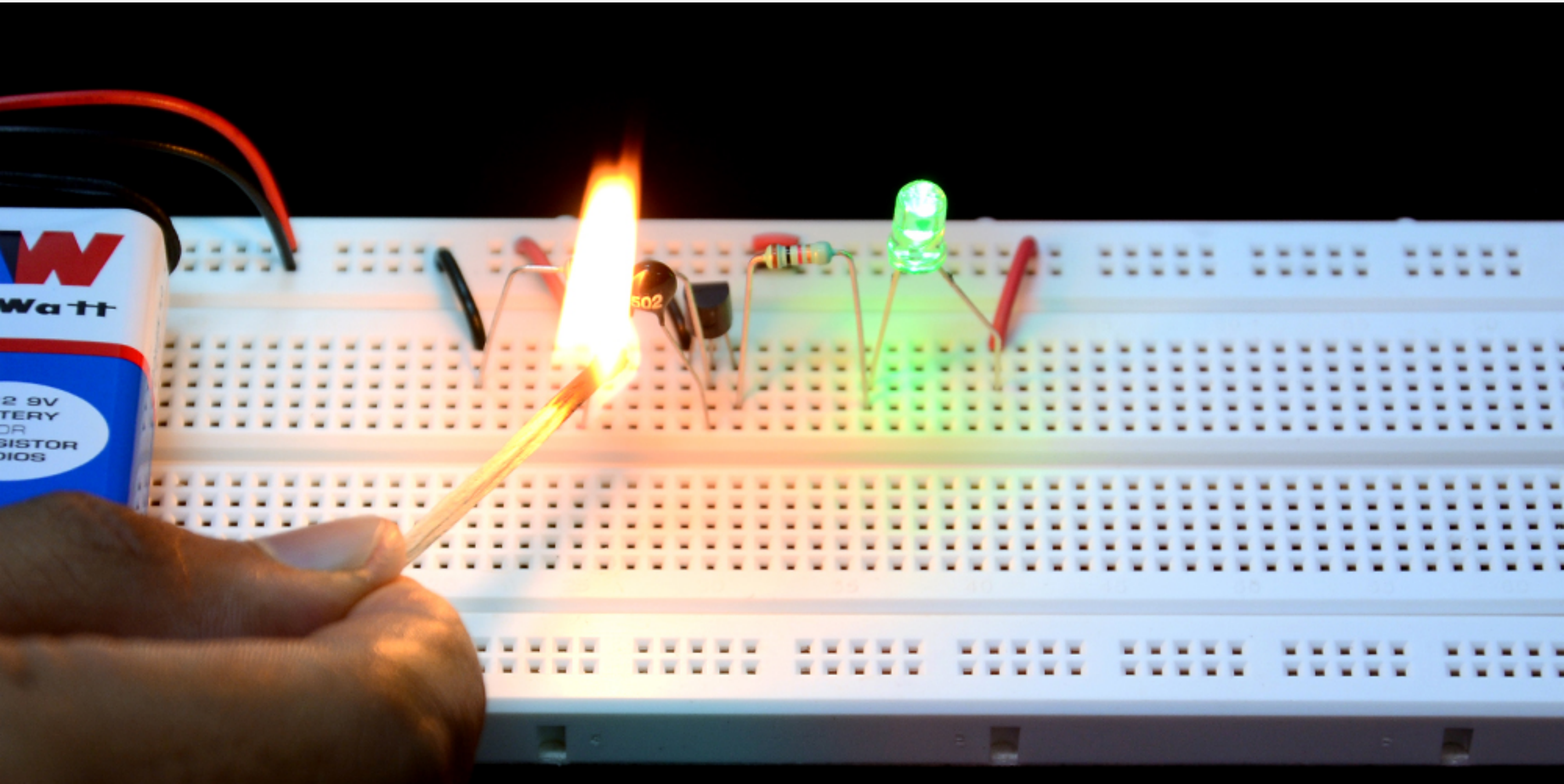
# Step No. 11

Connect the positive terminal of the LED to Vcc.



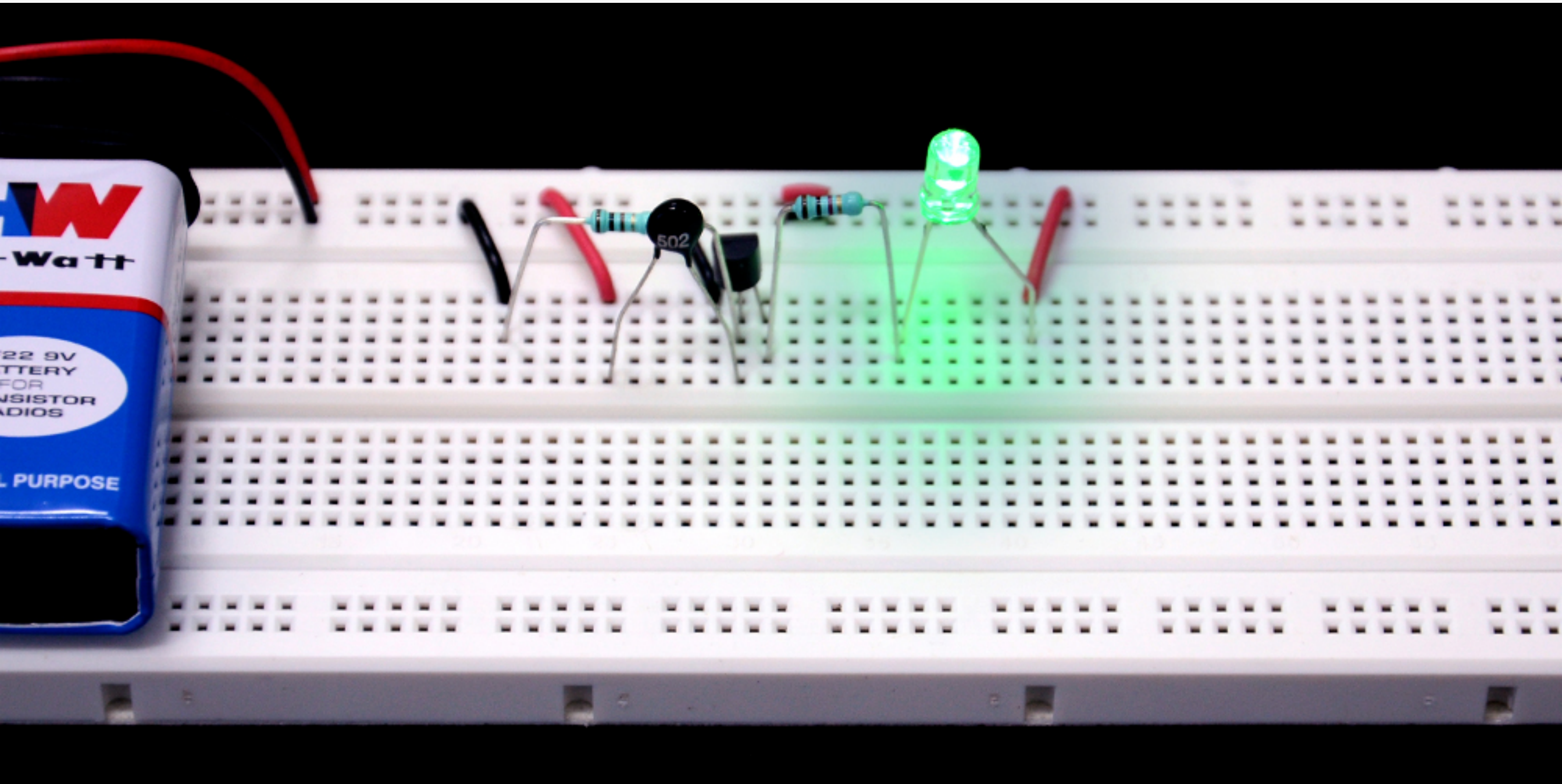
# Step No. 12

Now expose the surface of the thermistor to heat either using a burning matchstick or blow of hot air using a hair dryer. We will notice that after a while, the LED starts to glow.



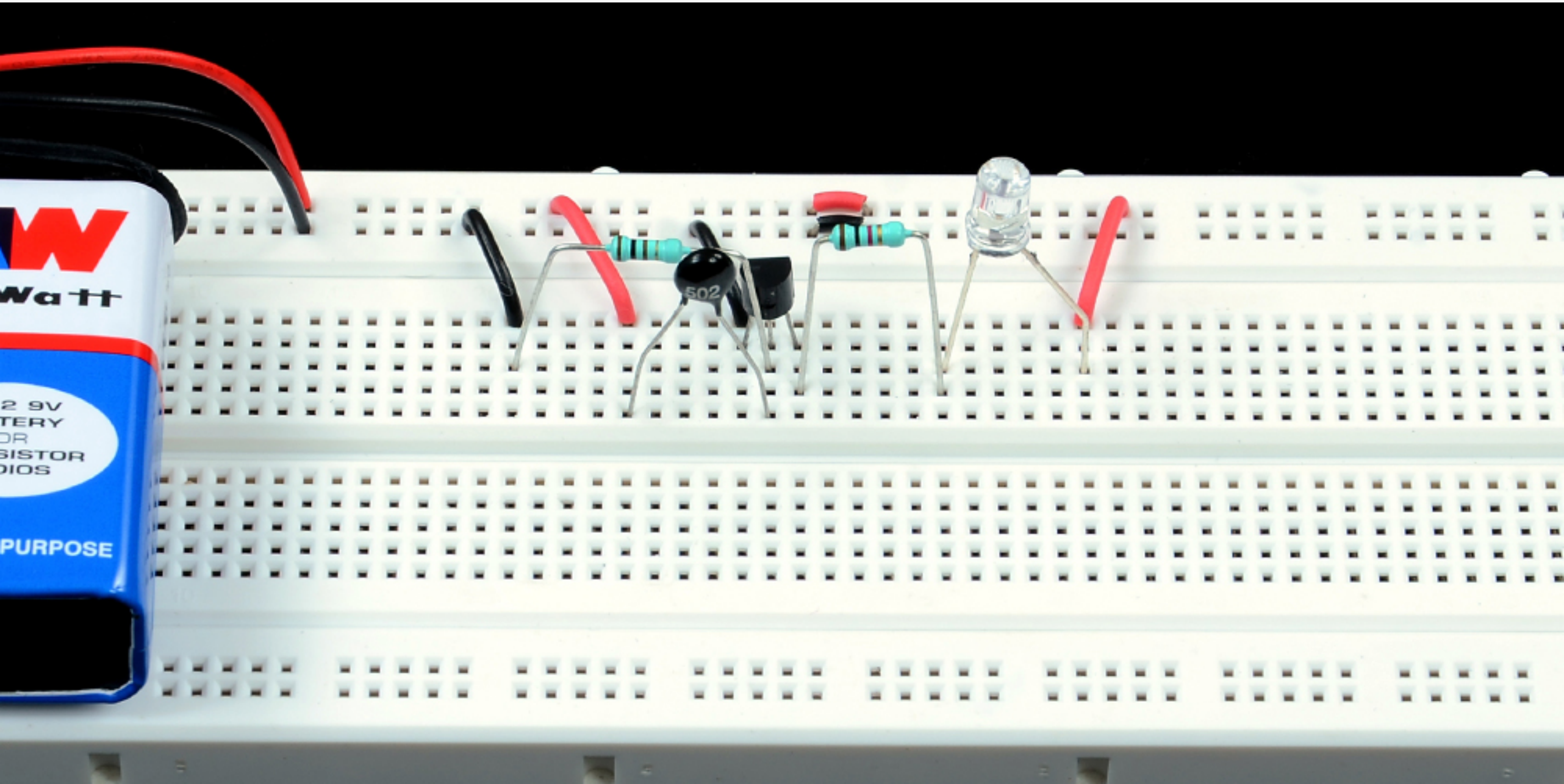
# Step No. 13

The LED will glow till the thermistor is hot above a certain threshold temperature.



# Step No. 14

The LED turns OFF the moment the temperature of the thermistor falls below the threshold value.



# Observation

When the thermistor is not exposed to heat, the LED remains OFF.

When the surface of thermistor is exposed to heat and it becomes hot above a certain threshold temperature value, the LED starts glowing.

When the thermistor gradually regains its usual state, the LED again turns OFF.

# Reasoning

If we refer the circuit diagram, we can see that one end of the thermistor is connected to Vcc and similarly, one end of the base resistor $R_1$ is connected to ground. The thermistor and the resistor are actually connected in series and their intersection point is connected to the base of the transistor.

So, the thermistor and the resistor forms a voltage divider circuit. The current starts from Vcc and enters into the ground. In this case, the current follows the following path: *Vcc---Thermistor---Resistor $R_1$---Ground.*

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# Reasoning

Now we will find out the voltage at their intersection point which is same as the input voltage to the base of the transistor. We can apply Ohm's law in the loop: Vcc---Thermistor---Resistor $R_1$---Ground.

Let resistance of thermistor be represented by $R_T$.

Total resistance in the loop = Resistance offered by thermistor + Resistor offered by resistor

Total resistance in the loop = $R_T + R_1$

Total voltage across the loop = Vcc

Current in the loop, i = $Vcc/(R_T + R_1)$

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# Reasoning

Now, we will find out the voltage at base B.

Voltage at base B = Vcc − Voltage drop across thermistor

$$= V_{cc} - (i \times R_T)$$

$$= V_{cc} - (V_{cc}/(R_T + R_1) \times R_T)$$

$$= V_{cc} - (V_{cc} \times R_T)/(R_T + R_1)$$

$$= V_{cc} \times R_1/(R_T + R_1)$$

$$= V_{cc} \times \frac{1}{(R_T/R_1 + 1)}$$

$$= \frac{V_{cc}}{(R_T/R_1 + 1)}$$

# Reasoning

$$\text{Voltage at base B} = \frac{V_{cc}}{(R_T/R_1 + 1)}$$

So, we can see that voltage at base B is inversely proportional to the value of $R_T$ since the value of $R_1$ is fixed.

**Voltage at base B $\propto$ $1/R_T$**

If the value of $\mathbf{R_T}$ increases, the base-voltage decreases, and vice-versa.

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# Reasoning

**When the thermistor is exposed to heat:** Thermistor we are using in our kit is a NTC resistor. 'NTC' stands for negative temperature coefficient. This means, they are temperature dependent semiconductors. Thermistors have a wider operating range between − 50 ℃ to + 160 ℃.

When a NTC resistor is exposed to heat, its resistance decreases. When we blow hot air or expose the surface of the NTC resistor to heat, its resistance decreases due to which the voltage at the base increases (voltage at the base is inversely proportional to the resistance offered by NTC).

# Reasoning

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When a NTC resistor is exposed to heat, its resistance decreases. When we blow hot air or expose the surface of the NTC resistor to heat, its resistance decreases due to which the voltage at the base increases (voltage at the base is inversely proportional to the resistance offered by NTC).

# Reasoning

If the base voltage increases, a point comes when the base-emitter junction gets forward biased. As a result, the transistor turns ON and an output current flows from its collector to the emitter, making the LED glow.

When the thermistor cools down, its resistance increases due to which the the voltage at the base decreases. So, if the base voltage decreases, it becomes so low that the base-emitter junction is not forward biased and the transistor turns OFF. No collector current flows from the collector to the emitter and hence, the LED stops glowing.

For:

- Activity
- Modification
- Reasoning
- Inference

Refer the Temperature Sensor Manual (PDF)

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# Troubleshooting Tips

- Ensure that the battery voltage is more than 6 volt.
- Ensure that the wires of the battery connector are properly inserted into the breadboard. The red wire should be inserted into the first row, and the black wire into the second row of the breadboard.
- Ensure that a 547-B transistor is chosen for the experiment.
- Ensure that the transistor is connected on the breadboard such that its curved surface faces you.
- Ensure that the transistor is connected properly on the breadboard without twisting its legs.

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# Troubleshooting Tips

- Ensure that the stripped ends of the connecting wires should be long enough to fit inside the holes of the breadboard completely.

- Ensure that there are no loose connections.

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