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step by step

Electronic Series, KIT-1

Experiment 55:
IR Security Alarm

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DIY
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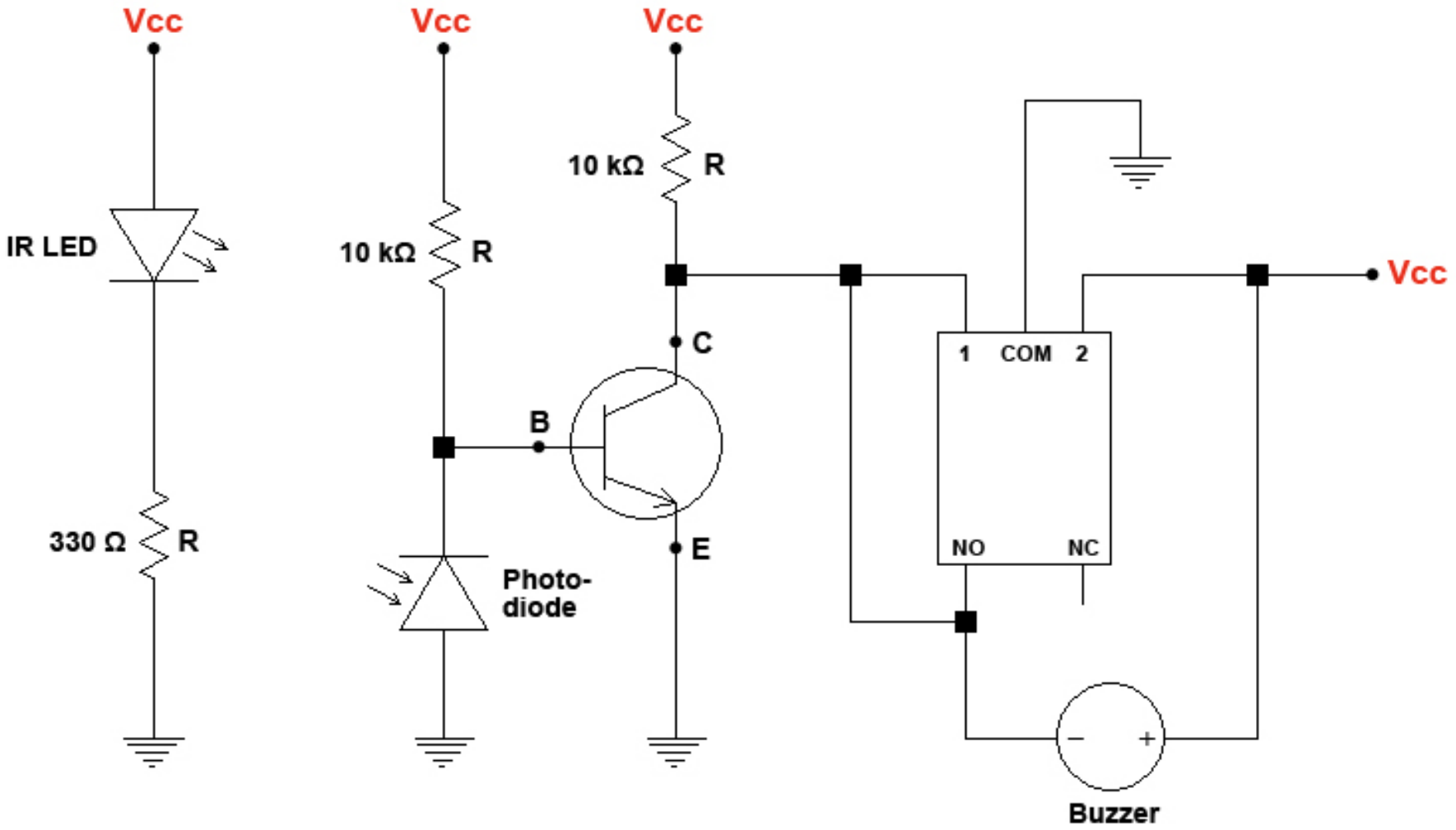
Circuit Diagram



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Materials Required

i. Breadboard - 2
ii. 9V Battery - 2
iii. IR LED (Transmitter) - 1
iv. Photodiode (Receiver) - 1
v. Resistor: 330 Ω - 1, 10 kΩ - 2
Colour Code: 330 Ω - Orange Orange Brown Gold
10 kΩ - Brown Black Orange Gold
vi. Relay - 1
vii. Transistor: 547 B - 1
viii. Buzzer - 1
ix. Connecting Wire Pieces

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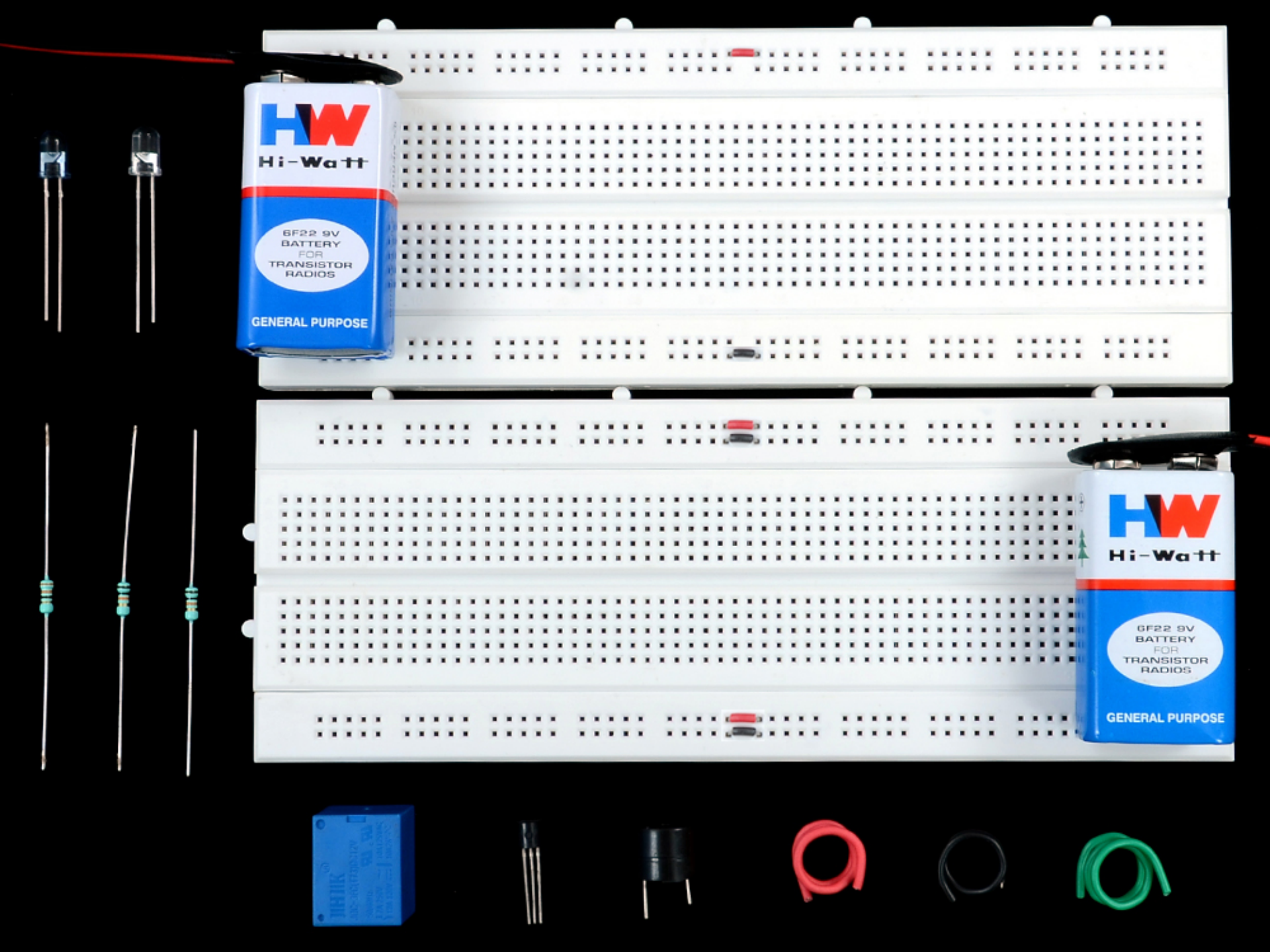
HW
Hi-Watt
6F22 9V
BATTERY
FOR
TRANSISTOR
RADIOS
GENERAL PURPOSE
HW
Hi-Watt
6F22 9V
BATTERY
FOR
TRANSISTOR
RADIOS
GENERAL PURPOSE

Points to Remember

- In this experiment, we will build two different circuits: Transmitter and Receiver.
- Each circuit should be built on a separate breadboard.

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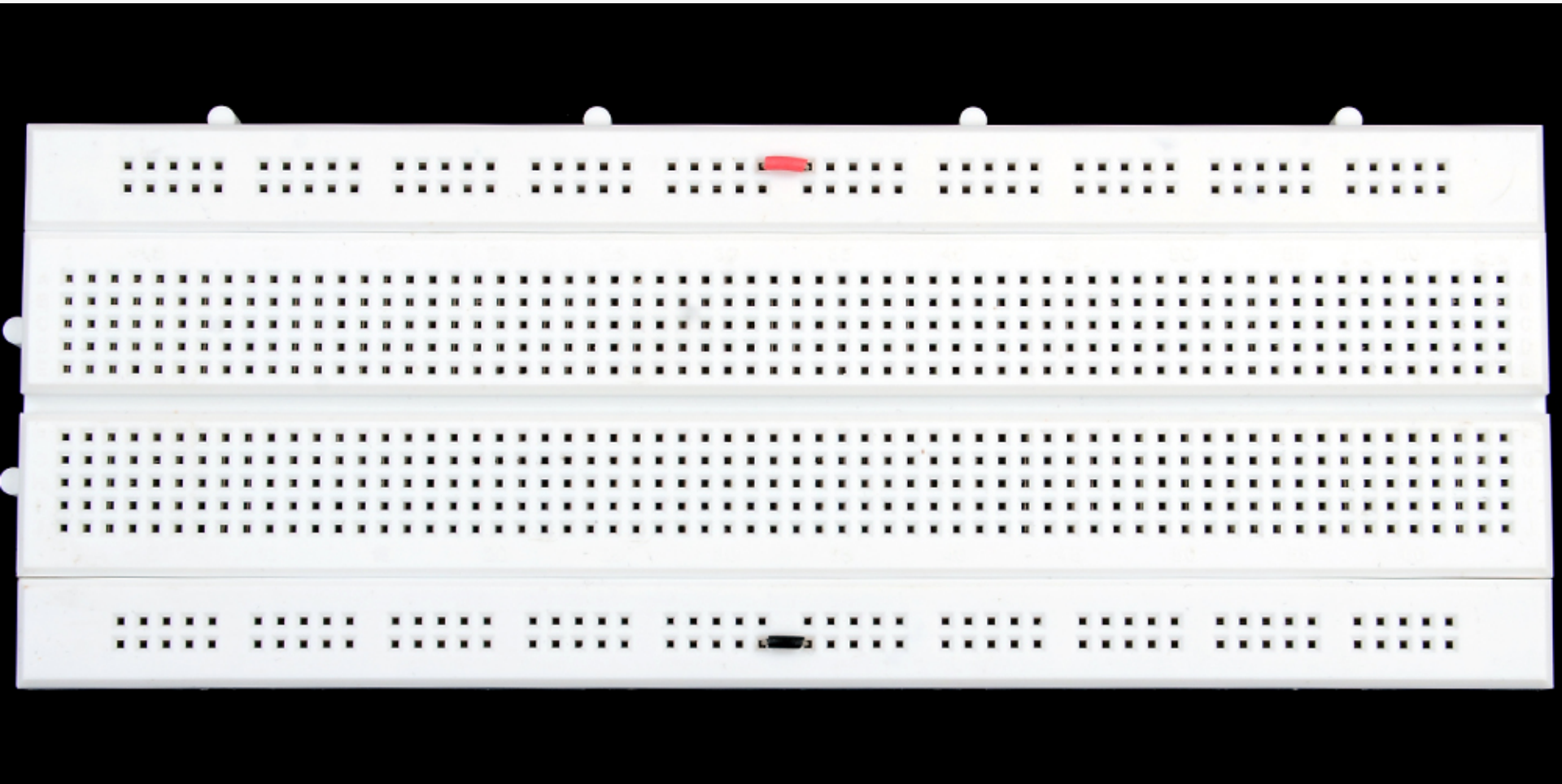
Step No. 1

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

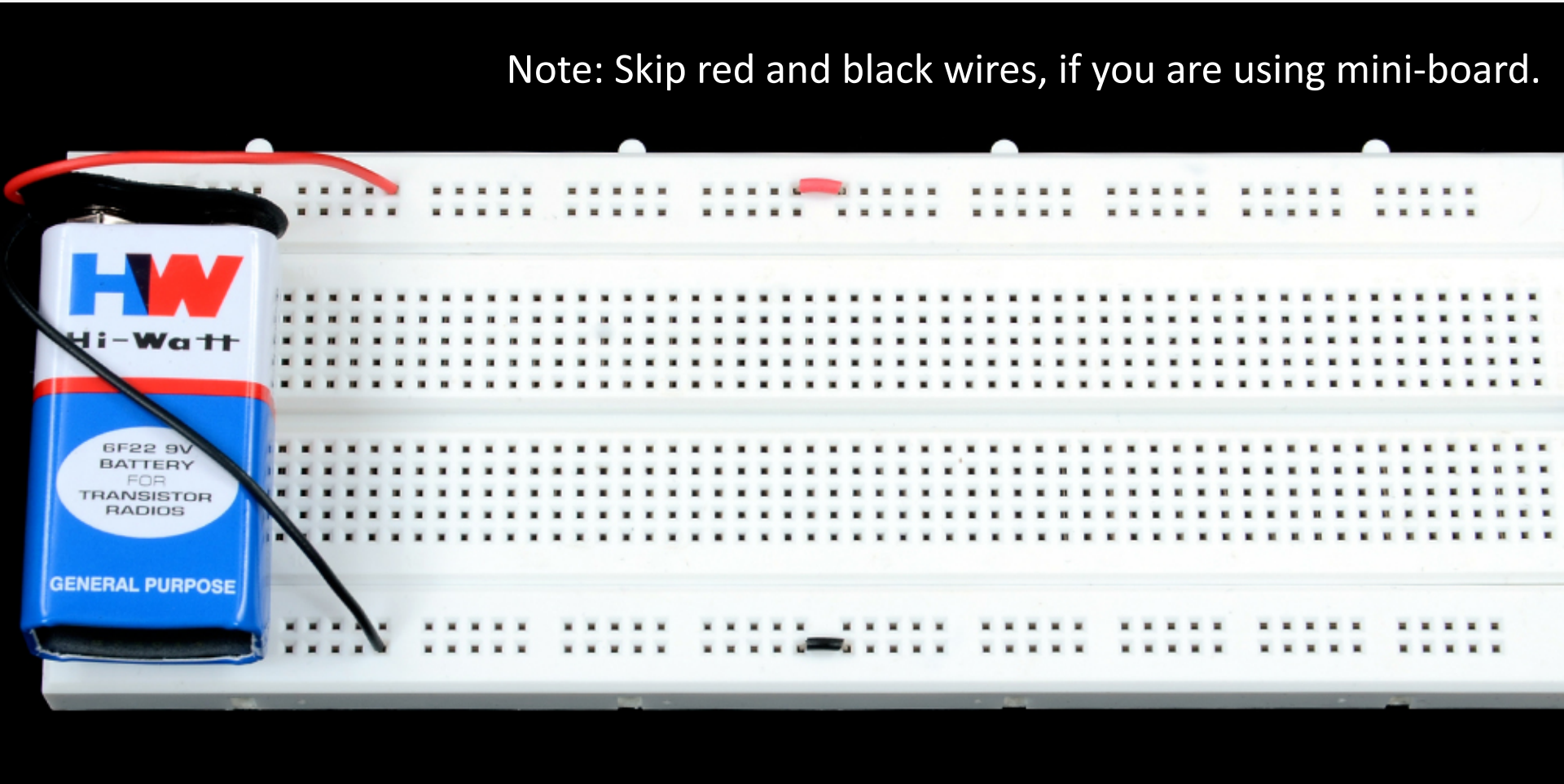
For this, use the mini breadboard in your kit.



Mini Breadboard

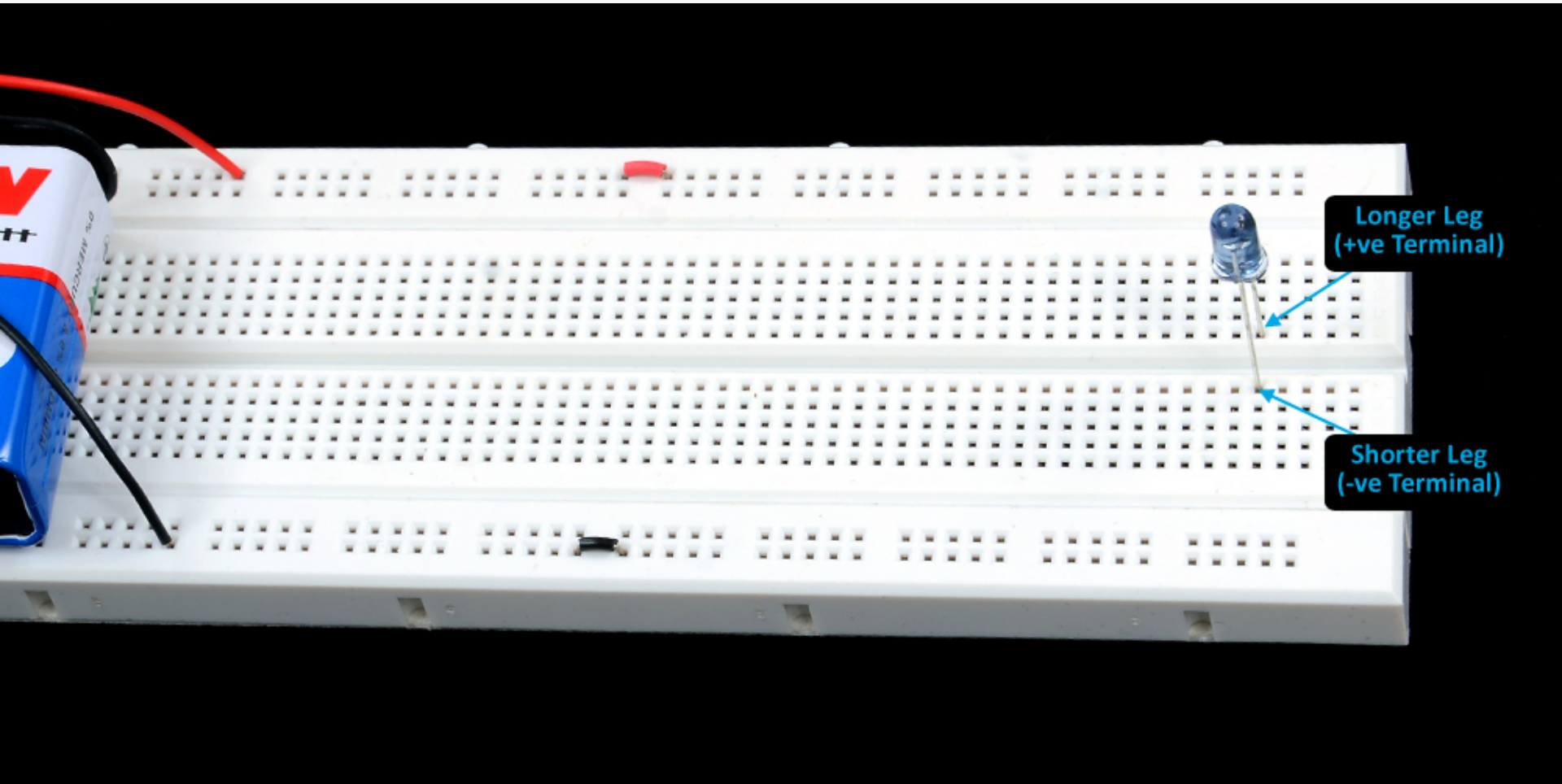
Step No. 2

Connect a 9 V battery on the breadboard. Connect the red wire of the battery connector to the first row of the upper half of the breadboard. Connect the black wire of the battery connector to the second row of the lower half of the breadboard.



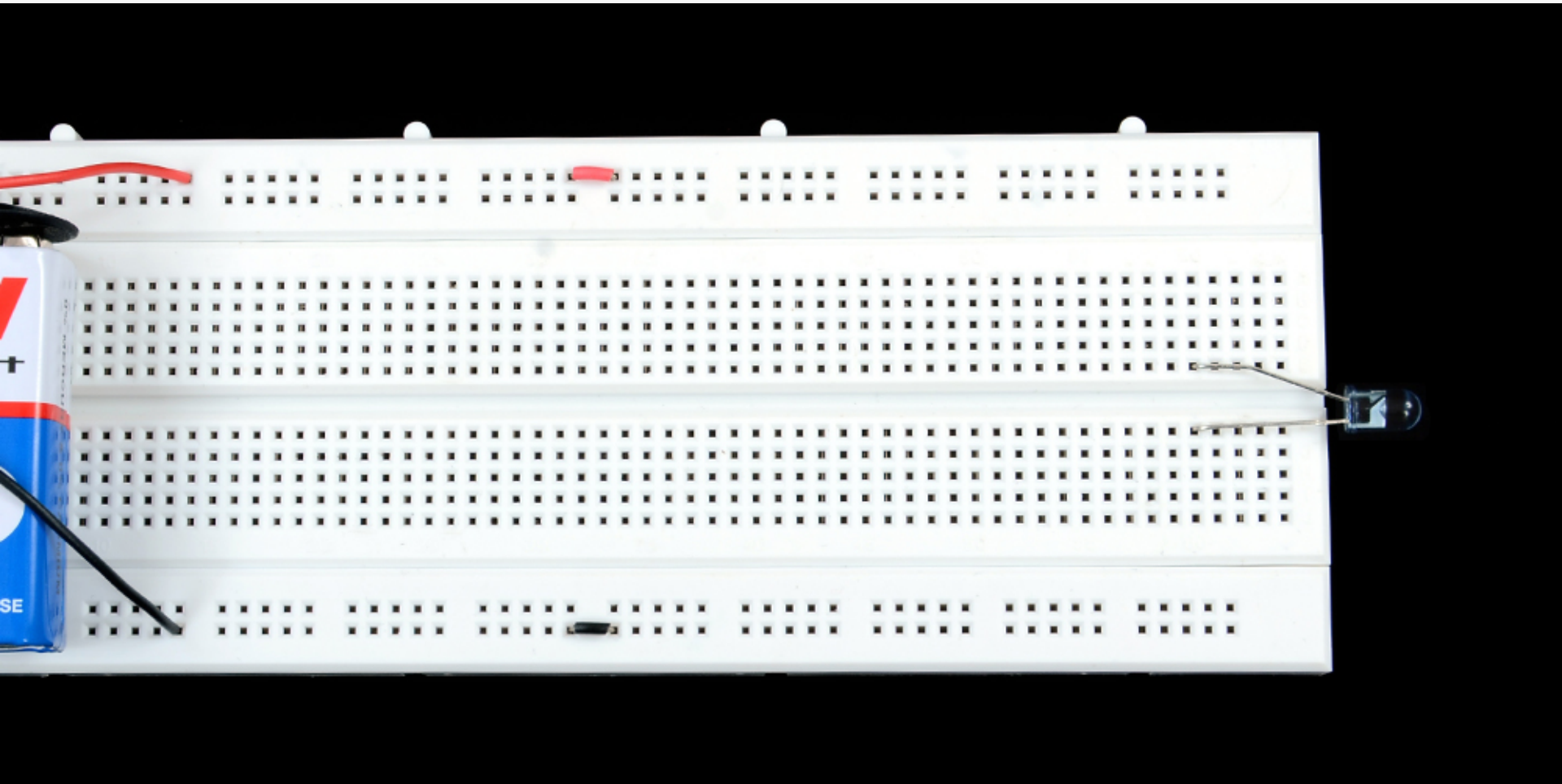
Step No. 3

Take an IR (Infrared) LED. Connect its positive (longer leg) and negative (shorter leg) terminals to the upper and lower halves, respectively. Note that we will use the right side and the second half of the breadboard.



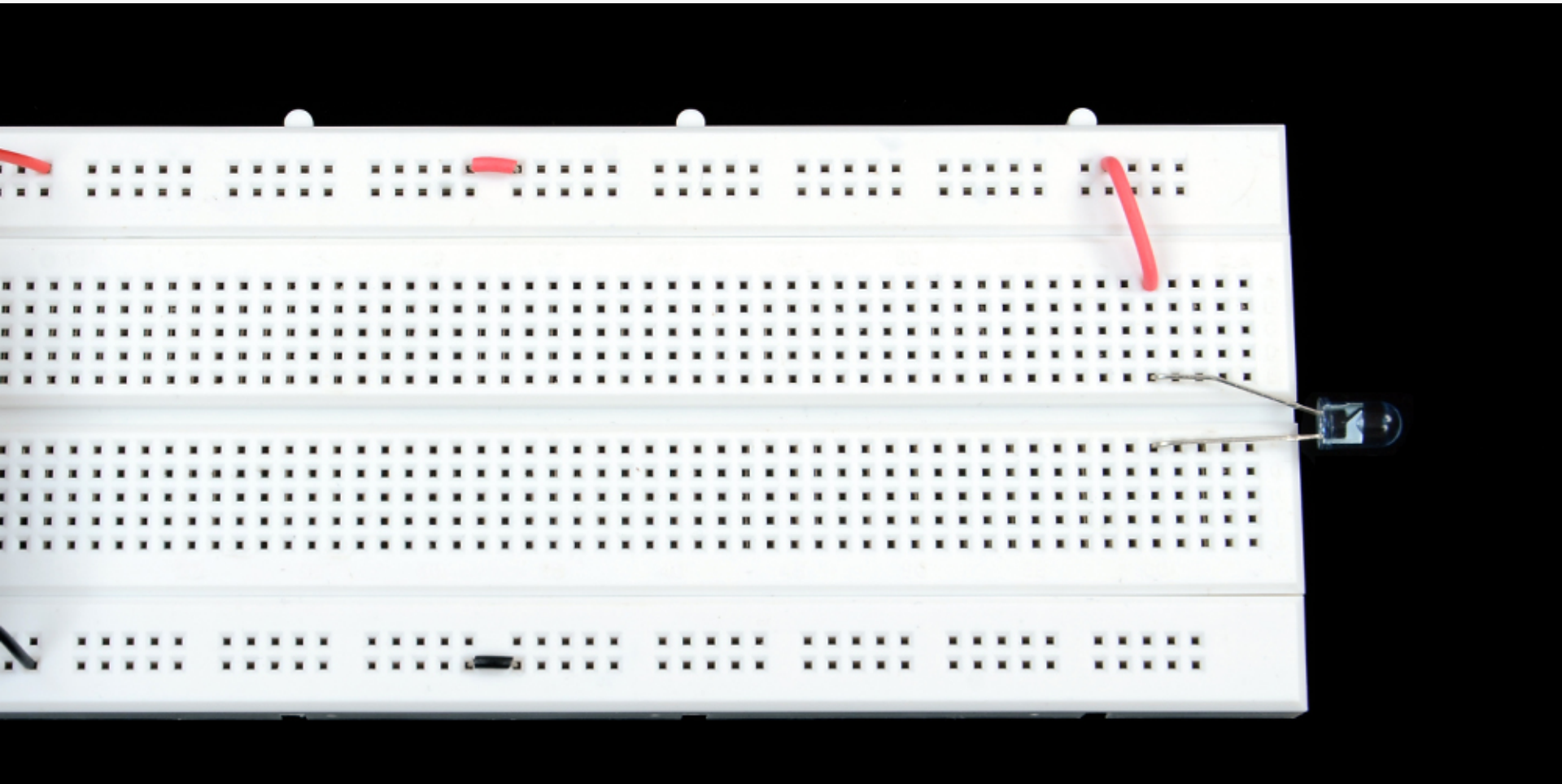
Step No. 4

Bend the IR LED so that it points towards the right hand side.



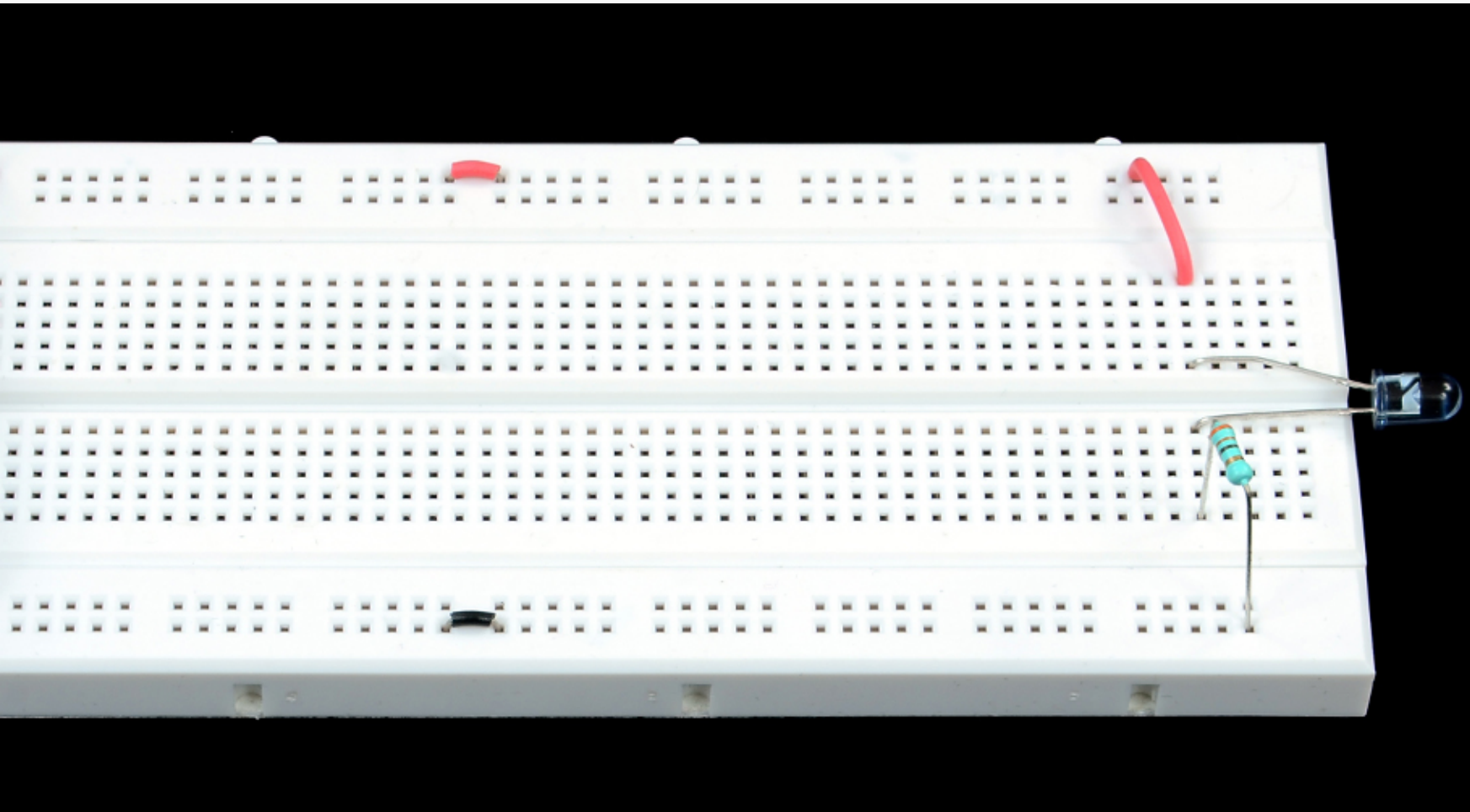
Step No. 5

Connect the positive terminal of the IR LED to Vcc.



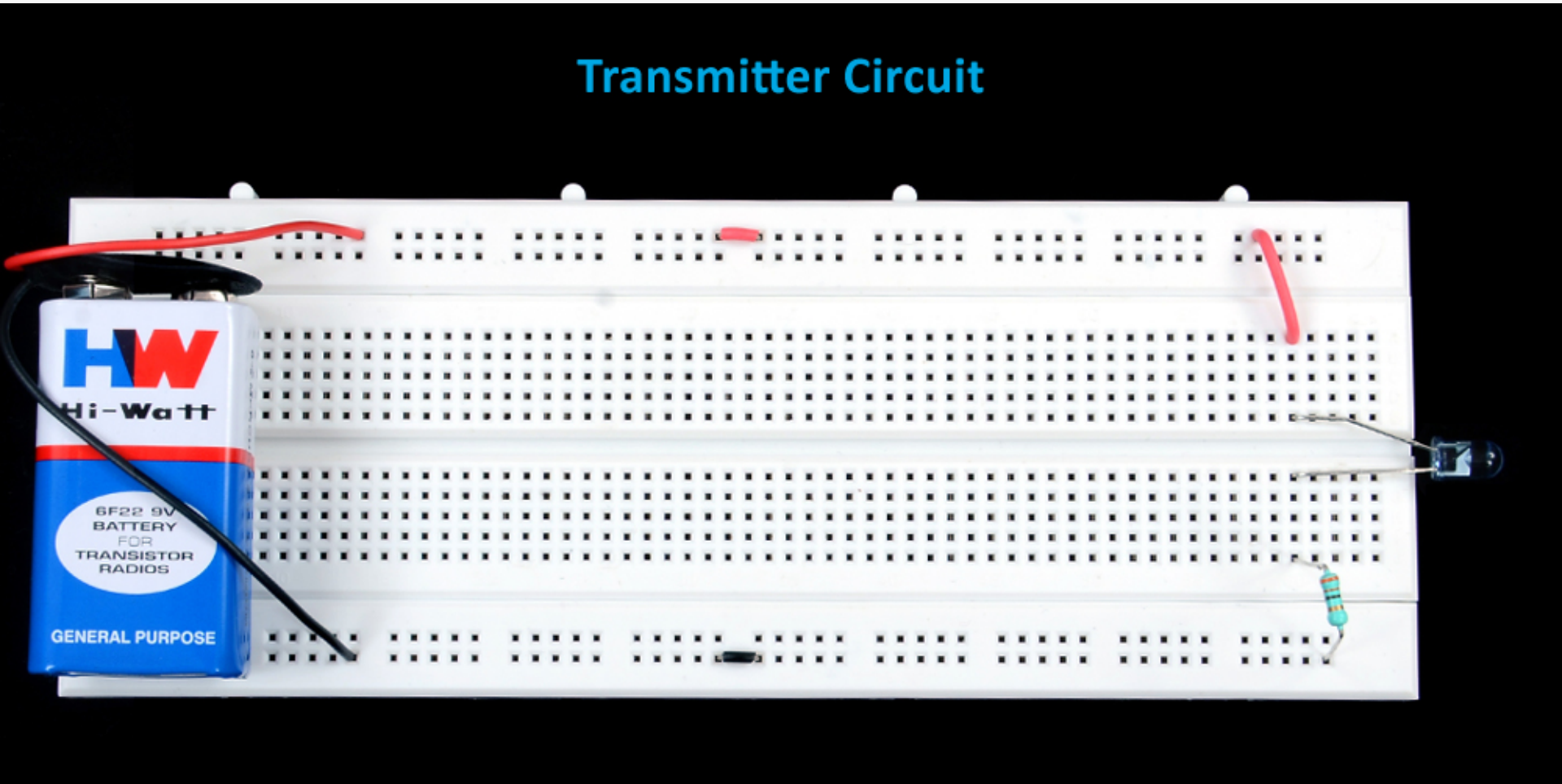
Step No. 6

Take a 330 Ω resistor. Connect its one leg to the negative terminal of the IR LED and its other leg to ground.



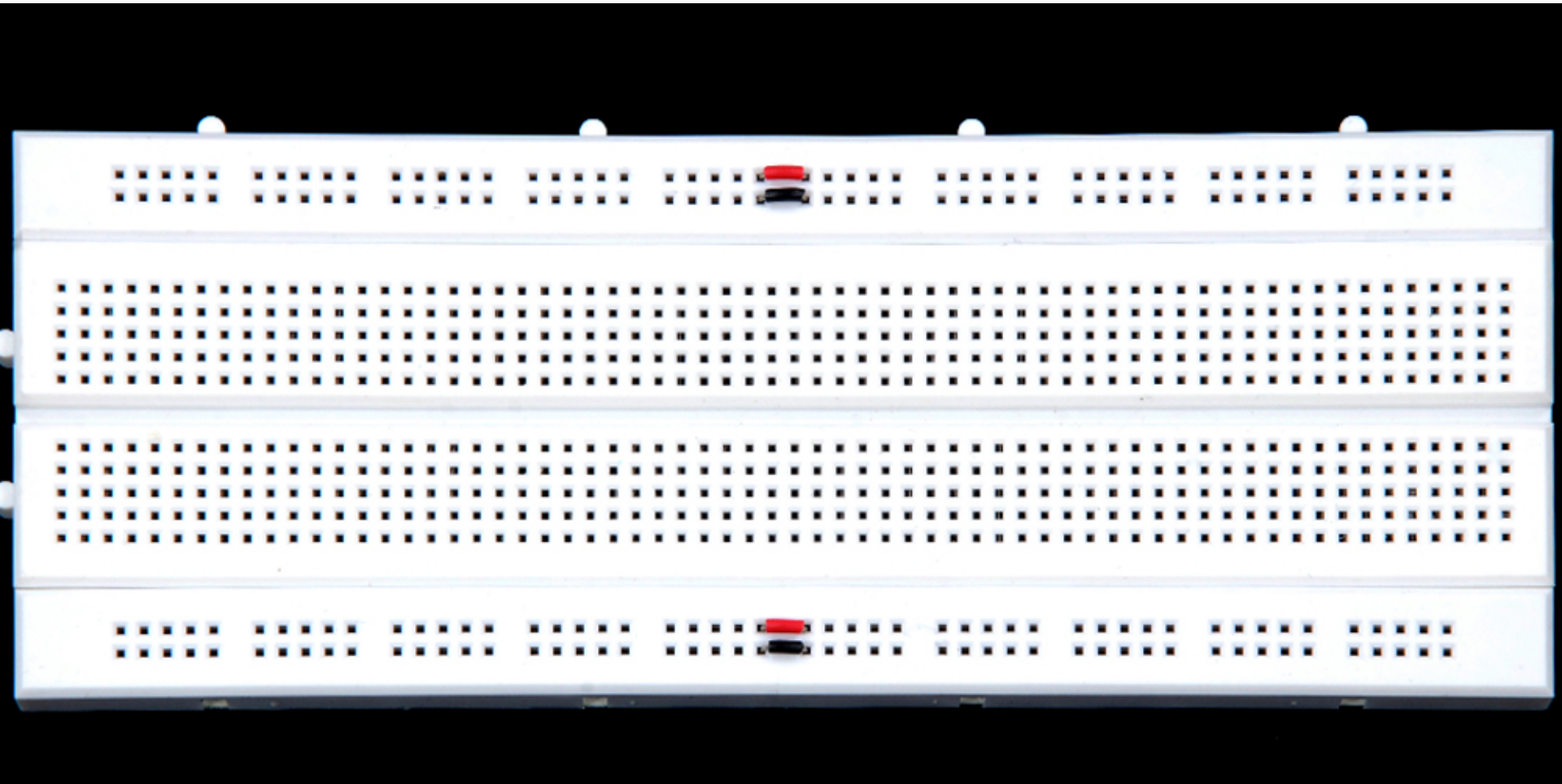
Review

Congratulations! You have successfully built your transmitter circuit. Keep it aside, we will now build the receiver circuit.



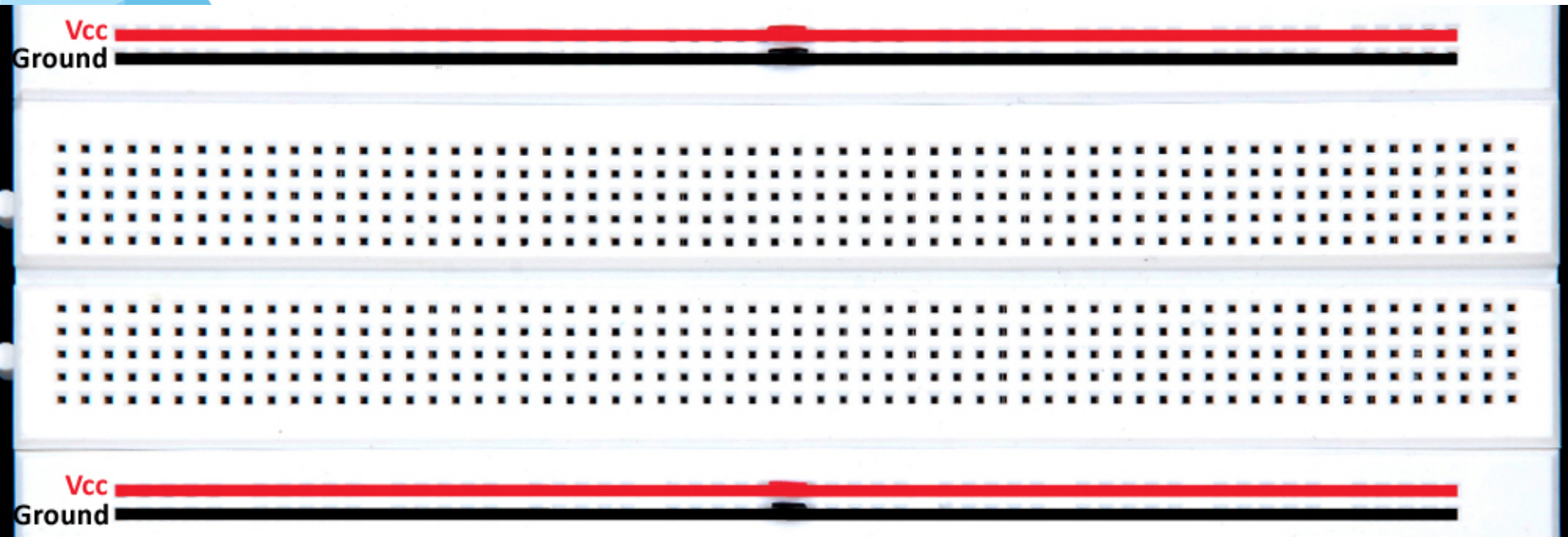
Step No. 7

Take a new breadboard and connect its two halves (both upper and lower) by using red and black connecting wires as shown below.



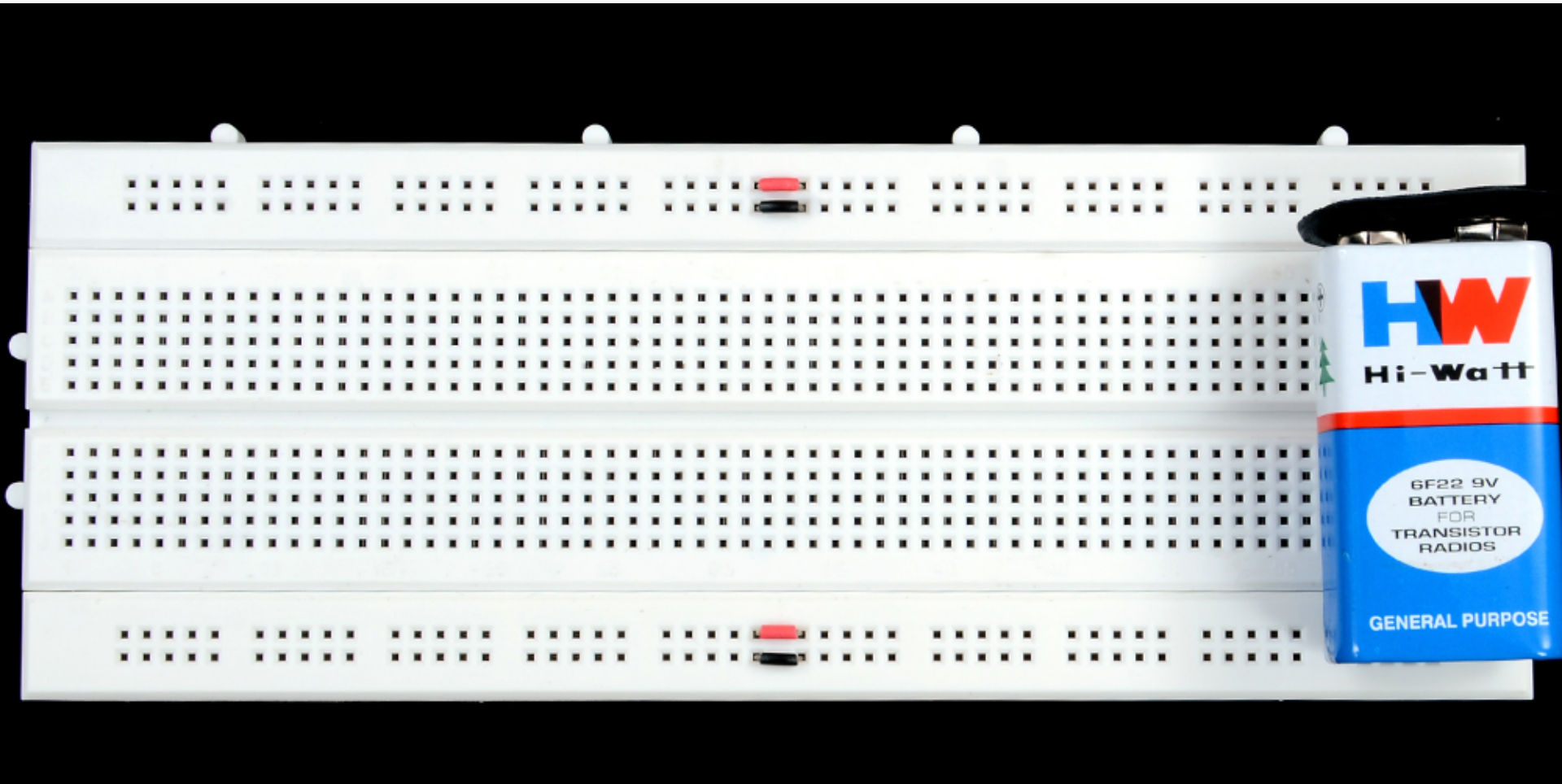
Points to Remember

- While building the receiver circuit, we have to keep in mind that we will provide supply to the breadboard after the completion of the circuit.
- Assume that the first row of the upper (red line) and lower (red line) halves of the breadboard consists of Vcc. Similarly, the second row of the upper (black line) and lower (black line) halves of the breadboard consists of ground.
- After completing the circuit, we will connect the the red and black wires of the battery snap to the first and second rows of the breadboard, respectively.



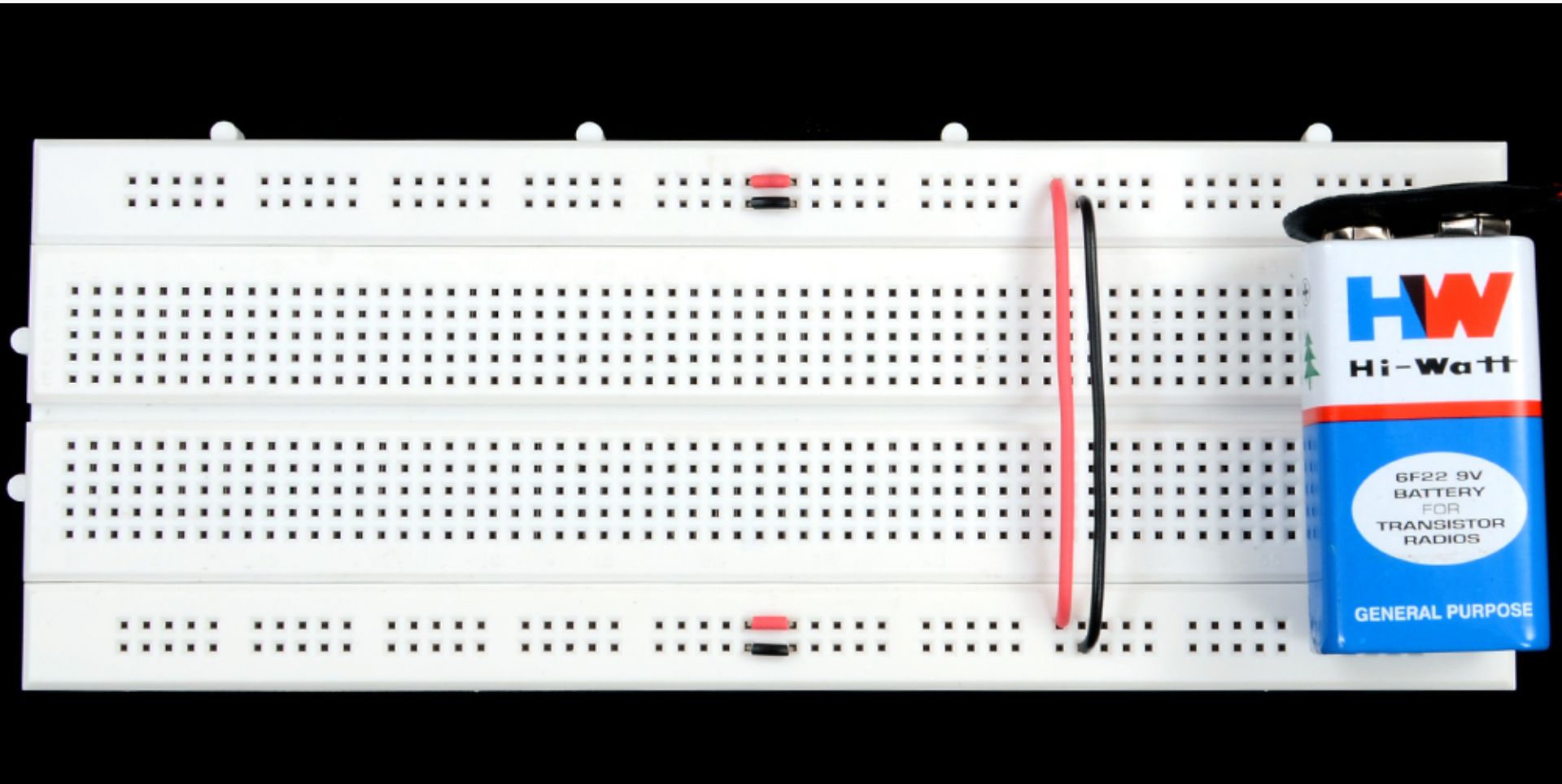
Step No. 8

Take a battery and paste it (using a double-sided tape) on the right side of the breadboard. **Note that we have not connected the battery wires to the breadboard.**



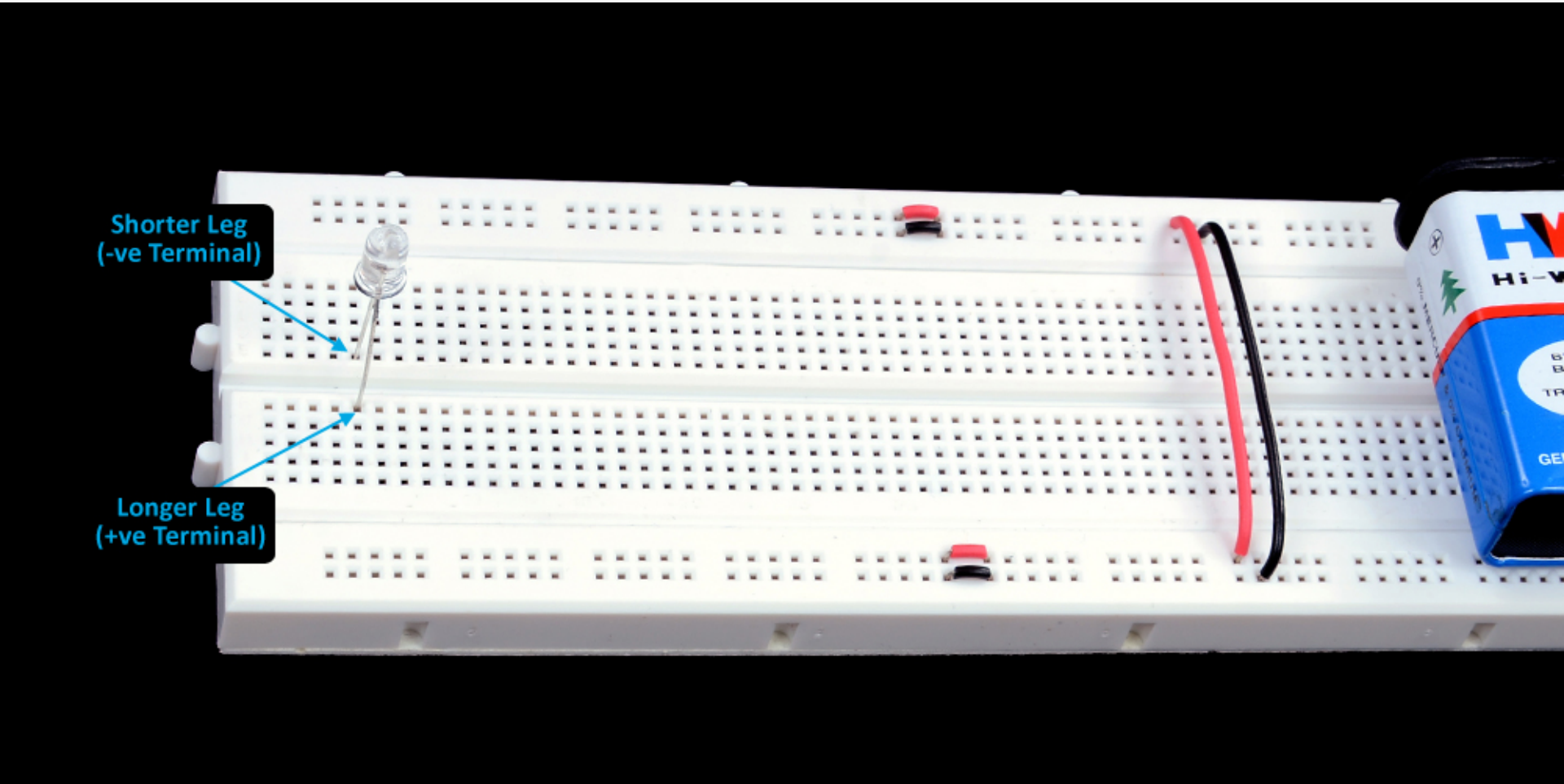
Step No. 9

Connect the first rows of the upper and the lower halves of the breadboard (shown by the red wire). Similarly, connect the second rows of the upper and the lower halves of the breadboard (shown by the black wire).



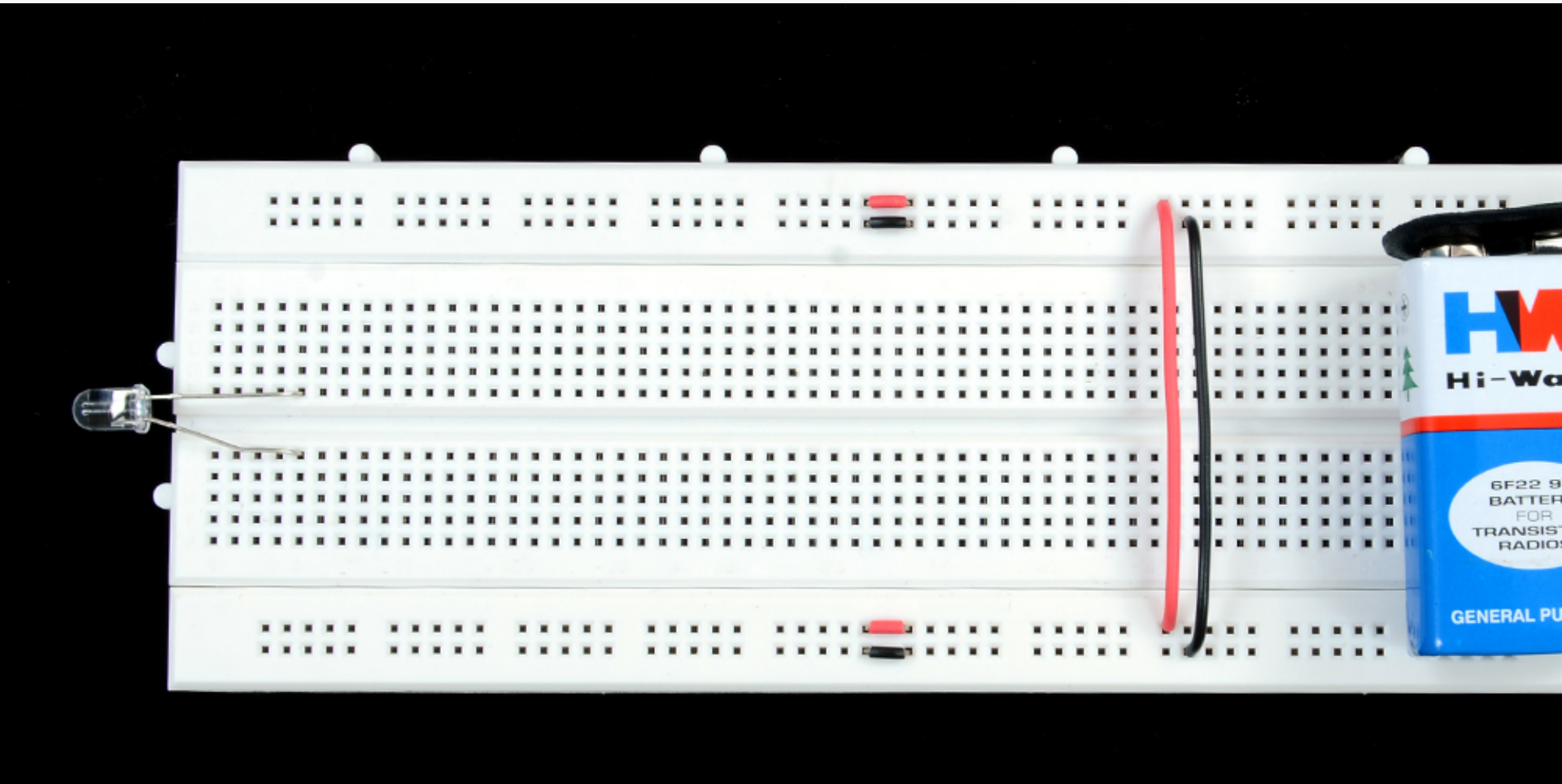
Step No. 10

Take a Photodiode. Connect its positive (longer leg) and negative (shorter leg) terminals to the lower and upper halves, respectively. Note that we will use the left side and the second half of the breadboard.



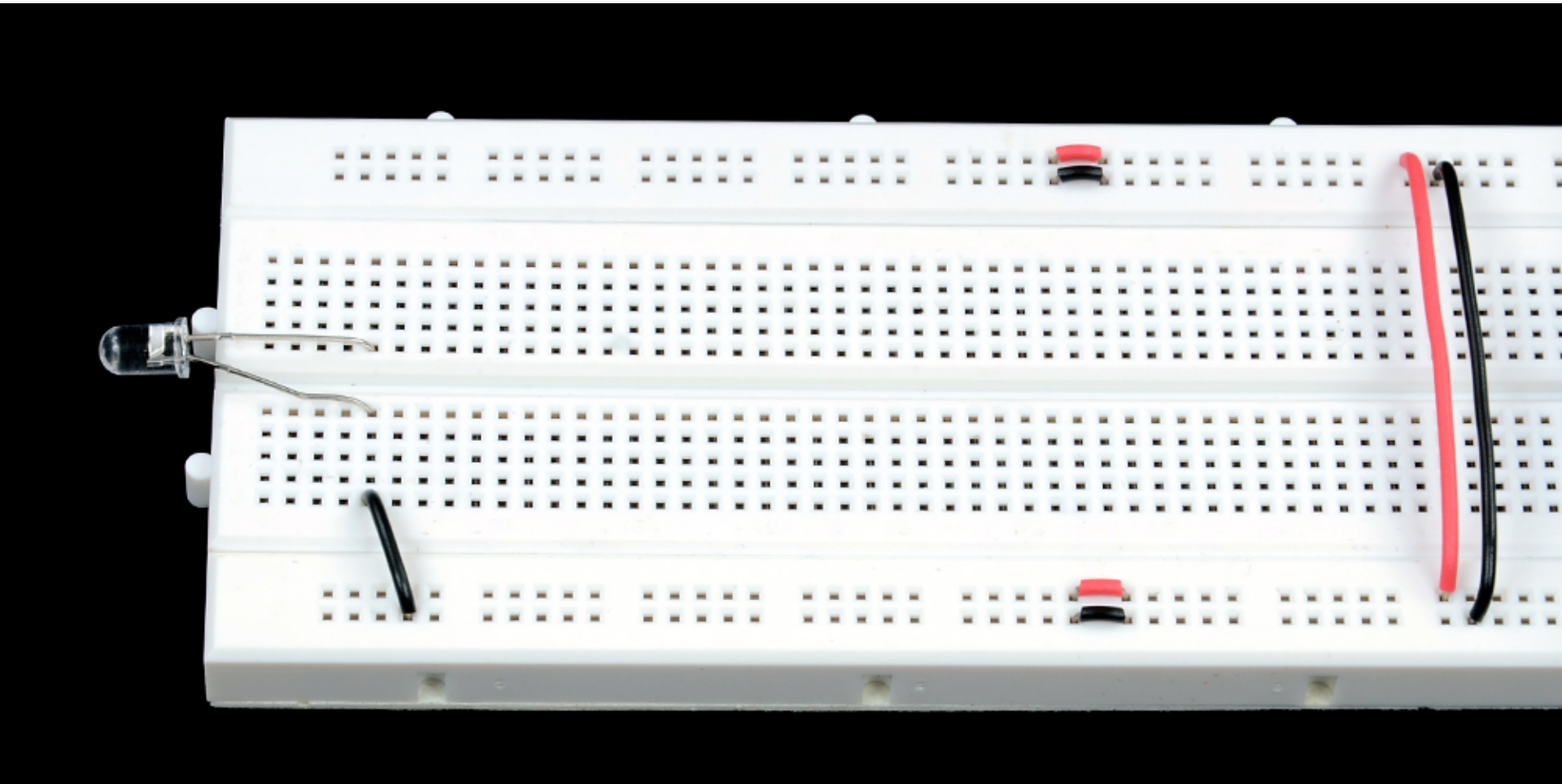
Step No. 11

Bend the photodiode so that it points towards the left side.



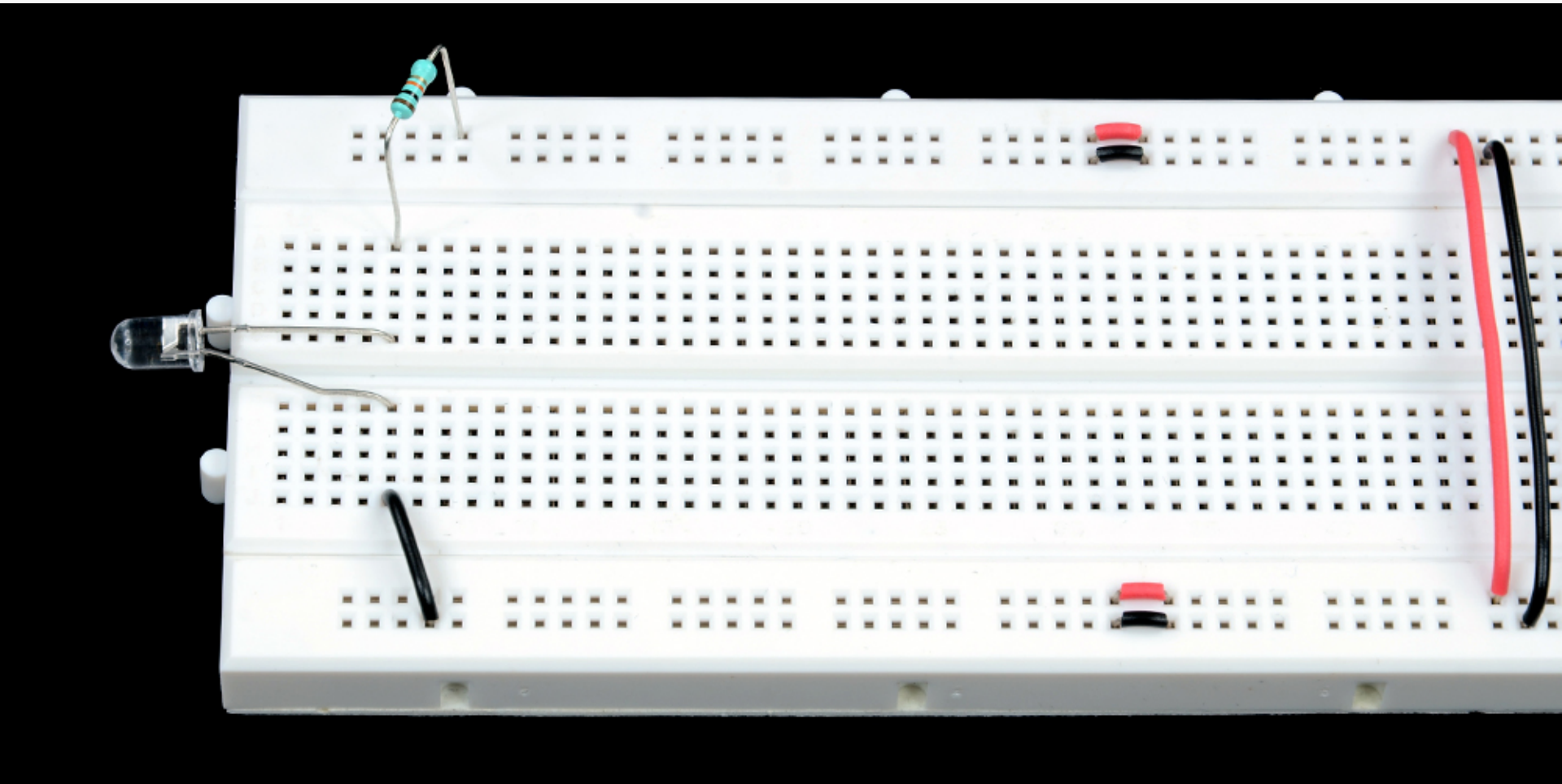
Step No. 12

Connect the positive terminal of the photodiode to ground.



Step No. 13

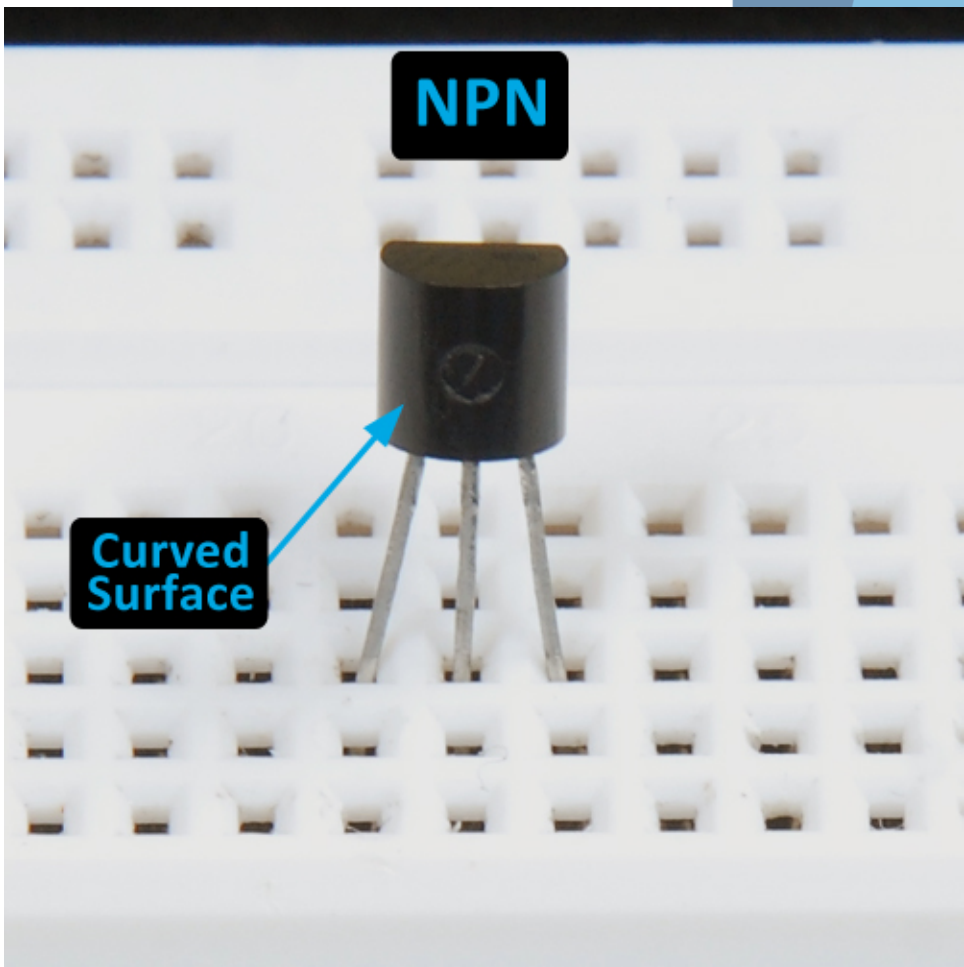
Take a 10 kΩ resistor and connect its one leg to the positive terminal of the photodiode. Connect the other leg of the resistor to Vcc.



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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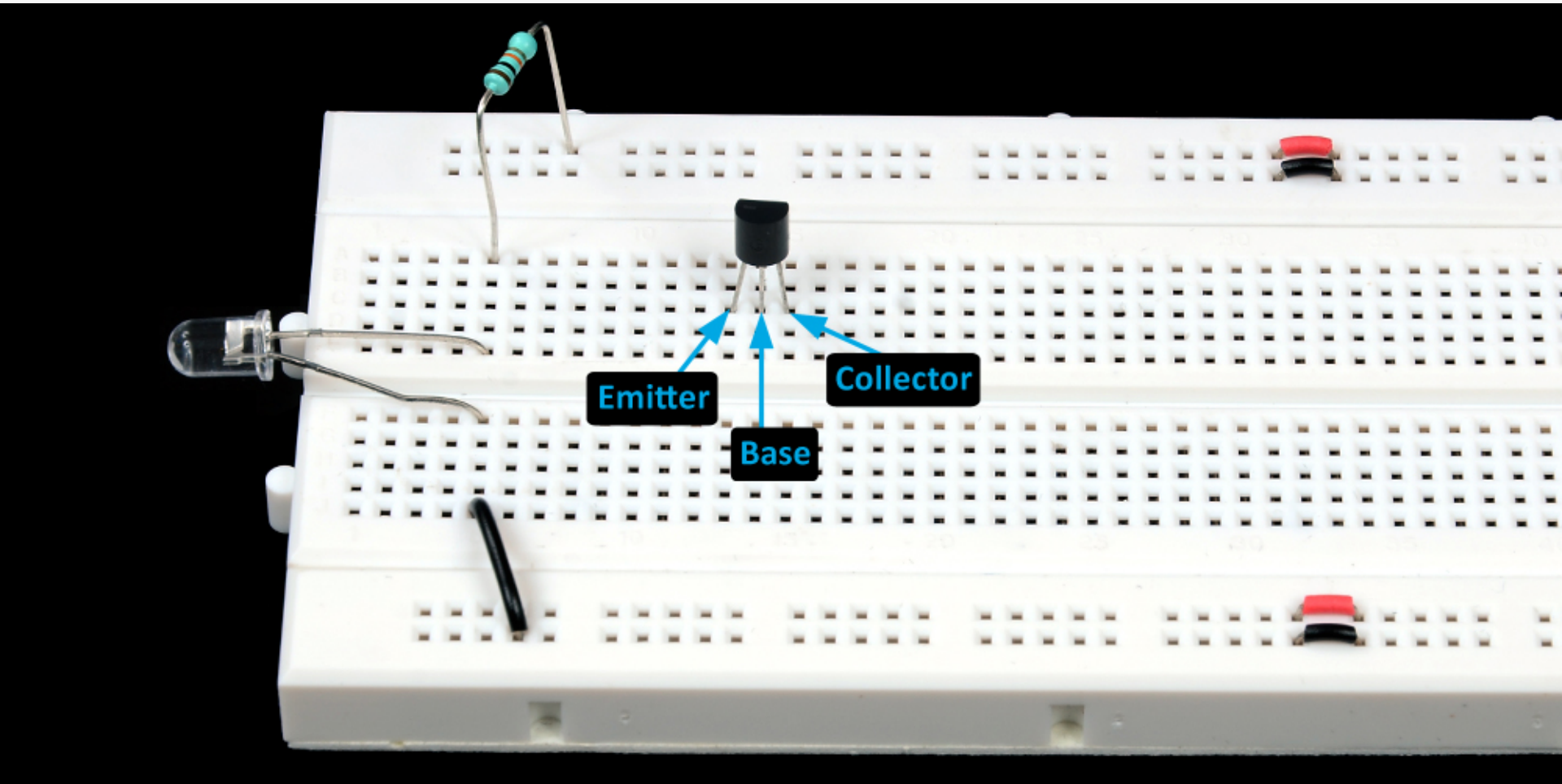
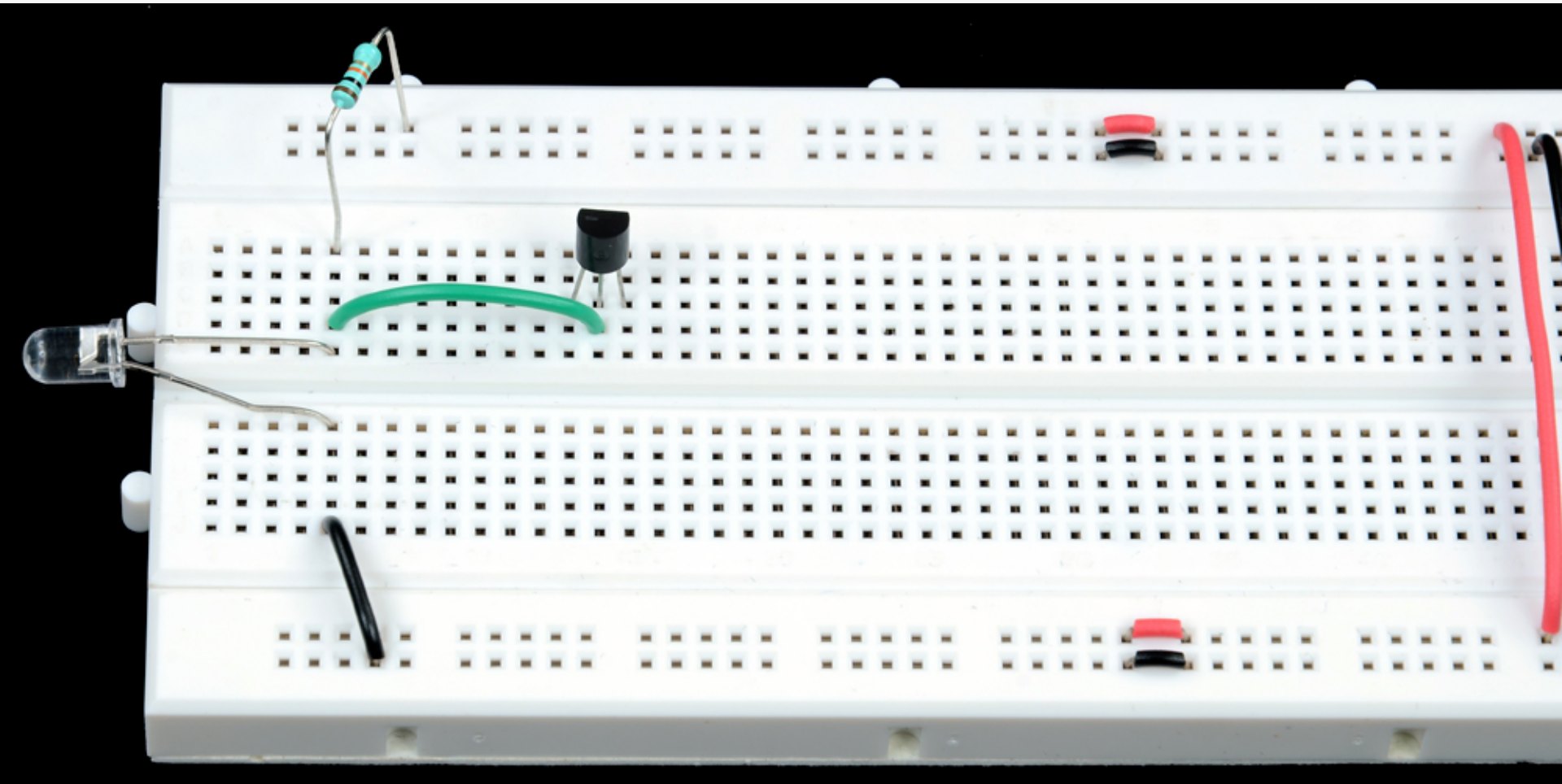
Step No. 14

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.**



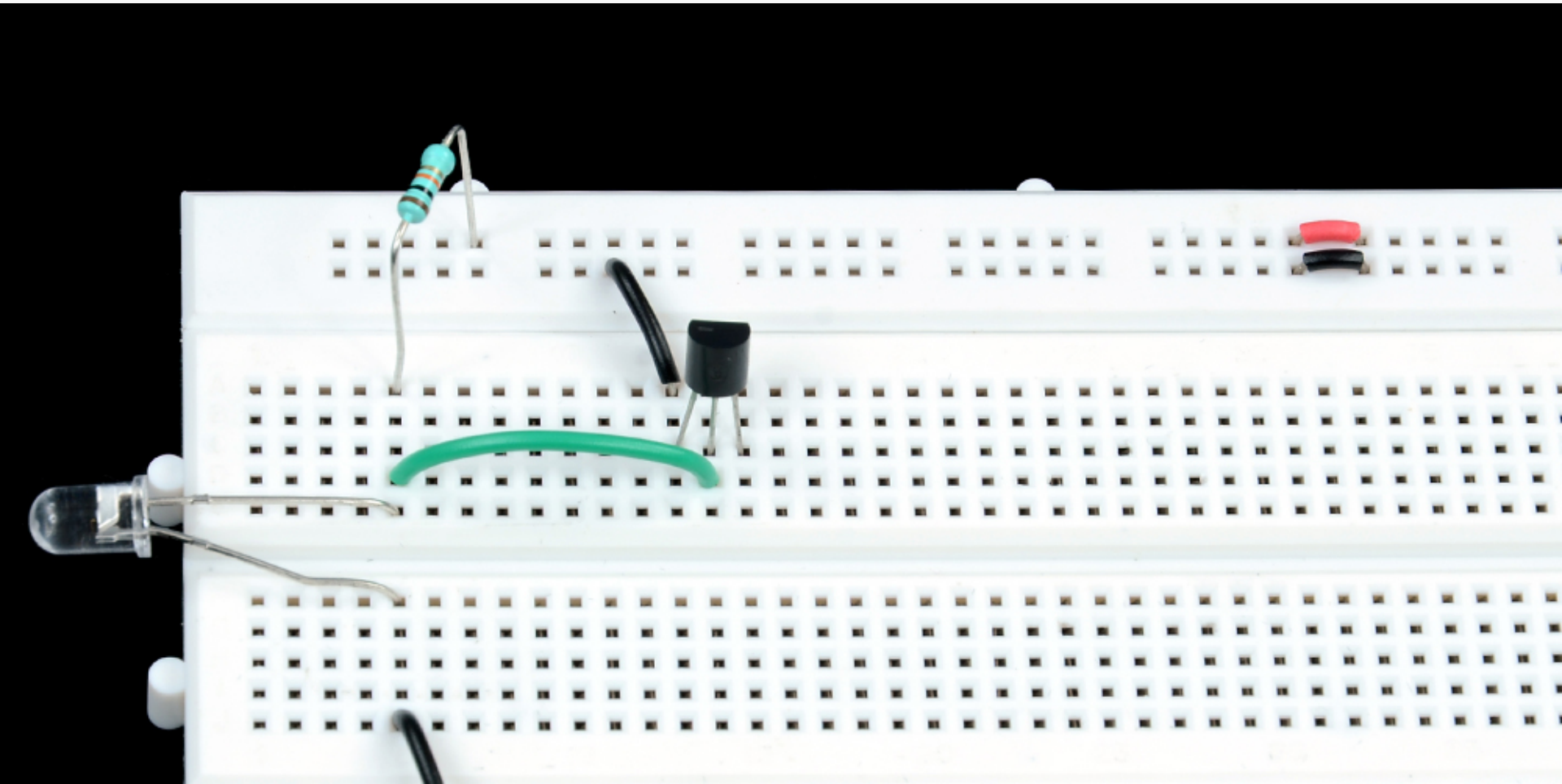
Step No. 15

Connect the base of the transistor to the positive terminal of the photodiode.



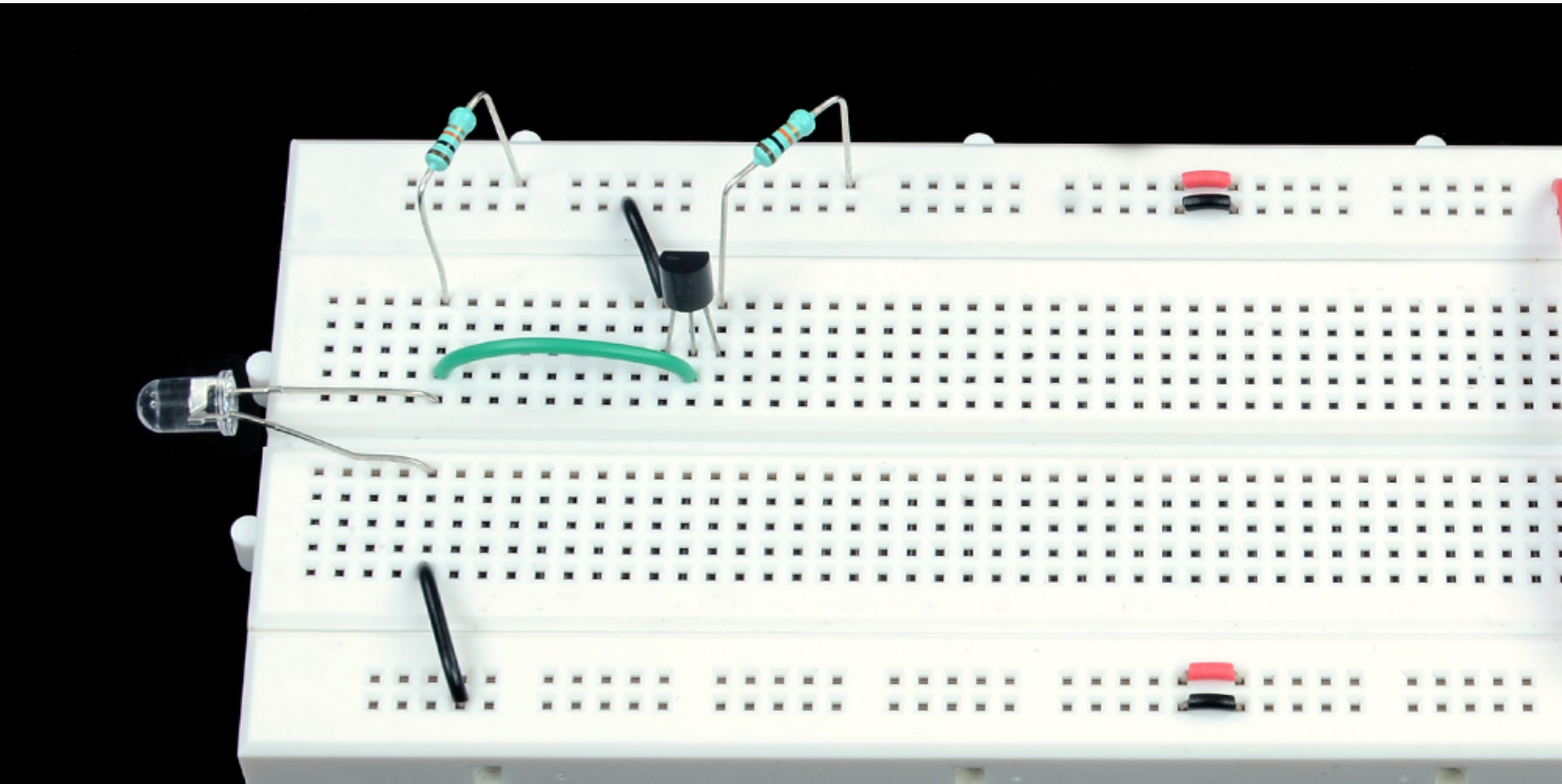
Step No. 16

Connect the emitter of the transistor to ground.



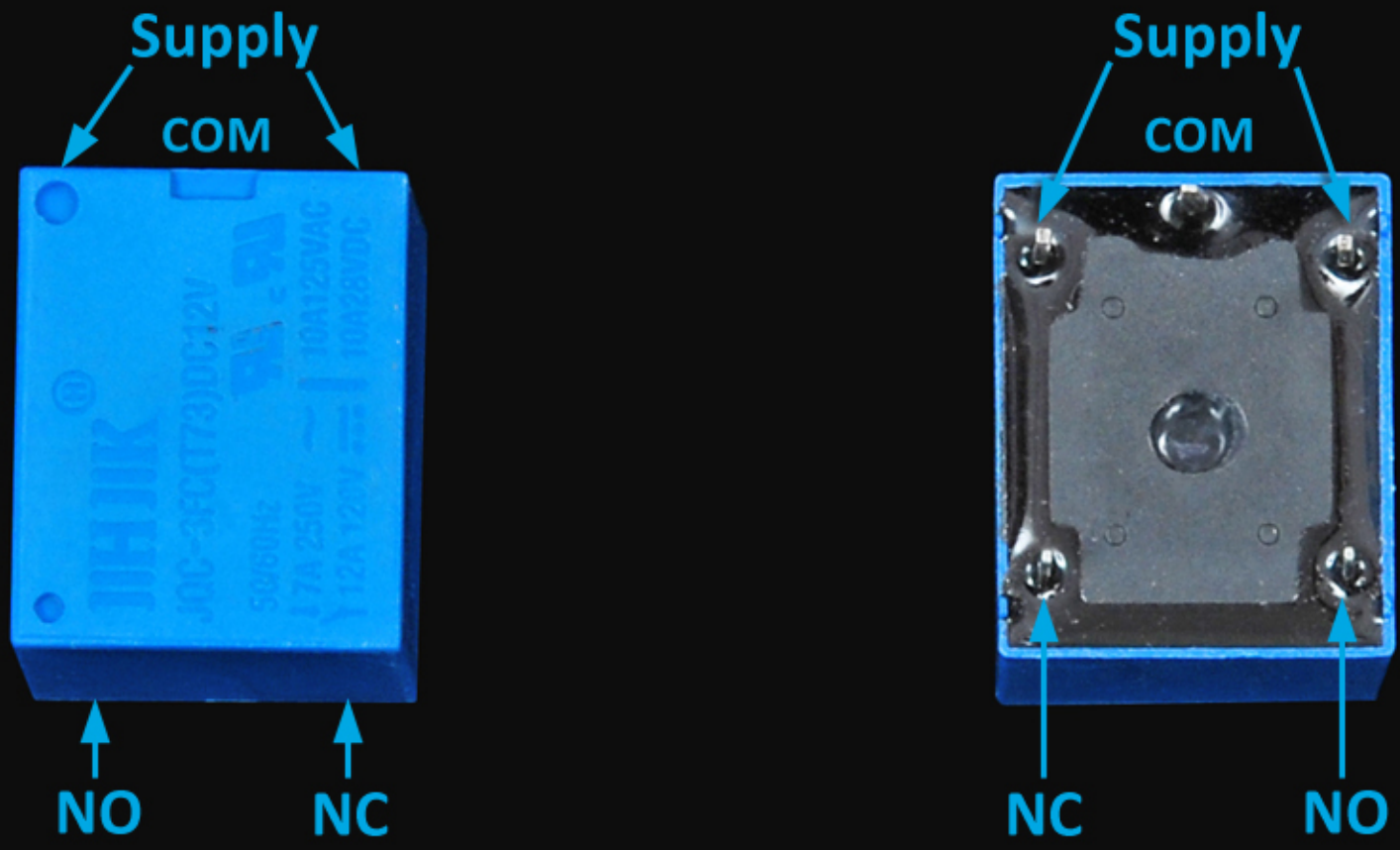
Step No. 17

Take another 10 kΩ resistor and connect its one leg to the collector of the transistor. Connect the other leg of the resistor to Vcc.



Points to Remember

The relay in the kit has five legs (terminals). Two of them represent the supply terminals while the other three terminals (**COM**-Common, **NO**-Normally open, **NC**- Normally closed) represent the contact terminals of an SPDT switch.



Points to Remember

- There is a lever inside the relay. One end of the relay is fixed and permanently attached to the COM (common terminal). The other end of the lever is either connected to NO or NC depending upon supply to the relay.
- When there is no supply to the relay, the lever is between COM and NC terminal.
- When there is supply to the relay, the lever at the COM shifts its position from NC terminal to NO terminal.

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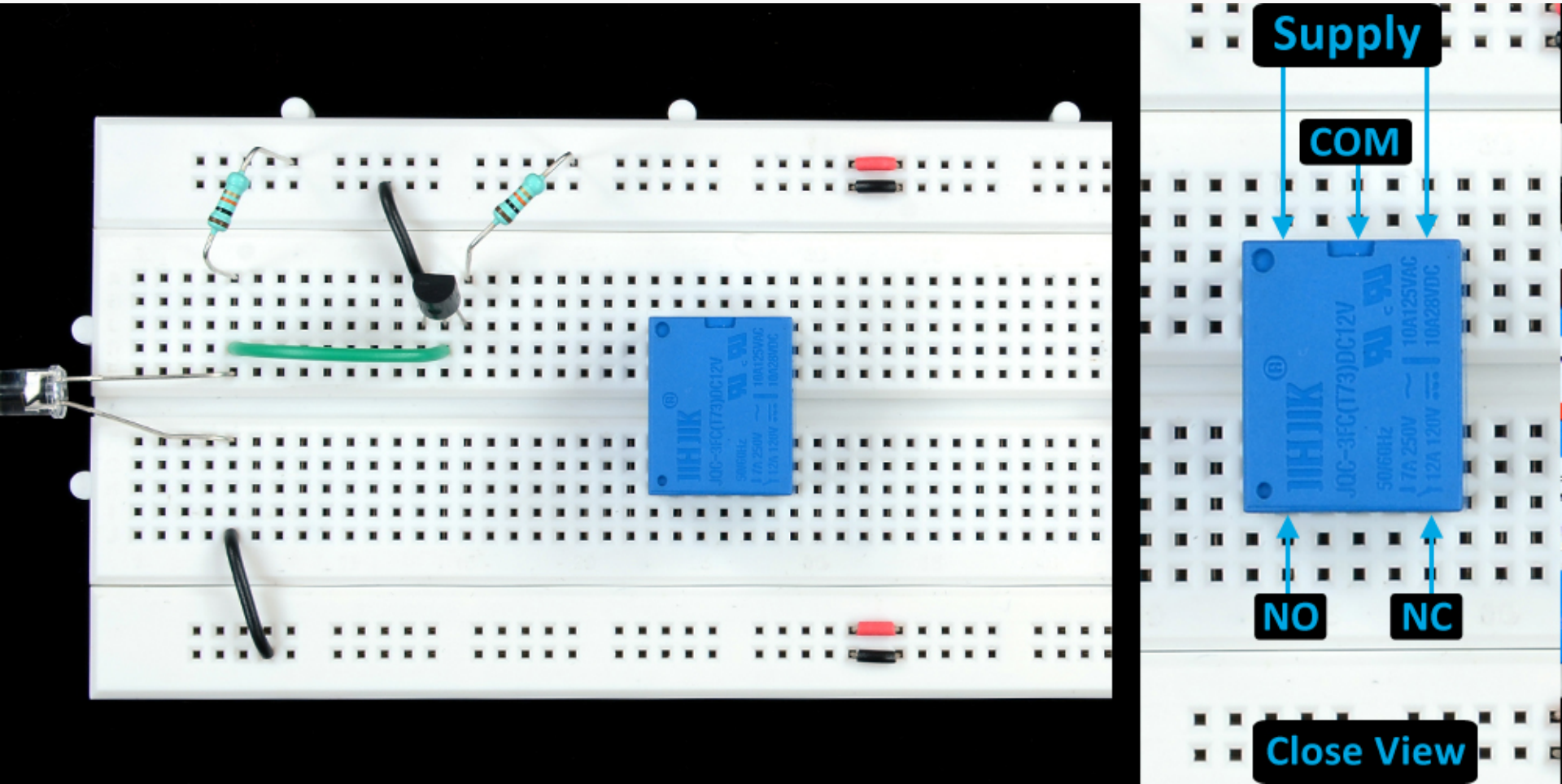
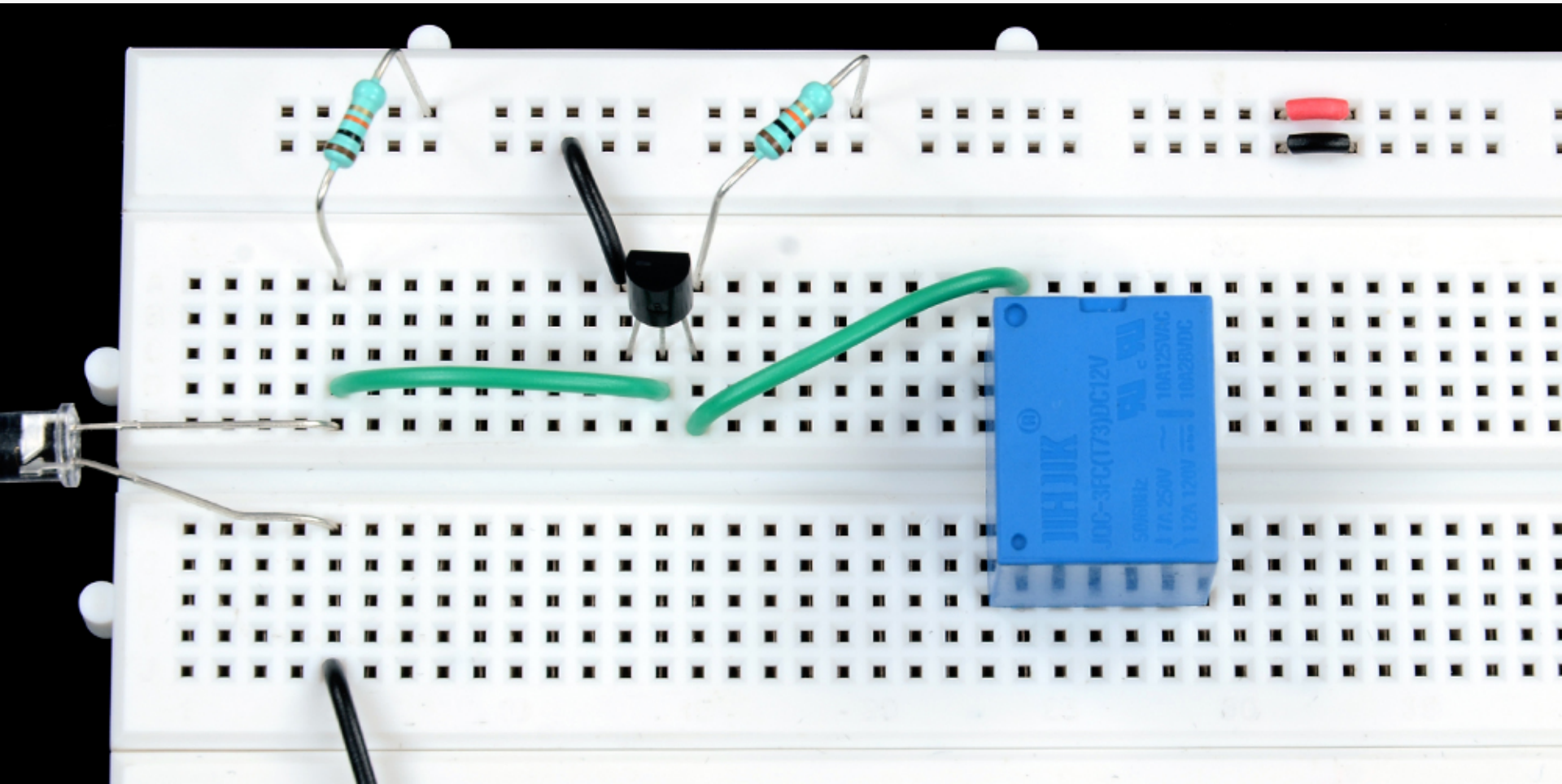
Step No. 18

Connect a relay on the breadboard across two halves of the breadboard such that all its terminals are in different columns; keep the supply terminals and COM terminal on the first halve and terminals, NO and NC, on the lower halve of the breadboard.



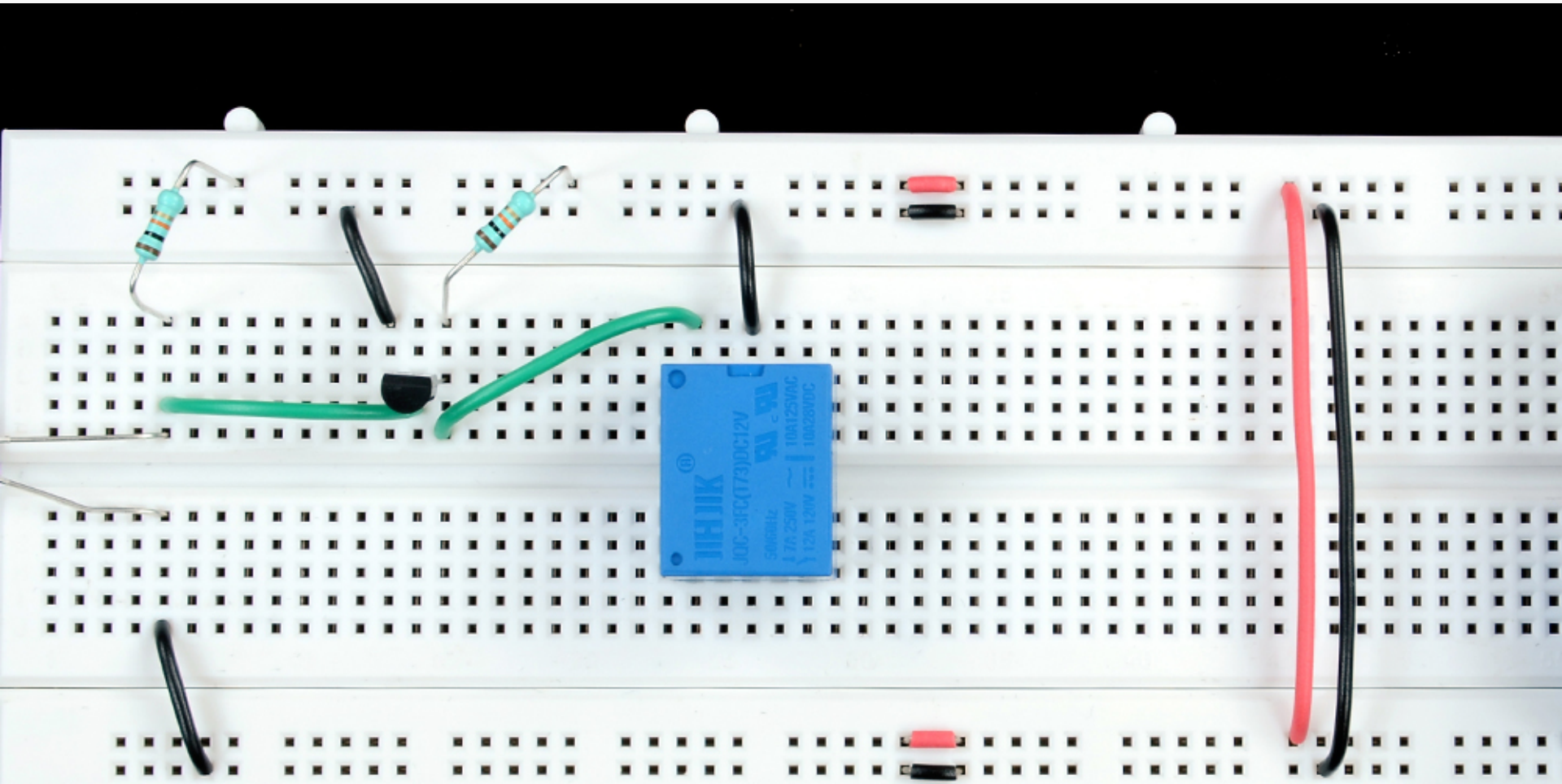
Step No. 19

Connect the supply terminal 1 (leftmost terminal) of the relay to the collector of the transistor.



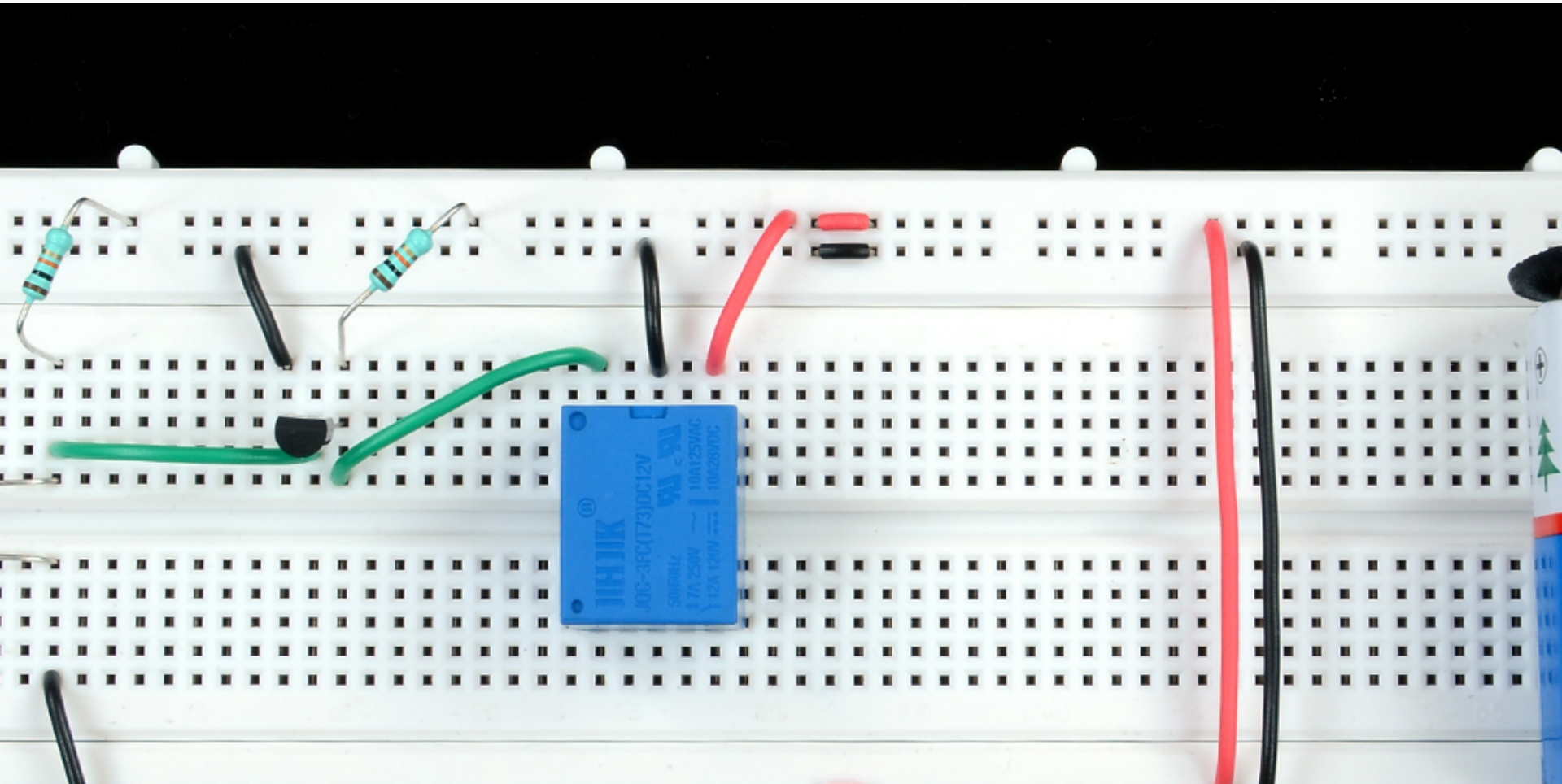
Step No. 20

Connect the COM (middle) terminal of the relay to ground.



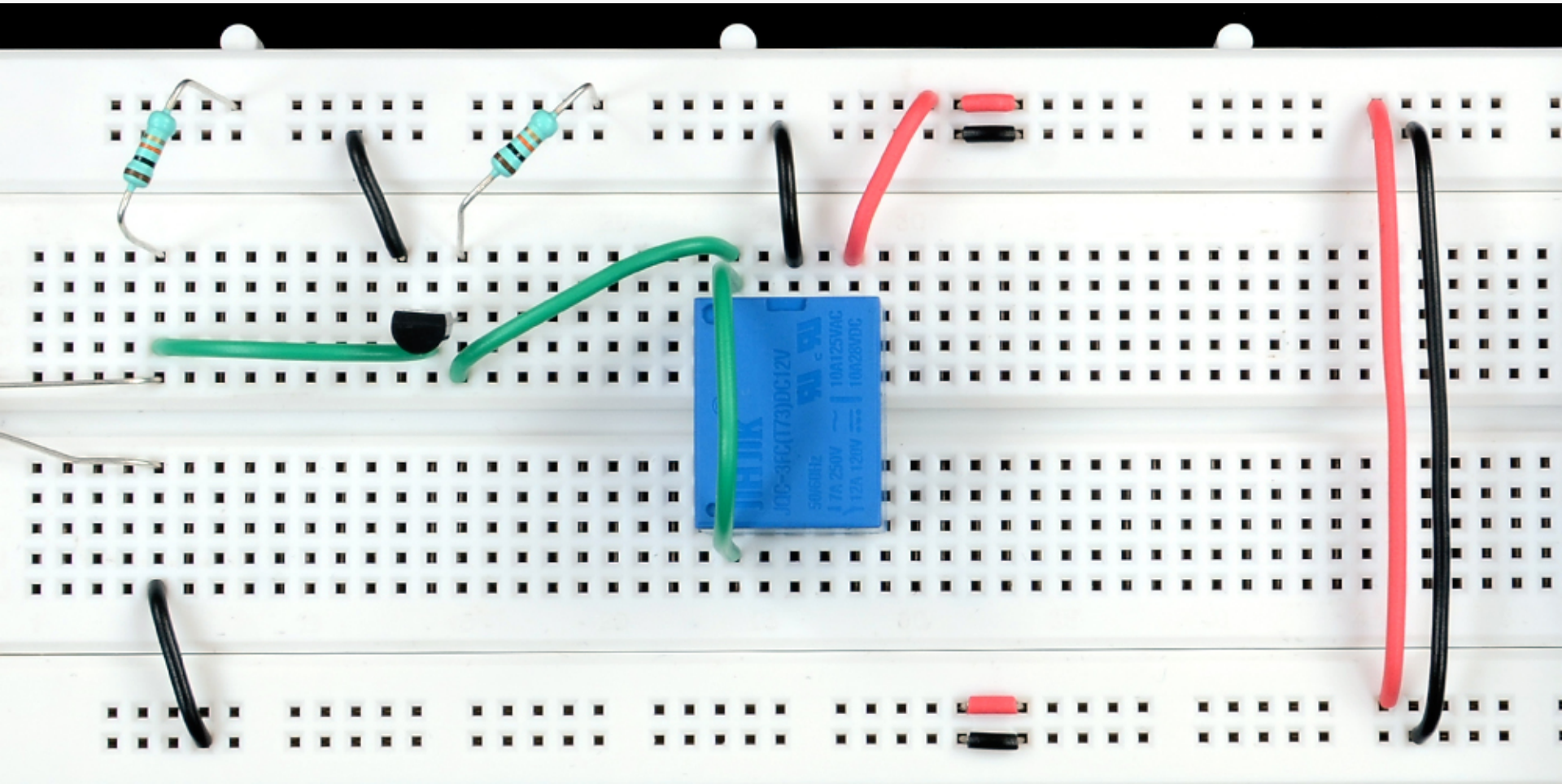
Step No. 21

Connect the supply terminal 2 (rightmost terminal) of the relay to Vcc.



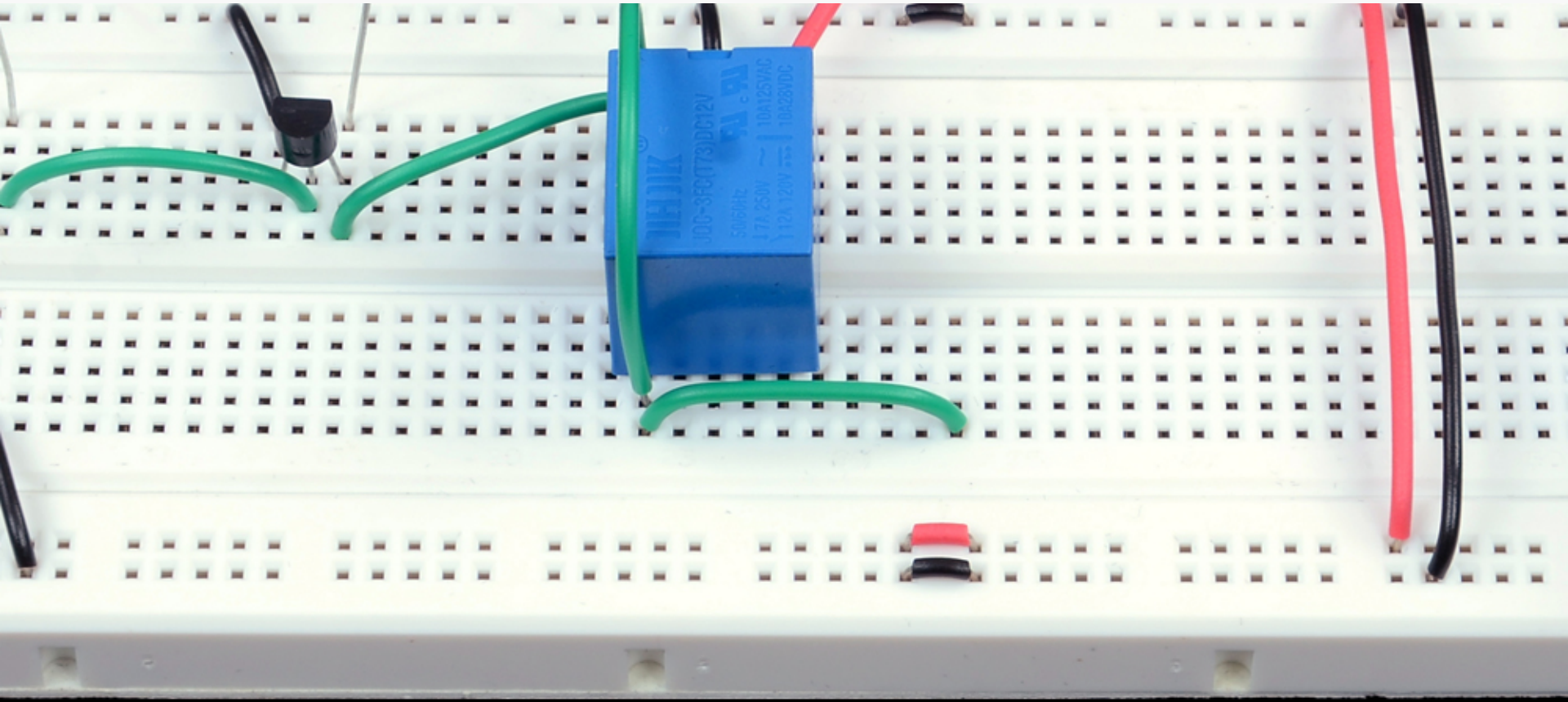
Step No. 22

Connect the supply terminal 1 (leftmost terminal) of the relay to its NO terminal.



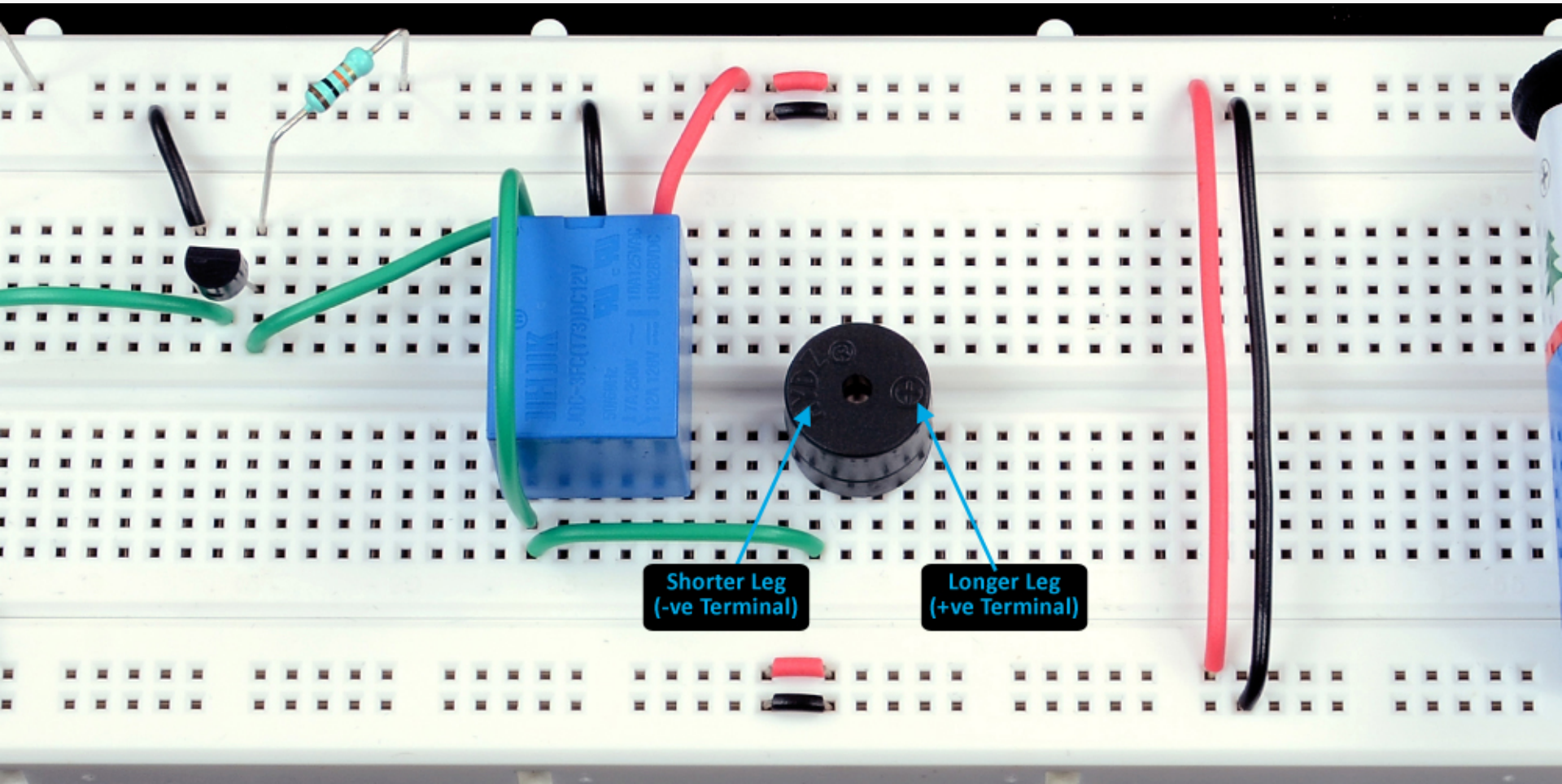
Step No. 23

Take a connecting wire. Connect its one end to the NO terminal of the relay, and other end to any different column of the breadboard.



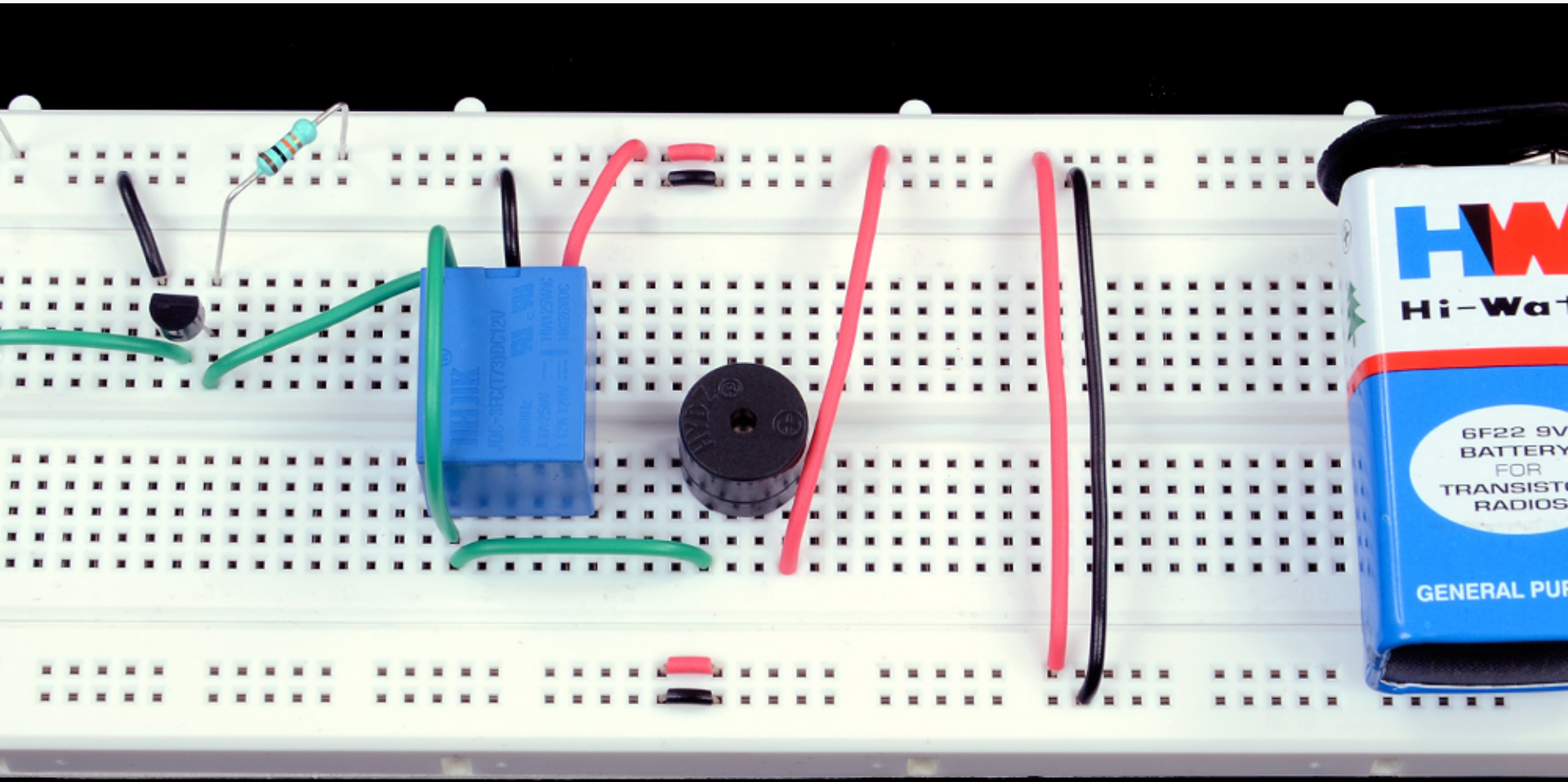
Step No. 24

Take a buzzer. Connect its negative terminal to the corresponding column where the other end of the wire was connected in the last step. Connect the positive terminal of the buzzer to any different column of the breadboard.



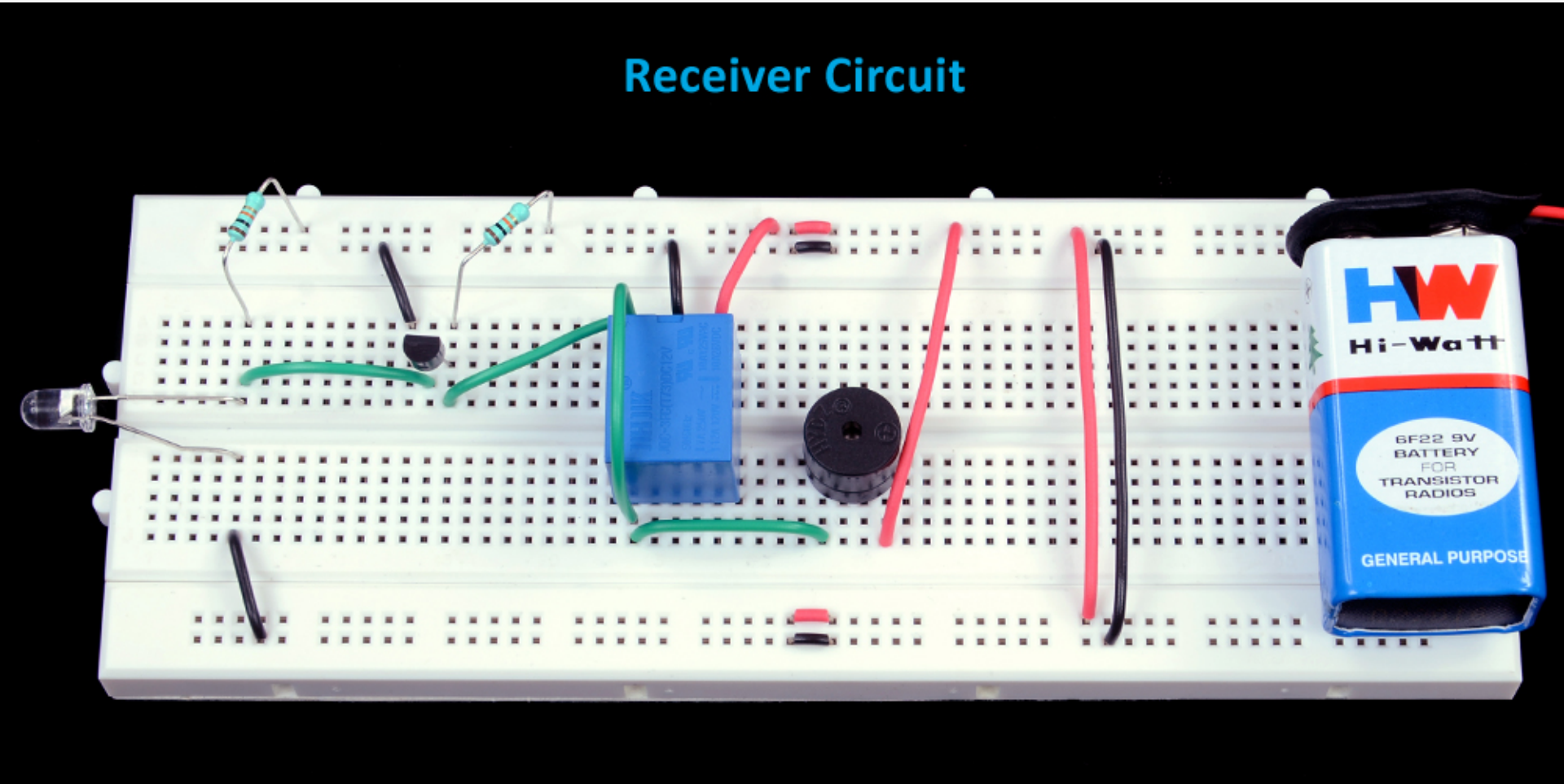
Step No. 25

Connect the positive terminal of the buzzer to Vcc.



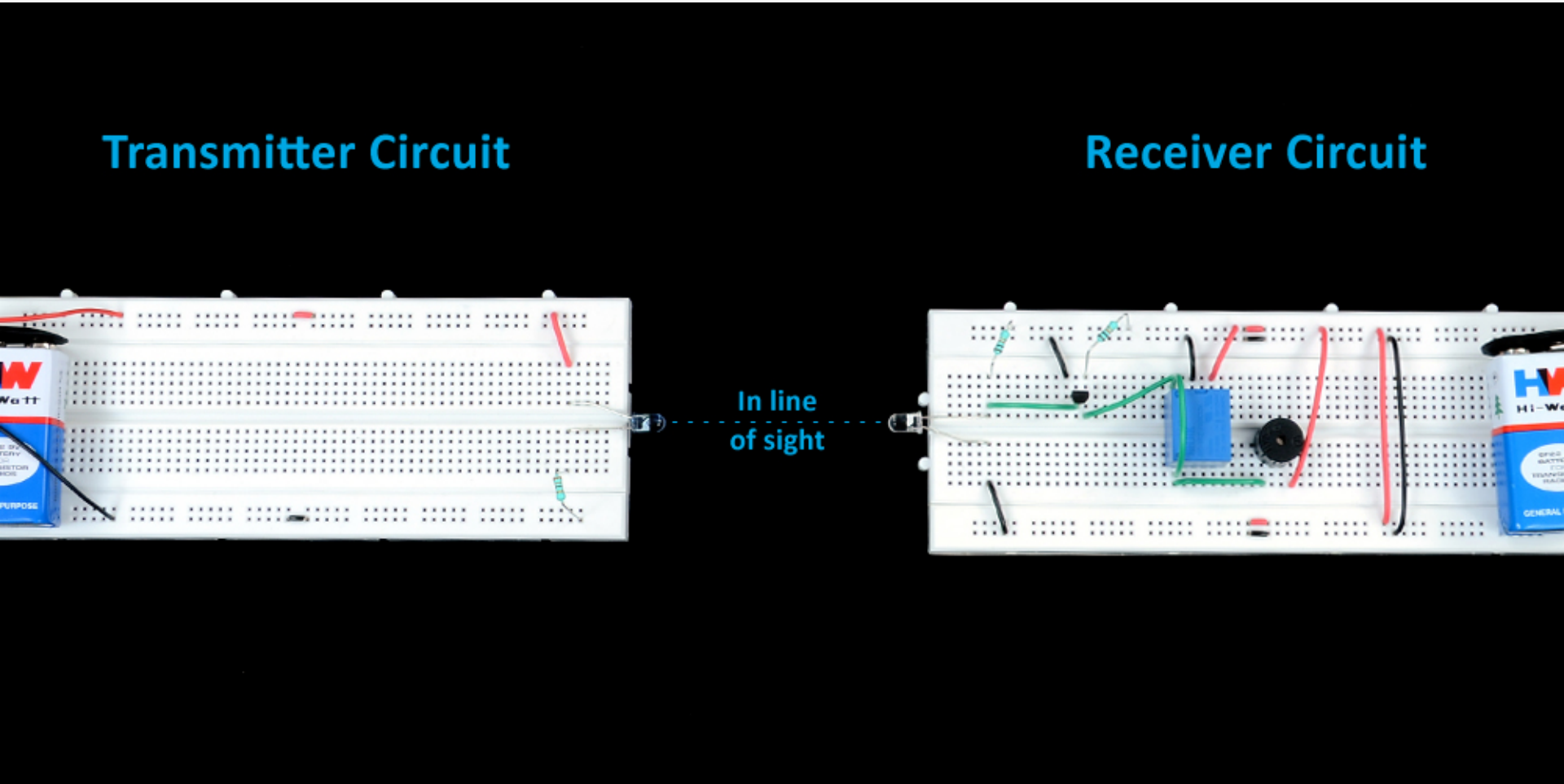
Review

Congratulations! We have built our Receiver Circuit.



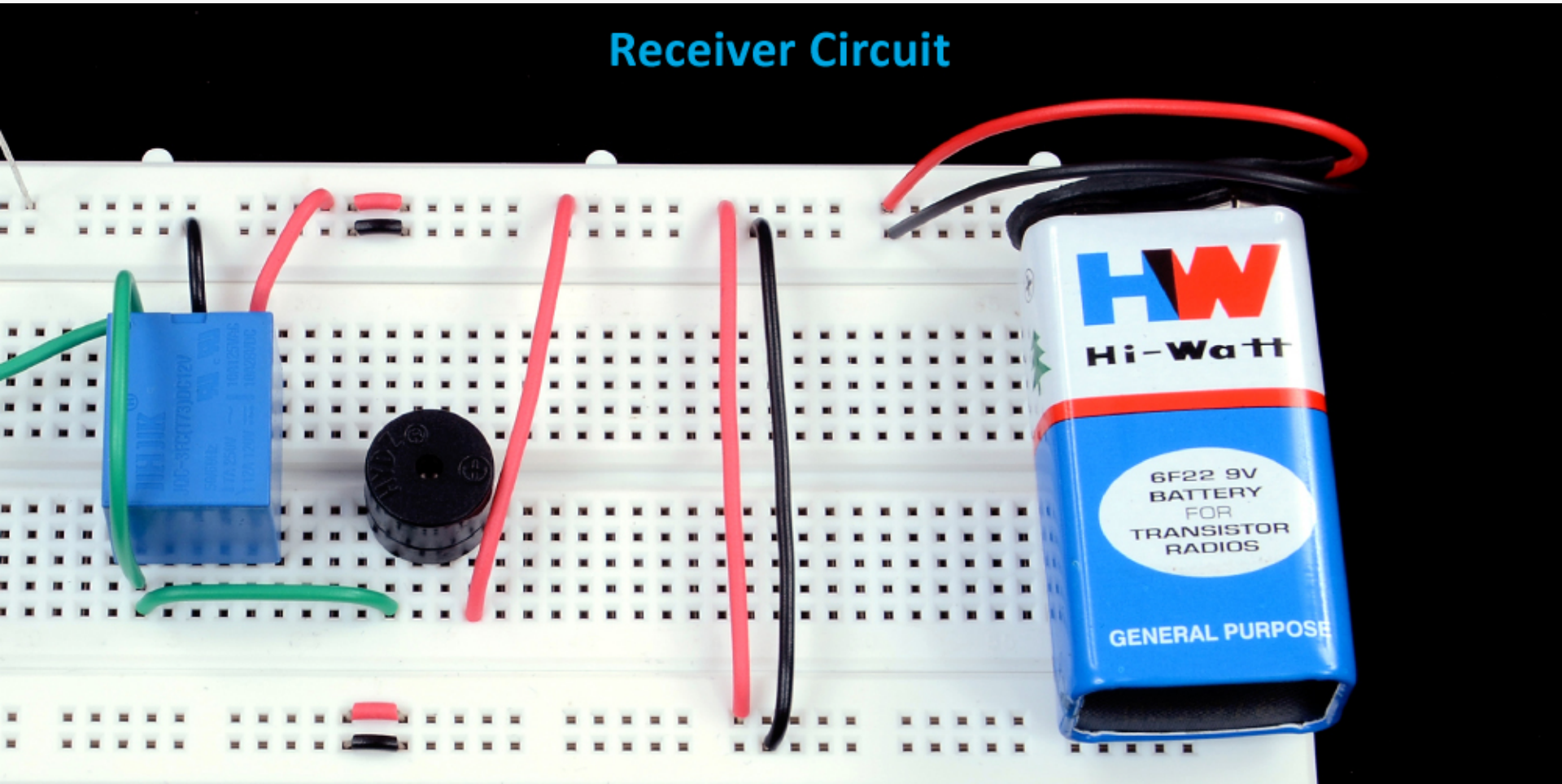
Step No. 26

Keep the transmitter and receiver circuit on a plane. Make sure that the IR LED and photodiode are in the **line of sight**. We recommend that you should first bring both the circuits closer to each other until the buzzer stops beeping, and then slowly pull them apart.



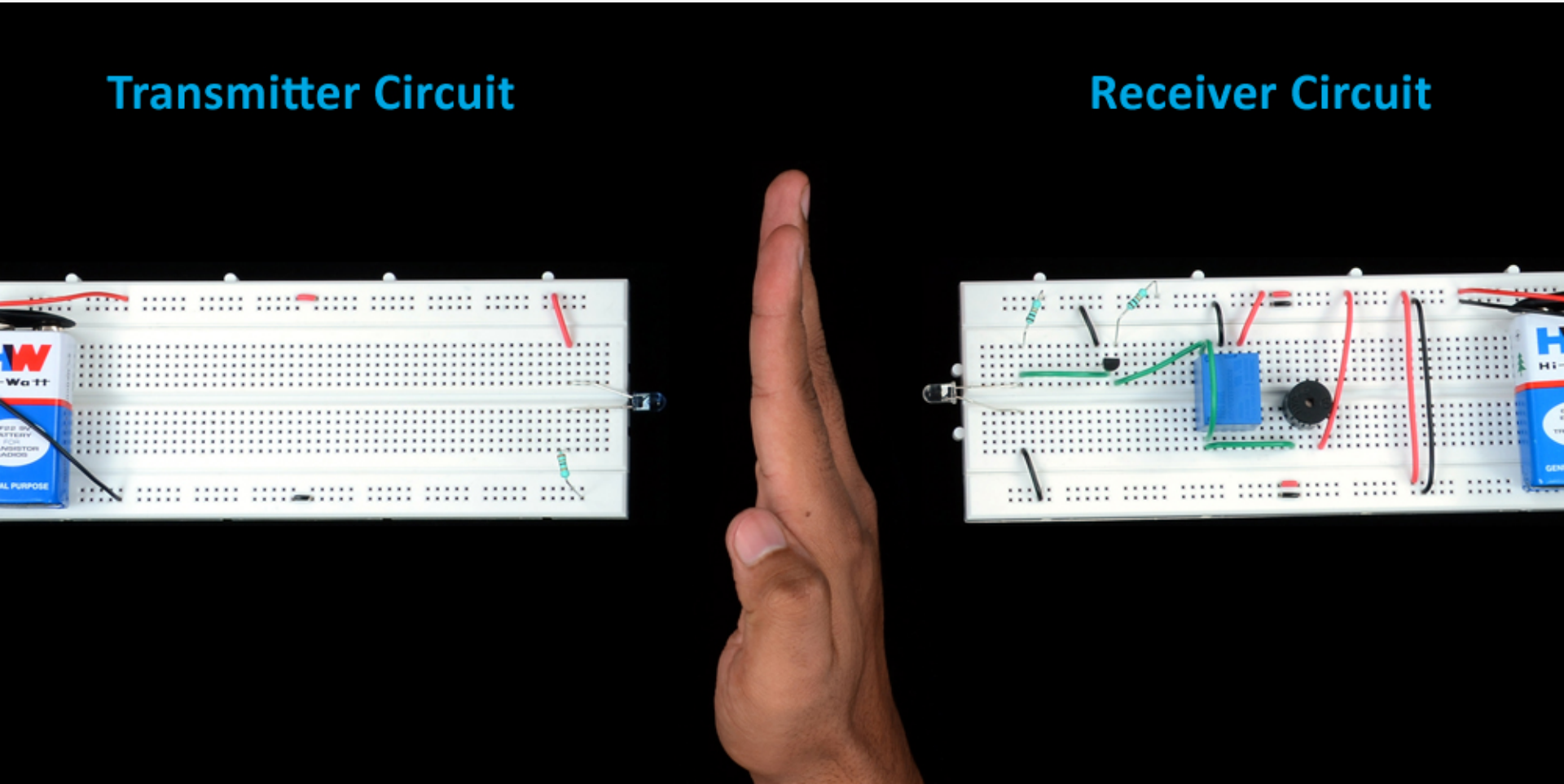
Step No. 27

Power the receiver circuit by connecting the battery supply to the breadboard. To do this, connect the red and black wires to the first and second row the breadboard, respectively.



Step No. 28

So, we are ready! Now we will put our hand between the two circuits. We will notice that the buzzer starts beeping. As the system detects an obstacle between the line of sight of the transmitter and the receiver, it starts generating a beep sound.

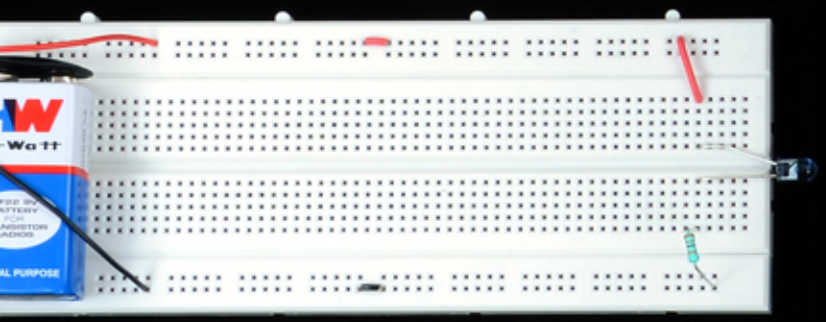


Activity

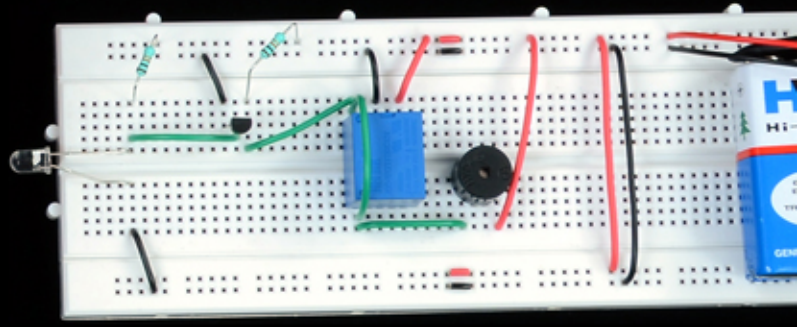
Take off the hand. Even after the obstacle is removed between the two circuits, the buzzer still continues to beep.

Note: To deactivate the system, remove the battery connections from the receiver circuit.

Transmitter Circuit



Receiver Circuit



Observation

- When an obstacle comes in between the transmitter and receiver circuits, the buzzer starts to beep.

- Even after the obstacle is removed, the buzzer continues to beep.

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Reasoning

To understand the working, we will separately understand the basics of the transmitter and receiver circuits.

Transmitter:

The transmitter circuit consists of a series combination of an IR (infrared) LED and a resistor R. Since the positive terminal of the IR LED is connected to a positive voltage source, it becomes forward biased and starts transmitting the Infrared light. We cannot see the IR light through our naked eyes. That is why, the IR LED does not seem to glow when it is forward biased. We can use a camera to see the IR light.

Simply take a camera and look through it!

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Reasoning

Receiver:

The receiver circuit consists of two parts: one is a Photodiode, and the other is the combination of a transistor and a relay.

Let us look at the receiver part. When a photodiode is reverse biased, its resistance changes when light falls upon it. The resistance of the photodiode decreases in the light, and increases in the dark.

To use a photodiode, we need to reverse-bias it. This means, we will connect its positive terminal to ground.

Contd. in next slide

Reasoning

From the circuit diagram, we can see that the photodiode is connected in series with a 10 kΩ resistor. The positive terminal of the photodiode is connected to ground (negative). Let us name the resistor 10 kΩ as R_2. The other end of the resistor is connected to a positive voltage source (Vcc).

The photodiode and the resistor R_2 forms a voltage divider circuit. The intersection point of the two is connected to the base *B* of the transistor. We will try to find out the voltage at the intersection point which is same as the input voltage to the base of the transistor.

Reasoning

Consider the following loop: Vcc---Resistor R_2--Photodiode---Ground.

Total resistance in the loop = Resistance offered by photodiode + Resistance offered by resistor

Let the resistance offered by the photodiode be R_D.

Total resistance in the loop = $R_D + R_2$

Total voltage across the loop = Vcc

Current in the loop, $i = Vcc/(R_D + R_2)$

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Reasoning

Now, we will find out the voltage at intersection point which is same as the voltage at the base terminal B of the transistor.

Voltage at base B = Vcc − Voltage drop across resistor R_2

$= Vcc - (i \times R_2)$

$= Vcc - (Vcc/(R_D + R_2) \times R_2)$

$= Vcc - (Vcc \times R_2)/ (R_D + R_2)$

$= Vcc \times R_D/(R_D + R_2)$

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Reasoning

$$\text{Voltage at base B} = \frac{Vcc \times R_D}{(R_D + R_2)}$$

So, we can see that voltage at base B is directly proportional to the value of R_D since the value of R_2 is fixed.

Voltage at base B $\propto$ R_D

If the value of **R_D** increases, the base-voltage increases, and if the value of **R_D** decreases, the base-voltage decreases. Thus, *the voltage at the base is directly proportional to the resistance offered by the photodiode.*

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Reasoning

When there is no obstacle between the transmitter and the receiver circuit:

Assume that both the circuits are powered. The IR light emitted by the transmitter continuously falls upon the surface of the photodiode. When the photodiode is in light, its resistance decreases due to which the base voltage decreases. So, if the base voltage decreases, it becomes so low that the base-emitter junction is not forward biased and the transistor is OFF.

When the transistor is OFF, the voltage at the collector with respect to the emitter is high, and is equivalent to Vcc.

Reasoning

The collector terminal of the transistor is connected to the supply terminal 1 of the relay. The supply terminal 2 of the relay is also connected to Vcc. So, there is no potential difference between the supply terminals of the relay which represent the two ends of the coil. Due to this, no current flows into the coil of the relay and hence, it remains deactivated.

When the relay is not activated, its COM terminal is connected to connected to its NC terminal. Nothing is connected on the NC terminal of the relay. No closed circuit is formed and thus, the buzzer does not beep.

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Reasoning

The negative terminal of the buzzer is connected to the supply terminal 1 of the relay which receives Vcc from the collector of the transistor. The positive terminal of the buzzer is connected to Vcc. Since there is no potential difference across the two terminals of the buzzer, it does not beep.

This is the system in its usual state.

Reasoning

When there is an obstacle between the transmitter and the receiver circuit:

The obstacle intersects the path of the IR light due to which no light would fall upon the surface of the photodiode and hence, its resistance increases. The resistance of the photodiode is directly proportional to the input voltage to the base of the transistor. Since the resistance increases, the base voltage also increases and a point comes when the base-emitter junction gets forward biased. As a result, the transistor turns ON and an output current flow from its collector to its emitter.

Reasoning

When the transistor is ON, its collector and emitter terminals get nearly shorted and hence, the potential of the collector is approximately equal to the potential of the emitter. Since the emitter is grounded and at 0 V, the collector voltage also becomes close to 0 V (zero volt).

The collector of the transistor is connected to the supply terminal 1 of the relay due to which the supply terminal 1 also receives zero volt. The supply terminal 2 of the relay is connected to Vcc. Since there is a potential difference across the two supply terminals of the relay, a current flows into the relay and it gets activated.

Reasoning

When the relay gets activated, its COM terminal gets connected to it NO terminal.

A closed circuit is formed on the NO side. Consider the following current loop: Vcc---Positive terminal of buzzer---COM terminal of relay---ground.

Since the current gets a closed path and move through the buzzer, it beeps.

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Reasoning

When the relay is activated, its terminals COM and NO get interconnected. Since terminal COM is connected to ground, terminal NO also gets grounded.

Now, terminal NO of the relay is connected to supply terminal 1 of the relay. This means supply terminal 1 of the relay eventually gets connected to ground.

We can also say that we have given a feedback from the output side (where the negative terminal of the buzzer is connected) to the input side (where supply terminal 1 of the relay is connected).

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Reasoning

We know that for the buzzer to beep, its negative terminal must be connected to ground or zero volt. The negative terminal would receive zero volt through the COM terminal (which is grounded), if the relay is activated. The relay would get activated only, if its supply terminal 1 gets grounded.

Reasoning

First we actuate the relay by providing ground (or zero volt) to the supply terminal 1 through the collector of the transistor. Then due to relay activation, terminals COM and NO get connected, and the buzzer starts beeping.

Lastly, we divert the zero voltage from the NO terminal to the supply terminal 1 (which is a necessary condition for the relay activation and buzzer beeping) so that the relay remains activated for continuous beeping.

In brief, we give a feedback from the output to the input so that we get a desired output.

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For:

- Activity
- Modification
- Reasoning
- Inference

Refer the PDF Manual of IR Security Alarm.

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Troubleshooting Tips

- Ensure that the battery voltage in the transmitter circuit is more than 6 V.
- Ensure that the battery voltage in the receiver circuit is more than 9 V.
- Ensure that the LED used in the transmitter circuit is an IR LED.
- Ensure that the LED used in the receiver circuit is a photodiode LED.
- Ensure that the relay is inserted properly into the breadboard with none of its pins twisted or popped out.
- 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.

Troubleshooting Tips

- 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.
- Ensure that the stripped ends of the connecting wire should be long enough to fit inside the holes of the breadboard completely.
- Ensure that there are no loose connections.

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Troubleshooting Tips

- Ensure that the positive terminal of the IR LED is connected to Vcc.
- Ensure that the p-side (positive terminal) of the photodiode is connected to ground.

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