SUBJECT: BASIC ELECTRONICS

Thevenin's theorem

Elementrix Classes

Thevenin's Theorem

Any linear electric network or a complex circuit with current and voltage sources can be replaced by an equivalent circuit containing a single independent voltage source V_{TH} and a Series Resistance R_{TH}.

- **V_{TH} = Thevenin's Voltage**
- **R_{TH} = Thevenin's Resistance**

This theorem is useful to quickly and easily solve complex linear circuits and networks, especially electric circuits and electronic networks.

Steps to Analyze an Electric Circuit using Thevenin's Theorem:

1. Open the load resistor.

1. Calculate / measure the open circuit voltage. This is the Thevenin Voltage (V_{TH}).

1. Open current sources and short voltage sources.

1. Calculate /measure the Open Circuit Resistance. This is the Thevenin Resistance (R_{TH}).

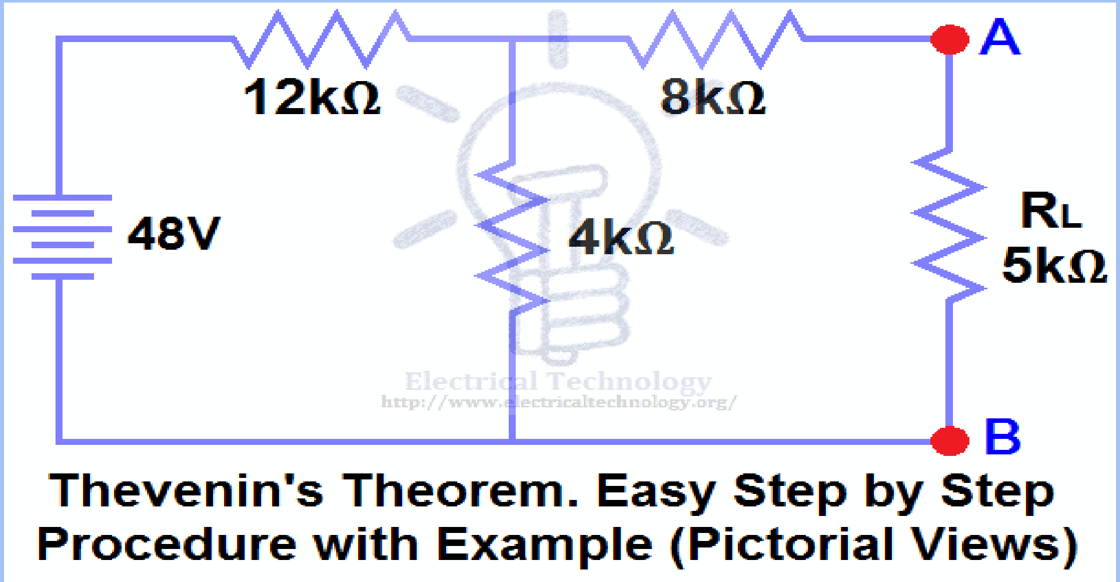
5. Now, redraw the circuit with measured open circuit Voltage (V_{TH}) in Step (2) as voltage source and measured open circuit resistance (R_{TH}) in step (4) as a series resistance and connect the load resistor which we had removed in Step (1). This is the equivalent Thevenin circuit of that linear electric network or complex circuit which had to be simplified and analyzed by Thevenin's Theorem. You have done it.

6. Now find the Total current flowing through the load resistor by using the Ohm's Law: .

$$I_T = \frac{V_{TH}}{(R_{TH} + R_L)}$$

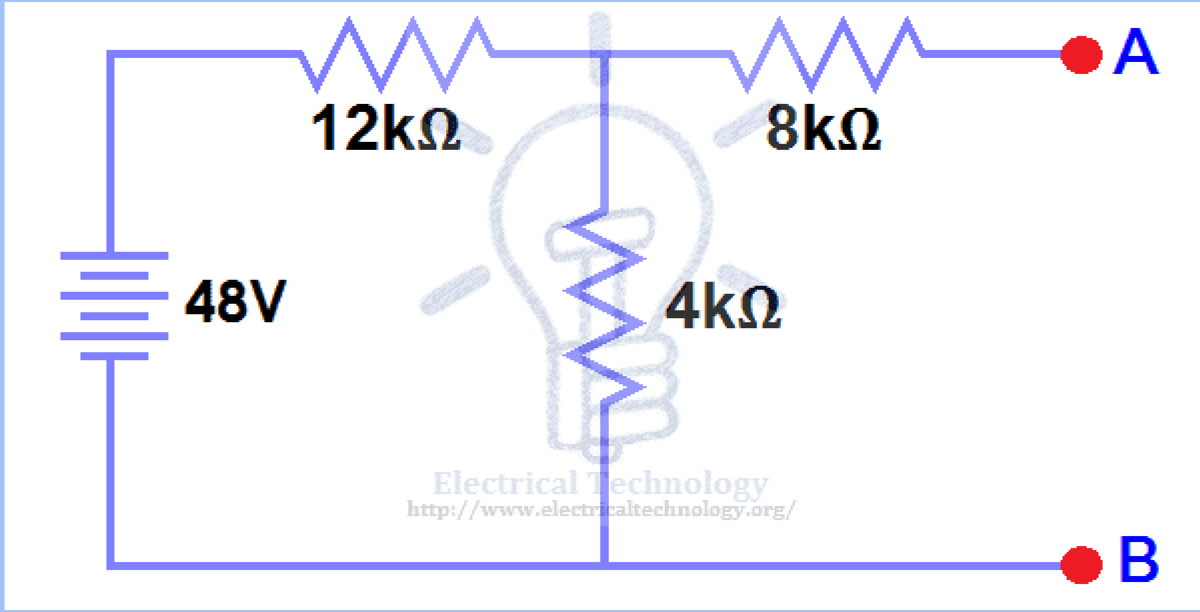
Example:

Find V_{TH}, R_{TH} and the load current I_L flowing through and load voltage across the load resistor in fig (1) by using Thevenin's Theorem.



STEP 1.

Open the 5kΩ load resistor (Fig 2).



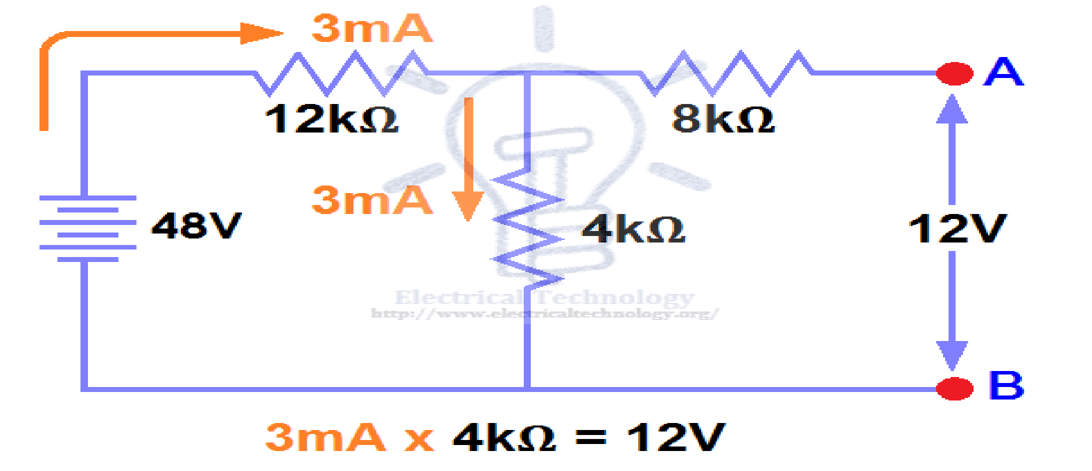
STEP 2.

Calculate / measure the open circuit voltage. This is the Thevenin Voltage (V_{TH}). Fig (3).

We have already removed the load resistor in figure 1, so the circuit became an open circuit as shown in fig 2. Now we have to calculate the Thevenin's Voltage. Since 3mA current flows in both 12kΩ and 4kΩ resistors as this is a series circuit and current will not flow in the 8kΩ resistor as it is open.

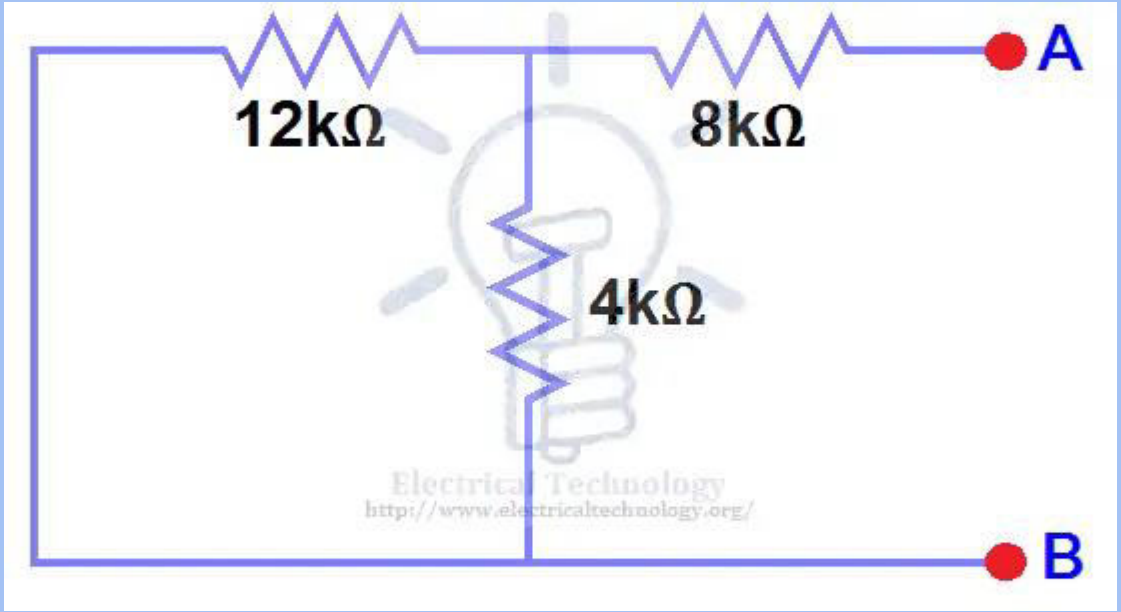
This way, 12V (3mA x 4kΩ) will appear across the 4kΩ resistor. We also know that current is not flowing through the 8kΩ resistor as it is an open circuit, but the 8kΩ resistor is in parallel with 4k resistor. So the same voltage i.e. 12V will appear across the 8kΩ resistor as well as 4kΩ resistor. Therefore 12V will appear across the AB terminals. i.e,

$$V_{TH} = 12V$$



STEP 3.

Open current sources and short voltage sources as shown below. Fig (4)



STEP 4.

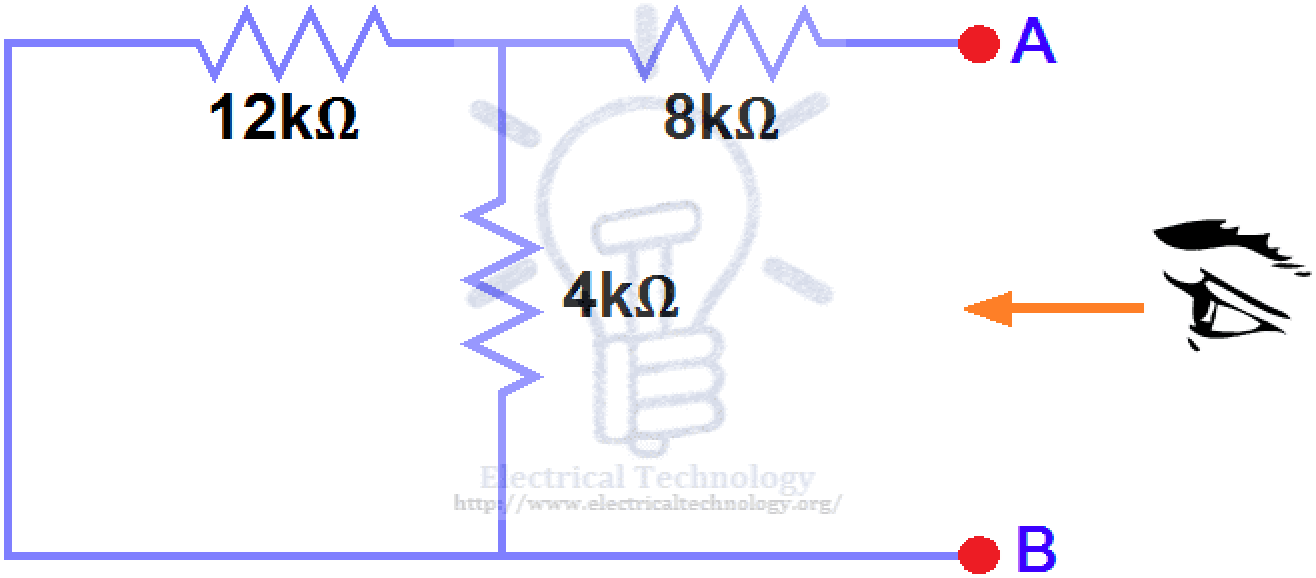
Calculate / measure the open circuit resistance. This is the Thevenin Resistance (R_{TH})

We have removed the 48V DC source to zero as equivalent i.e. 48V DC source has been replaced with a short in step 3 (as shown in figure 3). We can see that 8kΩ resistor is in series with a parallel connection of 4kΩ resistor and 12k Ω resistor. i.e.:

8kΩ + (4k Ω || 12kΩ) ….. (|| = in parallel with)

$$R_{TH} = 8k\Omega + \left[\frac{4k\Omega \times 12k\Omega)}{4k\Omega + 12k\Omega)} \right]$$

R_{TH} = 8kΩ + 3kΩ= 11kΩ

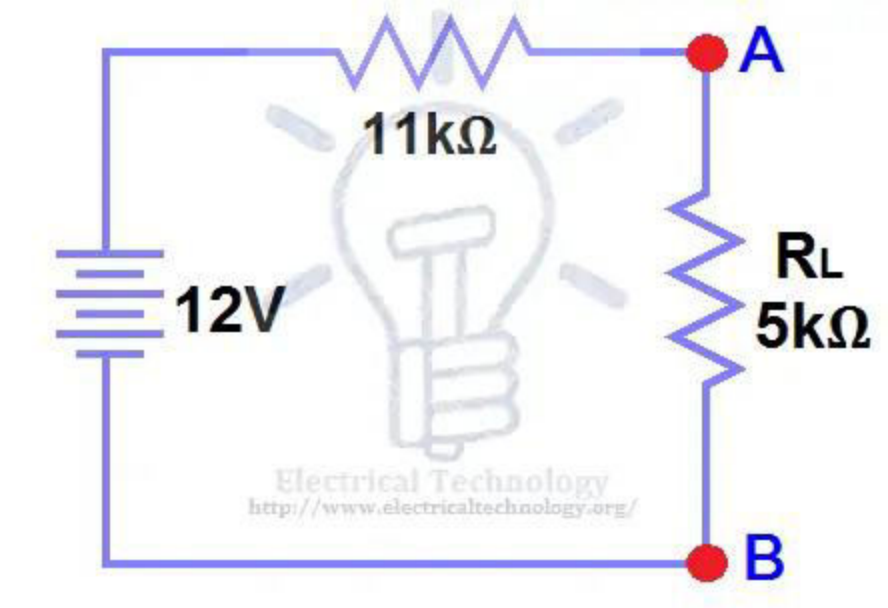


$= 8k\Omega + (4k\,\Omega \,||\, 12k\Omega) \rightarrow = 8k\Omega + 3k\Omega$

$R_{TH} = 11k\Omega$

STEP 5.

Connect the R_{TH} in series with Voltage Source V_{TH} and re-connect the load resistor. This is shown in fig (6) i.e. Thevenin circuit with load resistor. This the Thevenin's equivalent circuit.



STEP 6.

Now apply the last step i.e Ohm's law . Calculate the total load current and load voltage as shown in fig 6.

$$I_L = \frac{V_{TH}}{(R_{TH} + R_L)}$$

$$I_L = \frac{12V}{(11k\Omega + 5k\Omega)} \rightarrow= \frac{12V}{16k\Omega}$$

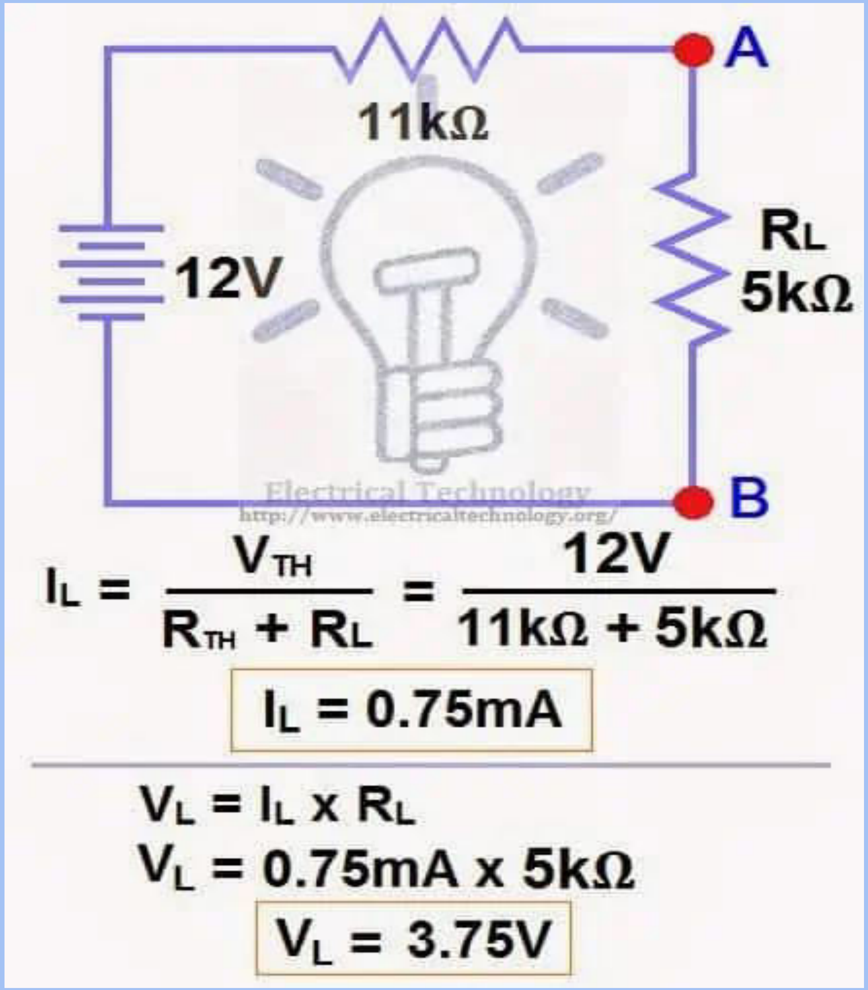
$$I_L = 0.75mA$$

And

$V_L = I_L \times R_L$

$V_L = 0.75mA \times 5k\Omega$

$V_L = 3.75V$



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