UNIT 1: DC CIRCUITS

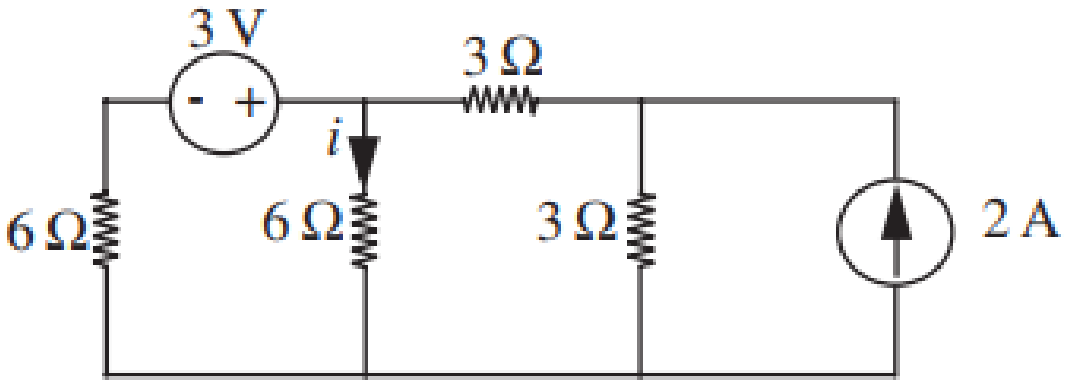
Lecture 7

Prepared By: Pawandeep Kaur
Assistance Professor and Head

Recap Quiz (POLL 1)

Total number of nodes and meshes in the given circuit are:

A. n= 3, m=6
B. n= 4, m=6
C. n= 3, m=3
D. n= 4, m=3



Superposition Theorem

- If a circuit has two or more independent sources, one way to determine the value of a specific variable (voltage or current) is to use nodal or mesh analysis.
- Another way is to determine the contribution of each independent source to the variable and then add them up. The latter approach is known as the *superposition.*
- The idea of superposition rests on the linearity property.

Linearity Property

- Linearity is the property of an element describing a linear relationship between cause and effect.
- The property is a combination of both the homogeneity (scaling) property and the additivity property.

❖**Homogenity:** The homogeneity property requires that if the input (also called the *excitation*) is multiplied by a constant, then the output (also called the *response*) is multiplied by the same constant.

❖**Additivity:** The additivity property requires that the response to a sum of inputs is the sum of the responses to each input applied separately.

Quiz (POLL 3)

Superposition theorem does not work for:

A. Current
B. Voltage
C. Power
D. All of these

Statement

“The superposition principle states that the voltage across (or current through) an element in a linear circuit is the algebraic sum of the voltages across (or currents through) that element due to each independent source acting alone”.

Procedure to Apply Superposition Principle/Theorem

1. **Turn off** all independent sources except one source.

2. Find the output (voltage or current) due to that active source using any techniques such as Ohm's Law, KCL, KVL, Nodal/Mesh Analysis etc.

3. Repeat step 1 for each of the other independent sources.

4. Find the total contribution by adding algebraically all the contributions due to **the independent sources.**

Recap Quiz (POLL 1)

Superposition theorem is valid for:

A. Linear System
B. Non Linear System
C. Both types of system
D. None of them

Procedure to Apply Superposition Principle/Theorem

IMPORTANT POINTS:

1. We consider one independent source at a time while all other independent sources are *turned off*. This implies that:

- ❑ Replace every voltage source by 0 V (or a short circuit), and
- ❑ Replace every current source by 0 A (or an open circuit).

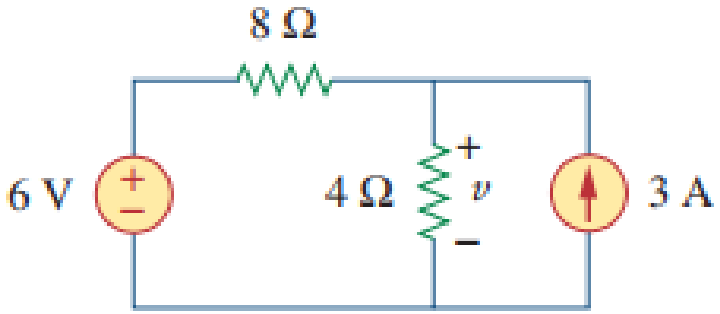
2. Dependent sources are left intact because they are controlled by circuit variables.

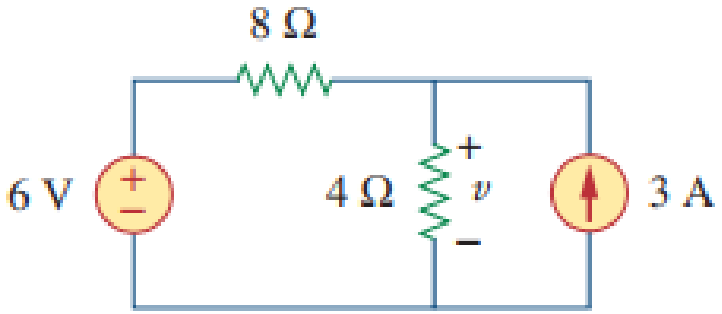
Quiz (POLL 2)

Superposition Theorem is applicable to:

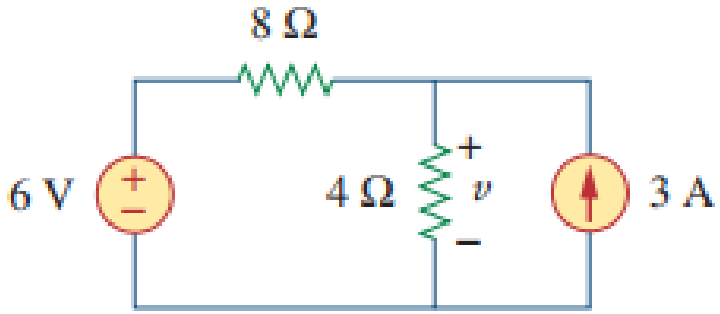
A. All types of energy sources
B. Only independent voltage sources
C. Only dependent energy sources
D. Only independent energy sources

Find v using superposition

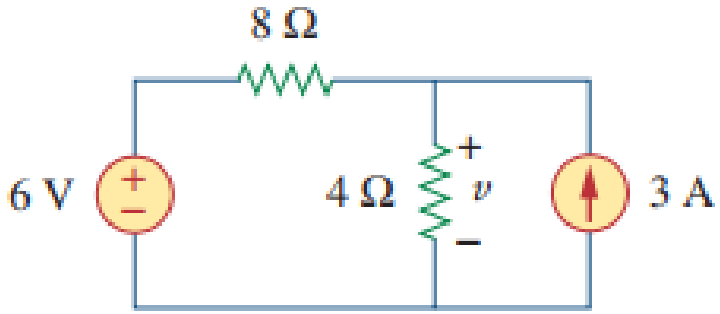




Solve previous Question using Nodal Analysis



Solve previous Question using Nodal Analysis



Recap Quiz (POLL 3)

For an independent voltage source, replacement with internal resistance means:

A. Open circuit
B. Short Circuit
C. Finite resistor value
D. Can’t say

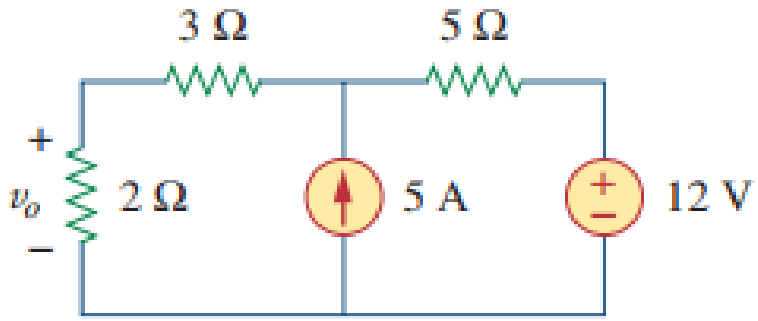
Recap Quiz (POLL 4)

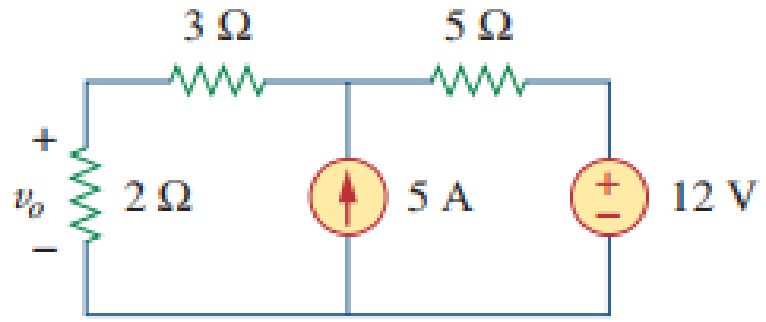
For dependent voltage/current source, we need to:

A. Replace them with internal resistances
B. Short circuit such sources
C. Open circuit such sources
D. Let them stay intact

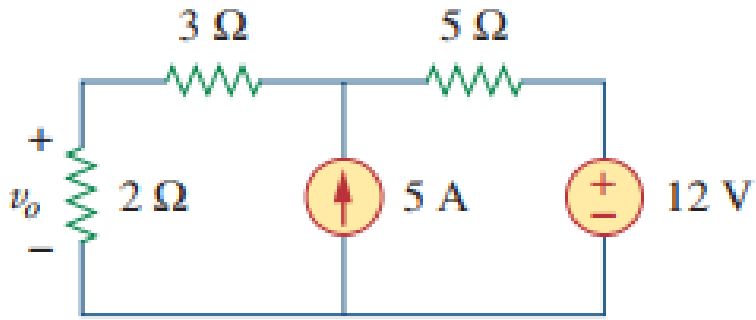
Practice Problem

Using Superposition Theorem, find v_0?




3 Ω
5 Ω
+
v_o
−
2 Ω
5 A
+
−
12 V

Solve previous Question using Nodal Analysis



Recap Quiz (POLL 1)

In superposition theorem, when we consider the effect of one current source, all the other voltage sources are:

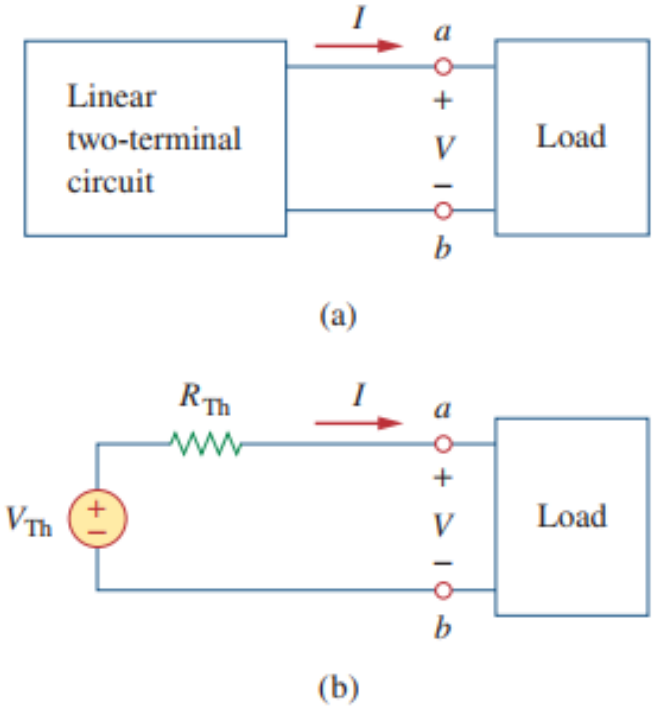
A. shorted
B. opened
C. removed
D. undisturbed

Thevenin's Theorem

- It often occurs in practice that a particular element in a circuit is variable (usually called the load) while other elements are fixed.
- As a typical example, a household outlet terminal may be connected to different appliances constituting a variable load. Each time the variable element is changed, the entire circuit has to be analyzed all over again.
- To avoid this problem, Thevenin's theorem provides a technique by which the fixed part of the circuit is replaced by an equivalent circuit.

Background and Significance

- According to Thevenin's theorem, the linear circuit in Fig. (a) can be replaced by that in Fig. (b).
- The circuit to the left of the terminals in Fig. (b) is known as the Thevenin equivalent circuit.
- It was developed in 1883 by M. Leon Thevenin (1857–1926), a French telegraph engineer.



Statement of Thevenin's Theorem

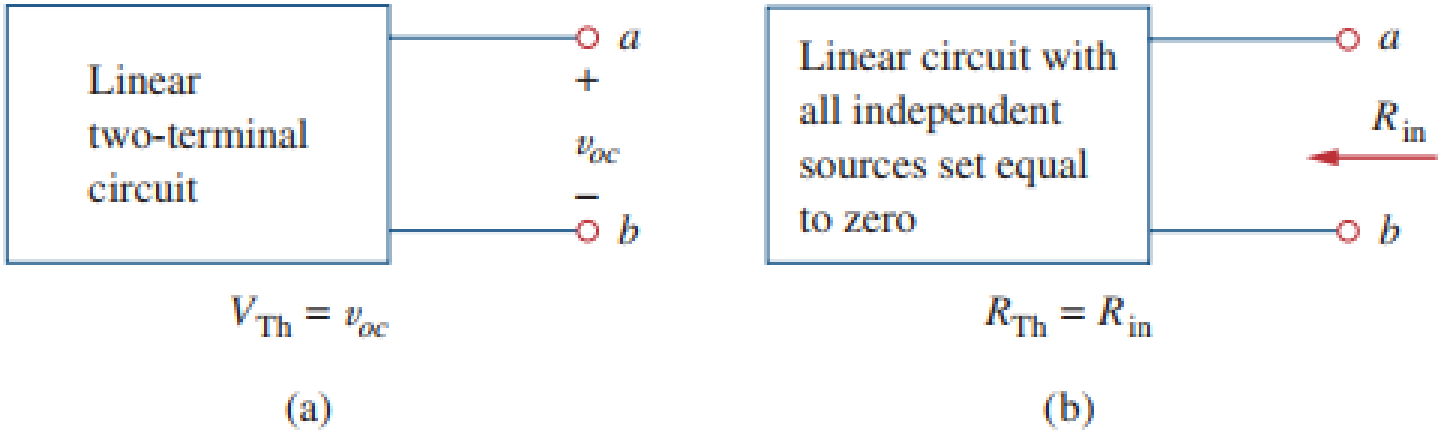
Thevenin's theorem states that:

a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source V_{Th} in series with a resistor R_{Th}, where V_{Th} is the open-circuit voltage at the terminals and R_{Th} is the input or equivalent resistance at the terminals when the independent sources are turned off.

A Method for Determining the Thévenin Equivalent Circuit The Thévenin equivalent circuit for any linear network at a given pair of terminals consists of a voltage source v_{TH} in series with a resistor R_{TH}. The voltage v_{TH} and resistance R_{TH} can be obtained as follows:

1. v_{TH} can be found by calculating or measuring the open-circuit voltage at the designated terminal pair on the original network.

2. R_{TH} can be found by calculating or measuring the resistance of the open-circuit network seen from the designated terminal pair with all independent sources internal to the network set to zero. That is, with independent voltage sources replaced with short circuits, and independent current sources replaced with open circuits. (Dependent sources must be left intact, however.)



Example 1

STEPS:

1. VTH:

- Open the LOAD
- Find Voltage across LOAD

2. RTH:

- Open the LOAD
- Indep Sources----- Int. Resistance

(VS---Short circuit and CS---open circuit

- Dep. sources ------- Left intact
- Find Req. across LOAD terminal

Example 1

STEPS:

1. VTH:

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2. RTH:

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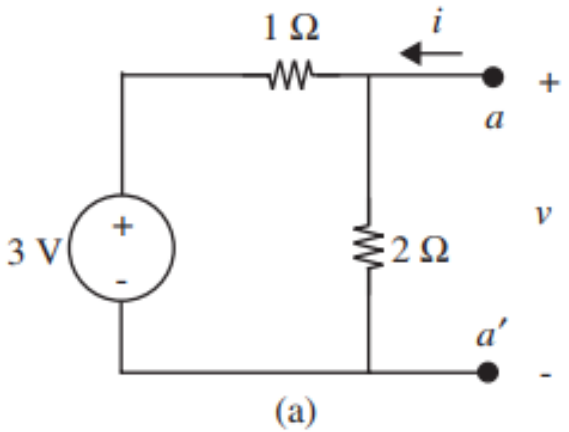
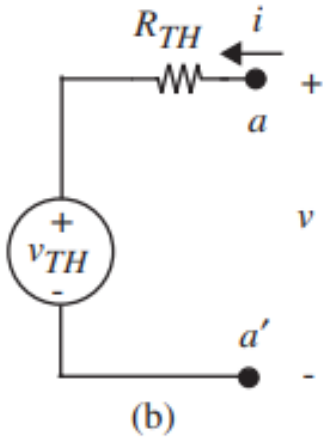
Example 2



(a)



(b)

STEPS:

1. VTH:
- Open the LOAD
- Find Voltage across LOAD

2. RTH:
- Open the LOAD
- Indep Sources----- Int. Resistance

(VS---Short circuit and CS---open circuit
- Dep. sources ------- Left intact
- Find Req. across LOAD terminal

Quiz (POLL 4)

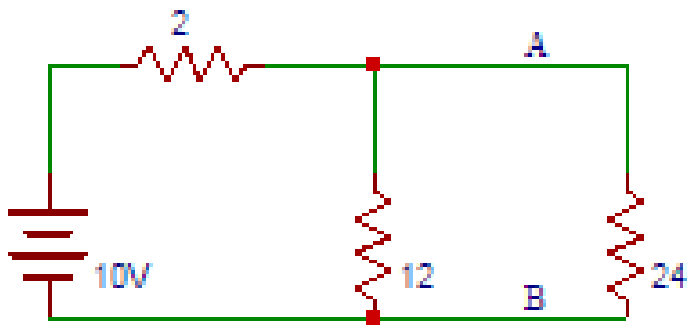
Find Thevenin voltage in the following circuit:

A. 8 V

B. 8.5 V

C. 9 V

D. 9. 5 V



Quiz (POLL 5)

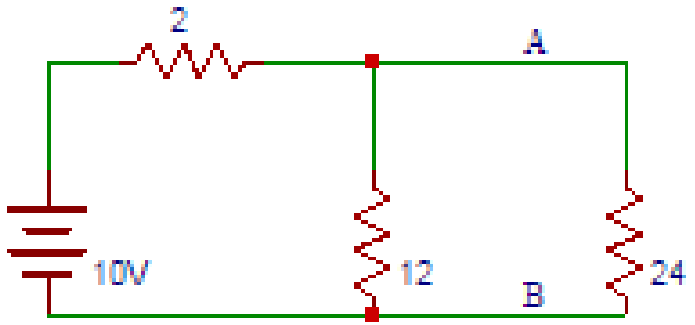
In the circuit shown in above question, Thevenin's resistance between terminals A and B is:

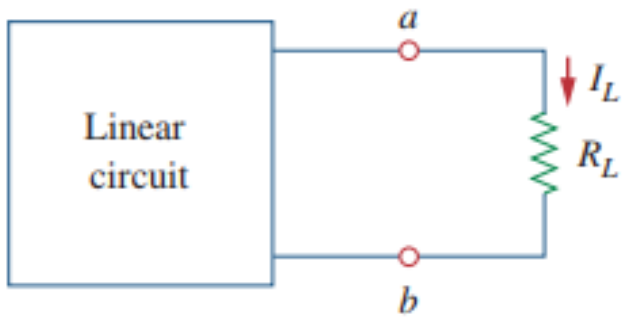
A. 1

B. 2

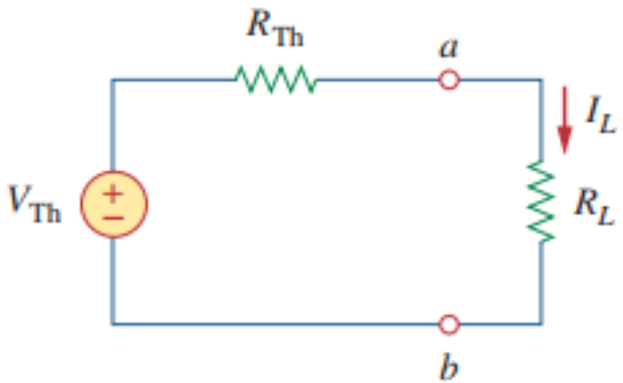
C. 2.7

D. 1.7





(a)



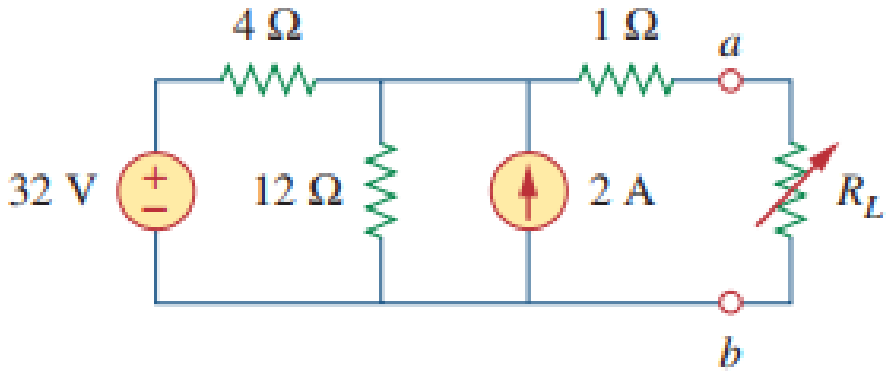
(b)

$$I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

$$V_L = R_L I_L = \frac{R_L}{R_{Th} + R_L} V_{Th}$$

Practice Numerical

Find the Thevenin equivalent circuit of the circuit shown in Figure, to the left of the terminals. Then find the current through $R_L = 6,16\ and\ 36\ \Omega$.



STEPS:

1. VTH:

Open the LOAD

Find Voltage across LOAD

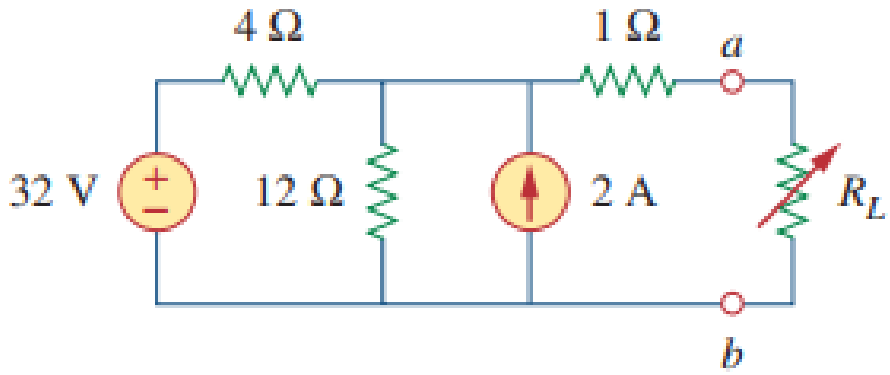
2. RTH:

Open the LOAD

Indep Sources----- Int. Resistance

Dep. sources ------- Left intact

Find Req. across LOAD terminal



STEPS:

1. VTH:

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Find Voltage across LOAD

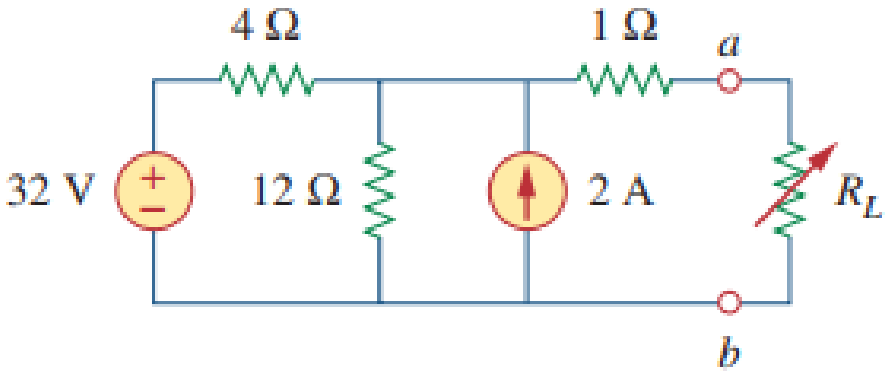
2. RTH:

Open the LOAD

Indep Sources----- Int. Resistance

Dep. sources ------- Left intact

Find Req. across LOAD terminal



STEPS:

1. VTH:

Open the LOAD

Find Voltage across LOAD

2. RTH:

Open the LOAD

Indep Sources----- Int. Resistance

Dep. sources ------- Left intact

Find Req. across LOAD terminal

Quiz (POLL 6)

Thevenin's resistance R_{th} is found by:

A. By removing voltage sources along with their internal resistances
B. By short-circuiting the given two terminals
C. Between any two open terminals
D. Between same open terminals as for V_{th}

Quiz (POLL 7)

Thevenin voltage between two terminals, is equal to:

A. Short-circuit terminal voltage
B. Open-circuit terminal voltage
C. Net voltage available in the circuit
D. E.M.F. of the battery nearest to the terminals