UNIT 1: DC CIRCUITS

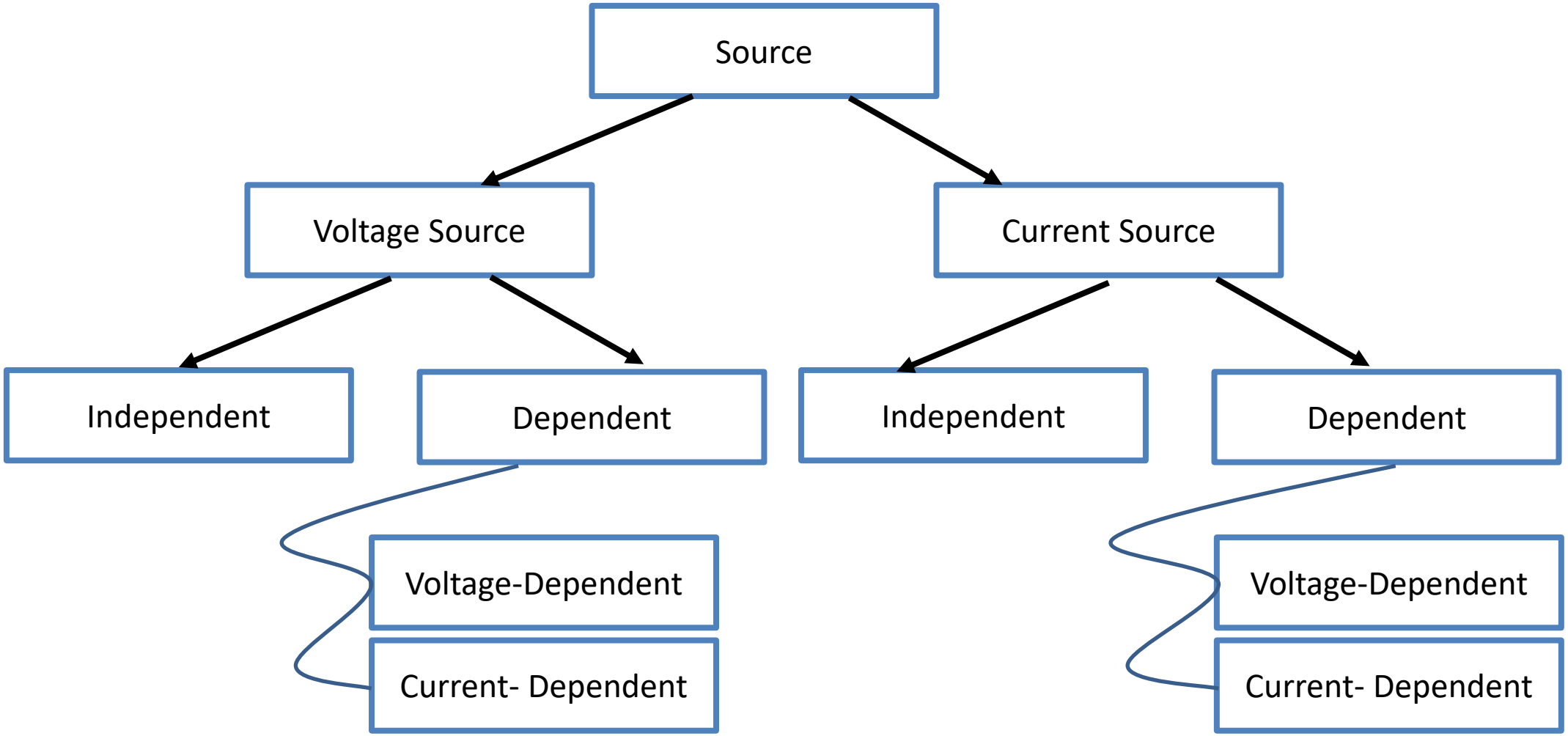
Lecture 6-7

Prepared By: Pawandeep Kaur

Topics

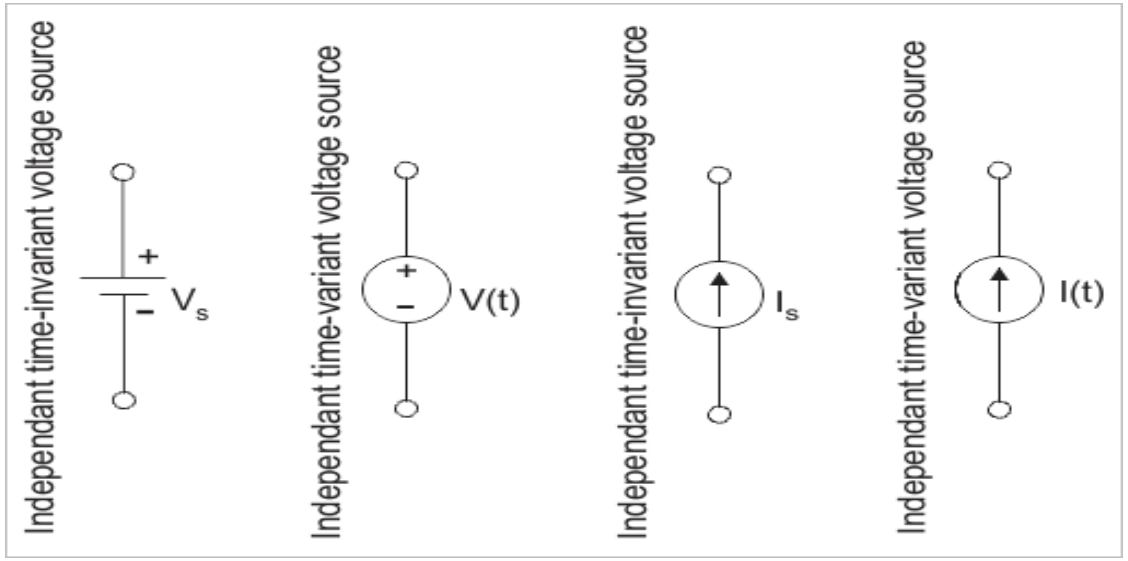
- Energy Sources (Dependent and Independent)
- Ideal and Practical Sources
- Source Transformation
- Nodal mesh Analysis

Energy Sources

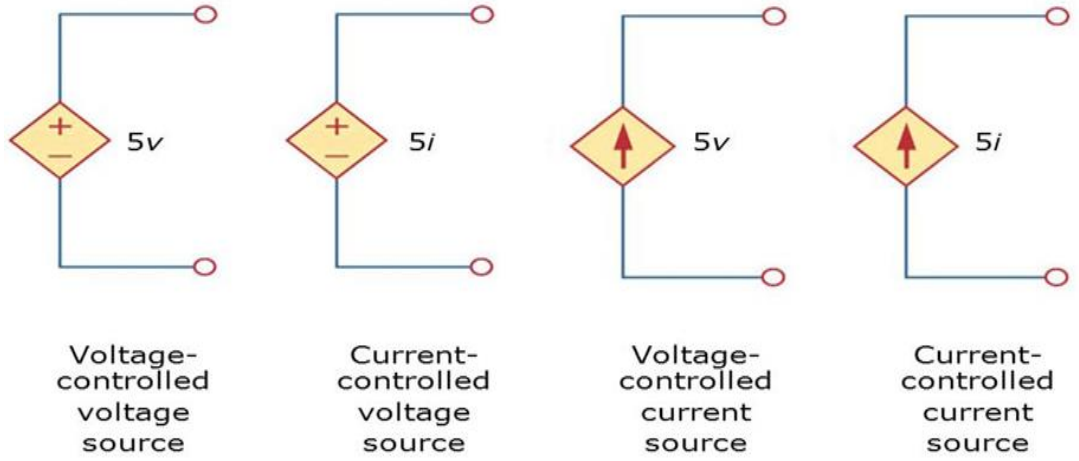


Independent and Dependent Sources

- Independent



- Dependent



Independent and Dependent Sources

- Independent sources are those which does not depend on any other quantity in the circuit. They are two terminal devices and has a constant value, i.e. the voltage across the two terminals remains constant irrespective of all circuit conditions. The Independent sources are represented by a circular shape.

- Dependent or Controlled sources are those whose output voltage or current is NOT fixed but depends on the voltage or current in another part of the circuit is called. They are four terminal devices. When the strength of voltage or current changes in the source for any change in the connected network, they are called dependent sources. The dependent sources are represented by a diamond shape.

QUICK QUIZ (Poll 1)

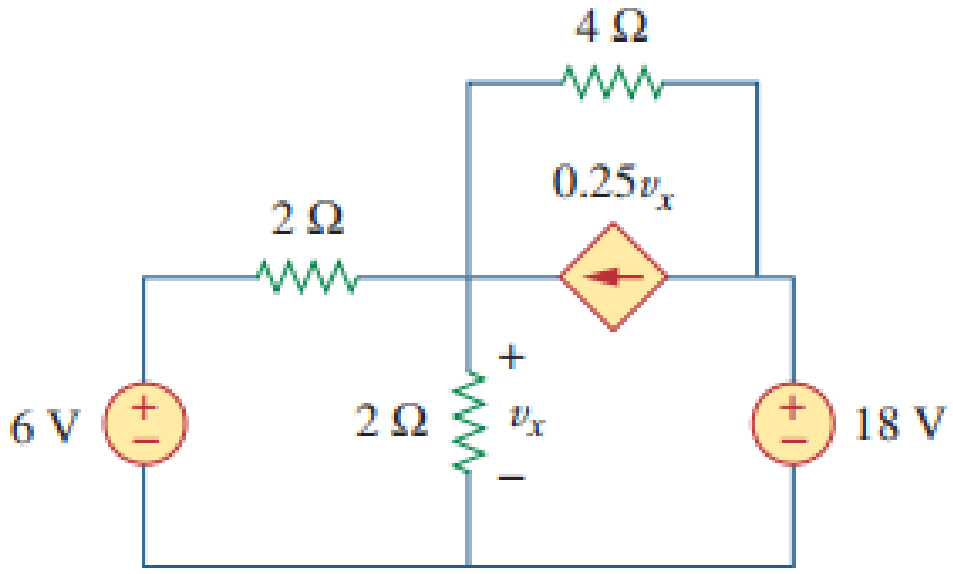
Identify the type of dependent source used in the network:

A. VCVS

B. CCCS

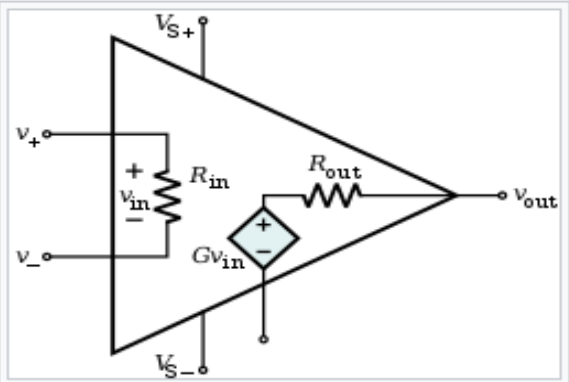
C. VCCS

D. CCVS

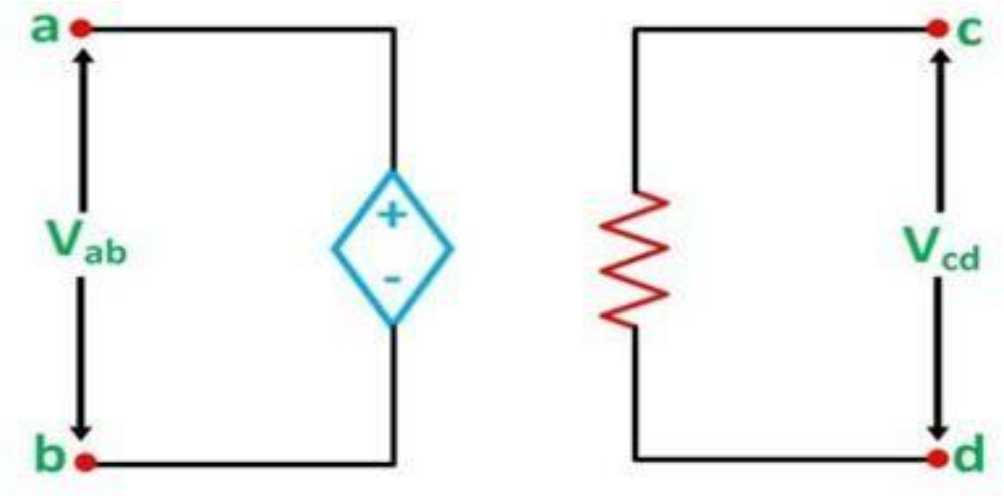


Voltage Controlled Voltage Source (VCVS)

In **voltage controlled voltage source** the voltage source is dependent on the element of a circuit.



An equivalent circuit of an operational amplifier that models some resistive non-ideal parameters.



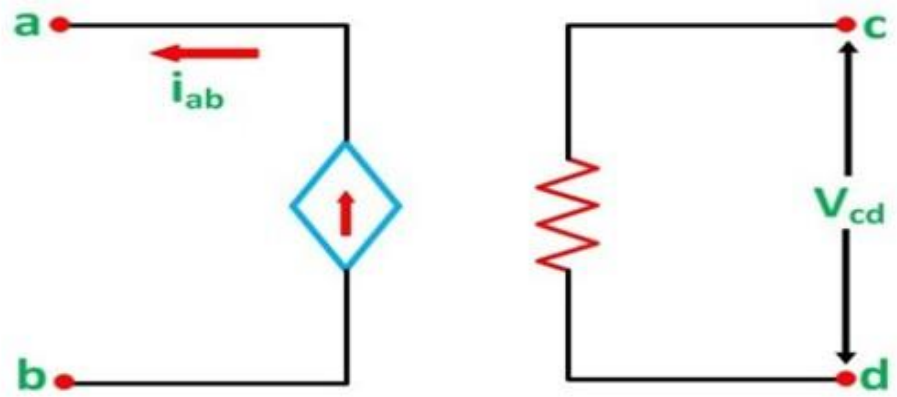
In the above figure, the voltage across the source terminal V_{ab} is dependent on the voltage across the terminal V_{cd},

$$V_{ab} \propto V_{cd} \quad \text{or}$$
$$V_{ab} = kV_{cd}$$

Gain

Voltage Controlled Current Source (VCCS)

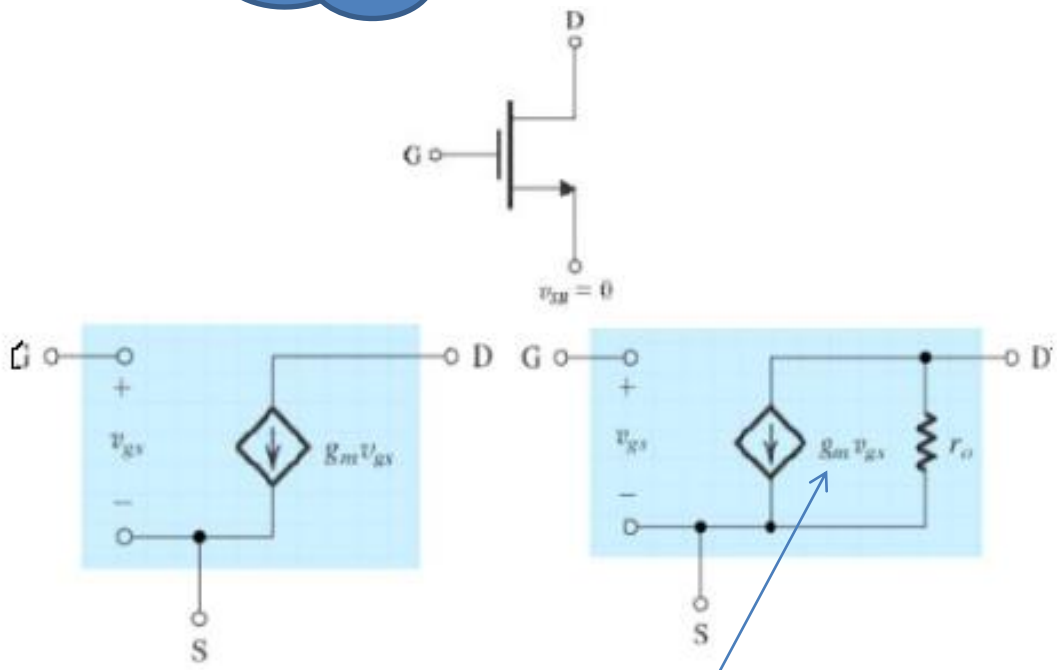
In the **voltage controlled current source**, the current of the source i_{ab} depends on the voltage across the terminal cd (V_{cd}) as shown in the figure below.



$$i_{ab} \propto V_{cd}$$
$$i_{ab} = \eta V_{cd}$$

Where η is a constant known as **transconductance** and its unit is mho.

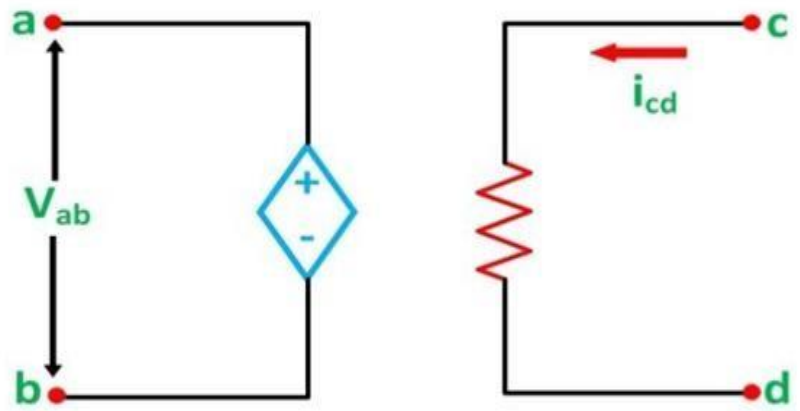
Example is MOSFET



Transconductance

Current Controlled Voltage Source (CCVS)

In the **current controlled voltage source** voltage source of the network depends upon the current of the network as shown in the figure below

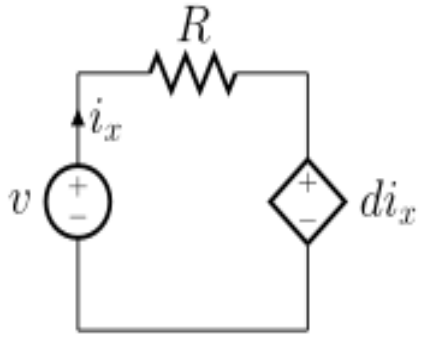


Here the voltage of source V_{ab} depends on the current of the branch cd

$$V_{ab} \propto i_{cd}$$

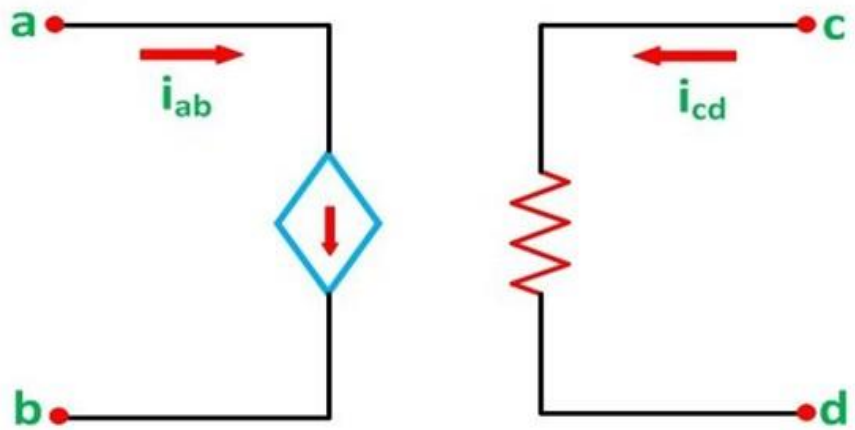
$$V_{ab} = r\, i_{cd}$$

Example is DELAY analysis



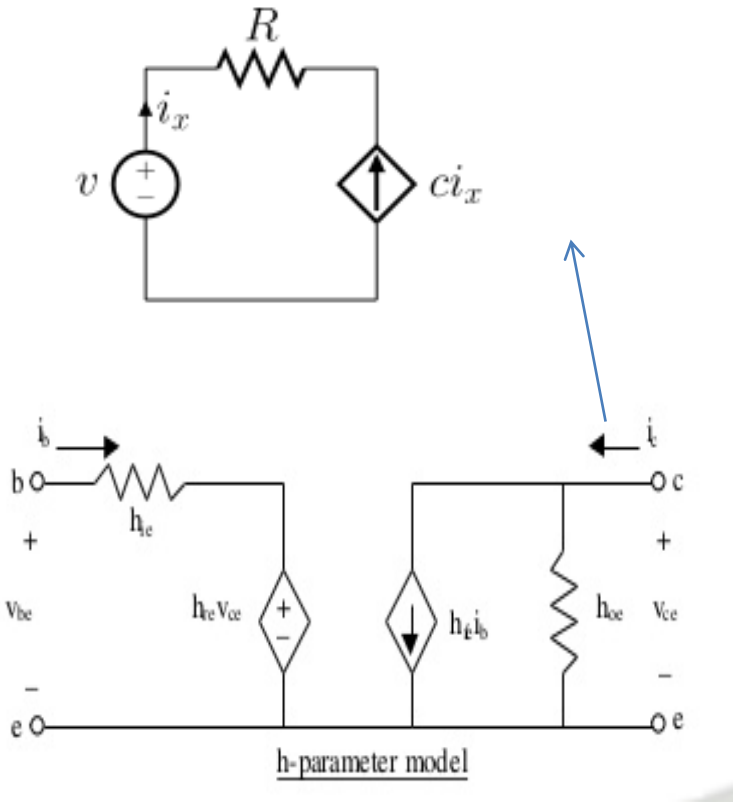
Current Controlled Current Source (CCCS)

In the **Current Controlled Current Source**, the current source is dependent on the current of the branch another branch as shown in the figure below



$$i_{ab} \propto i_{cd}$$
$$i_{ab} = \beta i_{cd}$$

Where β is a constant



BJT mathematical Model

Practical Dependent Sources

In practice

- VCVS is often used in modeling Operational Amplifiers (OP- AMPs)
- VCCS is often used in modeling MOSFETs.
- CCVS is often used in modeling delays and transient analysis.
- CCCS is often used in modeling Bipolar Junction Transistors (BJTs)

QUIZ

- In a circuit with dependent sources the obtained voltage is proportional to the input voltage. The source is

A. CCVS
B. VCVS
C. CCCS
D. VCCS

QUICK QUIZ (Poll 4)

BJT is an example of :

A. VCVS

B. CCCS

C. VCCS

D. CCVS

Ideal and Practical Voltage Source

- Ideal is one where internal resistance does NOT exist.

NOTE:

1. For a voltage source, internal resistance must be ZERO.
2. For a current source, internal resistance must be INFINITY.

- Practical is one where internal resistance is present.

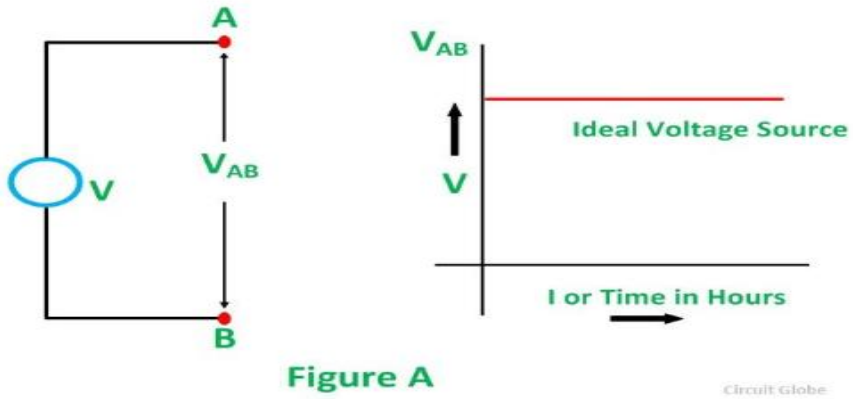


Figure A

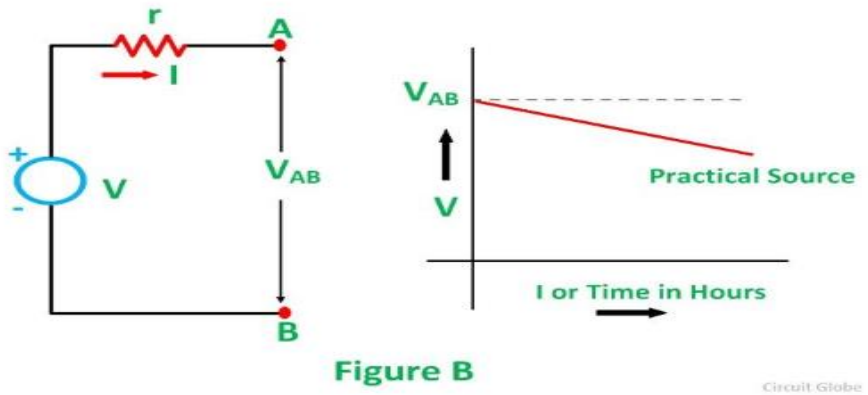


Figure B

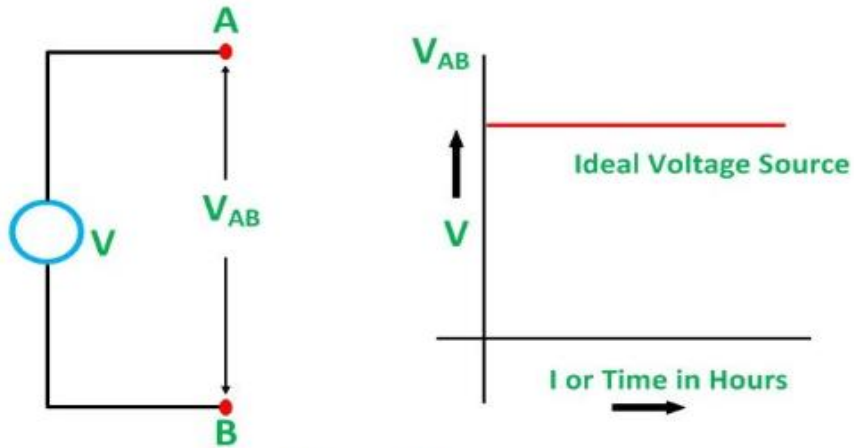


Figure A

Circuit Globe

The figure B shown below gives the circuit diagram and characteristics of Practical Voltage Source

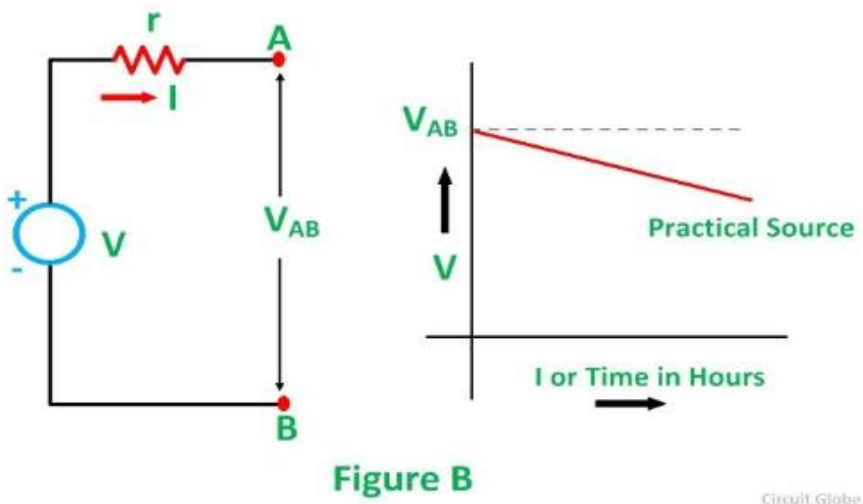


Figure B

Circuit Globe

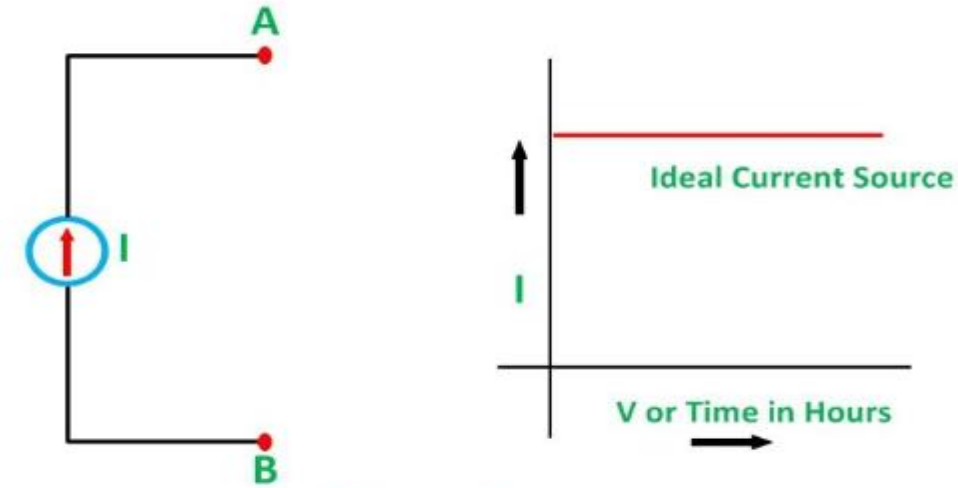


Figure C

Circuit Globe

Figure D shown below shows the characteristics of Practical Current Source.

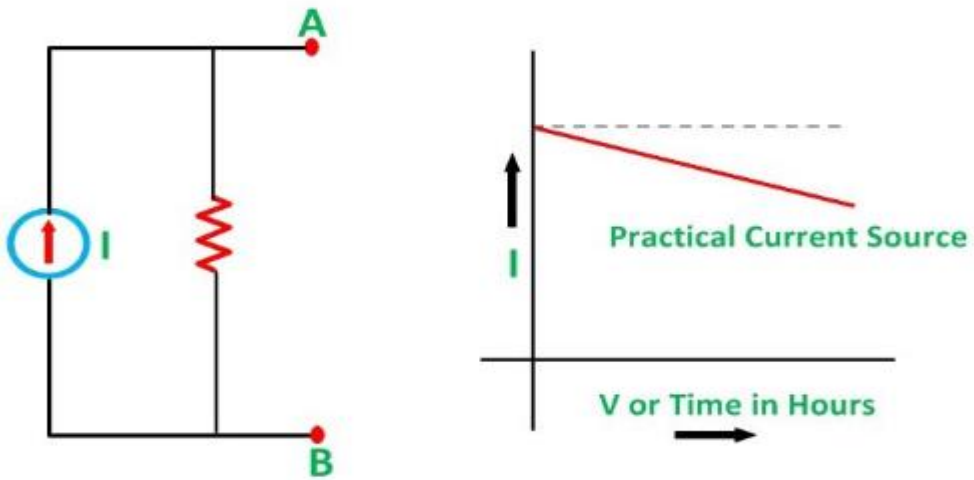


Figure D

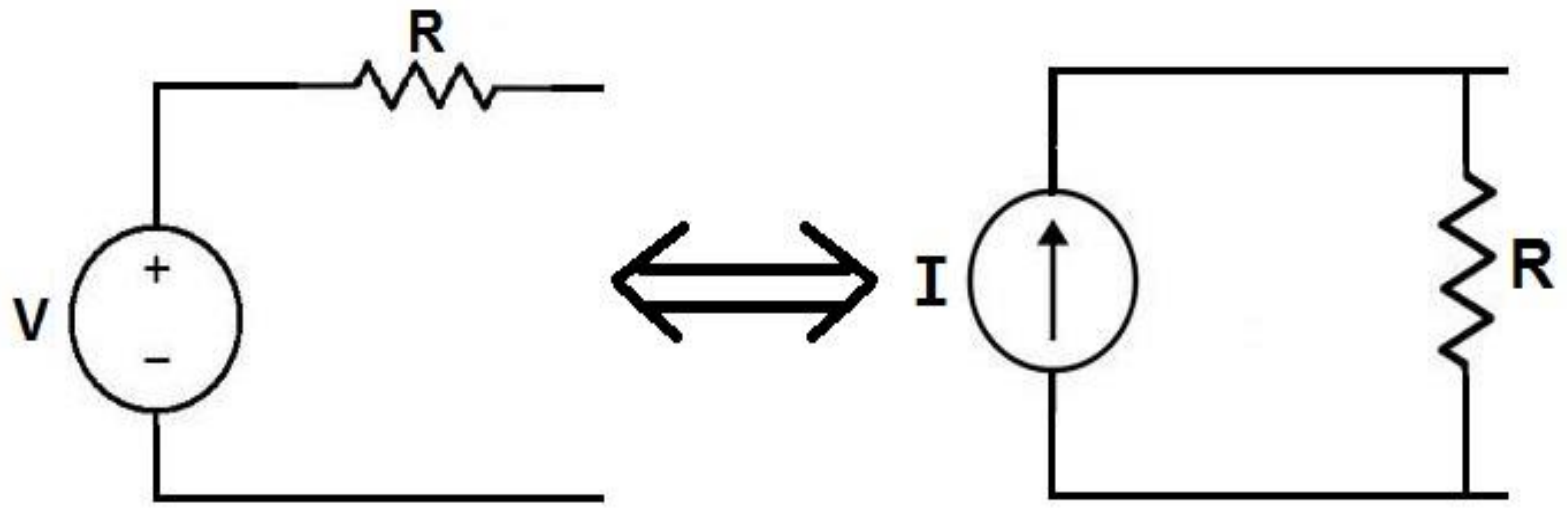
Circuit Globe

Quick Quiz (Poll)

- Practical constant current source should have internal resistance :
- A)low
- B)High
- C)zero
- D)infinite

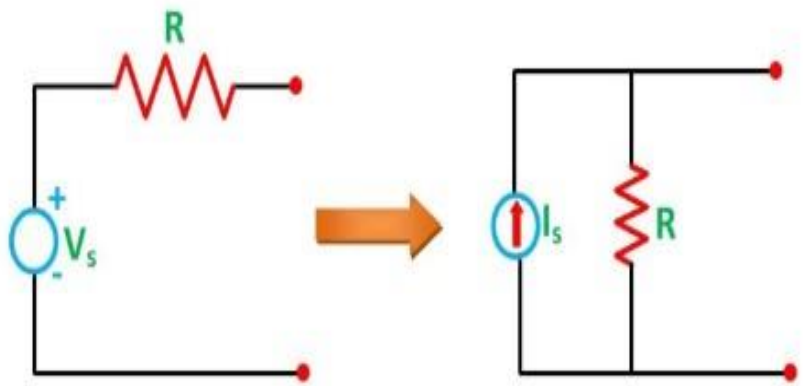
SOURCE TRANSFORMATION

A source transformation is the process of replacing a voltage source V in series with a resistor R by a current source is in parallel with a resistor R, or vice versa.



Source Transformation

Source Transformation : Conversion of Voltage Source into Current Source

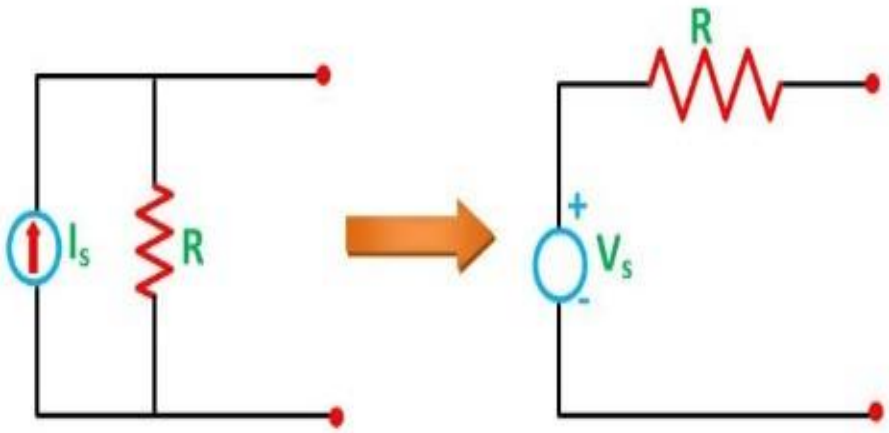


Circuit Globe

When the voltage source is connected with the resistance in series and it has to be converted into the current source than the resistance is connected in parallel with the current source as shown in the above figure.

Where $I_s = V_s / R$

Conversion of Current Source into Voltage Source



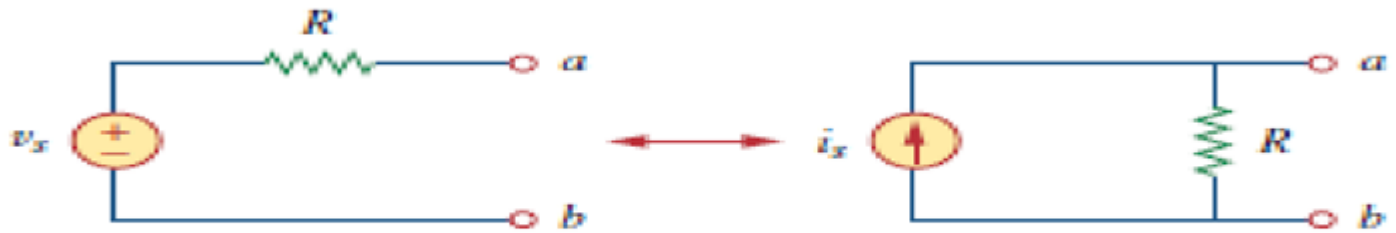
Circuit Globe

In the above circuit diagram a current source which is connected in parallel with the resistance is transformed into a voltage source by placing the resistance in series with the voltage source.

Where, $V_s = I_s \times R$

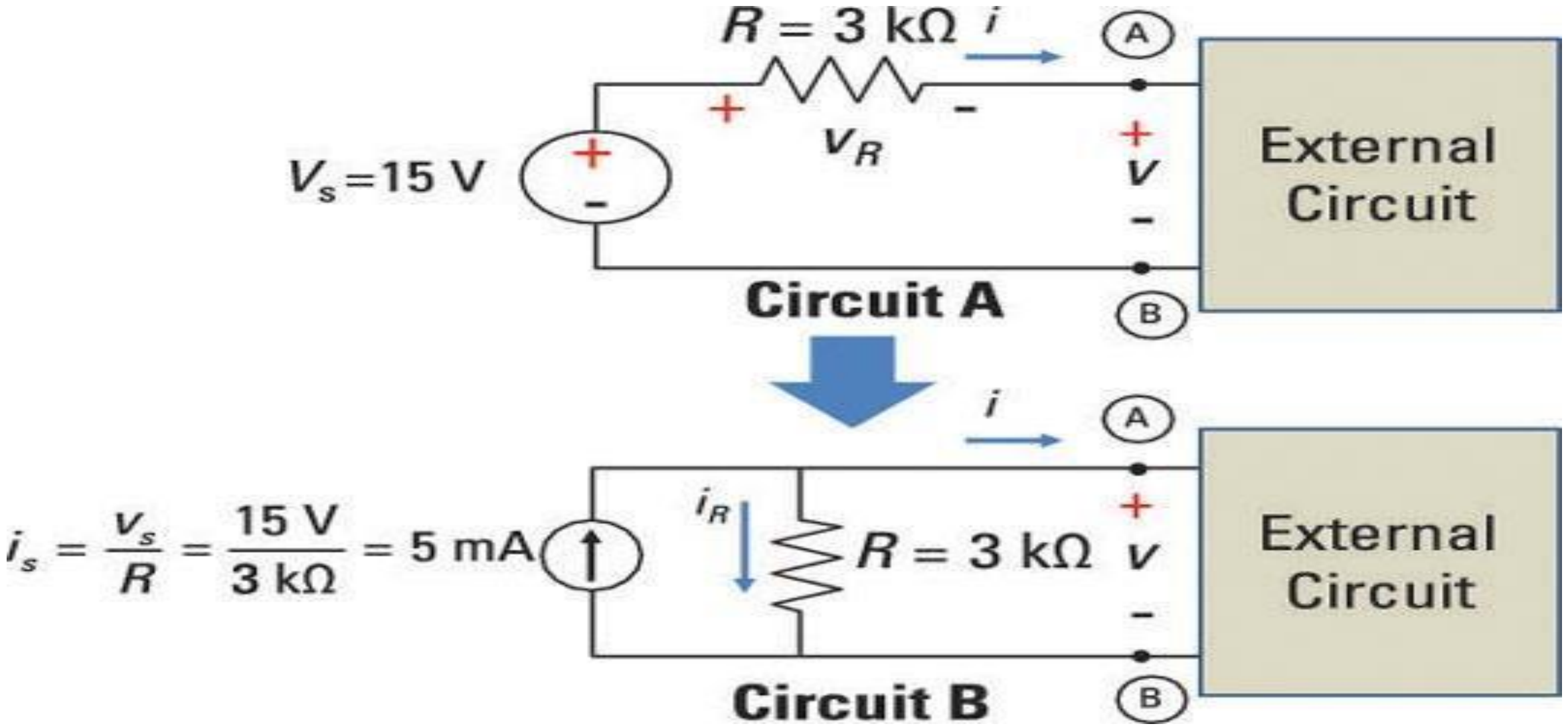
SOURCE TRANSFORMATION FOR INDEPENDENT SOURCES

SOURCE TRANSFORMATION FOR INDEPENDENT SOURCES



$$v_s = i_s R \qquad \text{or} \qquad i_s = \frac{v_s}{R}$$

Example for Source Transformation



QUIZ

In source transformation,

A. Voltage sources remain same

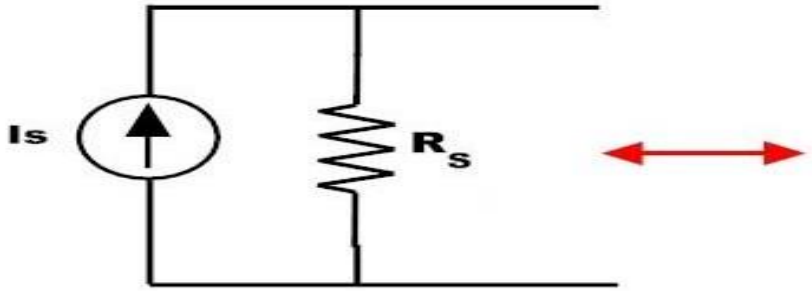
B. Current sources remain same

C. Both voltage and current sources undergo change

D. Resistances/Impedances remain same

Quick Quiz (POLL)

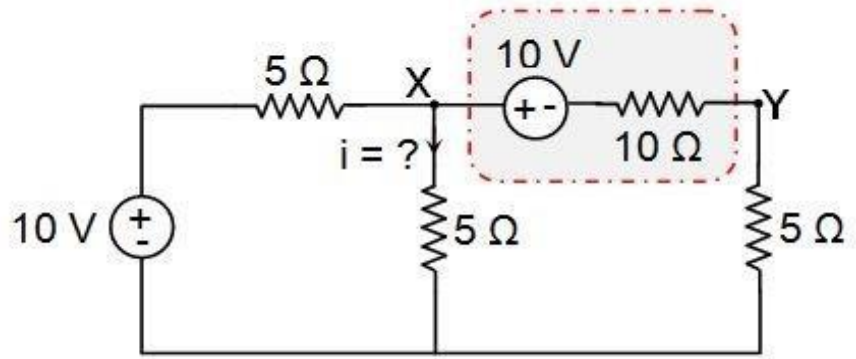
Using Source Transformation find the equivalent values of practical voltage source, where I_S = 10A, R_S =2.5 ohms.
Also draw a equivalent circuit diagram with voltage source share on LPU live

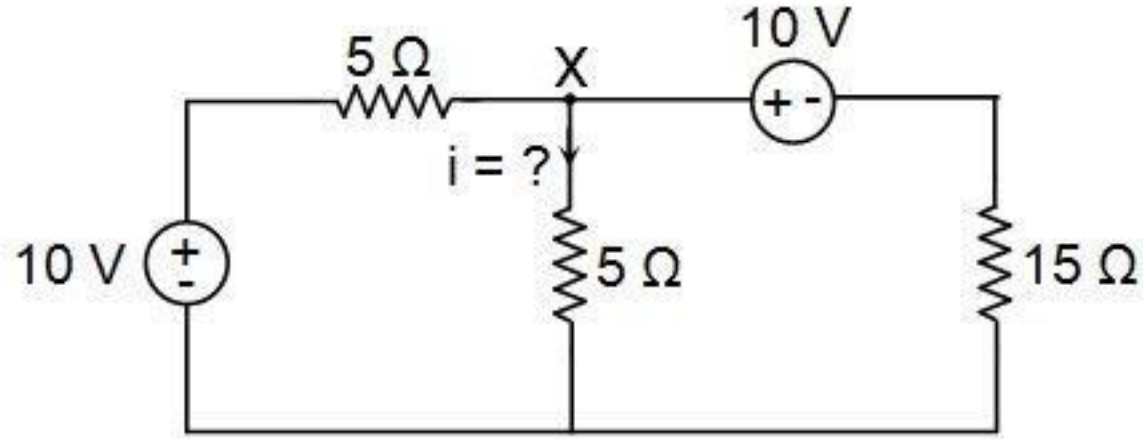


A) 25V ,series resistor 2.5 ohms
B) 25V ,parallel resistor 2.5 ohms
C) 10V ,series resistor 25 ohms
D) 10V ,series resistor 25 ohms

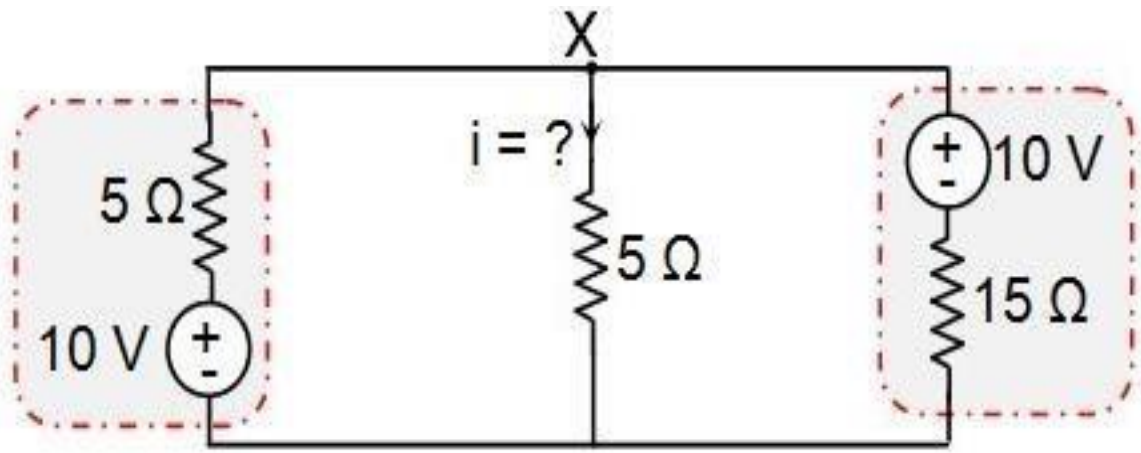
Example source transformation

Find the current in 5 ohm resistance using source transformation

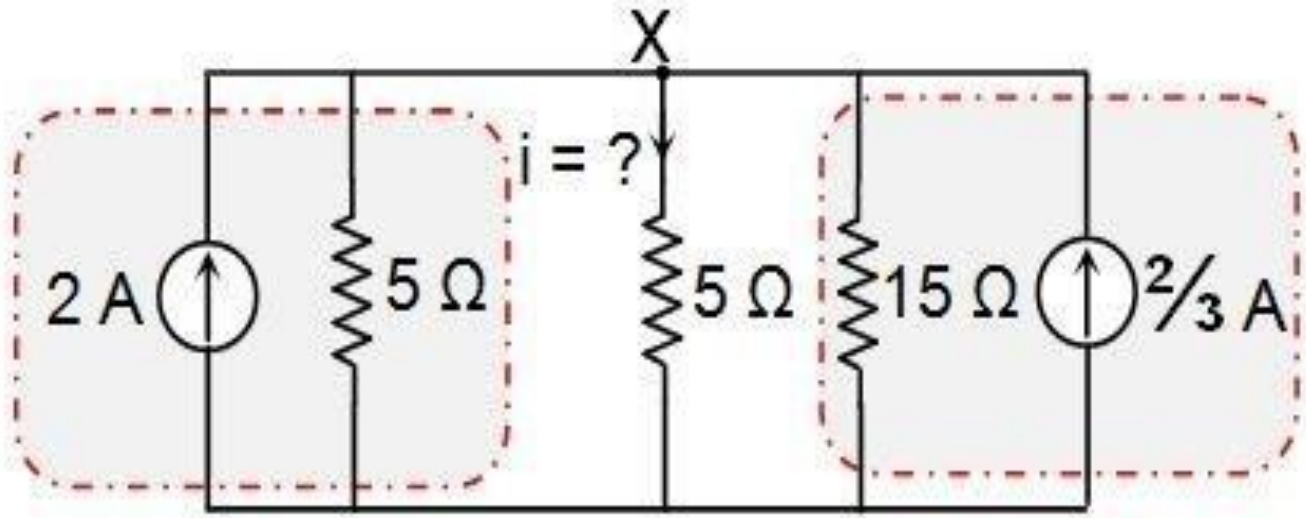


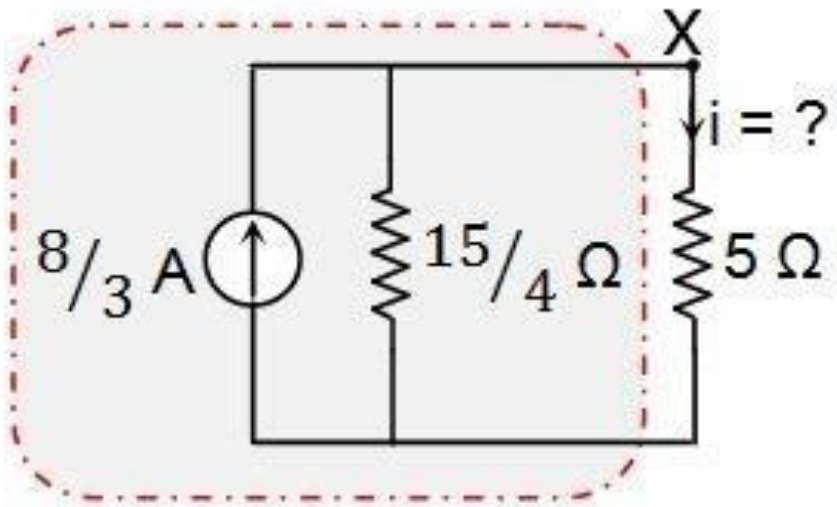


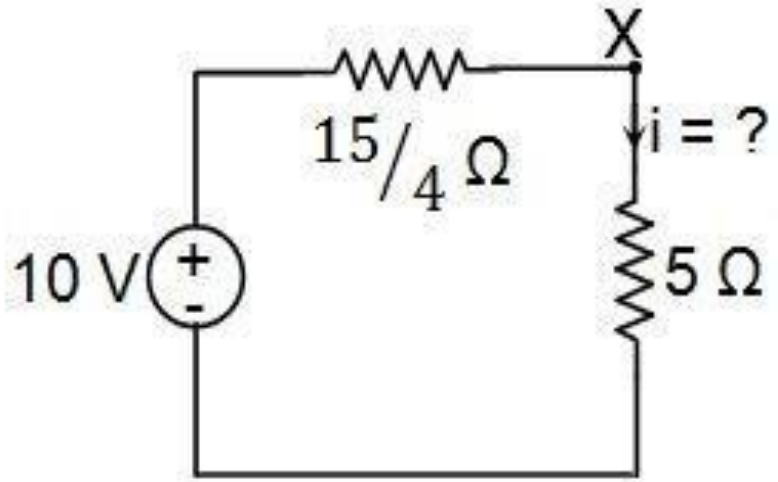
(a)



(b)

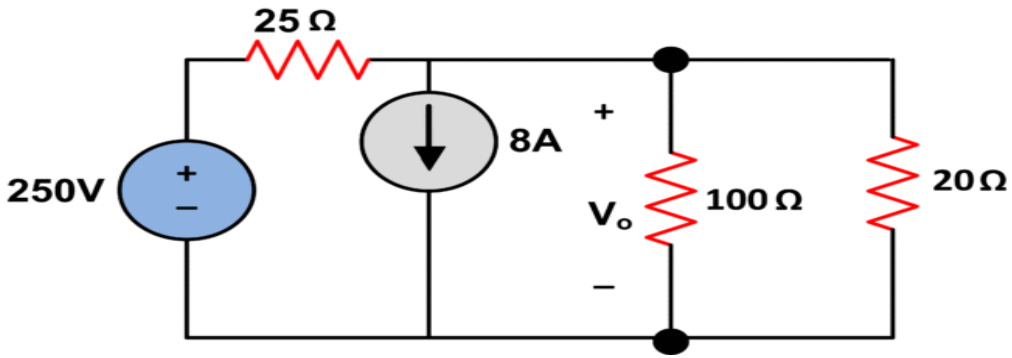

X
i = ?
2 A
5 Ω
5 Ω
15 Ω
⅔ A


X
i = ?
8/3 A
15/4 Ω
5 Ω


X
15/4 Ω
i = ?
10 V
+
-
5 Ω

Practice Problem

Find the voltage across 100 ohms resistance using source transformation



Can You Recall! (Poll)

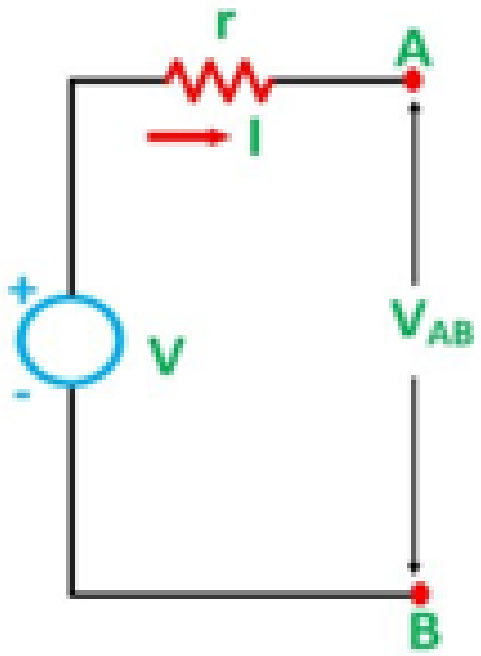
MOSFET is an example of:

A. VCVS
B. CCCS
C. VCCS
D. CCVS

Can You Recall! (Poll)

The given figure represents:

A. Voltage source with R value infinity.
B. Voltage source with R value Zero
C. Voltage source with R value finite
D. Current source with R value finite



Nodal Analysis or Nodal Method

- Nodal analysis provides a general procedure for analyzing circuits using node voltages as the circuit variables.
- Choosing node voltages instead of element voltages as circuit variables is convenient and reduces the number of equations one must solve simultaneously.
- Applicable to **Nodes only.**
- Based on KCL
- Used to find unknown **Voltages**

Steps to Determine Node Voltages

1. Select one nodes out of ‘n’ node as the reference node. Assign voltages to the remaining nodes. The voltages are referenced with respect to the reference node.

2. Apply KCL to each of the non-reference nodes.

3. Use Ohm’s law to express the branch currents in terms of node voltages.

3. Solve the resulting simultaneous equations to obtain the unknown node voltages.

Points to Remember

- Selecting a node as the *reference* or *datum node*: The reference node is commonly called as *ground.*
- Method is Application of KCL+ Ohm's Law Only
- The number of non-reference nodes is equal to the number of independent equations that we have to derive.
- Current flows from a higher potential to a lower potential in a resistor

$$i = \frac{v_{\text{higher}} - v_{\text{lower}}}{R}$$

QUICK QUIZ (Poll 1)

For “N” number of nodes, the number of non-reference nodes is equal to:

$A.\ N + 1$

$B.\ N - 1$

C. 2N

D. $2N - 1$

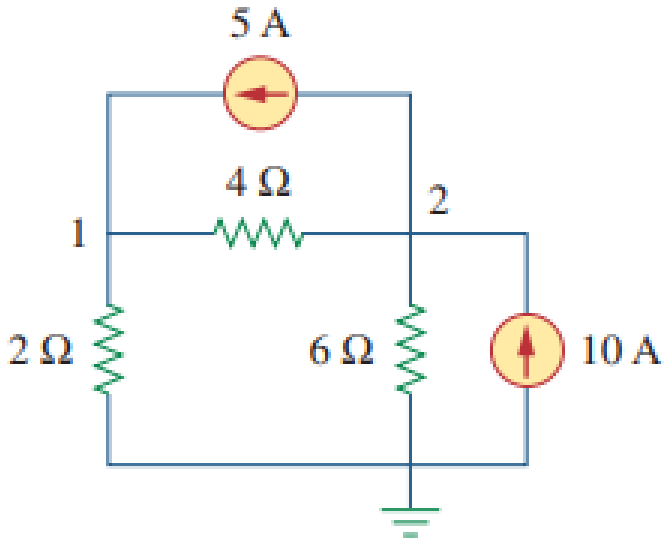
QUICK QUIZ (Poll 2)

Nodal analysis, which is based on KCL is used to find unknown:

A. *Current*
B. *Voltage*
C. *none*

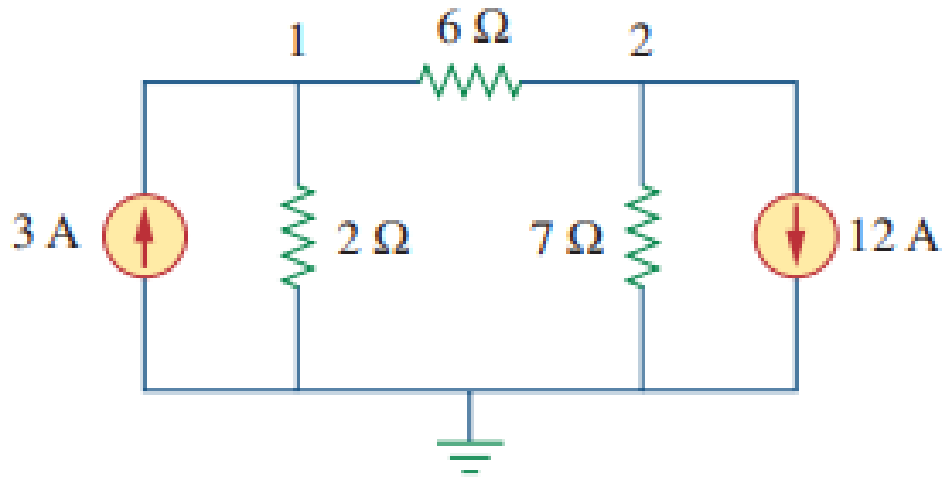
Practice Problem

Find node voltages?



Home Practice

- Obtain the node voltages in the given circuit?



Mesh Analysis

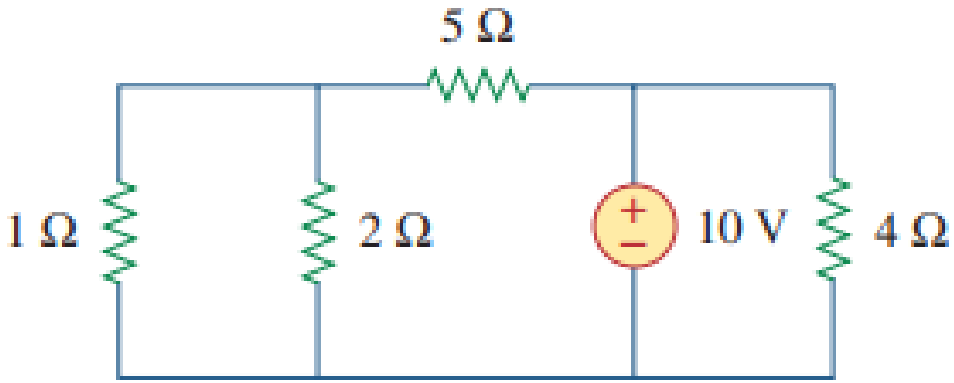
- Mesh analysis provides another general procedure for analyzing circuits, using mesh currents as the circuit variables.
- It is based on KVL.

RECALL!

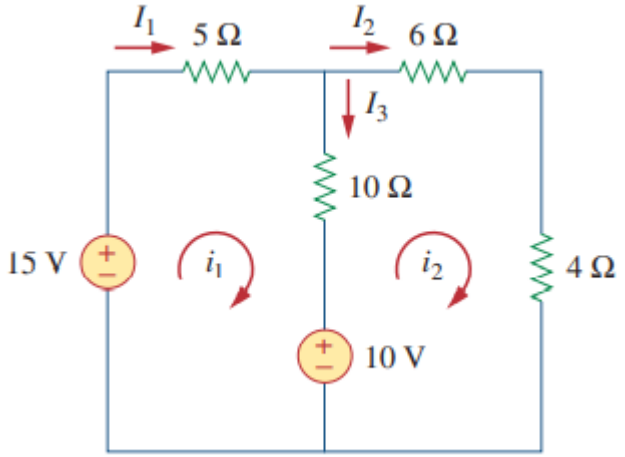
- LOOP: A loop is a closed path with no node passed more than once.
- MESH: A mesh is a loop that does not contain any other loop within it.
- Mesh analysis is not quite as general as nodal analysis because it is only applicable to a circuit that is planar.
- **PLANAR CIRCUIT:** A planar circuit is one that can be drawn in a plane with no branches crossing one another; otherwise it is nonplanar.

Steps to Determine Mesh Currents

1. Assign mesh currents to ‘n’ meshes
2. Apply KVL to each of the ‘n’ meshes.
3. Solve the resulting ‘n’ simultaneous equations to obtain the unknown mesh currents.



Practice Find the branch currents and using mesh analysis.

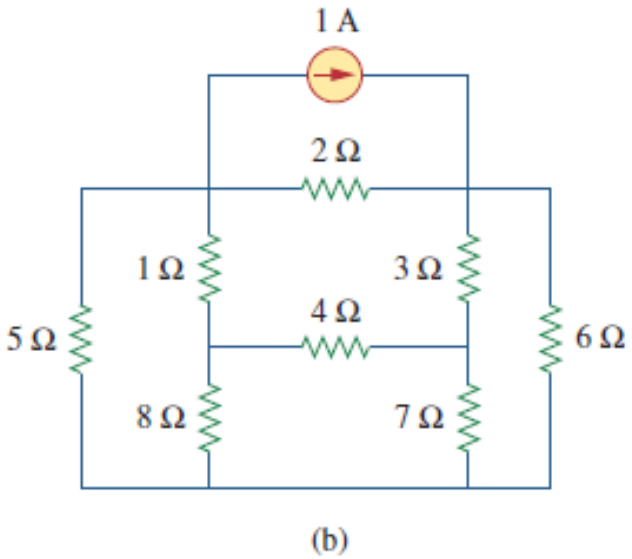


QUICK QUIZ (Poll 4)

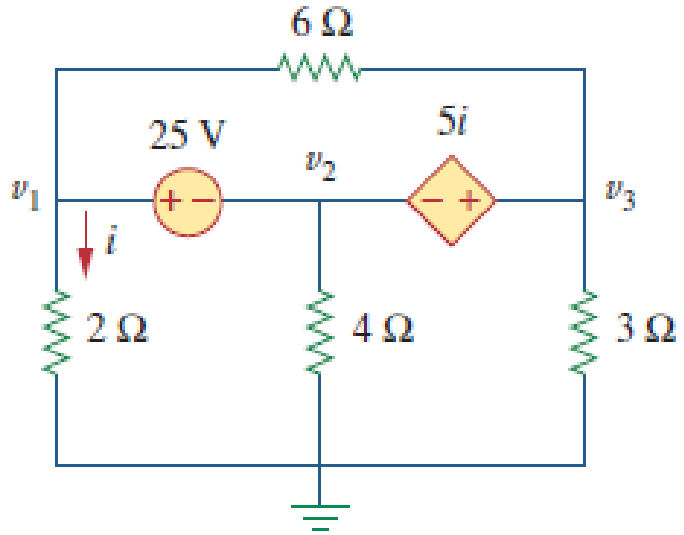
Mesh Analysis to applicable to_____ type networks.:

A. Planar and Loop
B. Non planar and mesh
C. Planar and mesh
D. Non planar and Loop

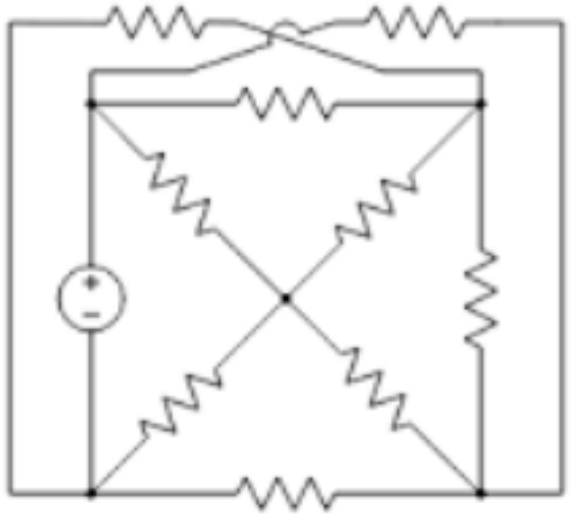
Examples of Planar Circuits

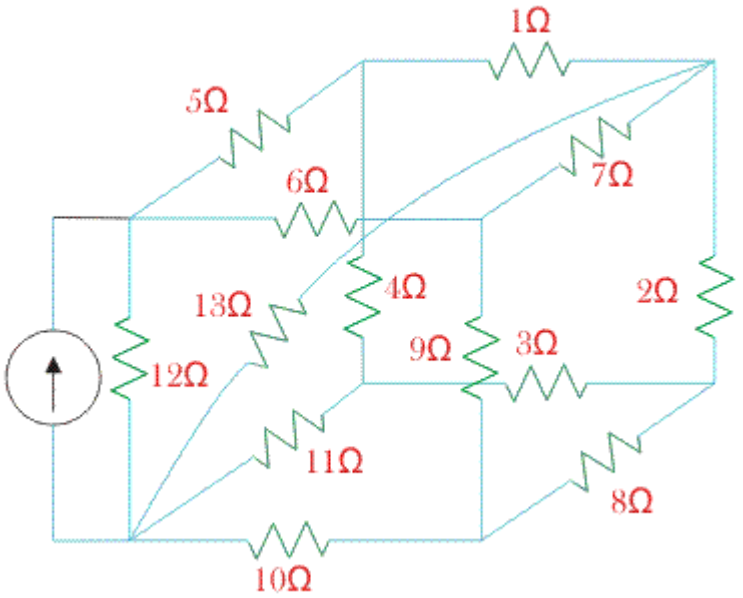


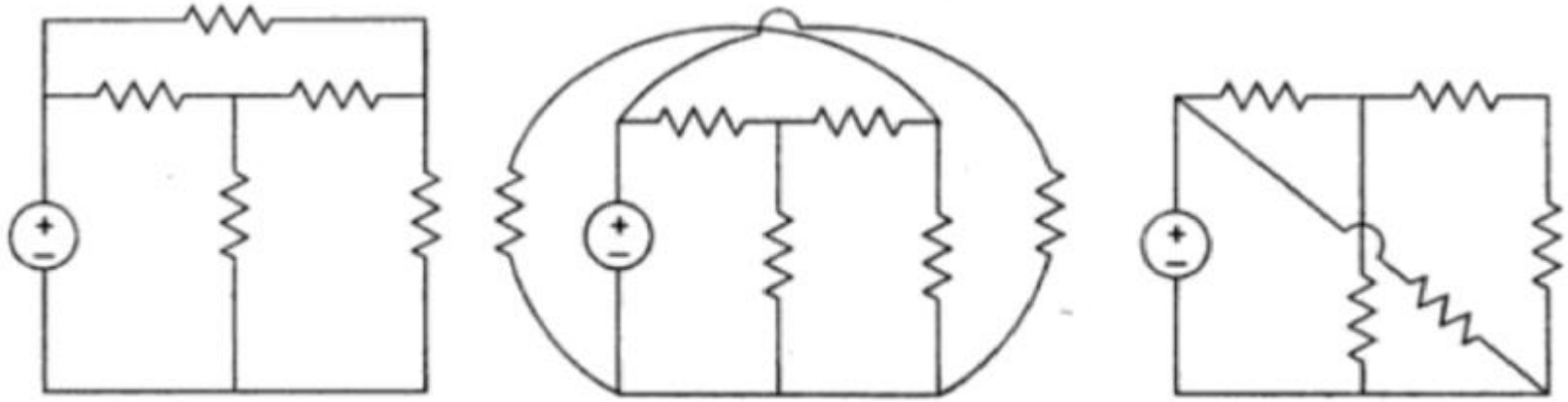
(b)



Examples of Non-Planar Circuits





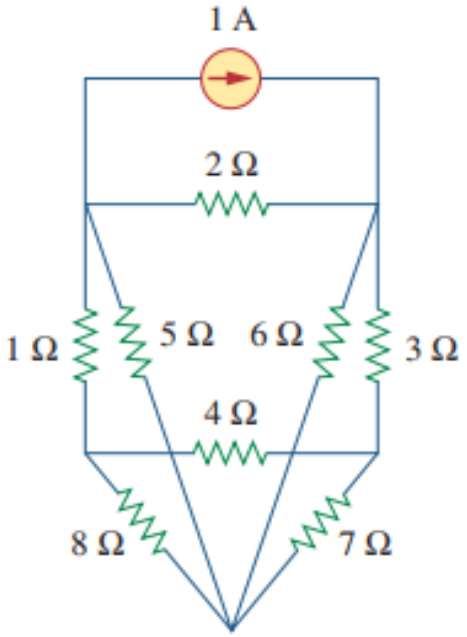


(a) (b) (c)

Quick Quiz :

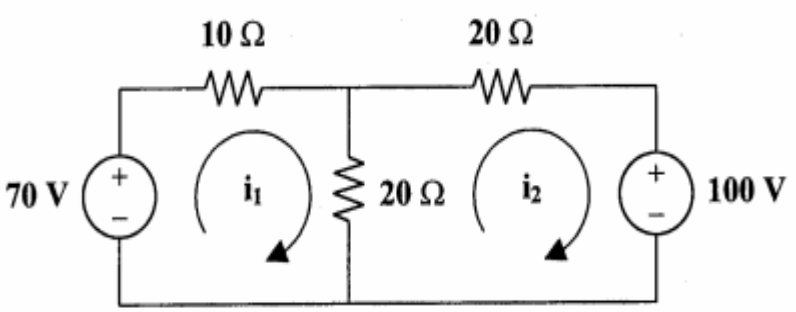
Identify the circuit:

A. Planar
B. Non Planar
C. Can’t be determined



Practice Problem

Obtain the mesh currents in the given circuit?



QUICK QUIZ (Poll 6)

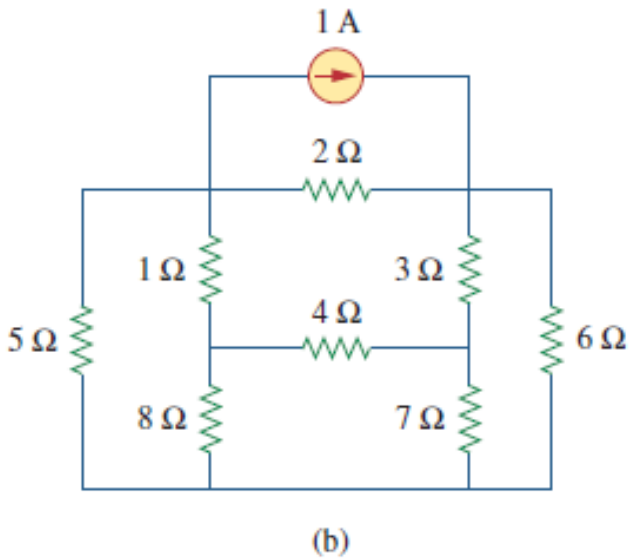
How many meshes are present here:

A. 3

B. 4

C. 5

D. 6



QUICK QUIZ (Poll 9)

Mesh analysis, which is based on KVL is used to find unknown:

A. $current$

B. *voltage*

Home Work

Obtain the mesh currents in the given circuit?