UNIT 1: DC CIRCUITS

Lecture 9

Prepared By: Pawandeep Kaur

Recap Quiz (POLL 1)

Identify the correct statement(s):

In Thevenin theorem, when we calculate the Thevenin resistance:

1. Voltage sources are replaced with short circuit.
2. Current source is open circuited.
3. Load is short circuited.
4. Dependent sources are left intact.

A. 1 and 2

B. 1, 4

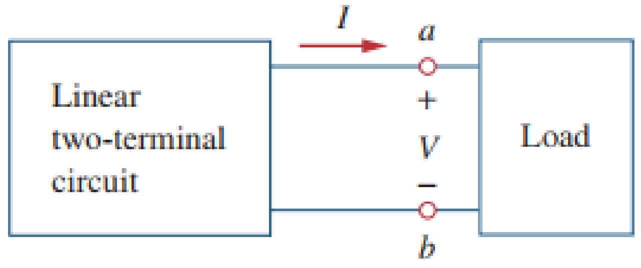
C. 1, 2 3, 4

D. 1, 2,4

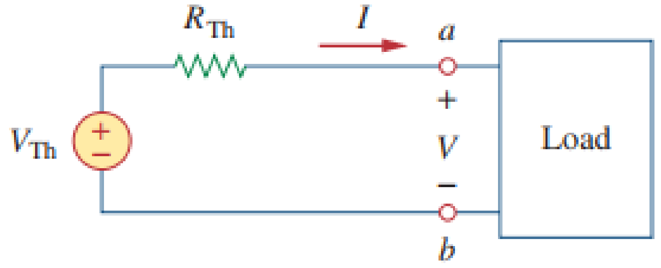
Thevenin Theorem

- 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.

- 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.



(a)



(b)

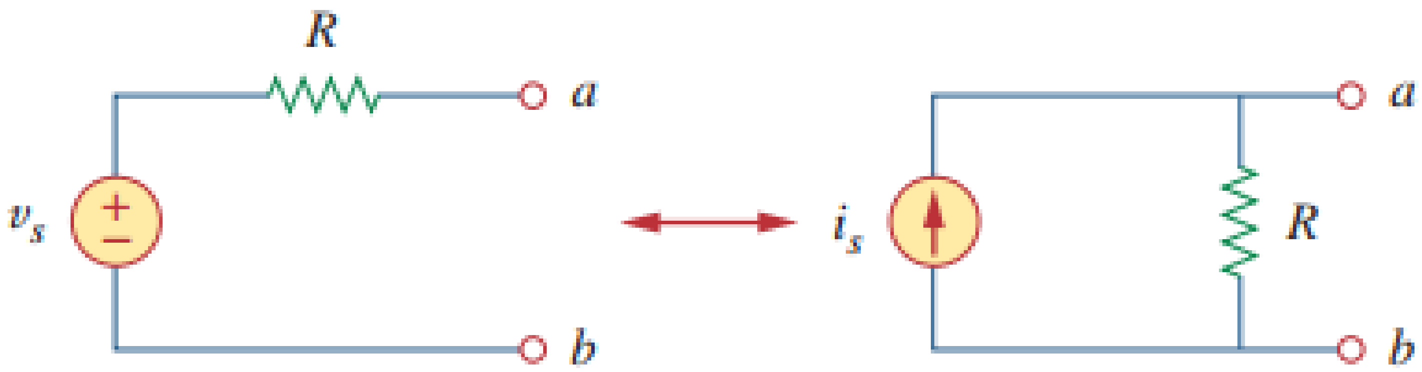
Statement of Thevenin's Theorem

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.

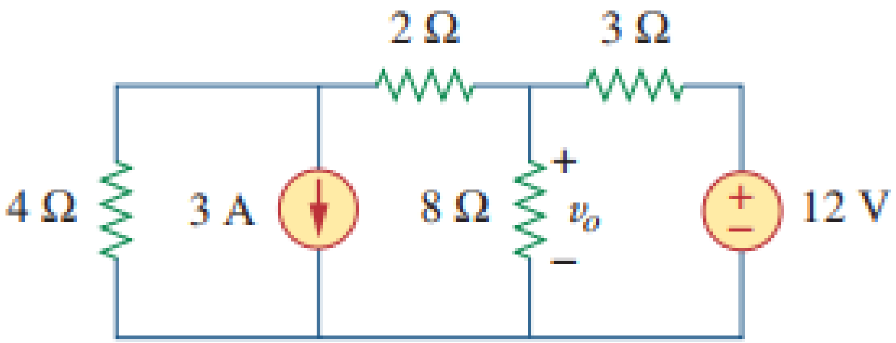
Source Transformation

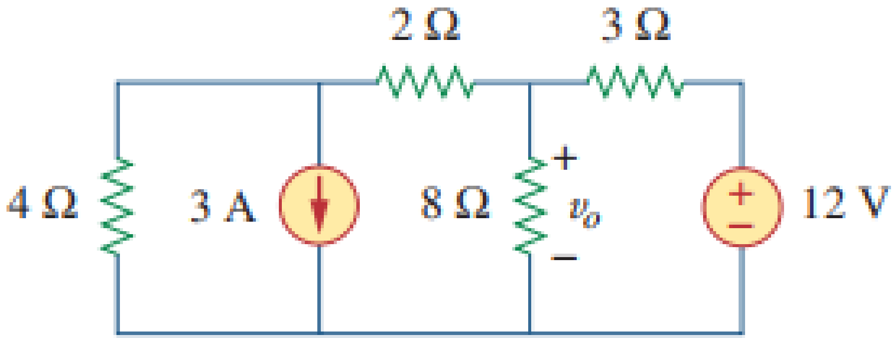
- We have noticed that series-parallel combination and wye-delta transformation help simplify circuits.
- *Source transformation* is another tool for simplifying circuits. Basic to these tools is the concept of *equivalence*.



PRACTICE PROBLEM

Using Source Transformation, find Vo?

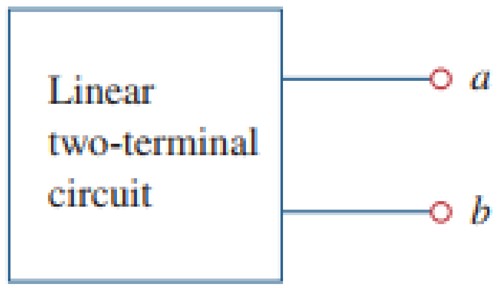



2 Ω
3 Ω
4 Ω
3 A
8 Ω
+
v_o
−
12 V

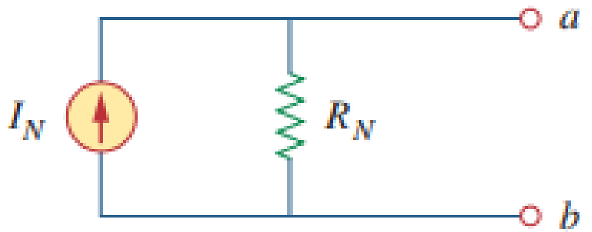
Norton Theorem

- In 1926, about 43 years after Thevenin's published his theorem, E. L. Norton, an American engineer at Bell Telephone Laboratories, proposed a similar theorem.
- STATEMENT:

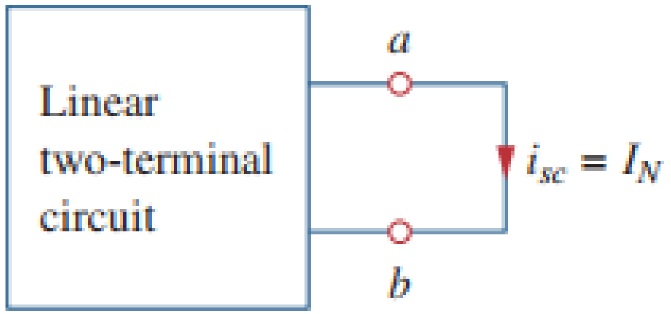
Norton's theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a current source I_N in parallel with a resistor R_N, where I_N is the short-circuit current through the terminals and R_N is the input or equivalent resistance at the terminals when the independent sources are turned off.


Linear
two-terminal
circuit
a
b

(a)

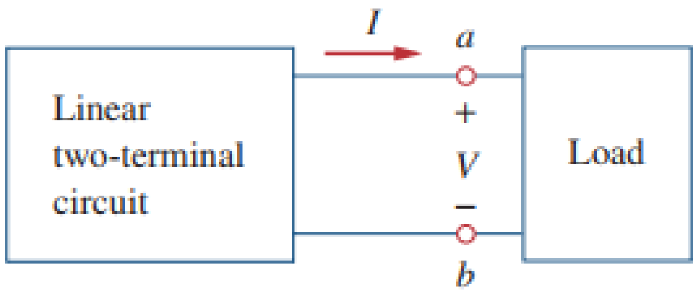

I_N
R_N
a
b

(b)

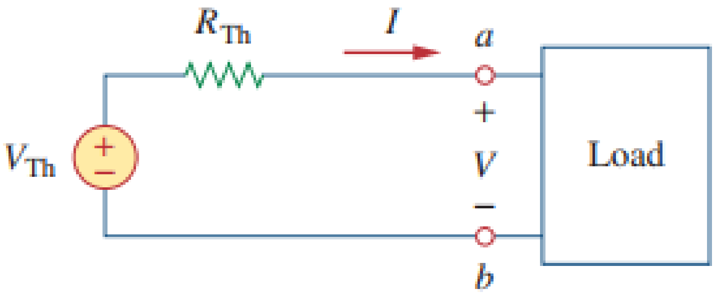

Linear
two-terminal
circuit
a
b
$i_{sc} = I_N$

COMPARISON

Thevenin's Theorem

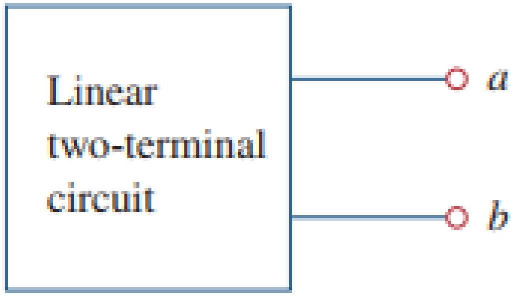


(a)

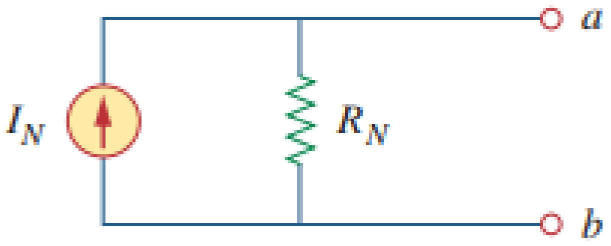


(b)

Norton Theorem



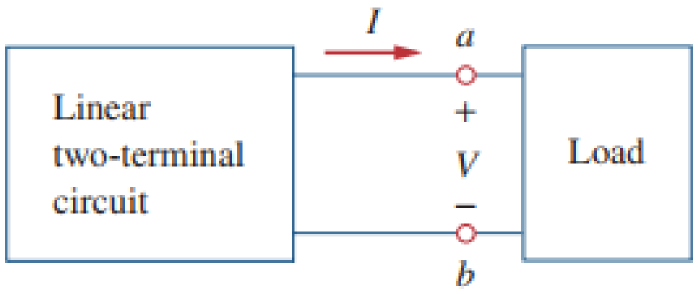
(a)



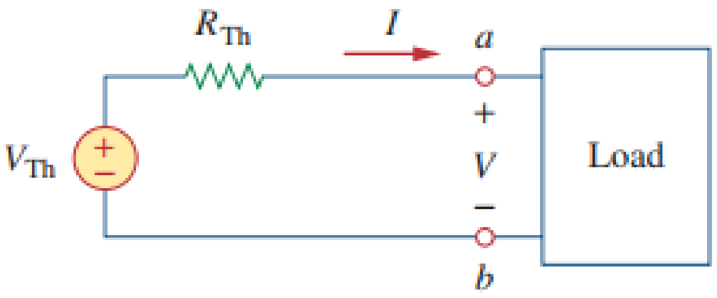
(b)

COMPARISON

Thevenin Theorem



(a)



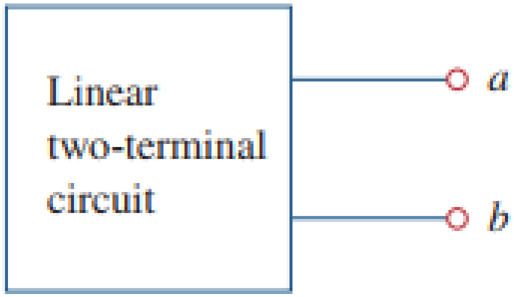
(b)

$$V_{Th} = v_{oc}$$

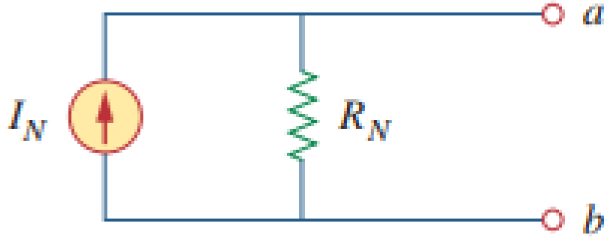
$$I_N = i_{sc}$$

$$R_{Th} = \frac{v_{oc}}{i_{sc}} = R_N$$

Norton Theorem



(a)



(b)

Quick Quiz (POLL 2)

Norton current across the load is calculated by finding:

A. Short circuit current across load

B. Open circuit current across load

C. Short circuit voltage across load

D. Open circuit voltage across load

Steps for Applying Norton Theorem

Step 1. Short the two terminals between which you want to find the Norton equivalent circuit.

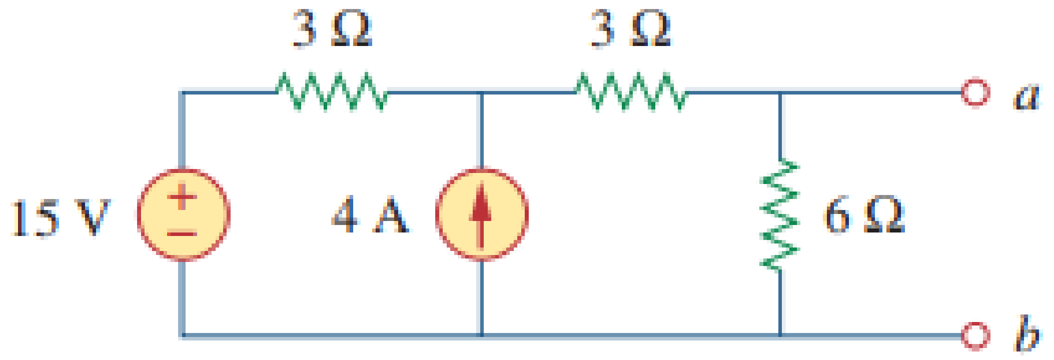
Step 2. Determine the current (I_N) through the shorted terminals.

Step 3. Determine the resistance (R_N) between the two open terminals with all sources replaced with their internal resistances (ideal voltage sources shorted and ideal current sources opened). $R_N = R_{TH}$.

Step 4. Connect I_N and R_N in parallel to produce the complete Norton equivalent for the original circuit.

Practice Numerical

Find the Norton Equivalent circuit for the circuit shown in Figure across terminals a and b.

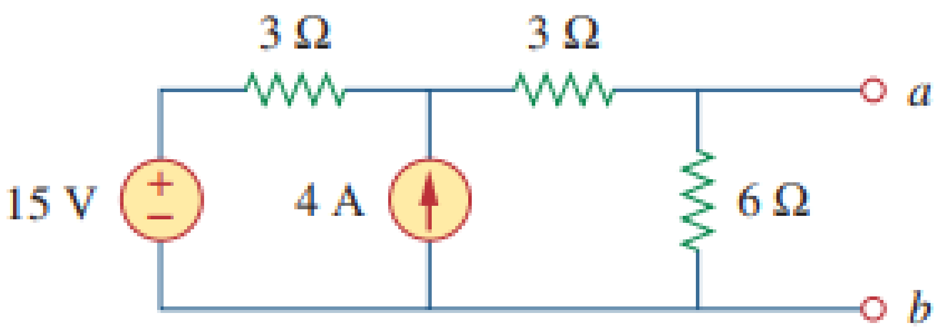


STEPS:

1. IN:
- Short the LOAD
- Find Voltage across LOAD

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

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



STEPS:

1. IN:
- Short the LOAD
- Find Voltage across LOAD
2. RN:
- Open the LOAD
- Indep Sources----- Int. Resistance

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

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

Quick Quiz (POLL 3)

Identify the correct statement(s):

A. V_{Th} needs load as open circuit and I_N needs load to be shorted.

B. V_{Th} needs load as short circuit and I_N needs load to be opened.

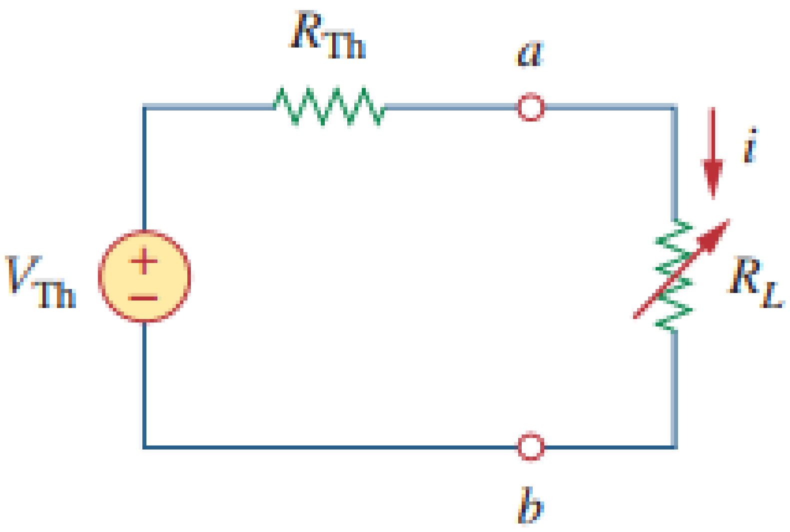
C. R_{Th} needs load as open circuit and R_N needs load to be shorted.

D. R_{Th} needs load as open circuit and R_N also needs same.

a. A and B
b. B and C
c. A and D
d. A, B and D

Maximum Power Transfer Theorem

In many practical situations, a circuit is designed to provide power to a load. There are applications in areas such as communications where it is desirable to maximize the power delivered to a load.

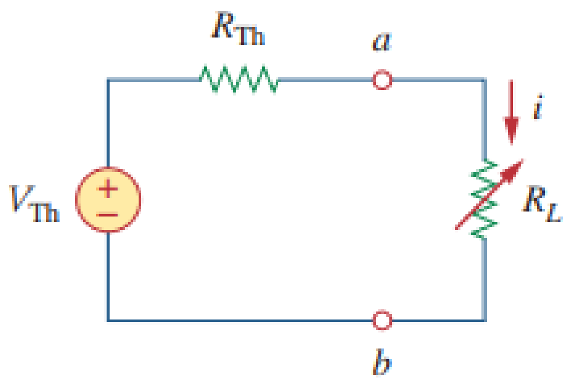


$$p = i^2 R_L = \left(\frac{V_{Th}}{R_{Th} + R_L} \right)^2 R_L$$

Maximum Power Transfer Theorem

STATEMENT:

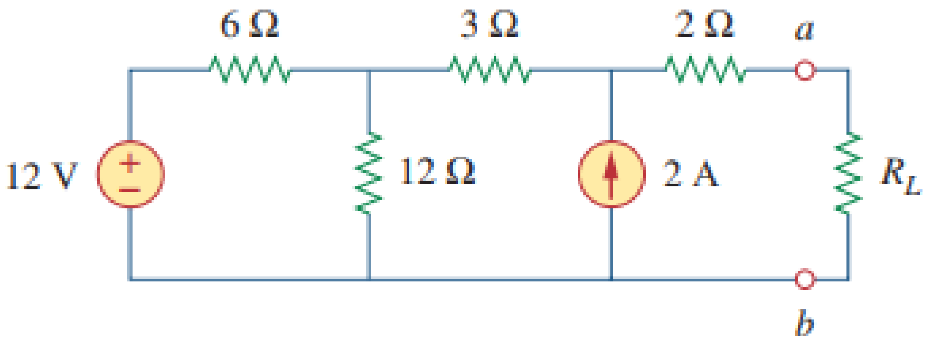
Maximum power is transferred to the load when the load resistance equals the Thevenin resistance as seen from the load (R_{Th}=R_L).

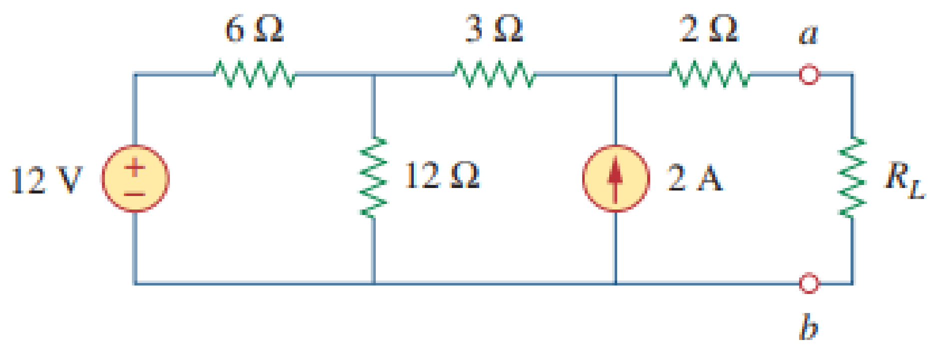


$$p = i^2 R_L = \left(\frac{V_{Th}}{R_{Th} + R_L}\right)^2 R_L$$

Practice Problem 1

Find the value of resistor R_L for transferring maximum power? Also find maximum power?




6 Ω
3 Ω
2 Ω
a
12 V
12 Ω
2 A
R_L
b

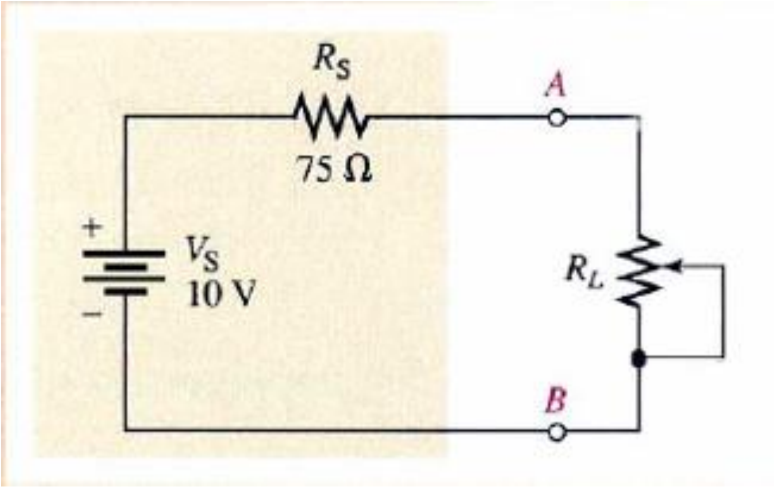
Practice Problem 2

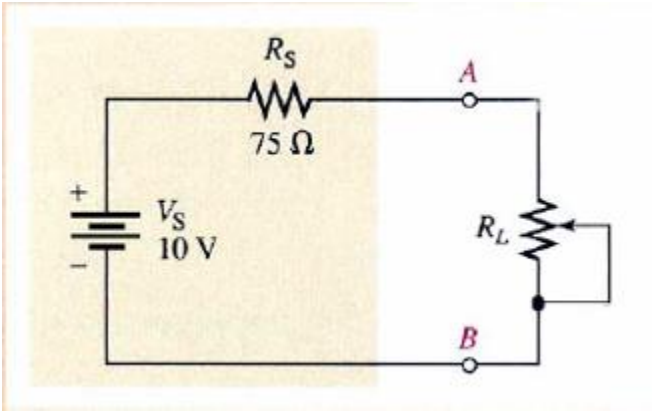
Determine the power across resistor R_L for following values?

1) 50 Ω

2) 75 Ω

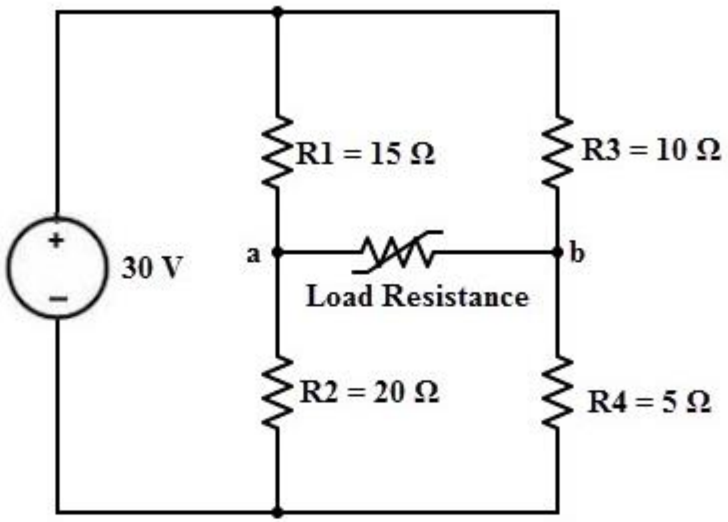
3) 100 Ω





R_S
75 Ω
A
+
V_S
10 V
−
R_L
B

Practice Problem 3



UNIT 2: AC CIRCUITS

Lecture 10

Prepared By: Irfan Ahmad Pindoo

Have an Overview!

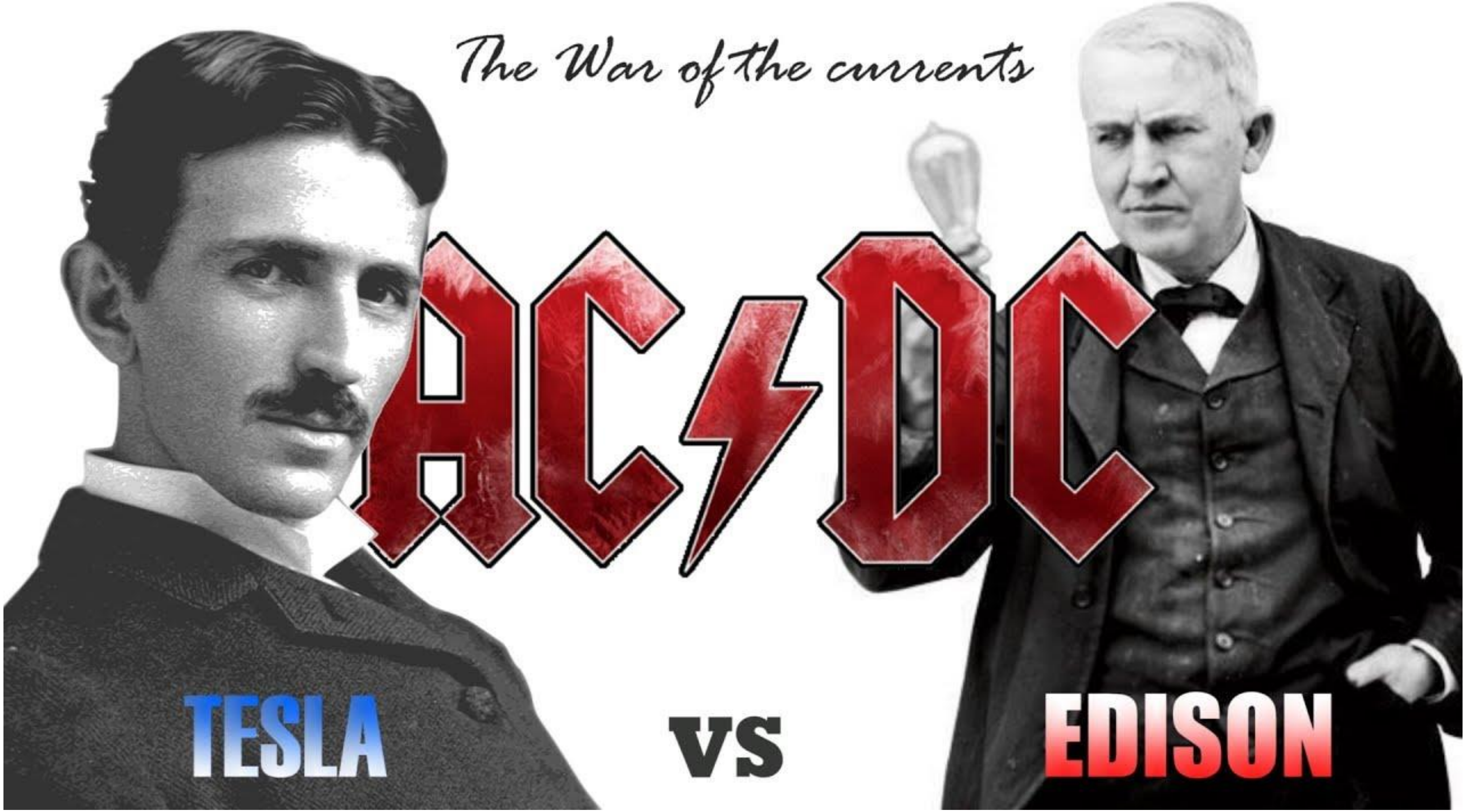
Syllabus

Unit I

Fundamentals of D.C. circuits : resistance, inductance, capacitance, voltage, current, power and energy concepts, ohm's law, Kirchhoff's laws, basic method of circuit analysis, intuitive method of circuit analysis- series and parallel simplification, voltage division rule, current division rule, star–delta transformation, mesh and nodal analysis, introduction to dependent and independent sources, network theorems- superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem

Unit II

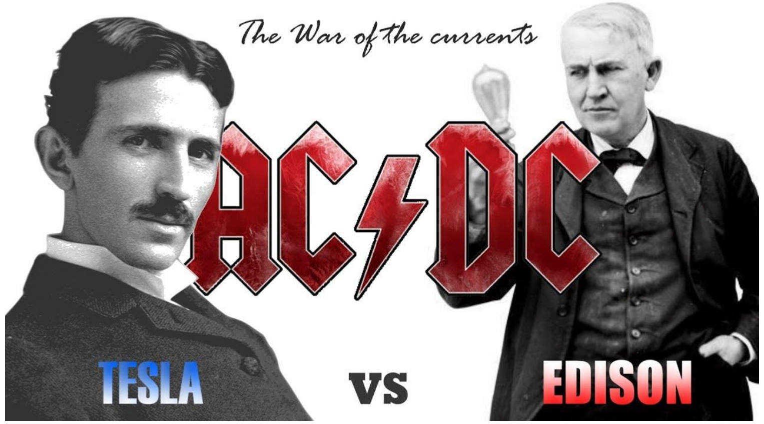
Fundamentals of A.C. circuits : alternating current and voltage, concept of notations (i, v, I, V), definitions of amplitude, phase, phase difference, RMS value and average value of an AC signal, complex representation of impedance, steady state analysis of ac circuits consisting of RL, RC and RLC (series), resonance in series RLC circuit, power factor and power calculation in RL, RC and RLC circuits, three-phase circuits- numbering and interconnection (delta or mesh connection) of three phases, relations in line and phase voltages and currents in star and delta


The War of the currents
AC/DC
TESLA
VS
EDISON

Introduction

- Historically, dc sources were the main means of providing electric power up until the late 1800s.
- At the end of that century, the battle of direct current versus alternating current began. Both had their advocates among the electrical engineers of the time.
- Because ac is more efficient and economical to transmit over long distances, ac systems ended up the winner.

DC	AC
Cannot be transmitted to longer distances because of the losses.	Safe to transfer over longer city distances
It flows in one direction in the circuit.	It reverses its direction while flowing in a circuit.
Magnitude of current or voltage does not vary with time	Magnitude of current or voltage does not vary with time
Electrons move steadily in one direction only.	Electrons keep switching directions - forward and backward.
Power Factor is always 1	Power Factor lies between 0 & 1.
The frequency of direct current is zero.	The frequency of alternating current is 50Hz or 60Hz depending upon the country.
Example: Cell, Battery.	Example: Generator.



Terminologies used in AC Circuits

1. Peak value
2. Peak to Peak value
3. Instantaneous value
4. Average (Mean) value
5. Cycle
6. Frequency
7. Timeperiod
8. Phase
9. RMS value