Ministry of Higher Education and
Scientific Research
Southern Technical University
Basra Technical Institute
Department of Electrical Techniques

Learning package

Electrical Circuits

First Semester

For

First year students

By

M.Sc. Wasan Loay Jassim

2025

Course Description

Course Name:
Electrical Circuits /1
Semester / Year:
Semester
Description Preparation Date:
14/ 05/ 2025
Available Attendance Forms:
Attendance only
Number of Credit Hours (Total)
30 hours/2 hours weekly
Course administrator's name (mention all, if more than one name)
Name: Ms.c. Wasan Loay Jassim Email: wasan.loay@stu.edu.iq
Course Objectives
1. To understand the fundamental principles of electricity and circuit behavior. 2. To analyze and design basic electrical circuits using laws such as Ohm's Law and Kirchhoff's Laws. 3. To gain practical skills in building and troubleshooting electrical circuits. 4. To prepare for advanced topics in electronics, power systems, and control engineering. 5. To develop problem-solving and critical-thinking skills related to electrical systems. 6. To understand the role of components like resistors, capacitors, inductors, and power sources. 7. To enable safe and efficient use of electrical equipment in the real world applications. 8. To support academic and professional growth in engineering and technology fields.
Teaching and Learning Strategies
1. Active Learning through Hands-on Experiments. 2. Inquiry-Based Learning. 3. Visual Aids and Circuit Diagrams. 4. Collaborative Learning and Group Projects.

Course Structure

Weeks	Hours	Required Learning Outcomes	Unit or subject name	Learning method	Evaluation method
1	2hours	1. Understand and explain fundamental electrical concepts. 2. Apply Ohm’s Law and Kirchhoff’s Laws. 3. Analyze series, parallel, and combination circuits. 4. Calculate total resistance, current distribution, and voltage drops in various circuit configurations. 5. Design and construct basic electrical circuits. 6. Measure electrical quantities accurately. 7. Interpret and draw circuit diagrams. 8. Demonstrate problem-solving and critical thinking skills.	1. Systems of Units, the elements effect of at resistance. 2. Ohm’s Law, Resistance connection. 3. Resistance connection. 4. Delta(Δ) - star (Y) Transformation. 5. Kirchhoff's laws. 6. Mesh analysis. 7. Thevenin’s theorem. 8. Norton’s Theorem 9. Supper position theorem. 10. Alternating current (A.C.). 11. Alternating Values. 12. The effect of alternating current on electrical circuits in series connection. 13. The effect of alternating current on electrical circuits in parallel connection. 14. series resonance. 15. parallel resonance.	1. Define basic electrical quantities. 2. Apply fundamental electrical laws. 3. Analyze different types of circuits. 4. Perform circuit calculations. 5. Use measurement tools correctly. 6. Interpret and construct circuit diagrams. 7. Build and test physical circuits.	Weekly, Monthly, Daily , and Written Exams, and Final Term Exam.
2	2hours				
3	2hours				
4	2hours				
5	2hours				
6	2hours				
7	2hours				
8	2hours				
9	2hours				
10	2hours				
11	2hours				
12	2hours				
13	2hours				
14	2hours				
15	2hours				

Course Evaluation

Distribution as follows: 20 points for Midterm Theoretical Exams for the first semester, 20 points for Midterm Practical Exams for the first semester, 10 points for Daily Exams and Continuous Assessment, 50 points for the Final Exam.

References

- **Electrical Technology (Edward Hughes).**
- **Basic Electrical Engineering (Fitzgerald and Rlgginborthan .**
- **Electrical Technology (B.L Theraja) .**
- **Introductory circuit Analysis by Robert L. Boylestad.**
- **Fundamental Electric circuits (David A . B ell).**
- **Basic circuits (A.M.F Brooks) pergaman press.**
- **Introduction to Electric circuits (M.Roman witz) John willy.**

Overview

A- Population target

- Students of first year of Department Electrical Techniques

B –Rationale

- It is very important to study Units system
- Also to study the elements effect of at resistance.

C – Central Idea

- Definition voltage, current, and resistance.
- Units' system
- The element effects resistance .

D- Aim of lecture : To let the student be able to identify the ana lyses different elements effect at the resistance value .

Pretest

1- **Define:-**

(Resistance, current, Potential difference, voltage).

2- **What are the factors that affect electrical resistance?**

3- **What is the meaning of the Ampere (A)?**

Solution

1. R (The appetite of material to oppose the flow of electrons, its unit is (Ω).

I (The electric current means the flout of electrons through the conductor)

Potential difference (The difference in potential between two points in an electrical system , its unit is volt (V)).

Volt (V) (The unit of measurement applied to the difference in potential between two points).

2. Material, Length, Cross-sectional area ,Temperature.

3. (A) : The unit of measurement applied to the flow of charge through a conductor.

Introduction

Electric circuit theory and electromagnetic theory are the two fundamental theories upon which all branches of electrical engineering are built. In electrical engineering, we are often interested in communicating or transferring energy from one point to another. To do this requires interconnection of electrical devices. Such interconnection is referred to as an electric circuit, and each component of the circuit is known as an element. An electric circuit is an interconnection of electrical elements. A simple electric circuit is shown in Fig. 1.1. It consists of three basic elements: a battery, a lamp, and connecting wires. Such a simple circuit can exist by itself; it has several applications, such as a flashlight, a search light, and so forth.

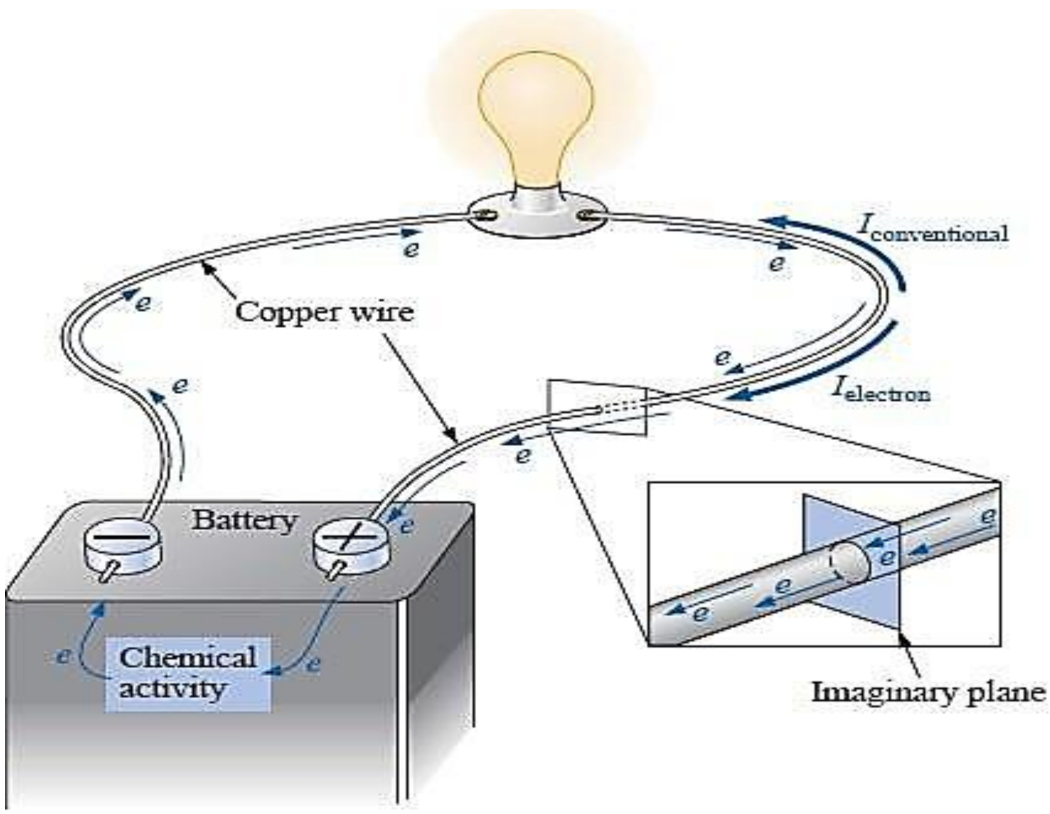


Fig. 1.1 A simple electric circuit.

1.1 Systems of Units

As electrical engineers, we deal with measurable quantities. Our measurement, however, must be communicated in a standard language that virtually all professionals can understand, irrespective of the country where the measurement is conducted. Such an international measurement language is the International System of Units (SI), adopted by the General

Conference on Weights and Measures in 1960. In this system, the units of all other physical quantities can be derived from seven principal units. Table 1.1 shows the six units and one derived unit that are relevant to this text. The SI units are used throughout this text.

One great advantage of the SI unit is that it uses prefixes based on the power of 10 to relate larger and smaller units to the basic unit. Table 1.2 shows the SI prefixes and their symbols. For example, the following are expressions of the same distance in meters (m):

600,000,000 mm   600,000 m   600 km

TABLE 1.1

Six basic SI units and one derived unit relevant to this text.

Quantity	Basic unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Charge	coulomb	C

TABLE 1.2

The SI prefixes.

Multiplier	Prefix	Symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

Example 1

a. Convert 20 kHz to megahertz.
b. Convert 0.01 ms to microseconds.
c. Convert 0.002 km to millimeters.

Solutions:

a. In the power-of-ten format:

$$20 \text{ kHz} = 20 \times 10^3 \text{ Hz}$$

The conversion requires that we find the multiplying factor to appear in the space below:

Increase by 3

$$20 \times 10^3 \text{ Hz} \Rightarrow \_\_\_ \times 10^6 \text{ Hz}$$

Decrease by 3

Since the power of ten will be *increased* by a factor of *three*, the multiplying factor must be *decreased* by moving the decimal point *three* places to the left, as shown below:

$$\underbrace{020.}_{3} = 0.02$$

and $$20 \times 10^3 \text{ Hz} = 0.02 \times 10^6 \text{ Hz} = \mathbf{0.02\ MHz}$$

b. In the power-of-ten format:

$$0.01 \text{ ms} = 0.01 \times 10^{-3} \text{ s}$$

Reduce by 3

and $$0.01 \times 10^{-3} \text{ s} = \_\_\_ \times 10^{-6} \text{ s}$$

Increase by 3

Since the power of ten will be *reduced* by a factor of three, the multiplying factor must be *increased* by moving the decimal point three places to the right, as follows:

$$0.010 = 10 \quad (3)$$

and $\qquad 0.01 \times 10^{-3}\ \text{s} = 10 \times 10^{-6}\ \text{s} = \mathbf{10\ \mu s}$

There is a tendency when comparing -3 to -6 to think that the power of ten has increased, but keep in mind when making your judgment about increasing or decreasing the magnitude of the multiplier that 10^{-6} is a great deal smaller than 10^{-3}.

c.

Reduce by 6

$$0.002 \times 10^{3}\ \text{m} \Rightarrow \_\_\_ \times 10^{-3}\ \text{m}$$

Increase by 6

In this example we have to be very careful because the difference between $+3$ and -3 is a factor of 6, requiring that the multiplying factor be modified as follows:

$$0.002000 = 2000 \quad (6)$$

and $\qquad 0.002 \times 10^{3}\ \text{m} = 2000 \times 10^{-3}\ \text{m} = \mathbf{2000\ mm}$

1.2 Charge and Current

The concept of electric charge is the underlying principle for explaining all electrical phenomena. In addition, the most basic quantity in an electric circuit is the electric charge. We all experience the effect of electric charge when we try to remove our wool sweater and have it stick to our body or walk across a carpet and receive a shock.

Charge is an electrical property of the atomic particles of which matter consists, measured in coulombs (C).

Electric current is the time rate of change of charge, measured in amperes (A).

If $6.242 * 10^{18}$ electrons drift at uniform velocity through the imaginary circular cross section of Fig. 1.1 in 1 second, the flow of charge, or current, is said to be 1 ampere (A)

$$\text{Charge/electron} = Q_e = \frac{1\ \text{C}}{6.242 \times 10^{18}} = 1.6 \times 10^{-19}\ \text{C}$$

The current in amperes can now be calculated using the following equation:

$$\boxed{I = \frac{Q}{t}} \qquad \begin{aligned} I &= \text{amperes (A)} \\ Q &= \text{coulombs (C)} \\ t &= \text{seconds (s)} \end{aligned} \qquad (1.1)$$

$$\boxed{Q = It} \qquad \text{(coulombs, C)} \qquad 1.2$$

and

$$\boxed{t = \frac{Q}{I}} \qquad \text{(seconds, s)} \qquad 1.3$$

Example 2 The charge flowing through the imaginary surface of Fig. 1.1 is 0.16 C every 64 ms. Determine the current in amperes.

Solution:

$$I = \frac{Q}{t} = \frac{0.16\ \text{C}}{64 \times 10^{-3}\ \text{s}} = \frac{160 \times 10^{-3}\ \text{C}}{64 \times 10^{-3}\ \text{s}} = \mathbf{2.50\ A}$$

Example 3 Determine the time required for ($4 * 10^{16}$) electrons to pass through the imaginary surface of Fig. 1.1 if the current is 5 mA.

Solution:

$$4 \times 10^{16}\ \text{electrons} \left(\frac{1\ \text{C}}{6.242 \times 10^{18}\ \text{electrons}} \right) = 0.641 \times 10^{-2}\ \text{C}$$

$$= 0.00641\ \text{C} = 6.41\ \text{mC}$$

$$t = \frac{Q}{I} = \frac{6.41 \times 10^{-3}\ \text{C}}{5 \times 10^{-3}\ \text{A}} = \mathbf{1.282\ s}$$

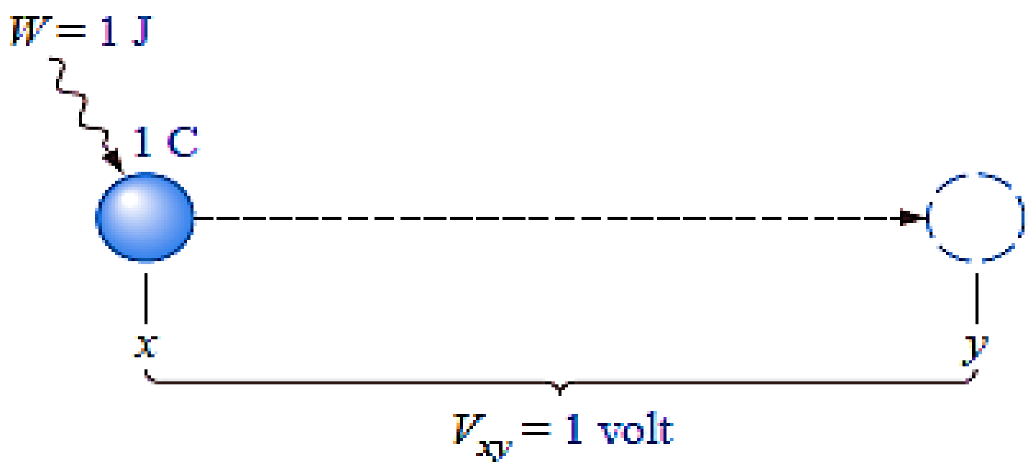
1.3 VOLTAGE

Charge can be raised to a higher potential level through the expenditure of energy from an external source, or it can lose potential energy as it travels through an electrical system. In any case, by definition:

A potential difference of 1 volt (V) exists between two points if 1 joule (J) of energy is exchanged in moving 1 coulomb (C) of charge between the two points.

The unit of measurement volt was chosen to honor Alessandro Volta.

a potential difference or voltage is always measured between two points in the system. Changing either point may change the potential difference between the two points under investigation.



In general, the potential difference between two points is determined by :

$$V = \frac{W}{Q} \quad \text{(volts)} \qquad (1.4)$$

Through algebraic manipulations, we have

$$W = QV \quad \text{(joules)} \qquad (1.5)$$

and

$$Q = \frac{W}{V} \quad \text{(coulombs)} \qquad (1.6)$$

Example 4 Find the potential difference between two points in an electrical system if 60 J of energy are expended by a charge of 20 C between these two points.

Solution: equ. 1.4

$$V = \frac{W}{Q} = \frac{60\ \text{J}}{20\ \text{C}} = \mathbf{3\ V}$$

Example 5 Determine the energy expended moving a charge of 50 μC through a potential difference of 6 V.

Solution : equ. 1.5

$$W = QV = (50 \times 10^{-6}\ \text{C})(6\ \text{V}) = 300 \times 10^{-6}\ \text{J} = \mathbf{300\ \mu J}$$

1.4 Resistance

The flow of charge through any material encounters an opposing force similar in many respects to mechanical friction. This opposition, due to the collisions between electrons and

between electrons and other atoms in the material, which converts electrical energy into another form of energy such as heat, is called the resistance of the material. The unit of measurement of resistance is the ohm, for which the symbol is **Ω**, the capital Greek letter omega. The resistance of any material with a uniform cross-sectional area is determined by the following four factors:

1. Material
2. Length
3. Cross-sectional area
4. Temperature

At a fixed temperature of 20°C (room temperature), the resistance is related to the other three factors by

$$R = \rho \frac{l}{A} \quad \text{(ohms, } \Omega) \qquad \mathbf{(1.7)}$$

Example 6 Determine the resistance of 100 ft. of copper telephone wire if the diameter is 0.0126 in.

solution:

$$l = 100\,\text{ft}\left(\frac{12\text{ in.}}{1\text{ ft}}\right)\left(\frac{2.54\text{ cm}}{1\text{ in.}}\right) = 3048\text{ cm}$$

$$d = 0.0126\text{ in.}\left(\frac{2.54\text{ cm}}{1\text{ in.}}\right) = 0.032\text{ cm}$$

Therefore,

$$A = \frac{\pi d^2}{4} = \frac{(3.1416)(0.032\text{ cm})^2}{4} = 8.04 \times 10^{-4}\text{ cm}^2$$

$$R = \rho\frac{l}{A} = \frac{(1.723 \times 10^{-6}\ \Omega\cdot\text{cm})(3048\text{ cm})}{8.04 \times 10^{-4}\text{ cm}^2} \cong \mathbf{6.5\ \Omega}$$

Homework

1. **Convert 0.002Km to mm.**
2. **Calculate the resistance of copper wire having a length of (1Km) and diameter (0.5mm) (Resistivity of copper = 1.7 x 10^{-8} Ω.m).**
3. **Determine the time required for (50x10^{3} C) to pass through the imaginary surface if the current is 5 mA.**

(The second and third weeks)

Ohm’s Law, Resistances connection

Overview

A- Population target

- Students of first year
of
Department Electrical Techniques

B –Rationale

- **It is very important to study**

  Resistances connection:

  (Series circuit, Parallel circuits, and complex connections)

- **Also, to study Voltage divider rules, Ohms, law.**

C – Central Idea

- **Connect the resistance as series, parallel, and complex.**
- **Voltage divider rule, the current divider rule.**
- **Ohms' law.**

D- Aim of lecture :

To let the student be able to identify the analyses different kinds of resistance connection (series, parallel ,complex)

Pretest

1) If number of resistances connection in series write total voltage , current laws .

2) If number of resistances connection in Parallel wrights' total voltage , current laws .

solution

1) $V_T = V_1 + V_2 + \ldots + V_n$, $I_T = I_1 = I_2 = {}_n$

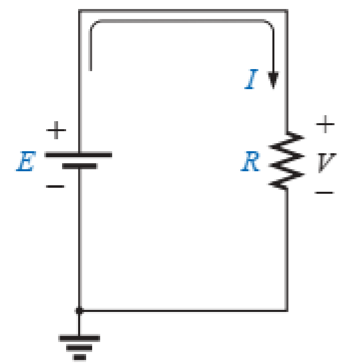
2) $I_T = I_1 + I_2 + \ldots + I_n$, $V_T = V_1 = V_2 = {}_n$

Ohm's Law

Georg Simon Ohm (1787–1854), a German physicist, is credited with finding the relationship between current and voltage for a resistor. This relationship is known as Ohm's law. Ohm's law states that the voltage V across a resistor is directly proportional to the current I flowing through the resistor.

$$\text{Current} = \frac{\text{potential difference}}{\text{resistance}}$$

and $$I = \frac{E}{R} \quad \text{(amperes, A)} \qquad (2.1)$$

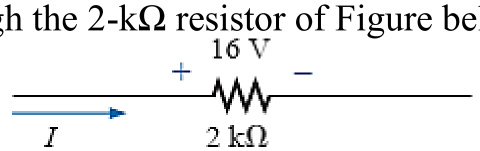


$$E = IR \quad \text{(volts, V)}$$

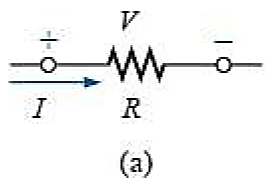
and $$R = \frac{E}{I} \quad \text{(ohms, }\Omega\text{)} \qquad (2.2)$$

EXAMPLE 1 : Calculate the current through the 2-kΩ resistor of Figure below if the voltage drop across it is 16 V.

$$I = \frac{V}{R} = \frac{16\ \text{V}}{2 \times 10^3\ \Omega} = \mathbf{8\ mA}$$



For an isolated resistive element, the polarity of the voltage drop is as shown in Fig. 4.3(a) for the indicated current direction. A reversal in current will reverse the polarity, as shown in Fig. 4.3(b). In general, the flow of charge is from a high (+) to a low (-) potential. Polarities as established by current direction will become increasingly important in the analysis to follow.



A short circuit is a circuit element with resistance approaching zero.

An open circuit is a circuit element with resistance approaching infinity.

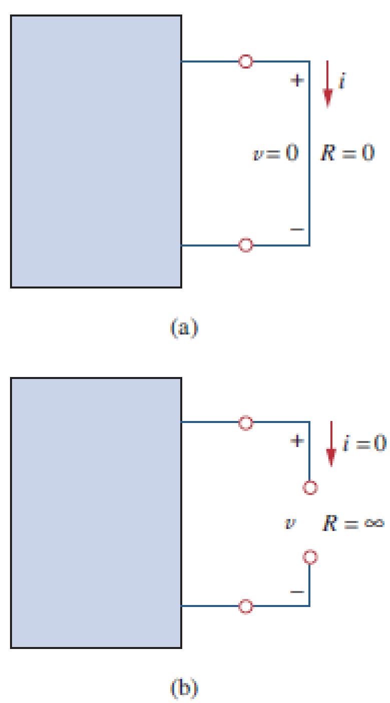


Figure 2.1

(a) Short circuit (R=0)   , (b) Open circuit (R = ∞).

A useful quantity in circuit analysis is the reciprocal of resistance R, known as conductance and denoted by G:

$$G = \frac{1}{R} = \frac{i}{v} \qquad (2.3)$$

Conductance is the ability of an element to conduct electric current; it is measured in mhos (℧) or siemens (S).

$$i = Gv \qquad (2.4)$$

The power dissipated by a resistor can be expressed in terms of R.

$$p = vi = i^2R = \frac{v^2}{R} \quad \textbf{watts} \qquad (2.5)$$

The power dissipated by a resistor may also be expressed in terms of *G* as

$$p = vi = v^2G = \frac{i^2}{G} \quad \textbf{watts} \qquad (2.6)$$

The Power delivered from the source is

$$P = EI \qquad \text{(watts)} \qquad (2.7)$$

with E the battery terminal voltage and I the current through the source.

EXAMPLE 2: Determine the current through a 5-kΩ resistor when the power dissipated by the element is 20 mW.

Solution:

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{20 \times 10^{-3}\,\text{W}}{5 \times 10^{3}\,\Omega}} = \sqrt{4 \times 10^{-6}} = 2 \times 10^{-3}\,\text{A}$$

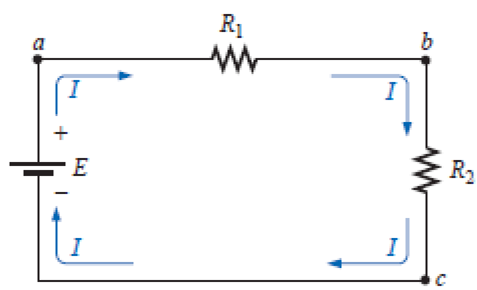
$$= \textbf{2 mA}$$

2.2 Series Circuits

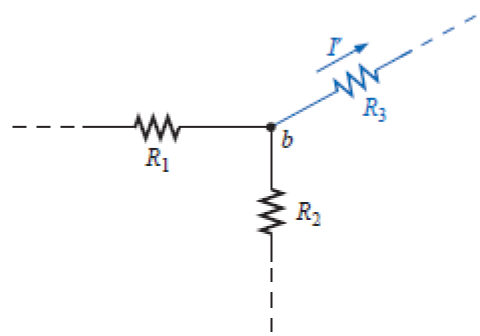
A circuit consists of any number of elements joined at terminal points, providing at least one closed path through which charge can flow. The circuit of Fig. 2.2(a) has three elements joined at three terminal points (a, b, and c) to provide a closed path for the current I.

Two elements are in series if

***1.* They have only one terminal in common (i.e., one lead of one is connected to only one lead of the other).**
***2.* The common point between the two elements is not connected to another current-carrying element.**



(a) series circuit



(b) R1 and R2 not in series

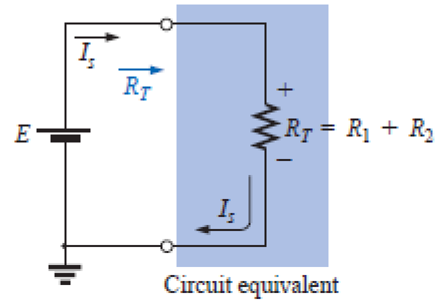
Figure 2.2

In general, to find the total resistance of N resistors in series, the following equation is applied:

$$R_T = R_1 + R_2 + R_3 + \cdots + R_N \quad \text{(ohms, } \Omega\text{)} \qquad \textbf{(2.8)}$$

The current drawn from the source can be determined using Ohm's law, as follows:

$$I_s = \frac{E}{R_T} \quad \text{(amperes, A)} \qquad \textbf{(2.9)}$$



The fact that the current is the same through each element of Fig. 2.2 (a) permits a direct calculation of the voltage across each resistor using Ohm's law; that is,

$$V_1 = IR_1,\ V_2 = IR_2,\ V_3 = IR_3,\ \ldots,\ V_N = IR_N \quad \text{(volts, V)} \qquad \textbf{(2.10)}$$

2.3 Parallel Circuits

Two network configurations, series and parallel, form the framework for some of the most complex network structures. A clear understanding of each will pay enormous dividends as more complex methods and networks are examined. We will now examine the parallel circuit and all the methods and laws associated with this important configuration.

Two elements, branches, or networks are in parallel if they have two points in common.

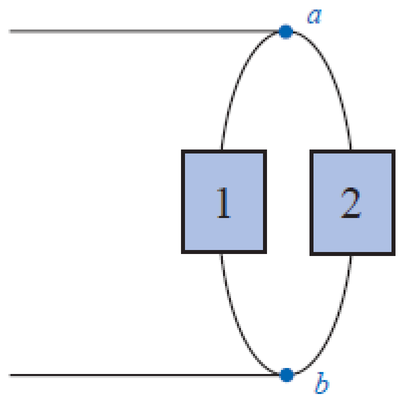


Figure 2.3 Parallel elements.

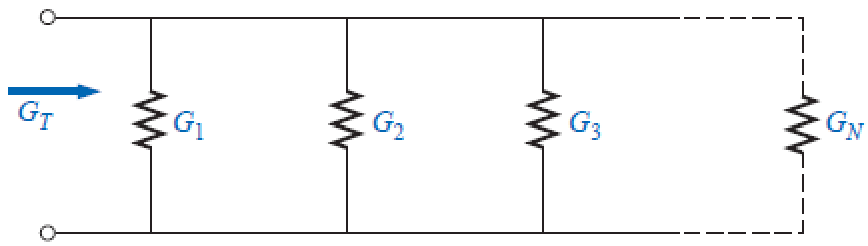


Figure 2.4 determining the total conductance of parallel conductances.

For parallel elements, the total conductance is the sum of the individual conductances.

$$G_T = G_1 + G_2 + G_3 + \cdots + G_N \qquad \textbf{(2.11)}$$

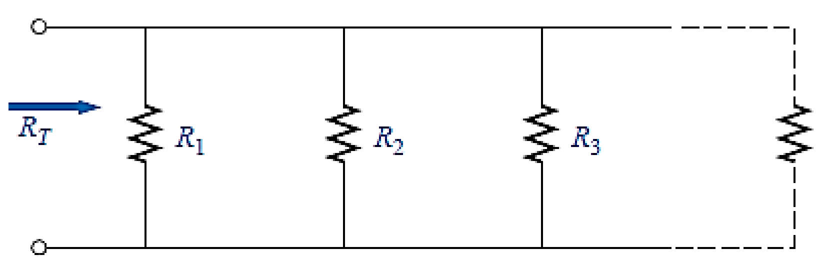
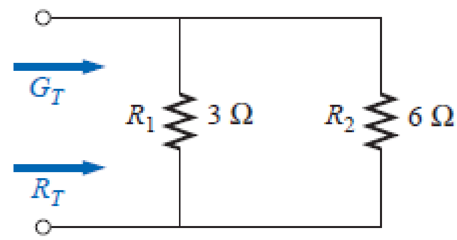


Figure 2.5 Determining the total resistance of parallel resistors.

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_N} \quad \textbf{(2.12)}$$

EXAMPLE 4 Determine the total conductance and resistance for the parallel network of Fig. 2.5.



solution

$$G_T = G_1 + G_2 = \frac{1}{3\ \Omega} + \frac{1}{6\ \Omega} = 0.333\ \text{S} + 0.167\ \text{S} = \mathbf{0.5\ S}$$

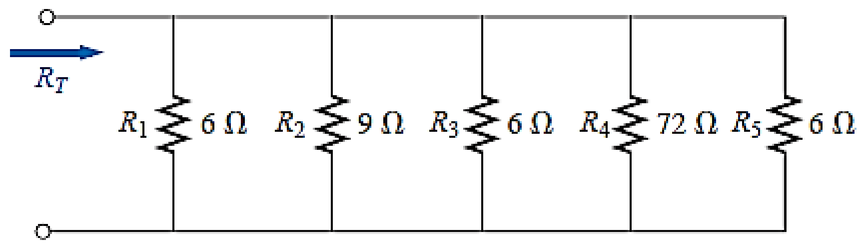
and

$$R_T = \frac{1}{G_T} = \frac{1}{0.5\ \text{S}} = \mathbf{2\ \Omega}$$

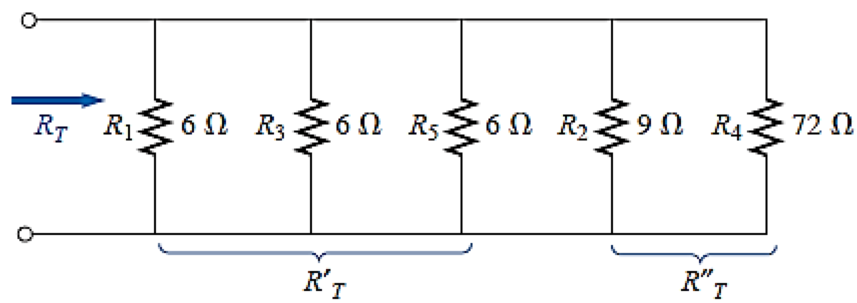
the total resistance of two parallel resistors is the product of the two divided by their sum.

$$R_T = \frac{R_1 R_2}{R_1 + R_2} \quad \textbf{(2.13)}$$

EXAMPLE 5 Calculate the total resistance of the parallel network of Fig. below ??



Solution: The network is redrawn in Fig. below :



$$R'_T = \frac{R}{N} = \frac{6\ \Omega}{3} = 2\ \Omega$$

$$R''_T = \frac{R_2 R_4}{R_2 + R_4} = \frac{(9\ \Omega)(72\ \Omega)}{9\ \Omega + 72\ \Omega} = \frac{648\ \Omega}{81} = 8\ \Omega$$

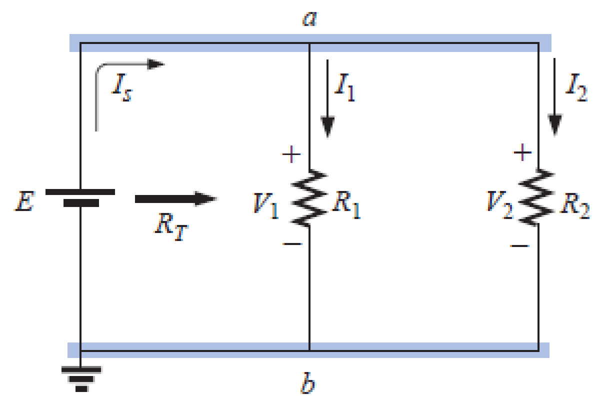
and $$R_T = R'_T \parallel R''_T$$

In parallel with

$$= \frac{R'_T R''_T}{R'_T + R''_T} = \frac{(2\ \Omega)(8\ \Omega)}{2\ \Omega + 8\ \Omega} = \frac{16\ \Omega}{10} = \mathbf{1.6\ \Omega}$$

PARALLEL CIRCUITS

The network below is the simplest of parallel circuits. All the elements have terminals a and b in common. The total resistance is determined by RT = R1R2 /(R1 + R2), and the source current by Is = E/RT. Throughout the text, the subscript s will be used to denote a property of the source. Since the terminals of the battery are connected directly across the resistors R1 and R2, the following should be obvious:



The voltage across parallel elements is the same. Using this fact will result in:

$$V_1 = V_2 = E$$

and
$$I_1 = \frac{V_1}{R_1} = \frac{E}{R_1}$$

with
$$I_2 = \frac{V_2}{R_2} = \frac{E}{R_2}$$

If we take the equation for the total resistance and multiply both sides by the applied voltage, we obtain

$$E\left(\frac{1}{R_T}\right) = E\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

and
$$\frac{E}{R_T} = \frac{E}{R_1} + \frac{E}{R_2}$$

Substituting the Ohm's law relationships appearing above, we find that the source current

$$I_s = I_1 + I_2$$

permitting the following conclusion:

For single-source parallel networks, the source current (I_s) is equal to the sum of the individual branch currents.

The power dissipated by the resistors and delivered by the source can be determined from

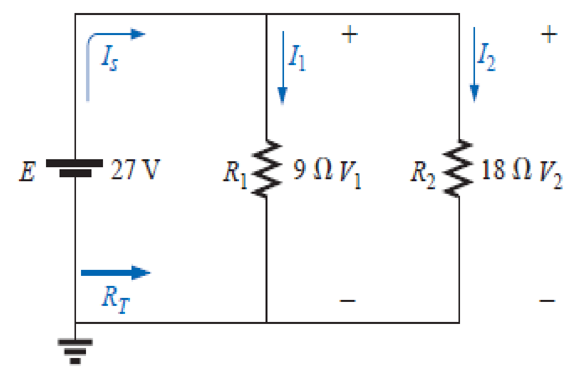
$$P_1 = V_1 I_1 = I_1^2 R_1 = \frac{V_1^2}{R_1}$$

$$P_2 = V_2 I_2 = I_2^2 R_2 = \frac{V_2^2}{R_2}$$

$$P_s = E I_s = I_s^2 R_T = \frac{E^2}{R_T}$$

Example 1:

a. Calculate R_T.
b. Determine I_s.
c. Calculate I_1 and I_2, and demonstrate that $I_s = I_1 + I_2$.
d. Determine the power to each resistive load.
e. Determine the power delivered by the source, and compare it to the total power dissipated by the resistive elements.



Solutions:

a. $R_T = \dfrac{R_1 R_2}{R_1 + R_2} = \dfrac{(9\ \Omega)(18\ \Omega)}{9\ \Omega + 18\ \Omega} = \dfrac{162\ \Omega}{27} = \mathbf{6\ \Omega}$

b. $I_s = \dfrac{E}{R_T} = \dfrac{27\ \text{V}}{6\ \Omega} = \mathbf{4.5\ A}$

c. $I_1 = \frac{V_1}{R_1} = \frac{E}{R_1} = \frac{27\text{ V}}{9\ \Omega} = \mathbf{3\ A}$

$I_2 = \frac{V_2}{R_2} = \frac{E}{R_2} = \frac{27\text{ V}}{18\ \Omega} = \mathbf{1.5\ A}$

$I_s = I_1 + I_2$

$4.5\text{ A} = 3\text{ A} + 1.5\text{ A}$

$\mathbf{4.5\ A} = \mathbf{4.5\ A}$ (checks)

d. $P_1 = V_1 I_1 = EI_1 = (27\text{ V})(3\text{ A}) = \mathbf{81\ W}$

$P_2 = V_2 I_2 = EI_2 = (27\text{ V})(1.5\text{ A}) = \mathbf{40.5\ W}$

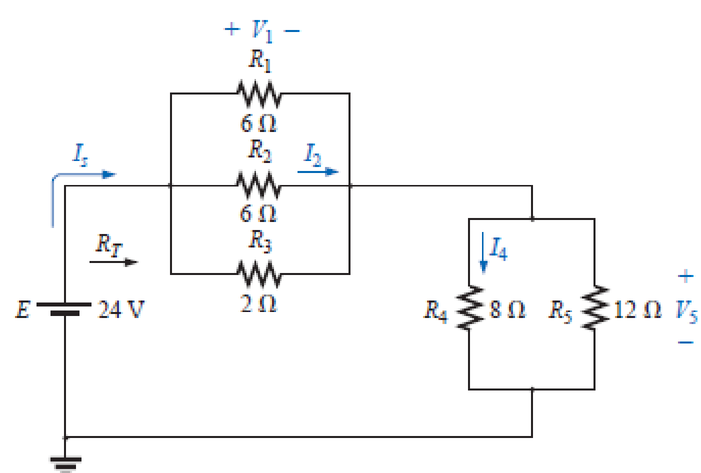
e. $P_s = EI_s = (27\text{ V})(4.5\text{ A}) = \mathbf{121.5\ W}$

$= P_1 + P_2 = 81\text{ W} + 40.5\text{ W} = \mathbf{121.5\ W}$

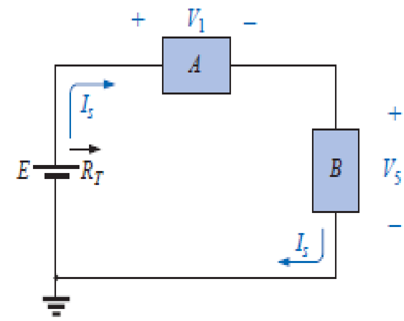
Series-Parallel Networks

Series-parallel networks are networks that contain both series and parallel circuit configurations.

EXAMPLE 2 Find the indicated currents and voltages for the network of Fig below ??



Solution:



$$R_{1\|2} = \frac{R}{N} = \frac{6\ \Omega}{2} = 3\ \Omega$$

$$R_A = R_{1\|2\|3} = \frac{(3\ \Omega)(2\ \Omega)}{3\ \Omega + 2\ \Omega} = \frac{6\ \Omega}{5} = 1.2\ \Omega$$

$$R_B = R_{4\|5} = \frac{(8\ \Omega)(12\ \Omega)}{8\ \Omega + 12\ \Omega} = \frac{96\ \Omega}{20} = 4.8\ \Omega$$

$$R_T = R_{1\|2\|3} + R_{4\|5} = 1.2\ \Omega + 4.8\ \Omega = \mathbf{6\ \Omega}$$

$$I_s = \frac{E}{R_T} = \frac{24\ \text{V}}{6\ \Omega} = \mathbf{4\ A}$$

with $V_1 = I_s R_{1\|2\|3} = (4\ \text{A})(1.2\ \Omega) = \mathbf{4.8\ V}$

$V_5 = I_s R_{4\|5} = (4\ \text{A})(4.8\ \Omega) = \mathbf{19.2\ V}$

Applying Ohm's law,

$$I_4 = \frac{V_5}{R_4} = \frac{19.2\ \text{V}}{8\ \Omega} = \mathbf{2.4\ A}$$

$$I_2 = \frac{V_2}{R_2} = \frac{V_1}{R_2} = \frac{4.8\ \text{V}}{6\ \Omega} = \mathbf{0.8\ A}$$

$$R_T = R_{1\|2\|3} + R_{4\|5} = 1.2\ \Omega + 4.8\ \Omega = \mathbf{6\ \Omega}$$

$$I_s = \frac{E}{R_T} = \frac{24\ \text{V}}{6\ \Omega} = \mathbf{4\ A}$$

with $V_1 = I_s R_{1\|2\|3} = (4\ \text{A})(1.2\ \Omega) = \mathbf{4.8\ V}$

$V_5 = I_s R_{4\|5} = (4\ \text{A})(4.8\ \Omega) = \mathbf{19.2\ V}$

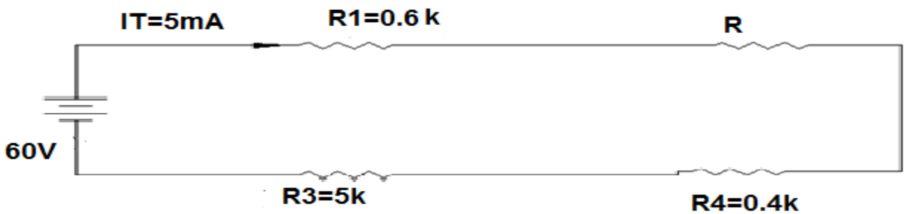
Applying Ohm's law,

$$I_4 = \frac{V_5}{R_4} = \frac{19.2\ \text{V}}{8\ \Omega} = \mathbf{2.4\ A}$$

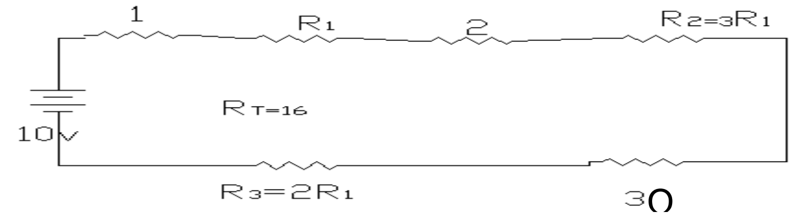
$$I_2 = \frac{V_2}{R_2} = \frac{V_1}{R_2} = \frac{4.8\ \text{V}}{6\ \Omega} = \mathbf{0.8\ A}$$

Posttest

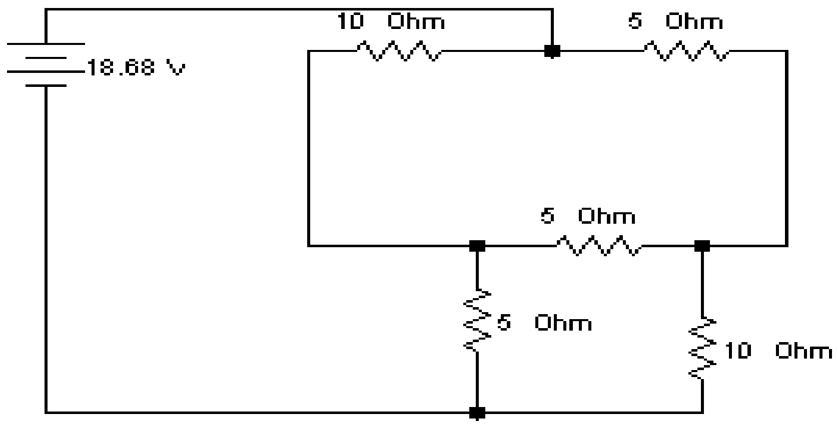
EX1/ For the CCT .shown find R_T .



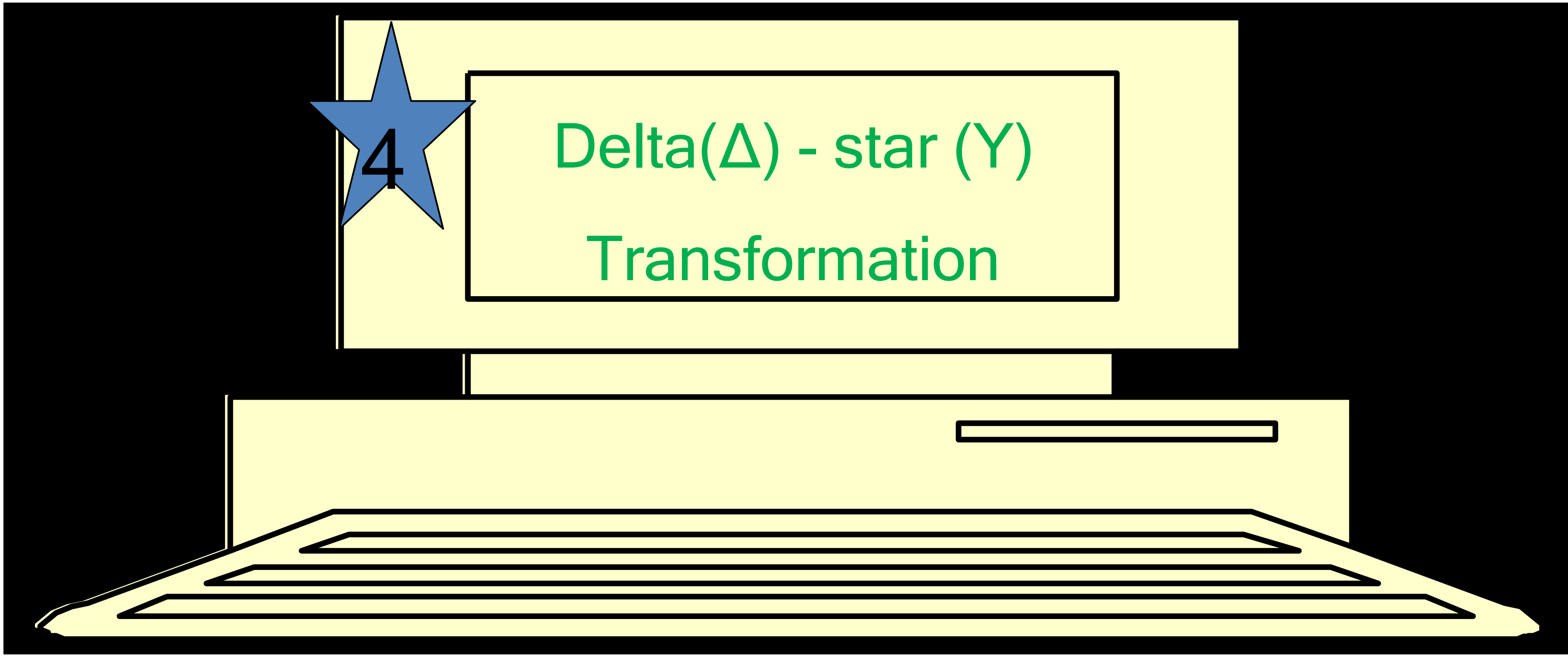
Ex2/ Find (R_1,I_T)



Ex3/ Find (I_T)



H.W.



(The fourth week)

Overview

A- Population target

- Students of first year
of
Department Electrical Techniques

B –Rationale

1. **Simplification of Circuit Analysis:**

Converting between Delta and Star configurations helps simplify complex three-phase circuits, especially when solving for current, voltage, or impedance.

2. **Facilitates Calculations:**

Certain circuit configurations are easier to analyze when transformed into an equivalent form. For example, star networks often allow easier calculation of line and phase values in power systems.

3. **Compatibility with System Design:**

Some equipment or loads are designed to be connected in either Delta or Star. Understanding the transformation ensures proper matching and compatibility in real-world systems.

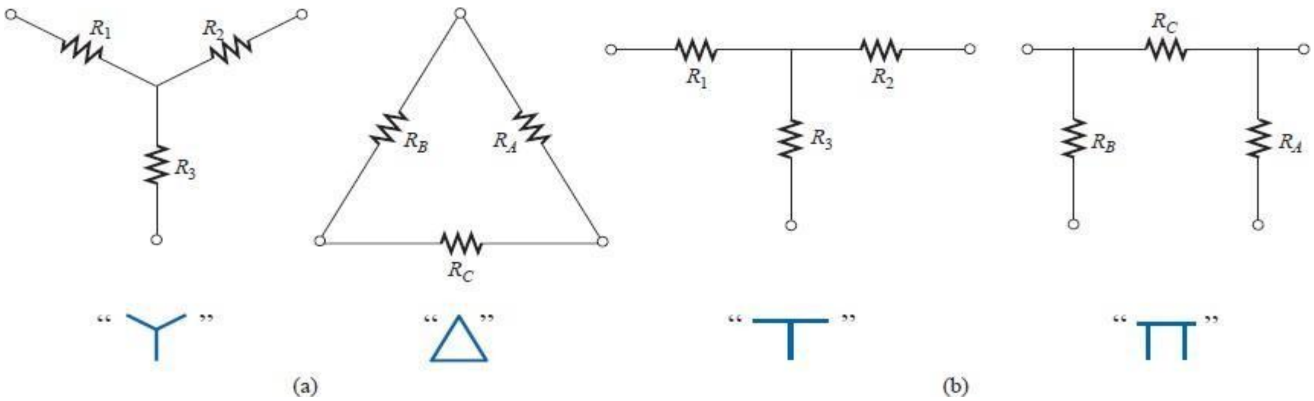
C – Central Idea

The transformation between Delta (Δ) and Star (Y) is essential f or simplifying the analysis and design of electrical circuits, especially in three-phase power systems.
It enables easier calculations, improves compatibility with different system components, and supports efficient and flexible electrical network operation.

D- Aim of lecture :

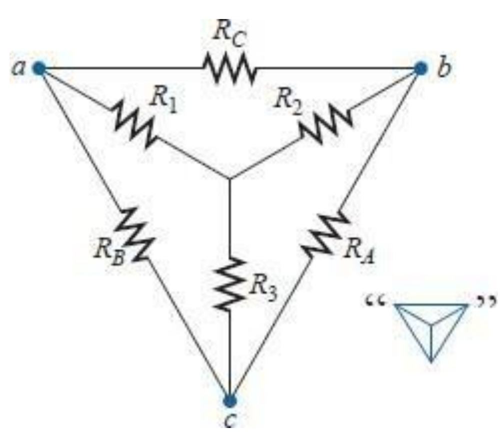
To let the student be able to identify Delta-to-Star (Δ-Y) and Star-to-Delta (Y-Δ) transformations is to simplify the analysis of complex electrical circuits, facilitate the calculation of voltages, currents, and impedances, and ensure proper configuration and operation of three-phase power systems for both balanced and unbalanced loads.

Circuit configurations are often encountered in which the resistors do not appear to be in series or parallel.



The Y (T) and D (p) configurations.

Under these conditions, it may be necessary to convert the circuit from one form to another to solve for any unknown quantities if mesh or nodal analysis is not applied. versa. Two circuit configurations that often account for these difficulties are the wye and delta configurations. They are also referred to as the tee (T) and pi (π), respectively,. Note that the pi is actually an inverted delta. The purpose of this section is to develop the equations for converting from D to Y, or vice



Introducing the concept of D-Y or Y-D conversions.

resulting in the following expression for R_3 in terms of R_A, R_B, and R_C:

$$R_3 = \frac{R_A R_B}{R_A + R_B + R_C} \qquad \textbf{(2.14)}$$

Following the same procedure for R_1 and R_2, we have

$$R_1 = \frac{R_B R_C}{R_A + R_B + R_C} \qquad \textbf{(2.15)}$$

and

$$R_2 = \frac{R_A R_C}{R_A + R_B + R_C} \qquad \textbf{(2.16)}$$

2. To obtain the relationships necessary to convert from a Y to a D

and

$$R_C = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_3} \qquad \textbf{(2.17)}$$

We follow the same procedure for R_B and R_A:

$$R_A = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_1} \qquad \textbf{(2.18)}$$

and

$$R_B = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_2} \qquad \textbf{(2.19)}$$

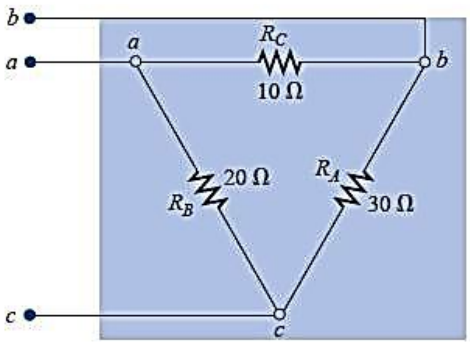
3. If R1 = R2 =R3 or RA = RB =RC

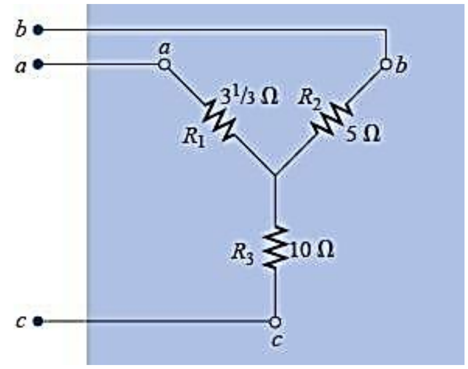
$$R_Y = \frac{R_\Delta}{3}$$

or

$$R_\Delta = 3R_Y$$

EXAMPLE 1 Convert the D of Fig. below to a Y .





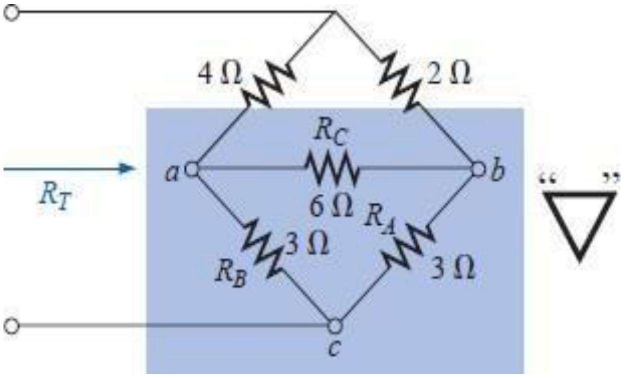
Solution:

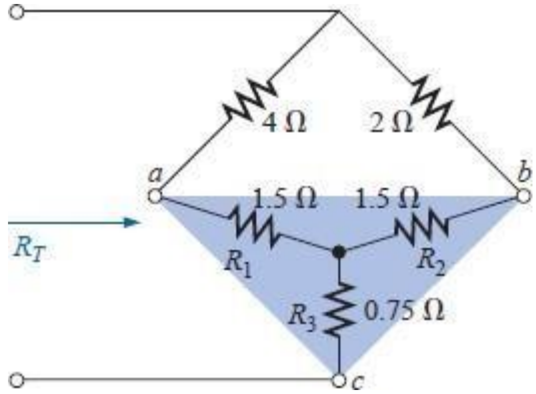
$$R_1 = \frac{R_B R_C}{R_A + R_B + R_C} = \frac{(20\ \Omega)(10\ \Omega)}{30\ \Omega + 20\ \Omega + 10\ \Omega} = \frac{200\ \Omega}{60} = \mathbf{3\tfrac{1}{3}\ \Omega}$$

$$R_2 = \frac{R_A R_C}{R_A + R_B + R_C} = \frac{(30\ \Omega)(10\ \Omega)}{60\ \Omega} = \frac{300\ \Omega}{60} = \mathbf{5\ \Omega}$$

$$R_3 = \frac{R_A R_B}{R_A + R_B + R_C} = \frac{(20\ \Omega)(30\ \Omega)}{60\ \Omega} = \frac{600\ \Omega}{60} = \mathbf{10\ \Omega}$$

EXAMPLE 2 Find the total resistor of figure below.





Solution:

Two resistors of the Δ were equal; therefore, two resistors of the Y will be equal.

$$R_1 = \frac{R_B R_C}{R_A + R_B + R_C} = \frac{(3\ \Omega)(6\ \Omega)}{3\ \Omega + 3\ \Omega + 6\ \Omega} = \frac{18\ \Omega}{12} = \mathbf{1.5\ \Omega}$$

$$R_2 = \frac{R_A R_C}{R_A + R_B + R_C} = \frac{(3\ \Omega)(6\ \Omega)}{12\ \Omega} = \frac{18\ \Omega}{12} = \mathbf{1.5\ \Omega}$$

$$R_3 = \frac{R_A R_B}{R_A + R_B + R_C} = \frac{(3\ \Omega)(3\ \Omega)}{12\ \Omega} = \frac{9\ \Omega}{12} = \mathbf{0.75\ \Omega}$$

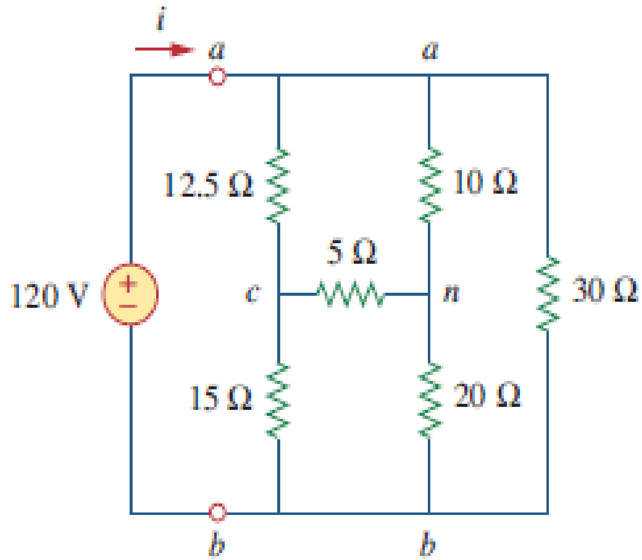
$$R_T = 0.75\ \Omega + \frac{(4\ \Omega + 1.5\ \Omega)(2\ \Omega + 1.5\ \Omega)}{(4\ \Omega + 1.5\ \Omega) + (2\ \Omega + 1.5\ \Omega)}$$

$$= 0.75\ \Omega + \frac{(5.5\ \Omega)(3.5\ \Omega)}{5.5\ \Omega + 3.5\ \Omega}$$

$$= 0.75\ \Omega + 2.139\ \Omega$$

$$R_T = \mathbf{2.889\ \Omega}$$

Example 3 : Obtain the equivalent resistance for the circuit in Figure below and use it to find current (i) .



Solution :

Attempt. In this circuit, there are two Y networks and three Δ networks. Transforming just one of these will simplify the circuit. If we convert the Y network comprising the 5-Ω, 10-Ω, and 20-Ω resistors, we may select

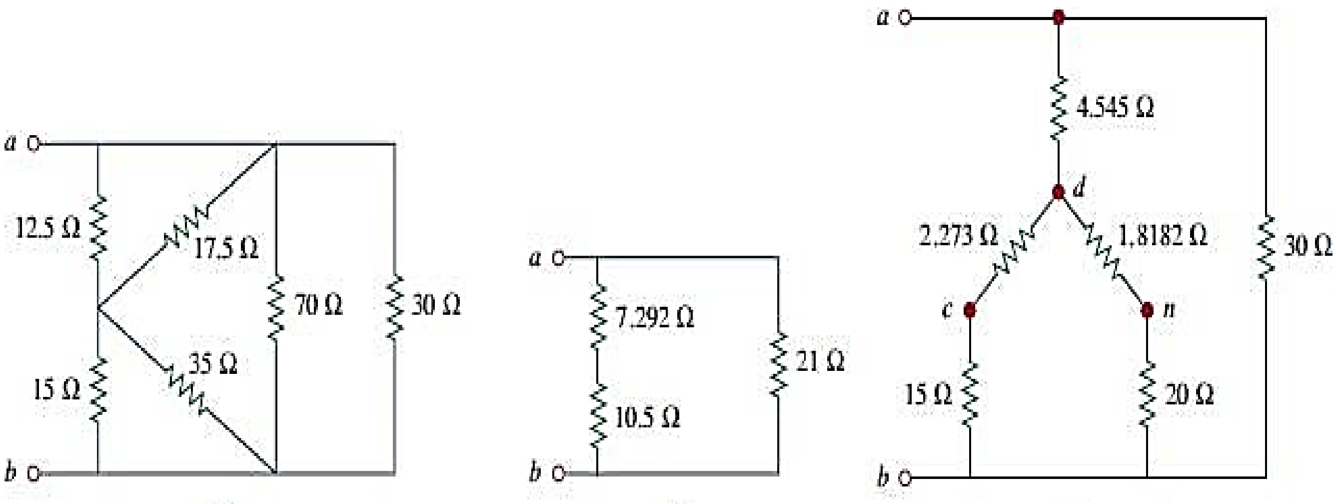
$$R_1 = 10\ \Omega, \qquad R_2 = 20\ \Omega, \qquad R_3 = 5\ \Omega$$

$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1} = \frac{10 \times 20 + 20 \times 5 + 5 \times 10}{10}$$

$$= \frac{350}{10} = 35\ \Omega$$

$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2} = \frac{350}{20} = 17.5\ \Omega$$

$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3} = \frac{350}{5} = 70\ \Omega$$



(a) (b) (c)

With the Y converted to Δ, the equivalent circuit (with the voltage source removed for now) is shown in Fig.**a**
Combining the three pairs of resistors in parallel, we obtain

$$70 \parallel 30 = \frac{70 \times 30}{70 + 30} = 21\ \Omega$$

$$12.5 \parallel 17.5 = \frac{12.5 \times 17.5}{12.5 + 17.5} = 7.292\ \Omega$$

$$15 \parallel 35 = \frac{15 \times 35}{15 + 35} = 10.5\ \Omega$$

so that the equivalent circuit is shown in Fig. 2.53(b). Hence, we find

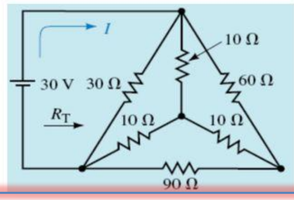
$$R_{ab} = (7.292 + 10.5) \parallel 21 = \frac{17.792 \times 21}{17.792 + 21} = \mathbf{9.632\ \Omega}$$

Then

$$i = \frac{v_s}{R_{ab}} = \frac{120}{9.632} = \mathbf{12.458\ A}$$

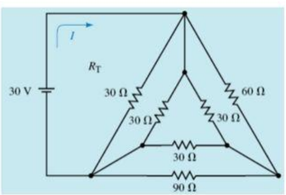
H.W.

Given the circuit of Figure, find the total resistance, RT, and the total current,I.



Solution:

□



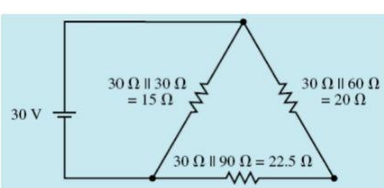
$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1},$$

□

And since that all the resistances have the same value 10

Then

□



5

(The fifth week)

Kirchhoff's Laws

over view

A- Population target

- Students of first year
of
Department Electrical Techniques

B –Rationale

- **It is very important to study Kirchhoff's laws**

C – Central Idea

- Definition Kirchhoff's current law in any electric point .
- Definition Kirchhoff's voltage law in any electric closed circuit .

D- Aim the lecture

To let the student be able to identify the analyses network by using Kirchhoff's laws .

Pretest

Define : electric Node(Point), electric closed circuit

Solution

Electric Node (Point):

An **electric node** (or simply **node**) is a point in an electrical circuit where **two or more components are connected**. It is a junction that allows the flow of electric current between those components.

- Example: The point where a resistor, a wire, and a capacitor meet in a circuit is a node.

Electric Closed Circuit:

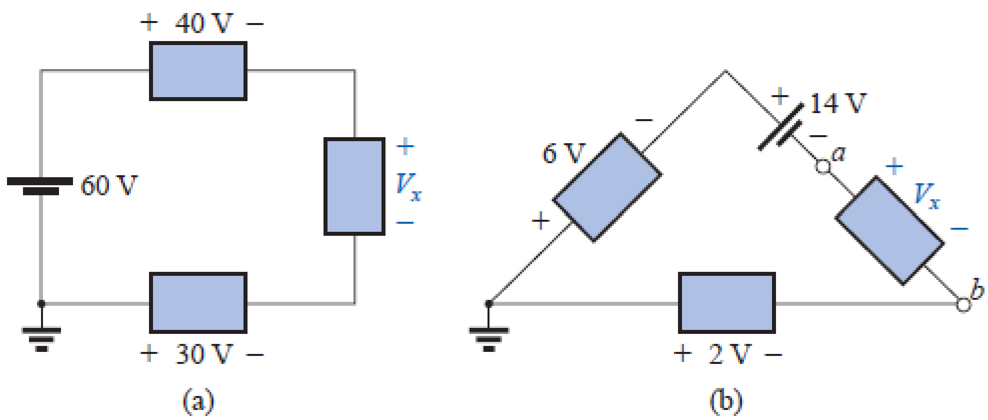
An **electric closed circuit** is a complete electrical connection where **current can flow uninterrupted** from the power source, through electrical components, and back to the power source.

- Key feature: There are **no breaks or open switches** in the path.
- Example: A battery connected to a bulb with wires, forming a loop, is a closed circuit if the bulb lights up.

1. KIRCHHOFF'S VOLTAGE LAW

Kirchhoff's voltage law (KVL) states that the algebraic sum of the potential rises and drops around a closed loop (or path) is zero. A closed loop is any continuous path that leaves a point in one direction and returns to that same point from another direction without leaving the circuit.

Example1 Using Kirchhoff's voltage law, determine the unknown voltages for the network of Fig. below .



Solution:

For Fig a

$$60\text{ V} - 40\text{ V} - V_x + 30\text{ V} = 0$$

and
$$V_x = 60\text{ V} + 30\text{ V} - 40\text{ V} = 90\text{ V} - 40\text{ V}$$
$$= \mathbf{50\text{ V}}$$

For Fig b

$$-6\text{ V} - 14\text{ V} - V_x + 2\text{ V} = 0$$

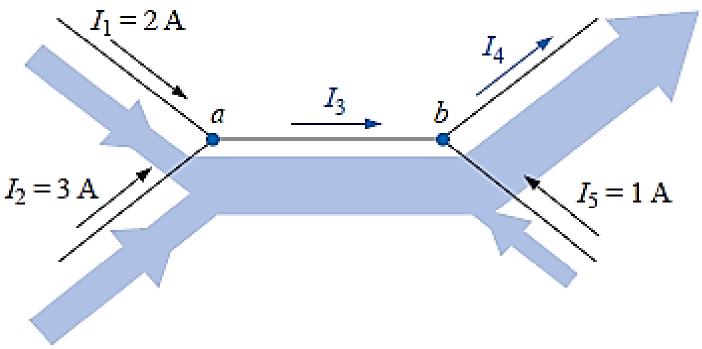
and
$$V_x = -20\text{ V} + 2\text{ V}$$
$$= \mathbf{-18\text{ V}}$$

2. KIRCHHOFF'S CURRENT LAW

the sum of the currents entering an area, system, or junction must equal the sum of the currents leaving the area, system, or junction.

$$\Sigma I_{\text{entering}} = \Sigma I_{\text{leaving}} \qquad (2.14)$$

Example1 Determine the currents I_3 and I_4 of Fig. below using Kirchhoff's current law ??



Solution:

At a:

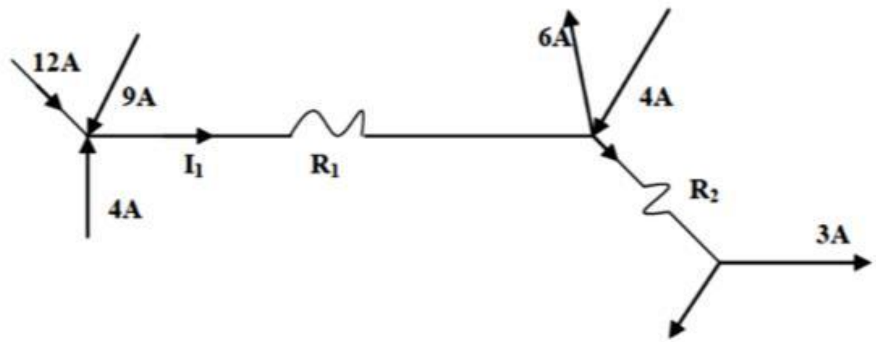
$$\begin{aligned} \Sigma I_{\text{entering}} &= \Sigma I_{\text{leaving}} \\ I_1 + I_2 &= I_3 \\ 2\text{ A} + 3\text{ A} &= I_3 \\ I_3 &= \mathbf{5\text{ A}} \end{aligned}$$

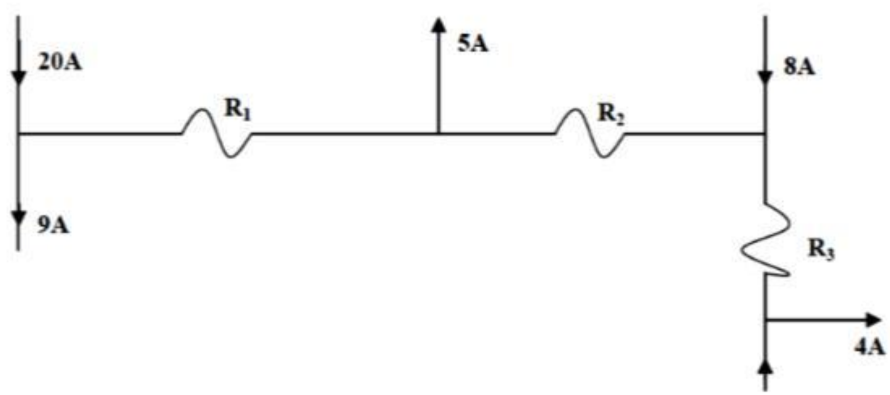
At b:

$$\begin{aligned} \Sigma I_{\text{entering}} &= \Sigma I_{\text{leaving}} \\ I_3 + I_5 &= I_4 \\ 5\text{ A} + 1\text{ A} &= I_4 \\ I_4 &= \mathbf{6\text{ A}} \end{aligned}$$

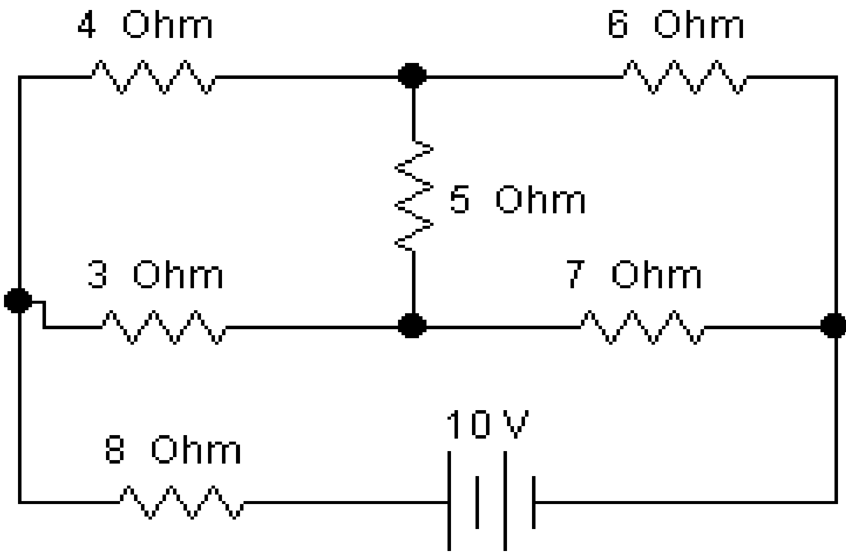
Example:

Find the unknown currents and their directions in the circuit shown below:

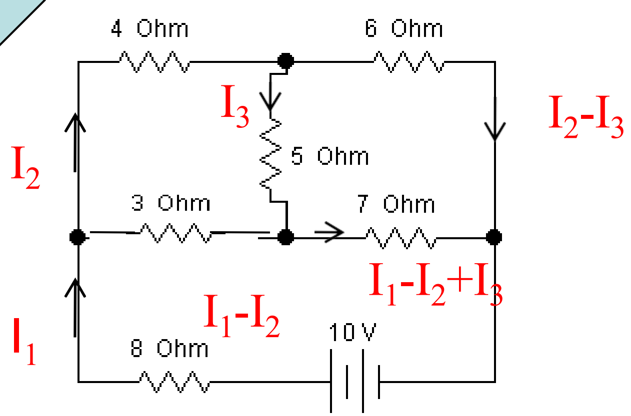




Posttest : ***Using Kirchhoff's theorem to calculate the current at each Resistance . (H.W)***



solution



$10=8I_1+3(I_1-I_2)+7(I_1-I_2+I_3)$

$\therefore 10=18I_1-10I_2+7I_3$ ....(1)

$0=4I_2+5I_3-3(I_1-I_2)$

$\therefore -3I_1+7I_2+5I_3=0$......(2)

$0=6(I_2-I_3)-7(I_1-I_2+I_3)-5I_3$

$\therefore 0=-7I_1+13I_2-18I_3$............(3)

6

Mesh method

(The 6th week)

over view

A- Population target

- Students of first year
of
Department Electrical Techniques

B –Rationale

- It is very important to study Mesh method.

C – Central Idea

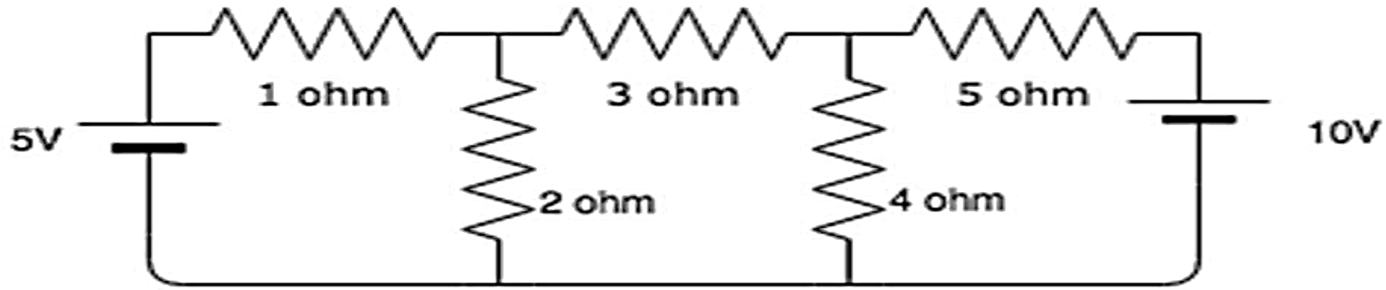
- The study of Mesh Theory focuses on using loop currents to simplify the analysis of electrical circuits, especially planar circuits. It allows for the systematic application of Kirchhoff's Voltage Law (KVL) to determine unknown currents in a circuit, making the analysis more efficient and organized.

D- Aim the lecture

To let the student be able to identify the analyses network by using Mesh analysis .

Pretest

1. Find the value of the currents I1, I2 and I3 flowing clockwise in the first, second and third mesh respectively.



a) 1.54A, -0.189A, -1.195A
b) 2.34A, -3.53A, -2.23A
c) 4.33A, 0.55A, 6.02A
d) -1.18A, -1.17A, -1.16A

Solution:

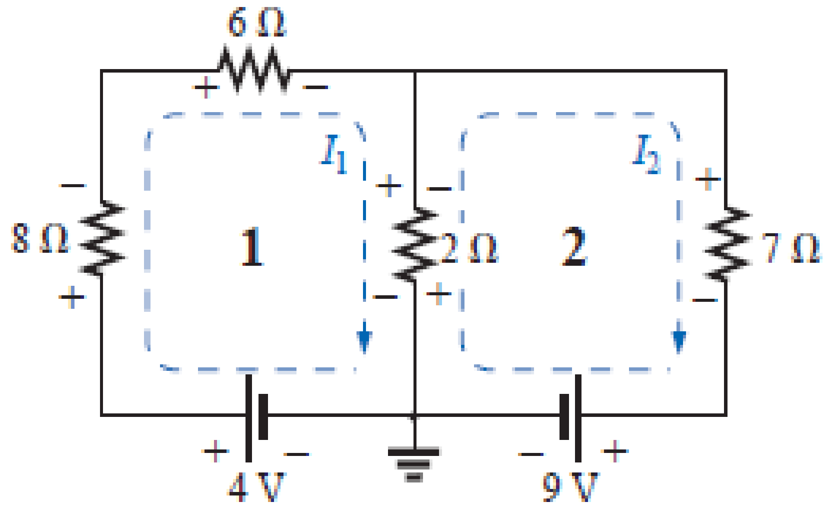
Answer: a
Explanation: The three mesh equations are:
-3I1+2I2-5=0
2I1-9I2+4I3=0
4I2-9I3-10=0
Solving the equations, we get I1= 1.54A, I2=-0.189 and I3= -1.195A.

Mesh analysis

Mesh analysis is also known as loop analysis or the mesh-current method. The mesh-analysis approach simply eliminates the need to substitute the results of Kirchhoff's current law into the equations derived from Kirchhoff's voltage law.

1. Assign a loop current to each independent, closed loop.
2. The number of required equations is equal to the number of chosen independent, closed loops.
3. The column to the right of the equality sign is the algebraic sum of the voltage sources through which the loop current of interest passes.
4. Solve the resulting simultaneous equations for the desired loop currents.

EXAMPLE 1:Write the mesh equations for the network of Fig. below, and find the current through the 7-Ω resistor.



Solution

$$I_1: \quad (8\,\Omega + 6\,\Omega + 2\,\Omega)I_1 - (2\,\Omega)I_2 = 4\text{ V}$$
$$I_2: \quad (7\,\Omega + 2\,\Omega)I_2 - (2\,\Omega)I_1 = -9\text{ V}$$

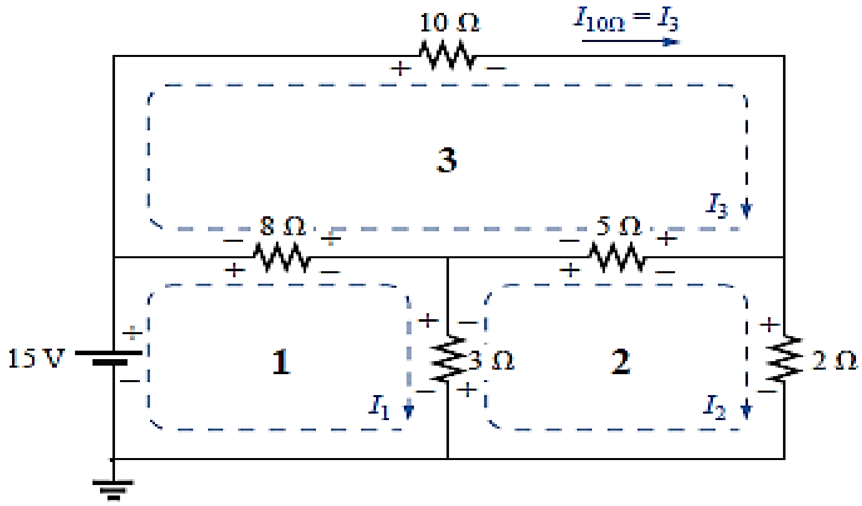
and
$$16I_1 - 2I_2 = 4$$
$$9I_2 - 2I_1 = -9$$

which, for determinants, are

$$16I_1 - 2I_2 = 4$$
$$-2I_1 + 9I_2 = -9$$

and
$$I_2 = I_{7\Omega} = \frac{\begin{vmatrix} 16 & 4 \\ -2 & -9 \end{vmatrix}}{\begin{vmatrix} 16 & -2 \\ -2 & 9 \end{vmatrix}} = \frac{-144 + 8}{144 - 4} = \frac{-136}{140}$$
$$= \mathbf{-0.971\ A}$$

EXAMPLE 2: Find the current through the 10-Ω resistor of the network of Figure below.



Solution:

$$
\begin{aligned}
I_1&: \quad (8\,\Omega + 3\,\Omega)I_1 - (8\,\Omega)I_3 - (3\,\Omega)I_2 = 15\text{ V} \\
I_2&: \quad (3\,\Omega + 5\,\Omega + 2\,\Omega)I_2 - (3\,\Omega)I_1 - (5\,\Omega)I_3 = 0 \\
I_3&: \quad (8\,\Omega + 10\,\Omega + 5\,\Omega)I_3 - (8\,\Omega)I_1 - (5\,\Omega)I_2 = 0
\end{aligned}
$$

$$
\begin{aligned}
11I_1 - 8I_3 - 3I_2 &= 15 \\
10I_2 - 3I_1 - 5I_3 &= 0 \\
23I_3 - 8I_1 - 5I_2 &= 0
\end{aligned}
$$

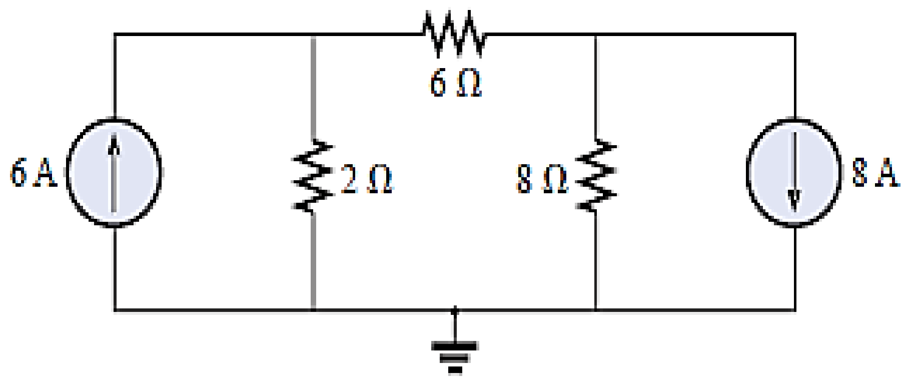
or

$$
\begin{aligned}
11I_1 - 3I_2 - 8I_3 &= 15 \\
-3I_1 + 10I_2 - 5I_3 &= 0 \\
-8I_1 - 5I_2 + 23I_3 &= 0
\end{aligned}
$$

and

$$I_3 = I_{10\Omega} = \frac{\begin{vmatrix} 11 & -3 & 15 \\ -3 & 10 & 0 \\ -8 & -5 & 0 \end{vmatrix}}{\begin{vmatrix} 11 & -3 & -8 \\ -3 & 10 & -5 \\ -8 & -5 & 23 \end{vmatrix}} = \mathbf{1.220\ A}$$

EXAMPLE 3:Using mesh analysis, determine the currents for the network of Figure below.



Solution:

Mesh

$I_1 = 6$ A

Mesh

$(2 + 6 + 8) I_2 - (2) I_1 - (8) I_3 = 0$

Mesh

$I_3 = 8$ A

From mesh 2 :

$$I_2 = \frac{76\text{ A}}{16} = \mathbf{4.75\ A}$$

Then $I_{2\Omega}\downarrow = I_1 - I_2 = 6\text{ A} - 4.75\text{ A} = \mathbf{1.25\ A}$

and $I_{8\Omega}\uparrow = I_3 - I_2 = 8\text{ A} - 4.75\text{ A} = \mathbf{3.25\ A}$

(The 7th week)

Thevinin's theorem

over view

A- Population target

- Students of first year of Electrical Techniques Department

B –Rationale

- It is very important to study Thevenin’s theorem.
- Also to study how apply the three step to the saving theorem .

C – Central Idea

- Definition Thevenin's theorem .
- How we find the current at each resistance in the network by the above theorem.

D- Aim of lecture

To let the student be able to identify the analyses network by using Thevenin’s' theorem.

Pretest

Define : Load resistance, The equivalent circuit.

Solution

Load Resistance: This is the resistance connected to the output terminals of a circuit. It's the part of the circuit that consumes power—like a speaker connected to an amplifier or a lamp connected to a battery.

Equivalent Circuit (Thevenin's Equivalent): A more complex linear electrical network can be simplified into an equivalent circuit that has:

- A single voltage source (**Thevenin voltage**)
- In series with a single resistor (**Thevenin resistance**)
- Connected to the **load resistance** you're analyzing

1. The′venin's Theorem

The′venin's Theorem states the following: **Any two-terminal, linear bilateral dc network can be replaced by an equivalent circuit consisting of a voltage source and a series resistor, as shown below:**

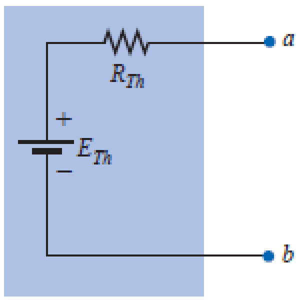


Fig.1 Thévenin equivalent circuit.

The following sequence of steps will lead to the proper value of R_{Th} and E_{Th}. Preliminary:

R_{Th}

1. **Remove that portion of the network across which the Thévenin equivalent circuit is to be found. In Fig.1, this requires that the load resistor RL be temporarily removed from the network.**

2. **Mark the terminals of the remaining two-terminal network. (The importance of this step will become obvious as we progress through some complex networks.) .**

3. **Calculate R_{Th} by first setting all sources to zero (voltage sources are replaced by short circuits, and current sources by open circuits) and then find the resultant resistance between the two marked terminals. (If the internal resistance of the voltage and/or current sources is included in the original network, it must remain when the sources are set to zero.) E_{Th}:**

4. **Calculate E_{Th} by first returning all sources to their original position and finding the open- circuit voltage between the marked terminals. (This step is invariably the one that will lead to the most confusion and errors. In all cases, keep in mind that it is the open-circuit potential between the two terminals marked in step 2.) Conclusion:**

5. **Draw the Thévenin equivalent circuit with the portion of the circuit previously removed replaced between the terminals of the equivalent circuit. This step is indicated by the placement of the resistor RL between the terminals of the Thévenin equivalent circuit as shown in Fig. below.**

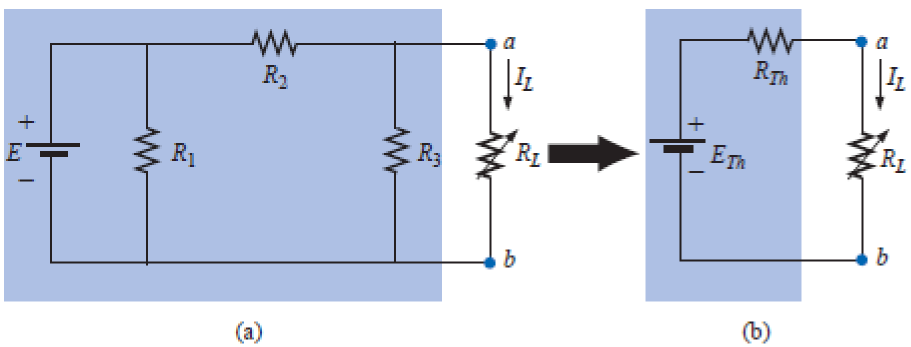
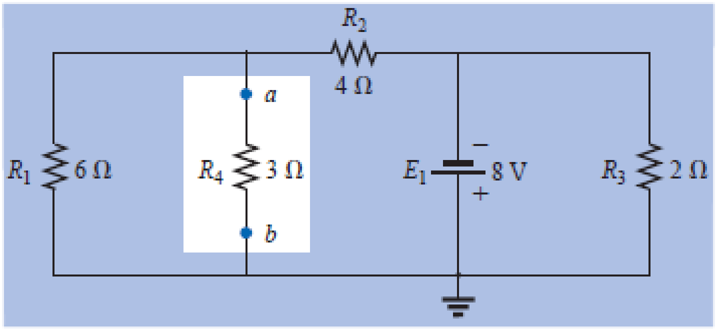


Fig.2 Substituting the Thévenin equivalent circuit for a complex network

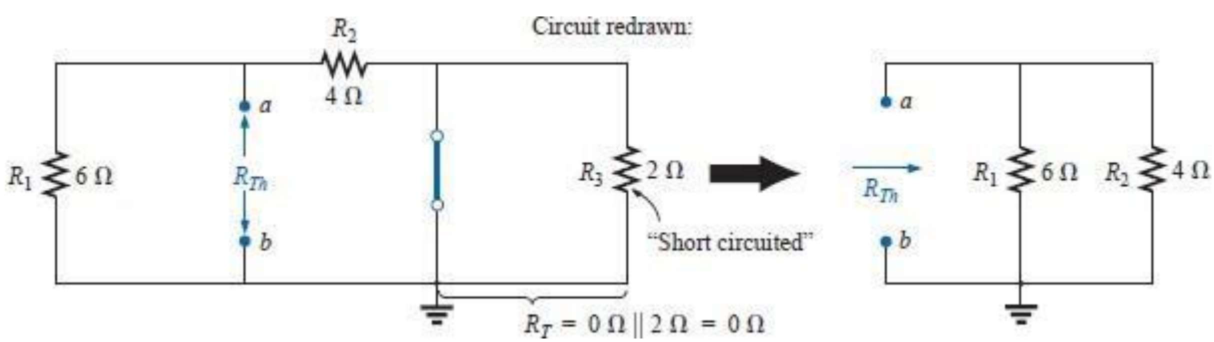
Example 1 Find the Thévenin equivalent circuit for the network in the shaded area of the network of Fig. below.



Solution

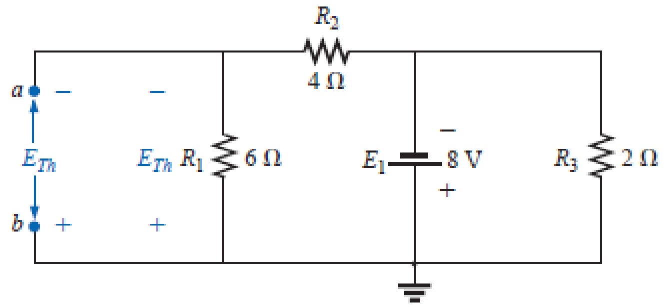
1- R_{TH}

$$R_{Th} = R_1 \parallel R_2 = \frac{(6\ \Omega)(4\ \Omega)}{6\ \Omega + 4\ \Omega} = \frac{24\ \Omega}{10} = \mathbf{2.4\ \Omega}$$

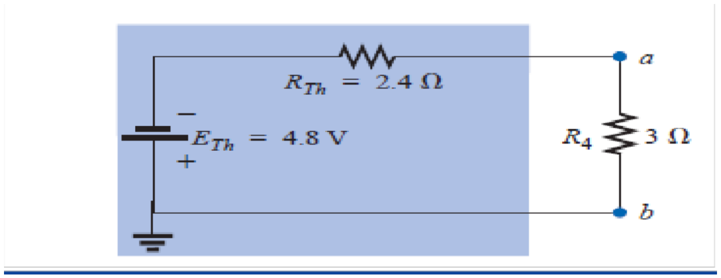


2- E_{TH}

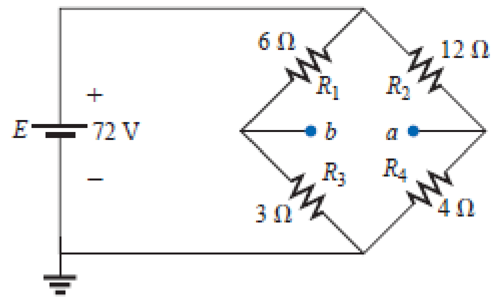
$$E_{Th} = \frac{R_1E_1}{R_1 + R_2} = \frac{(6\ \Omega)(8\ \text{V})}{6\ \Omega + 4\ \Omega} = \frac{48\ \text{V}}{10} = \mathbf{4.8\ V}$$



3- Equivalent Circuit



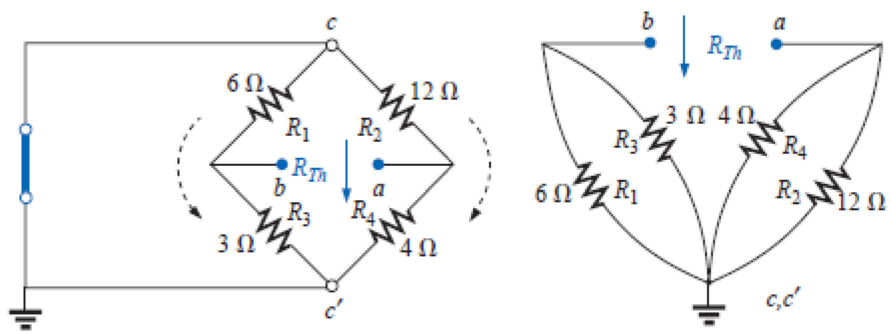
Example 2 Find the Thévenin equivalent circuit for the bridge network of Fig. below .



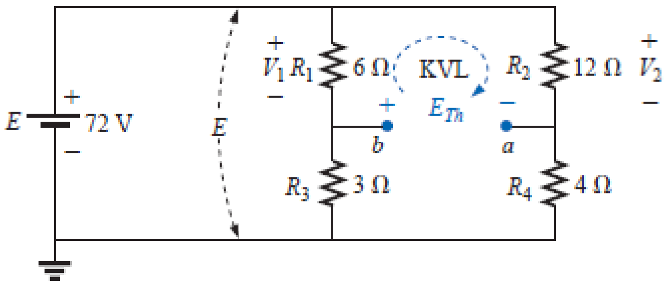
Solution :

1- R_{TH}

$$R_{Th} = R_{a\text{-}b} = R_1 \parallel R_3 + R_2 \parallel R_4$$
$$= 6\ \Omega \parallel 3\ \Omega + 4\ \Omega \parallel 12\ \Omega$$
$$= 2\ \Omega + 3\ \Omega = \mathbf{5\ \Omega}$$



(a) (b)



2- E_{TH}

$$V_1 = \frac{R_1E}{R_1 + R_3} = \frac{(6\ \Omega)(72\ \text{V})}{6\ \Omega + 3\ \Omega} = \frac{432\ \text{V}}{9} = 48\ \text{V}$$

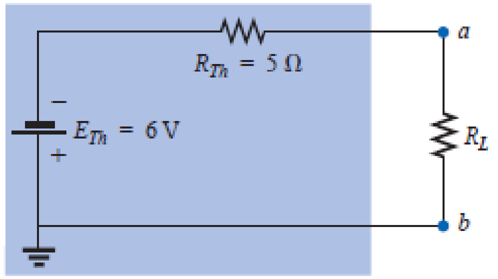
$$V_2 = \frac{R_2E}{R_2 + R_4} = \frac{(12\ \Omega)(72\ \text{V})}{12\ \Omega + 4\ \Omega} = \frac{864\ \text{V}}{16} = 54\ \text{V}$$

Assuming the polarity shown for E_{Th} and applying Kirchhoff's voltage law to the top loop in the clockwise direction will result in

$$\Sigma_{\circlearrowright} V = +E_{Th} + V_1 - V_2 = 0$$

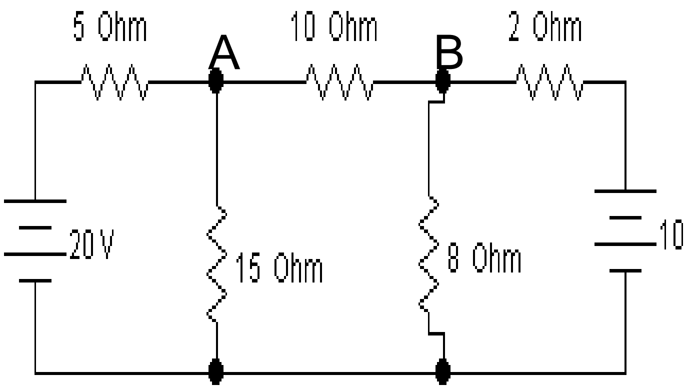
and

$$E_{Th} = V_2 - V_1 = 54\ \text{V} - 48\ \text{V} = \mathbf{6\ V}$$

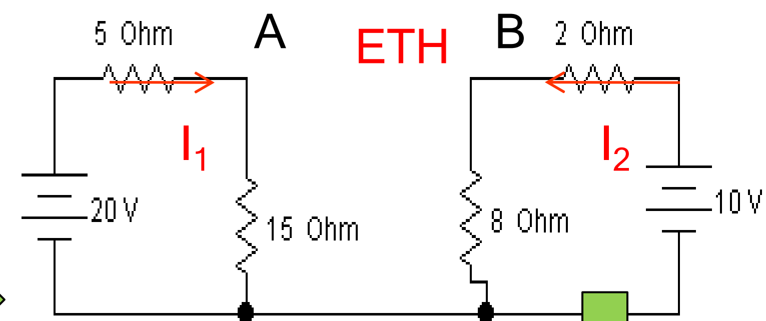


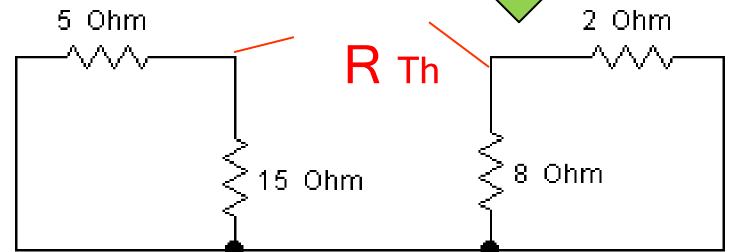
Posttest

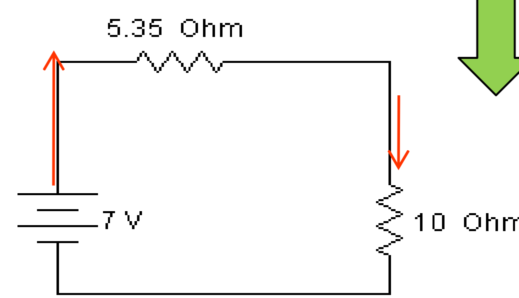
<u>Homework</u> : Using Thevenin's theorem To Find (I_L) .



Solution







$I_1=20/(5+15)=1A$, $V_{at15\Omega}=1x15=15v$

$I_2=10/(2+10)=1A$ ∴ $V_{at8\Omega}=1x8=8v$

∴ $E_{th}=15-8=7v$

$RTh=(5x15)/(5+15)+(8x2)/(8+2)=5.35\Omega$

∴ $I_L=I_T=7/(5.35+10)=0.456$ A

(The 8^{th} week)

Norton's theorem

over view

A- Population target

 Students of first year

of

Electrical Techniques Department

B –Rationale

- It is very important to study Norton's theorem.
- Also to study how apply the three step to the saving theorem .

C – Central Idea

- Definition Norton's theorem .
- How we find the current at each resistance in the network by the above theorem.

D- Aim of lecture

To let the student be able to identify the analyses network by using Norton's theorem.

Pretest

Define : short circuit , Open circuit

solution

Short Circuit: A short circuit occurs when there's a direct, low-resistance connection between two points in a circuit—usually across a power source—bypassing the normal load. This causes a sudden surge in current, which can damage components, trip breakers or even start fires.

Open Circuit: An open circuit is the opposite: there's a break or gap in the electrical path, so current can't flow at all. Even if a voltage is present, no current means the circuit is inactive—like a switch turned off or a broken wire

Norton's Theorem

Norton's theorem states the following:

An equivalent circuit consisting of a current source and a parallel resistor can replace any two-terminal linear bilateral dc network.

The discussion of Thévenin's theorem with respect to the equivalent circuit can also be applied to the Norton equivalent circuit. The steps leading to the proper values of I_N and R_N are now listed.

1. Remove that portion of the network across which the Norton equivalent circuit is found.
2. Mark the terminals of the remaining two-terminal network.

R_N:

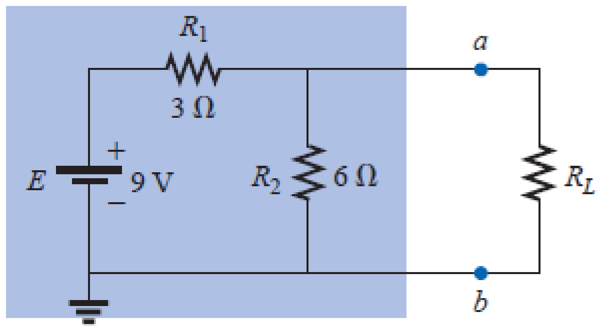
3. Calculate R_N by first setting all sources to zero (voltage sources are replaced with short circuits, and current sources with open circuits) and then finding the resultant resistance between the two marked terminals. (If the internal resistance of the voltage and/or current sources is included in the original network, it must remain when the sources are set to zero.) Since $R_N = R_{Th}$, the procedure and value obtained using the approach described for Thévenin's theorem will determine the proper value of R_N.

I_N:

4. Calculate I_N by first returning all sources to their original position and then finding the short-circuit current between the marked terminals. It is the same current that would be measured by an ammeter placed between the marked terminals.

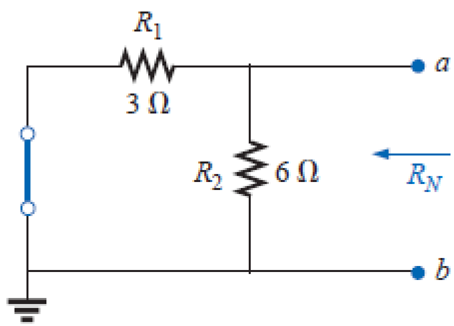
5. Draw the Norton equivalent circuit with the portion of the circuit previously removed replaced between the terminals of the equivalent circuit.

Example 3 Find the Norton equivalent circuit for the network in the shaded area of Fig. below .



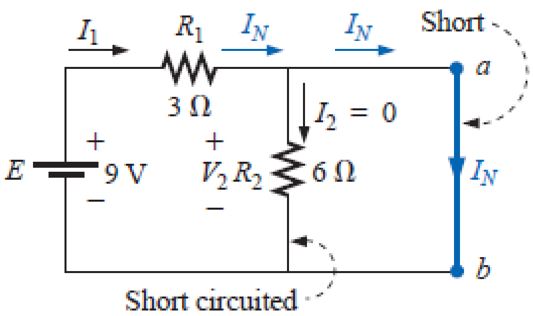
Solution:

1- R_N



$$R_N = R_1 \parallel R_2 = 3\ \Omega \parallel 6\ \Omega = \frac{(3\ \Omega)(6\ \Omega)}{3\ \Omega + 6\ \Omega} = \frac{18\ \Omega}{9} = \mathbf{2\ \Omega}$$

2- I_N

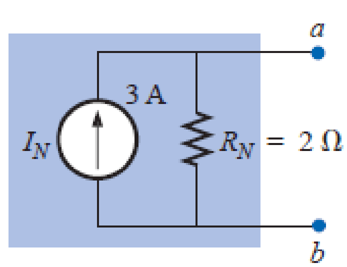


$$V_2 = I_2R_2 = (0)6\ \Omega = 0\ \text{V}$$

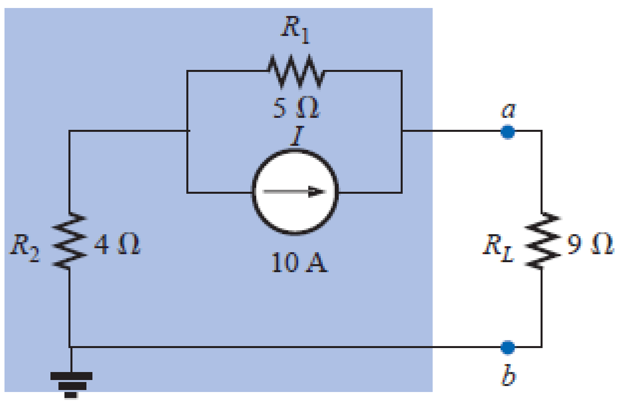
Therefore,

$$I_N = \frac{E}{R_1} = \frac{9\ \text{V}}{3\ \Omega} = \mathbf{3\ A}$$

3- Equivalent Circuit



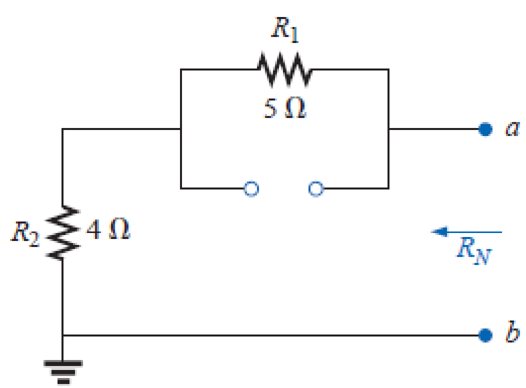
Example 4 Find the Norton equivalent circuit for the network external to the 9-Ω resistor in Fig. below.



Solution

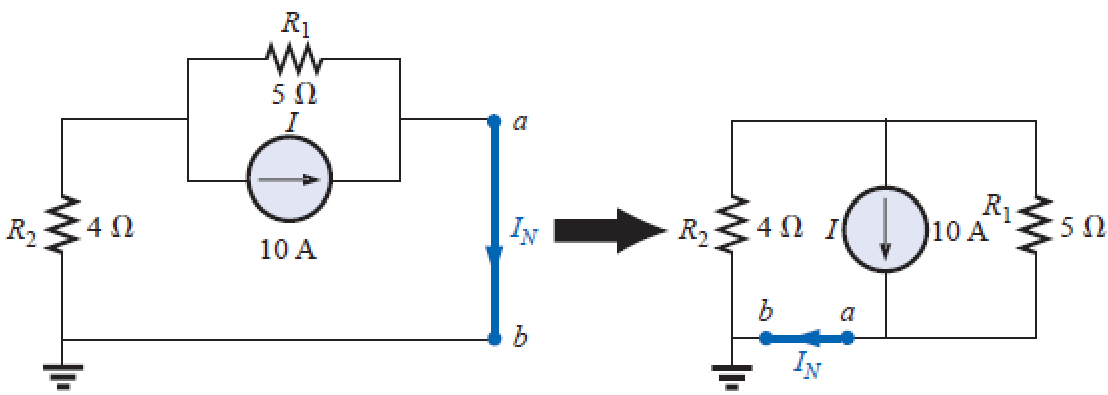
1- R_N

$$R_N = R_1 + R_2 = 5\ \Omega + 4\ \Omega = \mathbf{9\ \Omega}$$

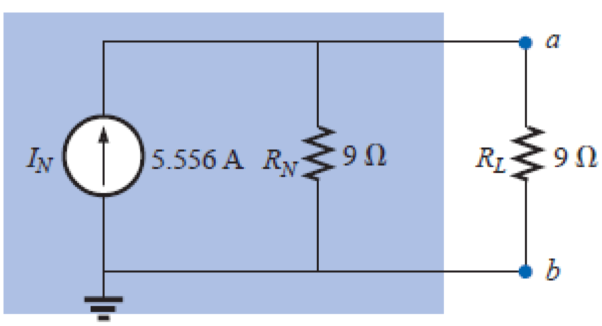


2. I_N

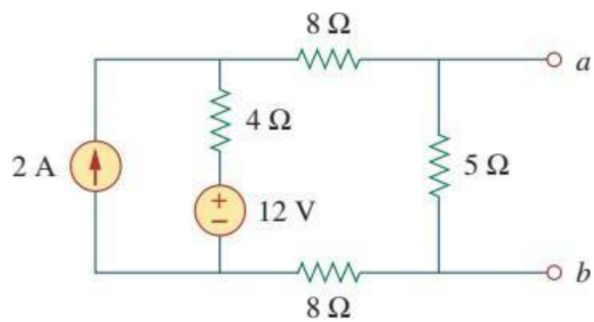
$$I_N = \frac{R_1 I}{R_1 + R_2} = \frac{(5\ \Omega)(10\ \text{A})}{5\ \Omega + 4\ \Omega} = \frac{50\ \text{A}}{9} = \mathbf{5.556\ A}$$



3. Equivalent Circuit



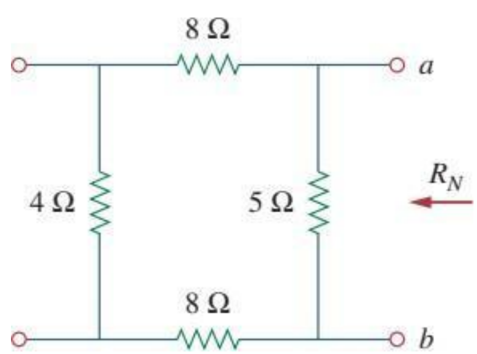
Example 5 Find the Norton equivalent circuit for the network below.



Solution:

1- R_N

$$R_N = 5 \parallel (8 + 4 + 8) = 5 \parallel 20 = \frac{20 \times 5}{25} = 4\ \Omega$$



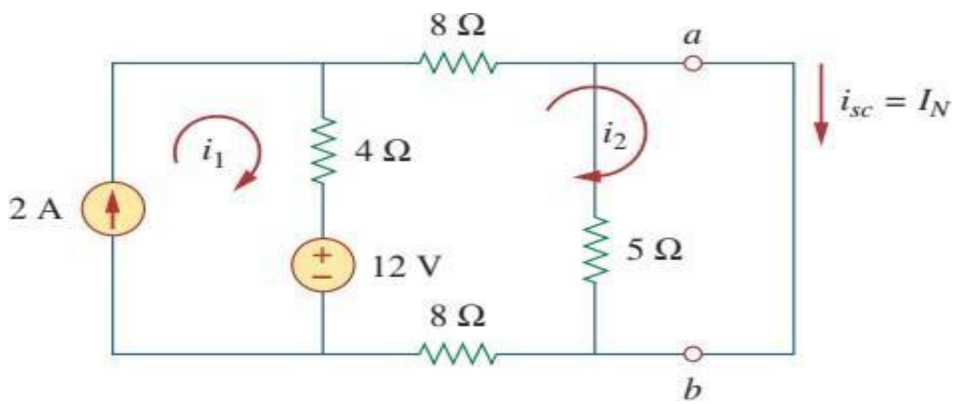
2. I_N

Applying mesh analysis, we obtain

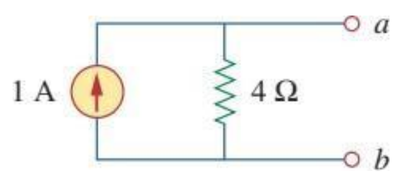
$$i_1 = 2\text{ A}, \qquad 20i_2 - 4i_1 - 12 = 0$$

From these equations, we obtain

$$i_2 = 1\text{ A} = i_{sc} = I_N$$

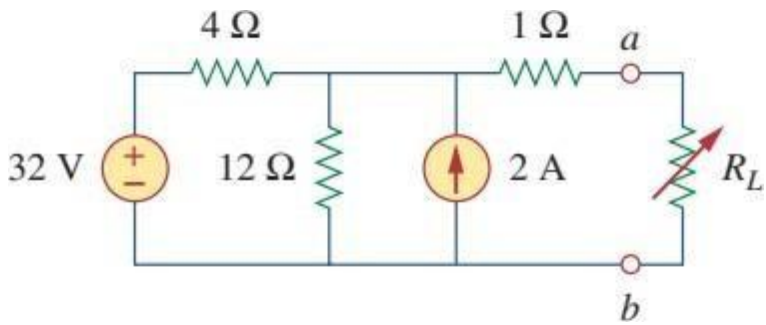


3. Equivalent Circuit



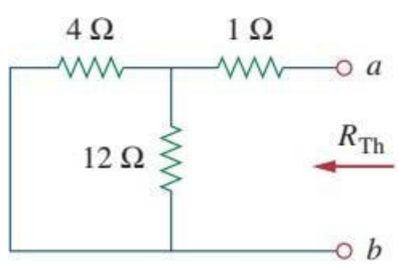
Example 6

Find the Thévenin equivalent circuit for the network in the shaded area of the network of Fig. below.



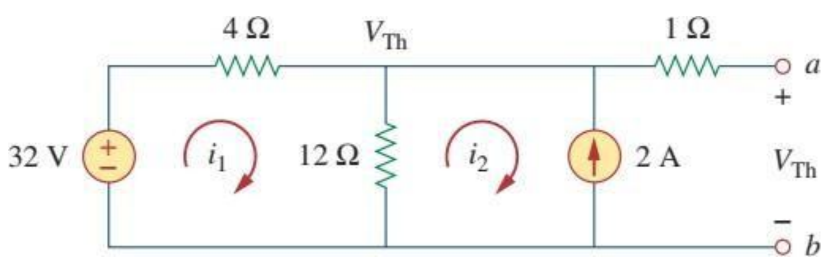
Solution:

1- RTH



$$R_{Th} = 4 \parallel 12 + 1 = \frac{4 \times 12}{16} + 1 = 4\ \Omega$$

2- ETH



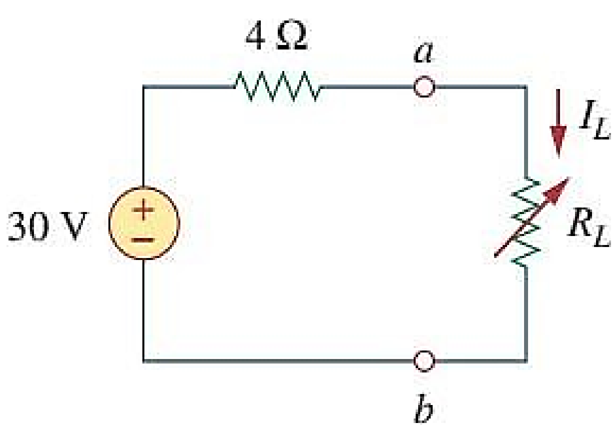
$(12+4)\, i_1 - 12\, i_2 = 32$

$$i_2 = -2 \text{ A}$$

Solving for i_1, we get $i_1 = 0.5$ A. Thus,

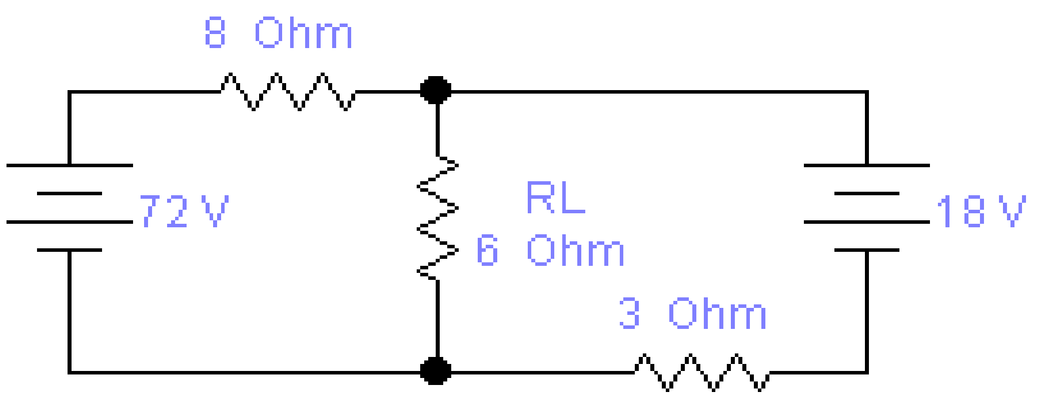
$$V_{Th} = 12(i_1 - i_2) = 12(0.5 + 2.0) = 30 \text{ V}$$

3 – Equivalent circuit



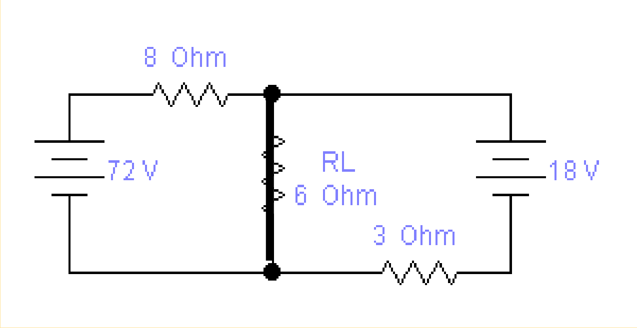
Posttest

Homework: For the cct. Shown find ($I_{L\ at\ 6\Omega}$) using Norton's theorem



Solution

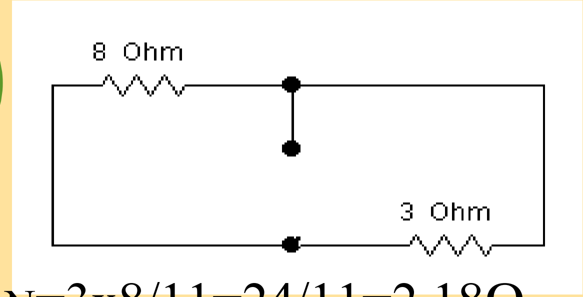
1



$I_{s.c} = I_1 + I_2$, $I_1 = 72/8 = 9A$

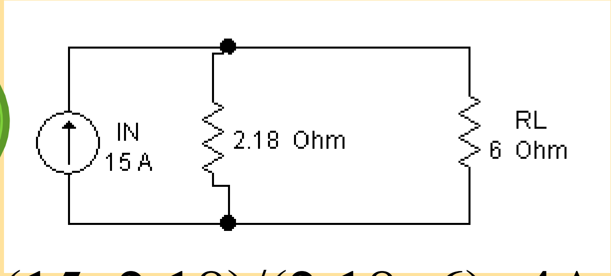
$I_2 = 18/3 = 6A$ $I_N = I_{s.c} = 15A$

2



$R_N = 3x8/11 = 24/11 = 2.18\Omega$

3



$I_L = (15x2.18)/(2.18+6) = 4A$

Suppers position theorem

(The 9th week)

over -view

A- Population target

 First year Student

of

Electrical Techniques Department

B –Rationale

- It is very important to study Supper’s position theorem.

.

C – Central Idea

- Definition Suppers position theorem.
- To calculate the load current flows from each source and to find the result from the total currents.

D- Aim of lecture :

To let the student be able to identify the analyses network by using Supper position theorem.

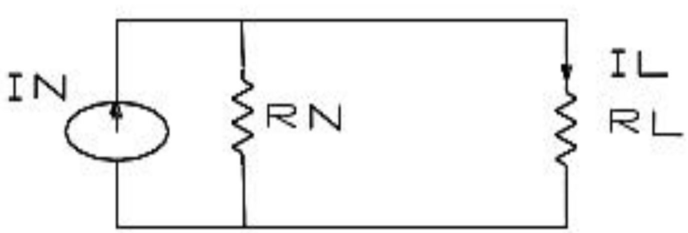
.

Pretest

Define : Current load (IL) ,draw Norton equivalent

Solution:

Current Load (IL): This is the **electric current flowing through the load resistance** in a circuit. It depends on the voltage across the load and the resistance itself, following Ohm's Law: $$I_L = \frac{V}{R_{load}}$$ where V is the voltage across the load and R_{load} is the load resistance.



$$I_L = I_n \times R_N / (R_N + R_L)$$

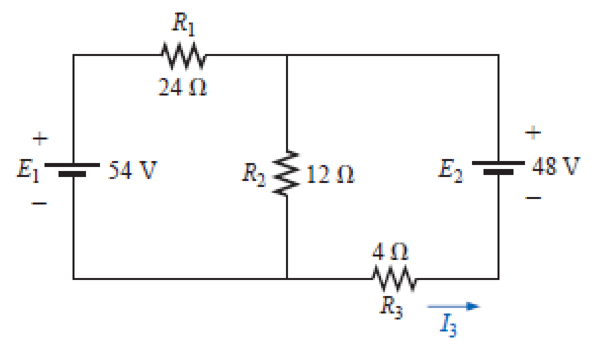
Superposition Theorem

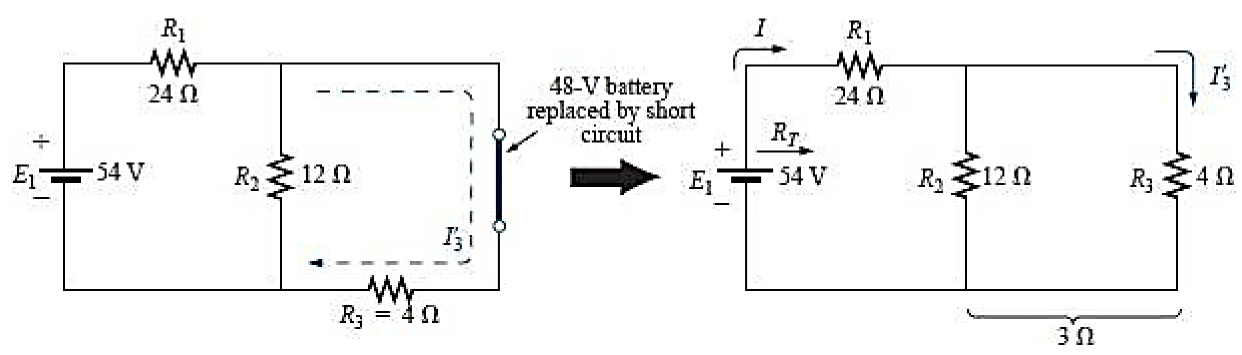
The superposition theorem, like the methods of the last chapter, can be used to find the solution to networks with two or more sources that are not in series or parallel. The most obvious advantage of this method is that it does not require the use of a mathematical technique such as determinants to find the required voltages or currents. Instead, each source is treated independently, and the algebraic sum is found to determine a particular unknown quantity of the network.

The superposition theorem states the following:

The current through, or voltage across, an element in a linear bilateral network is equal to the algebraic sum of the currents or voltages produced independently by each source.

Example 1 Using superposition, determine the current through the 4-Ω resistor.

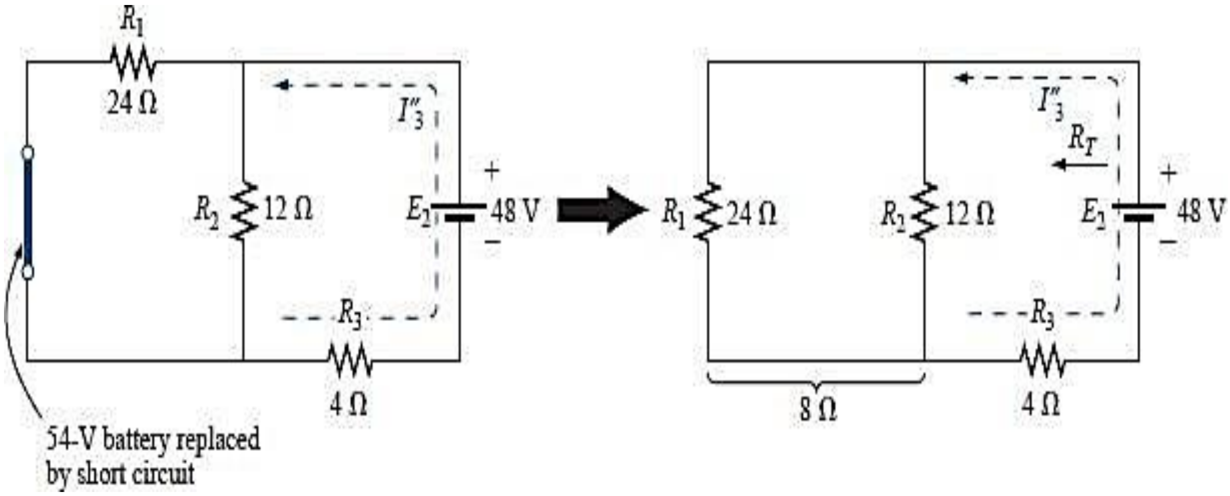




Solution: *Considering the effects of a 54-V source*

$$R_T = R_1 + R_2 \parallel R_3 = 24\ \Omega + 12\ \Omega \parallel 4\ \Omega = 24\ \Omega + 3\ \Omega = 27\ \Omega$$

$$I = \frac{E_1}{R_T} = \frac{54\ \text{V}}{27\ \Omega} = 2\ \text{A}$$



Using the current divider rule,

$$I'_3 = \frac{R_2 I}{R_2 + R_3} = \frac{(12\ \Omega)(2\ \text{A})}{12\ \Omega + 4\ \Omega} = \frac{24\ \text{A}}{16} = 1.5\ \text{A}$$

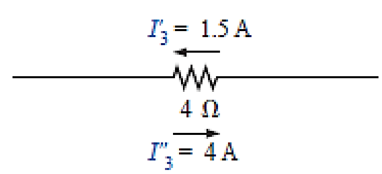
Considering the effects of the 48-V source

$$R_T = R_3 + R_1 \parallel R_2 = 4\ \Omega + 24\ \Omega \parallel 12\ \Omega = 4\ \Omega + 8\ \Omega = 12\ \Omega$$

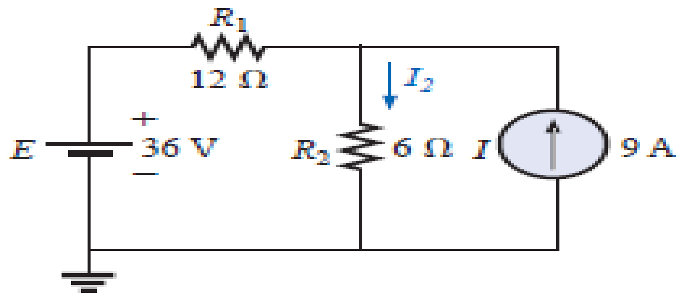
$$I''_3 = \frac{E_2}{R_T} = \frac{48\ \text{V}}{12\ \Omega} = 4\ \text{A}$$

The total current through the 4-Ω resistor

$$I_3 = I''_3 - I'_3 = 4\ \text{A} - 1.5\ \text{A} = 2.5\ \text{A} \qquad (\text{direction of } I''_3)$$



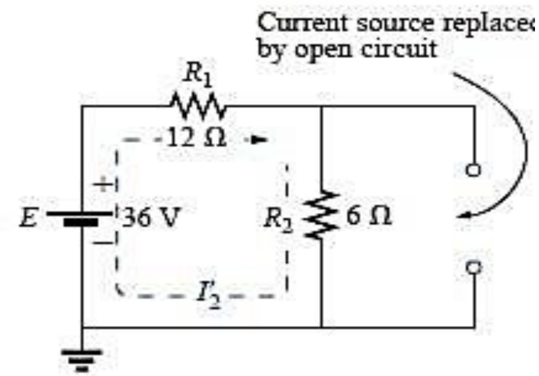
Example 2: Using superposition, determine the current through the 6-Ω resistor.



Solutions:

Considering the effect of the 36-V source

$$I'_2 = \frac{E}{R_T} = \frac{E}{R_1 + R_2} = \frac{36\text{ V}}{12\ \Omega + 6\ \Omega} = 2\text{ A}$$

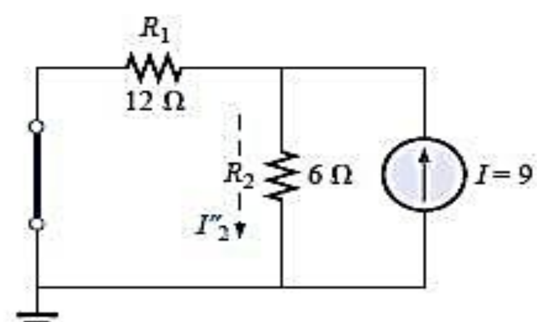


The contribution of E to I_2.

Considering the effect of the 9-A source

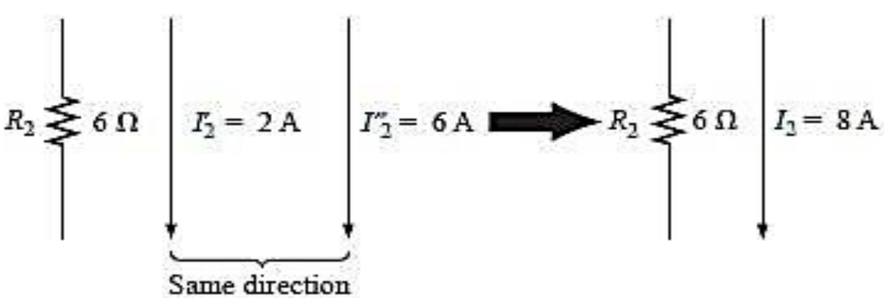
Applying the current divider rule,

$$I''_2 = \frac{R_1 I}{R_1 + R_2} = \frac{(12\ \Omega)(9\text{ A})}{12\ \Omega + 6\ \Omega} = \frac{108\text{ A}}{18} = 6\text{ A}$$



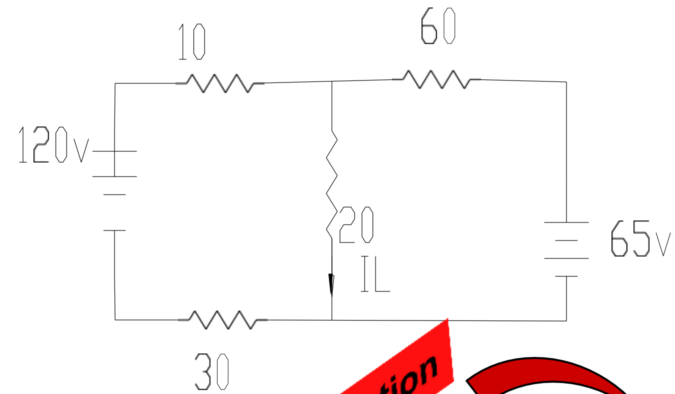
The total current through the 6-Ω resistor

$$I_2 = I'_2 + I''_2 = 2\text{ A} + 6\text{ A} = 8\text{ A}$$

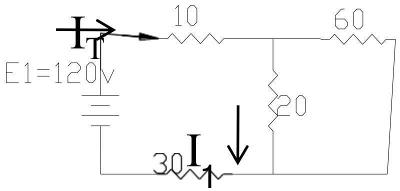


Posttest

For the cct. Shown find IL by using supper position theorem

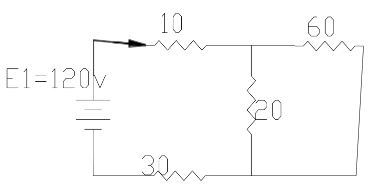


Solution



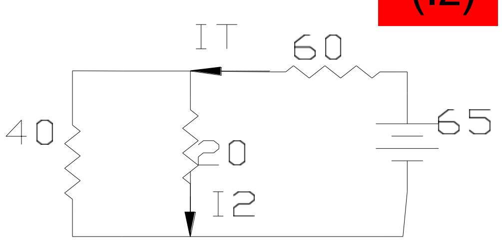
(I_1)

E_1=120   E2=0 , R_T=(60//20) +10+30=(20x60)/80+40=55Ω



I_T=120/55=2.182A , :.I_1=60/(60+20)x2.182=1.64A

(I2)



E_1=0 , E_2=65v , R_T=[(10+30)//20]+60
=(40x20)/60+60=73Ω

(The 10th week)

Alternating current (A.C)

Aim of lecture: To let the student be able to identify and Study Alternating circuits. And finding the Instantaneous value, Maximum value, the Root mean square value, and Average value.

overview

A- Population target

- Student of the first year of Electrical Techniques Department

B –Rationale

- It is very important to study. **Alternating current (A.C)**

- Also, to analyze the sine wave.

C – Central Idea

- Define the sine wave
- To learn how the sine wave
is generated
- To learn how we find R.m.s current
and average value.

Pretest

Define :1- frequency

2- Angular frequency

Solution:

1- Frequency is the number of times a repeating event occurs per unit of time. In electrical and wave systems, it refers to how many complete cycles of a wave happen in one second.

It's measured in hertz (Hz), where 1 Hz = 1 cycle per second

2- Angular frequency (often represented by the Greek letter ω\omega) measures *how quickly* something rotates or oscillates in terms of angle, instead of cycles.

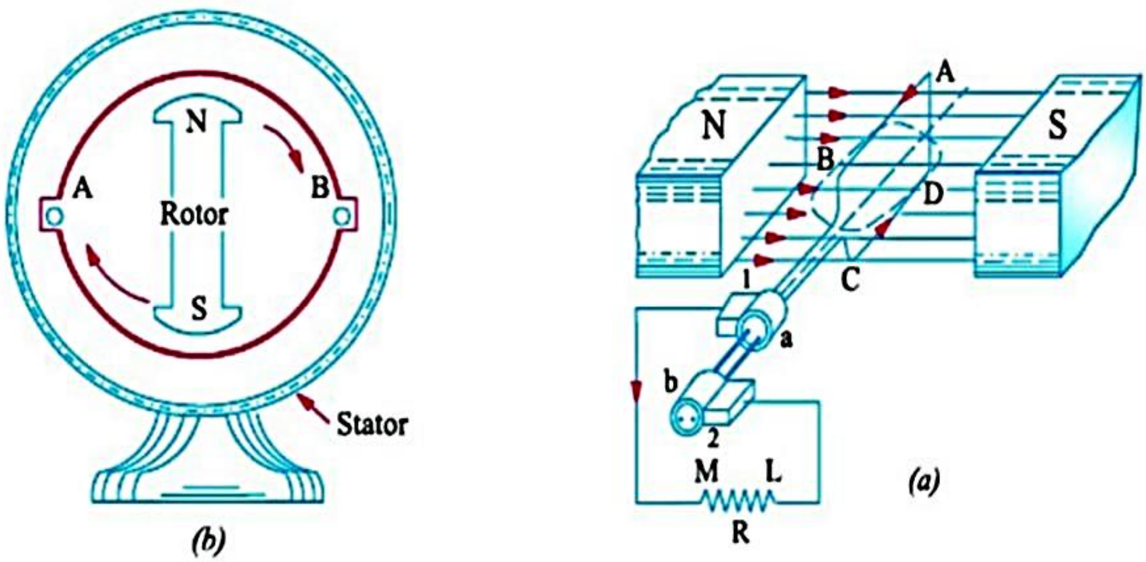
It's defined as: ω=2πf\omega = 2\pi f where:

- ω\omega is the angular frequency (in radians per second)
- f is the regular frequency (in hertz or cycles per second)

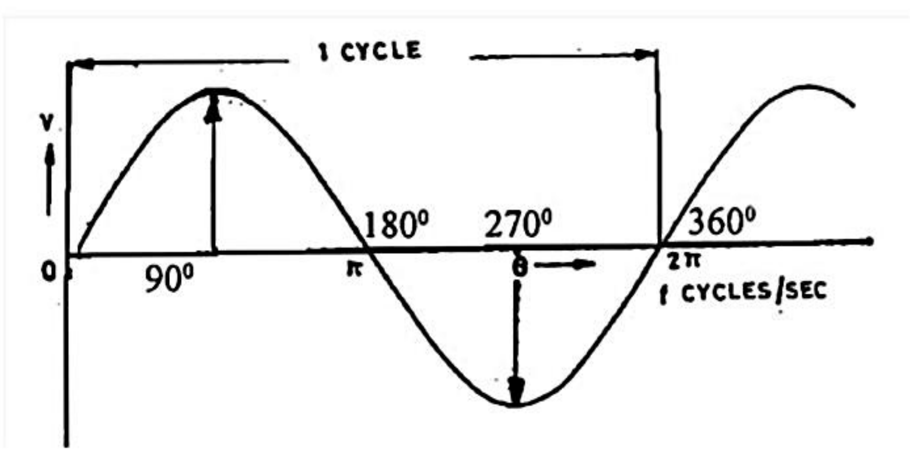
AC Circuits

Alternating Current:

Alternating current may be generated by rotating a coil in a magnetic field as shown in figure(a) or by rotating a magnetic field within a stationary coil as shown in figure(b).



Alternating current flows in one direction one time and later its changes its direction of flows. And the magnitude changes at every time. The magnitude depends upon the position of the coil.



Advantage and disadvantage of AC current:

Advantage:

- It easy to conduct AC to one place to another place.
- In AC current easy to develop high voltage.
- AC equipment is low cost.
- Possible to convert to DC.
- Easy to step down of setup the voltage by transformer.
- AC motors are cheapest.

Disadvantage:

- Can not able to store in battery.
- Because of high starting current in AC the voltage drop is occurred.
- The speed of the AC motors is depending up on the frequency.
- According to the induction load; power factor gets low.

If coil rotate in magnetic field or magnetic field rotate inside the coil there is an alternating e. m. f. generate in the coil. The generated emf is proportional to the number of turns of coil, magnetic field strength, and the angle between the coil and magnetic field.

$$e = BLv \sin\theta$$

From this:

$$L = Length\ of\ the\ conductor.$$

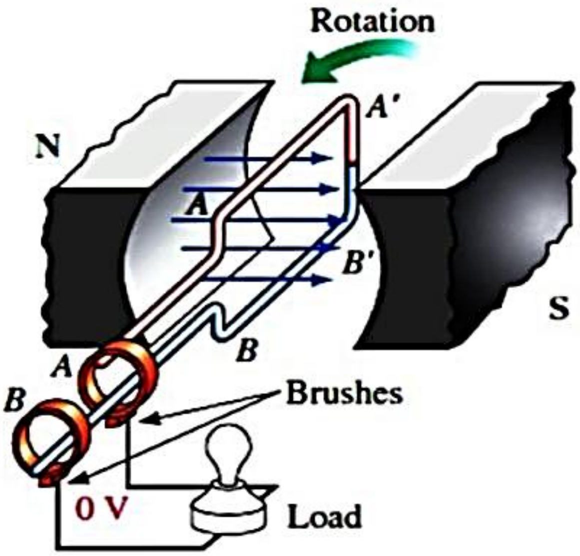
$$v = Velocity\ of\ conductor.$$

$$B = Flux\ density.$$

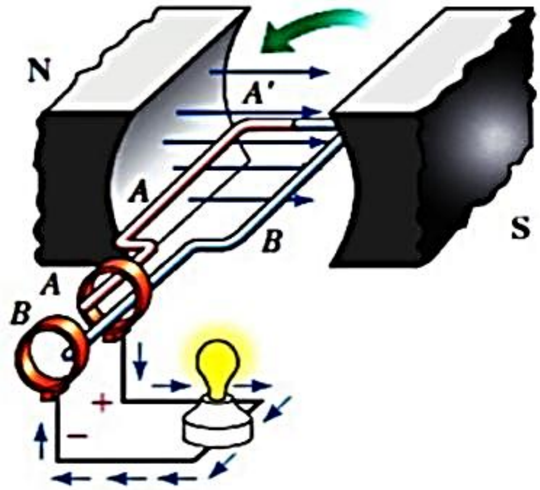
$$\theta = angle\ between\ field\ to\ conductor.$$

$$e = generated\ AC\ emf$$

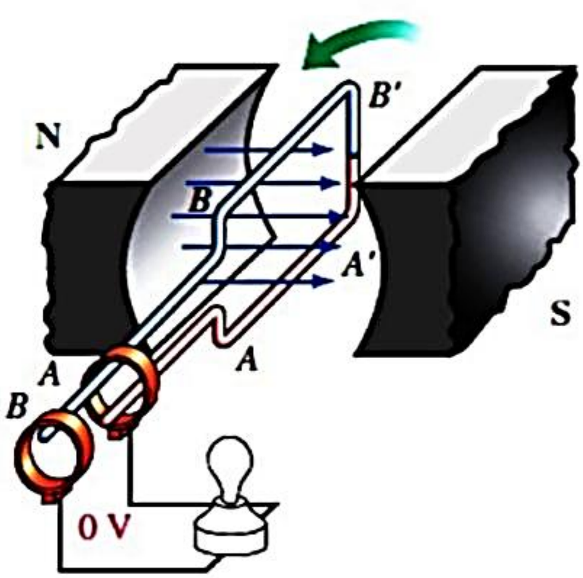
The generated AC emf value is depending upon the sine value of the angle between the magnetic field and conductor.



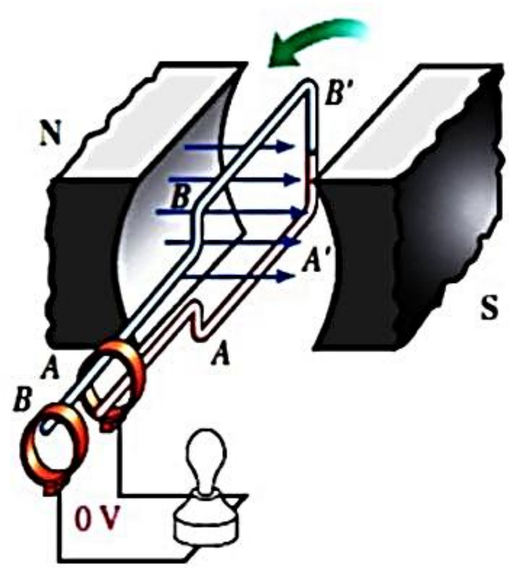
(a) 0° Position: Coil sides move parallel to flux lines. Since no flux is being cut, induced voltage is zero.



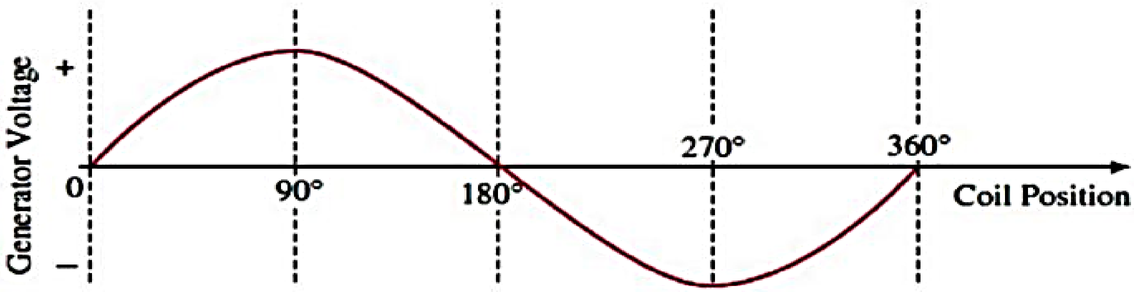
(b) 90° Position: Coil end *A* is positive with respect to *B*. Current direction is out of slip ring *A*.



(c) 180° Position: Coil again cutting no flux. Induced voltage is zero.



(c) 180° Position: Coil again cutting no flux. Induced voltage is zero.



Cycle:

An alternating current complete set of one positive half cycle and one negative half cycle is called one cycle.

Time period:

The time taken by an alternating quantity to complete one cycle is called time period. It is denoted by the letter "T".

Frequency:

The number of cycle per second is called the frequency of the alternating quantity. The unit is hertz (Hz).

Instantaneous value:

The alternating quantity changes at every time.

$$v = V_{max} \sin \omega t \quad or \quad i = I_{max} \sin \omega t$$

Maximum value:

The maximum value positive or negative of an alternating quantity is known as its maximum value. Denoted by "I_{max} or V_{max}".

Effective value and RMS value:

The effective value of an alternating current is given by that DC current which when flowing through a given circuit for a given time produces the same heat as produced by the alternating current when flowing through the same circuit for the same time also is called root mean square value RMS. The voltmeter and ammeter are read the effective value only.

$$RMS\ value = \frac{I_{max}}{\sqrt{2}} \quad or \quad \frac{V_{max}}{\sqrt{2}}$$

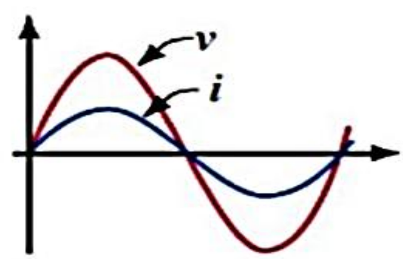
Average value:

The average value is calculated by the averages of the maximum value of alternating quantity at different instances.

$$Average\ value = \frac{2I_{max}}{\pi} \quad or \quad \frac{2V_{max}}{\pi}$$

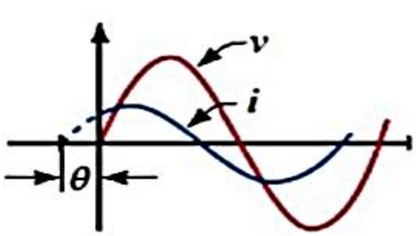
In phase:

If waveform of two AC quantities (voltage or current) get the maximum and zero at same time then they are said to be in phase.

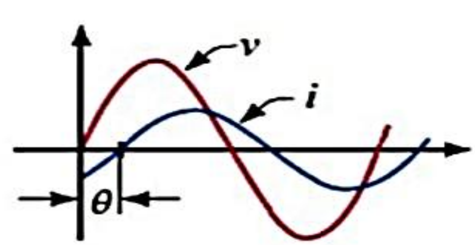


Out of phase:

If in AC circuit two quantities namely voltage or current waves get the maximum and zero at different value then they are said to be out of phase.



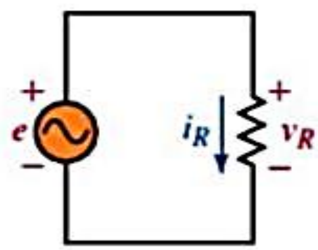
Current leads

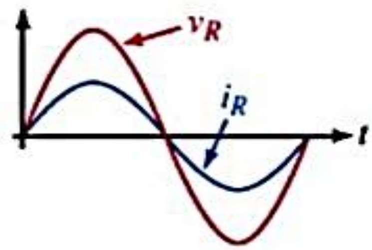


Current lags

AC circuit with pure resistance:

A circuit without inductance and capacitance is called pure resistance circuit as shown in figure.





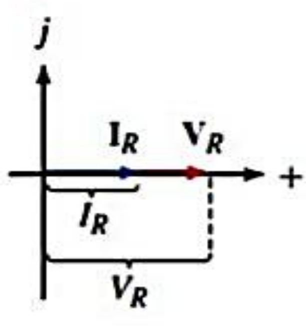
By applying Ohm's law:

$$i_R = \frac{v_R}{R} = \frac{V_m \sin \omega t}{R} = \frac{V_m}{R}\sin \omega t = I_m \sin \omega t$$

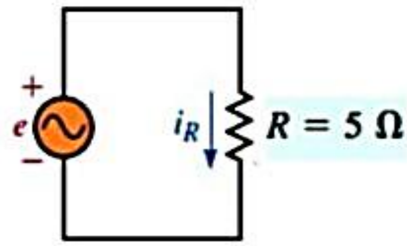
where $I_m = V_m/R$

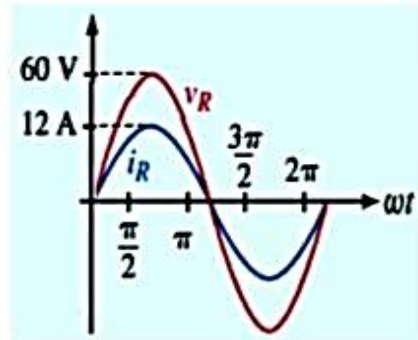
Transposing, $V_m = I_m R$

Note that current and voltage as in phase:



<u>Example-21</u>: For the circuit shown in figure find the value of i_R , if v(t)=60sinωt.



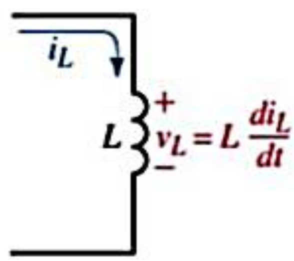


Solution:

$$i_R = \frac{v}{R} = \frac{60\sin(\omega t)}{5} = 12\sin(\omega t) \quad A$$

AC circuit with Purely Inductive Load:

Consider a purely inductive circuit with an inductor connected to an AC generator, as shown in Figure.



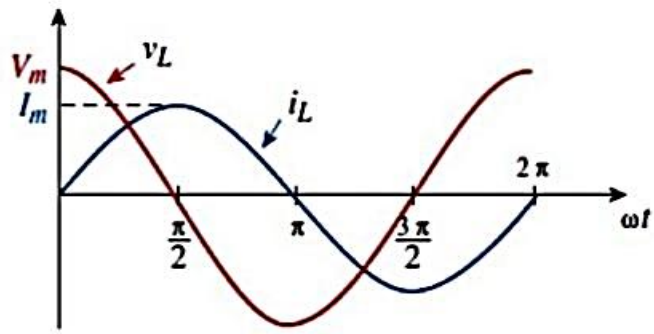
$$v_L = L\frac{di_L}{dt} = L\frac{d}{dt}(I_m \sin\omega t) = \omega L I_m \cos\omega t = V_m \cos\omega t$$

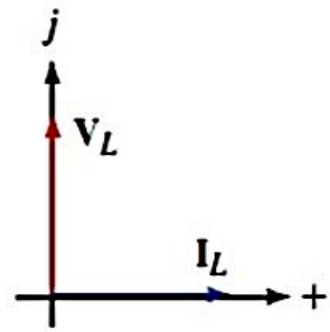
Utilizing the trigonometric identity [$\cos\omega t = \sin(\omega t + 90^\circ)$ you can write this as:

$$v_L = V_m \sin(\omega t + 90^\circ)$$

$$V_m = \omega L I_m$$

Voltage and current waveforms are shown in Figure (a), and phasors in Figure(b). As you can see, *for a purely inductive circuit, current lags voltage by 90°*





From Equation above, we see that the ratio V_m to I_m is:

$$\frac{V_m}{I_m} = \omega L$$

This ratio is defined as **inductive reactance** and is given the symbol *XL*. Since the ratio of volts to amps is ohms, reactance has units of ohms.

$$X_L = \frac{V_m}{I_m} \quad (\Omega)$$

Combining Equations above yields:

$$X_L = \omega L \quad (\Omega)$$

Where ω is radians per second $\omega = 2\pi f$

Example-22: The voltage across a 0.2H inductance is $v_L = 100 \sin(400t - 70°)$ V. Determine i_L and sketch it

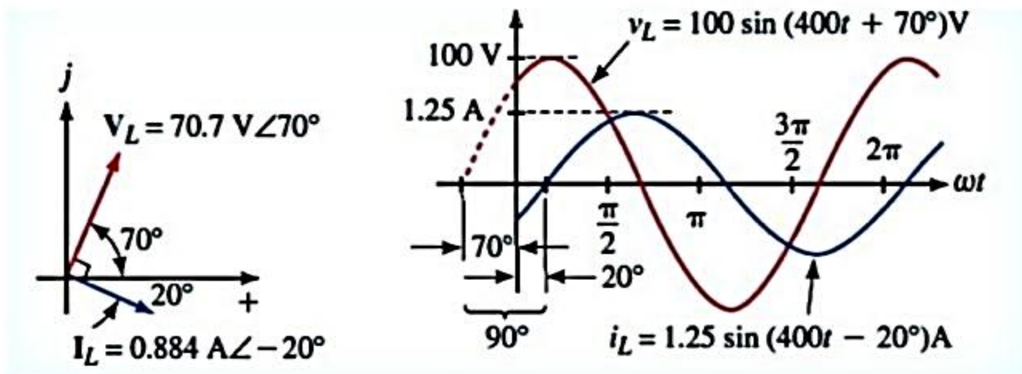
Solution:

$\omega = 400$ rad/s therefore $x_L = \omega L = 400 \times 0.2 = 80\Omega$

$$I_m = \frac{V_m}{x_L} = \frac{100}{80} = 1.25A$$

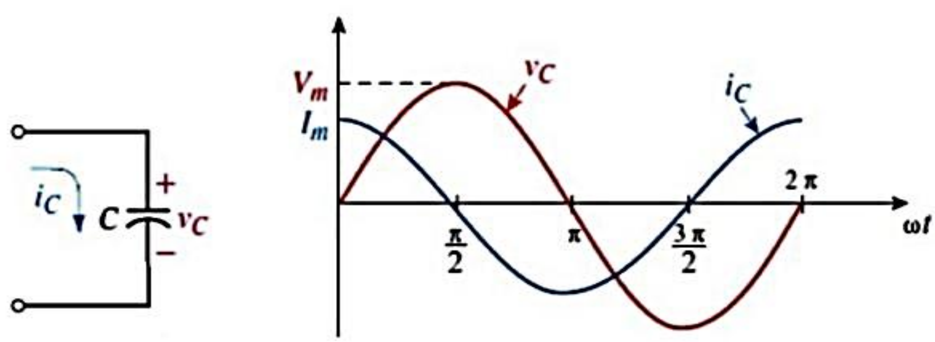
The current lags the voltage by 90° therefore:

$i_L = 1.25\sin(400t - 20^{\circ})$ A as indicated in figure below



AC circuit with Purely Capacitive Load:

In the purely capacitive case, both resistance R and inductance L are zero. The circuit diagram is shown in Figure



For capacitance, current is proportional to the rate of change of voltage:

$$i_C = C\frac{dv_C}{dt} = C\frac{d}{dt}(V_m \sin \omega t) = \omega C V_m \cos \omega t = I_m \cos \omega t$$

Using the appropriate trigonometric identity, this can be written as:

$i_C = I_m \sin(\omega t + 90°)$

Where $I_m = \omega C V_m = \frac{V_m}{X_c}$

X_c is called the capacitance reactance

Example-23: The voltage across a 10-mF capacitance is $v_C = 100\sin(\omega t - 40°)$ V and f = 1000 Hz. Determine i_C and sketch its waveform.

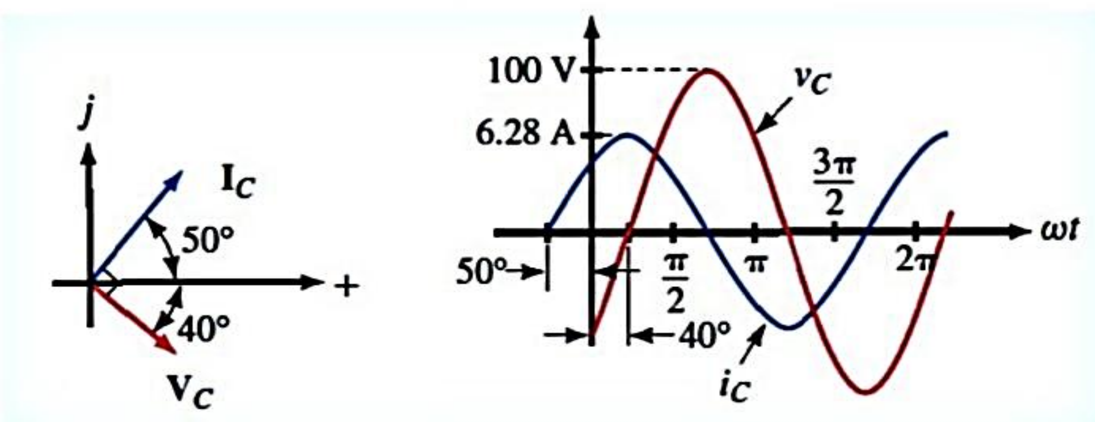
Solution:

$$\omega = 2\pi f = 2\pi(1000 \text{ Hz}) = 6283 \text{ rad/s}$$

$$X_C = \frac{1}{\omega C} = \frac{1}{(6283)(10 \times 10^{-6})} = 15.92\ \Omega$$

$$I_m = \frac{V_m}{X_C} = \frac{100 \text{ V}}{15.92\ \Omega} = 6.28 \text{ A}$$

Since current leads voltage by 90°, $i_C = 6.28\sin(6283t - 50°)$ A as indicated in Figure below.



Impedance:

The opposition that a circuit element presents to current in the phasor domain is defined as its **impedance.**

$$\mathbf{Z} = \frac{\mathbf{V}}{\mathbf{I}} \quad \text{(ohms)}$$

For resistor:

$$\mathbf{Z}_R = R$$

For inductance:

$$\mathbf{Z}_L = j\omega L = jX_L$$

For capacitance:

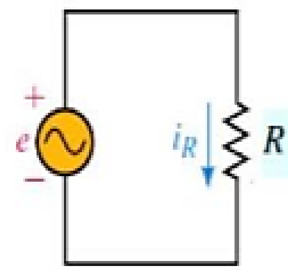
$$\mathbf{Z}_C = -j\frac{1}{\omega C} = -jX_C \quad \text{(ohms)}$$

Posttest

H.W. *For the circuit shown in figure if R= 10Ω, find the sinusoidal expression for the current if :-*

a) $v(t) = 100\sin(377t)$

b) $v(t) = 25\sin(377t + 60°)$



H.W. ***:The voltage across a 1-μf capacitor is $V_C = 30\sin(400t)$V. Determine i_c and sketch it with V_C***

H.W. *The voltage across a 10-mF capacitance is $v_C = 100\sin(\omega t - 40°)$ V and f = 1000 Hz. Determine i_C and sketch its waveform.*

11th week

Alternating Values

Aim of lecture :

To let the student be able to identify and Study vector values

over view

A- Population target

Students of first year

of

Electrical Techniques Department

B –Rationale

- It is very important to study Alternating Values

C – Central Idea

- Definition Alternating Values

- To learn the Pooler simple and J-operator.

Pretest

Define: The polar symbol , J - operator

solution

Polar Symbol

In mathematics and electrical engineering, the **polar symbol** typically refers to the notation used to express complex numbers or vectors in **polar form**. Instead of writing a complex number as A + Bj (rectangular form), the polar form uses:

r∠θr \angle \theta
Where:

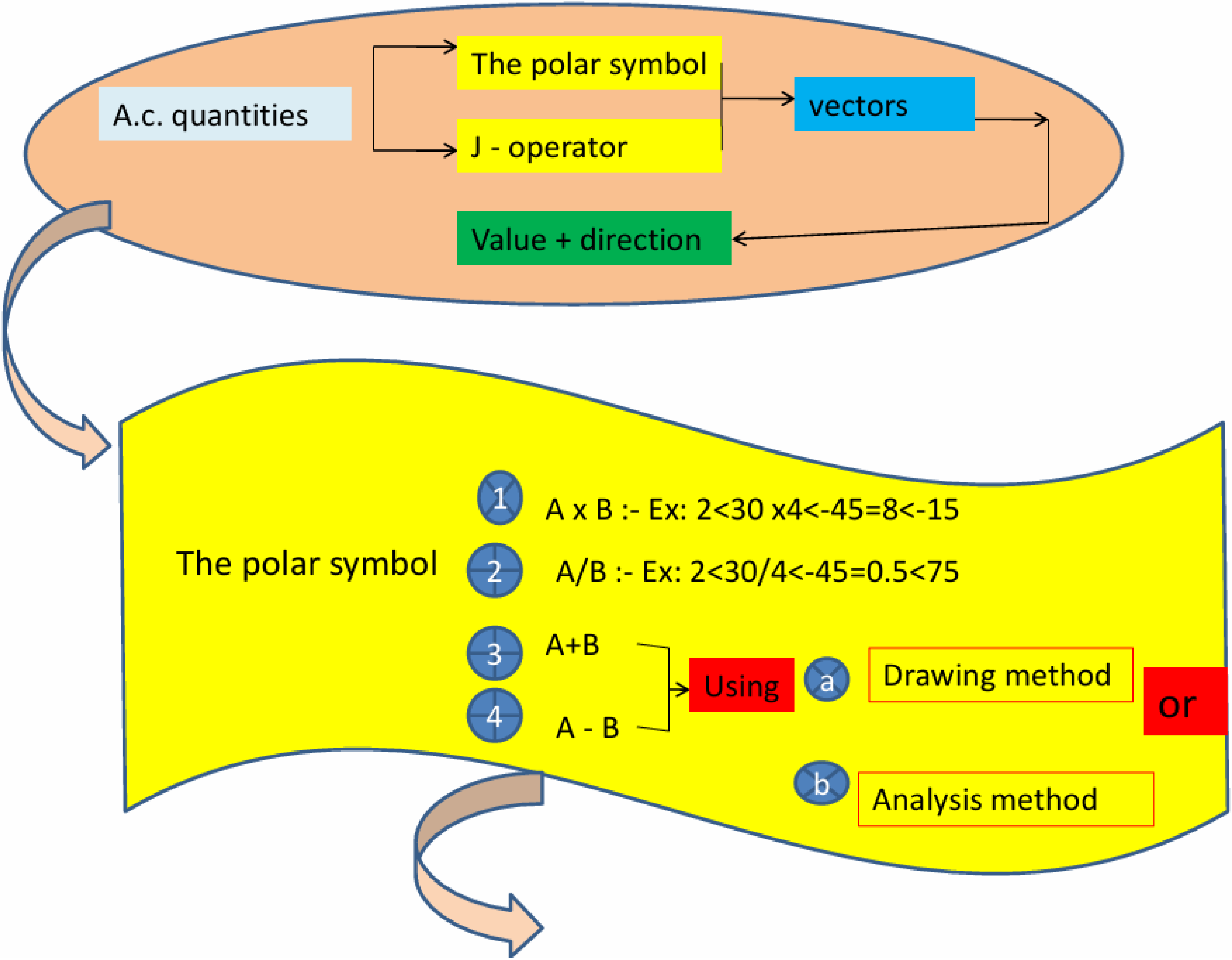
- r is the **magnitude** (or modulus) of the complex number.
- θ\theta is the **angle** (or argument), usually in degrees or radians, representing the direction from the origin.

This form is especially useful in AC circuit analysis and phasor diagrams, where sinusoidal signals are represented as rotating vectors.

The **j-operator** is a mathematical symbol used in electrical engineering to represent the **imaginary unit**, equivalent to $\sqrt{-1}$. It's written as **j** instead of **i** to avoid confusion with current (which is denoted by **i** in circuit theory).

Key properties:

- $j^2 = -1$
- Multiplying a vector by **j** rotates it **90° counterclockwise** in the complex plane.
- It's used to express **reactive components** in AC circuits:
  - Inductive reactance: $j\omega L$
  - Capacitive reactance: $-\frac{1}{j\omega C}$


A.c. quantities
The polar symbol
J - operator
vectors
Value + direction
The polar symbol
1 A x B :- Ex: 2<30 x4<-45=8<-15
2 A/B :- Ex: 2<30/4<-45=0.5<75
3 A+B
4 A - B
Using
a Drawing method
or
b Analysis method

a

Drawing method

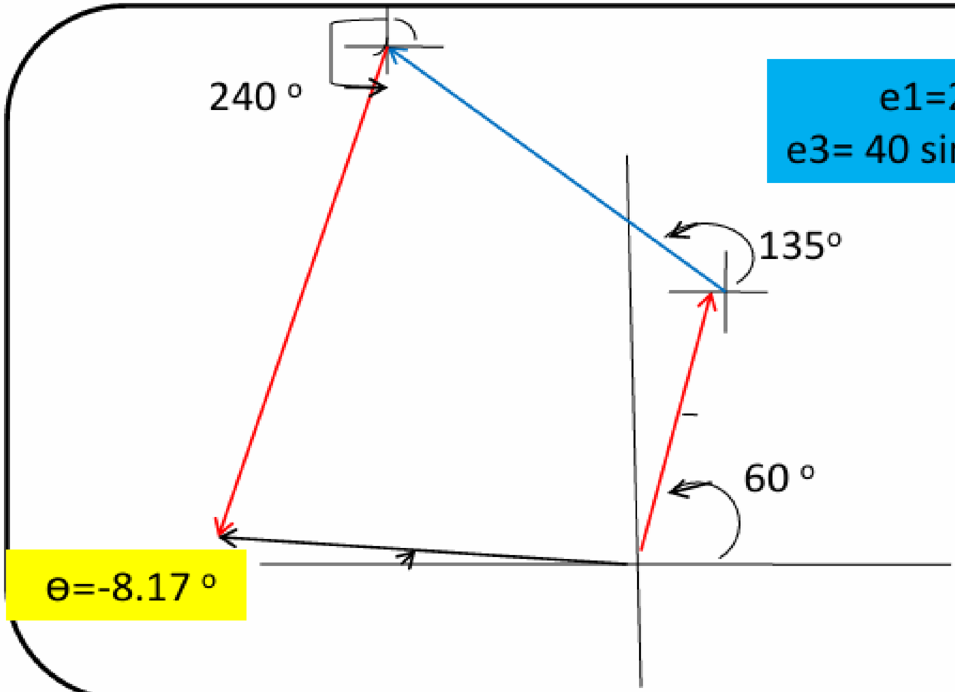
Ex:-Find $\vec{e} = \vec{e1} + \vec{e2} + \vec{e3}$ When:

$e1 = 20 \sin(\omega t + 60)$; $e2 = 30 \sin(\omega t + 135)$; $e3 = 40 \cos(\omega t + 150)$

Solution

$e1 = 20 < 60$; $e2 \; 30 < 135$

$e3 = 40 \sin(\omega t + 150 + 90) = 40 < 240$

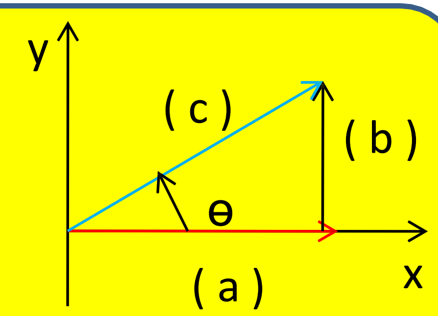


:. e= 27.34 v <-8.17°

b Analysis method

$a = c \times \cos\theta$

$b = c \times \sin\theta$



Ex . 1 : Find the resultant of A. c. current for :

$i_1 = 3\angle 30$ $\quad$ $i_2 = 4\angle 60$ $\quad$ using Analysis method

$$I\cos\theta = i_1\cos\theta_1 + i_2\cos\theta_2 = 3\cos 30 + 4\cos 60 = 4.59$$

$$I\sin\theta = i_1\sin\theta_1 + i_2\sin\theta_2 = 3\sin 30 + 4\sin 60 = 4.964$$

$$\therefore I = \sqrt{(I\sin\theta)^2 + (I\cos\theta)^2} = 6.76 \quad , \theta = \tan^{-1} I\sin\theta / I\cos\theta = 47.24^{\circ}$$

12th week

The effect of alternating current on electrical circuits in series connection.

Aim of lecture:

To make the students should be able to determine the impact of AC circuits linking series, and to learn to find the relationship between the current and voltages in connecting series and finding the phase angle and total defiance of the electrical circuit.

over view

A- Population target

Students of first year

of

Electrical Techniques Department

Pretest

Define: Phase shift, Phase diagram, Phase angle(ϕ), Inductance (L), Capacitance (C), Inductive reactance (X_L), Capacitive reactance (X_c), Impedance(Z).

Phase shift refers to the horizontal displacement between two waveforms of the same frequency. It indicates how much one waveform leads or lags another in time. It's typically measured in degrees (°) or radians.

A **phase diagram** is a graphical representation showing the states of matter (solid, liquid, gas) of a substance at various temperatures and pressures. In electronics, however, it can also refer to a **phasor diagram**, which shows the phase relationships between voltage and current in AC circuits using vectors.

The **phase angle φ** is the angular difference between the voltage and current waveforms in an AC circuit. It determines whether the current leads or lags the voltage:

- In inductive circuits, current **lags** voltage (positive φ).
- In capacitive circuits, current **leads** voltage (negative φ).

Inductance is the property of a coil (or inductor) that resists changes in current. It stores energy in a magnetic field and is measured in **Henries (H)**.

Capacitance is the ability of a capacitor to store electric charge. It resists changes in voltage and is measured in **Farads (F)**.

Inductive reactance is the opposition offered by an inductor to AC current. It increases with frequency and inductance.

Capacitive reactance is the opposition offered by a capacitor to AC current. It decreases with increasing frequency and capacitance.

Impedance is the total opposition to AC, combining both resistance (R) and reactance (X). It’s a complex quantity with both magnitude and phase.

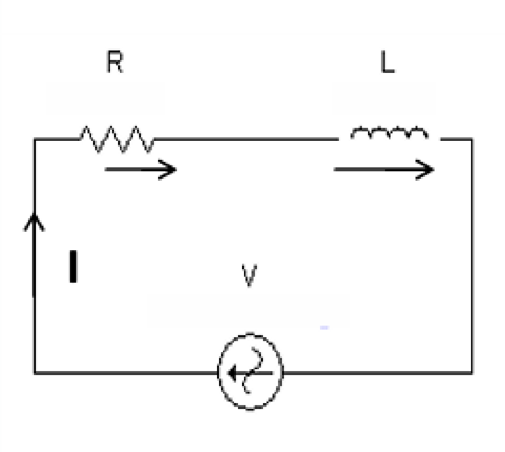
R- L in series

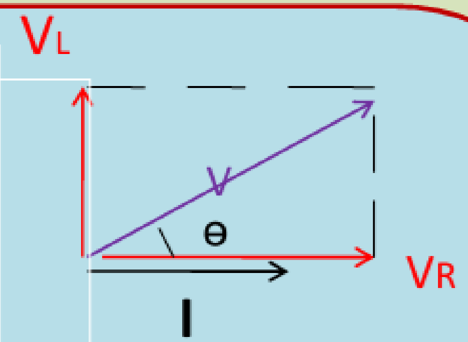
$V_R = I.R$, $V_L = I.X_L$

$V = \sqrt{V_R^{\,2} + V_L^{\,2}}$

$= \sqrt{(I.R)^2 + (I.X_L)^2}$

$V = I\sqrt{(R^2 + X_L^2)}$



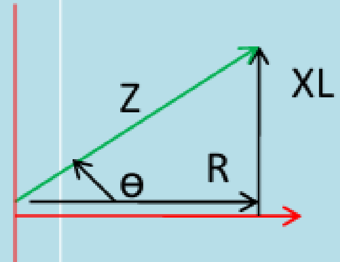


$\therefore Z = V/I = \sqrt{(R^2 + X_L^2)}$

(Ω) Impedance of the cct. ,

$\tan\theta = V_L/V_R = I.X_L/I.R = X_L/R$

$\therefore \tan\theta = V_L/V_R \;\therefore\; \theta = \tan^{-1} V_L/V_R$



Triangle of Impedance

$\tan\theta = X_L/R \;\therefore\; \theta = \tan^{-1} X_L/R$

ϴ =phase angle between V and I

قيمة الزاوية تتراوح اكبر من الصفر واصغر من 90 درجة (موجبة)مثل +30 او +45او +60 = ϴ

(قيمة الزاوية الفولتية – قيمةϴ)مثل -30 او -45او -60 = زاوية التيار) في حال زاوية الفولتية =0

Ex(1):- For the cct. Shown find the value and direction the current

$Z=\sqrt{R^2+XL^2}$, $XL=\omega.L=314\times0.1=31.4\ \Omega$

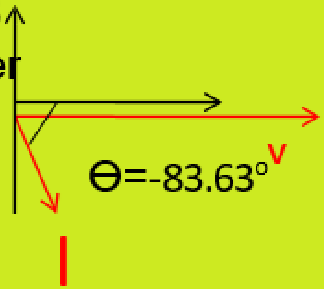
$Z=\sqrt{(3.5)^2+(31.4)^2}=31.6\Omega$

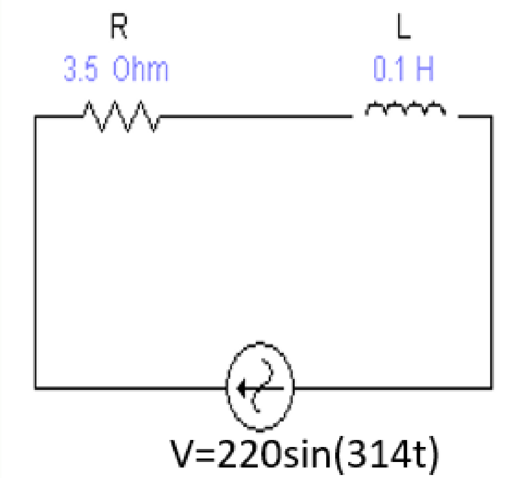
$I=v/Z=220/31.6=6.96\ A$

$\Theta=\tan^{-1}XL/R=\tan^{-1}31.4/3.5=\tan^{-1}8.97$

$\therefore\Theta=83.63^{o}$ $\therefore i=6.96\angle-83.63$

$\therefore i=6.96\sin(314t-83.63)$ Amer





R-c in series

$V_R=I.R$, $V_C=I.XC$

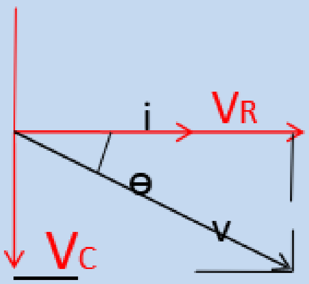
$V=\sqrt{V_R^2+V_C^2}=\sqrt{(I.R)^2+(I.Xc)^2}$

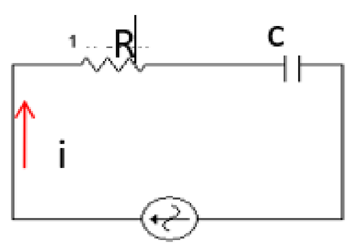
$V=I\sqrt{(R^2+Xc^2)}$

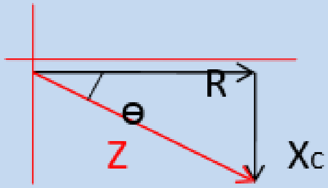
$\therefore Z=V/I=\sqrt{(R^2+Xc^2)}$, $Xc=1/\omega.c$

$\tan\theta=V_c/V_R=I.Xc/I.R=Xc/R$

$\therefore\theta=\tan^{-1}V_c/V_R$ Or $\tan\theta=Xc/R$







find (f), then what is the value of (R) that
connected with (C) to reduce the current to (0.5A) with the same frequency.

Solution

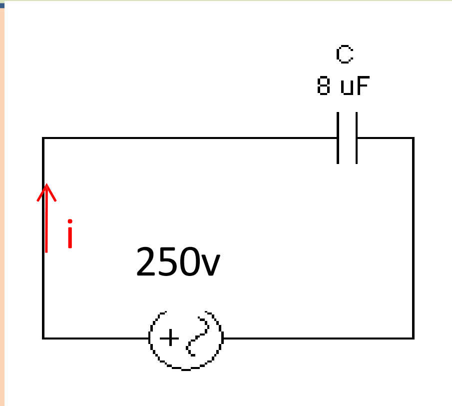
$X_c = V_c / I_c = 250/1 = 250\ \Omega$

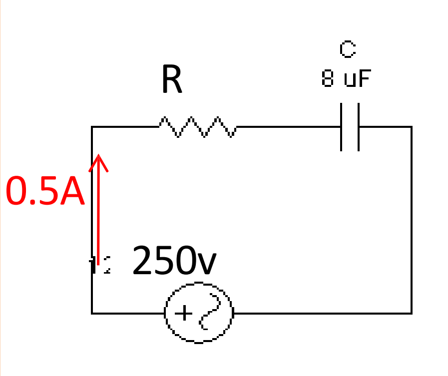
$X_c = 1/\omega.c = 1/2\pi fc \quad \therefore f = 1/(2\pi.c.X_c)$

$f = 1/(2 \times 3.14 \times 8 \times 10^{-6} \times 250) = 79.5$ HZ

$Z = \sqrt{(R^2 + X_c^2} = \sqrt{(R^2 + 250^2}, \quad Z = 250/0.5 = 500\ \Omega$

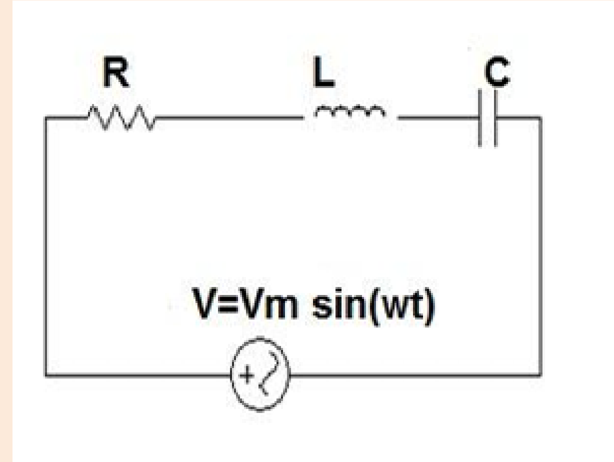
$\therefore 500^2 = R^2 + 250^2 \quad \therefore R^2 = 500^2 - 250^2 \therefore R = 433\ \Omega$





R-L-C in series

1- If $X_L > X_C$:. $V_L > V_C$



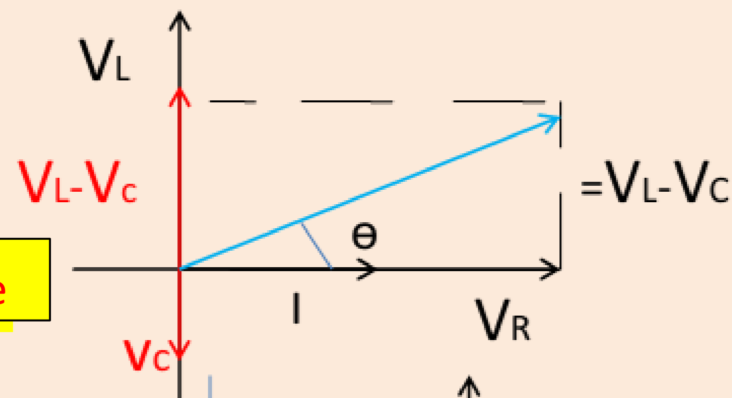
$V_R = I.R$, $V_L = I.X_L$, $V_C = I.X_C$, $V = \sqrt{V_R^2 + (V_L - V_C)^2}$

$V = I . \sqrt{R^2 + (X_L - X_C)^2}$

:. $Z = V/I = \sqrt{R^2 + (X_L - X_C)^2}$ {The impedance of the cct.}

$\theta = \tan^{-1} (V_L - V_C) / V_R$

$\theta = \tan^{-1} (X_L - X_C) / R$

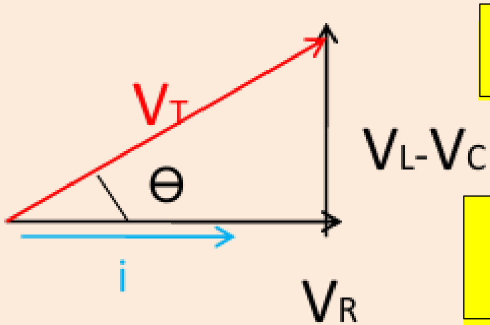


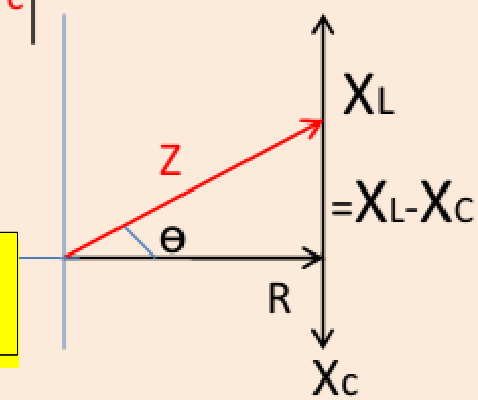
Also : $X_L > X_C$:

1- The cc.t is inductive

2- ϴ is positive

3- V_T led I_T by ϴ





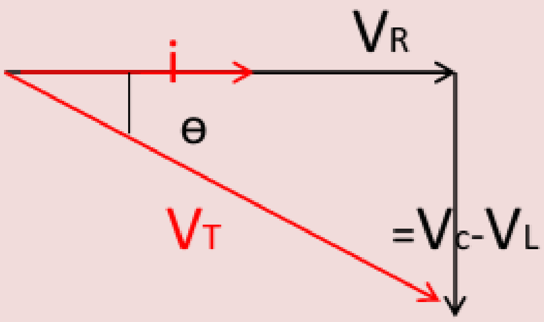
2/ If $X_c > X_L$:. $V_c > V_L$

When $X_L < X_c$

1/ The cct. Is capacitive

2/ϴ is negative

3/ i_T leads يتقدم V_T by ϴ



3/ If $X_L = X_C$;. $V_L = V_C$

When $X_L = X_c$

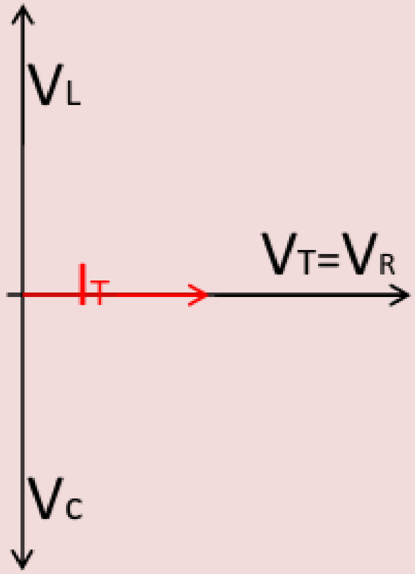
1/ We have **resonance case**

2/ ϴ =0

3/Z =R

4/ $V_L = V_c$

5/ $V_T = V_R$



Resonance series frequancy

$X_L = X_C$:.$2\pi f_o . L = (1/2\pi f_o . C)$

:.$f_o^2 = (1/4\pi^2 L.C)$

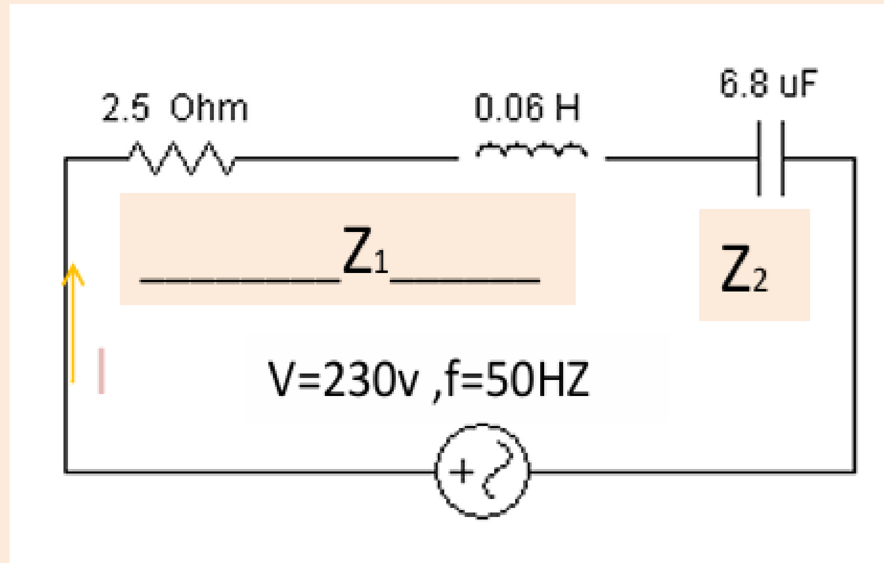
$f_r = f_o = 1/(2.\pi.\sqrt{L.C})$ HZ

The energy stord in the coil(w,e)

$W = (1/2) L.I_m^2$ joule

EX(3) : For the cct. Shown Find (Z_T, I, θ, V_{Z1} ,V_{Z2}) draw the phaser diagram .

$$Z_T = \sqrt{R^2 + (X_L - X_C)^2}$$



$X_L = 2\pi f.L = 2x3.14x50x0.06 = 18.8\Omega$

$X_C = 1/2\pi f.c = 1/(2x3.14x50x6.8x10^{-6}) = 468.1\Omega$

$Z_T = \sqrt{2.5^2 + (18.8-468.1)^2} = 449.3\ \Omega$

$I = V/Z = 230/449.3 = 0.5$ A

$\theta = \tan^{-1}\ (X_L - X_C)/R = \tan^{-1}(-449.3)/2.5$

:. $\theta = -89.68^o$

:. $V = 230 < -89.68^o$ v

$i = 0.5 < 0$ A

$Z_1 = \sqrt{(2.52 + (18.8)^2}$

$= 18.965\Omega$

Z2 $= XC = 468.1\ \Omega$

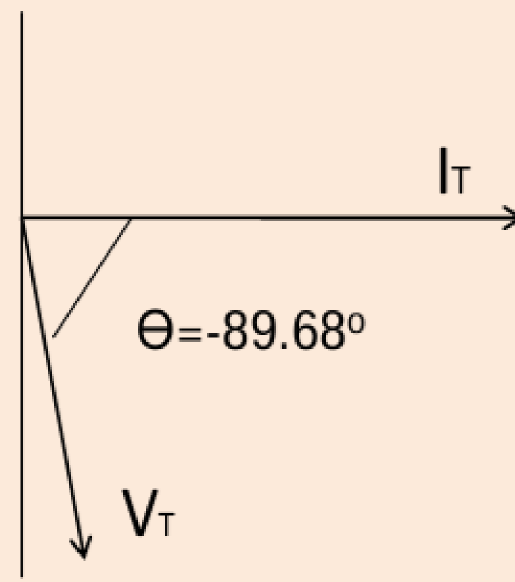
:.$V_{Z1} = I.Z1 = 0.5x\ 18.965$

$= 9.48$ v

:.$V_{Z2} = I.Z_2 = I.XC$

$= 0.5x468.1$

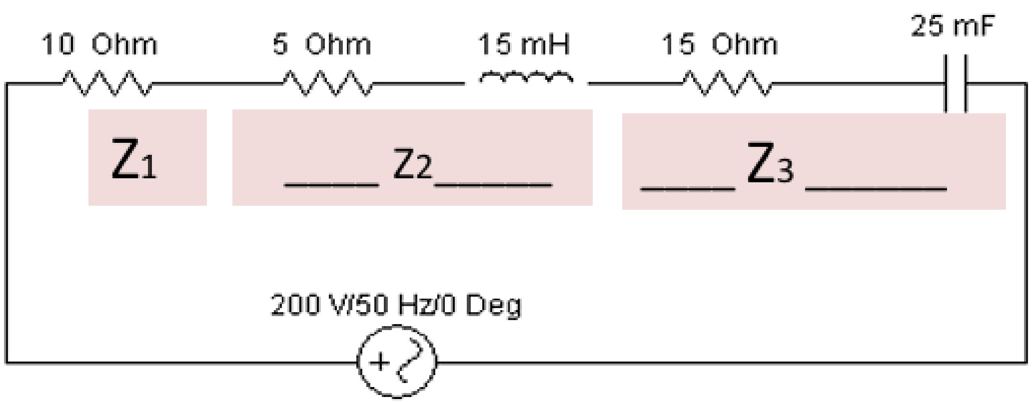
$= 234$v



Post test

Ex(a) : For the cct. Shown Find (Z_T, I, ɵ , V_{Z1}, V_{Z2} , V_{Z3})then draw the phaser diagram .

H .W



solution

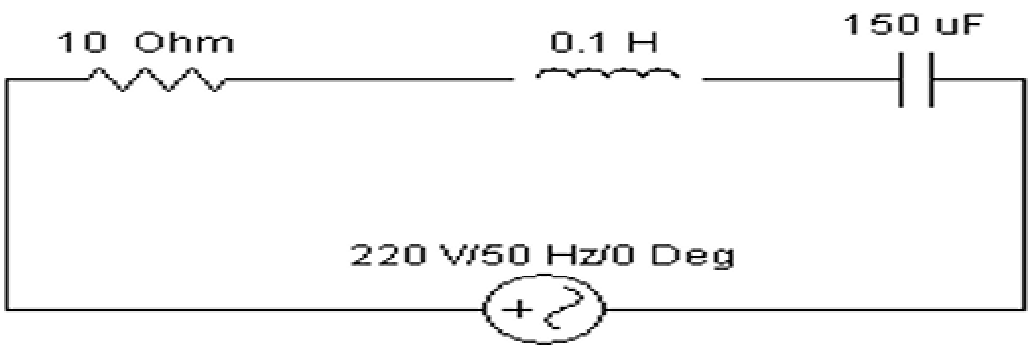
Z_T=31.6 Ω ,
I=6.329A A

ϴ =18.43°

V_{Z1}= 63.29v
V_{Z2}= 99.998v
V_{Z3}=184.49v

EX(b): For the cct. Shown Find: I, ɵ ,VR,Vc , VL and draw the phaser diagram.

H.W



solution

I= 14 A

ϴ =45.55°

V_R= 140v
V_C =297v
V_L= 439.81v

13^{th} week

The effect of alternating current on electrical circuits in parallel connection.

Aim of lecture:

To make the students should be able to determine the impact of AC circuits linking parallel, and to learn to find the relationship between the current and voltages in connecting parallel and finding phase angle and total defiance of the electrical circuit.

over view

A- Population target

Students of first year

of

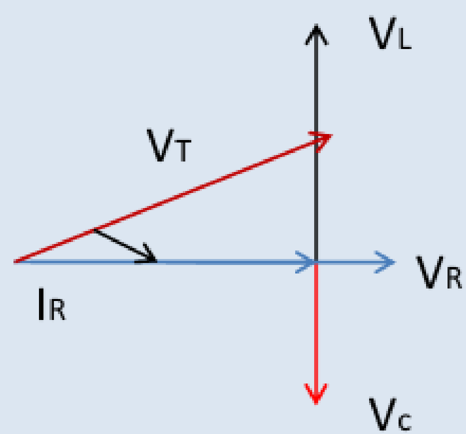
Electrical Techniques Department

Aim of lecture : To make the student should be able to decipher complex electrical networks linking parallel and current knowledge of the relationship Balvoltaip in this case, and how to find a phase angle and the reluctance of the circle and permittivity

Pretest

Ex: Drawing the phase diagram for the cct contain (L,C)in series .If xL > xc

Solution :-



R-L in parallel — في حالات التوازي

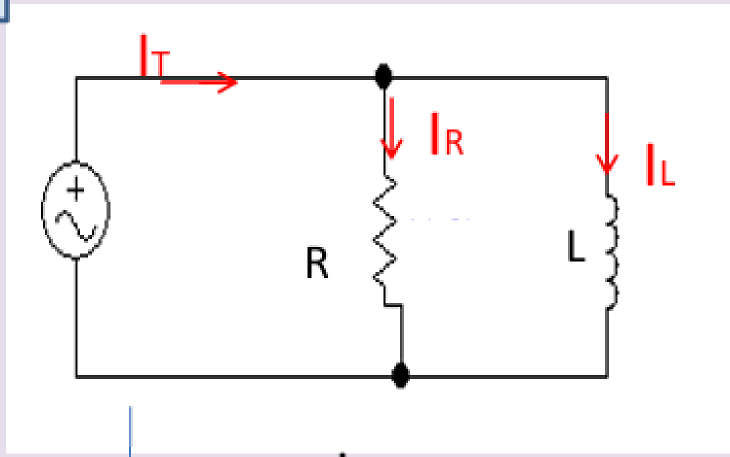
$I_R = V/R$, $I_L = V/X_L$, $I_T = \sqrt{I_R^2 + I_L^2}$

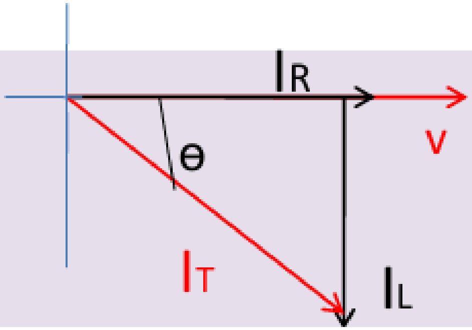
$$I_T = \sqrt{(V/R)^2 + (V/X_L)^2} = \sqrt{V^2/R^2 + V^2/X_L^2}$$

$$I_T = V\sqrt{1/R^2 + 1/X_L^2} = I/V = Y = \sqrt{1/R^2 + 1/X_L^2} \text{ (Moh)},$$

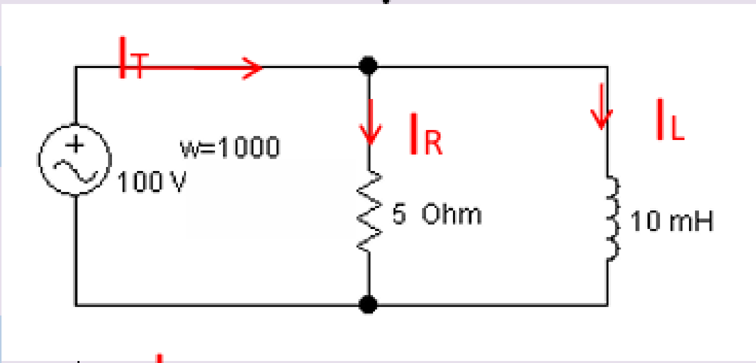
$1/\Omega$,(Siemens) ,(admittance of the cct.) , $Y=1/Z$, $Z=1/Y$

$\Theta = \tan^{-1}$ **(-IL / IR)**





EX(1): for the cct. Shown find YT, ZT, IR ,IL , IT ,ɵ Drawing the phaser diagram.



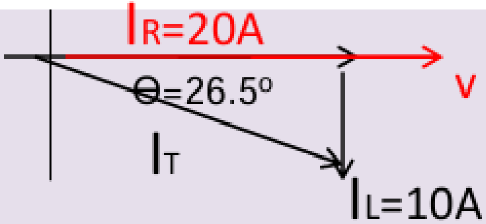
$I_R = v/R = 100/5 = 20A$, $I_L = V/X_L = 100/(1000*0.01)) = 10A$

$I_T = \sqrt{I_R^2 + I_L^2} = \sqrt{20^2 + 102} = 22A$

$\Theta = \tan^{-1} -I_L/I_R = \tan{-1}\ (-10/20) = -26.5$

$Z_T = V/I_T = 100/22 = 4.545\Omega$

$Y_T = 1/Z_T = 0.22$ moh



R-C in Parallel

$I_R = V/R$, $I_C = V/X_c$

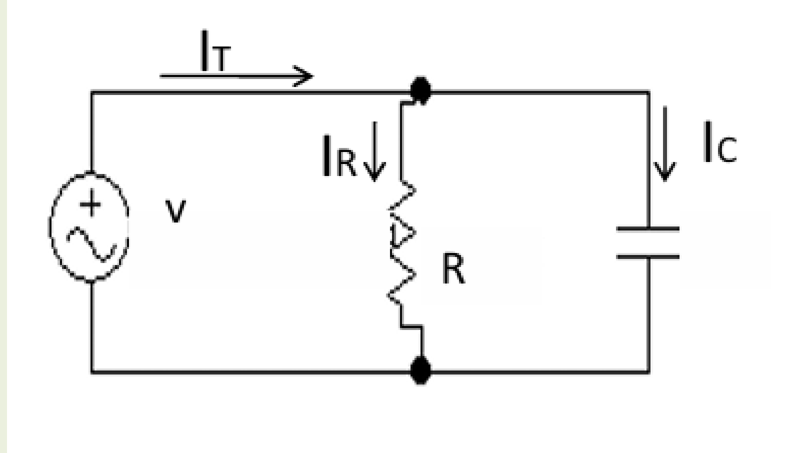
$I_T = \sqrt{I_R^2 + I_c^2}$

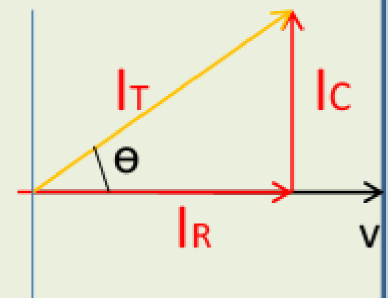
$= \sqrt{(V/R)^2 + (V/X_c)^2}$

$I = V\sqrt{(1/R^2) + (1/X_c^2)}$

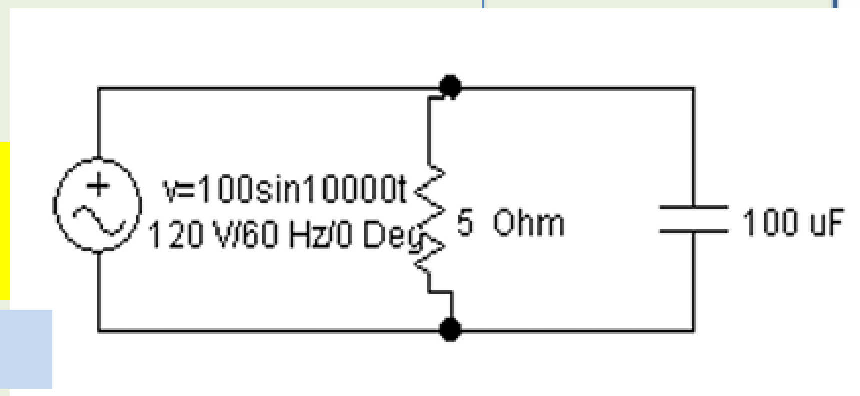
$I/v = Y = \sqrt{(1/R^2) + (1/X_c^2)}$

$\Theta = \tan^{-1}(I_C / I_R)$





EX(2) : for the cct. Shown find Y_T, Z_T, I_R ,I_c , I_T ,θ Drawing the phaser diagram.



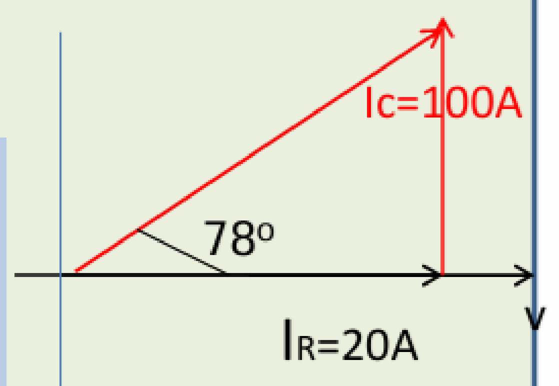
Solution :$X_c = 1/\omega.C = 1/(10000 \times 100 \times 10^{-6}) = 1\Omega$

$Y = \sqrt{1/R^2 + 1/Xc^2} = \sqrt{1/52 + 1/12} = 1.01$moh ,

$Z = 1/Y = 0.98\ \Omega$, or $Z = V/I = 100/101 = 0.98\ \Omega$, $IR = V/R = 100/5 = 20A$

$Ic = V/Xc = 100/1 = 100A$, $IT = \sqrt{IR^2 + Ic^2} = \sqrt{20^2 + 1002} = 101A$

$\theta = \tan^{-1} Ic/IR = \tan^{-1} 5 = 78^o$



The general Parallel case

1

If $X_L > X_C$:. $I_C > I_L$:. $I_T = \sqrt{I_R^2 + (I_C - I_L)^2}$

$Z_T = 1/\sqrt{(1/R)^2 + (1/X_C - 1/X_L)^2}$ OR $Z = V/I_T$

$\theta = \tan^{-1} (I_C - I_L) / I_R$

2

If $X_C > X_L$:. $I_L > I_C$:. $I_T = \sqrt{I_R^2 + (I_C - I_L)^2}$

$Z_T = 1/\sqrt{(1/R)^2 + (1/X_L - 1/X_C)^2}$ OR $Z = V/I_T$

$\theta = \tan^{-1} (I_C - I_L) / I_R$

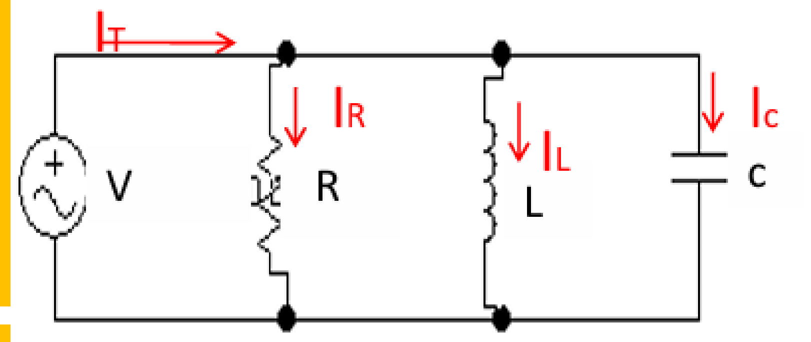
3

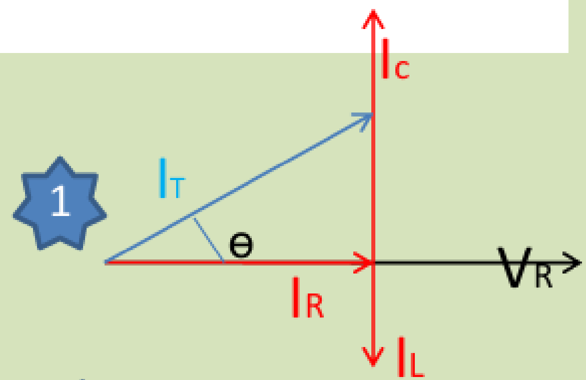
If $X_C = X_L$ (Resonance Parallel case) :. $I_C = I_L$:. $I_T = I_R$

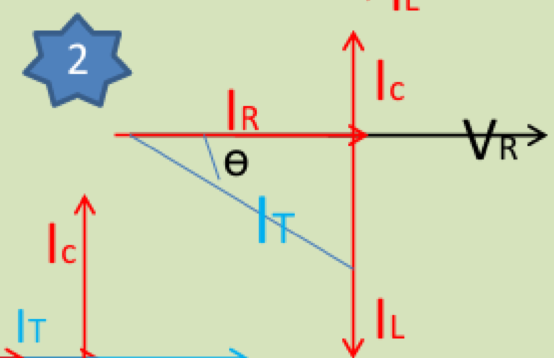
$Z_T = 1/\sqrt{(1/R)^2}$:. $Z_T = R$, $V_T = I_T . Z_T$, $\theta = 0$

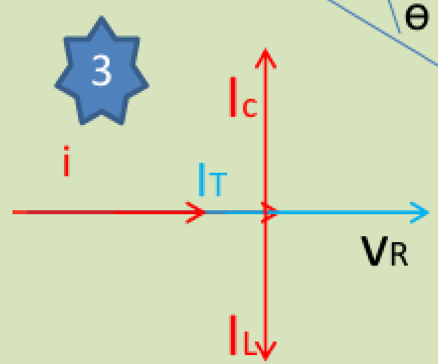
$f_r = 1/ 2.\pi.\sqrt{L.C}$ HZ

f_r: (Resonance Parallel frequancy)





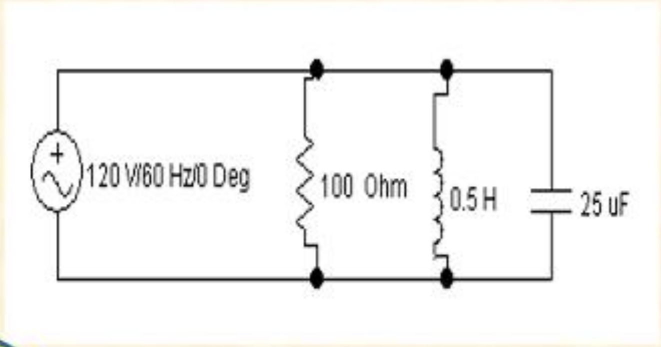




Example(3):

For the parallel cct. Shown in figer find : 1/ The total current 2/ phase angle 3/ Impedance of the cct. 4/ phase diagram .

solution



$I_R = V/R = 120/100 = 1.2A$, $X_c = 1/2\pi f.c = 1/2\,\pi \times 60 \times 25 \times 10^{-6}$

$\therefore X_c = 100\Omega$, $I_c = V/X_c = 120/100 = 1.2A$, $X_L = 2\,\pi f.L = 2\,\pi \times 60 \times 0.5$

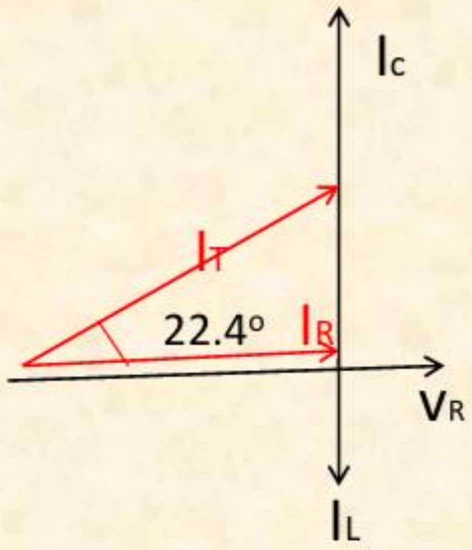
$\therefore X_L = 188.4\Omega$, $I_L = V/X_L = 120/188.4 = 0.63A$

$I_c - I_L = 1.2 - 0.63 = 0.57A$ $\therefore I_T = \sqrt{I_R^2 + (I_c - I_L)^2}$

$\therefore I_T = \sqrt{(1.2)^2 + (0.57)^2}$ $\therefore I_T = 1.3A$,

$\theta = \tan^{-1} I_c - I_L / I_R = \tan^{-1} 0.57/1.2 = 22.4^o$

$Z = V/I_T = 120/1.3 = 92\Omega$



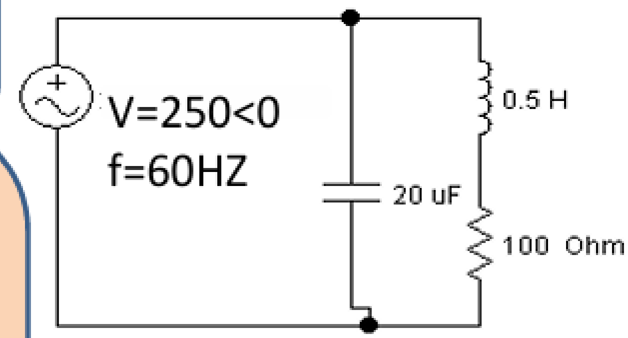
Posttest

Ex: For the cct. Shown in figer find 1) the source current I_T .
2) Active and reactive power and apparent power

Solution

$X_L=2\pi x60x0.5=188\Omega$

$X_c=1/2\ \pi x60x20x10^{-6}\ =132.6\Omega$



$Z_L=\sqrt{(1002 +188^2)} = 213\,\Omega$, $\theta=\tan^{-1} 188/100=62^o$

$Z_L=213< 62^o\ \Omega$, $Z_c=132.6<-90^o$

$I_L=V/Z_L=250/213<62 =1.17 <-62$ A

$I_c=V/Z_c= 250/132.6<-90^o =1.88<90A$, $I_T= I_L + I_C$

:. $I_T= 1.88<90 + 1.17<-62$

:. $I\cos\theta=1.17x\cos -62 + 1.88x\cos 90 =0.423A$

$I\sin\theta =1.17x\sin -62 + 1.88x\sin 90 =0.79A$

:. $I_T= \sqrt{(0.423)^2 + (0.79)^2} =0.896A$

$\theta=\tan^{-1} 0.79/ 0.423 = 61.8^o$:. $I =0.896<61.8A$

P=I.Vcos θ =250x0.896xcos61.8=105.73 watt (Active power)

Q=I.Vsinθ =250x0.896 xsin61.8 =197.4 var (Reactive power)

S=V.I =250x0.896=224 V.A (Apparent power)

14^{th} week
series resonance

overview

A- Population target

Students of first year

of

Electrical Techniques Department

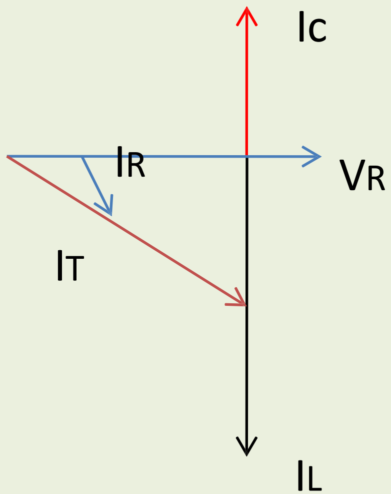
Aim of lecture

To make students able to learn circuits respectively ringing and how to access them and calculate the current and voltage and impedance at resonance condition, as well as finding the bandwidth and finding a quality factor and how to draw a relationship between the inductive reactance and capacitive reactance with frequency.

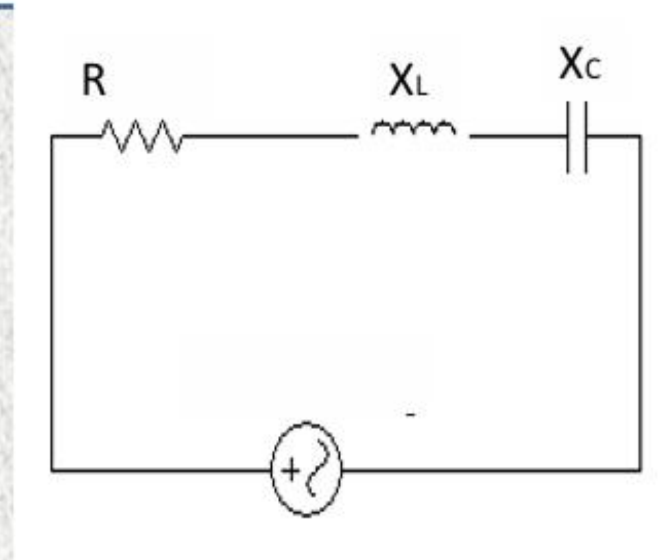
pretest

Ex: Draw the phaser diagram at parallel circuit contain (L,c) If $X_L > X_C$

solution



If $X_L=X_C$;. $V_L=V_C$



When $X_L= X_C$

Resonance series frequency

XL=XC

:. $2\pi f_o.L=(1/2\pi f_o.C)$

:. $f_o^2=(1/4\pi^2 L.C)$

$fr=fo=1/ 2.\pi. \sqrt{L . C}$ HZ

The energy stord in the coil(w,e)

$W=(1/2)\ L.I_m^2$ joule

We have **resonance case when**

1/ $X_L=X_C$

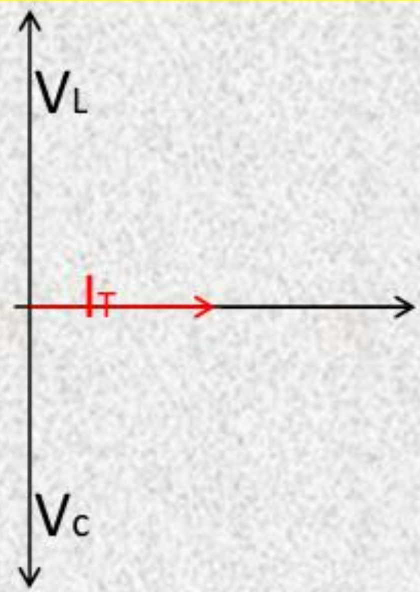
2/ $Z=R$

3/ $V_L=V_C$

4/ $V_T=V_R$

5/ $\theta=0$

6/ Imax is flow



Quality factor (Q operator) : - It is the relation between reactive and active power at Resonance case

1) $Q = I^2 . X_L / I^2 . R$ $:.Q = X_L/R$ 2) $Q = 2\pi f_r.L/R = 2\pi \left(1/2\pi \sqrt{L.c}\right) .L/R$

$:.Q = \omega_r.L/R = 2\pi f_r.L/R$ { When resonance case :. $X_L = X_c$ $:.\omega_r.L = 1/\omega_r.c$ }

$:. Q = (1/R) . \sqrt{L.c}$

$:.Q = 1/\omega_r.R.C = \omega_r.L/R = (1/R)\sqrt{L.c}$

Band width (B.w) OR Pass Band

$B.w = f_2 - f_1$

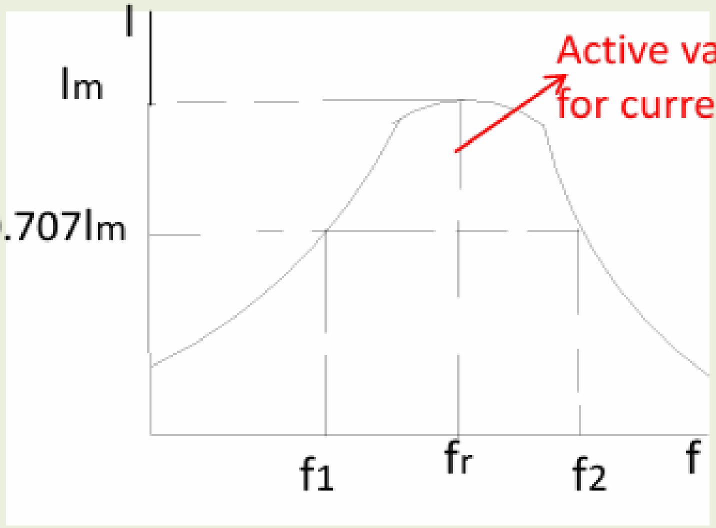
$I_{r.m.s} = I_m/\sqrt{2} = 0.707\, I_m$

$f_r = \sqrt{f_1 \times f_2}$, $Q = f_r/B.w$

For the cct. Have $Q \geq 10$

$\{f_2 = f_r + B.w/2$, $f_1 = f_r - B.w/2\}$because :

$F_r = 1/2\pi \sqrt{L.c}$



Q factor of a series resonant cct. Reconsider the equations for I, VL and Vc at resonance

$V_L = I.X_L$, $I = V/R$, $V_L = (V/R).X_L$, Or :

$V_L/V = X_L/R$ .....(1)

similarly ; $Vc/V = Xc/R$

The ratio (capacitor voltage ,voltage, or inductor voltage at resonancy/ (supply voltage)is a measure of the quality of a resonance cct.

This is termed the (Q) factor of the cct and it is also known as the voltage magnification factor .

From equ. (1);

$Q = \omega.L/R$ ...(2) and $Q = X_c/R$ giving $Q = 1/\omega.C.R$

Since the coil resistance is often the only resistance in a series resonance cct, the (Q) is some times referred to as the (Q) factor of the coil, Rewriting equation....(2)

$Q = (2\pi.f_r.L)/R$ and substituting for fr from equation : $f_r = 1/(2\pi\sqrt{L.c})$

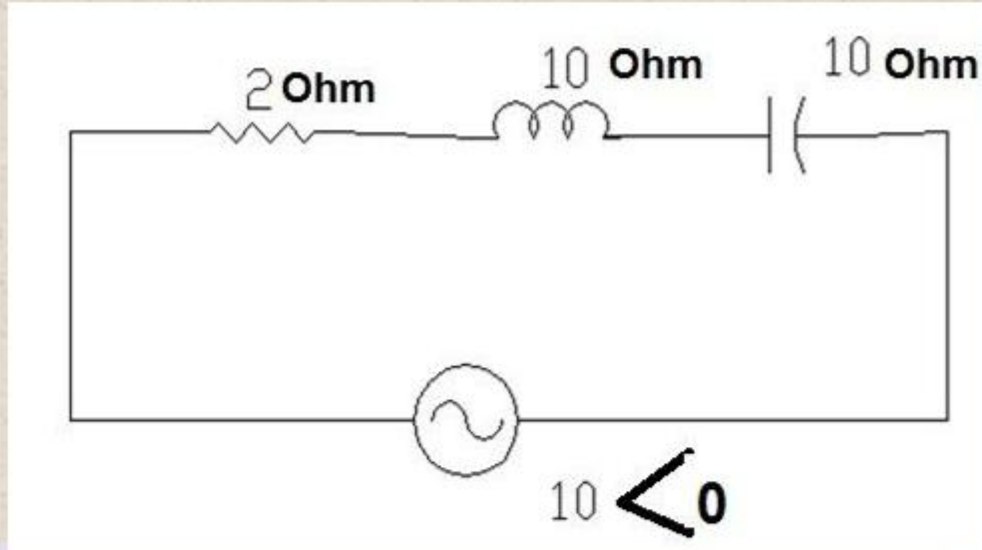
$\therefore Q = [2\pi.L(1/2\pi\sqrt{L.c})]/R$ which reduces to ; $Q = 1/R(\sqrt{L}/C)$

It is seen that the Q factor of a series resonance cct. May be increased either by reducing (R)
Or by increasing the L/C ratio .

The Q factor can also be defined in terms of the ratio of the reactive power to the power dissipated in the cct. Resistance. Using this the equations for Q come out exactly as derived above .

Ex.1 **For the resonance cct. Shown below find :**

1) **I,VR,VL,Vc , in polar form .**
2) **The quality factor .**
3) **The band width B.W if the resonance frequency (5000)HZ .**
4) **The Band width (B.W) if the resonance frequency (500) HZ.**



Solution :

1) $X_L=X_C$ (resonance case) , $Z_T= R=2$, $I= V/Z= 10<0/2<0= 5<0$ A

$V_R= I.R=5<0x2<0=10<0$ V. , $V_L= I.X_L= 5<0x10<90=50<90$ v

$V_c= I.X_c= 5<0x10<-90=50<-90$ v , **2)** $Q= X_L/R= 10/2=5$

3) $B.W=f_r/Q=5000/5=1000$Hz , **4)** $B.W=f_r/Q=500/5=100$Hz

Ex2;The band width of a series resonance cct. Is (400Hz), R=10Ω Find : Q , XL , L , C

solution :

$Q = fr/B.W = 4000/400 = 10$, $Q = X_L/R$

$\therefore X_L = Q.R = 10.10 = 100\Omega$

$X_L = 2\prod.f.L$, $L = X_L/2\prod.f = 100/(2(3.14)4000) = 0.0039\ H$

in resonance case : $X_L = X_c$

$\therefore X_C = 1/(2\prod f.c)$, $\therefore C = 1/(X_c(2\prod)f)$

$C = 1/(100(2)(3.14)\,4000) = 0.39\times10^{-6}\ F$

Ex 3:. A series L-c-R cct. Which resonates at (fr) =500kHZ , has L=100 μH, R=25Ω ,and C=1000P.f . Deter mine the (Q) factor of the cct. Also , determine the new value of (C) required for resonance at (500 KHz) when the value of (L) is doubled (تضاعف) and calculate the new (Q) factor .

Solution : $Q=1/R(\sqrt{L/C})$,$Q = (1/25\Omega) (\sqrt{100\ \mu H/1000 p.F}) =12.6$

When : L is doubled:

$f_r = (1/2\pi)(\sqrt{L.C})$, :. $C= 1/(4\pi^2 x\ f_r^2 x L) = 1/[4\pi^2 x(500kHz)^2 x 200\mu F]$

:. C=500P.F

$Q^2=(1/25)(\sqrt{200\mu H/500p.f})$, :. Q =25

EX(4) . A series L-c-R cct. Which resonates at (fr) =500kHZ , has L=100 μH, R=25Ω ,and C=1000P.f . Deter mine the (Q) factor of the cct. Also , determine the new value of (C) required for resonance at (500 KHz) when the value of (L) is doubled (تضاعف) and calculate the new (Q) factor .

Solution :

$Q=1/R(\sqrt{L/C})$, $Q = (1/25\Omega)(\sqrt{100\ \mu H/1000 p.F}) = 12.6$

When L is doubled:

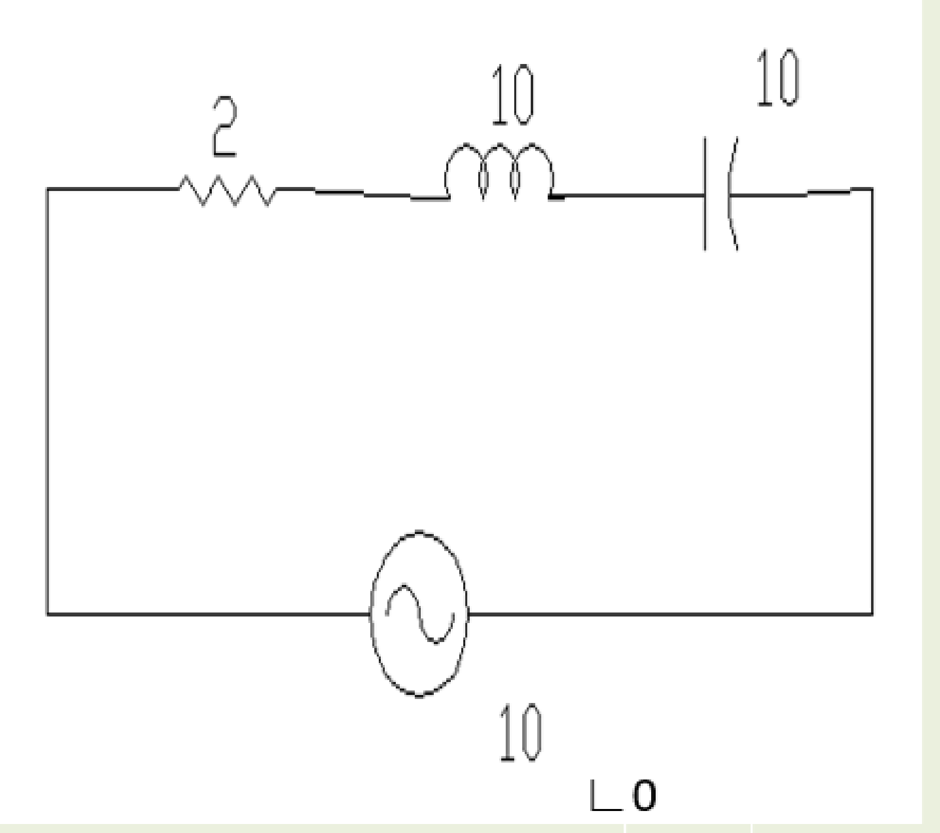
$f_r = (1/2\pi)(\sqrt{L.C})$, $\therefore C= 1/(4\pi^2 x\ f_r^2 x L) = 1/[4\pi^2 x(500kHz)^2 x200\mu F]$

$\therefore C=500P.F$

$Q^2=(1/25)(\sqrt{200\mu H/500p.f})$, $\therefore Q = 25$

Posttest

H.W. For the resonance cct.



Shown below find :

1) I,VR,VL,Vc , in polar form .
2) The quality factor .
3) The band width B.W if the resonance frequency .
4) The Band width (B.W) if the resonance frequency (500 HZ)

Solution :

$X_L=X_C$ (resonance case) , Z_T= R=2 , I= V/Z= 10 <0/2<0= 5<0 A

V_R= I.R=5<0x2<0=10<0 V. , V_L= I.X_L= 5<0x10<90=50<90 v

V_c= I.X_c= 5<0x10<-90=50<-90 v , Q= X_L/R= 10/2=5

B.W=F_r/Q=5000/5=1000Hz

H.W. The band width of a series resonance cct. Is (400Hz), R=10Ω Find : Q , XL , L , C

solution : Q= fr/B.W =4000/400 =10 , $Q=X_L/R$

:. X_L= QxR=10x10=100Ω

X_L=2∏.F.L , .: L =X_L/2∏.f.L =100/(2x3.14x4000)

= 0.0039 Hz

in resonance $X_L=X_c$

:. X_C= 1/(2∏f.c) , :. C= 1/ (X_cx2x∏xf)

= 1/(100x2x3.14x 4000)=0.39x1o-6 F

15th week

Parallel resonance

Aim of the lecture:

Student to be able to tell the parallel ringing and how to calculate the voltage and current impedance and phase angle and the resonant frequency and bandwidth with the knowledge of drawing graphs relations with the frequency and find the quality factor.

overview

A- Population target

- Student of the first year of Electrical Techniques Department

pretest

Explain cases that get then resonance series case , and drawing the phaser diagram at this case .

Solution

We have **resonance case when**

1/ $X_L = X_C$

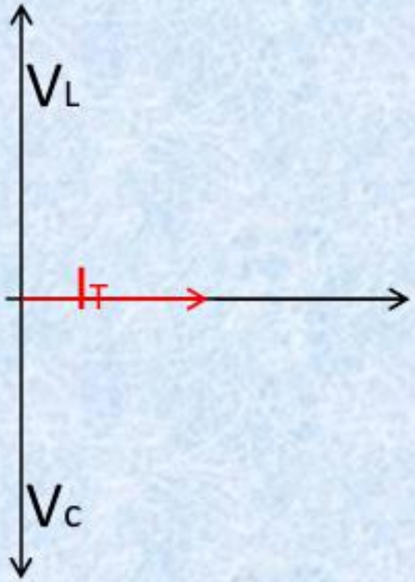
2/ $Z = R$

3/ $V_L = V_C$

4/ $V_T = V_R$

5/ $\Theta = 0$

6/ Imax is flow



Resonance Parallel case

If $X_C=X_L$:. (Resonance Parallel case)

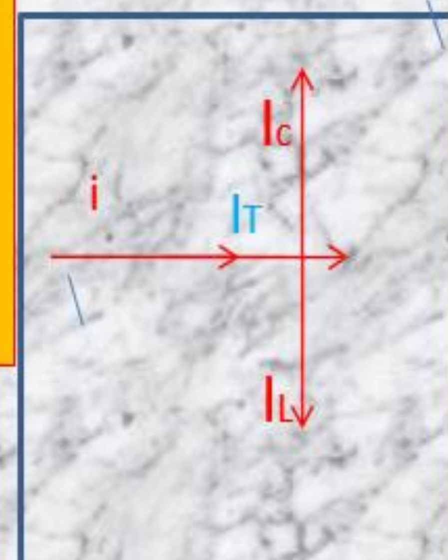
:. $I_c=I_L$:. $I_T= I_R$

$Z_T= 1/\sqrt{(1/R)^2}$:. $Z_T= R$, $V_T= I_T.Z_T$, $V_T=I_T.R$, $\theta=0$

$f_r= 1/ 2.\pi.\sqrt{L.C}$ HZ

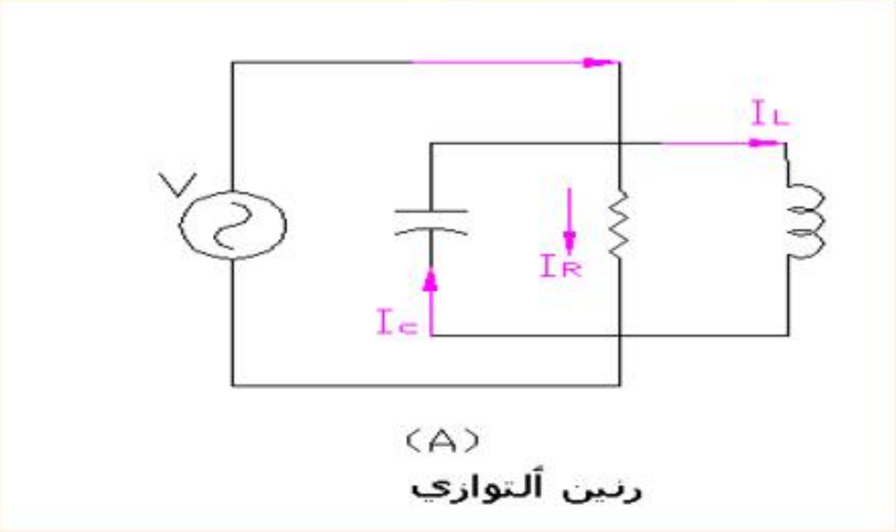
f_r: (Resonance Parallel frequency)

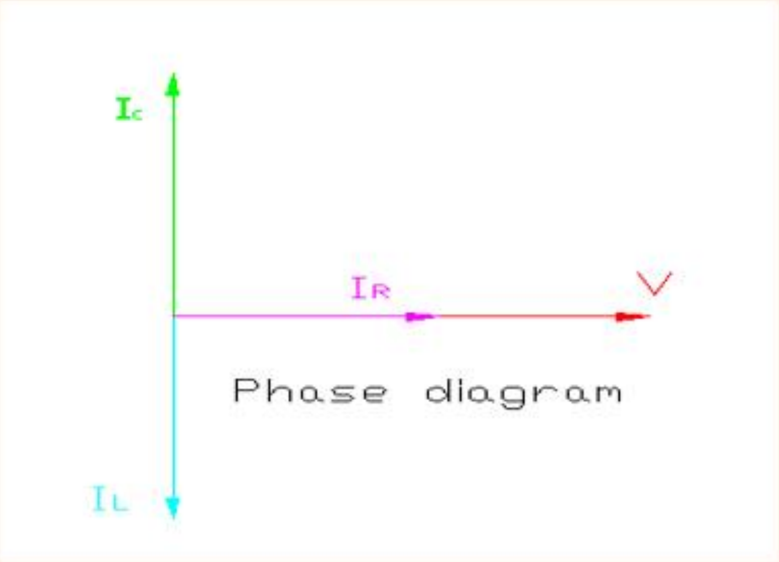
i

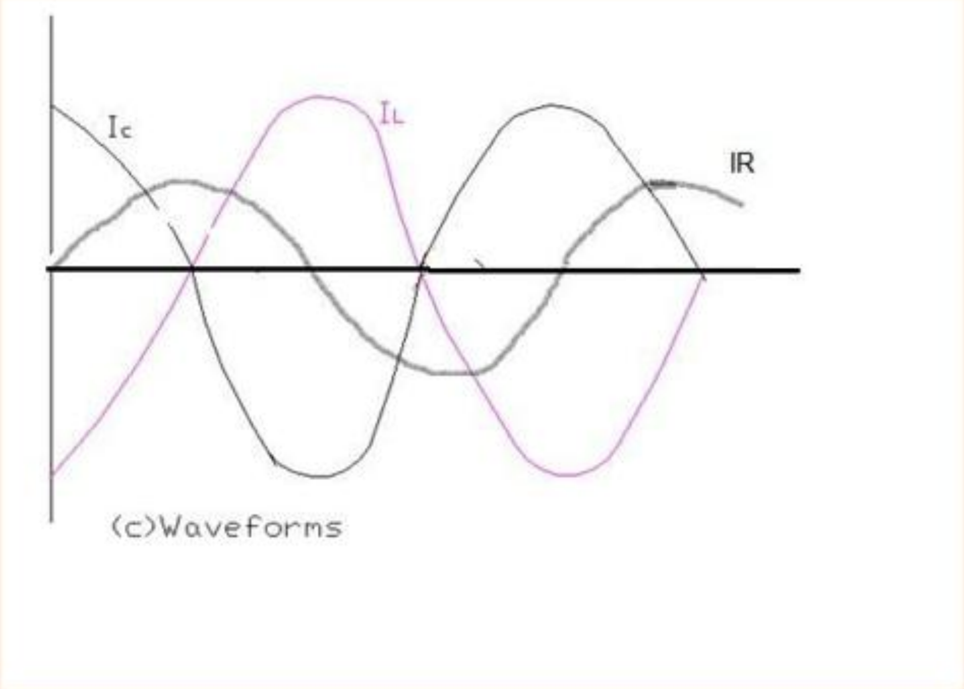


Parallel resonance :

$Y=(1/R) - j(1/X_L) + j(1/X_c)$





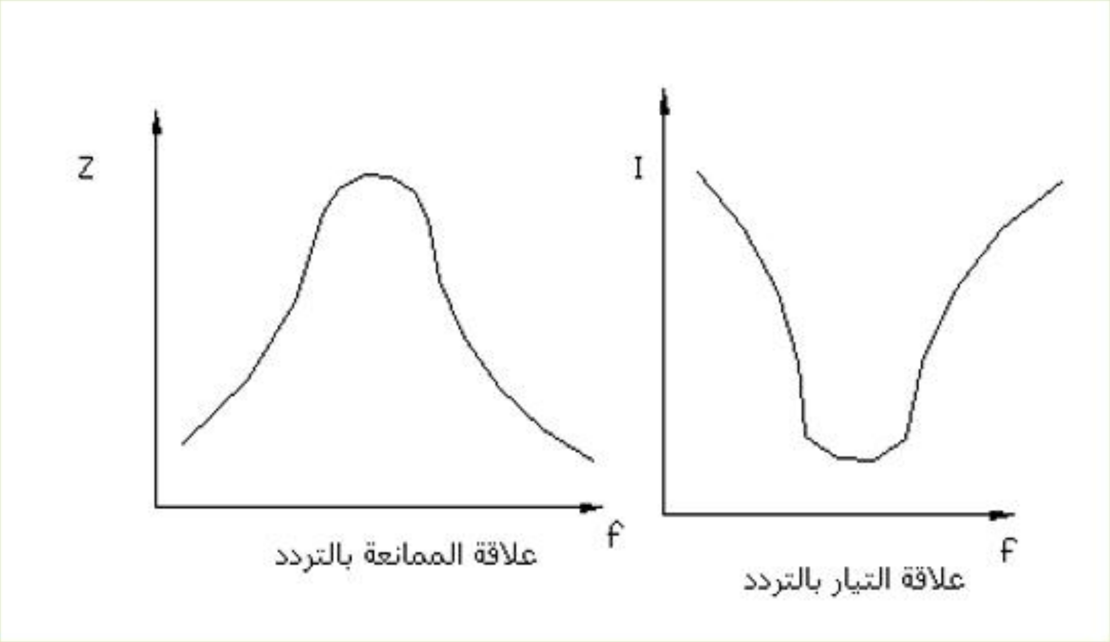


I_R with the same phase with (v) , If the supply frequency is adjusted until X_L and X_c are equal, the admittance becomes: Y=1/R , and the cct. Impedance, R=Z . Consequently, the current taken from the supply source is I=V/R

The current through (R) is in phase with the supply voltage. The current through (L) lags the supply voltage by 90^o . This is illustrated by the phaser diagram (b), and by the cct. Wave forms in figure (C) .When X_L , X_c are equal, the inductive and capacitive currents are equal and opposite, as illustrated in the phaser diagram. Thus, the total current supplied by the voltage source is I_R ,I_c and I_L are the result of the energy stored in the cct. Being continuously transferred from the inductor to the capacitor , and back again .

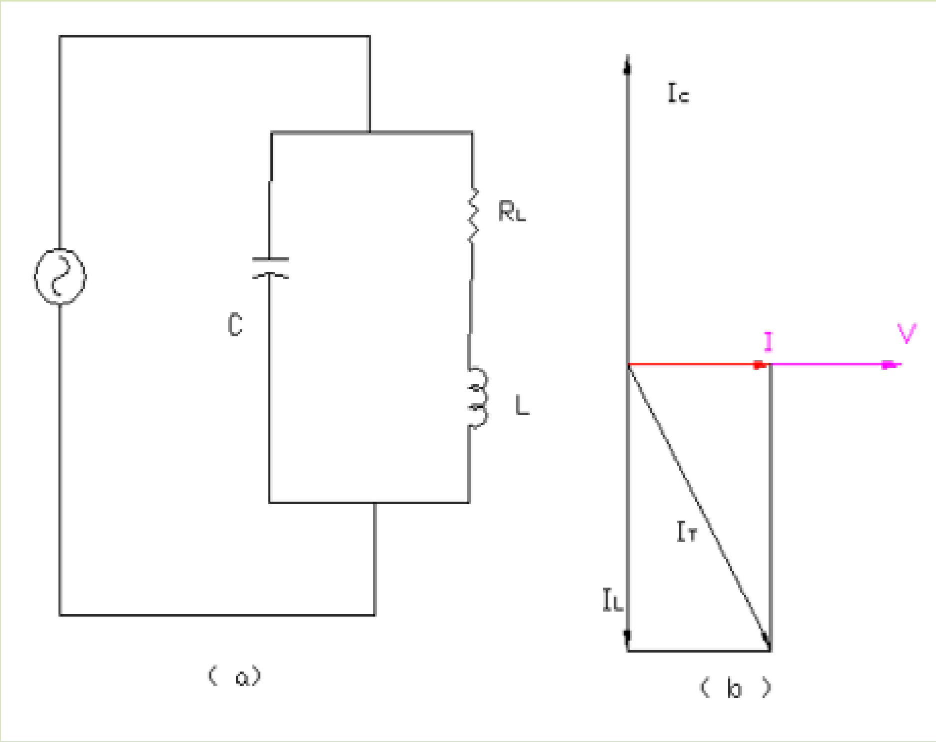
A parallel L- C ccts has a maximum impedance at the resonance frequency

When we discussed series resonance, we found that the impedance is lower in the case of parallel resonance, and the current taken from the source in the case of resonance is as shown.



Ex1/ L-c circuit has R=5.5 Ω , L=68μH , C adjustable from 200 p.f to 1200 pf ,and stray capacitance of 30 p.f in parallel with C.
Determine the maximum cct impedance at resonance

$I = I_L.\cos\theta = I_L(R_L/X_L)$, $Q = I_L/I = X_L/R_L$,
$Q = \omega.L/R_L$ .... (3)



The eq.(3) is exactly the same as the (Q) factor equation for a series resonant cct. That is the (Q) is

Again the (Q) factor of the inductance.

Resonance frequency

In equation $Xc= (R_L^2+X_L^2)/X_L$ ....(4) IN cct (a) above:
$Y=[1/R_L+jX_L]+ j(1/Xc)$,(نضرب بالمرافق) (R L- jXL)/(RL-jXL):
$Y=[R_L/(R_L^2+X_L^2)] – j[X_L/(R_L^2+X_L^2)] +j\ 1/Xc$, $1/Xc= X_L/(R_L^2+X_L^2)$, Or
$Xc= (R_L^2+X_L^2)/X_L$

When Q > 10 , $X_L^2 >> R_L^2$ also $X_c=X_L$

This gives the resonance frequency for a parallel L-C cct for Q > 10 :-
$f_r=[1/(2\Pi.\sqrt{L.C})$ ....(5) this is the same as in series resonance frequency .

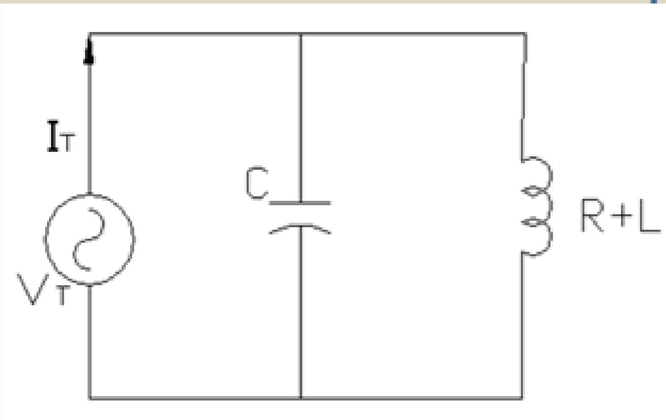
المعادلة (5) لانطبق في حالة ألتوازي عندما (Q) أقل من (10) . وقيمة (f_r) في حالة ألتوازي يمكن أن يكون

$Fr=1/2\Pi.\sqrt{L.C}\ x\sqrt{1-(CRL^2/L)}$

The band width of a parallel resonanant cct. Determined in exactly the same way as that for a series resonant cct.

$\Delta f= f_r/Q$

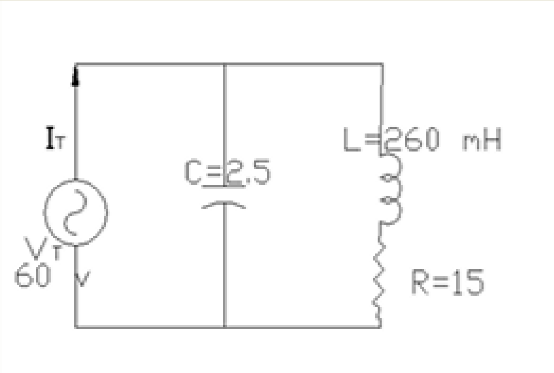
Resonance in parallel cct. s



We will consider the practical case of a coil in Parallel with a capacitor as shown

$Fr = (½\Pi) \sqrt{(1/L.c) - (R^2/L^2)}$ .....(1) , If the coil resistance is very small , so the equation of the resonance frequency . Will be :

$Fr = 1/(2\Pi\sqrt{L.C}\ )$ ....(2)



Ex(2) : For the cct shown below find the resonance frequency .

Solution: $F_r = (½\Pi) x \sqrt{(1/L.c) - (R^2/L^2)}$, = 197 HZ

Post test

Ex(3) : An inductive cct. Of resistance 2Ω and inductance 0.01H is connected to a 250 mho , 50 Hz .
What is the value of the capacitance should be placed in parallel to produce resonance ?

Solution : $F_r = (1/2\pi) * \sqrt{(1/L.C) - (R^2/L^2)}$

, $50 = (1/2\pi) x \sqrt{(1/0.01x\ C) - 4/(0.01)^2}$

$\therefore$ C=721 μ F