وزارة التعليم العالي والبحث العلمي

الجامعة التقنية الجنوبية

المعهد التقني العمارة

قسم تقنيات الالكترونيك والاتصالات

الحقيبة التدريسية لمادة دوائر التيار الكهربائي المستمر

الصف الاول

Electric Circuits I

تدريسي المادة

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الفصل الدراسي الاول

جدول مفردات مادة دوائر التيار الكهربائي المستمر

الأسبوع	الفصل الاول تفاصيل المفردات النظرية
الأول	Electric units system- Mathmatic applications- definition of basic units of voltage, current and resistance-electric circuit components- ohm's law- factors effecting on resistance- resistivity of conductors and insulators- effect of temp. on resistance- temp. Coeff. of resistance- Examples
الثاني	DC current circuits includes: - Series connection of resistances and examples - Parallel connection of resistances and examples - Combind connection of resistances and examples - Star and delta connection of resistances, conversion between star and delta with examples -
الثالث	Applications on series, parallel, combind and star-delta connections
الرابع	Kirchoff Laws- Kirchoff current and voltage laws with examples
الخامس	Maxwell's law with examples
السادس	Definition of Thevinin's theorem- How to apply in dc current
السابع	Definition of Norton's theorem- How to apply in dc current
الثامن	Examples on Thevinin's and Norton's theorems
التاسع	Definition of Supper position theorem-application of it in dc current- examples- Max. power transfer theorem with examples
العاشر	AC quantities-definintion of AC current characterstics – generation of AC current with waveform drawing- RMS value-Form factor – examples
الحادي عشر	Vector of AC quantities-definintion of it – Phasor representation of its- phase angle- resultant of vector AC add., Subt., multiply, division with examples

Effect of AC current on only resistance circuit-only inductance circuit-only capacitor circuit- phase angle between voltage and current with examples	**الثاني عشر**
Effect of AC current on resistance and inductance in series circuit- resistance and capacitor in series- resistance and inductance and capacitor in series- phase angle- total impedance with examples	**الثالث عشر**
Effect of AC current on resistance and inductance in parallel circuit- resistance and capacitor in series- resistance and inductance and capacitor in series- phase angle- total impedance with examples	**الرابع عشر**
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الفصل ٢	**الاسبوع**

الهدف من دراسة مادة دوائر التيار الكهربائي المستمر (الهدف العام):

تهدف دراسة مادة **دوائر التيار الكهربائي المستمر** للصف الاول الى:

١) أن الطالب قادرا على فهم وتطبيق القوانين الخاصئ بالدوائر الكهربائية العامة .

٢) ان يكون الطالب قادرا على تطبيق النظريات الخاصة بالدوائر الكهربائية .

الفئة المستهدفة:

طلبة الصف الاول / قسم التقنيات الالكترونية والاتصالات

التقنيات التربوية المستخدمة:

١. سبورة واقلام
٢. السبورة التفاعلية
٣. عارض البيانات Data Show
٤. جهاز حاسوب محمول Laptop

الاسبوع الأول

الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

- ان يتعرف الطالب على وحدات القياس الرئيسية المستخدمة في الدوائر الكهرائية
- ان يتعرف الطالب على مكونات الدوائر الكهربائية
- ان يتعرف الطالب ويكون قادرا على تطبيق قانون اوم
- ان يتعرف الطالب العوامل المؤثرة على قيمة المقاومة
- ان يتعرف الطالب ثاثير درجة الحرارة على قيم المقاومة

مدة المحاضرة: ٢ ساعة نظري.

الأنشطة المستخدمة:

١. أنشطة تفاعلية صفية
٢. أسئلة عصف ذهني
٣. أنشطة جماعية (إذا تطلب الامر)
٤. واجب بيتي
٥. واجب الكتروني (ويفضل انشاء صفوف الكترونية Classrooms لدمج التعليم الحضوري بالتعليم الالكتروني حسب التوجهات الحديثة للتعليم والتعلم)

أساليب التقويم:

١. التغذية الراجعة الفورية من قبل التدريسي (التقويم البنائي).
٢. اشراك الطلبة بالتقويم الذاتي (تصحيح اخطائهم بأنفسهم).
٣. التغذية الراجعة النهائية (التقويم الختامي)، ويقصد به حل الأسئلة المعطاة كنشاط صفي في نهاية المحاضرة.

Electric units system

Units associated with basic electrical quantities

SI units :

SI unit is an international system of measurements that are used universally in technical and scientific research to avoid the confusion with the units.

The basic units in the SI system are listed with their symbols, in Table below

Quantity	Basic unit	symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Luminous intensity	candela	cd

SI units may be made larger or smaller by using prefixes which denote multiplication or division by a particular amount. The six most common multiples, with their meaning, are listed in Table below.

Prefix		Base 10	Decimal
Name	Symbol		
kilo	k	10^{3}	1000
mega	M	10^{6}	1000000
giga	G	10^{9}	1000000000
tera	T	10^{12}	1000000000000
milli	m	10^{-3}	0.001
micro	µ	10^{-6}	0.000001
nano	n	10^{-9}	0.000000001
pico	p	10^{-12}	0.000000000001

Definition of basic units of voltage, current and resistance

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

Mathematically, the relationship between current i, charge q, and time t

$$i = \frac{dq}{dt}$$

1 ampere = 1 coulomb/second

Voltage (or potential difference): is the energy required to move a unit charge through an element, measured in volts (V).

1 volt = 1 joule/coulomb = 1 newton meter/coulomb

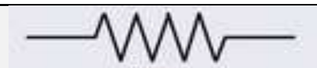
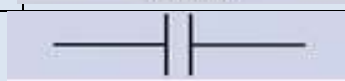
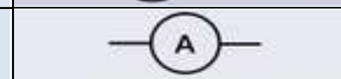
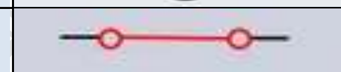
Resistance : It may be defined as the property of a substance due to which it opposes (or restricts) the flow of electricity n(i.e., electrons) through it.

The unit of electric resistance is the ohm (Ω).

The reciprocal of resistance is called conductance and is measured in siemens (S). Thus conductance, in siemens

$$G = \frac{1}{R}$$

Electric circuit components

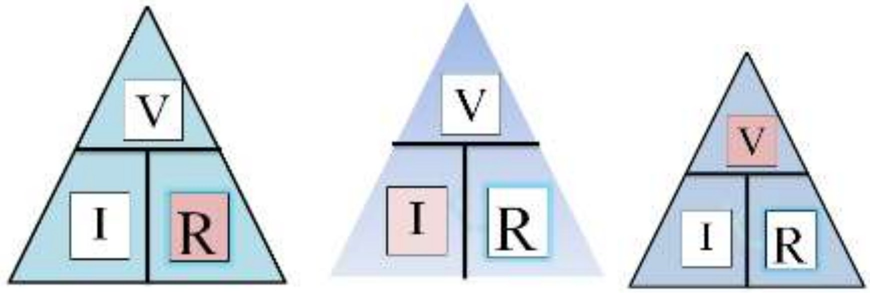
Resistance		Battery	
Inductor		Voltemeter	
Capacitor		Ammeter	
Open Switch		Close switch	
Variable resistor		Connecting Wire	

Ohm's law

Ohm's law:The ratio of potential difference (V) between any two points on a conductor to the current (I) flowing between them, is constant, provided the temperature of the conductor does not change.. Thus

$$R = \frac{V}{I}$$

Ohm's law triangle



$R = \frac{V}{R}$ or $I = \frac{V}{R}$ or $V = I * R$

Power: is the time rate of expending or absorbing energy, measured in watts (W)

Power P in an electrical circuit is given by the product of potential difference V and current I

$P = V \times I \quad watts$

From Ohm's law

$P = \frac{V^2}{R} \quad watts \quad , \quad P = I^2 \times R \quad watts$

الاسبوع الثانى   المحاضرة الثانية

الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

مدة المحاضرة: ٢ ساعة نظري +٢ ساعة عملي

<u>Factors effecting on resistance</u>

The resistance of an electrical conductor depends on 4 factors, these

(a) the length of the conductor(Resistance, R, is directly proportional to length) $R\alpha L$
(b) the cross-sectional area of the conductor (Resistance, R, is inversely proportional to cross-sectional area, a, of a conductor) $R\alpha \frac{1}{A}$
(c) the type of material
(d) the temperature of the material
resistance

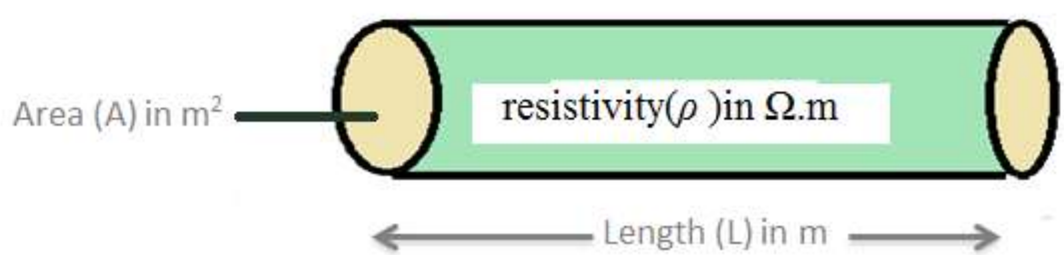
$$R = \frac{\rho L}{A}$$

ρ : resistivity in Ω.m

L: length in m

A: cross section area in m^2

The value of the resistivity is that resistance of a unit cube of the material measured between opposite faces of the cube



Example : Calculate the resistance of a 2 km length of aluminium overhead power cable if the cross-sectional area of the cable is 100 mm^2. Take the resistivity of aluminium to be $0.03 * 10^{-6}$ Ωm.

<u>Soluation :</u>

Length =2 km = 2000 m;

cross-sectional area=100 mm2 = 100 * 10^{-6} m^2

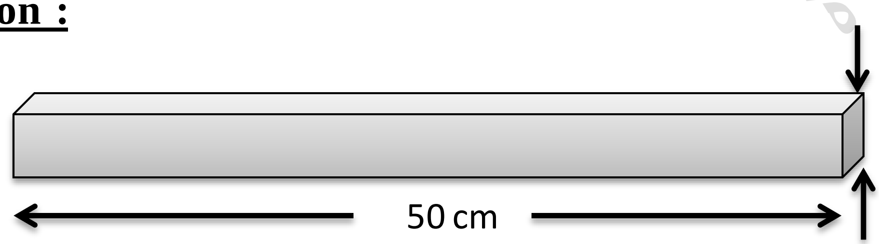
resistivity = 0.03 * 10^{-6} Ω m

$$\text{Resistance} \quad R = \frac{\rho l}{a} = \frac{(0.03 \times 10^{-6}\ \Omega\text{m})(2000\ \text{m})}{(100 \times 10^{-6}\ \text{m}^2)} = \frac{0.03 \times 2000}{100}\ \Omega$$

$$= \mathbf{0.6\ \Omega}$$

Example : A rectangular carbon block has dimensions 1.0 cm × 1.0 cm × 50 cm. (i) What is the resistance measured between the two square ends ? (ii) between two opposing rectangular faces / Resistivity of carbon at 20°C is 3.5 × 10−5 Ω-m.

Soluation :



$$R = \frac{\rho L}{A}$$

(i) $A = 1 \times 1 = 1\ \text{cm2} = 10^{-4}\ \text{m2}\ ;\ l = 0.5\ \text{m}$

$$\text{R} = \frac{3.5\times10^{-5}\times0.5}{10^{-4}} = 0.175\Omega)$$

(ii) $L = 1\ \text{cm};\ A = 1 \times 50 = 50\ \text{cm}^2 = 5 \times 10^{-3}\ \text{m2}$

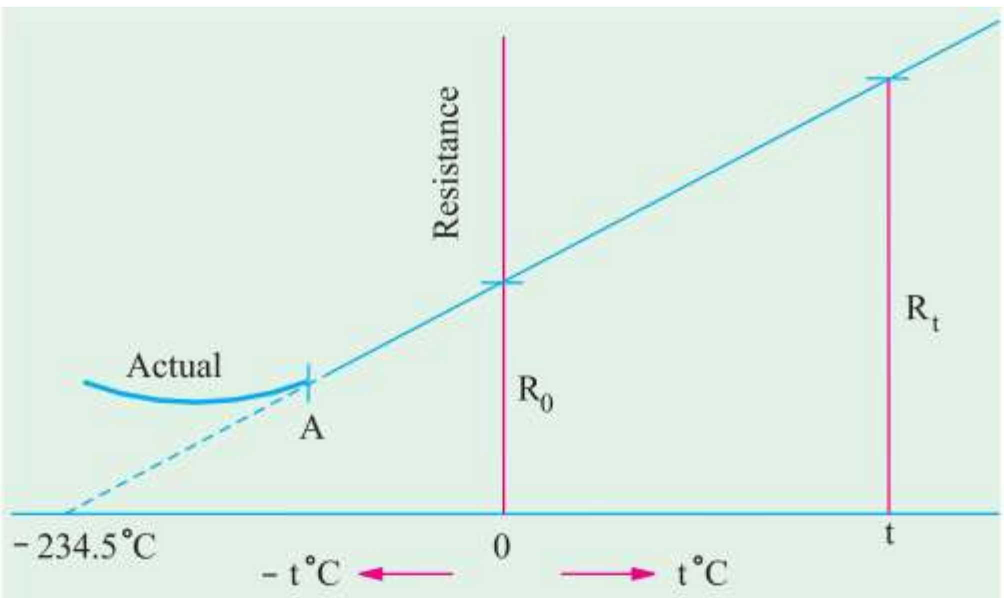
$$R = \frac{3.5\times10^{-5}\times10^{-2}}{5\times10^{-3}} = 7\times10^{-5}\Omega$$

H.W :A coil consists of 2000 turns of copper wire having a cross-sectional area of 0.8 mm2. The mean length per turn is 80cm and the resistivity of copper is 0.02 μΩ–m. Find the resistance of the coil.

Temperature Coefficient of Resistance

The resistance of most good conducting material increases almost linearity with temperature over range of normal operating temperature.

$R_t = R_0 (1 + \alpha t)$



$$R_2 = R_1(1 + \alpha_0(T_2 - T_1))$$

$$R_T = R_0(1 + \alpha_0 T)$$

$$\alpha_T = \frac{\alpha_0}{1 + \alpha_0 * T}$$

R_1: resistance at lower temperature T_1
R_2: resistance at higher temperature T_2
R_T: resistance at temperature T
R_0: resistance at zero temperature $0C^0$
α_0: temperature coefficient at $0C^0$
α_T: temperature coefficient at TC^0 (Ω/C^0)

Example: Aplatinum coil has a resistance is 3.146 Ω at $40C^0$ and 3.717Ω at $100C^0$.

Find

1) Temperature coefficient at $0C^0$.
2) Coil resistance at $0C^0$.
3) Temperature coefficient at $40C^0$.

Solution:

1)

$R_2=R_1(1+\alpha_0(T_2-T_1))$

$3.717=3.146(1+\alpha_0(100-40))$

$3.717=3.146(1+\alpha_0*60)$

$3.717=((3.146*1)+(3.146\alpha_0*60))$

$3.717=3.146+188.76\alpha_0$

$3.717-3.146=188.76\alpha_0$

$0.571=188.76\alpha_0$

$$\alpha_0=\frac{0.571}{188.76}=0.003\ \Omega/C^0$$

(2)

$R_T=R_0(1+\alpha_0 T)$

$3.146=R_0(1+0.003*40)$

$3.146=1.12\ R_0$

$$R_0=\frac{3.146}{1.12}=2.825\ \Omega$$

$$\alpha_T=\frac{\alpha_0}{1+\alpha_0*T}$$

$$\alpha_{40}=\frac{0.003}{1+0.003*40}=0.0026\ \Omega/C^0$$

H.W

Example: A copper coil has a resistance of(100Ω) at)($20C^0$) and the temperature cofficient of this Copper coil (0.0043)per K^0 at ($20C^0$) . Determine the resistance of this ciol at ($100C^0$).

الاسبوع الثانى المحاضرة الثانية

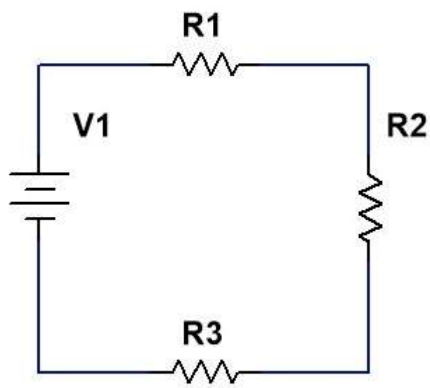
الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

- ان يتعرف الطالب ربط المقاومات على التوالي وخصائص ربط التوالي والعلاقات الرياضية
- ان يتعرف الطالب ربط المقاومات على التوازي وخصائص ربط التوالي والعلاقات الرياضية
- ان يتعرف الطالب الربط النجمي والمثلثي والتمييز بينهما.
- ان يتعرف الطالب على قوانيين التحويل من الربط النجمي الى الربط المثلثي وبالعكس ويكون قادرا على استخدام القوانين وتطبيقها للتحويل بينهما .

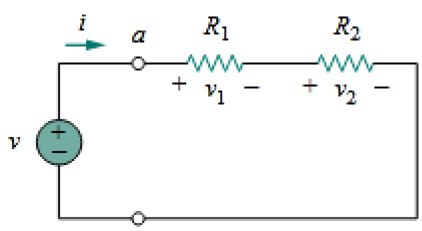
مدة المحاضرة: ٢ ساعة نظري +٢ ساعة عملي

Series and parallel Circuit

✦Resistance in Series Connection



In fig below The three resistors are in series



In a series circuit

(a) the current I is the same in all parts of the circuit ($I_1 = I_2 = I$)
(b) the sum of the voltages V1, V2 is equal to the total applied voltage, V, i.e

$V=V_1+V_2+3$

Applying Ohm's law to each of the resistors, we obtain

$V_1 = IR_1, V_2 = IR_2,$

then $IR = IR_1 + IR_2$

Dividing throughout by I give

$R= R_1+R_2+R_3$

:For N resistors in series, the equivalent resistor has a value given by

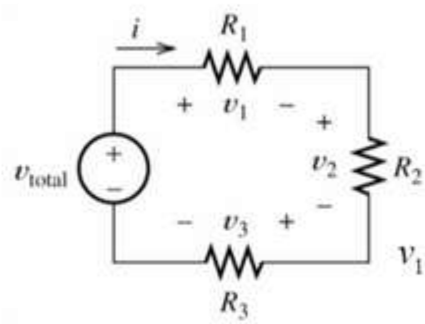
$$R_{eq} = R_1 + R_2 + \cdots + R_N = \sum_{n=1}^{N} R_n$$

To determine the voltage across each resistor

Voltage divider rule

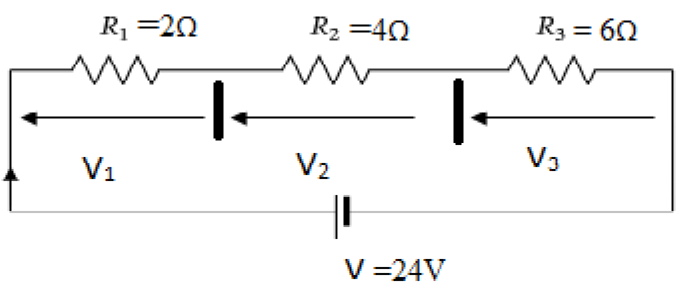
$$v_1 = \frac{R_1}{R_1+R_2+R_3} v_{total}, \qquad v_2 = \frac{R_2}{R_1+R_2+R_3} v_{total}$$

$$v_3 = \frac{R_3}{R_1 + R_2 + R_3} v_{total}$$



$$v_X = \frac{R_X}{R_{eg}} v_{total}$$

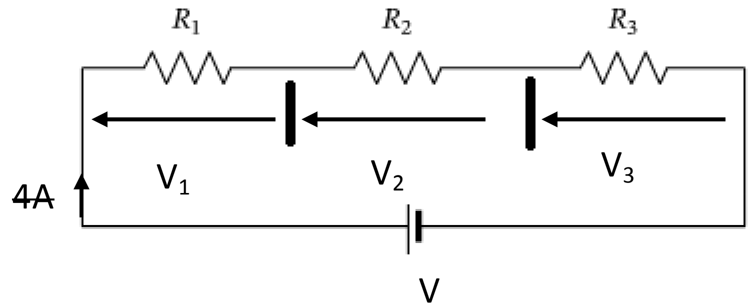
Example: in fig below find V_1, V_2 and V_3



$$v_1 = \frac{R_1}{R_1 + R_2 + R_3} v_{total}, \quad v_2 = \frac{R_2}{R_1 + R_2 + R_3} V_t, \quad v_3 = \frac{R_3}{R_1 + R_2 + R_3} V_t$$

$$V_1 = \frac{2 \times 24}{2+4+6} = 4V \quad , V_2 = \frac{4 \times 24}{2+4+6} = 8V \quad , V_3 = \frac{6 \times 24}{2+4+6} = 12V$$

Example2. For the circuit shown in Figure below, determine (a) the battery voltage V, (b) the total resitance of the circuit, and (c) the values of resistance of resistors R1, R2 and R3, given that the p.d.'s across R1, R2 and R3 are 5 V, 2 V and 6 V respectively



SOL

V_1=5V , V_2 = 2V , V_3=6V

(a) Battery voltage $V = V_1 + V_2 + V_3$

$$= 5 + 2 + 6 = \mathbf{13\ V}$$

(b) Total circuit resistance $R = \frac{V}{I} = \frac{13}{4} = \mathbf{3.25\ \Omega}$

(c) Resistance $R_1 = \frac{V_1}{I} = \frac{5}{4} = \mathbf{1.25\ \Omega}$

Resistance $R_2 = \frac{V_2}{I} = \frac{2}{4} = \mathbf{0.5\ \Omega}$

Resistance $R_3 = \frac{V_3}{I} = \frac{6}{4} = \mathbf{1.5\ \Omega}$

(Check: $R_1 + R_2 + R_3 = 1.25 + 0.5 + 1.5 = 3.25\ \Omega = R$)

Resistance in Parallel

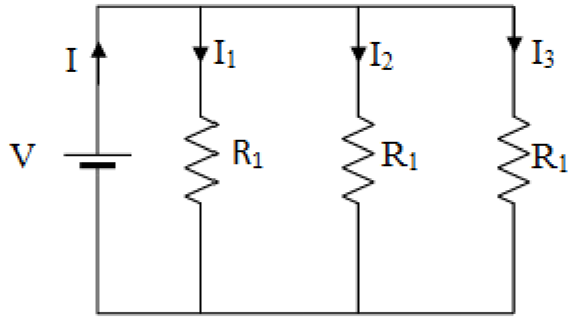


Figure shows three resistors, R1, R2 and R3 connected across each other, i.e., in parallel, across a battery source of V volt

a) the sum of the currents I_1, I_2 and I_3 is equal to the total circuit current, I, i.e.

$I = I_1 + I_2 + I_3$, and

b) the source p.d., V volts, is the same across each of the resistors $V_1 = V_2 = V_3 = V$

From Ohm's law:

$$I_1 = \frac{V}{R_1},\ I_2 = \frac{V}{R_2},\ I_3 = \frac{V}{R_3} \text{ and } I = \frac{V}{R}$$

where R is the total circuit resistance.

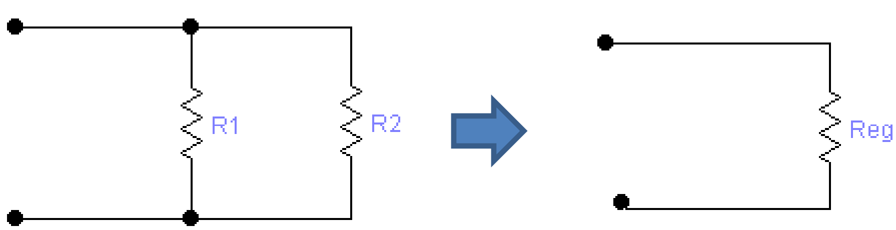
Since $I = I_1 + I_2 + I_3$

then, $\dfrac{V}{R} = \dfrac{V}{R_1} + \dfrac{V}{R_2} + \dfrac{V}{R_3}$

Dividing by V gives

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}$$

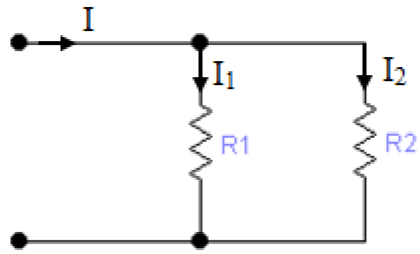
For the special case of two resistors in parallel



$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_2 + R_1}{R_1 R_2}$$

Hence $\boxed{R = \dfrac{R_1 R_2}{R_1 + R_2}}$ $\left(\text{i.e. } \dfrac{\text{product}}{\text{sum}}\right)$

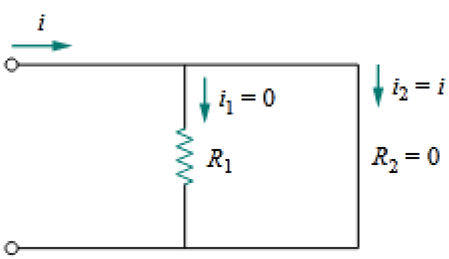
current divider rule



$$I_1 = \frac{R_2\ I}{R_1 + R_2} \quad , \quad I_2 = \frac{R_1\ I}{R_1 + R_2}$$

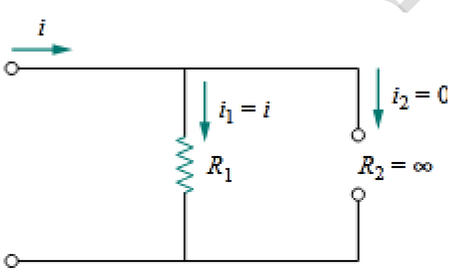
Cases

A) Suppose one of the resistors is zero as shown in fig



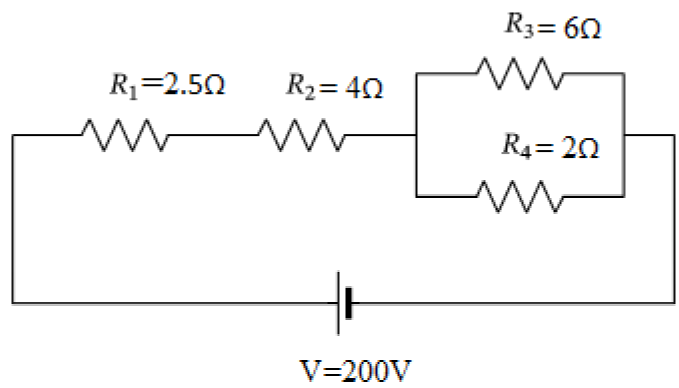
say R2 = 0; that is, R2 is a short circuit, that the entire current i bypasses R1 and flows through .the short circuit R2 = 0, the path of least resistance

B) Suppose R2 = ∞, that is, R2 is an open circuit, as shown in Fig. below.



The current still flows through the path of least resistance, R1

Example3: For the series-parallel arrangement shown in Figure below, find (a) the supply current, (b) the current flowing through each resistor and (c) the p.d. across each resistor .



Soluation:

(a) The equivalent resistance R_x of R_3 and R_4 in parallel is:

$$R_x = \frac{6 \times 2}{6+2} = \frac{12}{8} = 1.5\ \Omega$$

The equivalent resistance R_T of R_1, R_x and R_2 in series is:

$$R_T = 2.5 + 1.5 + 4 = 8\ \Omega$$

$$\text{Supply current } I = \frac{V}{R_T} = \frac{200}{8} = \mathbf{25\ A}$$

(b) The current flowing through R_1 and R_4 is 25 A

$$\text{The current flowing through } R_2 = \left(\frac{R_3}{R_2 + R_3}\right) I = \left(\frac{2}{6+2}\right) 25$$

$$= \mathbf{6.25\ A}$$

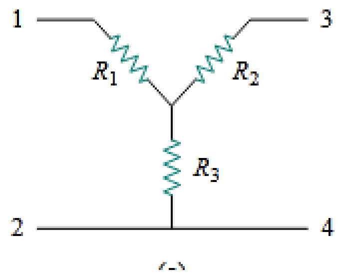
$$\text{The current flowing through } R_3 = \left(\frac{R_2}{R_2 + R_3}\right) I = \left(\frac{6}{6+2}\right) 25$$

(C)

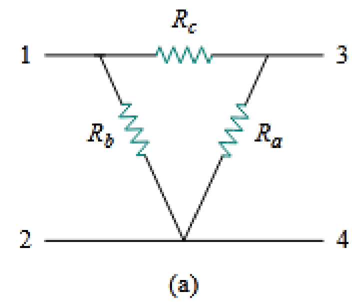
$$=18.75\text{A}$$

p.d. across R_1, i.e., $V_1 = IR_1 = (25)(2.5) = \mathbf{62.5\ V}$
p.d. across R_x, i.e., $V_x = IR_x = (25)(1.5) = \mathbf{37.5\ V}$
p.d. across R_4, i.e., $V_4 = IR_4 = (25)(4) = \mathbf{100\ V}$
Hence the p.d. across R_2 = p.d. across $R_3 = \mathbf{37.5\ V}$

WYE-DELTA TRANSFORMATIONS



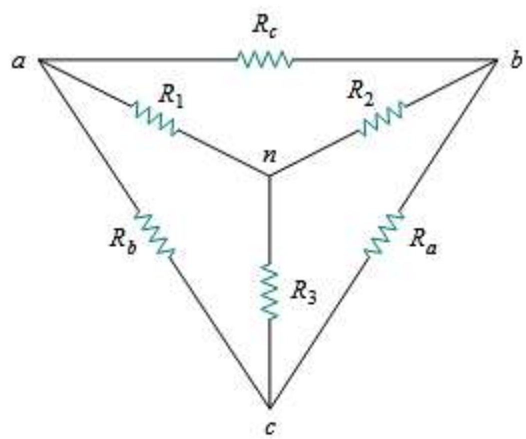
(a) Y



(b) Δ

Delta to Wye Conversion

To transform aΔ network to Y



the conversion rule for Δ to Y is as follows

$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$

Wye to Delta Conversion

the conversion rule for Y toΔ is as follows:

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

$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$

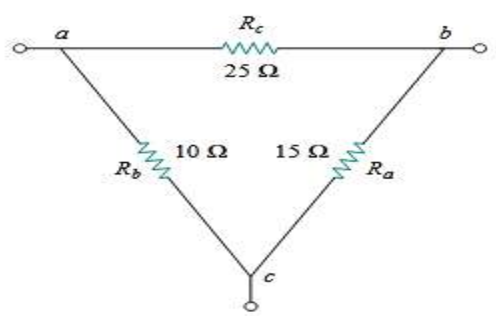
The Y and Δ" networks are said to be balanced when

$$R_1 = R_2 = R_3 = R_Y, \qquad R_a = R_b = R_c = R_\Delta$$

Under these conditions, conversion formulas become

$$R_Y = \frac{R_\Delta}{3} \qquad \text{or} \qquad R_\Delta = 3R_Y$$

E xample:Convert the network in Fig.below to an equivalent Y network



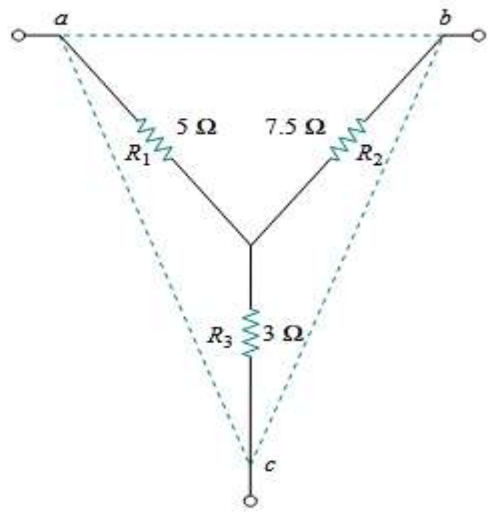
Solution:

$$R_1 = \frac{R_bR_c}{R_a + R_b + R_c} = \frac{25 \times 10}{25 + 10 + 15} = \frac{250}{50} = 5\ \Omega$$

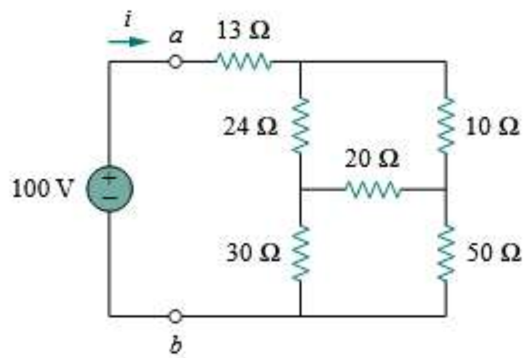
$$R_2 = \frac{R_cR_a}{R_a + R_b + R_c} = \frac{25 \times 15}{50} = 7.5\ \Omega$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c} = \frac{15 \times 10}{50} = 3\ \Omega$$

The equivalent Y network is shown in Fig below



H.W :For the bridge network in Fig. below, find R ab and i



الاسبوع الثالث المحاضرة الثالثة

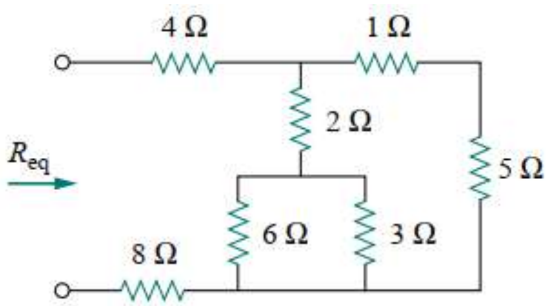
الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

- ان يكون الطالب على التمييز بين انواع ربط المقاومات (التوالي والتوازي والمركب)
- ان يكون الطالب قادرا على حل المسائل المتعلقة بربط المقاومات وايجاد المقاومة المكافئة والتيارات الكلية و الفرعية وكذلك الفولتيات الكلية او هبوطات الجهد عبر كل مقاومة .

مدة المحاضرة: ٢ ساعة نظري +٢ ساعة عملي

مدة المحاضرة: ٢ ساعة نظري +٢ ساعة عملي

Example : .Find R eq for the circuit shown in Fig below.

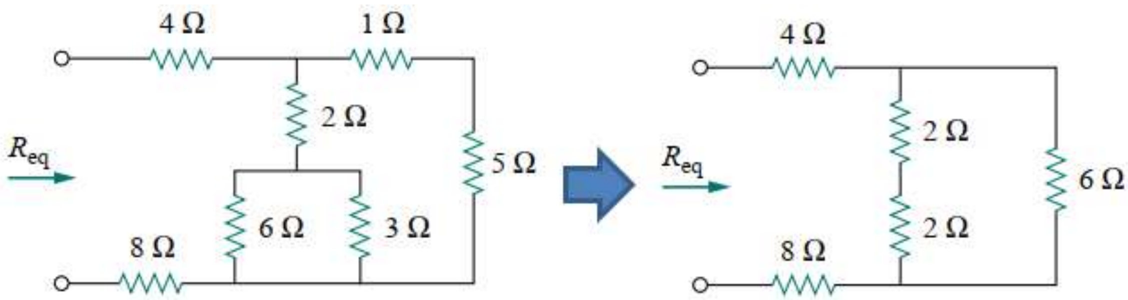


<u>Soluation</u>

3Ω//6Ω

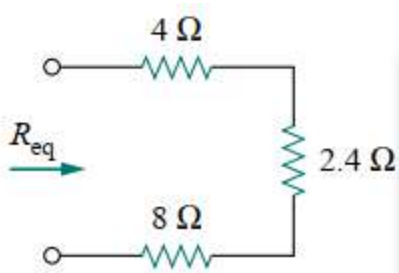
$$\frac{\mathbf{3\times 6}}{\mathbf{3+6}} = 2\Omega$$

1Ω and 5Ω in series (1+5=6Ω)



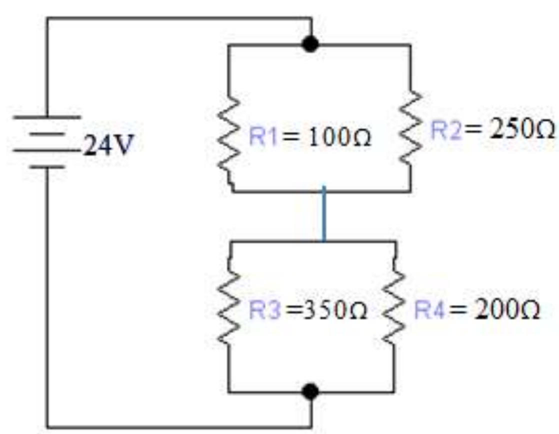
In fig (a) (2Ω and 2Ω) in series (2Ω+2Ω=4Ω)

4Ω//6Ω =4×6/4+6=2.4Ω



Reg=4+2.4+8= 14.4Ω

Example : For the series-parallel arrangement shown in Figure below, find the supply current .



Soluation:

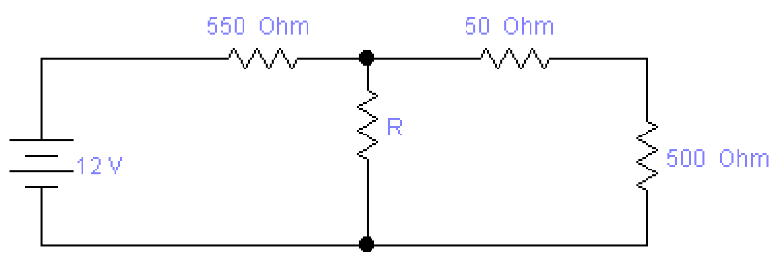
R1//R2 , R3//R4

Reg=100Ω//250Ω + 350Ω//200Ω

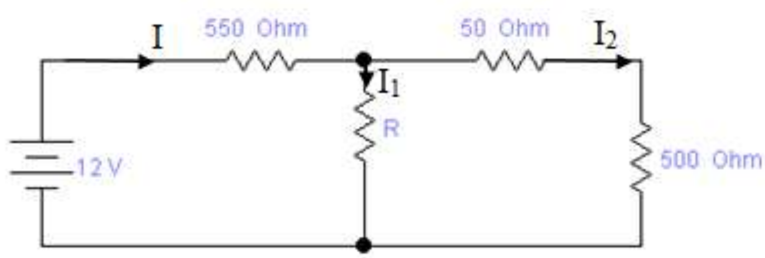
$$R_{eg} = \frac{100 \times 250}{100 + 250} + \frac{350 \times 200}{350 + 200} = 198.701\Omega$$

$$I = \frac{V}{R_{eg}} = \frac{24}{198.701} = 0.121A$$

Example: What is the value of the unknown resistor R in Fig .below if the voltage drop across the 500 Ω resistor is 2.5 volts ?



Soluation:



$$I_2 = \frac{V}{R} = \frac{2.5}{500} = 0.005A$$

V50Ω= 50×0.005=0.25V

Drop voltage across R = 2.5+0.25=2.75V

Drop voltage across 550Ω= 12 - 2.75=9.25V

I=9.25/550=0.0168A

$$R = \frac{V}{I} = \frac{9.25}{0.0168} = 233\Omega$$

الاسبوع الرابع المحاضرة الرابعة

الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

- ان يتعرف الطالب على قوانين كيرشوف للفولتية والتيار وفهمها.
- ان الطاب قادرا على تطبيق قوانين كيرشوف وحل المسائل الرياضية.

مدة المحاضرة: ٢ ساعة نظري +٢ ساعة عملي

KIRCHHOFF'S LAWS

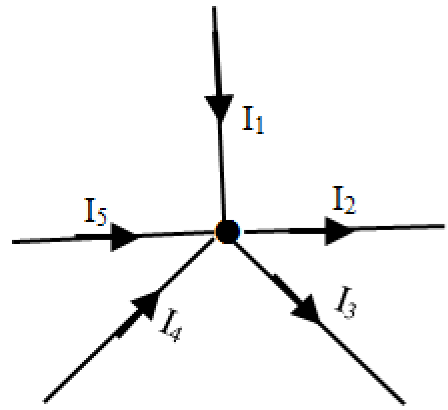
Kirchhoff's first law

Kirchhoff's Current Law (KCL) : The algebraic sum of the currents present at a junction (node) in a circuit equal zero.

(current flowing towards the junction = current flowing away from the junction)

current flowing towards the junction are positive (+)

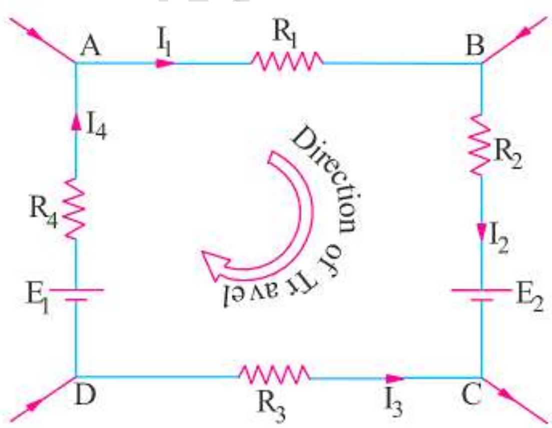
current flowing away from the junction are negative (-)



$I_1 - I_2 - I_3 + I_4 + I_5 = 0$

second law

Kirchhoff's voltage Law (KVL) : The voltage around a loop equals the sum of every voltage drop in the same loop for any closed network and equals zero .



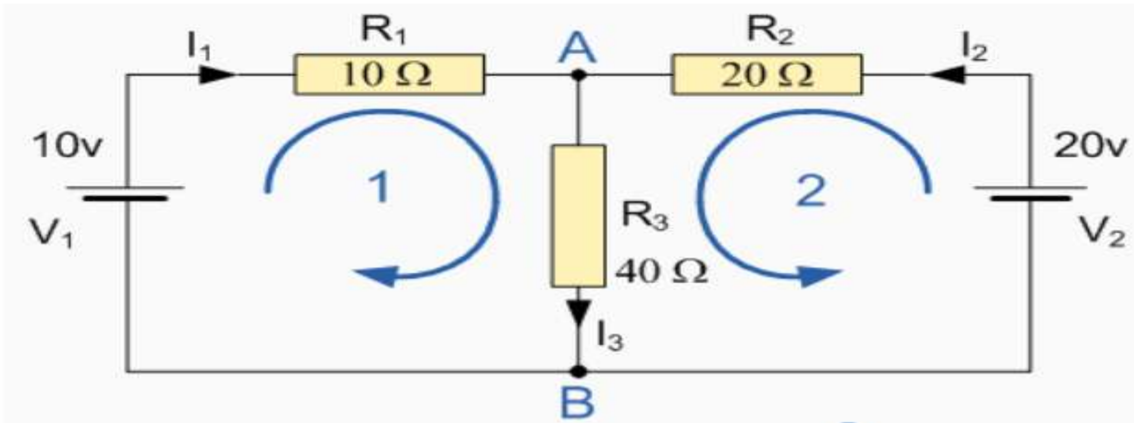
Using Kirchhoff's voltage law, we get

$-I_1R_1 - I_2R_2 - I_3R_3 - I_4R_4 - E_2 + E_1 = 0$

or

$I_1R_1 + I_2R_2 - I_3R_3 + I_4R_4 = E_1 - E_2$

Example 2: Use Kirchhoff's laws to determine the currents flowing in each branch of the network shown in Figure below.



<u>Soluation</u>

Using Kirchhoff's first law, at B and A we get, $I_1+I_2=I_3$

$$I_3=I_1+I_2$$

Loop1 KVL

$$V_1=R_1I_1+R_3I_3$$

$$10=10I_1+40I_3$$

$$10=10I_1+40(I_1+I_2)$$

$$10=10I_1+40I_1+40I_2$$

$$10=50I_1+40I_2)$$

$$1=5I_1+4I_2 \quad ========1$$

Loop2 KVL

$$V_2=R_2I_2+R_3I_3$$

$$20=20I_2+40I_3$$

$$20=20I_2+40(I_1+I_2)$$

$$20=20I_2+40I_1+40I_2$$

→

$$20=40I_1+60I_2$$

$$1=2I_1+3I_3 \quad ======2$$

$1 = 5I_1 + 4I_2$ ========1 ⬅ *3

$1 = 2I_1 + 3I_3$ =======2 ⬅ *4

$3 = 15I_1 + 12I_2$ ========3

$4 = 8I_1 + 12I_2$ ========3

نطرح معادلة ٤ من معادلة ٣ فيكون الناتج

$-1 = 7I_1 + 0$

$I_1 = -0.143A$

نعوض قيمة التيار I_1 في المعادلة رقم (١)

$1 = 5(-0.143) + 4I_2$

$1 = -0.715 + 4I_2$

$1 + 0.715 = 4I_2$

$1.715 = 4I_2$

$I_2 = 0.429A$

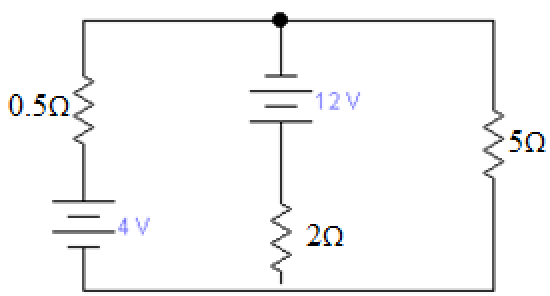
$I_3 = I_1 + I_2$

$I_3 = (-0.715) + 0.429$

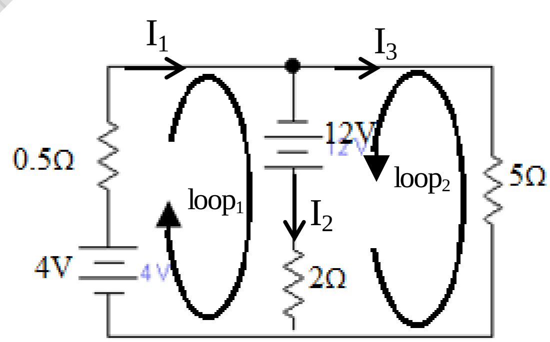
$I_3 = 0.286A$

÷

Example: Determine, using Kirchhoff's laws, each branch current for the network shown in Fig below_



Soluation



KCL

$I_1 - I_2 - I_3 = 0$

$I_3 = I_1 - I_2$

<u>KVL</u>

Loop(1)

$E_1+E_2=I_1R_1+I_2R_2$

$4+12=0.5I_1+2I_2$

$16=0.5I_1+2I_2$ -----------(1)

Loop(2)

$E_2=I_2R_2-I_3R_3$

$12=2I_2-5(I_1-I_2)$

$12=-5I_1+7I_2$ ----------------(2)

$16=0.5I_1+2I_2$ *7

$12=-5I_1+7I_2$ *2

$112=3.5I_1+14I_2$ -------3

$\underline{24=-10I_1+14I_2}$ ---4

$88=13.5I_1$ $I_1=88/13.5=6.518A$

From equation (1) $16=0.5(6.518)+2I_2$ $I_2=\underline{6.37A}$

$I_3=I_1-I_2$

$I_3=6.518 - 6.37 =0.148A$

الاسبوع الخامس المحاضرة الخامسة

الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

- ان يفهم الطالب ويكون قادر على تطبيق طريقة ماكسويل في الدوائر الكهربائية .
- ان يكون الطالب قادرا على تطبيق طريقة حلقات ماكسويل لايجاد التيارات والفولتيات في فروع الدائرة الكهربائية المعقدة.

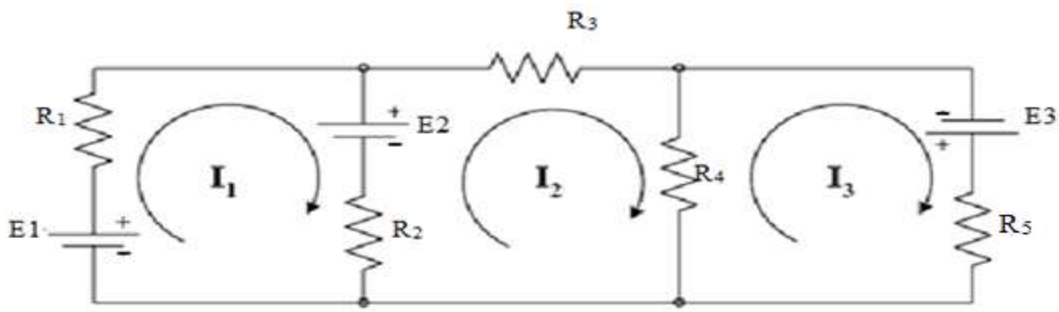
<u>Maxwell 's Loop Current Methode (Mesh analysis)</u>

Loop : is a closed path (closed connection of branches) in a circuit that starts and ends at the same node without passing through any node more than once.

Mesh : It is a closed loop that does not contain any other loop.

This method can be applied by the following step:

1- Suppose that the direction of the currents in each closed loop circulates clockwise.



2- Write the loop equations of the circuit as in the following formulas (form each loop one equation).

$$\sum E = \sum I \times R$$

<u>Loop1</u>

$E_1 - E_2 = I_1 R_1 + R_2 (I_1 - I_2)$

Loop3

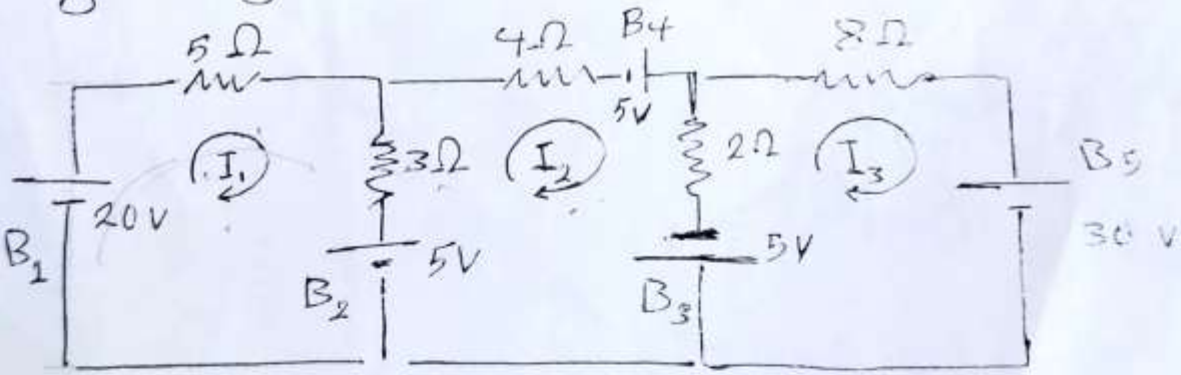
$E_2 = R_2(I_2 - I_1) + R_3 . I_2 + R_4(I_2 - I_3)$

Loop3

$E_3 = R_4(I_3 - I_2) + R_5 . I_3$

3- Solve the above equation to find out the current value(I_1,I_2 ,I_3…..In)

Example Determine the current supplied by each battery in the circuit shown in fig (using maxwell's)



(3)

For loop ①

$$20-5 = 5I_1 + 3(I_1 - I_2)$$
$$15 = 5I_1 + 3I_1 - 3I_2$$
$$15 = 8I_1 - 3I_2 \quad \text{——— ①}$$

For loop ②

$$5+5+5 = 3(I_2 - I_1) + 4I_2 + 2(I_2 - I_3)$$
$$15 = 3I_2 - 3I_1 + 4I_2 + 2I_2 - 2I_3$$
$$15 = -3I_1 + 9I_2 - 2I_3 \quad \text{— — — ②}$$

For loop ③

$$-5-30 = 8I_3 + 2(I_3 - I_2)$$
$$-35 = 8I_3 + 2I_3 - 2I_2$$
$$-35 = -2I_2 + 10I_3 \quad \text{— — — ③}$$

$$15 = 8I_1 - 3I_2 + 0$$
$$15 = -3I_1 + 9I_2 - 2I_3$$
$$-35 = 0 - 2I_2 + 10I_3$$

$$\begin{pmatrix} 8 & -3 & 0 \\ -3 & 9 & -2 \\ 0 & -2 & 10 \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 15 \\ 15 \\ -35 \end{pmatrix}$$

$$D = \begin{vmatrix} 8 & -3 & 0 \\ -3 & 9 & -2 \\ 0 & -2 & 10 \end{vmatrix} \begin{matrix} 8 & -3 \\ -3 & 9 \\ 0 & -2 \end{matrix}$$

$$D = 720 + 0 + 0 - (0 + 32 + 90)$$
$$D = 720 - 122 = 598$$

$$D_1 = \begin{vmatrix} 15 & -3 & 0 \\ 15 & 9 & -2 \\ -35 & -2 & 10 \end{vmatrix} \begin{matrix} 15 & -3 \\ 15 & 9 \\ -35 & -2 \end{matrix}$$

$$D_1 = 1350 - 210 + 0 - (0 + 60 - 450)$$
$$= 1530$$

$$I_1 = \frac{D_1}{D} = \frac{1530}{598} = 2.558 \text{ A}$$

$$D_2 = \begin{vmatrix} 8 & 15 & 0 \\ -3 & 15 & -2 \\ 0 & -35 & 10 \end{vmatrix} \begin{matrix} 8 & 15 \\ -3 & 15 \\ 0 & -35 \end{matrix}$$

$$D_2 = 1200 + 0 + 0 - (560 - 450)$$
$$D_2 = 1200 - 110 = 1090$$

$$\therefore I_2 = \frac{D_2}{D} = \frac{1090}{598} = 1.822 \text{ A}$$

$$D_3 = \begin{vmatrix} 8 & -3 & 15 \\ -3 & 9 & 15 \\ 0 & -2 & -35 \end{vmatrix} \begin{matrix} 8 & -3 \\ -3 & 9 \\ 0 & -2 \end{matrix}$$

$$D_3 = -2520 + 0 + 90 - (0 - 240 - 315)$$
$$= -2520 + 90 + 645 = -1875$$

$$\therefore I_3 = \frac{D_3}{D} = \frac{-1875}{598} = -3.135 \text{ A}$$

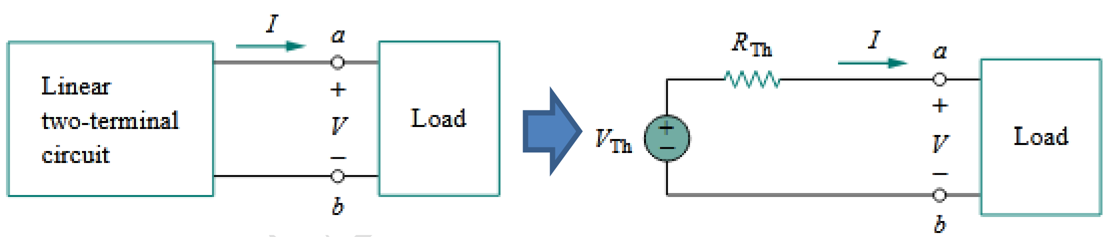
الاسبوع السادس   المحاضرة السادسة

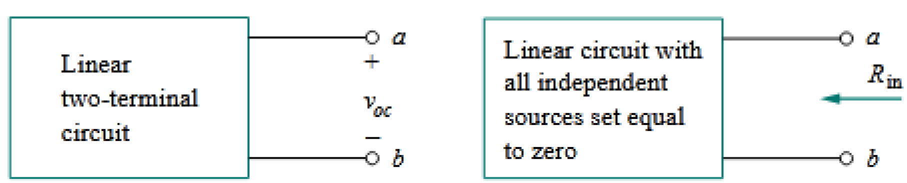
الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

- ان يتعرف الطالب على تحليل الدائرة الكهربائية وايجاد مكافئ ثفنن .
- ان يكون الطالب قادرا على تطبيق نظرية ثفنن وايجاد قيم التيارات (الحمل) والفولتيات في مقاومة معينة .

THEVENIN'S THEOREM

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





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

The procedure adopted when using Thevenin's theorem is summarized below. To determine the current in any branch of an active network (i.e. one containing a source of e.m.f.):

i) remove the resistance R_L from that branch

ii) determine the open-circuit voltageVoc

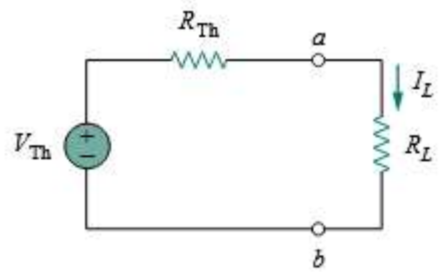
iii) Find the Thevenin's equivalent resistance, RTH at the terminals when all independent sources are zero(Replacing independent sources)

●If voltage source (short circuit)

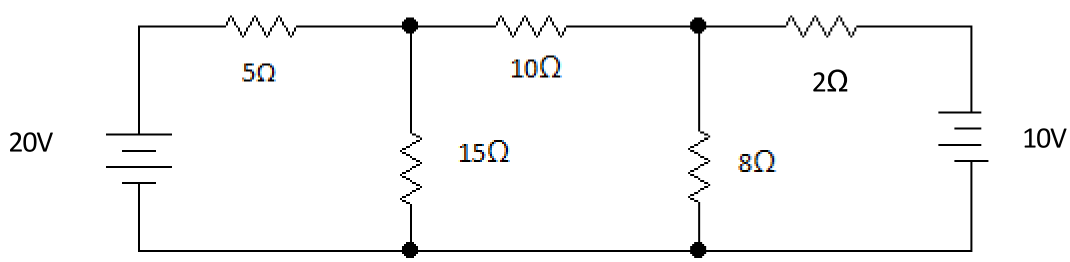
●If current source (open circuit)

iv) determine the value of the current from the equivalent circuit shown●

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

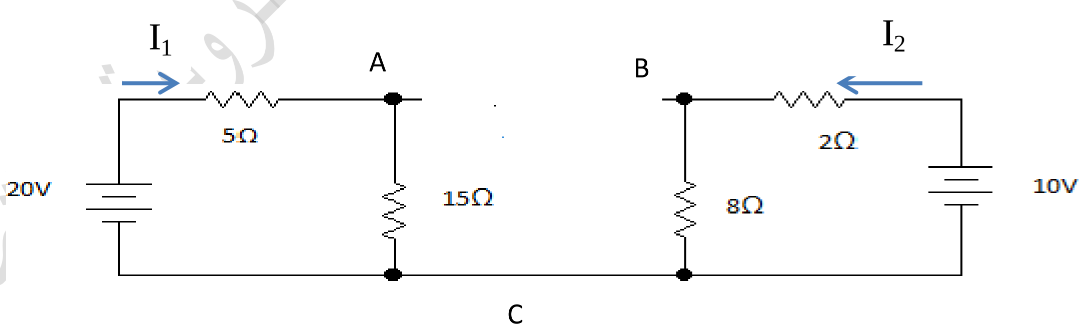


Example:For the circuit shown in fig below Calculate the current passes through (10Ω) resistance Using thevenins theorem



Solution:

$V_{TH} = ?$



$$I_1 = \frac{V}{R}$$

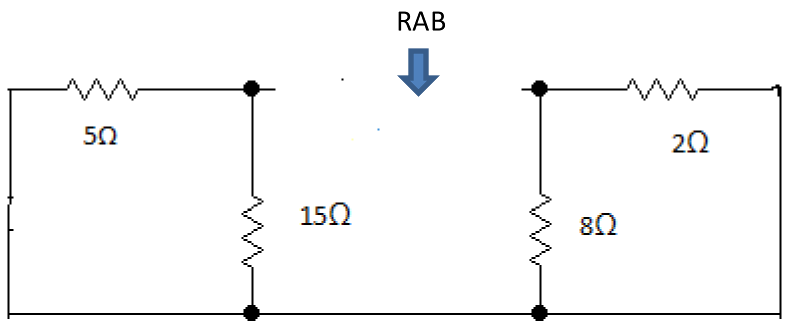
$$I_1 = \frac{20}{5+15} = 1A$$

$$I_2 = \frac{10}{8+2} = 1A$$

VAC = 1*15 =15V

VBC=1*8=8V

VAB= 15 - 8= 7



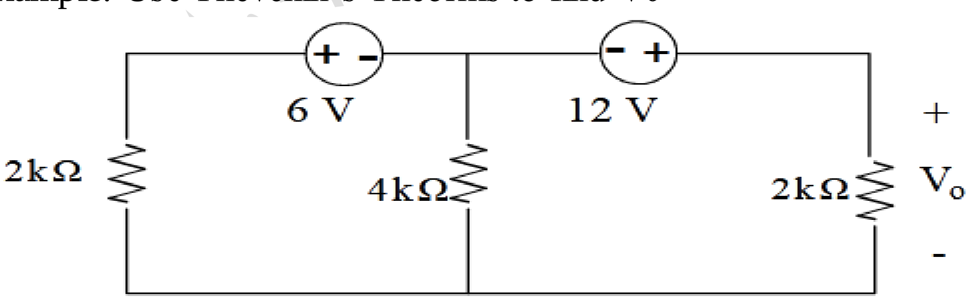
$R_{AB}=R_{TH}$

$$R_{AB} = \frac{2\times 8}{2+8} + \frac{15\times 5}{15+5} = 3.7 + 1.6 = 5.3\Omega = R_{TH}$$

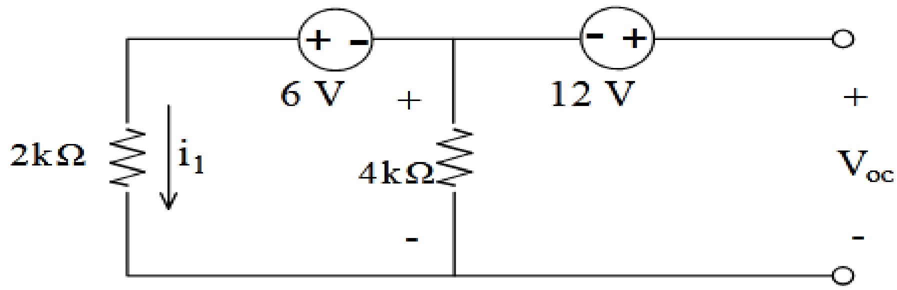
$$I_L = \frac{V_{TH}}{R_L + R_{TH}}$$

$$I_{10\Omega} = \frac{7}{10+5.3} = 0.46A$$

Example: Use Thevenin's Theorms to find V0



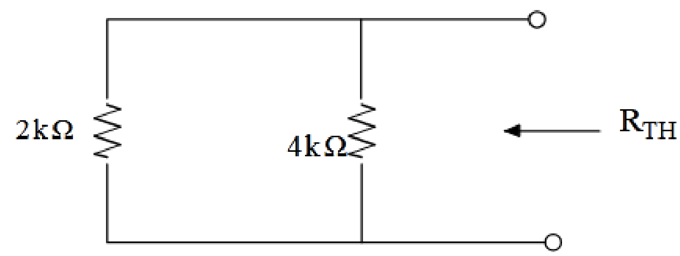
find V OC



$$i_1 = \frac{6\ V}{2\ k + 4\ k} = 1\ m\ A \quad \Rightarrow \quad V_{4k\Omega} = i_1\,(4\ k) = -4\ V$$

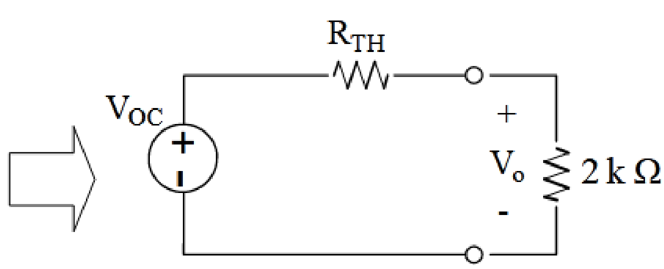
$$V_{oc} = 12\ V - 4\ V = 8\ V$$

Second, find R_{TH}



R_{TH} = 2k//4k = 4/3 k Ω

Thevenin equivalent circuit is



$$V_0 = \frac{2\ k\ \Omega}{2\ k + R_{TH}} V_{oc}$$

$$= \frac{2\ k}{10/3\ k}(8\ V)$$

$$V_0 = 4.8\ V$$

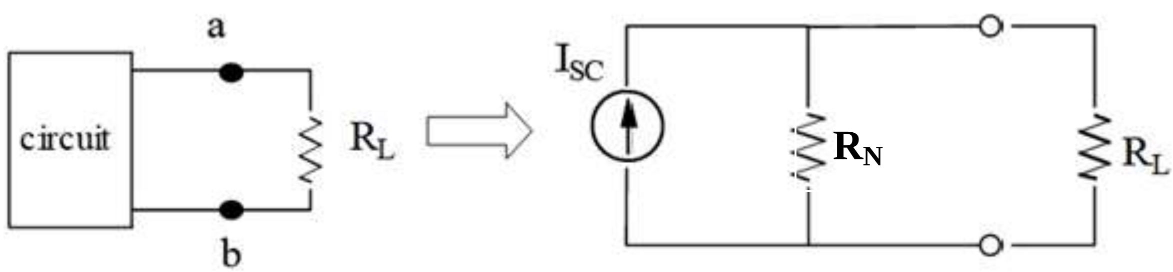
الاسبوع السابع المحاضرة السابعة

الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

- ان يتعرف الطالب على تحليل الدائرة الكهربائية وايجاد مكافئ نورتن .
- ان يكون الطالب قادرا على تطبيق نظرية نورتن وايجاد قيم التيارات (الحمل) والفولتيات في مقاومة معينة

NORTON'S THEOREM

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



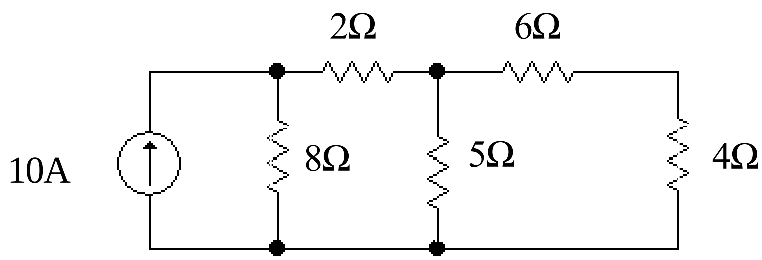
Procedure of Norton's Theorm

a. Find the short circuit current at the terminals, Isc

b. Find Thevenin's equivalent resistance, RTH (as before

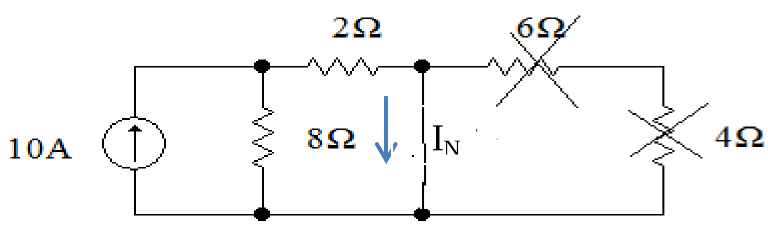
c. Reconnect the load to Norton's equivalent circuit

Example: Determine the current in the resistance (6Ω) of the network shown in fig (5) below by using norton s theorem.



Sluation

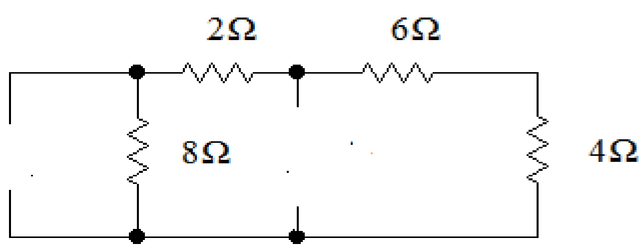
I_N= ?



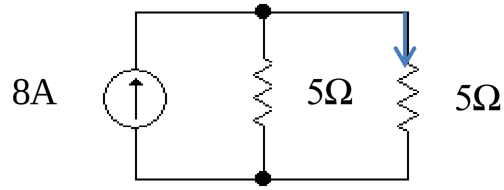
$$I_{2\Omega} = I_S = 10 \times \frac{8}{8+2} = 8A$$

I_S=I_N=8A

R_N=?



$$R_N = R_{TH} = \frac{(6+4)\times(2+8)}{(6+4)+(2+8)} = 5\Omega$$



$$I_{5\Omega} = 8 \times \frac{5}{5+5} = 4A$$

الاسبوع التاسع المحاضرة التاسعة

الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

- ان يكون الطالب قادرا على تطبيق وتحليل الدائرة باستخدام نظرية التطابق او التراكب.
- ان يكون الطالب قادرا على ايجاد التيار و الفولتية في اي مقاومة باستخدام نظرية التطابق او التراكب.
- ان يكون الطالب قادرا على فهم نظرية نقل اعظم قدرة

<u>Superposition theorem</u>

Whenever a linear circuit is excited by more than one independent source, the total response is the algebraic sum of individual responses The idea is to activate one independent source at a time to get individual response. Then add the individual response to get total response

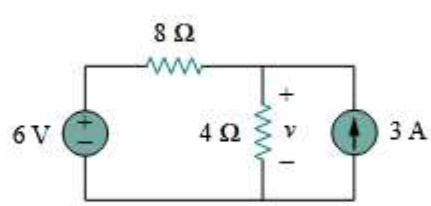
Steps to apply the superposition principle

●We consider one independent source at a time while all other independent sources are turned off

●This implies that we replace every voltage source by 0 V (or a short circuit)

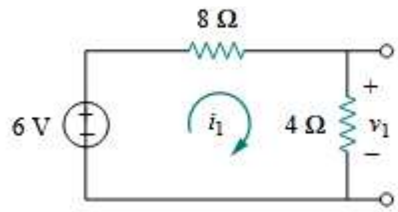
●every current source by 0 A (or an open circuit)

Example: Use the superposition theorem to find v in the circuit in Fig below



Solution:

1- Redraw the original circuit with source (6v) removed set the current source to zero(open circuit)



To obtain v1,Applying KVL

$$12i_1 - 6 = 0 \quad \Longrightarrow \quad i_1 = 0.5 \text{ A}$$

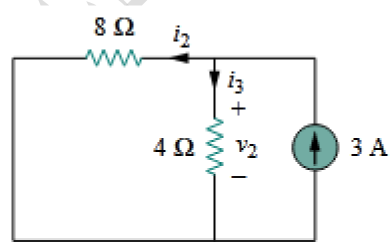
Thus,

$$v_1 = 4i_1 = 2 \text{ V}$$

Or use the voltage divition

$$v_1 = \frac{4}{4+8}(6) = 2 \text{ V}$$

Redraw the original circuit with source (3A), removed set the voltage source to -١ zero(short circuit)



Using current division obtain v_2

$$i_3 = \frac{8}{4+8}(3) = 2 \text{ A}$$

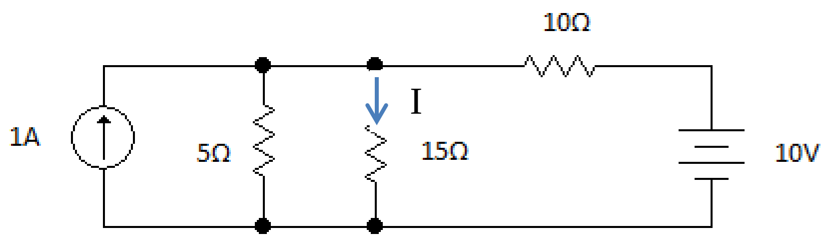
Hence,

$$v_2 = 4i_3 = 8 \text{ V}$$

And we find

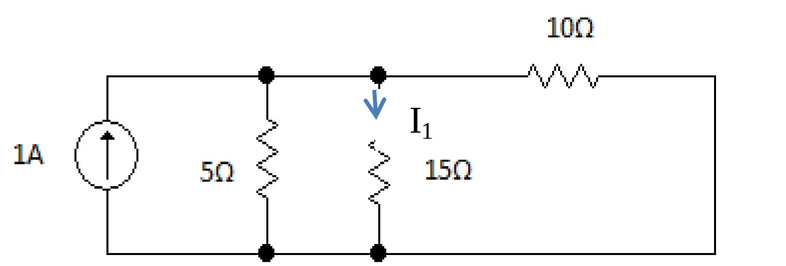
$$v = v_1 + v_2 = 2 + 8 = 10 \text{ V}$$

Example: Calculate the voltage across (15Ω) resistance using Superposition Theorem



Solution

removed the voltage source to zero(short circuit)

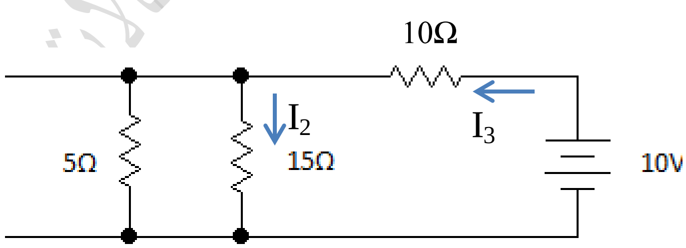


$$\frac{5 \times 10}{5+10} = \frac{50}{15} = 3.33\Omega$$

$$I_1 = \frac{3.33}{3.33+15} I$$

$$I_1 = \frac{3.33}{3.33+15} \times 1 = 0.18A$$

removed set the current source to zero(open circuit)



$$\frac{5\times 15}{5+15}+10=13.75\Omega$$

$$I_3=\frac{10}{13.75}=0.73A$$

$$I_2=0.73\times\frac{5}{5+15}=0.18A$$

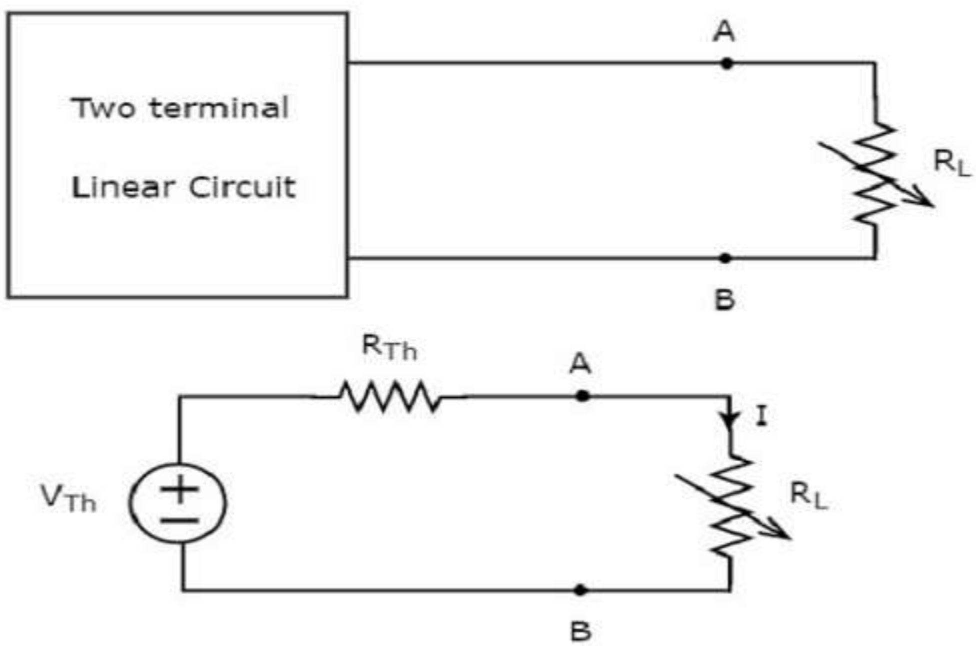
$$I=I_1+I_2=0.18+0.18=0.36A$$

I_{15}=0.36A

•

<u>Maximum power transfer theorem</u>

Max power transfer states that the DC voltage source will deliver maximum power to the variable load resistor only when the load resistance is equal to the source resistance.



when the load resistance is equal to the source resistance The amount of power dissipated across the load resistor is

Proof of Maximum Power Transfer Theorem

The power dissipated across the load resistor is

$$P_L=I^2R_L$$

Substitute $I = \frac{V_{Th}}{R_{Th}+R_L}$ in the above equation.

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

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

For maximum power transfer, differentiate PL with respect to RL and make it equal to zero

$$\frac{dP_L}{dR_L} = 0$$

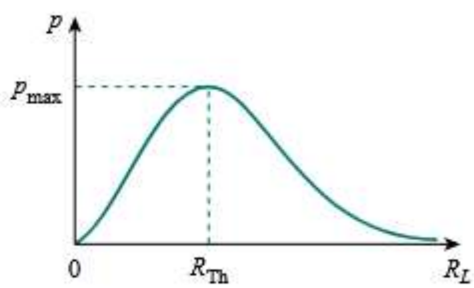
$$\frac{dP_L}{dR_L} = {V_{Th}}^2 \left\{\frac{(R_{Th}+R_L)^2 \times 1 - R_L \times 2(R_{Th}+R_L)}{(R_{Th}+R_L)^4}\right\} = 0$$

$$\Rightarrow (R_{Th}+R_L)^2 - 2R_L(R_{Th}+R_L) = 0$$

$$\Rightarrow (R_{Th}+R_L)(R_{Th}+R_L-2R_L) = 0$$

$$\Rightarrow (R_{Th}-R_L) = 0$$

$$R_{TH} = R_L$$



Max power transfer states that the DC voltage source will deliver maximum power to the variable load resistor only when the load resistance is equal to the source resistance.

$$p_{max} = \frac{V_{Th}^2}{4R_{Th}}$$

الاسبوع العاشر +الحادي عشر المحاضرة العاشرة+ الحادية عشرة

الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

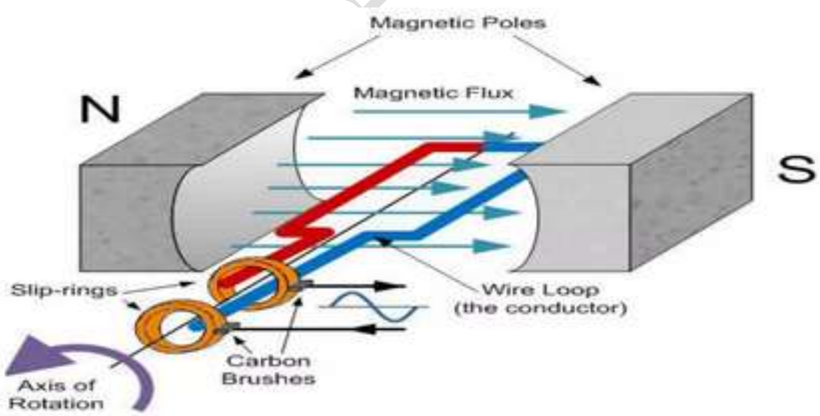
- تعريف الطالب بالكميات المتناوبة والعوامل المؤثرة على القوة الدافعة الكهربائية والتعاريف الاساسية للكميات المتناوبة واشكال الموجات .

مدة المحاضرة: ٤ ساعة نظري

Alternating Voltage and Current

An alternating voltage may be generated:

1. By rotating a coil at constant angular velocity in a uniform magnetic field.
2. By rotating a magnetic field at a constant angular velocity within a stationary coil.



The value of the voltage generated depends in each case upon:-

1-The number of turnes in the coil.

2-Strength of the field.

3-Speed at which the coil or magnetic field rotates.

Equation of the alternating voltage and current

Consider arectangular coil having (N) turnes and rotating in auniform magnetic field with an angular volocity of(ω) radian\second as shown in fig below

Let time be measured from the x-axis maximum flux (ϕm)is linked with the coil when its plane coincidedes with x-axis at the time (t)second this coil rotates through an angle (ωt).

In this deflected position ,the component of the flux which is perpendicular to the plane of the coil is

$$\phi = \phi m \ \cos \omega t$$

$$\phi N = N\phi m \ \cos \omega t$$

ϕ:magnetic flux

N: number of turns

According to Faraday's second law of electromagnetic induction, we know that the induced emf in a coil is equal to the rate of change of flux linkage. Therefore,

$$e = \frac{d\phi}{dt}$$

$$e = N\frac{d\phi}{dt}$$

Considering Lenz's law,

$$e = -N\frac{d}{dt}(\phi m cos\omega t)$$

$$e = -N\phi m \ \omega(-sin\omega t)$$

$$e = N\phi m \ \omega sin\omega t$$

$\Theta = \omega t$

$$e = N\phi m \ \omega sin\square$$

When $\Theta = 90^0$

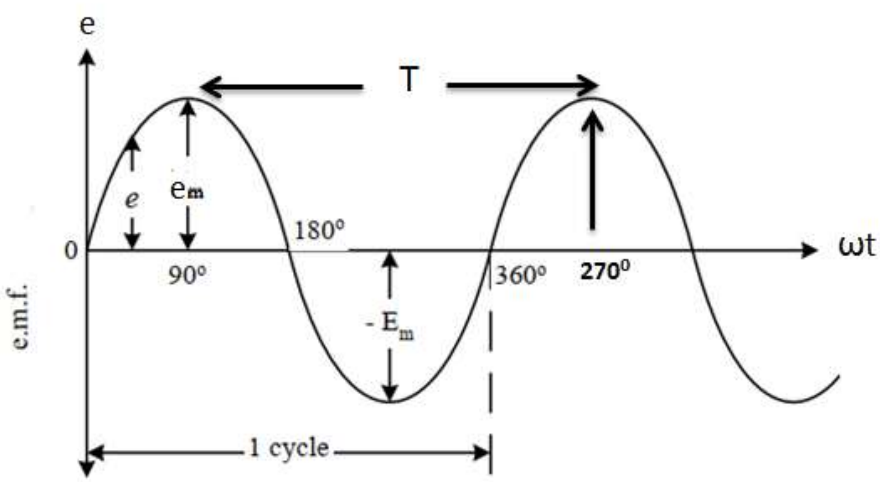
sin90 =1

$$e = N\phi m\ \omega = em$$

$$e = e_m sin\ \omega t$$

$$i = \frac{e_m sin\ \omega t}{R}$$

$$i = i_m sin\ \omega t$$



Definitions

A few basic terms will be defined in this section which can be applied to any waveform.

●***Periodic waveform*:** a waveform that continually repeats itself after the same time interval.

●***Period* (*T*)**: the time interval between successive repetitions of a periodic waveform or the time of one cycle.

●***Frequency* (*f*):** the number of cycles that occur in 1 second, the unit used for measuring frequency is cycle per second or hertz (Hz).

$$f = \frac{1}{T}$$

$$T = \frac{1}{F}$$

$$\theta = \omega t = \omega.\frac{1}{f}$$

$$\theta = 2\pi \qquad one\ cycle$$

$$2\pi = \omega.\frac{1}{f} \qquad \text{angular velocity} \quad \omega = 2\pi f \quad rad/second$$

• ***Instantaneous value***: the magnitude of the waveform at any instant of time.

• ***Amplitude or Peak value***: the maximum value of a waveform.

Example2: An alternating voltage has the equation v = 141.4 sin 377t; what are the values of:
(a) r.m.s. voltage;
(b) frequency;

(c) the instantaneous voltage when t = 3 ms?

Sol

$V = v_m \sin\omega t$

(a) $V_m = 141.4\ V = \sqrt{2}V$

hence $V = \frac{141.4}{\sqrt{2}} = 100\ V$

(b) Also by comparison

$\omega = 377\ rad/s = 2\pi f$

hence $f = \frac{377}{2\pi} = 60\ Hz$

(c) Finally

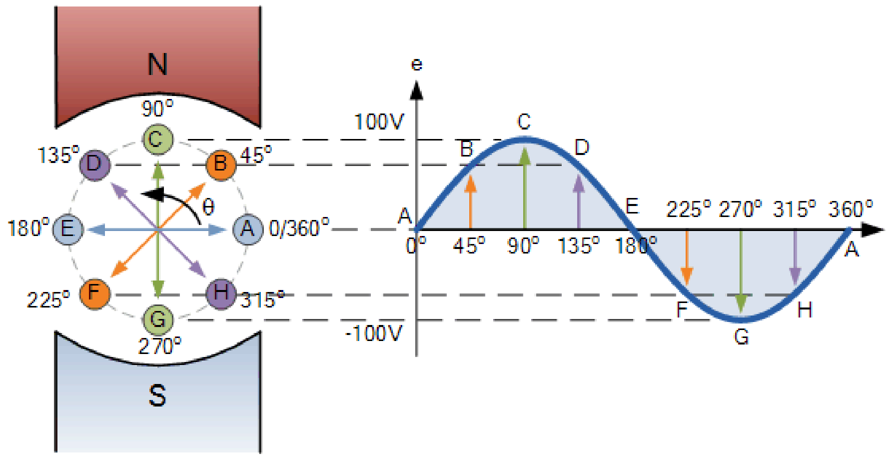
$v = 141.4 \sin 377t$

When $t = 3 \times 10^{-3}\ s$

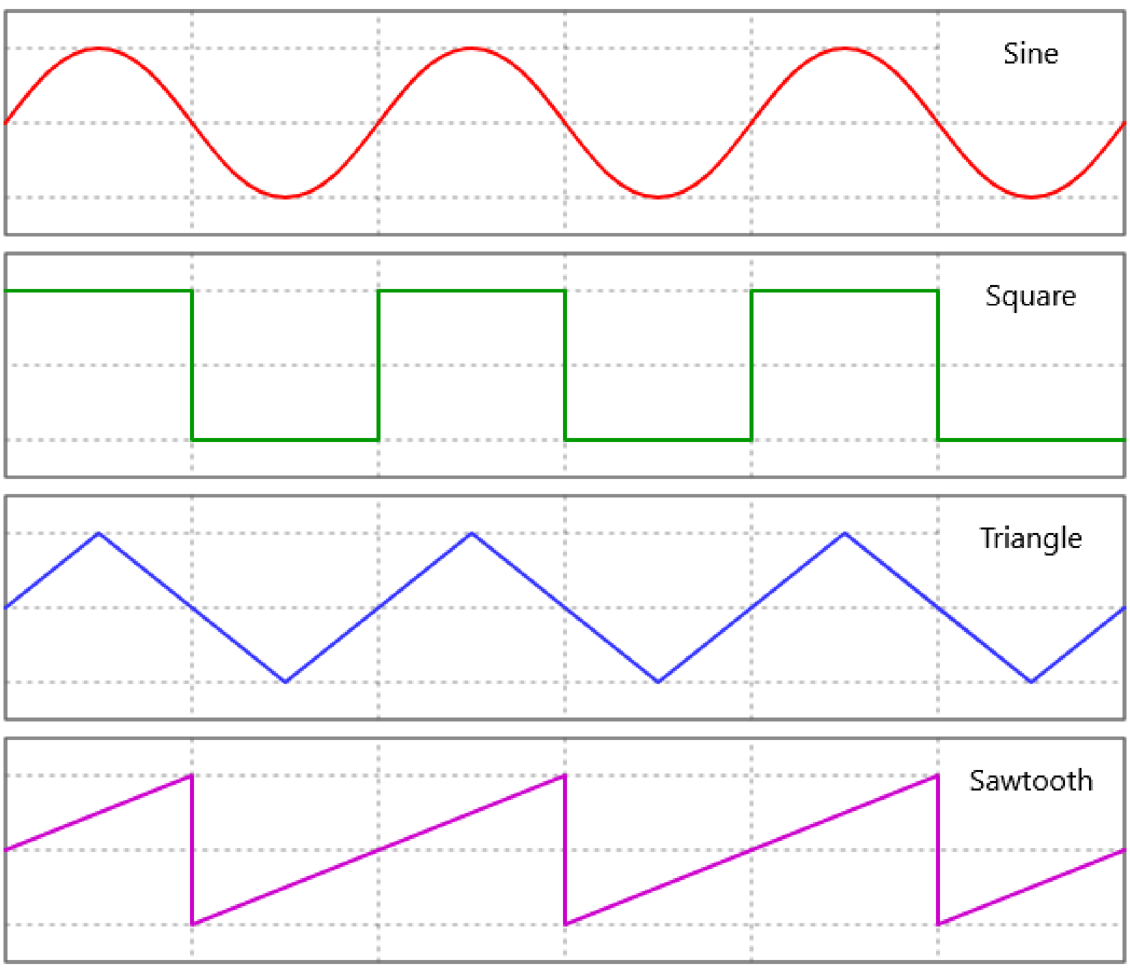
$v = 141.4 \sin(377 \times 3 \times 10^{-3}) = 141.4 \sin 1.131$

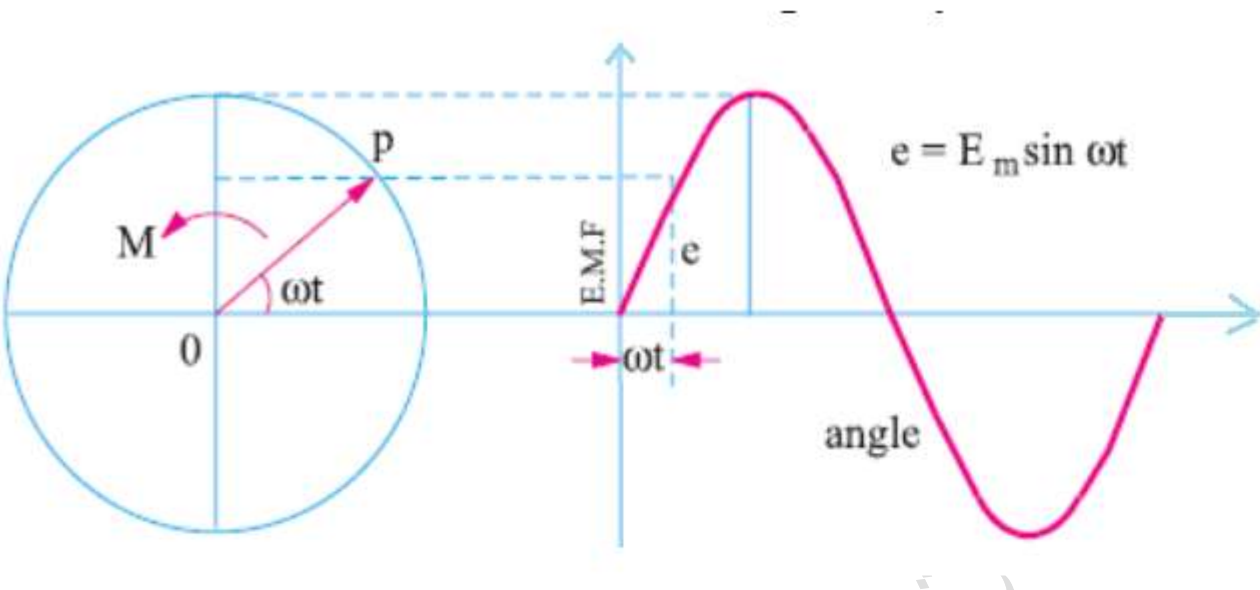
$= 141.4 \times 0.904 = 127.8\ V$

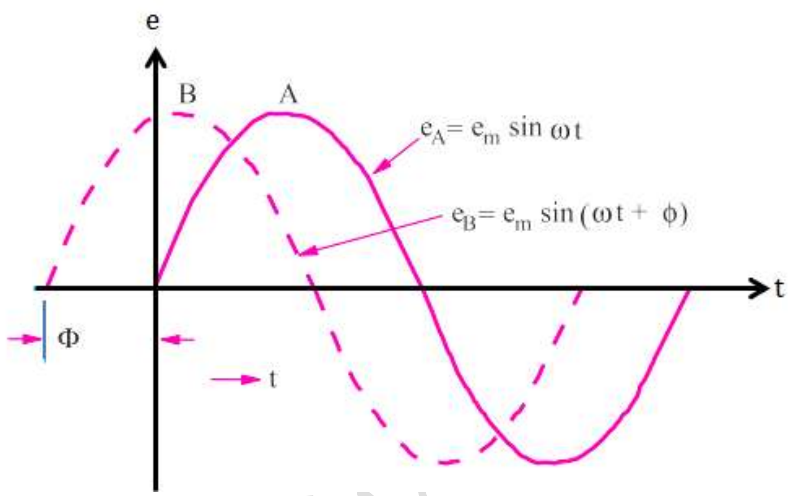
Representation of an alternating quantity by vector



Types of Periodic Waveform







eB leads eA by an angle ϕ

$eA = Em \sin \omega t$ ...reference quantity

$eB = Em \sin (\omega t + \phi)$

Root Mean Square (R.M.S) value

The r.m.s value of an alternating current is given by that steady (d.c.) current which when flowing through a given time produce the same heat (power) as produced by the alternating current when flowing through the same circuit for the same time. It is also known as the effective value of the alternating current.

$$I_{r.m.s} = \sqrt{\frac{1}{T}\int_0^T i^2\,(\theta)d\theta}$$

Average Value

The average value Ia of an alternating current is expressed by that steady current which transfers across any circuit the same charge as is transferred by that alternating current during the same time.

In the case of a symmetrical alternating current (*i.e.* one whose two half-cycles are exactly similar, whether sinusoidal or non-sinusoidal), the average value over a complete cycle is zero.

$$I_{av} = \frac{1}{T}\int_0^T i\,(\theta)d\theta$$

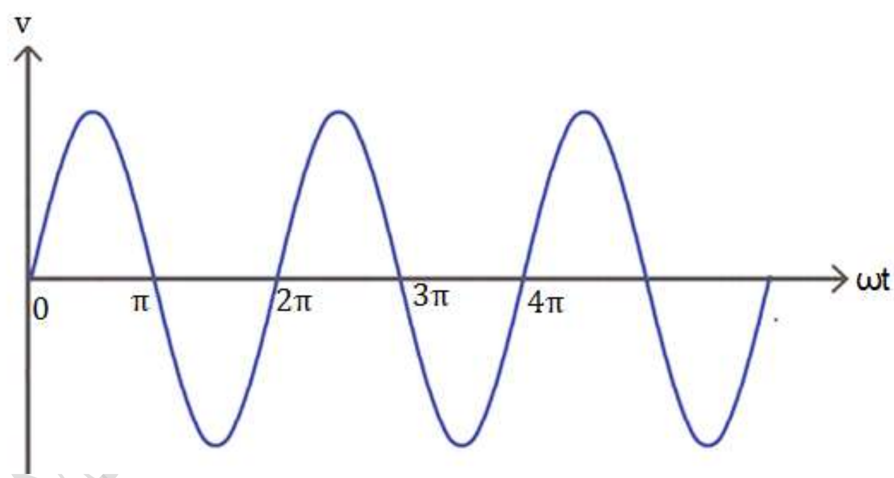
Form factor

$$K_F = \frac{r.m.s}{average}$$

Peak or Amplitude Factor

$$\mathbf{Ka} = \frac{\max \boldsymbol{value}}{r.m.s\ \boldsymbol{value}}$$

Example: Find Root Mean Square (R.M.S) value



$$I_{r.m.s} = \sqrt{\frac{1}{T}\int_0^T i^2\,(\theta)d\theta}$$

T=2π

$$I_{r.m.s} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi}((I_m sin\omega t)^2\, d\omega t}$$

Sinωt^2 =1-cos2ωt

$$I_{r.m.s} = \sqrt{\frac{{I_m}^2}{2\pi}\int_0^{2\pi}\frac{1}{2}(1 - con2\omega t)\, d\omega t}$$

$$I_{r.m.s} = \sqrt{\frac{{I_m}^2}{4\pi}\quad\left[\omega t - \frac{sin2\omega t}{2}\right]}$$

$$I_{r.m.s} = \sqrt{\frac{{I_m}^2}{4\pi}\quad\left[\omega t - \frac{sin2\omega t}{2}\right]_0^{2\pi}}$$

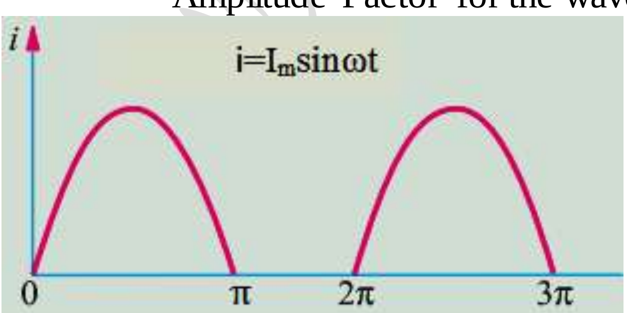
$$I^2{}_{r.m.s} = \frac{{I_m}^2}{4\pi}\,[2\pi - 0]$$

$$I^2{}_{r.m.s} = \frac{{I_m}^2}{4\pi}\,[2\pi]$$

$$I^2{}_{r.m.s} = \frac{{I_m}^2}{4\not\pi}\,[2\not\pi]$$

$$I^2{}_{r.m.s} = \frac{{I_m}^2}{2} \qquad \therefore I_{r.m.s} = \frac{I_m}{\sqrt{2}} = 0.707 I_m$$

Example: Find Root Mean Square (R.M.S) value, Average Value, Form factor and Amplitude Factor for the wave form in fig below.



Soluation

$$I_{r.m.s} = \sqrt{\frac{1}{T}\int_0^T i^2\,(\theta)d\theta}$$

T=2π

$$I_{r.m.s} = \sqrt{\frac{1}{2\pi}\int_0^{\pi}((I_m sin\omega t)^2\,d\omega t + \int_{\pi}^{2\pi} 0\,d_{\omega t})}$$

$Sin\omega t^2 = 1 - cos2\omega t$

$$I_{r.m.s} = \sqrt{\frac{{I_m}^2}{2\pi}\int_0^{\pi}\frac{1}{2}(1 - con2\omega t)\,d\omega t}$$

$$I_{r.m.s} = \sqrt{\frac{{I_m}^2}{4\pi}\quad\left[\omega t - \frac{sin2\omega t}{2}\right]}$$

$$I_{r.m.s} = \sqrt{\frac{{I_m}^2}{4\pi}\quad\left[\omega t - \frac{sin2\omega t}{2}\right]_0^{\pi}}$$

$$I^2{}_{r.m.s} = \frac{{I_m}^2}{4\pi}\,[\pi - 0]$$

$$I^2{}_{r.m.s} = \frac{{I_m}^2}{4\pi}\,[\pi]$$

$$I^2{}_{r.m.s} = \frac{{I_m}^2}{4\cancel{\pi}}\,[\cancel{\pi}]$$

$$I^2{}_{r.m.s} = \frac{{I_m}^2}{4} \qquad \therefore\ I_{r.m.s} = \frac{I_m}{2}$$

$$I_{av} = \frac{1}{T}\int_0^T i\,(\theta)d\theta$$

$$I_{av} = \frac{1}{2\pi}\int_0^{\pi}((I_m sin\omega t)\,d\omega t + \int_{\pi}^{2\pi} 0\,d_{\omega t})$$

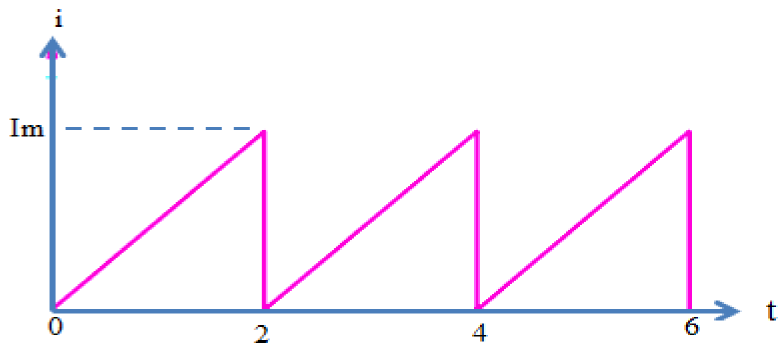
$$I_{av} = \frac{I_m}{2\pi}\,[-cos\omega t]_0^{\pi}$$

$$I_{av} = \frac{I_m}{2\pi}[-(-1+1)] = \frac{I_m}{2\pi}(2) \qquad \therefore I_{av} = \frac{I_m}{\pi}$$

$$K_F = \frac{I_{r.m.s}}{I_{av}} = \frac{\frac{I_m}{2}}{\frac{I_m}{\pi}} = \frac{\pi}{2}$$

$$K_A = \frac{I_m}{I_{r.m.s}} = \frac{I_m}{\frac{I_m}{2}} = 2$$

Example: Find the form-factor of the wave form given in fig below



Soluation:

$$M = \frac{y2 - y1}{x2 - x1} = \frac{I_m - 0}{2 - 0} = \frac{I_m}{2}$$

y-y1=m(x-x1) $\qquad i - 0 = \frac{I_m}{2}(t - 0)$

$$I_{r.m.s} = \sqrt{\frac{1}{T}\int_0^T i^2(\theta)d\theta} = \sqrt{\frac{1}{2}\int_0^2 i^2\,dt} = I_{r.m.s} = \sqrt{\frac{1}{2}\int_0^2 (\frac{I_m}{2}\ t)^2\,dt}$$

$$I_{r.m.s} = \sqrt{\frac{I_m{}^2}{8}\int_0^2 (t)^2\,dt} = \sqrt{\frac{I_m{}^2}{8}\left[\frac{t^3}{3}\right]}$$

$$\sqrt{\frac{I_m{}^2}{8}\left[\frac{t^3}{3}\right]_0^2}$$

$$I_{r.m.s} = \sqrt{\frac{I_m{}^2}{8}\left[\frac{2^3}{3}\right]} = \sqrt{\frac{I_m{}^2}{8}\left[\frac{8}{3}\right]} = \frac{I_m}{\sqrt{3}}$$

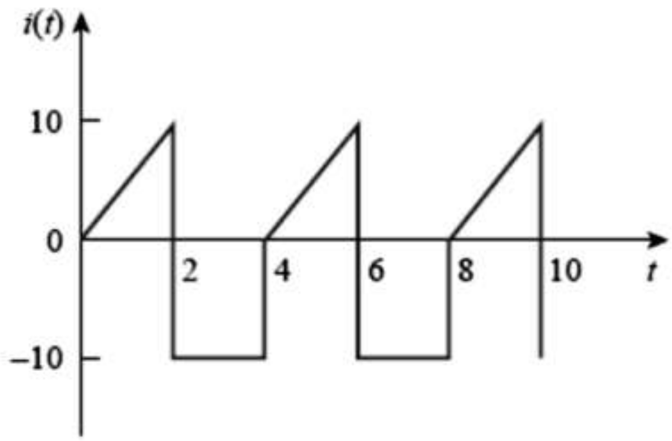
$$I_{av} = \frac{1}{T}\int_0^T i\,(\theta)d\theta = \frac{1}{2}\int_0^2 i\,dt = \frac{1}{2}\int_0^2 \frac{I_m}{2}\,t\,dt = \frac{I_m}{4}\int_0^2 t\,dt$$

$$I_{av} = \frac{I_m}{4}\left[\frac{t^2}{2}\right]_0^2$$

$$I_{av} = \frac{I_m}{2} \qquad \therefore K_F = \frac{I_{r.m.s}}{I_{av}} = \frac{\frac{I_m}{\sqrt{3}}}{\frac{I_m}{2}} = \frac{I_m}{\sqrt{3}} \times \frac{2}{I_m} = \frac{2}{\sqrt{3}}$$

<u>H.W</u>

<u>1-</u> Determine the rms value of the current waveform in Figure shown below.



2- prove that Root Mean Square value of the waveform below 0.707Im

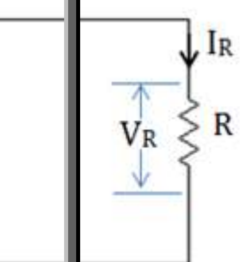
الاسبوع : الثاني عشر المحاضرة الثانية عشر

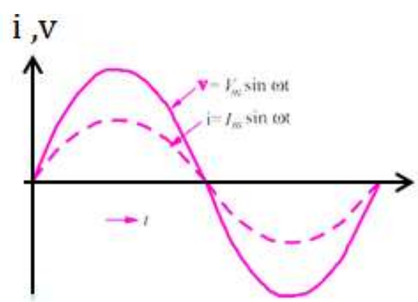
الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

- ان يكون الطالب قادرا على تطبيق فهم وتحليل تاثير التيار المتناوب على مقاومة و ملف ومتسعة .
- ان يكون الطالب قادرا على تطبيق فهم وتحليل تاثير التيار المتناوب على دوائر التوالي .

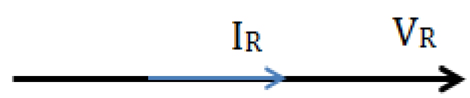
A.C. Through Resistance, Inductance and Capacitance

A.C. Through Pure Resistance





In Pure resistance: The current (I_R) is in phase with the applied voltage(V_R)as shown in the phasor.



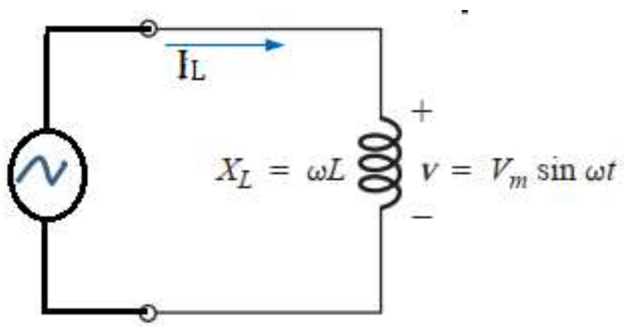
$$I_R = \frac{V_R}{R}$$

Z=R

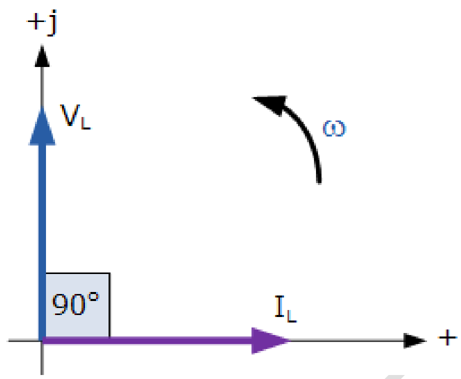
Z:Impedance in (Ω)

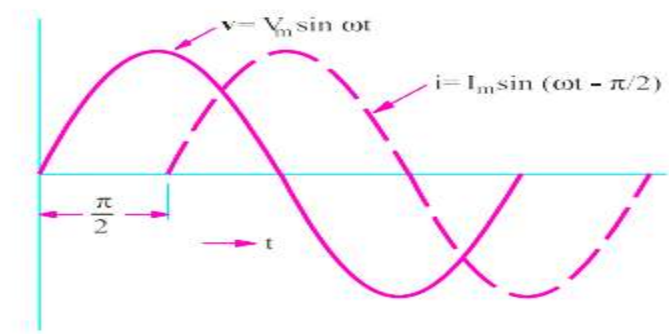
$$Z = \frac{V}{I}$$

Pure inductance



In an A.C. circuit containing pure inductance L only, the current I_L lags the applied voltage V_L by 90° as shown in the phasor diagram.





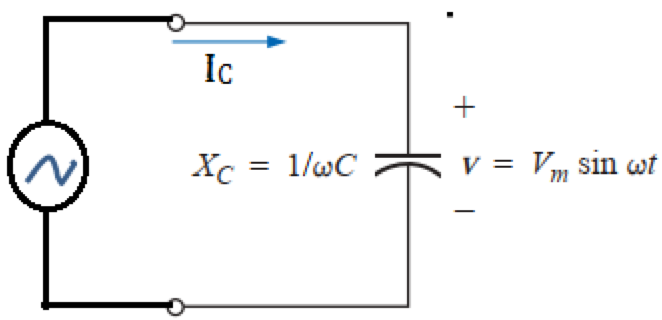
$X_L = 2\pi fL$

- Where:
- X_L = Inductive Reactance in Ohms, (Ω)
- π (pi) = 3.14
- *f* = Frequency in Hertz, (Hz)
- L = Inductance in Henries, (H)

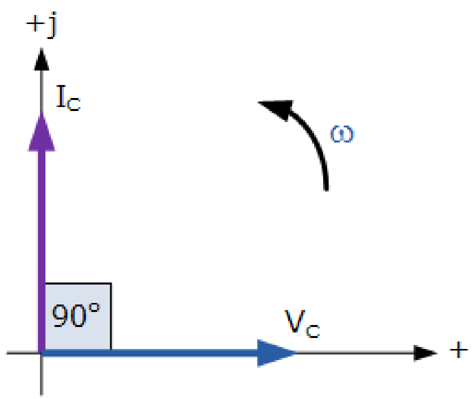
$X_L = \omega_L$, $Z = X_L$

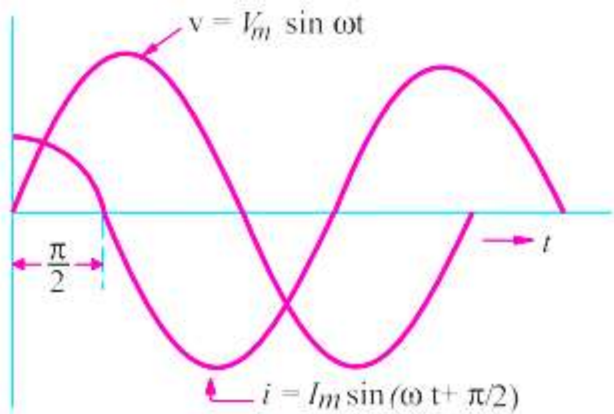
$$I_L = \frac{V}{X_L}$$

Pure capacitance:



In an A.C. circuit containing pure capacitance, the current IC leads the applied voltage VC by90^0.





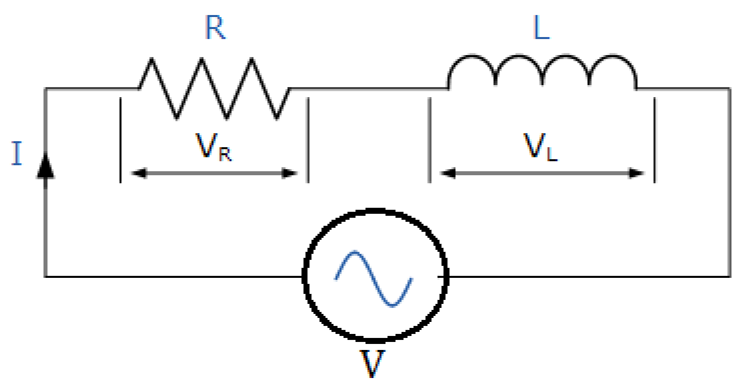
$$I_C = \frac{V}{X_C}$$

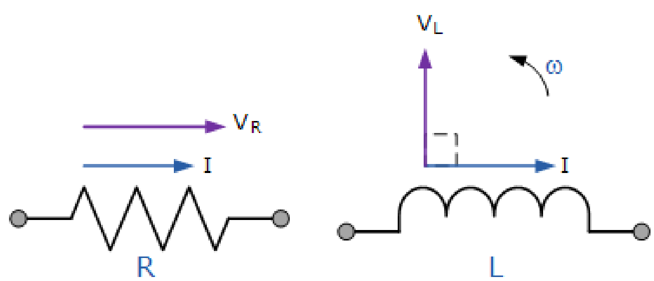
$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

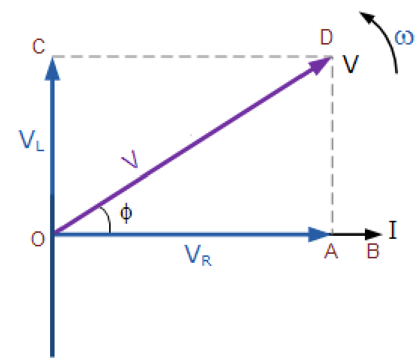
Where:

- X_C is the Capacitive Reactance in Ohms,
- *f* is the frequency in Hertz
- C is the AC capacitance in Farads,

Series Resistance-Inductance Circuit







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

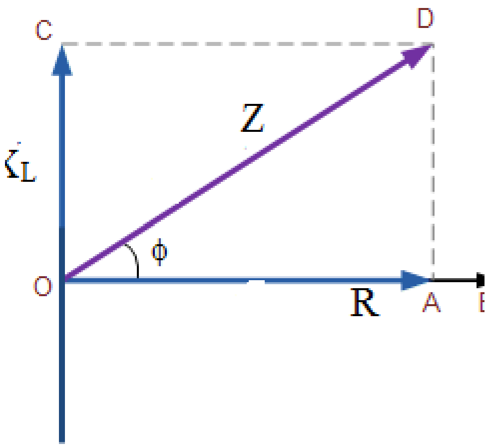
$$V = \sqrt{(I.R)^2 + (I.XL)^2}$$

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

Impedance

$$Z = \frac{V}{I}$$

$$Z = \sqrt{R^2 + {X_L}^2}$$

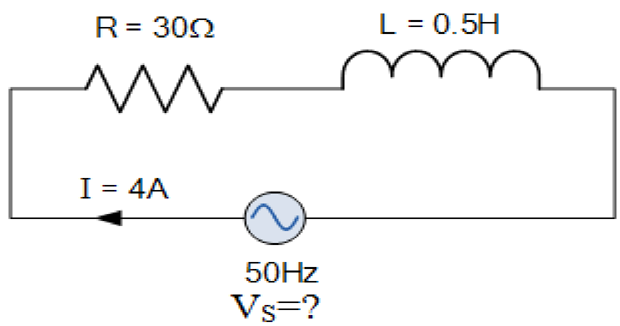


phase angle, θ between the voltage and current is calculated as :

$$\cos\theta = \frac{R}{Z} \quad , \quad \tan\theta = \frac{X_L}{R} \quad , \sin\theta = \frac{X_L}{Z}$$

$$\theta = \cos^{-1}\frac{R}{Z} \quad , \quad \theta = \tan^{-1}\frac{X_L}{R} \quad , \quad \theta = \sin^{-1}\frac{X_L}{Z}$$

Example: A coil has a resistance of 30Ω and an inductance of 0.5H. If the current flowing through the coil is 4amps. What will be the rms value of the supply voltage if its frequency is 50Hz.



Soluation:

$V_S = I.Z$

$X_L = 2\pi fL = 2\times3.14\times50\times0.5 = 157\Omega$

$$Z = \sqrt{R^2 + {X_L}^2} = \sqrt{30^2 + 157^2} = 189.8\Omega$$

$V_S = 4\times157 = 640V$

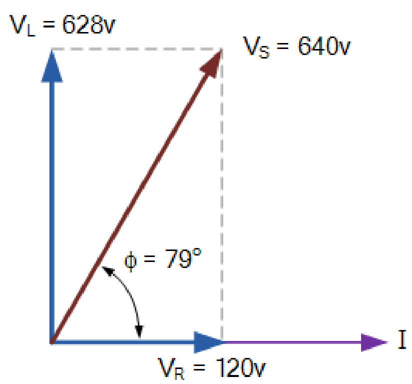
the voltage drops across each component

$VR = I.R = 4\times30 = 120V$

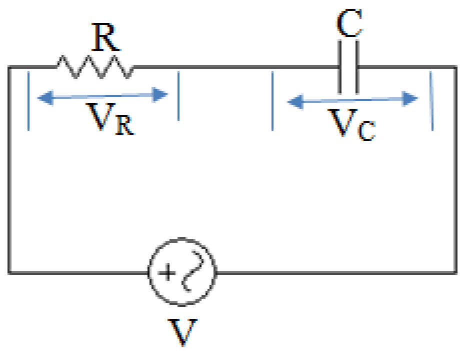
$VL = I.XL = 4\times157 = 628V$

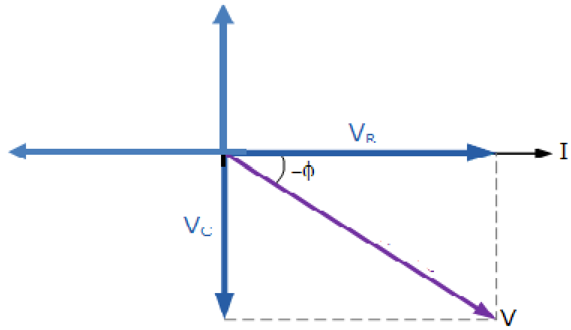
The phase angle between the current and supply voltage

$$\theta = \tan^{-1}\frac{X_L}{R} = \tan^{-1}\frac{157}{30} = 79.2^0$$



Series Resistance-Capacitance Circuit





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

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

$$I = \frac{V}{\sqrt{R^2 + X_c^{\ 2}}}$$

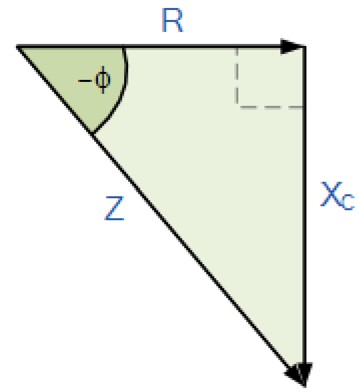
Impedance

$$Z = \frac{V}{I}$$

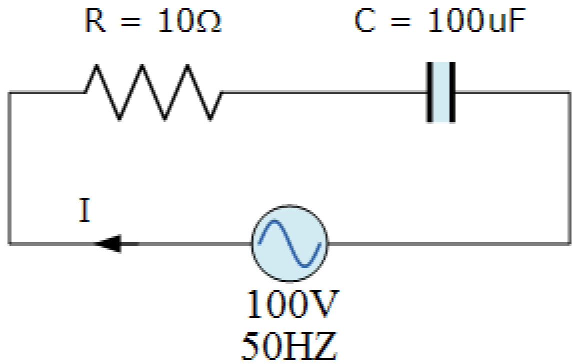
$$Z = \sqrt{R^2 + X_c^{\ 2}}$$

$$\cos\theta = \frac{R}{Z} \ , \qquad \tan\theta = \frac{X_c}{R} \qquad , \sin\theta = \frac{X_c}{Z}$$

$$\theta = \cos^{-1}\frac{R}{Z} \ , \qquad \theta = \tan^{-1}\frac{X_c}{R} \qquad , \qquad \theta = \sin^{-1}\frac{X_c}{Z}$$



Example: A capacitor which has an internal resistance of 10Ω and a capacitance value of 100uF is connected to a supply voltage 100V , 50 HZ Calculate current flowing into the capacitor. Also construct a voltage triangle showing the individual voltage drops.



Soluation:

$$X_C = \frac{1}{2\pi f c} = \frac{1}{2\times3.14\times50\times100\times10^{-6}} = 31.85\Omega$$

$$Z = \sqrt{R^2 + {X_c}^2} = \sqrt{10^2 + 31.85^2} = 33.4\Omega$$

$$I = \frac{V}{Z} = \frac{100}{33.4} = 3A$$

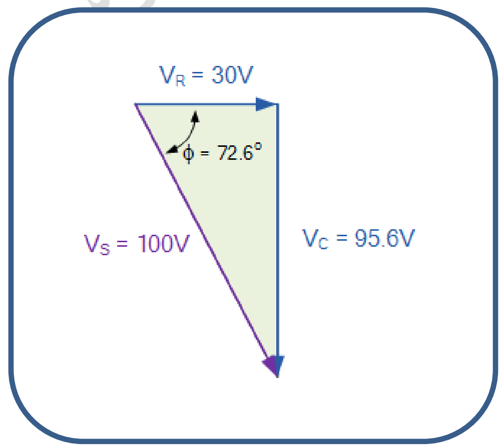
voltage drops around the circuit are calculated as:

V_R=I.R =3×10=30V

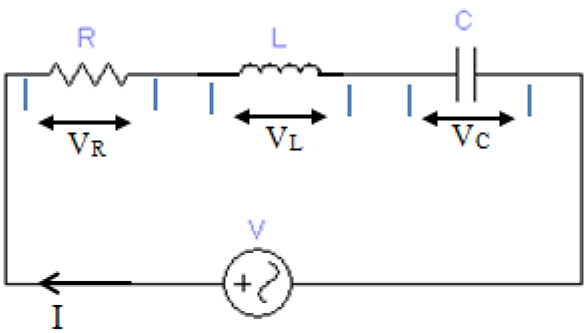
V_C=I.X_C=3×31.85=95.6V

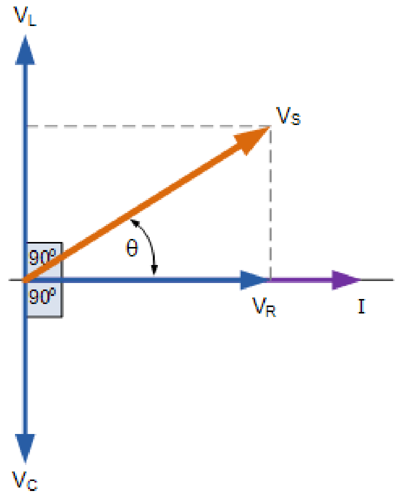
The phase angle between the current and voltage

$$\theta = \tan^{-1}\frac{X_c}{R} = \tan^{-1}\frac{31.85}{10} = 72.6^0$$



Series RLC Circuit



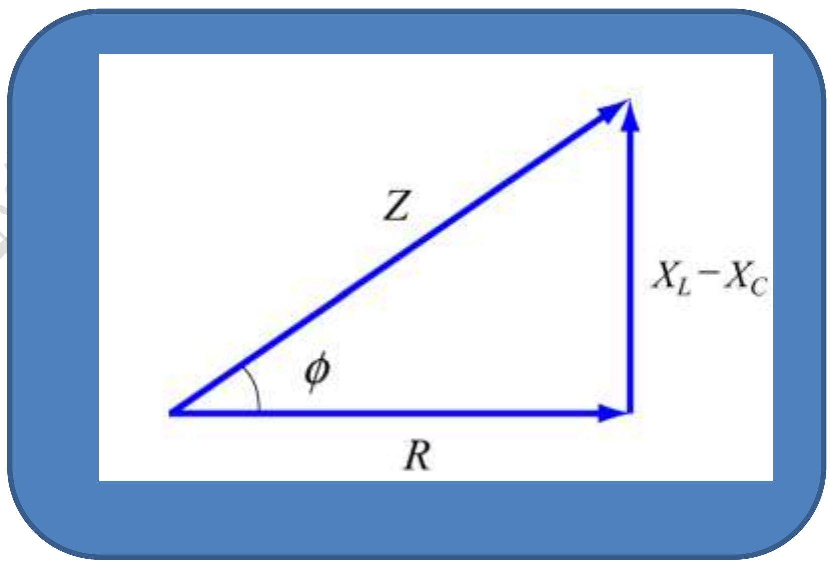


$V^2 = V_R{}^2 + (VL - V_c)^2$, $V = \sqrt{V_R{}^2 + (\text{VL} - \text{Vc})^2}$

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

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

Impedance



$$V = I.Z$$

$$Z = \frac{V}{I}$$

$$Z = \sqrt{R^2 + (XL - X_C)^2}$$

$$Z = \sqrt{R^2 + (X)^2}$$

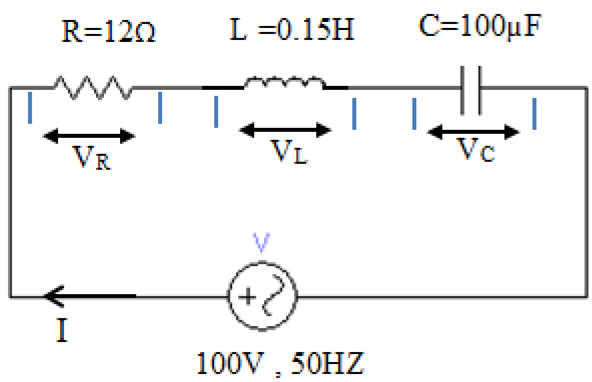
$X = X_L - X_C$

If
- $X_L = X_C$ (resitive circuit)
- $X_L > X_C$ (inductive circuit)
- $X_L < X_C$ (capactive circuit)

$\cos\theta = \frac{R}{Z}$, $\tan\theta = \frac{X_L - X_C}{R}$, $\sin\theta = \frac{X_L - X_C}{Z}$

$$\theta = \cos^{-1}\frac{R}{Z} \quad , \quad \theta = \tan^{-1}\frac{X_L - X_C}{R} \quad , \quad \theta = \sin^{-1}\frac{X_L - X_C}{Z}$$

Example: A series RLC circuit containing a resistance of 12Ω, an inductance of 0.15H and a capacitor of 100uF are connected in series across a 100V, 50Hz supply. Calculate the total circuit impedance, the circuits current, power factor and draw the voltage phasor diagram.



Soluation:

Inductive Reactance, X_L $\quad$ $XL = 2\pi fL = 2\times3.14\times50\times0.15 = 47.13\Omega$

Capacitive Reactance, X_C. $\quad$ $X_C = \frac{1}{2\times\pi\times F\times C} = \frac{1}{2\times\pi\times50\times100\times10^{-6}} = 31.83\Omega$

Impedance, **Z**. $\quad$ $Z = \sqrt{R^2 + (XL - X_C)^2} = \sqrt{12^2 + (47.13 - 31.83)^2} = 19.4\Omega$

Current, I. $\quad$ $I = \frac{V}{Z} = \frac{100}{19.4} = 5.14A$

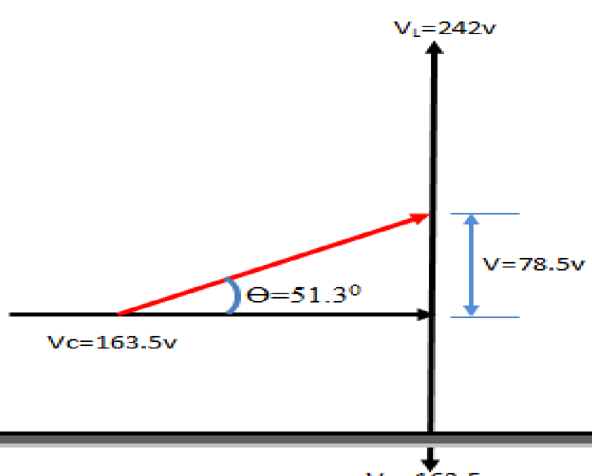
Voltages across V_R, V_L, V_C.

$$V_R = I.R = 5.14 \times 12 = 61.7V \ , \quad V_L = I \times X_L = 5.14 \times 47.13 = 242.2V \ ,$$

$$V_L = I.X_C = 163.5V$$

Phase Angle, θ

$$\theta = \tan^{-1}\frac{X_L - X_C}{R} = \tan^{-1}\frac{47.13 - 31.83}{12} = 51.8^0 \quad lag$$



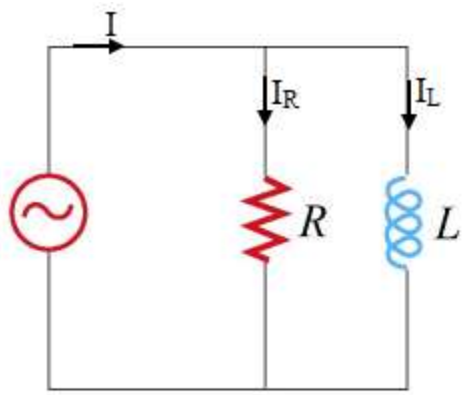
الاسبوع الرابع عشر المحاضرة الرابعة عشر

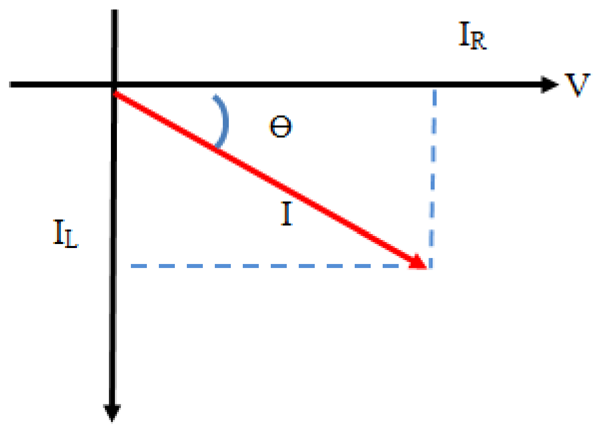
الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

- ان يكون الطالب قادرا على تطبيق فهم وتحليل ثاثير التيار المتناوب على دوائر التوازي .

مدة المحاضرة: ٢ ساعة نظري

Paraiiel RL Circuit





$I_R = \frac{V}{R}$, $I_L \frac{V}{X_L}$

$I^2 = I_R^2 + I_L^2$, $I = \sqrt{I_R^2 + I_L^2}\boldsymbol{I_R}$

$$I = \sqrt{(\frac{V}{R})^2 + (\frac{V}{X_L})^2} = V\sqrt{(\frac{1}{R})^2 + (\frac{1}{X_L})^2}$$

$$\frac{V}{I} = \frac{1}{\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L}\right)^2}}$$

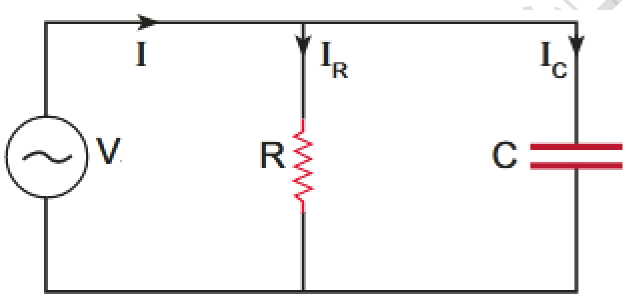
Impedance

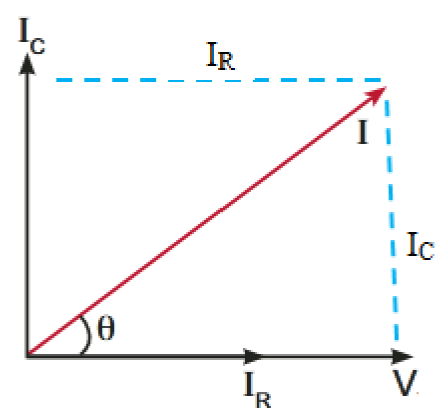
$$Z = \frac{V}{I} = \frac{1}{\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L}\right)^2}}$$

$$\cos\theta = \frac{I_R}{I} \quad , \quad \tan\theta = \frac{I_L}{I_R} \quad , \sin\theta = \frac{I_L}{I}$$

$$\theta = \cos^{-1}\frac{I_R}{I} \quad , \quad \theta = \tan^{-1}\frac{I_L}{I_R} \quad , \quad \theta = \sin^{-1}\frac{I_L}{I}$$

Paraiiel RC Circuit





$I_R = \frac{V}{R}$, $I_c = \frac{V}{X_c}$

$I^2 = I_R^2 + I_c^2$, $I = \sqrt{I_R^2 + I_c^2}$

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

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

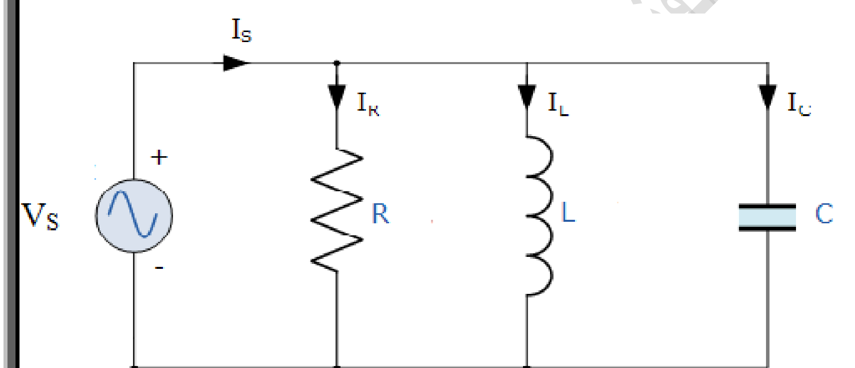
Impedance

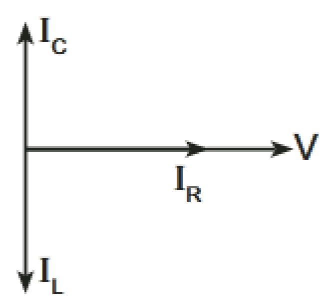
$$Z = \frac{V}{I} = \frac{1}{\sqrt{(\frac{1}{R})^2 + (\frac{1}{X_c})^2}}$$

$$\cos\theta = \frac{I_R}{I} \quad , \qquad \tan\theta = \frac{I_c}{I_R} \qquad , \sin\theta = \frac{I_c}{I}$$

$$\theta = \cos^{-1}\frac{I_R}{I} \quad , \qquad \theta = \tan^{-1}\frac{I_c}{I_R} \qquad , \qquad \theta = \sin^{-1}\frac{I_c}{I}$$

Paraiiel RC Circuit





$$\mathbf{I_R = \frac{V}{R}} \quad , \quad \mathbf{I_L = \frac{V}{X_L}} \qquad , \mathbf{I_c = \frac{V}{X_c}}$$

$$\mathbf{I^2 = I_R^2 + (I_L - I_c)^2} \quad , \qquad I = \sqrt{I_R^2 + (I_L - I_C)^2}$$

$$I = \sqrt{(\frac{V}{R})^2 + (\frac{V}{X_L} - \frac{V}{X_C})^2} = V\sqrt{(\frac{1}{R})^2 + (\frac{1}{X_L} - \frac{1}{X_C})^2}$$

$$\frac{V}{I} = \frac{1}{\sqrt{(\frac{1}{R})^2 + (\frac{1}{X_L} - \frac{1}{X_C})^2}}$$

Impedance

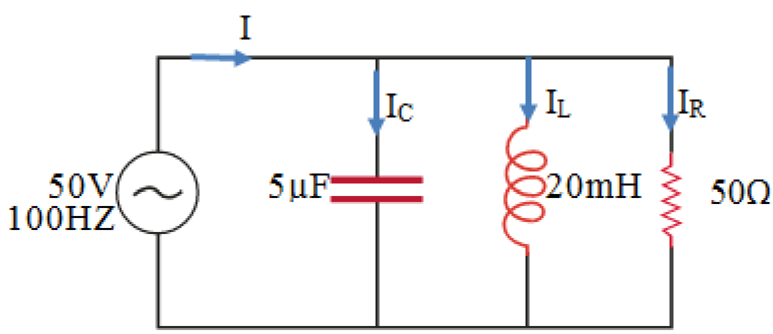
$$Z = \frac{V}{I} = \frac{1}{\sqrt{(\frac{1}{R})^2 + (\frac{1}{X_L} - \frac{1}{X_C})^2}}$$

Admittance (Y) : Admittance is the reciprocal of impedance, Z and is given the symbol Y. In AC circuits admittance is defined as the ease at which a circuit composed of resistances and reactances allows current to flow when a voltage is applied taking into account the phase difference between the voltage and the current. $Y = \frac{1}{Z}\ (S)$

$$Y = \frac{I}{V} = \sqrt{(\frac{1}{R})^2 + (\frac{1}{X_L} - \frac{1}{X_C})^2}$$

$$\theta = \cos^{-1}\frac{I_R}{I} \quad , \quad \theta = \tan^{-1}\frac{I_L - I_c}{I_R} \quad , \quad \theta = \sin^{-1}\frac{I_L - I_c}{I}$$

Example: A 50Ω resistor, a 20mH coil and a 5uF capacitor are all connected in parallel across a 50V, 100Hz supply. Calculate the total current drawn from the supply, the current for each branch, the total impedance of the circuit and the phase angle.



<u>Soluation:</u>

Inductive Reactance, X_L $\quad XL=2\pi fL = 2\times3.14\times100\times20\times10^{-3}=12.6\Omega$

Capacitive Reactance, X_C. $X_C = \frac{1}{2\times\pi\times F\times C} = \frac{1}{2\times\pi\times 00\times 5\times 10^{-6}} = 318.3\Omega$

Impedance, **Z**. $Z = \frac{\mathbf{1}}{\sqrt{(\frac{\mathbf{1}}{\mathbf{50}})^{\mathbf{2}} + (\frac{\mathbf{1}}{\mathbf{12.6}} - \frac{\mathbf{1}}{\mathbf{318.3}})^{\mathbf{2}}}} = 12.7\Omega$

Current through resistance, R (I_R): $\mathbf{I_R} = \frac{\mathbf{V}}{\mathbf{R}} = \frac{\mathbf{50}}{\mathbf{50}} = \mathbf{1}\boldsymbol{A}$

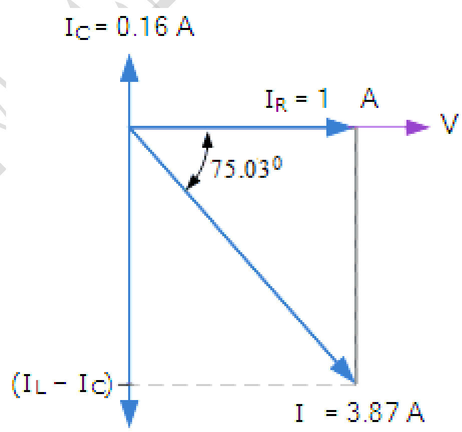
Current through inductor, L (I_L): $\mathbf{I_L} = \frac{\mathbf{V}}{\mathbf{X_L}} = \frac{\mathbf{50}}{\mathbf{12.5}} = \mathbf{3.9}\boldsymbol{A}$

Current through capacitor, C (I_C): , $\mathbf{I_c} = \frac{\mathbf{V}}{\mathbf{X_c}} = \frac{\mathbf{50}}{\mathbf{318.3}} = \mathbf{0.16}\boldsymbol{A}$

Total supply current $(\boldsymbol{I})$

$$\boldsymbol{I} = \sqrt{\boldsymbol{I_R}^{\mathbf{2}} + (\mathbf{I}_{\boldsymbol{L}} - \mathbf{I}_{\boldsymbol{C}})^2} = \sqrt{\mathbf{1^2} + (\mathbf{3.9} - \mathbf{0.16})^2} = \mathbf{3.87}\boldsymbol{A}$$

$$\theta = \tan^{-1}\frac{I_L - I_c}{I_R} = \tan^{-1}\frac{3.9 - 0.16}{1} = 75.03^0$$



الاسبوع الخامس عشر المحاضرة الخامسئ عشر

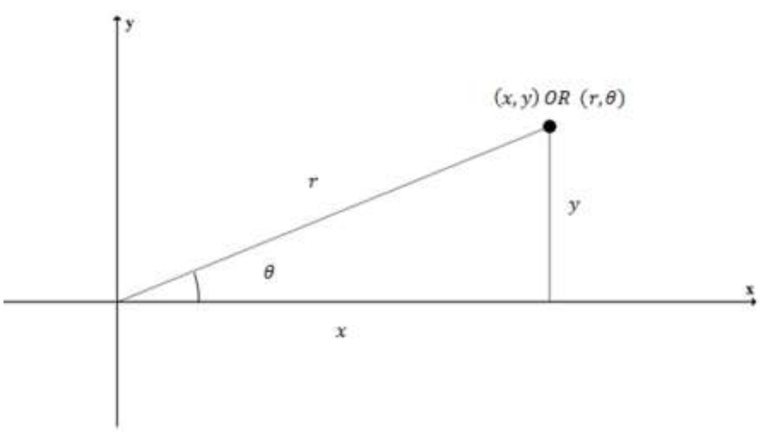
الهدف التعليمي (الهدف الخاص لكل للمحاضرة):

- ان يكون الطالب قادر على فهم j معامل Rectangular and polar forms والتحويل بينهما والعلاقات الرياضية الخاصة بهم.
- **مدة المحاضرة:** ٢ ساعة نظري

j operator

The j operator in electrical circuit has the same value as the i operator in mathematics. It is an imaginary number with a numeric value of, $j = \sqrt{-1}$. It is used in power systems to reflect the reactive portion of electrical quantities such as impedance, voltage, current and power. For example, with a complex impedance Z

Rectangular and polar forms



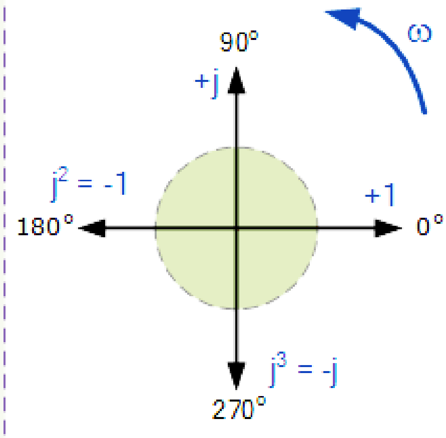
Rectangula form or Complex number : A= x+jy , $j = \sqrt{-1}$

90^0 rotation: $j^1 = \sqrt{-1} = +j$

180^0 rotation: $j^2 = \left(\sqrt{-1}\right)^2 = -1$

270^0 rotation: $j^3 = \left(\sqrt{-1}\right)^3 = -j$

360^0 rotation: $j^4 = \left(\sqrt{-1}\right)^4 = +1$

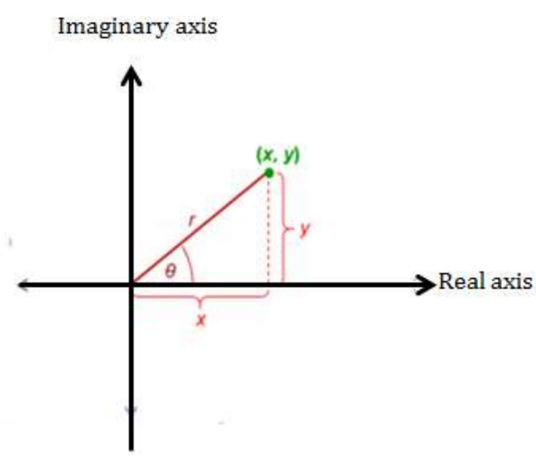


polar forms : B =r∟Ө

Convert between Polar and Rectangular Coordinates

Convert from Polar to Rectangular Coordinate

$$x = r\cos\theta \quad , \quad y = r\sin\theta$$



Convert from Rectangular to Polar Coordinate

$$r = \sqrt{x^2 + y^2} \quad , \theta = \tan^{-1}\frac{y}{x}$$

Example:

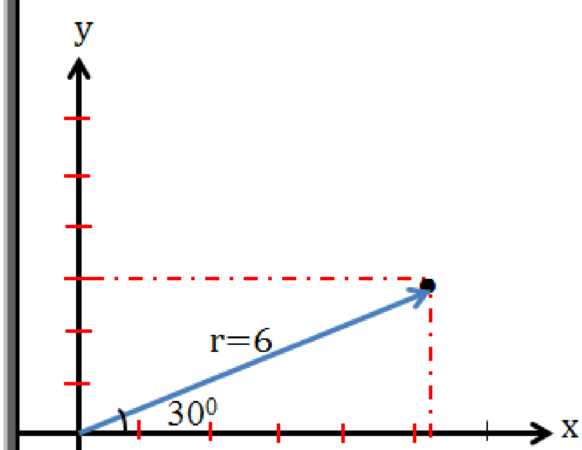
Example :Converting Polar Form (6∟30^0) into Rectangular Form.

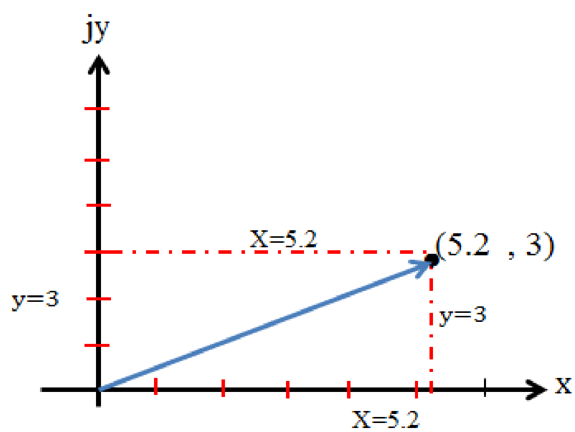
Soluation:

r∟ϴ ⟹ x+jy

$$x = r\cos\theta \quad , \quad y = r\sin\theta$$

$$6\angle 30^0 = (6\cos\theta) + j(6\sin\theta)$$
$$= (6\cos 30^o) + j(6\sin 30^o)$$
$$= (6 \times 0.866) + j(6 \times 0.5)$$
$$= 5.2 + j3$$





Example :Converting Rectangular (2+j3) Form into Polar Form

x+jy ⟹ r∟ϴ

$$r = \sqrt{x^2 + y^2} \quad , \theta = \tan^{-1}\frac{y}{x}$$

$$r = \sqrt{5.2^2 + 3^2} = 6 \quad , \theta = \tan^{-1}\frac{3}{5.2} = 30^0$$

$= 6∟30^0$

Addition and *subtraction* of complex numbers are better performed in *rectangular form*. *multiplication* and *division* are better done in *polar form*. Given the complex numbers

$A1 = x_1 + jy_1$, $A_2 = x_2 + jy_2$

Addition: $A_1 + A_2 = (x1 + x2) + j\,(y1 + y2)$

Subtraction: $A_1 - A2 = (x1 - x2) + j\,(y1 - y2)$

Multiplication : $A_1 \times A_2 = r_1 \times r_2\ (\angle \Theta_1 - \Theta_2)$

Division: $\frac{A_1}{A_2} = \frac{r_1}{r_2}(\angle\, \theta 1 - \theta 2)$

Complex Conjugate: $A^* = x - jy = r\angle - \varphi = r\, e^{-j\varphi}$

Example: Multiplying and Division $6\angle 30^o$ and $8\angle -45^o$.

$A_1 \times A_2 = r_1 \times r_2\ (\angle \Theta_1 - \Theta_2)$

$A_1 \times A_2 = 6 \times 8\ \angle 30^o - 45^0 = 48\angle -15^o$

$$\frac{A_1}{A_2} = \frac{6}{8}(\angle 30^0 - (-45^0)) = 0.75\angle 75^0$$

Example: *Addition* and *subtraction(A1=3+j4 , A2=5+j2).*

$A_1 + A_2 = (x1 + x2) + j\,(y1 + y2)$

$A_1 + A_2 = (3 + 5) + j\,(4 + 2) = 8 + j6$

$A_1 - A2 = (x1 - x2) + j\,(y1 - y2)$

$A_1 - A2 = (3 - 5) + j\,(4 - 2) = -2 + j2$

a) pure resistance, then R=Z and $Y\frac{1}{Z} = \frac{1}{R}$

b) pure inductance, then $Z = jx_L$ **and** $Y\frac{1}{Z} = \frac{1}{jxL}$

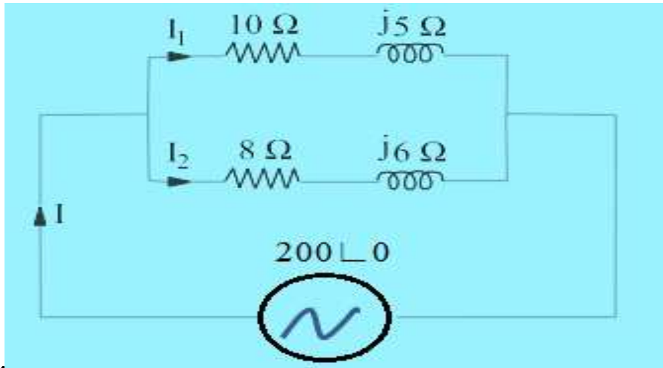
c) pure capacitance, then $Z = -jx_C$ **and** $Y = \frac{1}{Z} = \frac{1}{jxc}$

d) resistance and inductance in series, then $z = R + jX_L$ ***and*** $Y = \frac{1}{Z} = \frac{1}{R + jxc}$

e) resistance and capacitance in series, then $z = R - jX_L$ **and** $Y = \frac{1}{Z} = \frac{1}{R - jxc}$

f) resistance and inductance in parallel, then $\frac{1}{Z} = \frac{1}{R} + j\frac{1}{X_L}$

Example : For the circuit shown in fig below Calculate the circuit current.



$$Z_1=(10+j5)\ ,\quad Z_2=(8+j6)$$

$$\frac{1}{Z}=\frac{1}{Z_1}+\frac{1}{Z_2}=\frac{Z_1+Z_2}{Z_2.Z_1}$$

$$Y=\frac{1}{Z}=\frac{Z_1+Z_2}{Z_2.Z_1}=\frac{(10+j5)+(8+j6)}{(10+j5).(8+j6)}=\frac{(10+j5)+(8+j6)}{(10+j5).(8+j6)}$$

$$=\frac{(10+8)+j(5+6)}{80+j60+j40-30}=\frac{(18+j11)}{(50+j100)}$$

$$Y=\frac{(18+j11)(50-j100)}{(50+j100)(50-j100)}=\frac{200-j1250}{12,500}=0.16-j0.1$$

$$I=\frac{V}{Z}=V.Y$$

$$V=200\angle 0^{o}=200+j0$$

$$I=(200+j0).(0.16-j0.1)=32-j20\ A$$

polar form

$$I=\sqrt{32^2+20^2}\quad ,\tan^{-1}\frac{-20}{32}$$

$$I=37.74\angle -32^{0}A$$

THANK YOU