وزارة التعليم العالي والبحث العلمي
الجامعة التقنية الشمالية
اسم التشكيل

الحقيبة التعليمية

كلية البوليتكنيك
الموصل

القسم العلمي: تقنيات صناعة الاطراف والمساند

اسم المقرر: دوائر التيار المتناوب

المرحلة / المستوى: الاول

الفصل الدراسي: الثاني

السنة الدراسية: 2025-2026

معلومات عامة

اسم المقرر:	دوائر التيار المتناوب
القسم:	تقنيات صناعة الاطراف والمساند
الكلية:	كلية البوليتكنيك / الموصل
المرحلة / المستوى	الاول
الفصل الدراسي:	الثاني
عدد الساعات الاسبوعية:	نظري 2 عملي 2
عدد الوحدات الدراسية:	4
الرمز:	ETMI
نوع المادة	نظري √ عملي √ كلاهما
هل يتوفر نظير للمقرر في الاقسام الاخرى	
اسم المقرر النظير	
القسم	
رمز المقرر النظير	

معلومات تدريسي المادة

اسم مدرس (مدرسي) المقرر:	زيد خلف محمد
اللقب العلمي:	مدرس مساعد
سنة الحصول على اللقب	2023
الشهادة :	ماجستير
سنة الحصول على الشهادة	2021
عدد سنوات الخبرة (تدريس)	3

الوصف العام للمقرر

يهدف هذا المقرر إلى تعريف الطالب بالدوائر الكهربائية والقياسات الكهربائية، وذلك من خلال دراسة النظريات والمبادئ الأساسية التي تحكم عمل هذه الدوائر.

الاهداف العامة

- يهدف المقرر إلى تهيئة الطالب لدراسة الحسابات المختلفة في الدوائر ذات التيار المتناوب.
- يتضمن ذلك التعرف على مختلف النظريات لدراسة تلك الحسابات وتطبيقها عملياً.
- يتعلم الطالب كيفية تطبيق نظريات مثل نظرية ثيفينين ونورتون، وحسابات التيار وفولتية وفرق الطور بينهما في الدوائر المتناوبة.
- تصحيح معامل القدرة، بالإضافة إلى قياس المقاومة وطرق القياس المختلفة في الدوائر ثلاثية الطور.
- ظاهرة الرنين في دوائر التيار المتناوب

الأهداف الخاصة

- سيتمكن الطلاب من قراءة وفهم المخططات والرسوم البيانية للدوائر الكهربائية.
- سيتعرف الطلاب على مفهوم التيار المتردد وسيتمكنون من تحليل دوائر التيار المتناوب.
- سيتمكن الطلاب من حساب القدرة الكهربائية في الدوائر التي تحتوي على عناصر مثل المقاومات والملفات والمكثفات.
- سيتقن الطلاب استخدام القوانين والمبادئ الرياضية لتحليل دوائر التيار المتردد.
- سيتعرف الطلاب على التطبيقات العملية للمعادلات الرياضية في دوائر الكهربائية والكترونية.

الأهداف السلوكية او نواتج التعلم

- - تطبيق نظريات ثيفنن ونورتون ونقل اعظم قدرة على الدوائر المتناوبة
- - حسابات التيار وفولتية وفرق الطور بينهما في الدوائر المتناوبة

- - تصحيح معامل القدرة
- - طرق حساب المقاومة والممانعة
- - الدوائر ثلاثية الطور وخصائصها
- سلوك المحاثة والمتسعة في دوائر التيار المتناوب
- تأثير ظاهرة الرنين في دولئر التيار المتناوب

المتطلبات السابقة

-

الأهداف السلوكية او مخرجات التعليم الأساسية		
ت	تفصيل الهدف السلوكي او مخرج التعليم	آلية التقييم
1	طرق حساب المقاومة والممانعة	امتحان تحريري واسئلة شفوي ومناقشة
2	حسابات التيار وفولتية وفرق الطور بينهما في الدوائر المتناوبة	امتحان تحريري واسئلة شفوي ومناقشة
3	سلوك المحاثة والمتسعة في دوائر التيار المتناوب	امتحان تحريري واسئلة شفوي ومناقشة
4	تطبيق نظريات ثيفنن ونورتون ونقل اعظم قدرة على الدوائر المتناوبة	امتحان تحريري واسئلة شفوي ومناقشة
	الدوائر ثلاثية الطور وخصائصها	امتحان تحريري واسئلة شفوي ومناقشة

	• تأثير ظاهرة الرنين في دولئر التيار المتناوب	امتحان تحريري واسئلة شفوي ومناقشة

أساليب التدريس (حدد مجموعة متنوعة من أساليب التدريس لتناسب احتياجات الطلاب ومحتوى المقرر)

الاسلوب او الطريقة	مبررات الاختيار
1. **المحاضرة التفاعلية**	طرح الأسئلة على الطلاب أثناء المحاضرة لزيادة مشاركتهم
2. **التعلم التعاوني**	تشجيع الطلاب على المناقشة والتفاعل داخل المجموعات

الفصل الاول من المحتوى العلمي							
عنوان الفصل	الوقت						
التوزيع الزمني	النظري	العملي	العنوان الفرعي		طريقة التدريس	التقنيات	طرق القياس
الأسبوع الأول	2	2	تعريف تيار المتناوب		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	
الأسبوع الثاني	2	2	تمثيل التيار المتناوب	فرق طور جمع وطرح مصادر متناوبة تمثيل التيار متناوب	محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	
الأسبوع الثالث	2	2	**محاثة في دوائر التيار المتناوب**	تمثيل المحاثة في دوائر التيار متناوب وحساب ممانعة الحثية	محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	
الأسبوع الرابع	2	2	**متسعة في دوائر التيار المتناوب**		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	

الاسبوع الخامس	2	2	**دائرة المحاثة والمقاومة على التوالي مع مصدر متناوب**		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	
الاسبوع السادس	2	2	**دائرة مقاومة ومتسعة على التوالي مع مصدر متناوب**		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	
الاسبوع السابع	2	2	**مقاومة محاثة ومتسعة على توالي مع مصدر متناوب**		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	
الاسبوع الثامن	2	2	**مقاومة ومحاثة على توازي مع مصدر متناوب**		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	
الاسبوع التاسع	2	2	**مقاومة ومتسعة على توازي مع مصدر متناوب**		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	

الاسبوع العاشر	2	2	**مقاومة ومتسعة ومحاثة على توازي مع مصدر متناوب**		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	
الاسبوع الحادي عشر	2	2	**دائرة الرنين التوازي**		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	
الاسبوع الثاني عشر	2	2	**نظرية ثفنن**		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	
الاسبوع الثالث عشر	2	2	**نظرية نورتن**		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	
الاسبوع الرابع عشر	2	2	**نظرية نقل اعظم قدرة**		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	

الاسبوع الخامس عشر	2	2	نظام ثلاثي الطور		محاضرة	عرض تقديمي، شرح، أسئلة وأجوبة, مناقشة	

المحتوى العلمي

المحتويات (لكل فصل في المقرر)

رقم المحاضرة: 1	
عنوان المحاضرة:	Definition AC current
اسـم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
الهدف العام من المحاضرة :	تطوير إمكانية الطالب في فهم تيارات المتناوبة
الأهداف السلوكية او مخرجات التعلم:	1 -تميز تيار المتناوب. 2-التعرف على وحدات التيار المتناوب .
استراتيجيات التيسير المستخدمة	عرض التقديمي وامثلة محلولة
المهارات المكتسبة	التعرف على تيار المتناوب
طرق القياس المعتمدة	امتحان التحريري ومناقشة

4 - الاسئلة القبلية

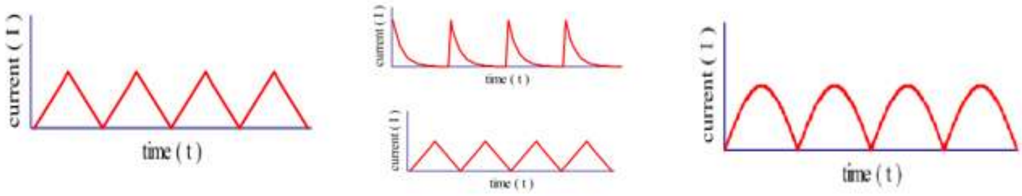
ماذا تعرف عن التيار المتناوب ؟

5- المحتوى العلمي

Definition AC current

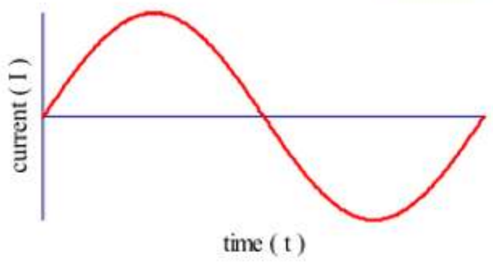
- DC stands for "Direct Current," meaning voltage or current that maintains constant polarity or direction, respectively, over time.

Pure D.C. Current



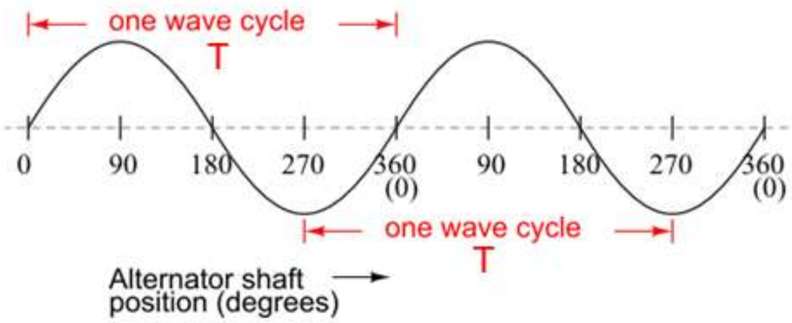
Pulsating Current

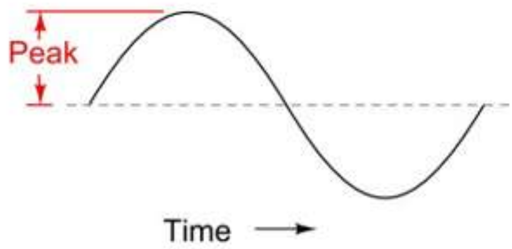
• AC stands for “Alternating Current,” meaning voltage or current that changes polarity or direction, respectively, over time



Alternating Current

MEASUREMENTS OF AC MAGNITUDE



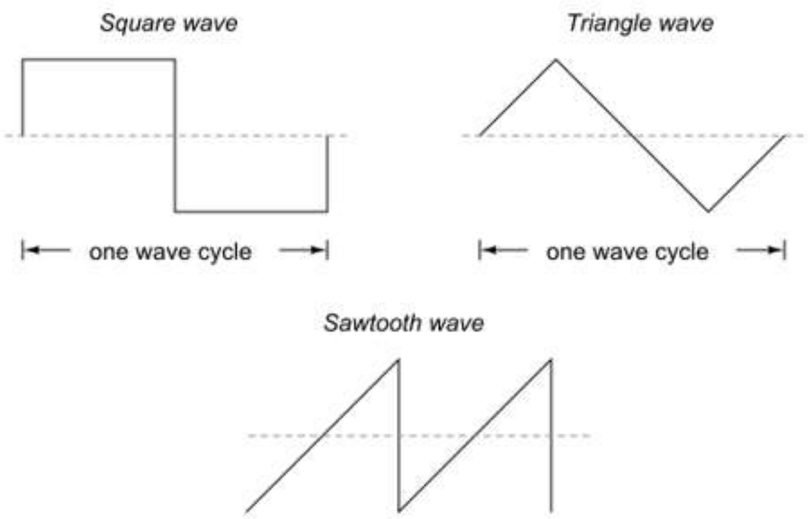


The frequency

A more popular measure for describing the alternating rate of an AC voltage or current wave than period is the rate of that back-and-forth oscillation. This is called frequency. The modern unit for frequency is the Hertz (abbreviated Hz), which represents the number of wave cycles completed during one second of time.

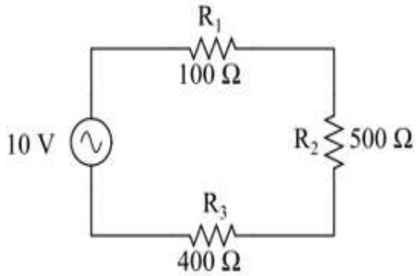
Period and frequency are mathematical reciprocals of one another. That is to say, if a wave has a period of 10 seconds, its frequency will be 0.1 Hz, or 1/10 of a cycle per second:

$f=1/T$ $T=1/f$



Simple AC circuit calculations

Over the course of the next few chapters, you will learn that AC circuit measurements and calculations can get very complicated due to the complex nature of alternating current in circuits with inductance and capacitance. However, with simple circuits (figure 1.23) involving nothing more than an AC power source and resistance, the same laws and rules of DC apply simply and directly.



AC circuit calculations for resistive circuits are the same as for DC

$$R_{total} = R_1 + R_2 + R_3$$

$$R_{total} = 1\ k\Omega$$

$$I_{total} = \frac{E_{total}}{R_{total}} \qquad I_{total} = \frac{10\ V}{1\ k\Omega} \qquad I_{total} = 10\ mA$$

$$E_{R1} = I_{total}R_1 \qquad E_{R2} = I_{total}R_2 \qquad E_{R3} = I_{total}R_3$$

$$E_{R1} = 1\ V \qquad E_{R2} = 5\ V \qquad E_{R3} = 4\ V$$

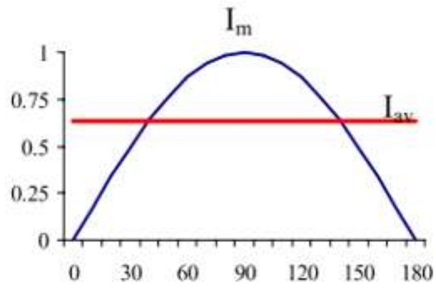
Average value of sine wave القيمة المتوسطة للموجة الجيبية

Average amplitude is the mathematical "mean" of all a waveform's points over the period of one cycle. Technically, the average amplitude of any waveform with equal-area portions above and below the "zero" line on a graph is zero. However, as a practical measure of amplitude, a waveform's average value is often calculated as the mathematical mean of all the points" absolute values (taking all the negative values and considering them as positive). For a sine wave, the average value so calculated is approximately 0.637 of its peak value.

For Half cycle :-

$$\pi I_{av} = \int_0^{\pi} I_m \sin\theta d\theta = I_m[\cos(\pi) - \cos(0)] = 2I_m$$

$$I_{av} = \frac{2}{\pi} I_m$$



For Full cycle:

$$I_{av} = \left(\frac{1}{2\pi}\right)\int I_m \sin\theta = I_m[\cos(0) - \cos(2\pi)] = 0$$

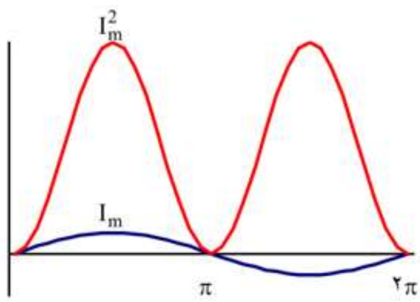
Effective value of sine wave القيمة الفعالة للموجة الجيبية

(Root mean square): "RMS" stands for Root Mean Square, and is a way of expressing an AC quantity of voltage or current in terms functionally equivalent to DC. For example, 10 volts AC RMS is the amount of voltage that would produce the same amount of heat dissipation across a resistor of given value as a 10 volt DC power supply. Also known as the "equivalent" or "DC equivalent" value of an AC voltage or current. For a sine wave, the RMS value is approximately 0.707 of its peak value.

$$\text{(square)}\ i^2 = (I_m \sin\theta)^2$$

(mean)

$$\frac{1}{\pi}\int\left(I_m^2 \times \sin^2\theta\right) = \left(\frac{I_m^2}{\pi}\right)\int\frac{(1-\cos 2\theta)}{2} = \frac{I_m^2}{2}$$



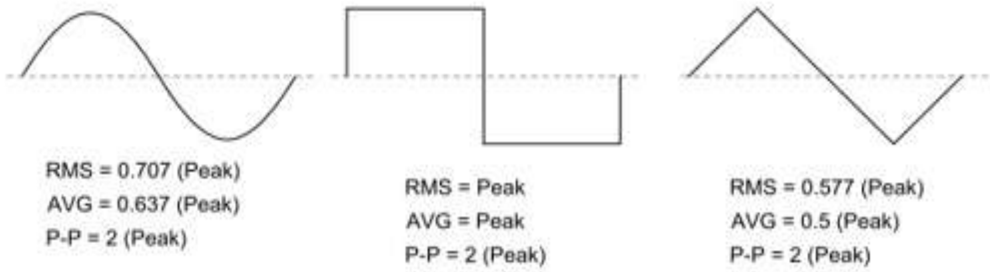
(root)

$$I_{eff} = \sqrt{\frac{I_m^2}{2}} = \frac{I_m}{\sqrt{2}}$$

(rms)

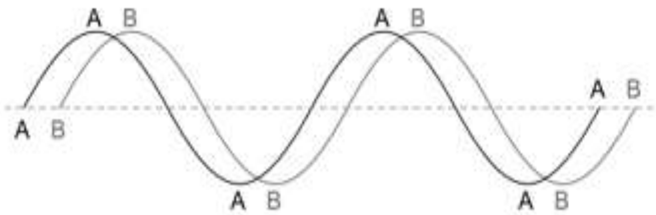
$$I_{eff} = \sqrt{\left(\left(\frac{1}{\pi}\right)\int I_m^2 \sin^2\theta\right)}$$

$$I = \frac{I_m}{\sqrt{2}} = 0.707\, I_m$$

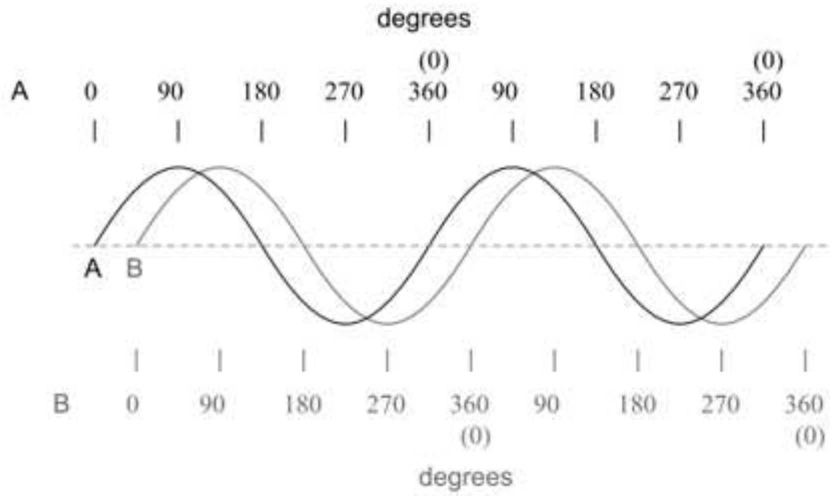


AC phase

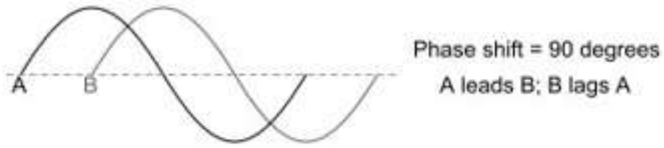
Things start to get complicated when we need to relate two or more AC voltages or currents that are out of step with each other. By "out of step," I mean that the two waveforms are not synchronized: that their peaks and zero points do not match up at the same points in time.



The two waves shown above (A versus B) are of the same amplitude and frequency, but they are out of step with each other. In technical terms, this is called a phase shift.



Wave A leads wave B by 45°



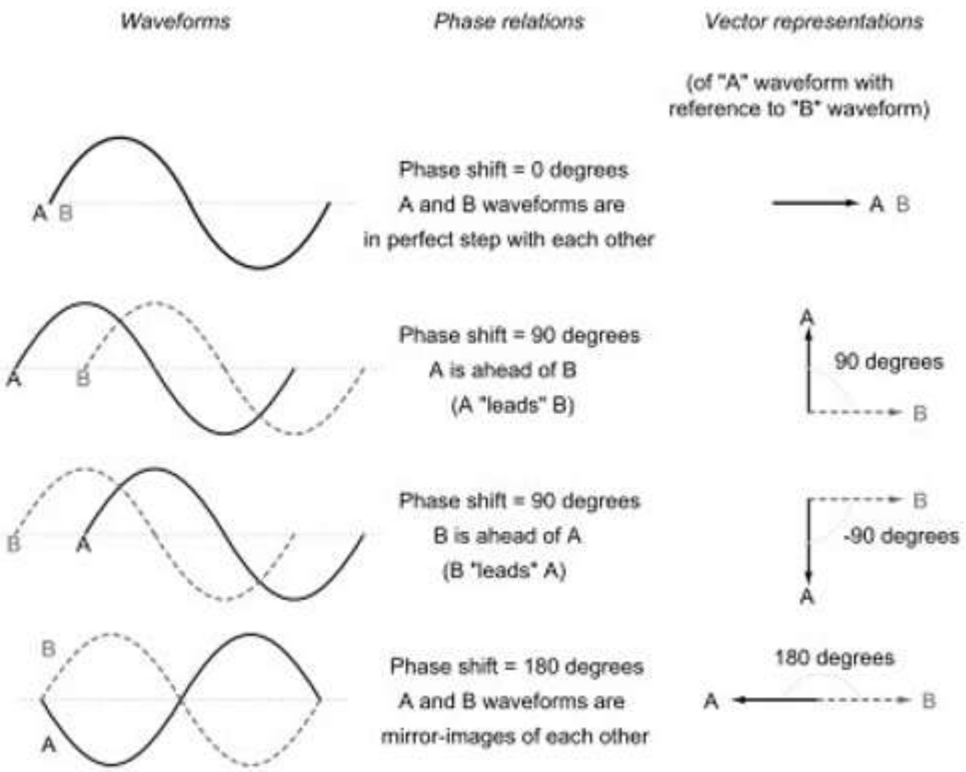


Figure *Vector angle is the phase with respect to another waveform.*

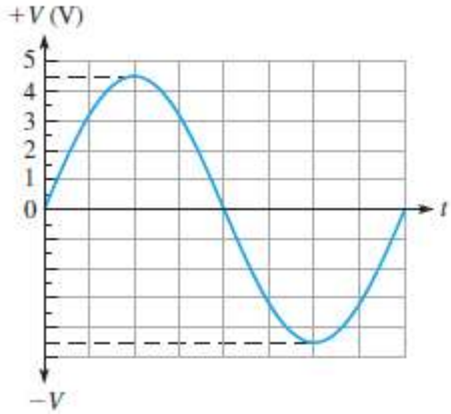
As the single vector rotates in an anti-clockwise direction, its tip at point A will rotate one complete revolution of 360° or 2π representing one complete cycle. If the length of its moving tip is transferred at different angular intervals in time to a graph as shown above, a sinusoidal waveform would be drawn starting at the left with zero time. Each position along the horizontal axis indicates the time that has elapsed since zero time, $t = 0$. When the vector is horizontal the tip of the vector represents the angles at 0°, 180° and at 360°.

Likewise, when the tip of the vector is vertical it represents the positive peak value, (+Am) at 90° or$\pi/2$ and the negative peak value, (-Am) at 270° or $3\pi/2$. Then the time axis of the waveform represents the angle either in degrees or radians through which the phasor has moved. So we can say that a phasor represent a scaled voltage or current value of a rotating vector which is "frozen" at some point in time, (t) and in our example above, this is at an angle of 30°.

6- الاسئلة البعدية

Determine V_p, V_{pp}, V_{rms}, and the half-cycle V_{avg} for the sine wave in Figure 11–15.

► FIGURE 11–15



$V_p = 4.5$ V is read directly from the graph. From this, calculate the other values.

$$V_{pp} = 2V_p = 2(4.5\text{ V}) = 9\text{ V}$$
$$V_{rms} = 0.707V_p = 0.707(4.5\text{ V}) = 3.18\text{ V}$$
$$V_{avg} = 0.637V_p = 0.637(4.5\text{ V}) = 2.86\text{ V}$$

في نهاية الحقيبة

- **المصادر** الاساسية :

- **1.Electrical Technology (Edward Hughes)**
- **2. Basic Circuits(A-M-F Brooks) pergaman press**

- **المصادر المقترحة:**

- **Principles of Electric Circuits Tenth Edition by Thomas L. Floyd**
- **Introductory Circuit Analysis-Prentice Hall by Robert L. Boylestad**

المحتويات (لكل فصل في المقرر)

رقم المحاضرة:	**2**
عنوان المحاضرة:	تمثيل تيار متناوب
اسـم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
الهدف العام من المحاضرة :	تمثيل تيار متناوب بمتجهات
الأهداف السلوكية او مخرجات التعلم:	يستطيع الطالب أن يستخدم متجهات لتمثيل التيار المتناوب وايجاد مقاومة في دوائر تيار متناوب .
استراتيجيات التيسير المستخدمة	عرض التقديمي وامثلة محلولة
المهارات المكتسبة	تمثيل تيار المتناوب
طرق القياس المعتمدة	امتحان التحريري ومناقشة

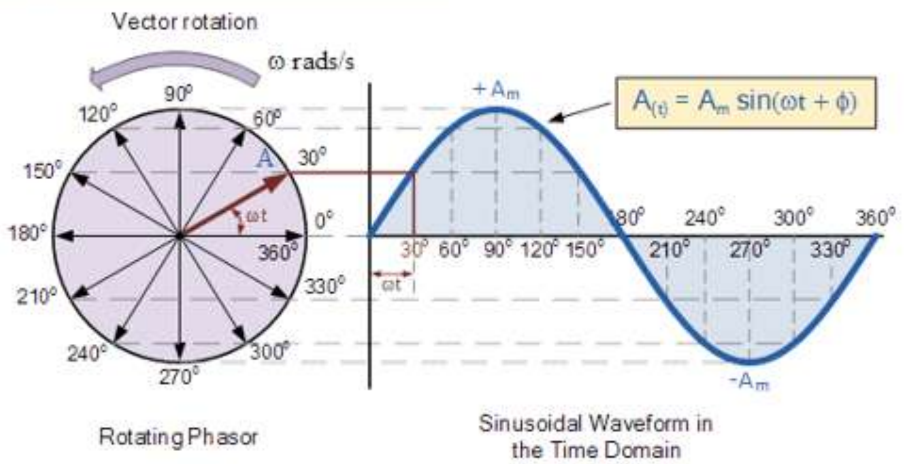
4 - الاسئلة القبلية

- ما معنى متجهات ودالة الجيبية ؟

5- المحتوى العلمي

Representation of Sine Wave التمثيل الاتجاهي للموجة الجيبية

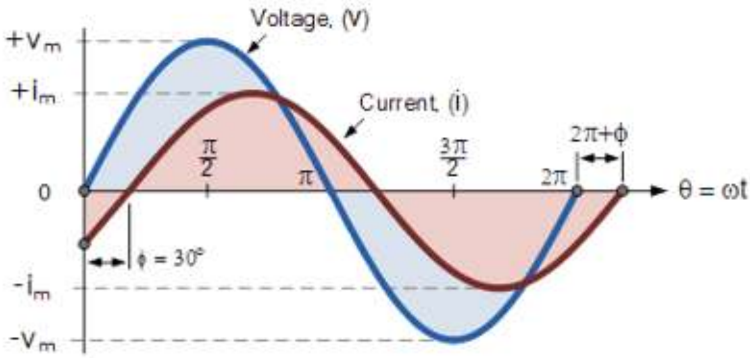
Phasor Diagram of a Sinusoidal Waveform



As the single vector rotates in an anti-clockwise direction, its tip at point A will rotate one complete revolution of 360° or 2π representing one complete cycle. If the length of its moving tip is transferred at different angular intervals in time to a graph as shown above, a sinusoidal waveform would be drawn starting at the left with zero time. Each position along the horizontal axis indicates the time that has elapsed since zero time, $t = 0$. When the vector is horizontal the tip of the vector represents the angles at 0°, 180° and at 360°.

Likewise, when the tip of the vector is vertical it represents the positive peak value, (+Am) at 90° or π/2 and the negative peak value, (-Am) at 270° or 3π/2. Then the time axis of the waveform represents the angle either in degrees or radians through which the phasor has moved. So we can say that a phasor represent a scaled voltage or current value of a rotating vector which is "frozen" at some point in time, (t) and in our example above, this is at an angle of 30°.

Phase Difference of a Sinusoidal Waveform



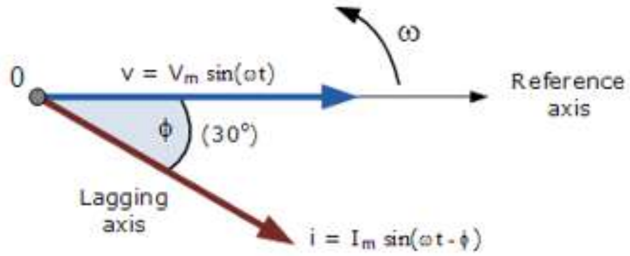
The generalized mathematical expression to define these two sinusoidal quantities will be written as:

$$v_{(t)} = V_m \sin(\omega t)$$

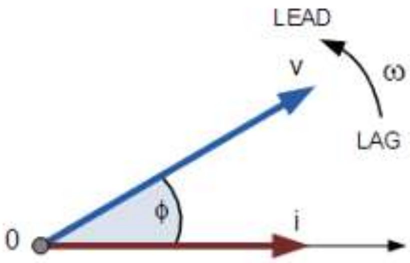
$$i_{(t)} = I_m \sin(\omega t - \phi)$$

The current, i is lagging the voltage, v by angle Φ and in our example above this is 30°.So the difference between the two phasors representing the two sinusoidal quantities is angle Φ and the resulting phasor diagram will be.

Phasor Diagram of a Sinusoidal Waveform



The phasor diagram is drawn corresponding to time zero (t = 0) on the horizontal axis. The lengths of the phasors are proportional to the values of the voltage, (V) and the current, (I) at the instant in time that the phasor diagram is drawn. The current phasor lags the voltage phasor by the angle, Φ as the two phasors rotate in an *anticlockwise* direction as stated earlier, therefore the angle, Φ is also measured in the same anticlockwise direction.



Simple vector addition

Remember that vectors are mathematical objects just like numbers on a number line: they can be added, subtracted, multiplied, and divided. Addition is perhaps the easiest vector operation to visualize, so well begin with that. If vectors with common angles are added, their magnitudes (lengths) add up just like regular scalar quantities:

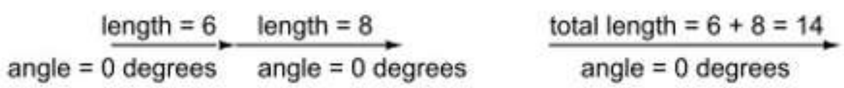
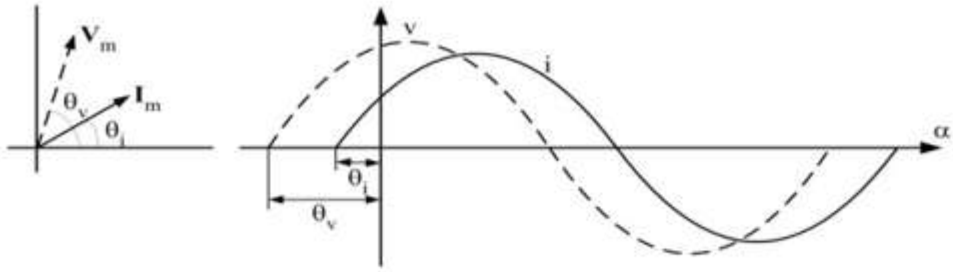
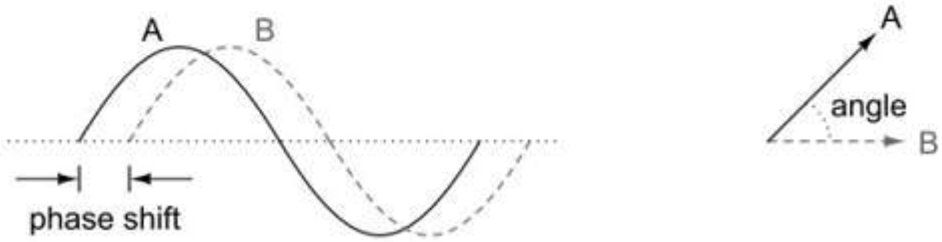


Figure *Vector magnitudes add like scalars for a common angle.*





Phase shift between waves and vector phase angle

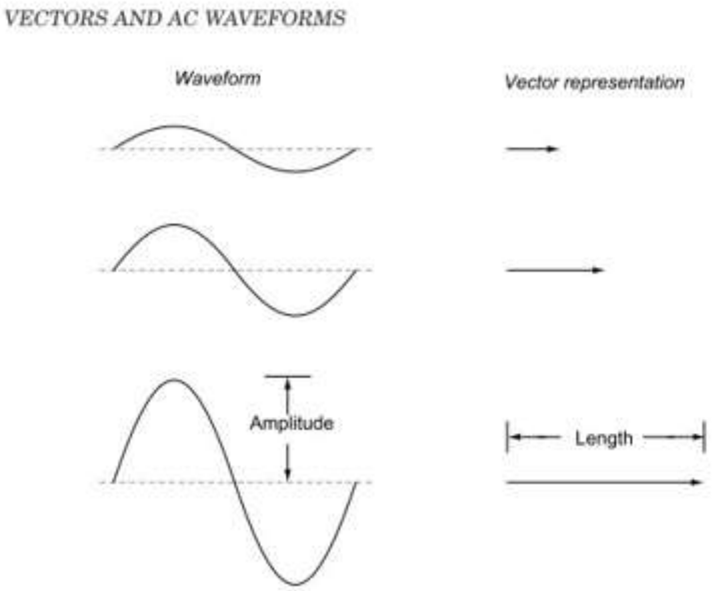
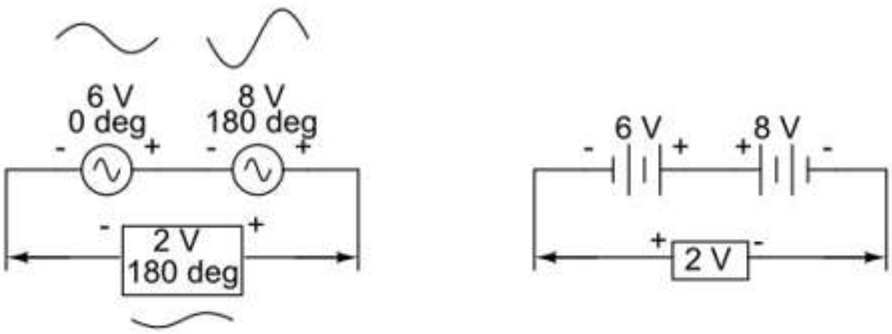
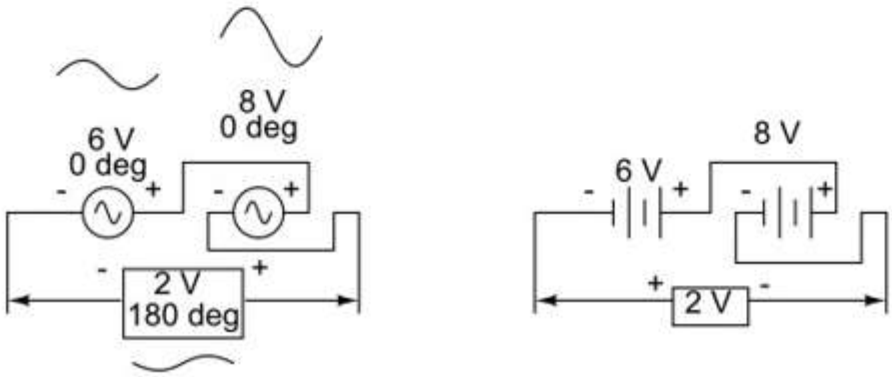


Figure *Vector length represents AC voltage magnitude.*

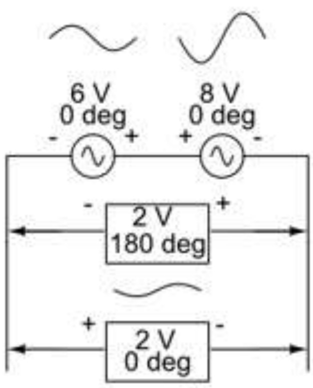


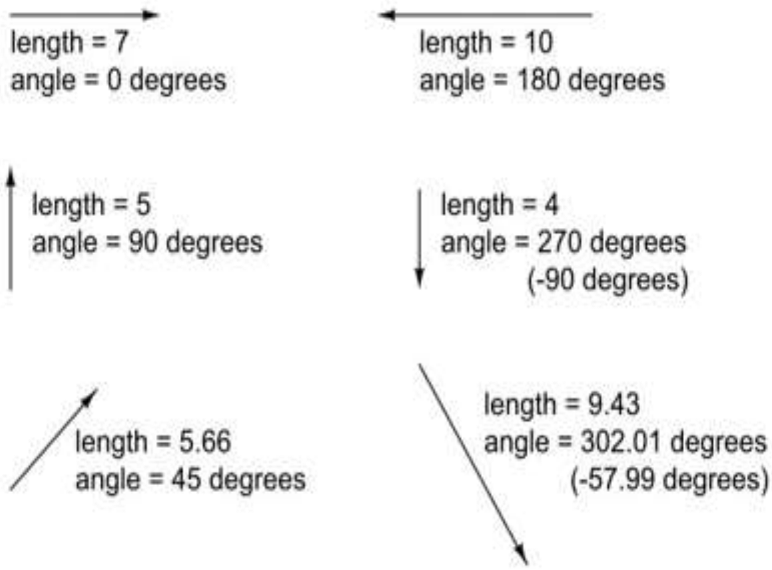
Opposing AC voltages subtract like opposing battery voltages.



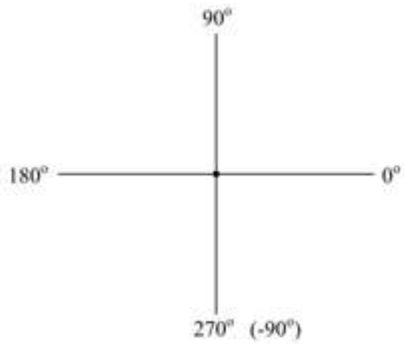
Opposing voltages in spite of equal phase angles.

Opposing voltages in spite of equal phase angles.



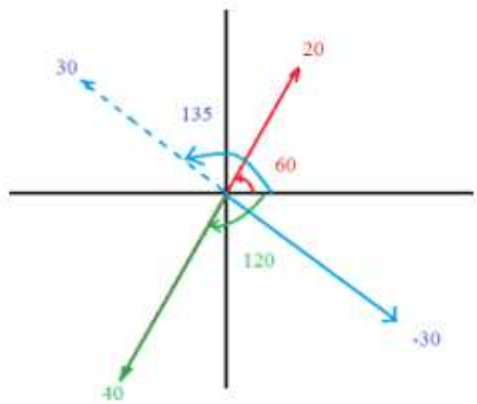


A vector has both magnitude and direction.



The vector compass

Ex: Draw Phase Diagram for the following voltages



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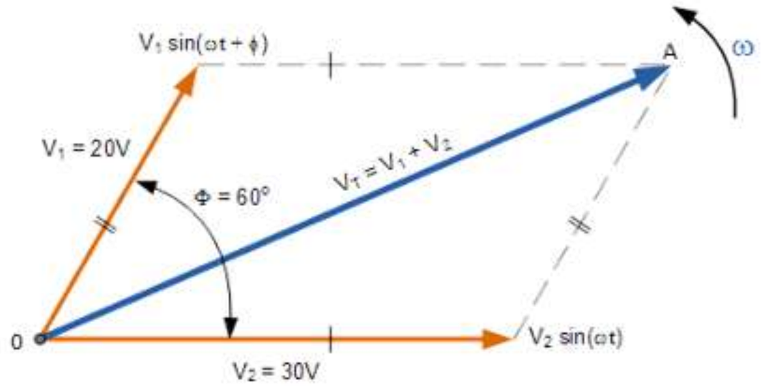
Phasor Addition of two Phasors



In the rectangular form, the phasor is divided up into a real part, x and an imaginary part, y forming the generalized expression Z = x ± jy. (we will discuss this in more detail in the next tutorial). This then gives us a mathematical expression that represents both the magnitude and the phase of the sinusoidal voltage as:

So the addition of two vectors, A and B using the previous generalized expression is as follows:

$$A = x + jy \qquad B = w + jz$$

$$A + B = (x + w) + j(y + z)$$

Phasor Addition using Rectangular Form

Voltage, V_2 of 30 volts points in the reference direction along the horizontal zero axis, then it has a horizontal component but no vertical component as follows.

- • Horizontal Component = 30 cos 0° = 30 volts
- • Vertical Component = 30 sin 0° = 0 volts
- This then gives us the rectangular expression for voltage V_2 of: 30 + j0

Voltage, V_1 of 20 volts leads voltage, V_2 by 60°, then it has both horizontal and vertical components as follows.

- • Horizontal Component = 20 cos 60° = 20 x 0.5 = 10 volts
- • Vertical Component = 20 sin 60° = 20 x 0.866 = 17.32 volts
- This then gives us the rectangular expression for voltage V_1 of: 10 + j17.32

The resultant voltage, V_T is found by adding together the horizontal and vertical components as follows.

- $V_{Horizontal}$ = sum of real parts of V_1 and V_2 = 30 + 10 = 40 volts
- $V_{Vertical}$ = sum of imaginary parts of V_1 and V_2 = 0 + 17.32 = 17.32 volts

Now that both the real and imaginary values have been found the magnitude of voltage, V_T is determined by simply using **Pythagoras's Theorem** for a 90° triangle as follows.

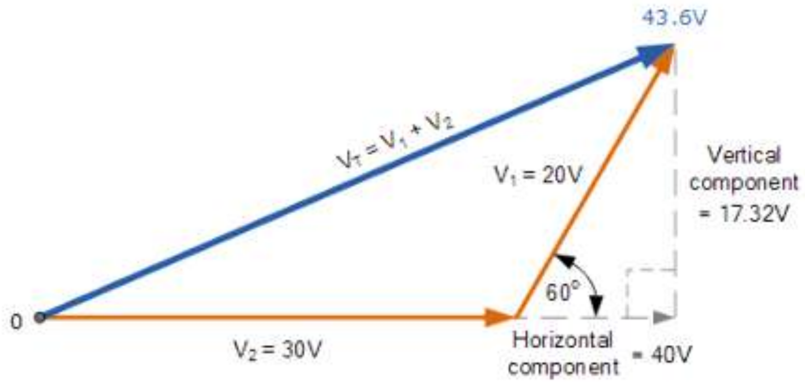
$$V_T = \sqrt{\left(\begin{matrix}\text{Real or Horizontal} \\ \text{Component}\end{matrix}\right)^2 + \left(\begin{matrix}\text{Imaginary or Vertical} \\ \text{Component}\end{matrix}\right)^2}$$

$$V_T = \sqrt{40^2 + 17.32^2}$$

$$\therefore V_T = 43.6\,\text{volts}$$

Then the resulting phasor diagram will be:

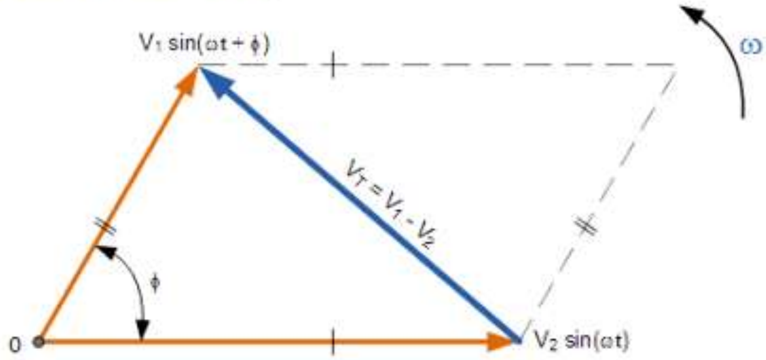
Resultant Value of V_T



Phasor Subtraction

Phasor subtraction is very similar to the above rectangular method of addition, except this time the vector difference is the other diagonal of the parallelogram between the two voltages of V_1 and V_2 as shown.

Vector Subtraction of two Phasors

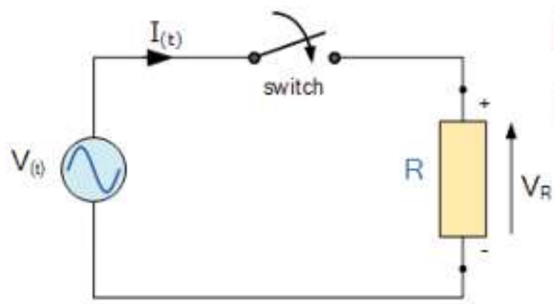


This time instead of “adding” together both the horizontal and vertical components we take them away, subtraction.

$$A = x + jy \qquad B = w + jz$$

$$A - B = (x - w) + j(y - z)$$

Effect AC Resistance with a Sinusoidal Supply



$$I_R = \frac{V_{(t)}}{R}$$

$$V_{R(t)} = I_{(t)}.R$$

When the switch is closed, an AC voltage, V will be applied to resistor, R. This voltage will cause a current to flow which in turn will rise and fall as the applied voltage rises and falls sinusoidally. they rise and fall simultaneously and are therefore said to be *"in-phase"*.

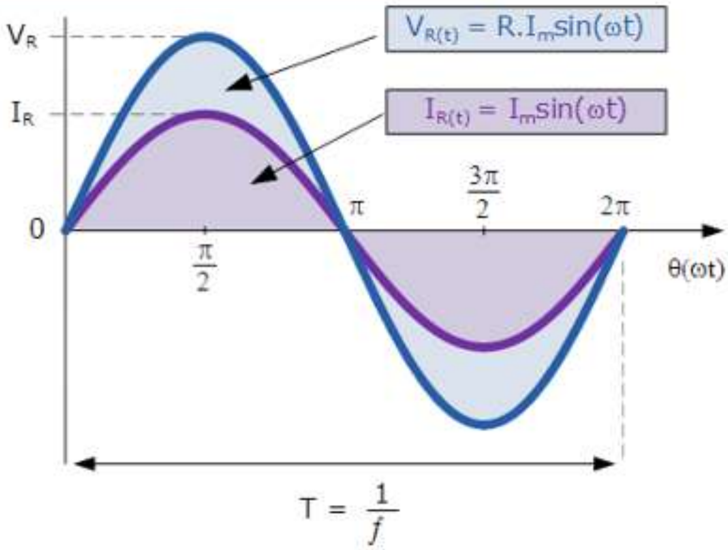
Then the electrical current that flows through an AC resistance varies sinusoidally with time and is represented by the expression, $I(t) = Im \times \sin(\omega t + \theta)$, where Im is the maximum amplitude of the current and θ is its phase angle. In addition we can also say that for any given current, i flowing through the resistor the maximum or peak voltage across the terminals of R will be given by Ohm"s Law as:

$$V_{(t)} = R.I_{(t)} = R.I_m \sin\left(\omega t + \theta\right)$$

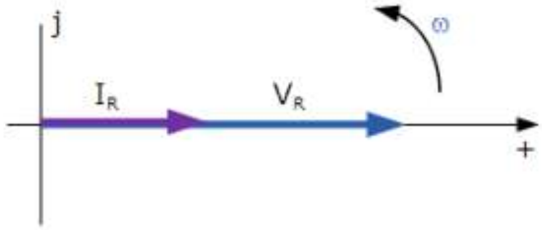
and the instantaneous value of the current, i will be:

$$i_{R(t)} = I_{R(max)} \sin \omega t$$

Sinusoidal Waveforms for AC Resistance



Phasor Diagram for AC Resistance



RMS Relationship

$$I = \frac{I_m}{\sqrt{2}}\angle\theta \text{ A} \quad \text{and} \quad V = \frac{R.I_m}{\sqrt{2}}\angle\theta \text{ V}$$

$$\therefore R = \frac{V}{I} = \frac{(R.I_m/\sqrt{2})\angle\theta}{(I_m/\sqrt{2})\angle\theta}$$

Phase Relationship

$$V = R.I_{RMS}\angle\theta \quad \text{and} \quad I = I_{RMS}\angle\theta$$

$$V\angle\theta_v = I\angle\theta_i$$

$$\therefore \theta_v = \theta_i \text{ (in-phase)}$$

AC Impedance

$$Z = \frac{V}{I}\ \Omega\text{'s}$$

Z = R + j0 = R Ω's

$$P = V.I = V_m \sin\omega t \times I_m \sin\omega t = V_m I_m \sin^2 \omega t$$

$$P_{max} = V_{max} I_{max}$$

AC Resistance Example No1

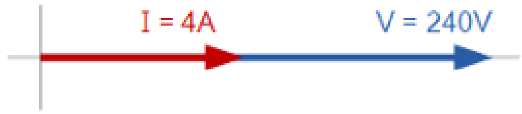
1. The supply current:

$$I = \frac{V}{R} = \frac{240}{60} = 4.0\ A$$

2. The Active power consumed by the AC resistance is calculated as:

$$P = I^2R = 4^2.60 = 960\ W$$

3. As there is no phase difference in a resistive component, (θ = 0), the corresponding phasor diagram is given as:



6- الاسئلة البعدية

A sinusoidal voltage supply defined as: $V(t) = 100 \times \cos(\omega t + 30^o)$ is connected to a pure resistance of 50 Ohms. Determine its impedance and the peak value of the current flowing through the circuit. Draw the corresponding phasor diagram.

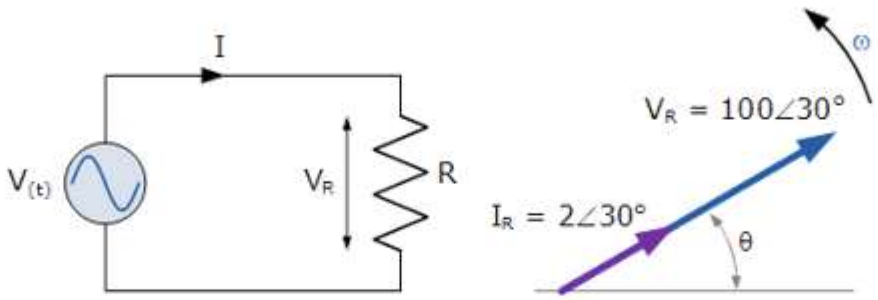
:

$$V_{R(t)} = 100\cos(\omega t + 30^{\circ}) \Rightarrow V_R = 100\angle 30^{\circ}\ \text{volts}$$

Applying Ohms Law gives us:

$$I_R = \frac{V_R}{R} = \frac{100\angle 30^o}{50\Omega} = 2\angle 30^o\ \text{Amps}$$

The corresponding phasor diagram will therefore be:



في نهاية الحقيبة

- **المصادر الاساسية** :

- **1.Electrical Technology (Edward Hughes)**
- **2. Basic Circuits(A-M-F Brooks) pergaman press**

- **المصادر المقترحة:**

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- **Introductory Circuit Analysis-Prentice Hall by Robert L. Boylestad**
-
-

المحتويات (لكل فصل في المقرر)

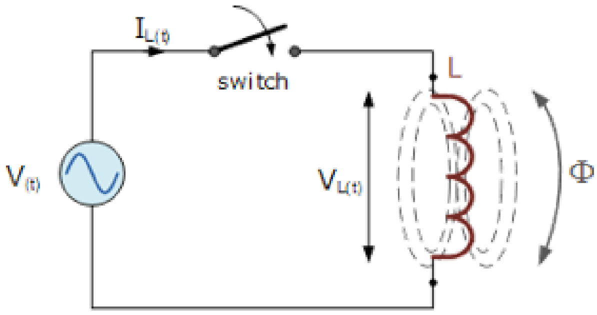
رقم المحاضرة:	**3**
عنوان المحاضرة:	محاثة في دوائر التيار المتناوب
اسـم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
الهدف العام من المحاضرة :	سلوك محاثة في التيار متناوب
الأهداف السلوكية او مخرجات التعلم: **1- ي**	ستطيع الطالب أن يعرف سلوك محاثة في دوائر تيار متناوب .
استراتيجيات التيسير المستخدمة	عرض التقديمي وامثلة محلولة
المهارات المكتسبة	تأثير محاثة في التيار متناوب
طرق القياس المعتمدة	امتحان التحريري ومناقشة

4 - الاسئلة القبلية

- ما هو سلوك محاثة في دوائر تيار مستمر ؟

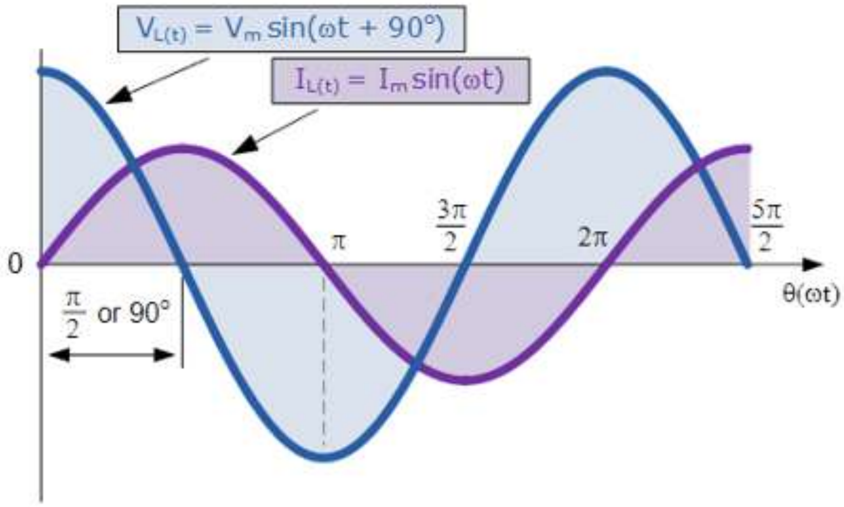
5- المحتوى العلمي

AC Inductance with a Sinusoidal Supply



This simple circuit above consists of a pure inductance of L Henries (H), connected across a sinusoidal voltage given by the expression: $V(t) = V_{max} \sin \omega t$. When the switch is closed this sinusoidal voltage will cause a current to flow and rise from zero to its maximum value. This rise or change in the current will induce a magnetic field within the coil which in turn will oppose or restrict this change in the current.

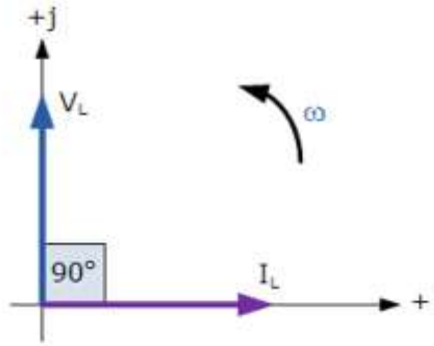
Sinusoidal Waveforms for AC Inductance



This effect can also be represented by a phasor diagram were in a purely inductive circuit the voltage "LEADS" the current by 90°. But by using the voltage as our reference, we can

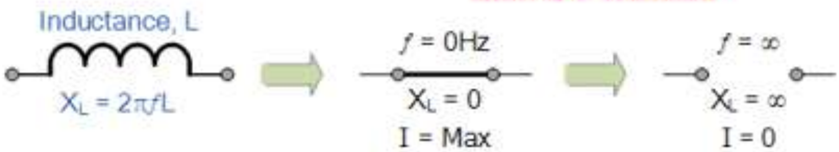
also say that the current "LAGS" the voltage by one quarter of a cycle or 90° as shown in the vector diagram below.

Phasor Diagram for AC Inductance



So for a pure loss less inductor, V_L "leads" I_L by 90°, or we can say that I_L "lags" V_L by 90°. We can present the effect of very low and very high frequencies on a the reactance of a pure AC Inductance as follows:

under DC condition



In an AC circuit containing pure inductance the following formula applies:

$$\text{Current, I} = \frac{\text{Voltage}}{\text{Opposition to current flow}} = \frac{V}{X_L}$$

Then the voltage in the inductor coil is given as:

$$v_L(t) = -E_L = \frac{d\phi_B}{dt} = \frac{d}{dt}(Li)$$

$$= L\frac{d}{dt} I_m \sin(\omega t) \qquad\qquad V = L \; di/dt$$

$$= \omega L I_m \cos(\omega t)$$

$$= \omega L I_m \sin(\omega t + \pi/2)$$

$$= X_L I_m \sin(\omega t + \pi/2)$$

then the voltage across an AC inductance will be defined as:

$$V_L = \omega L I_{max} \sin(\omega t + 90^o)$$

Where: of the following which is the voltage amplitude and $\theta = +90^o$ which is the phase difference or phase angle between the voltage and current.

In the Phasor Domain

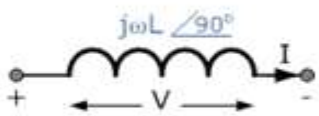
In the phasor domain the voltage across the coil is given as:

$$V_L = j\omega L I$$

$$\text{where: } j\omega L = jX_L = 2\pi f L = \text{IMPEDANCE, Z}$$

and in **Polar Form** this would be written as: $X_L \angle 90^o$ where:

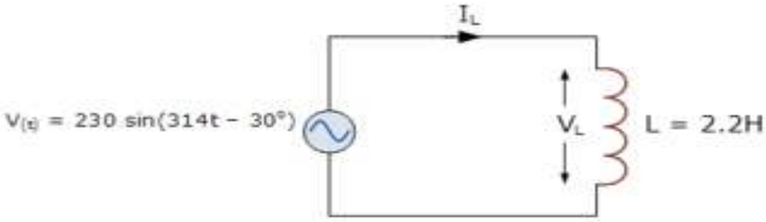
$$X_L \angle \theta = \frac{V_L \angle +90^o}{I_L \angle 0^o}$$



$$X_L \angle \theta = j\omega L = 0 + jX_L = \omega L \angle +90^o = Z \angle +90^o$$

AC Inductance Example No1

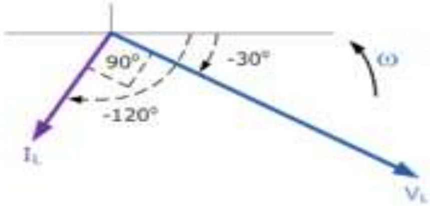
In the following circuit, the supply voltage is defined as: $V_{(t)} = 230 \sin(314t - 30°)$ and $L = 2.2H$. Determine the value of the current flowing through the coil and draw the resulting phasor diagram.



The voltage across the coil will be the same as the supply voltage. Converting this time domain value into polar form gives us: $V_L = 230\ \angle{-30°}$ (v). The inductive reactance of the coil is: $X_L = \omega L = 314 \times 2.2 = 690\Omega$. Then the current flowing through the coil can be found using Ohms law as:

$$I_L = \frac{V_L}{jX_L} = \frac{230\ \angle{-30°}}{690\ \angle{90°}} = 0.33\angle{-120°}\ (A)$$

With the current lagging the voltage by 90° the phasor diagram will be.



6- اللاسئلة البعدية

The voltage across a 0.5 H coil is provided below. What is the sinusoidal expression for the current?

$$v = 100 \sin 20t$$

Solution:

$$X_L = \omega L = (20\text{ rad/s})(0.5\text{ H}) = 10\ \Omega$$

$$I_m = \frac{V_m}{X_L} = \frac{100\text{ V}}{10\ \Omega} = 10\text{ A}$$

and we know the i lags v by 90°. Therefore,

$$i = \mathbf{10 \sin(20}t\ \mathbf{- 90°)}$$

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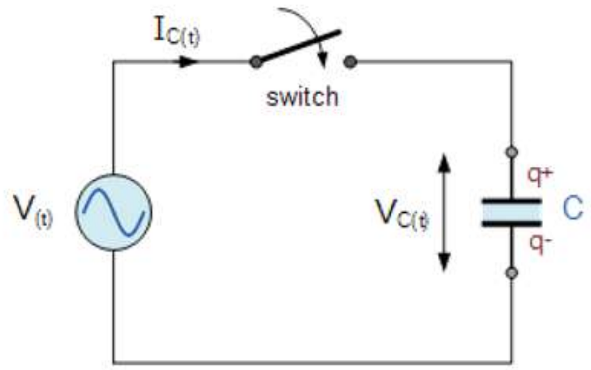
4 - الاسئلة القبلية

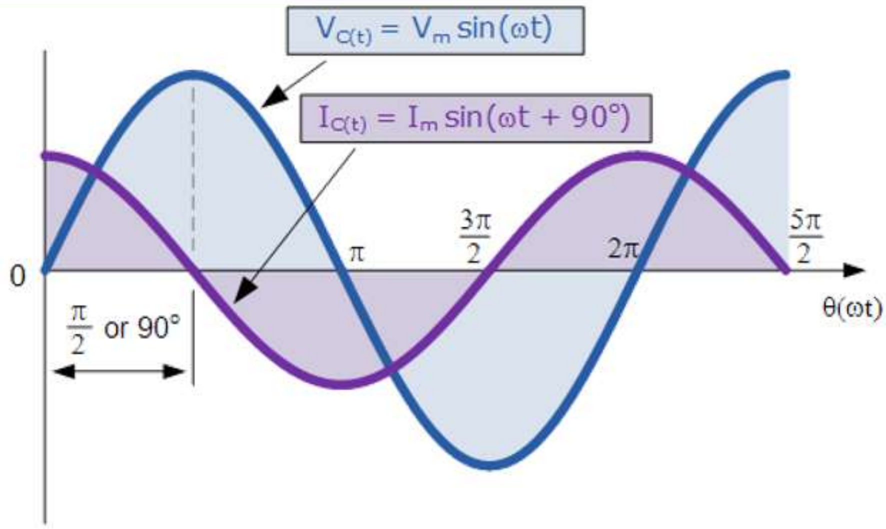
- ما هو سلوك متسعة في دوائر تيار مستمر ؟

5- المحتوى العلمي

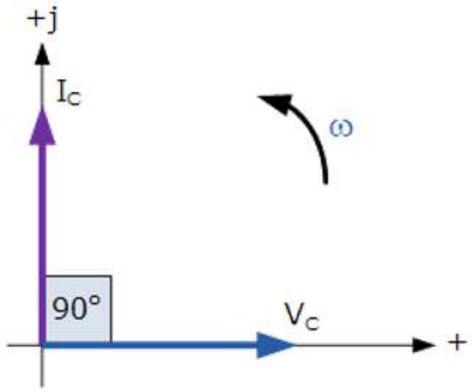
AC Capacitance with a Sinusoidal Supply



Sinusoidal Waveforms for AC Capacitance



Phasor Diagram for AC Capacitance



So for a pure capacitor, V_C "lags" I_C by 90°, or we can say that I_C "leads" V_C by 90°.

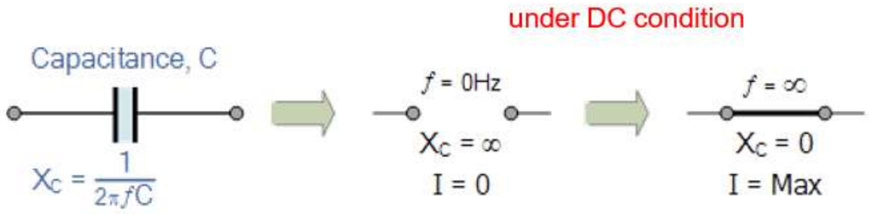
Capacitive Reactance

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

Where: X_C is the Capacitive Reactance in Ohms, f is the frequency in Hertz and C is the AC capacitance in Farads, symbol F.

When dealing with AC capacitance, we can also define capacitive reactance in terms of radians, where Omega, ω equals $2\pi f$.

$$X_C = \frac{1}{\omega C}$$



In an AC circuit containing pure capacitance the current (electron flow) flowing into the capacitor is given as:

$$I_{C(t)} = \frac{dq}{dt} \quad \text{where: } q = CV_C = CV_{max}\sin(\omega t)$$

where q is capacitor charge

$$\therefore I_{C(t)} = \frac{d}{dt}CV_{max}\sin(\omega t) = \omega CV_{max}\cos(\omega t)$$

$$\text{If: } I_{max} = \frac{V_{max}}{Xc} \quad \text{where: } Xc = \frac{1}{2\pi f C} = \frac{1}{\omega C}$$

$$\text{then: } I_{max} = \omega CV_{max}$$

and therefore, the rms current flowing into an AC capacitance will be defined as:

$$I_{C(t)} = I_{max}\sin\left(\omega t + 90^\circ\right)$$

i(t) = C dv/dt

Phasor Domain

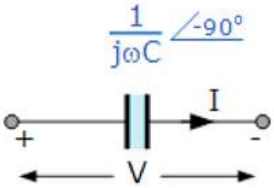
In the phasor domain the voltage across the plates of an AC capacitance will be:

$$V_C = \frac{1}{j\omega C} \times I_C$$

$$\text{where: } \frac{1}{j\omega C} = jX_C = \frac{1}{2\pi f C} = \text{IMPEDANCE, Z}$$

and in **Polar Form** this would be written as: $X_C\angle{-90^\circ}$ where:

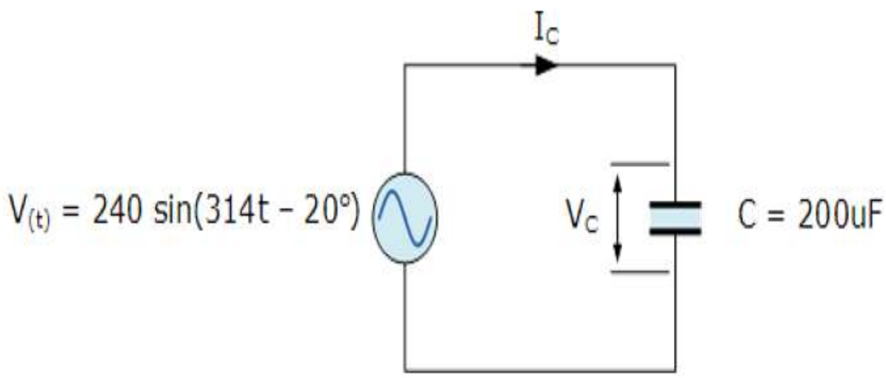
$$X_C\angle\theta = \frac{V_C\angle 0^\circ}{I_C\angle{+90^\circ}}$$



$$X_C\angle\theta = \frac{1}{j\omega C} = 0 - jX_C = \frac{1}{\omega C}\angle{-90^\circ} = Z\angle{-90^\circ}$$

AC Capacitance Example No1

A single-phase sinusoidal AC supply voltage defined as: $V_{(t)} = 240 \sin(314t - 20^o)$ is connected to a pure AC capacitance of 200uF. Determine the value of the current flowing into the capacitor and draw the resulting phasor diagram.

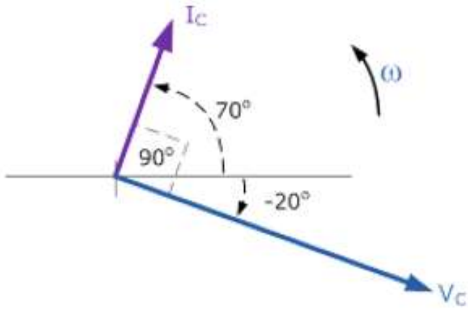


The voltage across the capacitor will be the same as the supply voltage. Converting this time domain value into polar form gives us: $V_C = 240 \angle{-20^o}$ (v). The capacitive reactance will be: $X_C = 1/(\omega.200uF)$. Then the current flowing into the capacitor can be found using Ohms law as:

$$X_C = \frac{1}{j\omega C} = \frac{1}{314 \times 200\mu F} = 16\angle{-90^\circ}$$

$$I_C = \frac{V_C}{jX_C} = \frac{240\angle{-20^\circ}}{16\angle{-90^\circ}} = 15\angle{70^\circ}\ (A)$$

With the current leading the voltage by 90° in an AC capacitance circuit the phasor diagram will be.



6- الاسئلة البعدية

EXAMPLE The voltage across a 1 μF capacitor is provided below. What□s the sinusoidal expression for the current? Sketch the v and i curves.

$$v = 30 \sin 400t$$

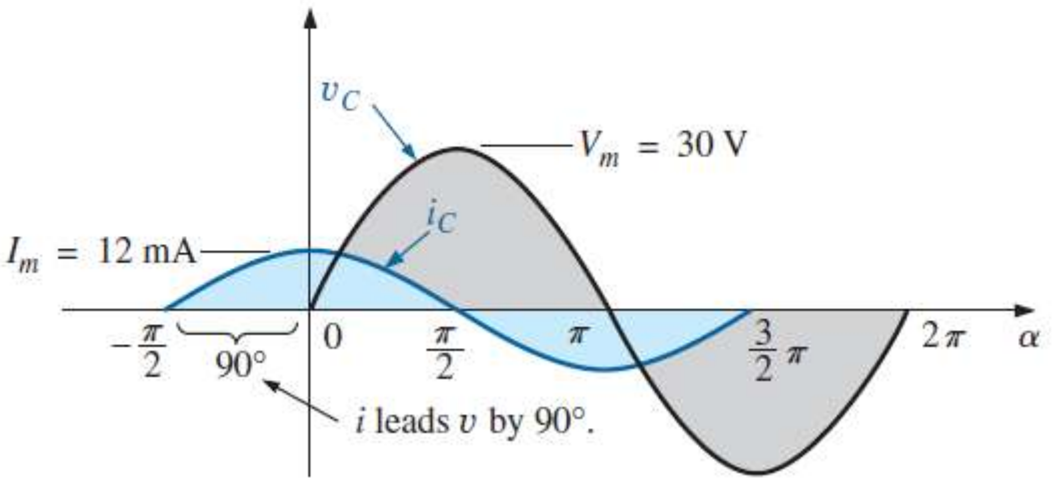
Solution:

$$X_C = \frac{1}{\omega C} = \frac{1}{(400 \text{ rad/s})(1 \times 10^{-6} \text{ F})} = \frac{10^6 \ \Omega}{400} = 2500 \ \Omega$$

$$I_m = \frac{V_m}{X_C} = \frac{30 \text{ V}}{2500 \ \Omega} = 0.0120 \text{ A} = 12 \text{ mA}$$

and we know that for a capacitor i leads v by 90°. Therefore,

$$i = 12 \times 10^{-3} \sin(400t + 90°)$$



المصادر الاساسية :

1. **Electrical Technology (Edward Hughes)**

2 .Basic Circuits(A-M-F Brooks) pergaman press

المصادر المقترحة:

1. Principles of Electric Circuits Tenth Edition by Thomas L. Floyd

2. Introductory Circuit Analysis-Prentice Hall by Robert L. Boylestad

المحتويات (لكل فصل في المقرر)

رقم المحاضرة:	**5**
عنوان المحاضرة:	دائرة المحاثة والمقاومة على التوالي مع مصدر متناوب
اسم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
الهدف العام من المحاضرة :	دراسة سلوك محاثة ومقاومة معاً في دوائر التيار المتناوب
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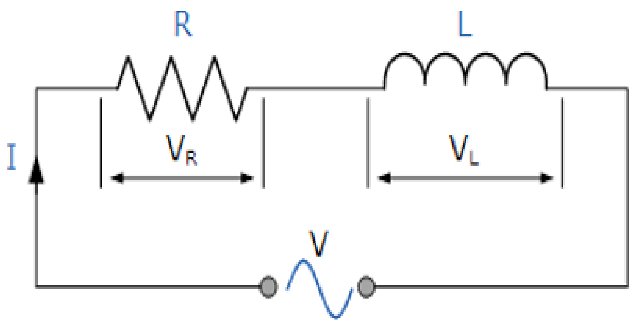
طرق القياس المعتمدة	امتحان التحريري ومناقشة

4 - الاسئلة القبلية

- ما تأثير كل من مقاومة ومحاثة كلاً على حدا في دوائر التيار المتناوب؟

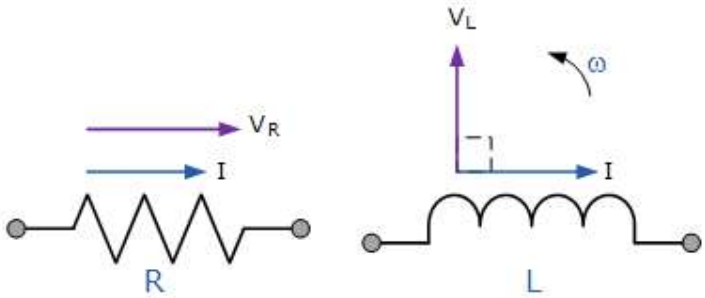
5- المحتوى العلمي

Series Resistance-Inductance Circuit

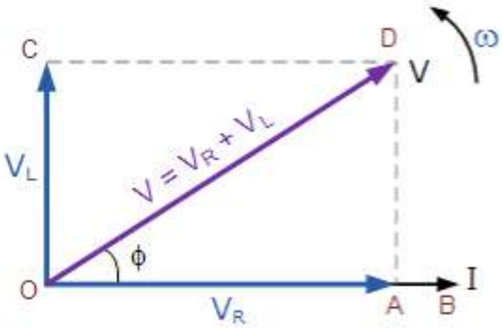


In the RL series circuit above, we can see that the current is common to both the resistance and the inductance while the voltage is made up of the two component voltages, V_R and V_L. The resulting voltage of these two components can be found either mathematically or by drawing a vector diagram. To be able to produce the vector diagram a reference or common component must be found and in a series AC circuit the current is the reference source as the same current flows through the resistance and the inductance. The individual vector diagrams for a pure resistance and a pure inductance are given as:

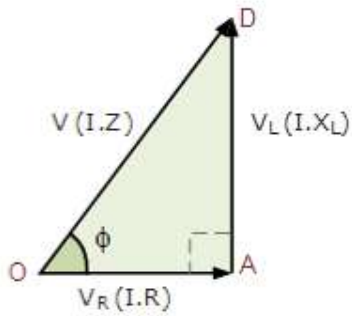
Vector Diagrams for the Two Pure Components



Vector Diagram of the Resultant Voltage



Vector Diagram



Voltage Triangle

From the vector diagram above, we can see that line OB is the horizontal current reference and line OA is the voltage across the resistive component which is in-phase with the current. Line OC shows the inductive voltage which is 90° in front of the current therefore it can still be seen that the current lags the purely inductive voltage by 90°. Line OD gives us the resulting supply voltage. Then:

- V equals the r.m.s value of the applied voltage.
- I equal the r.m.s. value of the series current.
- V_R equals the I.R voltage drop across the resistance which is in-phase with the current.
- V_L equals the $I.X_L$ voltage drop across the inductance which leads the current by 90°.

As $V_R = I.R$ and $V_L = I.X_L$ the applied voltage will be the vector sum of the two as follows:

$$V^2 = V_R^2 + V_L^2$$

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

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

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

The quantity $\sqrt{R^2 + X_L^2}$ represents the **impedance**, Z of the circuit.

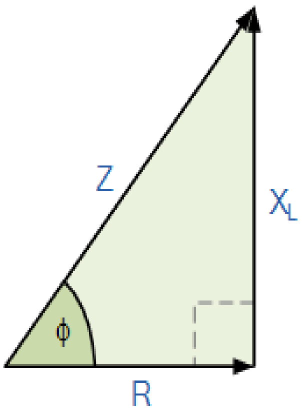
The quantity $\sqrt{R^2 + X_L^2}$ represents the **impedance**, Z of the circuit.

The RL Impedance Triangle

$$\text{Impedance, } Z = \frac{V}{I}$$

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

$$\therefore Z^2 = \left(R^2 + X_L^2\right)$$



Then: (Impedance)^2 = (Resistance)^2 + (*j* Reactance)^2 where *j* represents the 90° phase shift.

This means that the positive phase angle, θ between the voltage and current is given as.

Phase Angle

$$Z^2 = R^2 + X_L^2$$

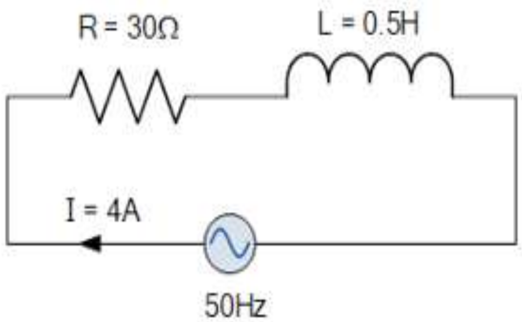
$$\cos\phi = \frac{R}{Z}$$

$$\sin\phi = \frac{X_L}{Z}$$

$$\tan\phi = \frac{X_L}{R}$$

AC Inductance Example No2

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 value of the supply voltage if its frequency is 50Hz.



The impedance of the circuit will be:

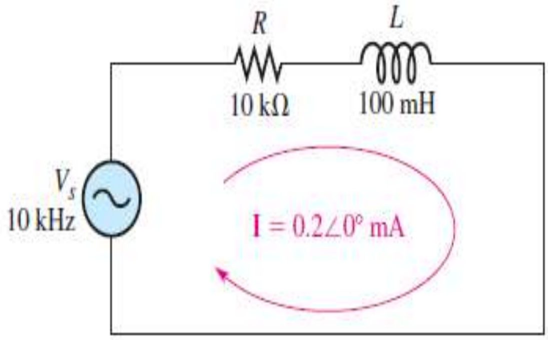
$$X_L = 2\pi f L = 2\pi \times 50 \times 0.5 = 157\Omega$$

$$Z = \sqrt{R^2 + X_L^2}$$
$$Z = \sqrt{30^2 + 157^2}$$
$$Z = 159.8\Omega$$

Then the voltage drops across each component is calculated as:

6- الاسئلة البعدية

The current in Figure 15–5 is expressed in polar form as $\mathbf{I} = 0.2\angle 0^\circ$ mA. Determine the source voltage expressed in polar form, and draw a phasor diagram showing the relationship between the source voltage and the current.



▲ FIGURE 15–5

Solution The magnitude of the inductive reactance is

$$X_L = 2\pi fL = 2\pi(10\text{ kHz})(100\text{ mH}) = 6.28\text{ k}\Omega$$

The impedance in rectangular form is

$$\mathbf{Z} = R + jX_L = 10\text{ k}\Omega + j6.28\text{ k}\Omega$$

Converting to polar form yields

$$\mathbf{Z} = \sqrt{R^2 + X_L^2}\angle\tan^{-1}\left(\frac{X_L}{R}\right)$$

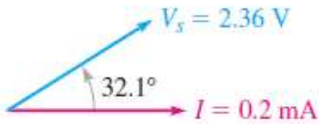
$$= \sqrt{(10\,k\Omega)^2 + (6.28\,k\Omega)^2}\angle\tan^{-1}\left(\frac{6.28\,k\Omega}{10\,k\Omega}\right) = \mathbf{11.8\angle 32.1°\,k\Omega}$$

Use Ohm's law to determine the source voltage.

$$\mathbf{V}_s = \mathbf{IZ} = (0.2\angle 0°\ \text{mA})(11.8\angle 32.1°\ k\Omega) = \mathbf{2.36\angle 32.1°\ V}$$

The magnitude of the source voltage is 2.36 V at an angle of 32.1° with respect to the current; that is, the voltage leads the current by 32.1°, as shown in the phasor diagram of Figure 15–6.

► FIGURE 15–6



في نهاية الحقيبة

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- **2. Basic Circuits(A-M-F Brooks) pergaman press**

- **المصادر المقترحة:**

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4 - الاسئلة القبلية

ما تأثير كل من مقاومة ومتسعة كلاً على حدا في دوائر التيار المتناوب؟

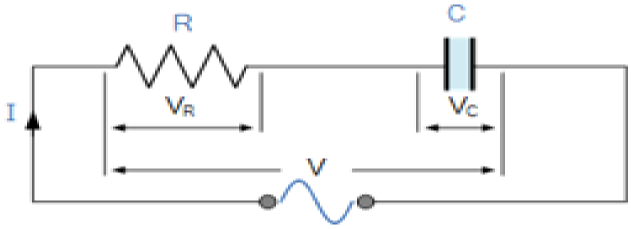
5- المحتوى العلمي

AC Across a Series R + C Circuit

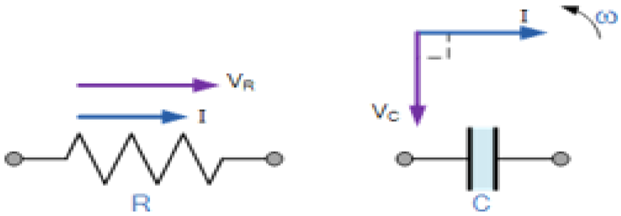
the current flowing into the capacitor will still lead the voltage, but by an amount less than 90° depending upon the values of R and C giving us a phasor sum with the corresponding phase angle between them given by the Greek symbol phi, Φ.

Consider the series RC circuit below where an ohmic resistance, R is connected in series with a pure capacitance, C.

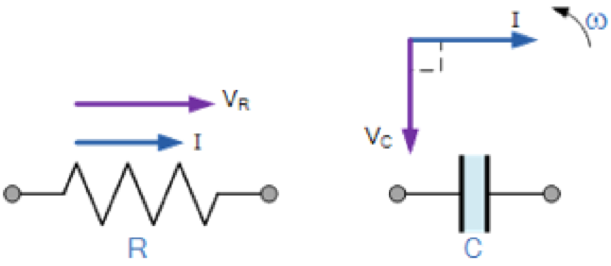
Series Resistance-Capacitance Circuit



Vector Diagrams for the Two Pure Components

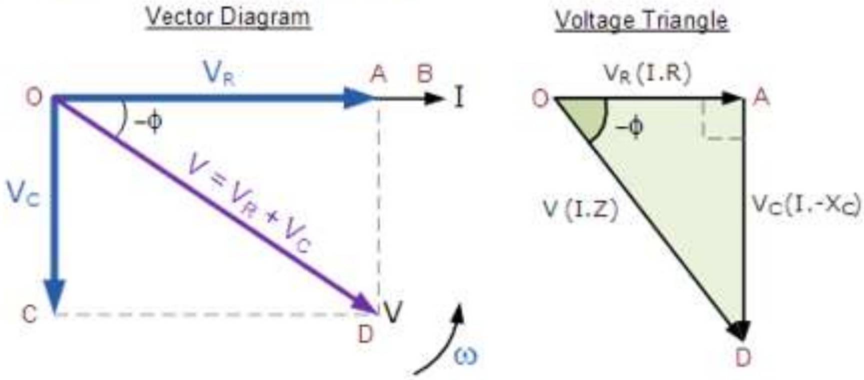


Vector Diagrams for the Two Pure Components



Both the voltage and current vectors for an **AC Resistance** are in phase with each other and therefore the voltage vector V_R is drawn superimposed to scale onto the current vector. Also we know that the current leads the voltage (ICE) in a pure AC capacitance circuit, therefore the voltage vector V_C is drawn 90° behind (lagging) the current vector and to the same scale as V_R as shown.

Vector Diagram of the Resultant Voltage



As $V_R = I.R$ and $V_C = I.X_C$ the applied voltage will be the vector sum of the two as follows.

$$V^2 = V_R^2 + V_C^2$$

$$V_R = I.R \quad \text{and} \quad V_C = I.X_C$$

$$V^2 = I^2.R^2 + I^2.X_C^2$$

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

$$\therefore\ I = \frac{V}{\sqrt{R^2 + X_C^2}} = \frac{V}{Z}$$

The quantity $\sqrt{R^2 + X_C^2}$ represents the **impedance**, Z of the circuit.

The Impedance of an AC Capacitance

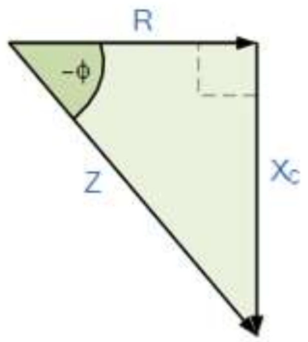
Impedance, **Z** which has the units of Ohms, Ω's is the "TOTAL" opposition to current flowing in an AC circuit that contains both Resistance, (the real part) and Reactance (the imaginary part). A purely resistive impedance will have a phase angle of 0° while a purely capacitive impedance will have a phase angle of -90°.

The RC Impedance Triangle

$$\text{Impedance, } Z = \frac{V}{I}$$

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

$$\therefore Z^2 = R^2 + X_C^2$$



Then:(Impedance)^2 = (Resistance)^2 + (*j* Reactance)^2 where *j* represents the 90° phase shift.

This means then by using Pythagoras's theorem the negative phase angle, θ between the voltage and current is calculated as.

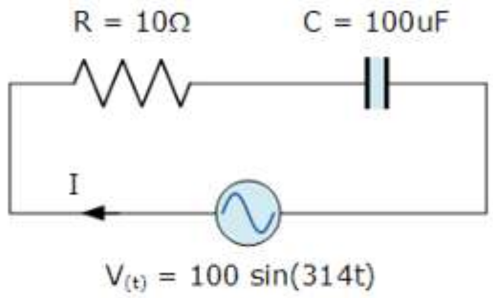
Phase Angle

$$Z^2 = R^2 + X_C^2$$

$$\cos\phi = \frac{R}{Z}, \quad \sin\phi = \frac{X_C}{Z}, \quad \tan\phi = \frac{X_C}{R}$$

AC Capacitance Example No2

A capacitor which has an internal resistance of 10Ω"s and a capacitance value of 100uF is connected to a supply voltage given as **$V_{(t)}$ = 100 sin (620t).** Calculate the current flowing into the capacitor. Also construct a voltage triangle showing the individual voltage drops.



The capacitive reactance and circuit impedance is calculated as:

$$X_C = \frac{1}{\omega C} = \frac{1}{314 \times 100uF} = 31.85\Omega$$

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

Then the current flowing into the capacitor and the circuit is given as:

$$I = \frac{V_C}{Z} = \frac{100}{33.4} = 3Amps$$

The phase angle between the current and voltage is calculated from the impedance triangle above as:

$$\tan^{-1}\phi = \frac{X_C}{R} = \frac{31.85}{10} = 72.6^{\circ}$$

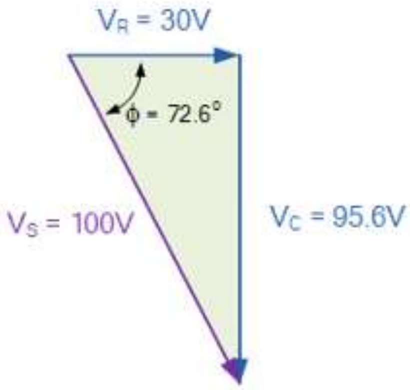
Then the individual voltage drops around the circuit are calculated as:

$$V_R = I \times R = 3 \times 10 = 30V$$

$$V_C = I \times X_C = 3 \times 31.85 = 95.6V$$

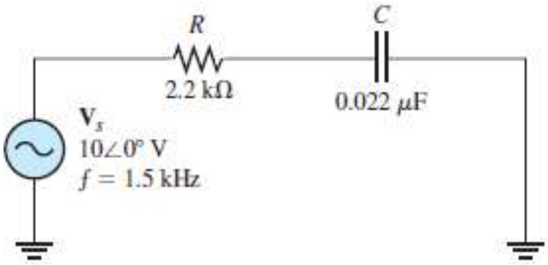
$$V_S = \sqrt{V_R^2 + V_C^2} = \sqrt{30^2 + 95.6^2} = 100V$$

Then the resultant voltage triangle will be.



Determine the current in the circuit of Figure 13–21, and draw a phasor diagram showing the relation between source voltage and current.

▶ FIGURE 13–21



Solution The magnitude of the capacitive reactance is

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(1.5\text{ kHz})(0.022\ \mu\text{F})} = 4.82\text{ k}\Omega$$

The total impedance in rectangular form is

$$\mathbf{Z} = R - jX_C = 2.2\text{ k}\Omega - j4.82\text{ k}\Omega$$

Converting to polar form yields

$$\mathbf{Z} = \sqrt{R^2 + X_C^2}\angle -\tan^{-1}\left(\frac{X_C}{R}\right)$$

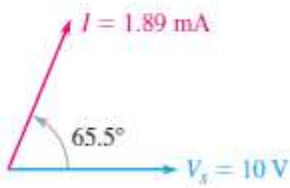
$$= \sqrt{(2.2\text{ k}\Omega)^2 + (4.82\text{ k}\Omega)^2}\angle -\tan^{-1}\left(\frac{4.82\text{ k}\Omega}{2.2\text{ k}\Omega}\right) = 5.30\angle -65.5^\circ\text{ k}\Omega$$

Use Ohm's law to determine the current.

$$\mathbf{I} = \frac{\mathbf{V}}{\mathbf{Z}} = \frac{10\angle 0^\circ\text{ V}}{5.30\angle -65.5^\circ\text{ k}\Omega} = \mathbf{1.89\angle 65.5^\circ\text{ mA}}$$

The magnitude of the current is 1.89 mA. The positive phase angle of 65.5° indicates that the current leads the voltage by that amount, as shown in the phasor diagram of Figure 13–22.

▶ FIGURE 13–22



في نهاية الحقيبة

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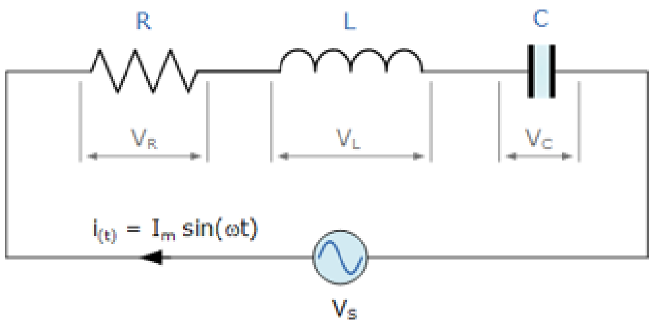
4 - الاسئلة القبلية

- ما تأثير كل من مقاومة ومتسعة ومحاثة كلاً على حدا في دوائر التيار المتناوب؟

5- المحتوى العلمي

RLC Series combinations

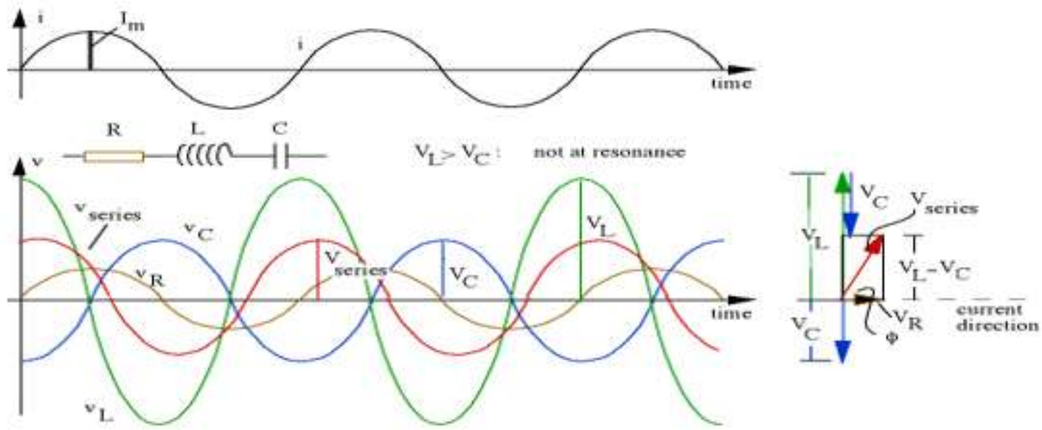
Now let's put a **resistor, capacitor and inductor in series**. At any given time, the voltage across the three components in series, $v_{series}(t)$, is the sum of these:



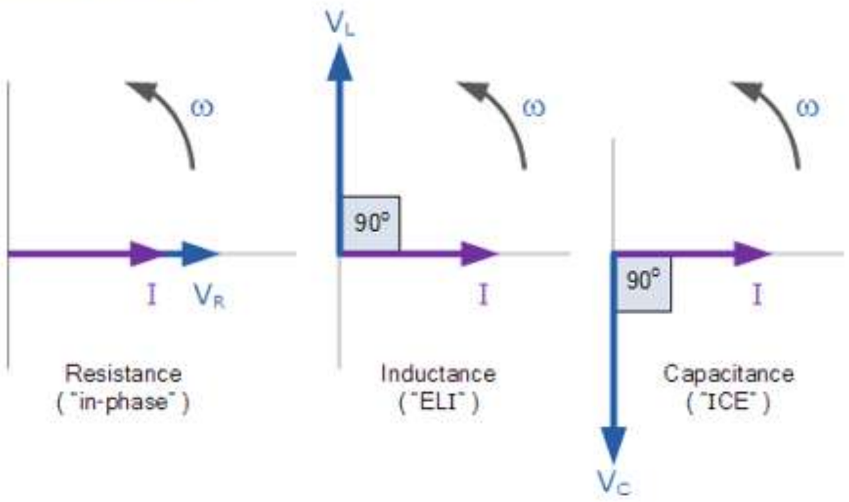
$$v_{series}(t) = v_R(t) + v_L(t) + v_C(t),$$

The current i(t) we shall keep sinusoidal, as before. The voltage across the resistor, $v_R(t)$, is in phase with the current. That across the inductor, $v_L(t)$, is 90° ahead and that across the capacitor, $v_C(t)$, is 90° behind.

Once again, the time-dependent voltages v(t) add up at any time, but the RMS voltages V do not simply add up. Once again they can be added by *phasors* representing the three sinusoidal voltages. Again, let's 'freeze' it in time for the purposes of the addition, which we do in the graphic below. Once more, be careful to distinguish v and V.



Individual Voltage Vectors



Look at the phasor diagram: The voltage across the ideal inductor is antiparallel to that of the capacitor, so the total reactive voltage (the voltage which is 90° ahead of the current) is $V_L - V_C$, so Pythagoras now gives us:

$$V^2_{series} = V^2_R + (V_L - V_C)^2$$

Now $V_R = IR$, $V_L = IX_L = I\omega L$ and $V_C = IX_C = I/\omega C$. Substituting and taking the common factor I gives:

$$V = I\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} = I Z_{series}$$

where Z_{series} is the series impedance: the ratio of the voltage to current in an RLC series ciruit. Note that, once again, reactances and resistances add according to Pythagoras' law:

$$Z_{series}^{\ 2} = R^2 + X_{total}^{\ 2}$$

$$= R^2 + (X_L - X_C)^2.$$

Remember that the inductive and capacitive phasors are 180° out of phase, so their reactances tend to cancel. Now let's look at the **relative phase**. The angle by which the voltage leads the current is

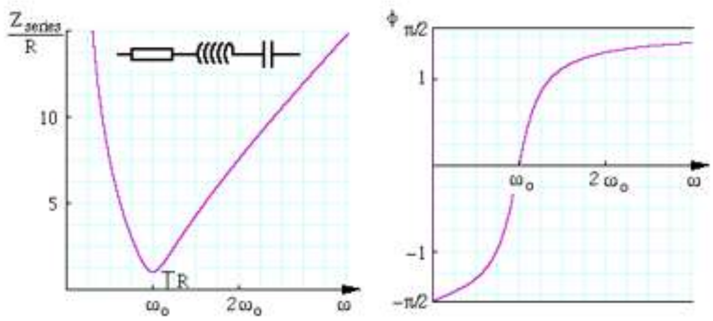
$$\varphi = \tan^{-1} ((V_L - V_C)/V_R).$$

Substituting $V_R = IR$, $V_L = IX_L = I\omega L$ and $V_C = IX_C = I/\omega C$ gives:

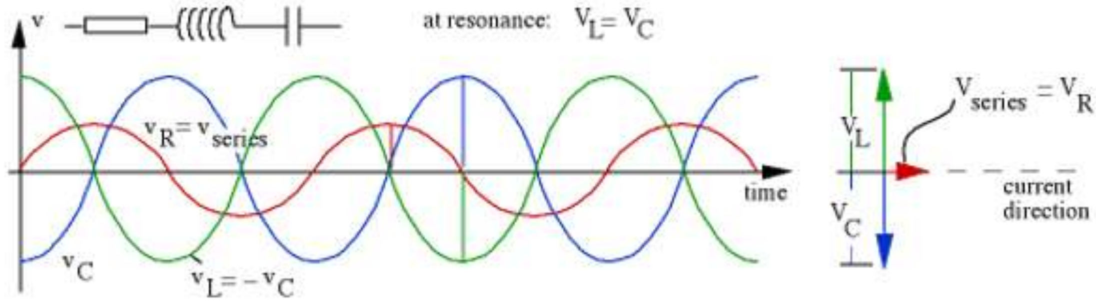
$$\phi = \tan^{-1} \frac{\omega L - 1/\omega C}{R}$$

The dependence of Z_{series} and φ on the angular frequency ω is shown in the next figure. The angular frequency ω is given in terms of a particular value ω_o, the resonant frequency

($\omega^2 = 1/LC$), which we meet below.



The next graph shows us the special case where the frequency is such that $V_L = V_C$.



Because $v_L(t)$ and v_C are 180° out of phase, this means that $v_L(t) = - v_C(t)$, so the two reactive voltages cancel out, and the series voltage is just equal to that across the resistor. This case is called series resonance, which is our next topic.

Element Impedance

Circuit Element	Resistance, (R)	Reactance, (X)	Impedance, (Z)
Resistor	R	0	$Z_R = R$ $= R\angle 0^0$
Inductor	0	ωL	$Z_L = j\omega L$ $= \omega L \angle +90^0$
Capacitor	0	$-\frac{1}{\omega C}$	$Z_C = \frac{1}{j\omega C}$ $= \frac{1}{\omega C}\angle -90^0$

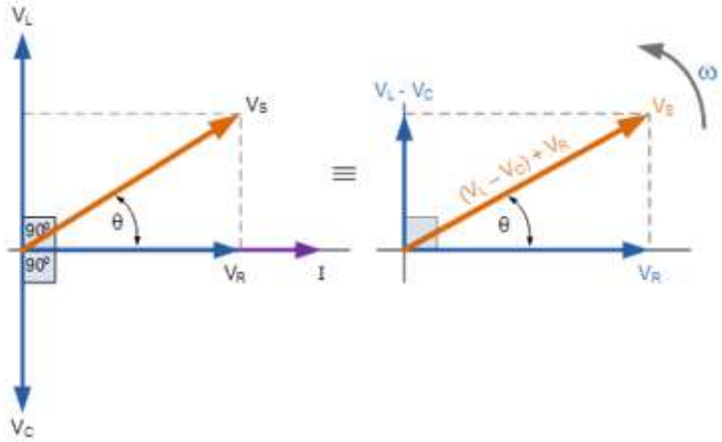
Instantaneous Voltages for a Series RLC Circuit

$$\text{KVL:} \quad V_S - V_R - V_L - V_C = 0$$

$$V_S - IR - L\frac{di}{dt} - \frac{Q}{C} = 0$$

$$\therefore V_S = IR + L\frac{di}{dt} + \frac{Q}{C}$$

Phasor Diagram for a Series RLC Circuit



Voltage Triangle for a Series RLC Circuit

$$V_S^2 = V_R^2 + (V_L - V_C)^2$$

$$V_S = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$V_R = iR\sin(\omega t + 0^\circ) = i.R$$

$$V_R = iR\sin(\omega t + 0^\circ) = i.R$$

$$V_L = iX_L\sin(\omega t + 90^\circ) = i.j\omega L$$

$$V_C = iX_C\sin(\omega t - 90^\circ) = i.\frac{1}{j\omega C}$$

By substituting these values into Pythagoras's equation above for the voltage triangle will give us:

$$V_R = I.R \quad V_L = I.X_L \quad V_C = I.X_C$$

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

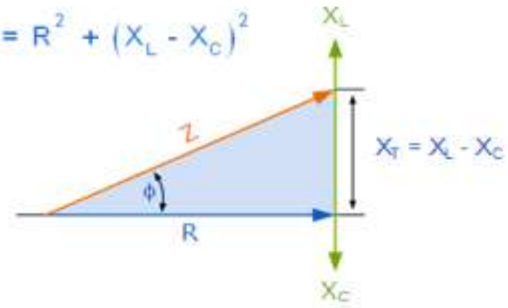
$$V_S = I.\sqrt{R^2 + (X_L - X_C)^2}$$

$$\therefore V_S = I \times Z \quad \text{where: } Z = \sqrt{R^2 + (X_L - X_C)^2}$$

The Impedance of a Series RLC Circuit

The Impedance Triangle for a Series RLC Circuit

$$Z^2 = R^2 + (X_L - X_C)^2$$



impedance can be re-written as:

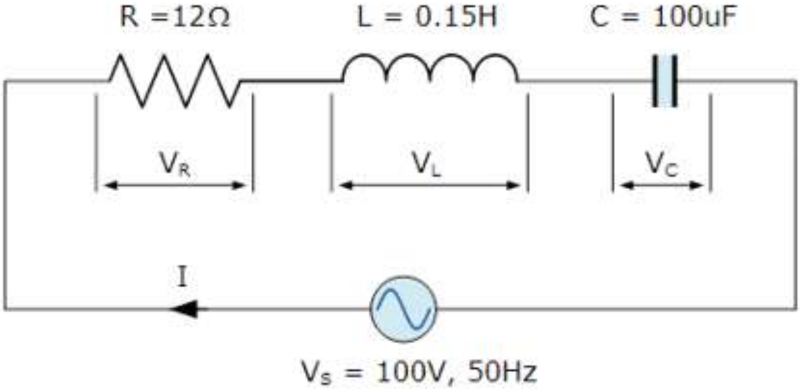
$$\text{Impedance, } Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

The phase angle, θ between the source voltage, V_S and the current, i, can be calculated from the ohmic values of the impedance triangle as:

$$\cos\phi = \frac{R}{Z} \quad \sin\phi = \frac{X_L - X_C}{Z} \quad \tan\phi = \frac{X_L - X_C}{R}$$

Series RLC Circuit Example No1

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



Inductive Reactance, X_L.

$$X_L = 2\pi fL = 2\pi \times 50 \times 0.15 = 47.13\Omega$$

Capacitive Reactance, X_C.

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}} = 31.83\Omega$$

Circuit Impedance, Z.

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

$$Z = \sqrt{12^2 + (47.13 - 31.83)^2}$$

$$Z = \sqrt{144 + 234} = 19.4\Omega$$

Circuits Current, I.

$$I = \frac{V_S}{Z} = \frac{100}{19.4} = 5.15\text{Amps}$$

Voltages across the Series RLC Circuit, V_R, V_L, V_C.

$$V_R = I \times R = 5.14 \times 12 = 61.7 \text{ volts}$$

$$V_L = I \times X_L = 5.14 \times 47.13 = 242.2 \text{ volts}$$

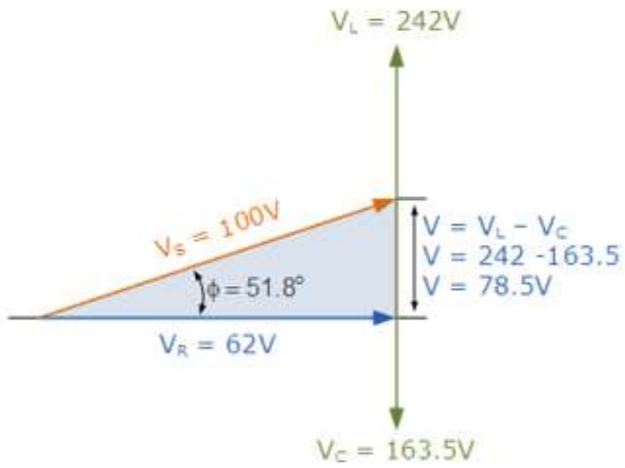
$$V_C = I \times X_C = 5.14 \times 31.8 = 163.5 \text{ volts}$$

Circuits Power factor and Phase Angle, θ.

$$\cos\phi = \frac{R}{Z} = \frac{12}{19.4} = 0.619$$

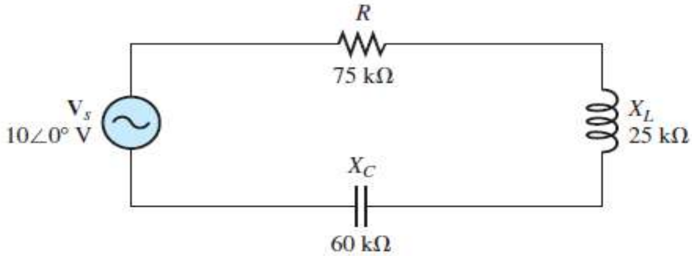
$$\therefore \cos^{-1} 0.619 = 51.8^{0} \text{ lagging}$$

Phasor Diagram.



6- الاسئلة البعدية

Find the current and the voltages across each component in Figure 17–11. Express each quantity in polar form, and draw a complete voltage phasor diagram.



▲ FIGURE 17–11

Solution First, find the total impedance.

$$\mathbf{Z} = R + jX_L - jX_C = 75\text{ k}\Omega + j25\text{ k}\Omega - j60\text{ k}\Omega = 75\text{ k}\Omega - j35\text{ k}\Omega$$

Convert to polar form for convenience in applying Ohm's law.

$$\mathbf{Z} = \sqrt{R^2 + X_{tot}^2}\angle -\tan^{-1}\left(\frac{X_{tot}}{R}\right)$$

$$= \sqrt{(75\text{ k}\Omega)^2 + (35\text{ k}\Omega)^2}\angle -\tan^{-1}\left(\frac{35\text{ k}\Omega}{75\text{ k}\Omega}\right) = 82.8\angle -25^\circ\text{ k}\Omega$$

where $X_{tot} = |X_L - X_C|$.

Apply Ohm's law to find the current.

$$\mathbf{I} = \frac{\mathbf{V}_s}{\mathbf{Z}} = \frac{10\angle 0^\circ\text{ V}}{82.8\angle -25^\circ\text{ k}\Omega} = \mathbf{121\angle 25.0^\circ\ \mu A}$$

Now, apply Ohm's law to find the voltages across *R*, *L*, and *C*.

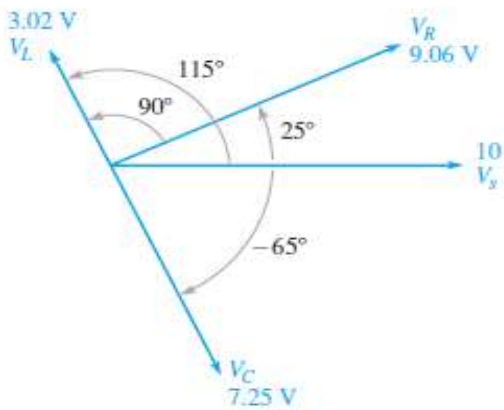
$$\mathbf{V}_R = \mathbf{I}R = (121\angle 25.0^\circ\ \mu\text{A})(75\angle 0^\circ\text{ k}\Omega) = \mathbf{9.06\angle 25.0^\circ\ V}$$

$$\mathbf{V}_L = \mathbf{I}\mathbf{X}_L = (121\angle 25.0^\circ\ \mu\text{A})(25\angle 90^\circ\text{ k}\Omega) = \mathbf{3.02\angle 115^\circ\ V}$$

$$\mathbf{V}_C = \mathbf{I}\mathbf{X}_C = (121\angle 25.0^\circ\ \mu\text{A})(60\angle -90^\circ\text{ k}\Omega) = \mathbf{7.25\angle -65.0^\circ\ V}$$

The phasor diagram is shown in Figure 17–12. The magnitudes represent rms values. Notice that V_L is leading V_R by 90°, and V_C is lagging V_R by 90°. Also, there is a 180° phase difference between V_L and V_C. If the current phasor were shown,

► FIGURE 17–12



في نهاية الحقيبة

- المصادر الاساسية :
- 1 .Electrical Technology (Edward Hughes)
- 2 .Basic Circuits(A-M-F Brooks) pergaman press
- المصادر المقترحة:
- Principles of Electric Circuits Tenth Edition by Thomas L. Floyd
- Introductory Circuit Analysis-Prentice Hall by Robert L. Boylestad

المحتويات (لكل فصل في المقرر)

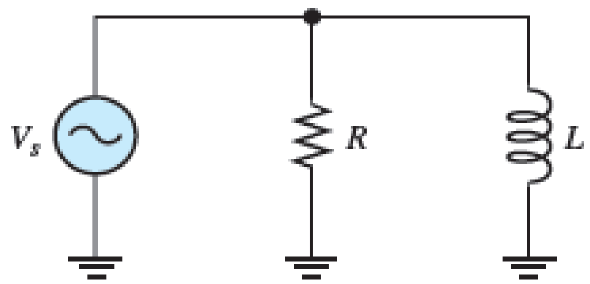
رقم المحاضرة:	8
عنوان المحاضرة	مقاومة ومحاثة على توازي مع مصدر متناوب
اسـم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
الهدف العام من المحاضرة	دراسة سلوك مقاومة ومحاثة على توازي معاً في دوائر التيار المتناوب.
الأهداف السلوكية او مخرجات التعلم: .	يستطيع الطالب ايجاد قيم فولتيات وتيارات في دائرة مقاومة ومحاثة على التوزاي
استراتيجيات التيسير المستخدمة	عرض التقديمي وامثلة محلولة
المهارات المكتسبة	التعرف على سلوك مقاومة ومحاثة على توازي معاً
طرق القياس المعتمدة	امتحان التحريري ومناقشة

4 - الاسئلة القبلية

- ما تأثير كل من مقاومة ومحاثة كلاً على حدا في دوائر التيار المتناوب على التوازي؟

5- المحتوى العلمي

a basic parallel *RL* circuit connected to an ac voltage source.



The expression for the total impedance of a two-component parallel *RL* circuit is developed as follows, using the product-over-sum rule.

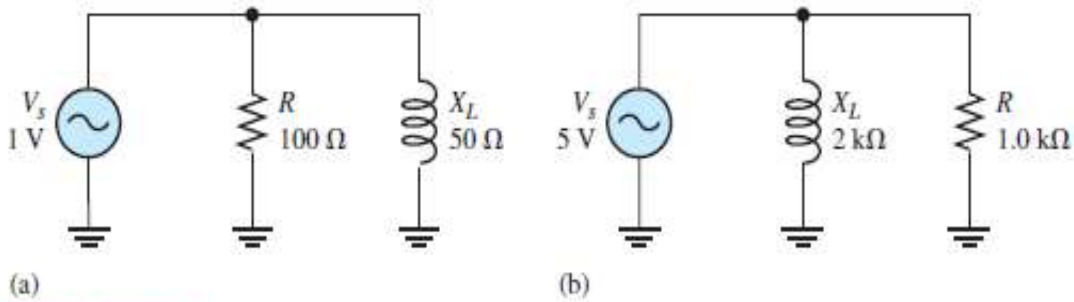
$$\mathbf{Z} = \frac{(R\angle 0^\circ)(X_L\angle 90^\circ)}{R + jX_L} = \frac{RX_L\angle(0^\circ + 90^\circ)}{\sqrt{R^2 + X_L^2}\angle\tan^{-1}\left(\frac{X_L}{R}\right)}$$

$$= \left(\frac{RX_L}{\sqrt{R^2 + X_L^2}}\right)\angle\left(90^\circ - \tan^{-1}\left(\frac{X_L}{R}\right)\right)$$

Equivalently, this equation can be expressed as

$$\mathbf{Z} = \left(\frac{RX_L}{\sqrt{R^2 + X_L^2}}\right)\angle\tan^{-1}\left(\frac{R}{X_L}\right)$$

For each circuit in Figure 15–21, determine the magnitude and phase angle of the total impedance.



▲ FIGURE 15–21

For the circuit in Figure 15–21(a), the total impedance is

$$\mathbf{Z} = \left(\frac{RX_L}{\sqrt{R^2 + X_L^2}}\right)\angle\tan^{-1}\left(\frac{R}{X_L}\right)$$

$$= \left(\frac{(100\ \Omega)(50\ \Omega)}{\sqrt{(100\ \Omega)^2 + (50\ \Omega)^2}}\right)\angle\tan^{-1}\left(\frac{100\ \Omega}{50\ \Omega}\right) = \mathbf{44.7\angle 63.4^\circ\ \Omega}$$

Thus, $Z = 44.7\ \Omega$ and $\theta = 63.4^\circ$.

For the circuit in Figure 15–21(b), the total impedance is

$$\mathbf{Z} = \left(\frac{(1.0\ \text{k}\Omega)(2\ \text{k}\Omega)}{\sqrt{(1.0\ \text{k}\Omega)^2 + (2\ \text{k}\Omega)^2}}\right)\angle\tan^{-1}\left(\frac{1.0\ \text{k}\Omega}{2\ \text{k}\Omega}\right) = \mathbf{894\angle 26.6^\circ\ \Omega}$$

Thus, $Z = 894\ \Omega$ and $\theta = 26.6^\circ$.

Notice that the positive angle indicates that the voltage leads the current, in contrast to the *RC* case where the voltage lags the current.

Conductance, Susceptance, and Admittance

As you know from the Chapter 13, conductance (G) is the reciprocal of resistance, susceptance (B) is the reciprocal of reactance, and admittance (Y) is the reciprocal of impedance.

For parallel RL circuits, the phasor expression for **inductive susceptance (B_L)** is

$$\mathbf{B}_L = \frac{1}{X_L\angle 90^\circ} = B_L\angle -90^\circ = -jB_L$$

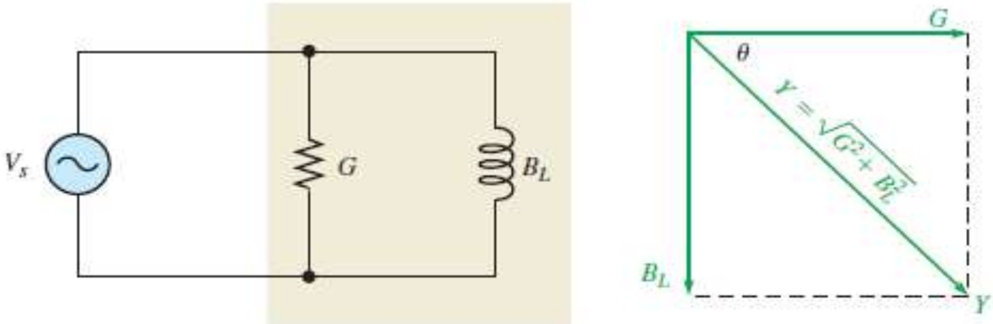
and the phasor expression for **admittance** is

$$\mathbf{Y} = \frac{1}{Z\angle \pm\theta} = Y\angle \mp\theta$$

For the basic parallel RL circuit shown in Figure 15–22(a), the total admittance is the phasor sum of the conductance and the inductive susceptance, as shown in part (b).

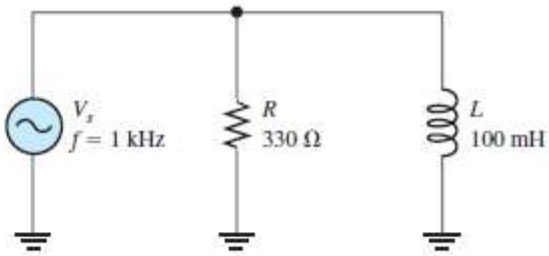
$$\mathbf{Y} = G - jB_L$$

As with the RC circuit, the unit for conductance (G), inductive susceptance (B_L), and admittance (Y) is the siemens (S).



Determine the total admittance and then convert it to total impedance in Figure 15–23. Draw the admittance phasor diagram.

▶ FIGURE 15–23



Solution First, determine the conductance magnitude. $R = 330\ \Omega$; thus,

$$G = \frac{1}{R} = \frac{1}{330\ \Omega} = 3.03\ \text{mS}$$

Then, determine the inductive reactance.

$$X_L = 2\pi fL = 2\pi(1{,}000\ \text{Hz})(100\ \text{mH}) = 628\ \Omega$$

The inductive susceptance magnitude is

$$B_L = \frac{1}{X_L} = \frac{1}{628\ \Omega} = 1.59\ \text{mS}$$

The total admittance is

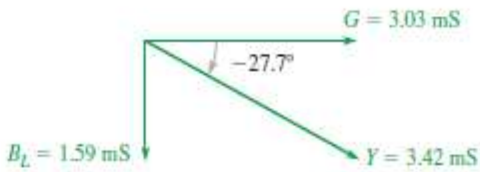
$$\mathbf{Y}_{tot} = G - jB_L = 3.03\ \text{mS} - j1.59\ \text{mS}$$

which can be expressed in polar form as

$$\mathbf{Y}_{tot} = \sqrt{G^2 + B_L^2}\angle -\tan^{-1}\left(\frac{B_L}{G}\right)$$

$$= \sqrt{(3.03\ \text{mS})^2 + (1.59\ \text{mS})^2}\angle -\tan^{-1}\left(\frac{1.59\ \text{mS}}{3.03\ \text{mS}}\right) = \mathbf{3.42\angle -27.7^\circ\ mS}$$

▶ FIGURE 15–24



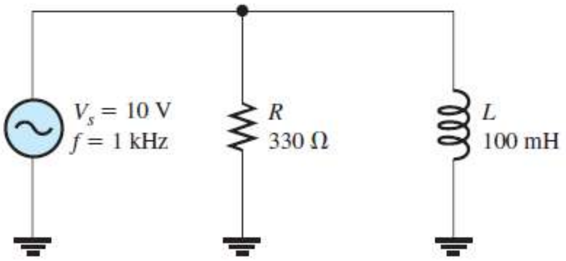
Convert total admittance to total impedance as follows:

$$\mathbf{Z}_{tot} = \frac{1}{\mathbf{Y}_{tot}} = \frac{1}{3.42\angle -27.7^\circ\ \text{mS}} = \mathbf{292\angle 27.7^\circ\ \Omega}$$

The positive phase angle indicates that the voltage leads the current.

Determine I_R, I_L, I_{tot} and the phase angle in the circuit of Figure 15–25. Notice that this is the same circuit given in Example 15–9 but with a source voltage defined as 10.0 V. Draw a phasor diagram of the currents.

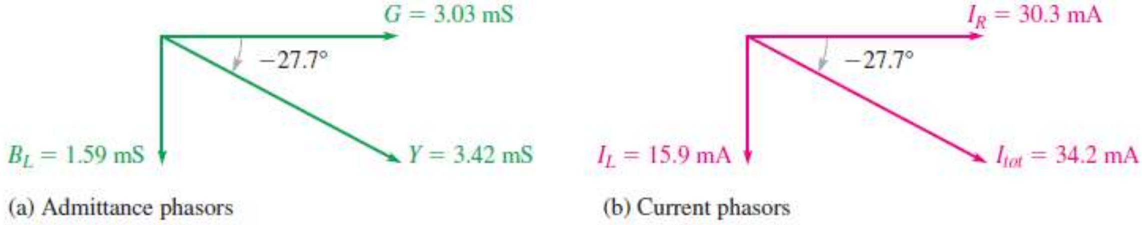
▶ FIGURE 15–25



Solution In Example 15–9, the conductance, susceptance, and admittance were found as $G = 3.03\,\text{ms}$, $B_L = 1.59\,\text{mS}$, and $Y_{tot} = 3.42\,\text{mS}$. Applying Ohm's law using conductance, susceptance, and admittance, we find that:

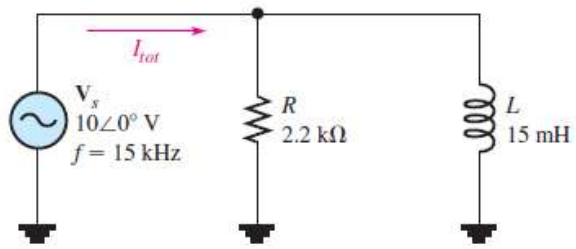
$$I_R = V_sG = (10\text{ V})(3.03\text{ mS}) = 30.3\text{ mA}$$
$$I_L = V_sB_L = (10\text{ V})(1.59\text{ mS}) = 15.9\text{ mA}$$
$$I_{tot} = V_sY_{tot} = (10\text{ V})(3.42\text{ mS}) = 34.2\text{ mS}$$

The phase angle between G and Y_{tot} was found in Example 15–9 as $-27.7°$.
The admittance phasor diagram was drawn as Figure 15–24. The current phasor diagram is proportional to the admittance phasor diagram with the voltage acting as a scaling factor. For comparison, both the admittance phasor diagram and the current phasor diagram are shown in Figure 15–26.



Determine the total current and the phase angle in the circuit of Figure 15–27. Draw a phasor diagram showing the relationship of $\mathbf{V}_s$ and $\mathbf{I}_{tot}$.

▶ FIGURE 15–27



Solution The inductive reactance is

$$X_L = 2\pi fL = 2\pi(15\text{ kHz})(15\text{ mH}) = 1.41\text{ k}\Omega$$

The inductive susceptance magnitude is

$$B_L = \frac{1}{X_L} = \frac{1}{1.41\text{ k}\Omega} = 707\ \mu\text{S}$$

The conductance magnitude is

$$G = \frac{1}{R} = \frac{1}{2.2\text{ k}\Omega} = 455\ \mu\text{S}$$

The total admittance is

$$\mathbf{Y}_{tot} = G - jB_L = 455\ \mu\text{S} - j707\ \mu\text{S}$$

Converting to polar form yields

$$\mathbf{Y}_{tot} = \sqrt{G^2 + B_L^2}\angle -\tan^{-1}\left(\frac{B_L}{G}\right)$$

$$= \sqrt{(455\ \mu\text{S})^2 + (707\ \mu\text{S})^2}\angle -\tan^{-1}\left(\frac{707\ \mu\text{S}}{455\ \mu\text{S}}\right) = 841\angle -57.3^\circ\ \mu\text{S}$$

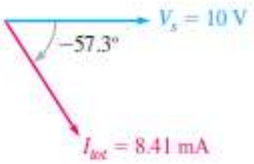
The phase angle is −57.3°.

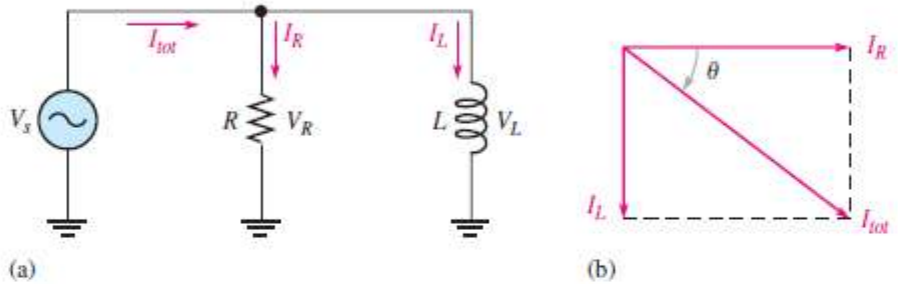
Use Ohm's law to determine the total current.

$$\mathbf{I}_{tot} = \mathbf{V}_s\mathbf{Y}_{tot} = (10\angle 0^\circ\text{ V})(841\angle -57.3^\circ\ \mu\text{S}) = \mathbf{8.41\angle -57.3^\circ\ mA}$$

The magnitude of the total current is 8.41 mA, and it lags the applied voltage by **57.3°**, as indicated by the negative angle associated with it. The phasor diagram in Figure 15–28 shows these relationships.

▶ FIGURE 15–28





▲ **FIGURE 15–29**

Currents in a parallel *RL* circuit. The current directions shown in part (a) are instantaneous and, of course, reverse when the source voltage reverses during each cycle.

This equation can be expressed in polar form as

$$\mathbf{I}_{tot} = \sqrt{I_R^2 + I_L^2}\angle -\tan^{-1}\left(\frac{I_L}{I_R}\right)$$

where the magnitude of the total current is

$$I_{tot} = \sqrt{I_R^2 + I_L^2}$$

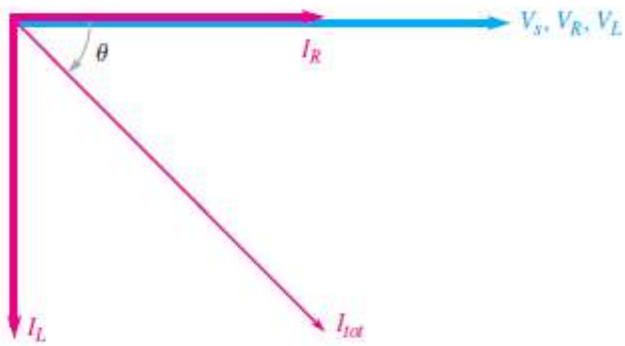
and the phase angle between the resistor current and the total current is

$$\theta = -\tan^{-1}\left(\frac{I_L}{I_R}\right)$$

Since the resistor current and the applied voltage are in phase, θ also represents the phase angle between the total current and the applied voltage. Figure 15–30 shows a complete current and voltage phasor diagram.

► **FIGURE 15–30**

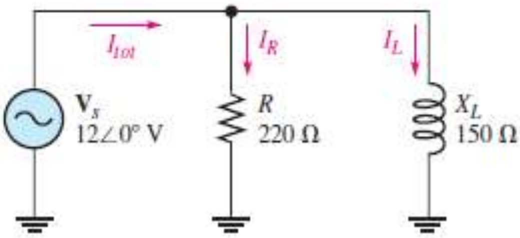
Current and voltage phasor diagram for a parallel *RL* circuit (amplitudes are arbitrary).



6- الاسئلة البعدية

Determine the value of each current in Figure 15–31, and describe the phase relationship of each with the applied voltage. Draw the current phasor diagram.

▶ FIGURE 15–31



Solution The resistor current, the inductor current, and the total current are expressed as follows:

$$\mathbf{I}_R = \frac{\mathbf{V}_s}{\mathbf{R}} = \frac{12\angle 0^\circ \text{ V}}{220\angle 0^\circ\ \Omega} = \mathbf{54.5\angle 0^\circ\ mA}$$

$$\mathbf{I}_L = \frac{\mathbf{V}_s}{\mathbf{X}_L} = \frac{12\angle 0^\circ \text{ V}}{150\angle 90^\circ\ \Omega} = \mathbf{80\angle -90^\circ\ mA}$$

$$\mathbf{I}_{tot} = I_R - jI_L = 54.5 \text{ mA} - j80 \text{ mA}$$

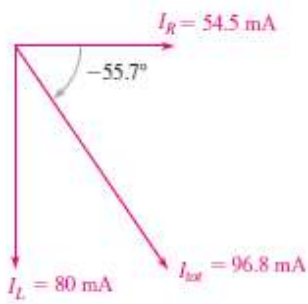
Converting $\mathbf{I}_{tot}$ to polar form yields

$$\mathbf{I}_{tot} = \sqrt{I_R^2 + I_L^2}\angle -\tan^{-1}\left(\frac{I_L}{I_R}\right)$$

$$= \sqrt{(54.5 \text{ mA})^2 + (80 \text{ mA})^2}\angle -\tan^{-1}\left(\frac{80 \text{ mA}}{54.5 \text{ mA}}\right) = \mathbf{96.8\angle -55.7^\circ\ mA}$$

As the results show, the resistor current is 54.5 mA and is in phase with the applied voltage. The inductor current is 80 mA and lags the applied voltage by 90°. The total current is 96.8 mA and lags the voltage by 55.7°. The phasor diagram in Figure 15–32 shows these relationships.

▶ FIGURE 15–32



في نهاية الحقيبة

- : المصادر الاساسية
- 1 . Electrical Technology (Edward Hughes)
- 2 . Basic Circuits(A-M-F Brooks) pergaman press
- :المصادر المقترحة
- Principles of Electric Circuits Tenth Edition by Thomas L. Floyd
- Introductory Circuit Analysis-Prentice Hall by Robert L. Boylestad

المحتويات (لكل فصل في المقرر)

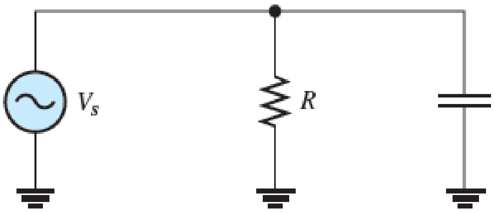
رقم المحاضرة:	9
عنوان المحاضرة	مقاومة ومتسعة على توازي مع مصدر متناوب
اسـم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
• الهدف العام من المحاضرة.	دراسة سلوك مقاومة ومتسعة على توازي معاً في دوائر التيار المتناوب
الأهداف السلوكية او مخرجات التعلم:	يستطيع الطالب ايجاد قيم فولتيات وتيارات في دائرة مقاومة ومتسعة على التوزاي.
استراتيجيات التيسير المستخدمة	عرض التقديمي وامثلة محلولة
المهارات المكتسبة	التعرف على سلوك مقاومة ومتسعة على توازي معاً
طرق القياس المعتمدة	امتحان التحريري ومناقشة

4 - الاسئلة القبلية

ما تأثير كل من مقاومة ومتسعة كلاً على حدا في دوائر التيار المتناوب على التوازي؟

5- المحتوى العلمي

Figure 13–38 shows a basic parallel *RC* circuit connected to an ac voltage source.



▶ FIGURE 13–38

Basic parallel *RC* circuit.

The expression for the total impedance is developed as follows, using complex numbers. Since there are only two circuit components, *R* and *C*, the total impedance can be found from the product-over-sum rule.

$$\mathbf{Z} = \frac{(R\angle 0^\circ)(X_C\angle -90^\circ)}{R - jX_C}$$

By multiplying the magnitudes, adding the angles in the numerator, and converting the denominator to polar form, you get

$$\mathbf{Z} = \frac{RX_C\angle(0° - 90°)}{\sqrt{R^2 + X_C^2}\angle -\tan^{-1}\left(\frac{X_C}{R}\right)}$$

Now, by dividing the magnitude expression in the numerator by that in the denominator, and by subtracting the angle in the denominator from that in the numerator, you get

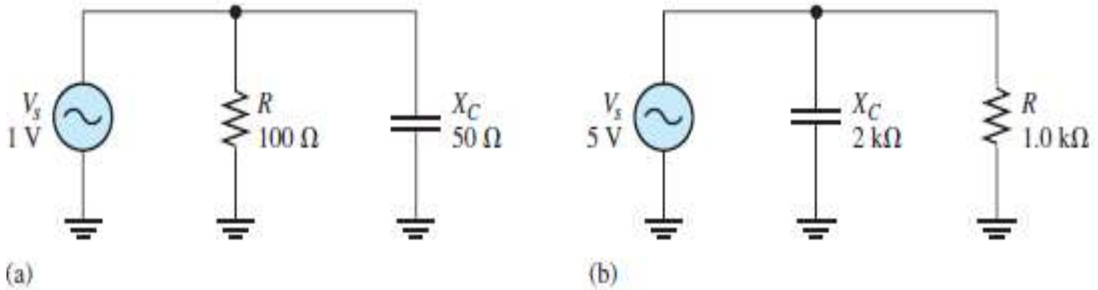
$$\mathbf{Z} = \left(\frac{RX_C}{\sqrt{R^2 + X_C^2}}\right)\angle\left(-90° + \tan^{-1}\left(\frac{X_C}{R}\right)\right)$$

Equivalently, this expression can be written as

$$\mathbf{Z} = \frac{RX_C}{\sqrt{R^2 + X_C^2}}\angle -\tan^{-1}\left(\frac{R}{X_C}\right)$$

Notice that Equation 13–18 is simply the complex version of the product-over-sum rule.

For each circuit in Figure 13–39, determine the magnitude and phase angle of the total impedance.



▲ FIGURE 13–39

For the circuit in Figure 13–39(a), the total impedance is

$$\mathbf{Z} = \left(\frac{RX_C}{\sqrt{R^2 + X_C^2}}\right)\angle -\tan^{-1}\left(\frac{R}{X_C}\right)$$

$$= \left(\frac{(100\ \Omega)(50\ \Omega)}{\sqrt{(100\ \Omega)^2 + (50\ \Omega)^2}}\right)\angle -\tan^{-1}\left(\frac{100\ \Omega}{50\ \Omega}\right) = \mathbf{44.7\angle -63.4°\ \Omega}$$

Thus, $Z = 44.7\ \Omega$ and $\theta = -63.4°$.

For the circuit in Figure 13–39(b), the total impedance is

Conductance, Susceptance, and Admittance

Recall that **conductance**, G, is the reciprocal of resistance. The phasor expression for conductance is expressed as

$$\mathbf{G} = \frac{1}{R\angle 0^\circ} = G\angle 0^\circ$$

Two new terms are now introduced for use in parallel RC circuits. **Capacitive susceptance (B_C)** is the reciprocal of capacitive reactance. The phasor expression for capacitive susceptance is

$$\mathbf{B}_C = \frac{1}{X_C\angle -90^\circ} = B_C\angle 90^\circ = +jB_C$$

Admittance (Y) is the reciprocal of impedance. The phasor expression for admittance is

$$\mathbf{Y} = \frac{1}{Z\angle \pm\theta} = Y\angle \mp\theta$$

The unit of each of these terms is the siemens (S), which is the reciprocal of the ohm.

In working with parallel circuits, it is often easier to use conductance (G), capacitive susceptance (B_C), and admittance (Y) rather than resistance (R), capacitive reactance (X_C), and impedance (Z). In a parallel RC circuit, as shown in Figure 13–40, the total admittance is simply the phasor sum of the conductance and the capacitive susceptance.

$$\mathbf{Y} = G + jB_C$$

Equation 13–19

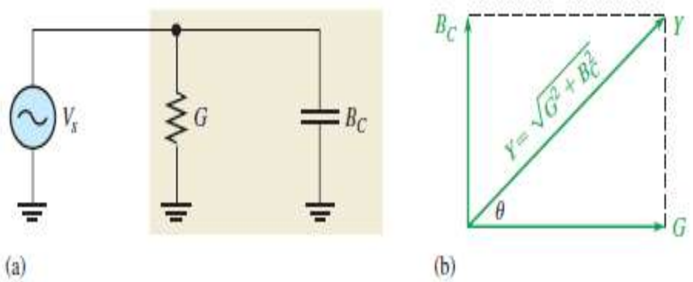
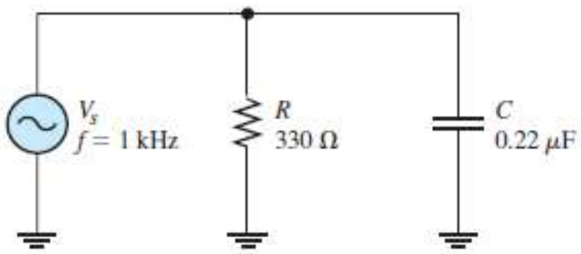


FIGURE 13–40

Admittance in a parallel RC circuit.

Determine the total admittance (Y) and then convert it to total impedance (Z) in Figure 13–41. Draw the admittance phasor diagram.

▶ FIGURE 13–41



Solution From Figure 13–41, $R = 330\ \Omega$; thus $G = 1/R = 1/330\ \Omega = 3.03$ mS. The capacitive reactance is

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(1{,}000\text{ Hz})(0.22\ \mu\text{F})} = 723\ \Omega$$

The capacitive susceptance magnitude is

$$B_C = \frac{1}{X_C} = \frac{1}{723\ \Omega} = 1.38\text{ mS}$$

The total admittance is

$$\mathbf{Y}_{tot} = G + jB_C = \mathbf{3.03\ mS + \mathit{j}1.38\ mS}$$

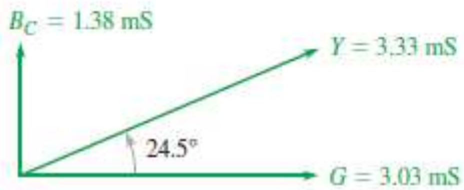
which can be expressed in polar form as

$$\mathbf{Y}_{tot} = \sqrt{G^2 + B_C^2}\angle\tan^{-1}\left(\frac{B_C}{G}\right)$$

$$= \sqrt{(3.03\text{ mS})^2 + (1.38\text{ mS})^2}\angle\tan^{-1}\left(\frac{1.38\text{ mS}}{3.03\text{ mS}}\right) = \mathbf{3.33\angle 24.5^\circ mS}$$

The admittance phasor diagram is shown in Figure 13–42.

▶ FIGURE 13–42



Convert total admittance to total impedance as follows:

$$\mathbf{Z}_{tot} = \frac{1}{\mathbf{Y}_{tot}} = \frac{1}{(3.33\angle 24.5^\circ\text{ mS})} = \mathbf{300\angle -24.5\ \Omega}$$

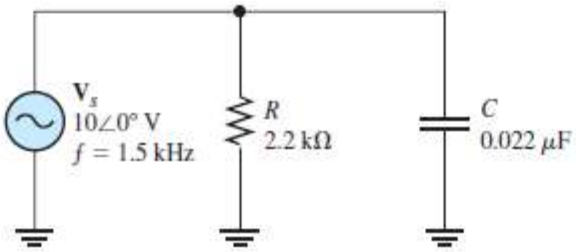
For convenience in the analysis of parallel circuits, the Ohm's law formulas using impedance, previously stated, can be rewritten for admittance using the relation $Y = 1/Z$. Remember, the use of boldface nonitalic letters indicates phasor quantities.

$$\mathbf{V} = \frac{\mathbf{I}}{\mathbf{Y}}$$

$$\mathbf{I} = \mathbf{VY}$$

$$\mathbf{Y} = \frac{\mathbf{I}}{\mathbf{V}}$$

Determine the total current and phase angle in Figure 13–43. Draw a phasor diagram showing the relationship of $\mathbf{V}_s$ and $\mathbf{I}_{tot}$.



▲ FIGURE 13–43

Solution The capacitive reactance is

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(1.5\text{ kHz})(0.022\ \mu\text{F})} = 4.82\text{ k}\Omega$$

The capacitive susceptance magnitude is

$$B_C = \frac{1}{X_C} = \frac{1}{4.82\text{ k}\Omega} = 207\ \mu\text{S}$$

The conductance magnitude is

$$G = \frac{1}{R} = \frac{1}{2.2\text{ k}\Omega} = 455\ \mu\text{S}$$

The total admittance is

$$\mathbf{Y}_{tot} = G + jB_C = 455\ \mu\text{S} + j207\ \mu\text{S}$$

Converting to polar form yields

$$\mathbf{Y}_{tot} = \sqrt{G^2 + B_C^2}\angle\tan^{-1}\left(\frac{B_C}{G}\right)$$

$$= \sqrt{(455\ \mu\text{S})^2 + (207\ \mu\text{S})^2}\angle\tan^{-1}\left(\frac{207\ \mu\text{S}}{455\ \mu\text{S}}\right) = 500\angle 24.5^\circ\ \mu\text{S}$$

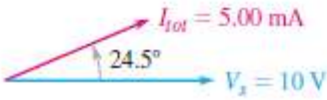
The phase angle is 24.5°.

Use Ohm's law to determine the total current.

$$\mathbf{I}_{tot} = \mathbf{V}_s\mathbf{Y}_{tot} = (10\angle 0^\circ\ \text{V})(500\angle 24.5^\circ\ \mu\text{S}) = \mathbf{5.00\angle 24.5^\circ\ mA}$$

The magnitude of the total current is 5.00 mA, and it leads the applied voltage by **24.5°**, as the phasor diagram in Figure 13–44 indicates.

▶ FIGURE 13–44



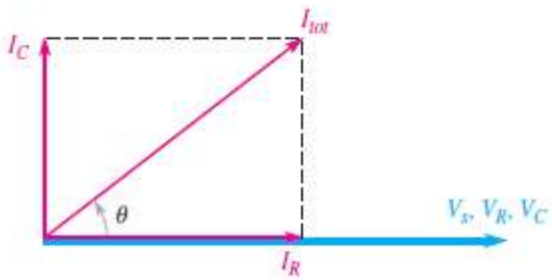
where the magnitude of the total current is

$$I_{tot} = \sqrt{I_R^2 + I_C^2}$$

and the phase angle between the resistor current and the total current is

$$\theta = \tan^{-1}\left(\frac{I_C}{I_R}\right)$$

Since the resistor current and the applied voltage are in phase, θ also represents the phase angle between the total current and the applied voltage. Figure 13–46 shows a complete current and voltage phasor diagram.



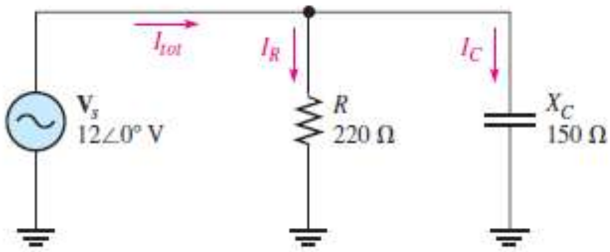
▲ FIGURE 13–46

Current and voltage phasor diagram for a parallel *RC* circuit (amplitudes depend on the particular circuit).

6- الاسئلة البعدية

Determine the value of each current in Figure 13–47, and describe the phase relationship of each with the applied voltage. Draw the current phasor diagram.

▶ FIGURE 13–47



Solution The resistor current, the capacitor current, and the total current are expressed as follows:

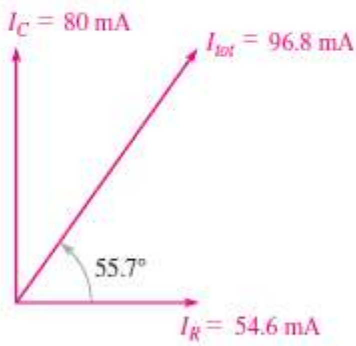
$$\mathbf{I}_R = \frac{\mathbf{V}_s}{\mathbf{R}} = \frac{12\angle 0^\circ\ \text{V}}{220\angle 0^\circ\ \Omega} = \mathbf{54.6\angle 0^\circ\ mA}$$

$$\mathbf{I}_C = \frac{\mathbf{V}_s}{\mathbf{X}_C} = \frac{12\angle 0^\circ\ \text{V}}{150\angle -90^\circ\ \Omega} = \mathbf{80\angle 90^\circ\ mA}$$

$$\mathbf{I}_{tot} = I_R + jI_C = 54.6\ \text{mA} + j80\ \text{mA}$$

As the results show, the resistor current is 54.6 mA and is in phase with the voltage. The capacitor current is 80 mA and leads the voltage by 90°. The total current is 96.8 mA and leads the voltage by 55.7°. The phasor diagram in Figure 13–48 illustrates these relationships.

▶ FIGURE 13–48



في نهاية الحقيبة

-
- **المصادر الاساسية :**

- **1 . Electrical Technology (Edward Hughes)**
- **2 . Basic Circuits(A-M-F Brooks) pergaman press**

- **المصادر المقترحة:**

- **Principles of Electric Circuits Tenth Edition by Thomas L. Floyd**
- **Introductory Circuit Analysis-Prentice Hall by Robert L. Boylestad**

المحتويات (لكل فصل في المقرر)

رقم المحاضرة:	**10**
عنوان المحاضرة	مقاومة ومتسعة ومحاثة على توازي مع مصدر متناوب
اسم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
• **الهدف العام من المحاضرة**	دراسة سلوك مقاومة ومتسعة على توازي معاً في دوائر التيار المتناوب
الأهداف السلوكية او مخرجات التعلم:	يستطيع الطالب ايجاد قيم فولتيات وتيارات في دائرة مقاومة ومتسعة ومحاثة على التوزاي
استراتيجيات التيسير المستخدمة	عرض التقديمي وامثلة محلولة
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4 - الاسئلة القبلية

- ما تأثير كل من مقاومة ومتسعة ومحاثة كلاً على حدا في دوائر التيار المتناوب على التوازي؟

5- المحتوى العلمي

Figure 17–23 shows a parallel *RLC* circuit. The total impedance can be calculated using the reciprocal of the sum-of-reciprocals method, just as was done for circuits with resistors in parallel.

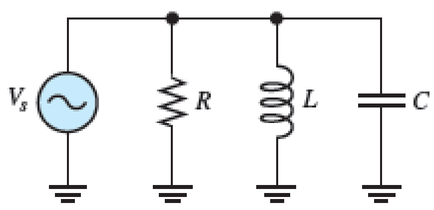
$$\frac{1}{\mathbf{Z}} = \frac{1}{R\angle 0^\circ} + \frac{1}{X_L\angle 90^\circ} + \frac{1}{X_C\angle -90^\circ}$$

or

$$\mathbf{Z} = \frac{1}{\dfrac{1}{R\angle 0^\circ} + \dfrac{1}{X_L\angle 90^\circ} + \dfrac{1}{X_C\angle -90^\circ}}$$

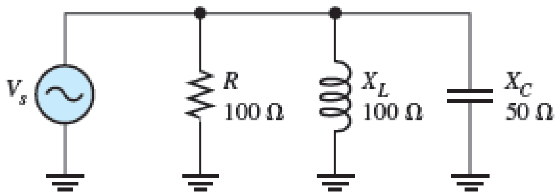
FIGURE 17–23

Parallel *RLC* circuit.



Find **Z** in polar form for the parallel *RLC* circuit in Figure 17–24.

▶ FIGURE 17–24



Solution Use the sum-of-reciprocals formula.

$$\frac{1}{\mathbf{Z}} = \frac{1}{R\angle 0^\circ} + \frac{1}{X_L\angle 90^\circ} + \frac{1}{X_C\angle -90^\circ} = \frac{1}{100\angle 0^\circ\ \Omega} + \frac{1}{100\angle 90^\circ\ \Omega} + \frac{1}{50\angle -90^\circ\ \Omega}$$

Apply the rule for division of polar numbers.

$$\frac{1}{\mathbf{Z}} = 10\angle 0^\circ\ \text{mS} + 10\angle -90^\circ\ \text{mS} + 20\angle 90^\circ\ \text{mS}$$

Recall that the sign of the denominator angle changes when dividing.

Next, convert each term to its rectangular equivalent and combine.

$$\frac{1}{\mathbf{Z}} = 10\ \text{mS} - j10\ \text{mS} + j20\ \text{mS} = 10\ \text{mS} + j10\ \text{mS}$$

Take the reciprocal to obtain **Z** and then convert to polar form.

$$\mathbf{Z} = \frac{1}{10\ \text{mS} + j10\ \text{mS}} = \frac{1}{\sqrt{(10\ \text{mS})^2 + (10\ \text{mS})^2}\angle \tan^{-1}\left(\frac{10\ \text{mS}}{10\ \text{mS}}\right)}$$

$$= \frac{1}{14.14\angle 45^\circ\ \text{mS}} = \mathbf{70.7\angle -45^\circ\ \Omega}$$

The negative angle shows that the circuit is capacitive. This may surprise you because $X_L > X_C$. However, in a parallel circuit, the smaller quantity has the greater effect on the total current because its current is the greatest. Similar to the case of resistances in parallel, the smaller reactance draws more current and has the greater effect on the total Z.

In this circuit, the total current leads the total voltage by a phase angle of 45°

Conductance, Susceptance, and Admittance

The concepts of conductance (G), capacitive susceptance (B_C), inductive susceptance (B_L), and admittance (Y) were discussed in Chapters 13 and 15. The phasor formulas are restated here.

$$\mathbf{G} = \frac{1}{R\angle 0^\circ} = G\angle 0^\circ$$ Equation 17–6

$$\mathbf{B}_C = \frac{1}{X_C\angle -90^\circ} = B_C\angle 90^\circ = jB_C$$ Equation 17–7

$$\mathbf{B}_L = \frac{1}{X_L\angle 90^\circ} = B_L\angle -90^\circ = -jB_L$$ Equation 17–8

$$\mathbf{Y} = \frac{1}{Z\angle \pm\theta} = Y\angle \pm\theta = G + jB_C - jB_L$$

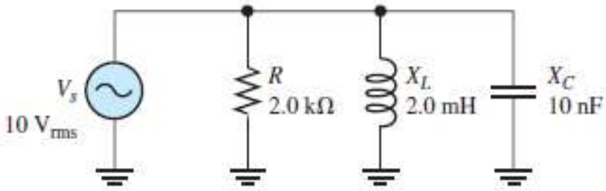
Equation 17–9 in polar form is

$$\mathbf{Y} = \sqrt{G^2 + (B_C - B_L)^2}\angle\tan^{-1}\left(\frac{B_C - B_L}{G}\right)$$

As you know, the unit of each of these quantities is the siemens (S).

For the *RLC* circuit in Figure 17–25 determine the conductance, capacitive susceptance, inductive susceptance, and total admittance at 20 kHz. Draw the admittance phasor diagram at 20 kHz and show a diagram of the frequency response of the circuit to 80 kHz.

► FIGURE 17–25



Solution The response of the circut at 20 kHz is solved by showing the explicit steps. Then the TI-84 Plus CE is then used to show the frequency response by a graphing calculator.

At 20 kHz:

$$X_C = \frac{1}{2\pi fC}$$

$$B_C = \frac{1}{X_C} = 2\pi fC = 2\pi(20\text{ kHz})(10\text{ nF}) = 1.26\text{ mS}$$

$$X_L = 2\pi fL$$

$$B_L = \frac{1}{X_L} = \frac{1}{2\pi fL} = \frac{1}{2\pi(20\text{ kHz})(2.0\text{ mH})} = 3.98\text{ mS}$$

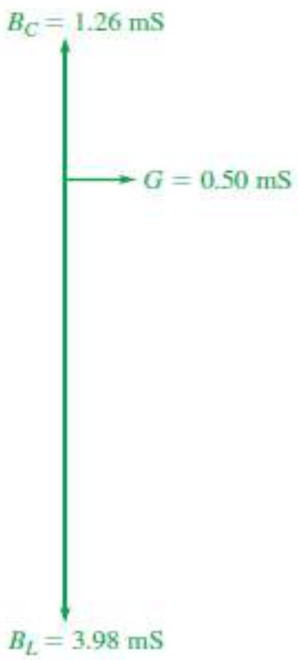
$$G = \frac{1}{R} = \frac{1}{2.0\text{ k}\Omega} = 0.50\text{ mS}$$

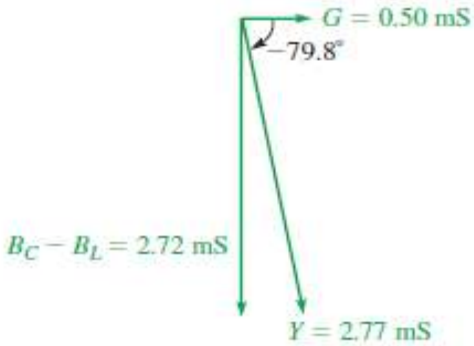
$$\mathbf{Y} = \sqrt{G^2 + (B_C - B_L)^2}\angle\tan^{-1}\left(\frac{B_C - B_L}{G}\right)$$

$$= \sqrt{0.50\text{ mS}^2 + (1.26\text{ mS} - 3.88\text{ mS})^2}\angle\tan^{-1}\left(\frac{1.26\text{ mS} - 3.98\text{ mS}}{0.50\text{ mS}}\right)$$

$$= \mathbf{2.77\text{ mS}\angle -79.6^\circ}$$

From the calculated values at 20 kHz, the admittance phasor diagram can be drawn as Figure 17–26.

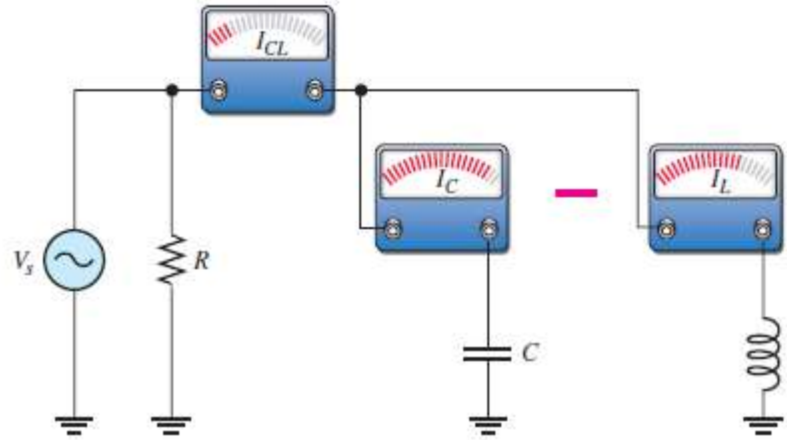

B_C = 1.26 mS
G = 0.50 mS
B_L = 3.98 mS


G = 0.50 mS
−79.8°
B_C − B_L = 2.72 mS
Y = 2.77 mS

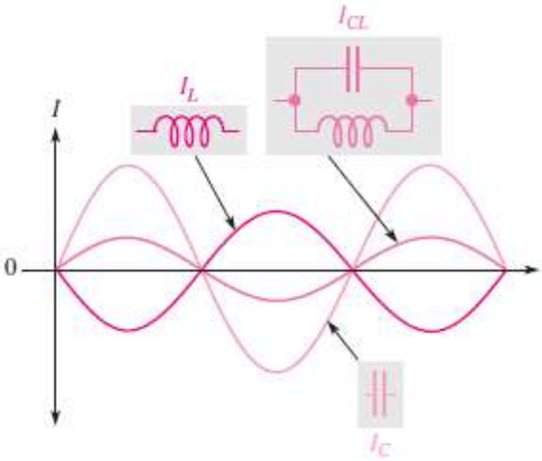
Recall that capacitive reactance varies inversely with frequency and that inductive reactance varies directly with frequency. In a parallel *RLC* circuit at low frequencies, the inductive reactance is less than the capacitive reactance; therefore, the circuit is inductive. As the frequency is increased, X_L increases and X_C decreases until a value is reached where $X_L = X_C$. This is the point of **parallel resonance**. As the frequency is increased further, X_C becomes smaller than X_L, and the circuit becomes capacitive.

Current Relationships

In a parallel *RLC* circuit, the current in the capacitive branch and the current in the inductive branch are *always* 180° out of phase with each other (neglecting any coil resistance). Because I_C and I_L add algebraically, the total current is actually the difference in their magnitudes. Thus, the total current into the parallel branches of L and C is always less than the largest individual branch current, as illustrated in Figure 17–28 and in the waveform diagram of Figure 17–29. Of course, the current in the resistive branch is always 90° out of phase with both reactive currents, as shown in the current phasor diagram of Figure 17–30. Notice that I_C is plotted on the positive y-axis and I_L is plotted on the negative y-axis.

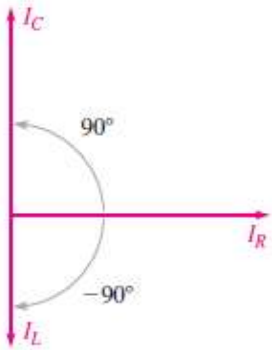


▲ FIGURE 17–28



◄ **FIGURE 17–29**

I_C and I_L effectively subtract.



◄ **FIGURE 17–30**

Typical current phasor diagram for a parallel *RLC* circuit.

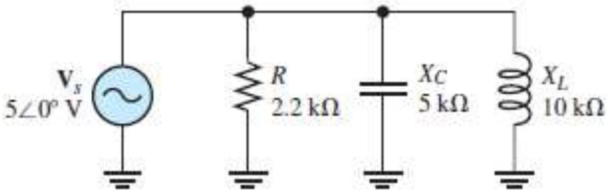
The total current can be expressed as

$$\mathbf{I}_{tot} = \sqrt{I_R^2 + (I_C - I_L)^2}\angle\tan^{-1}\left(\frac{I_{CL}}{I_R}\right)$$

6- الاسئلة البعدية

For the circuit in Figure 17–31 find each branch current and the total current. Draw a diagram of their relationship.

▶ FIGURE 17–31



Solution Use Ohm's law to find each branch current in phasor form.

$$\mathbf{I}_R = \frac{\mathbf{V}_s}{\mathbf{R}} = \frac{5\angle 0^\circ \text{ V}}{2.2\angle 0^\circ \text{ k}\Omega} = \mathbf{2.27\angle 0^\circ \text{ mA}}$$

$$\mathbf{I}_C = \frac{\mathbf{V}_s}{\mathbf{X}_C} = \frac{5\angle 0^\circ \text{ V}}{5\angle -90^\circ \text{ k}\Omega} = \mathbf{1\angle 90^\circ \text{ mA}}$$

$$\mathbf{I}_L = \frac{\mathbf{V}_s}{\mathbf{X}_L} = \frac{5\angle 0^\circ \text{ V}}{10\angle 90^\circ \text{ k}\Omega} = \mathbf{0.5\angle -90^\circ \text{ mA}}$$

The total current is the phasor sum of the branch currents. By Kirchhoff's law,

$$\mathbf{I}_{tot} = \mathbf{I}_R + \mathbf{I}_C + \mathbf{I}_L$$
$$= 2.27\angle 0^\circ \text{ mA} + 1\angle 90^\circ \text{ mA} + 0.5\angle -90^\circ \text{ mA}$$
$$= 2.27 \text{ mA} + j1 \text{ mA} - j0.5 \text{ mA} = 2.27 \text{ mA} + j0.5 \text{ mA}$$

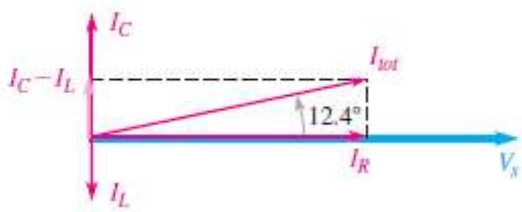
Converting to polar form yields

$$\mathbf{I}_{tot} = \sqrt{I_R^2 + (I_C - I_L)^2}\angle \tan^{-1}\left(\frac{I_{CL}}{I_R}\right)$$

$$= \sqrt{(2.27 \text{ mA})^2 + (0.5 \text{ mA})^2}\angle \tan^{-1}\left(\frac{0.5 \text{ mA}}{2.27 \text{ mA}}\right) = \mathbf{2.33\angle 12.4^\circ \text{ mA}}$$

The total current is 2.32 mA leading V_s by 12.4°. Figure 17–32 is the current phasor diagram for the circuit.

▶ FIGURE 17–32



في نهاية الحقيبة

- المصادر الاساسية :

- 1. Electrical Technology (Edward Hughes)
- 2 . Basic Circuits(A-M-F Brooks) pergaman press

- المصادر المقترحة:

- Principles of Electric Circuits Tenth Edition by Thomas L. Floyd
- Introductory Circuit Analysis-Prentice Hall by Robert L. Boylestad

المحتويات (لكل فصل في المقرر)

رقم المحاضرة:	11
• **عنوان المحاضرة**	دائرة الرنين التوازي
اسـم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
الهدف العام من المحاضرة •	دراسة سلوك رنين على توازي
الأهداف السلوكية او مخرجات التعلم: •	يستطيع الطالب ايجاد قيم فولتيات وتيارات في دائرة رنين على التوزاي
استراتيجيات التيسير المستخدمة	عرض التقديمي وامثلة محلولة
المهارات المكتسبة	التعرف على سلوك الرنين في دوائر تيار المتناوب
طرق القياس المعتمدة	امتحان التحريري ومناقشة

4 - الاسئلة القبلية

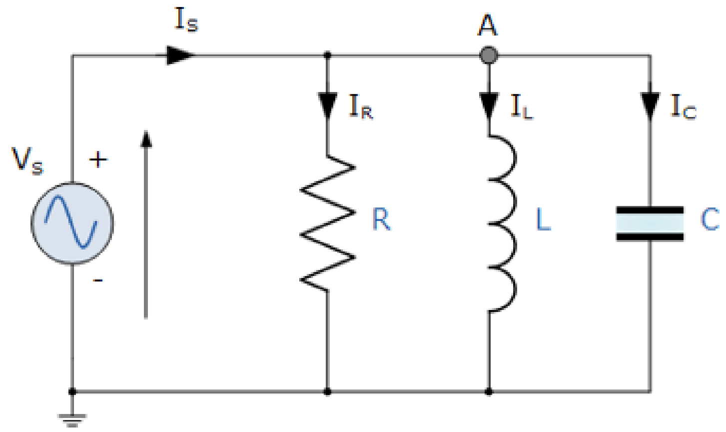
- ماذا نعني بالرنين ؟

5- المحتوى العلمي

The Parallel Resonance Circuit

In many ways a **parallel resonance** circuit is exactly the same as the series resonance circuit we looked at in the previous tutorial. Both are 3-element networks that contain two reactive components making them a second-order circuit, both are influenced by variations in the supply frequency and both have a frequency point where their two reactive components cancel each other out influencing the characteristics of the circuit. Both circuits have a resonant frequency point.

Parallel RLC Circuit



Let us define what we already know about parallel RLC circuits.

$$\text{Admittance, } Y = \frac{1}{Z} = \sqrt{G^2 - B^2}$$

$$\text{Conductance, } G = \frac{1}{R}$$

$$\text{Inductive Susceptance, } B_L = \frac{1}{2\pi f L}$$

$$\text{Capacitive Susceptance, } B_C = 2\pi f C$$

We know from the previous series resonance tutorial that resonance takes place when $V_L = -V_C$ and this situation occurs when the two reactances are equal, $X_L = X_C$. The admittance of a parallel circuit is given as:

$$Y = G + B_L + B_C$$

$$Y = \frac{1}{R} + \frac{1}{j\omega L} + j\omega C$$

or

$$Y = \frac{1}{R} + \frac{1}{2\pi f L} + 2\pi f C$$

Resonance occurs when $X_L = X_C$ and the imaginary parts of Y become zero. Then:

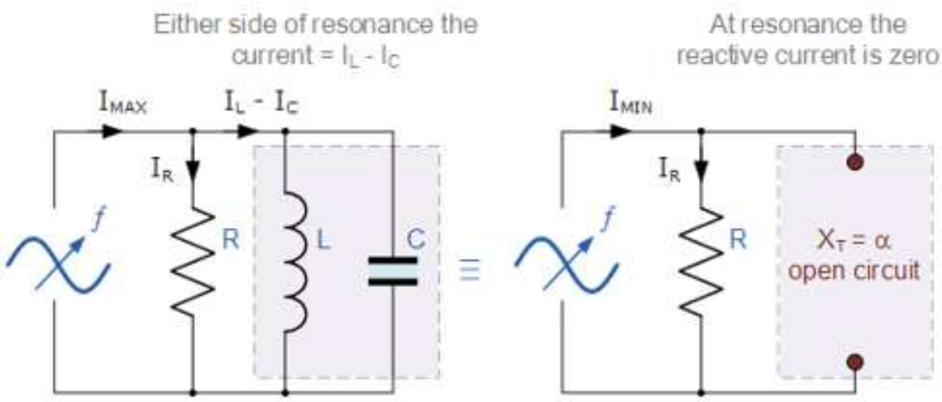
$$X_L = X_C \quad \Rightarrow \quad 2\pi f L = \frac{1}{2\pi f C}$$

$$f^2 = \frac{1}{2\pi L \times 2\pi C} = \frac{1}{4\pi^2 LC}$$

$$f = \sqrt{\frac{1}{4\pi^2 LC}}$$

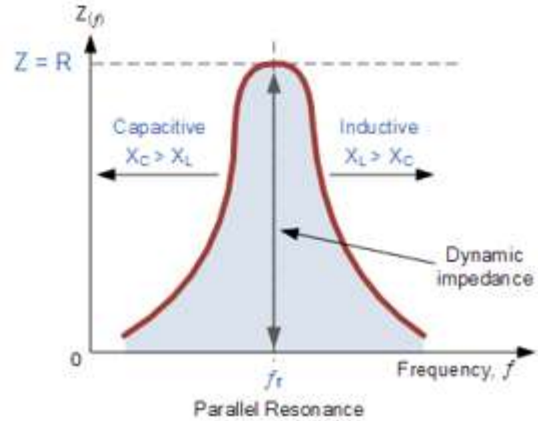
$$\therefore \ f_r = \frac{1}{2\pi\sqrt{LC}} \text{ (Hz)} \quad \text{or} \quad \omega_r = \frac{1}{\sqrt{LC}} \text{ (rads)}$$

So the total impedance of a parallel resonance circuit at resonance becomes just the value of the resistance in the circuit and Z = R as shown.

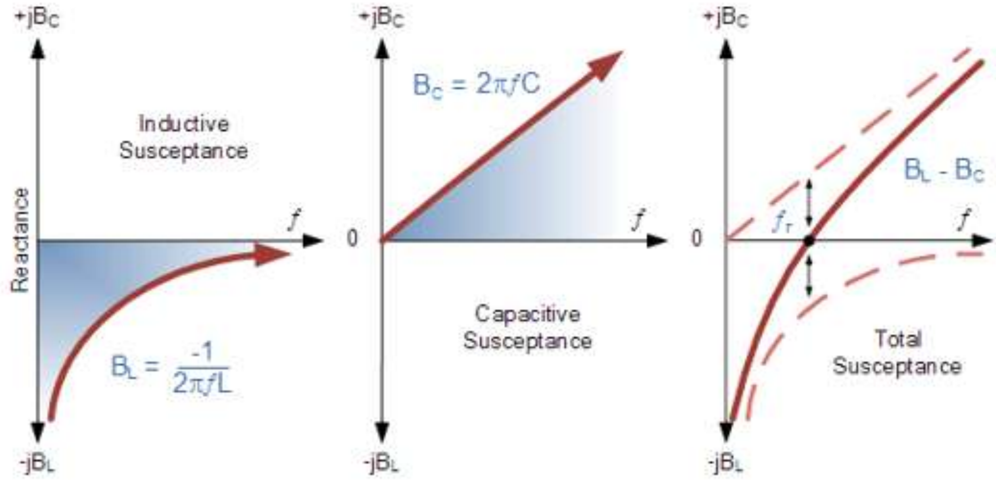


At resonance, the impedance of the parallel circuit is at its maximum value and equal to the resistance of the circuit. Also, the total circuit current, I will be "in-phase" with the supply voltage, V_S.

Impedance in a Parallel Resonance Circuit



Susceptance at Resonance



Current in a Parallel Resonance Circuit

As the total susceptance is zero at the resonant frequency, the admittance is at its minimum and is equal to the conductance, G. Therefore at resonance the current flowing through the circuit must also be at its minimum as the inductive and capacitive branch currents are equal (IL = IC) and are 180o out of phase.

the total current flowing in a parallel RLC circuit is equal to the vector sum of the individual branch currents and for a given frequency is calculated as:

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

$$I_L = \frac{V}{X_L} = \frac{V}{2\pi f L}$$

$$I_C = \frac{V}{X_C} = V.2\pi f C$$

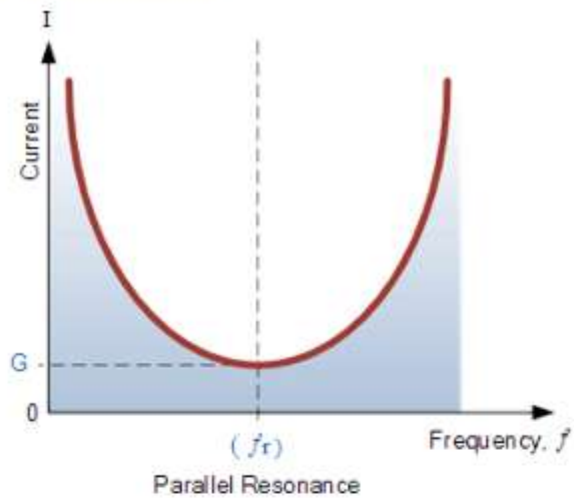
Therefore, I_T = vector sum of $(I_R + I_L + I_C)$

$$I_T = \sqrt{I_R^2 + (I_L + I_C)}$$

At resonance, currents I_L and I_L are equal and cancelling giving a net reactive current equal to zero. Then at resonance the above equation becomes.

$$I_T = \sqrt{I_R^2 + 0^2} = I_R$$

Parallel Circuit Current at Resonance



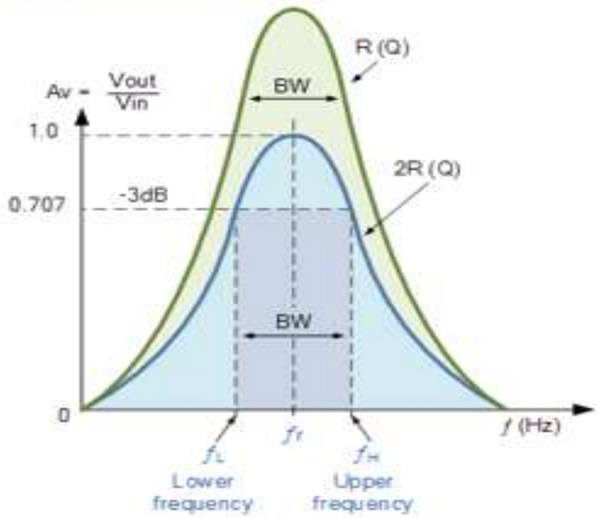
Bandwidth & Selectivity of a Parallel Resonance Circuit

The selectivity or **Q-factor** for a parallel resonance circuit is generally defined as the ratio of the circulating branch currents to the supply current and is given as:

$$\text{Quality Factor, } Q = \frac{R}{2\pi f L} = 2\pi f CR = R\sqrt{\frac{C}{L}}$$

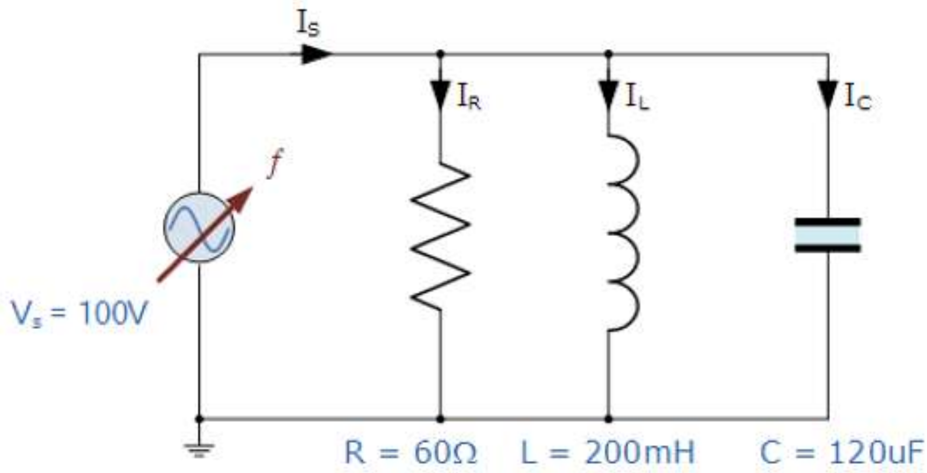
Note that the Q-factor of a parallel resonance circuit is the inverse of the expression for the Q-factor of the series circuit. Also in series resonance circuits the Q-factor gives the voltage magnification of the circuit, whereas in a parallel circuit it gives the current magnification.

Bandwidth of a Parallel Resonance Circuit



Parallel Resonance Example No1

A parallel resonance network consisting of a resistor of 60Ω, a capacitor of 120uF and an inductor of 200mH is connected across a sinusoidal supply voltage which has a constant output of 100 volts at all frequencies. Calculate, the resonant frequency, the quality factor and the bandwidth of the circuit, the circuit current at resonance and current magnification.



Resonant Frequency, f_r

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.2.120.10^{-6}}} = 32.5\text{Hz}$$

Inductive Reactance at Resonance, X_L

$$X_L = 2\pi fL = 2\pi.32.5.0.2 = 40.8\Omega$$

Quality factor, Q

$$Q = \frac{R}{X_L} = \frac{R}{2\pi fL} = \frac{60}{40.8} = 1.47$$

Bandwidth, BW

$$BW = \frac{f_r}{Q} = \frac{32.5}{1.47} = 22\text{Hz}$$

The upper and lower -3dB frequency points, f_H and f_L

$$f_L = f_r - \frac{1}{2}BW = 32.5 - \frac{1}{2}(22) = 21.5\text{Hz}$$

$$f_H = f_r + \frac{1}{2}BW = 32.5 + \frac{1}{2}(22) = 43.5\text{Hz}$$

Circuit Current at Resonance, I_T

At resonance the dynamic impedance of the circuit is equal to R

$$I_T = I_R = \frac{V}{R} = \frac{100}{60} = 1.67A$$

Current Magnification, I_{mag}

$$I_{MAG} = Q \times I_T = 1.47 \times 1.67 = 2.45A$$

We can check this value by calculating the current flowing through the inductor (or capacitor) at resonance.

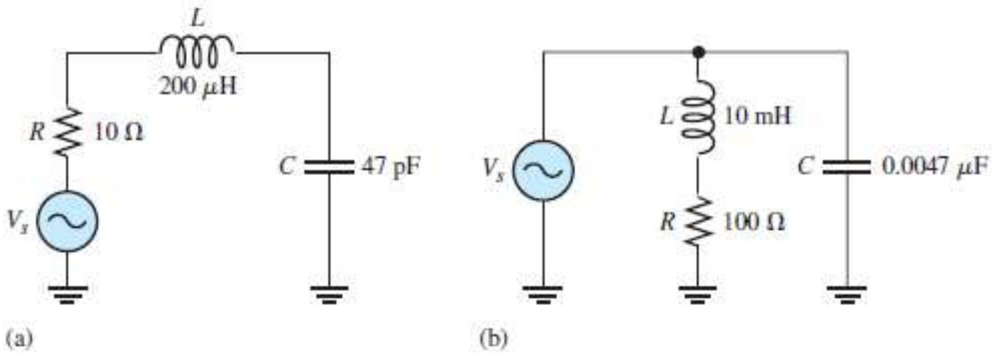
$$I_L = \frac{V}{X_L} = \frac{V}{2\pi fL} = \frac{100}{2\pi.32.5.0.2} = 2.45A$$

Resonant Frequency using Impure Components

$$f_r = \frac{1}{2\pi}\sqrt{\left(\frac{1}{LC} - \frac{R^2}{L^2}\right)}$$

6- الاسئلة البعدية

What is the bandwidth of each circuit in Figure 17–55?



▲ FIGURE 17–55

For the circuit in Figure 17–55(a), determine the bandwidth as follows:

$$fr = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(200\,\mu\text{H})(47\,\text{pF})}} = 1.64\,\text{MHz}$$

$$X_L = 2\pi f_r L = 2\pi(1.64\,\text{MHz})(200\,\mu\text{H}) = 2.06\,\text{k}\Omega$$

$$Q = \frac{X_L}{R} = \frac{2.06\,\text{k}\Omega}{10\,\Omega} = 206$$

$$BW = \frac{f_r}{Q} = \frac{1.64\,\text{MHz}}{206} = 7.96\text{ kHz}$$

For the circuit in Figure 17–55(b),

$$f_r = \frac{\sqrt{1-(R_W^2C/L)}}{2\pi\sqrt{LC}} \cong \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(10\,\text{mH})(0.0047\,\mu\text{F})}} 23.2\text{ kHz}$$

$$X_L = 2\pi f_r L = 2\pi(23.2\text{ kHz})(10\text{ mH}) = 1.46\text{ k}\Omega$$

$$Q = \frac{X_L}{R} = \frac{1.46\text{ k}\Omega}{100\,\Omega} = 14.6$$

$$BW = \frac{f_r}{Q} = \frac{23.2\text{ kHz}}{14.6} = 1.59\text{ kHz}$$

في نهاية الحقيبة

لمصادر الاساسية :

- **1 .Electrical Technology (Edward Hughes)**
- **2 . Basic Circuits(A-M-F Brooks) pergaman press**

المصادر المقترحة:

- **Principles of Electric Circuits Tenth Edition by Thomas L. Floyd**
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المحتويات (لكل فصل في المقرر)

رقم المحاضرة:	**12**
• **عنوان المحاضرة**	نظرية ثفنن
اسـم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
• **الهدف العام من المحاضرة**	دراسة نظرية ثفنن في دوائر التيار متناوب
الأهداف السلوكية او مخرجات التعلم:	يستطيع الطالب أن يطبق نظرية ثفنن على دوائر تيار متناوب

استراتيجيات التيسير المستخدمة	عرض التقديمي وامثلة محلولة
المهارات المكتسبة	تطبيق نظرية ثفنن على دوائر تيار متناوب
طرق القياس المعتمدة	امتحان التحريري ومناقشة

4 - الاسئلة القبلية

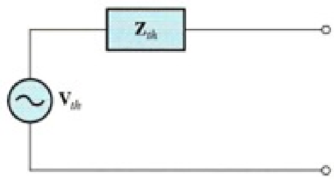
- كيف يتم تطبيق نظرية ثفنن في دوائر تيار المستمر ؟

5- المحتوى العلمي

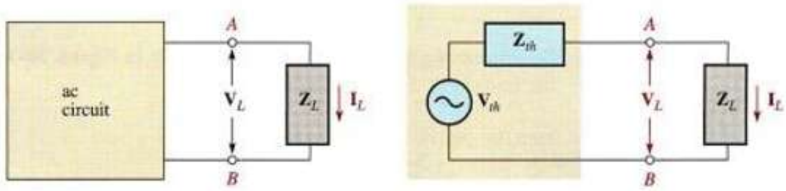
THEVENIN'S THEOREM

Thevenin's theorem, as applied to ac circuits, provides a method for reducing any circuit to an equivalent form that consists of an equivalent ac voltage source in series with an equivalent impedance.

The equivalent voltage source is designated ; the equivalent impedance is designated . Notice that the impedance is represented by a block in the circuit diagram. This is because the equivalent impedance can be of several forms: purely resistive, purely capacitive, purely inductive, or a combination of a resistance and a reactance.

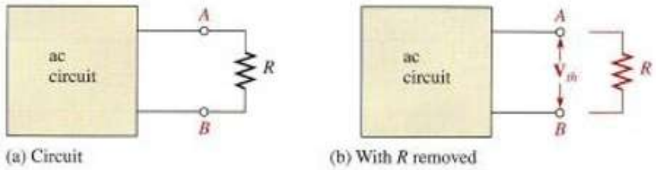


Thevenin's equivalent circuit.



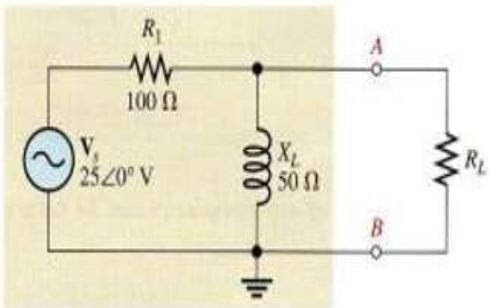
An ac circuit of any complexity can be reduced to a Thevenin equivalent for analysis purposes.

Thevenin's equivalent voltage is defined as the open circuit voltage between two specified terminals in a circuit.



How V_{th} is determined.

EXAMPLE Determine V_{th} for the circuit external to R_L in Figure The beige area identifies the portion of the circuit to be thevenized.

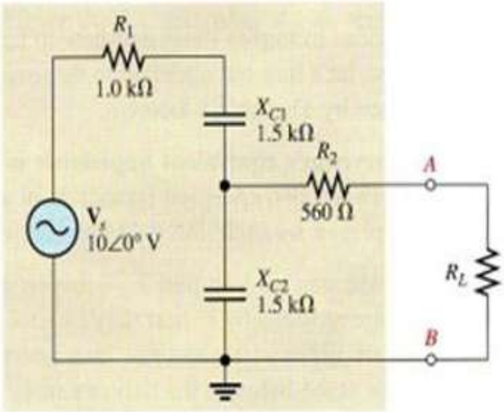


Solution Remove R_L and determine the voltage from A to B (V_{th}). In this case, the voltage from A to B is the same as the voltage across X_L. This is determined using the voltage-divider method.

$$V_L = \left(\frac{X_L\angle 90^\circ}{R_1 + jX_L}\right)V_s = \left(\frac{50\angle 90^\circ\ \Omega}{112\angle 26.6^\circ\ \Omega}\right)25\angle 0^\circ\ V = 11.2\angle 63.4^\circ\ V$$

$$V_{th} = V_{AB} = V_L = \mathbf{11.2\angle 63.4^\circ\ V}$$

EXAMPLE For the circuit in Figure , determine the Thevenin voltage as seen by R_L.



Solution Thevenin's voltage for the circuit between terminals A and B is the voltage that appears across A and B with R_L removed from the circuit.

There is no voltage drop across R_2 because the open across terminals A and B prevents current through it. Thus, $\mathbf{V}_{AB}$ is the same as $\mathbf{V}_{C2}$ and can be found by the voltage-divider formula.

$$\mathbf{V}_{AB} = \mathbf{V}_{C2} = \left(\frac{X_{C2}\angle -90^\circ}{R_1 - jX_{C1} - jX_{C2}}\right)\mathbf{V}_s = \left(\frac{1.5\angle -90^\circ \text{ k}\Omega}{1.0 \text{ k}\Omega - j3 \text{ k}\Omega}\right)10\angle 0^\circ \text{ V}$$

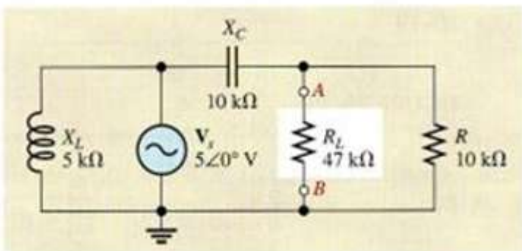
$$= \left(\frac{1.5\angle -90^\circ \text{ k}\Omega}{3.16\angle -71.6^\circ \text{ k}\Omega}\right)10\angle 0^\circ \text{ V} = 4.75\angle -18.4^\circ \text{ V}$$

$$\mathbf{V}_{th} = \mathbf{V}_{AB} = \mathbf{4.75\angle -18.4^\circ \text{ V}}$$

Related Problem Determine $\mathbf{V}_{th}$ if R_1 is changed to 2.2 kΩ

EXAMPLE For Figure , find $\mathbf{V}_{th}$ for the circuit external to R_L.

FIGURE 20–17



Solution First remove R_L and determine the voltage across the resulting open terminals, which is $\mathbf{V}_{th}$. Find $\mathbf{V}_{th}$ by applying the voltage-divider formula to X_C and R.

$$\mathbf{V}_{th} = \mathbf{V}_R = \left(\frac{R\angle 0^\circ}{R - jX_C}\right)\mathbf{V}_s = \left(\frac{10\angle 0^\circ \text{ k}\Omega}{10 \text{ k}\Omega - j10 \text{ k}\Omega}\right)5\angle 0^\circ \text{ V}$$

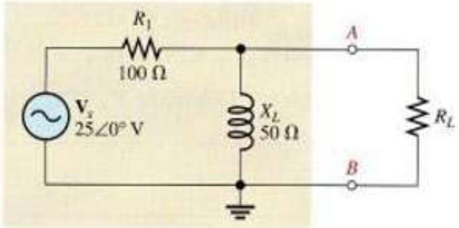
$$= \left(\frac{10\angle 0^\circ \text{ k}\Omega}{14.14\angle -45^\circ \text{ k}\Omega}\right)5\angle 0^\circ \text{ V} = \mathbf{3.54\angle 45^\circ \text{ V}}$$

Notice the L has no effect on the result, since the 5 V source appears across C and R in combination.

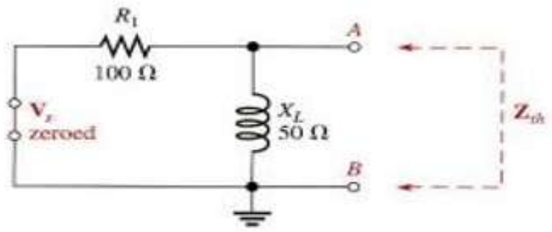
Related Problem Find $\mathbf{V}_{th}$ if R is 22 kΩ and R_L is 39 kΩ in Figure .

Thevenin's equivalent impedance is the total impedance appearing between two specified terminals in a given circuit with all sources replaced by their internal impedances.

EXAMPLE Find $\mathbf{Z}_{th}$ for the part of the circuit in Figure that is external to R_L.



Solution First, replace $\mathbf{V}_s$ with its internal impedance (zero), as shown in Figure



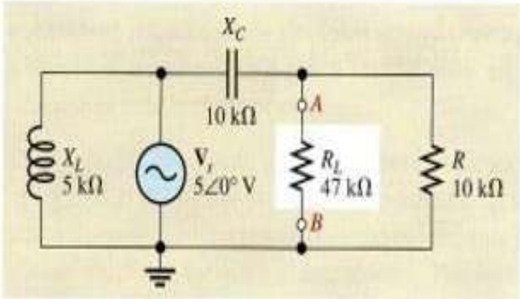
Looking in between terminals A and B, R and X_L are in parallel. Thus,

$$\mathbf{Z}_{th} = \frac{(R_1\angle 0°)(X_L\angle 90°)}{R_1 + jX_L} = \frac{(100\angle 0°\ \Omega)(50\angle 90°\ \Omega)}{100\ \Omega + j50\ \Omega}$$

$$= \frac{(100\angle 0°\ \Omega)(50\angle 90°\ \Omega)}{112\angle 26.6°\ \Omega} = \mathbf{44.6\angle 63.4°\ \Omega}$$

Related Problem Change R_1 to 47 Ω and determine $\mathbf{Z}_{th}$.

EXAMPLE For the circuit in Figure , determine $\mathbf{Z}_{th}$ for the portion of the circuit external to R_L. This is the same circuit as in Example 20–6.

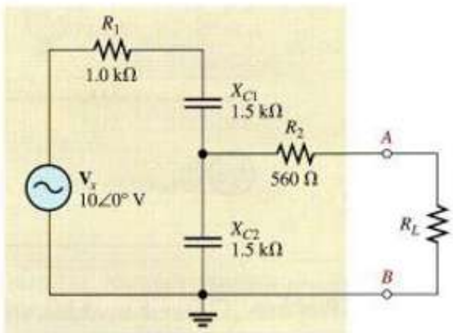


Solution With the voltage source replaced by its internal impedence (zero), X_L is effectively out of the circuit. R and C appear in parallel when viewed from the open terminals, as indicated in Figure . $\mathbf{Z}_{th}$ is calculated as follows:

$$\mathbf{Z}_{th} = \frac{(R\angle 0^\circ)(X_C\angle -90^\circ)}{R - jX_C} = \frac{(10\angle 0^\circ\ \text{k}\Omega)(10\angle -90^\circ\ \text{k}\Omega)}{14.1\angle -45^\circ\ \text{k}\Omega} = \mathbf{7.07\angle -45^\circ\ k\Omega}$$

6- الاسئلة البعدية

EXAMPLE For the circuit in Figure sketch the Thevenin equivalent circuit external to R_L.



Solution From Examples and , respectively, $\mathbf{V}_{th} = 4.75\angle -18.4^\circ$ V and $\mathbf{Z}_{th} = 1138\angle -46.4^\circ\ \Omega$. In rectangular form, the impedance is

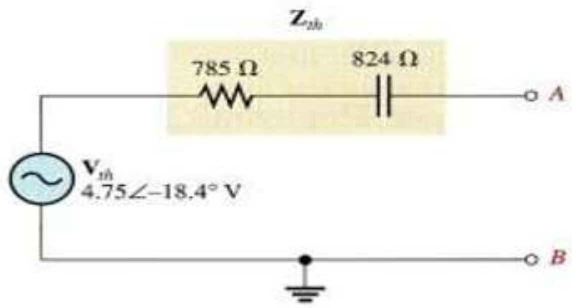
$$\mathbf{Z}_{th} = 785\ \Omega - j824\ \Omega$$

The Thevenin equivalent circuit is shown in Figure .

Solution From Examples and respectively, $\mathbf{V}_{th} = 4.75\angle{-18.4°}$ V and $\mathbf{Z}_{th} = 1138\angle{-46.4°}\ \Omega$. In rectangular form, the impedance is

$$\mathbf{Z}_{th} = 785\ \Omega - j824\ \Omega$$

The Thevenin equivalent circuit is shown in Figure .



في نهاية الحقيبة

-
- لمصادر الاساسية :

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-

المحتويات (لكل فصل في المقرر)

رقم المحاضرة:13	
•	نظرية نورتن
اســم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
• **الهدف العام من المحاضرة** •	دراسة نظرية نورتن في دوائر التيار متناوب
الأهداف السلوكية او مخرجات التعلم:	يستطيع الطالب أن يطبق نظرية نورتن على دوائر تيار متناوب
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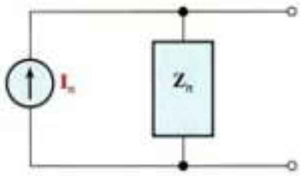
4 - الاسئلة القبلية

كيف يتم تطبيق نظرية نورتن في دوائر تيار المستمر ؟

5- المحتوى العلمي

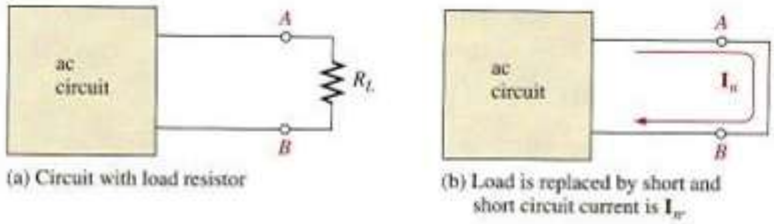
NORTON'S THEOREM

The form of Norton's equivalent circuit is shown in Figure . Regardless of how complex the original circuit is, it can be reduced to this equivalent form. The equivalent current source is designated I_n, and the equivalent impedance is Z_n. Nortons theorem shows you how to find and Z_n. Once they are known, simply connect them in parallel to get the complete Norton equivalent circuit.



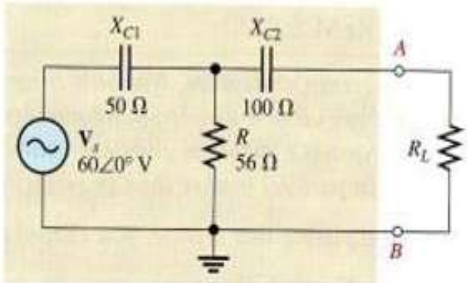
Norton equivalent circuit.

is one part of the Norton equivalent circuit ;is the other part . Norton's equivalent current is defined as the short-circuit current between two specified terminals in a given circuit.

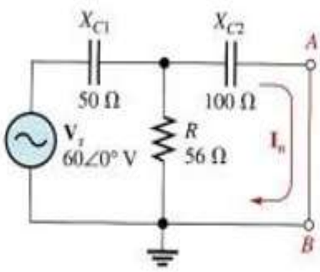


How I_n is determined.

EXAMPLE In Figure , determine I_n for the circuit as "seen" by the load resistor. The beig area identifies the portion of the circuit to be nortonized.



Solution Short the terminals A and B, as shown in Figure .

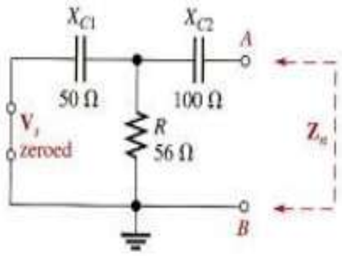


Norton's Equivalent Impedance (Zn)

is defined the same as Z_{th} is the total impedance appearing between two specified terminals of a given circuit viewed from the open terminals with all sources replaced by their internal impedances.

EXAMPLE Find $\mathbf{Z}_n$ for the circuit in Figure viewed from the open across terminals A and B.

Solution First, replace $\mathbf{V}_s$ with its internal impedance (zero), as indicated in Figure



Looking in between terminals A and B, C_2 is in series with the parallel combination of R and C_1. Thus,

$$\mathbf{Z}_n = \mathbf{X}_{C2} + \frac{\mathbf{R}\mathbf{X}_{C1}}{\mathbf{R} + \mathbf{X}_{C1}} = 100\angle{-90^\circ}\ \Omega + \frac{(56\angle 0^\circ\ \Omega)(50\angle{-90^\circ}\ \Omega)}{56\ \Omega - j50\ \Omega}$$
$$= 100\angle{-90^\circ}\ \Omega + 37.3\angle{-48.2^\circ}\ \Omega$$
$$= -j100\ \Omega + 24.8\ \Omega - j27.8\ \Omega = \mathbf{24.8\ \Omega - j128\ \Omega}$$

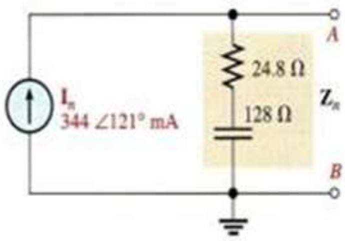
The Norton equivalent impedance is a 24.8 Ω resistance in series with a 128 Ω capacitive reactance.

Related Problem Find $\mathbf{Z}_n$ in Figure if $\mathbf{V}_s = 25\angle 0^\circ$ V and $R = 33\ \Omega$.

EXAMPLE

Show the complete Norton equivalent circuit for the circuit in Figure

Solution From Examples $\mathbf{I}_n = 344\angle 121^\circ$ mA and $\mathbf{Z}_n = 24.8\ \Omega - j128\ \Omega$. The Norton equivalent circuit is shown in Figure



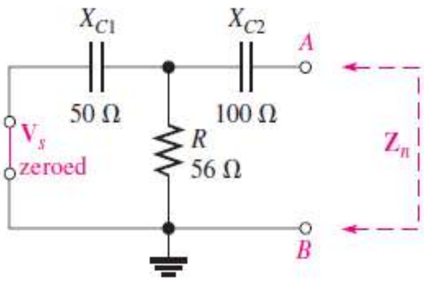
Related Problem Show the Norton equivalent for the circuit in Figure if $\mathbf{V}_s = 25\angle 0^\circ$ V and $R = 33\ \Omega$.

6- الاسئلة البعدية

Find $\mathbf{Z}_n$ for the circuit in Figure 19–33 (Example 19–13) viewed from the open across terminals *A* and *B*.

Solution First, replace $\mathbf{V}_s$ with its internal impedance (zero), as indicated in Figure 19–35.

▶ FIGURE 19–35



Looking in between terminals *A* and *B*, C_2 is in series with the parallel combination of *R* and C_1. Thus,

$$\mathbf{Z}_n = \mathbf{X}_{C2} + \frac{\mathbf{R}\mathbf{X}_{C1}}{\mathbf{R} + \mathbf{X}_{C1}} = 100\angle -90^\circ\ \Omega + \frac{(56\angle 0^\circ\ \Omega)(50\angle -90^\circ\ \Omega)}{56\ \Omega - j50\ \Omega}$$
$$= 100\angle -90^\circ\ \Omega + 37.3\angle -48.2^\circ\ \Omega$$
$$= -j100\ \Omega + 24.8\ \Omega - j27.8\ \Omega = \mathbf{24.8\ \Omega - j128\ \Omega}$$

The Norton equivalent impedance is a 24.8 Ω resistance in series with a 128 Ω capacitive reactance.

في نهاية الحقيبة

- **المصادر الاساسية :**

- **1 Electrical Technology (Edward Hughes)**
- **2. Basic Circuits(A-M-F Brooks) pergaman press**

- **المصادر المقترحة:**

- **Principles of Electric Circuits Tenth Edition by Thomas L. Floyd**
- **Introductory Circuit Analysis-Prentice Hall by Robert L. Boylestad**

-

رقم المحاضرة:	**14**
عنوان المحاضرة	نظرية نقل اعظم قدرة
اسـم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
• **الهدف العام من المحاضرة**	دراسة نظرية اعظم قدرة في دوائر التيار متناوب
الأهداف السلوكية او مخرجات التعلم	تطبيق نظرية اعظم قدرة على دوائر تيار متناوب

استراتيجيات التيسير المستخدمة	عرض التقديمي وامثلة محلولة
المهارات المكتسبة	تطبيق نظرية اعظم قدرة على دوائر تيار متناوب
طرق القياس المعتمدة	امتحان التحريري ومناقشة

4 - الاسئلة القبلية

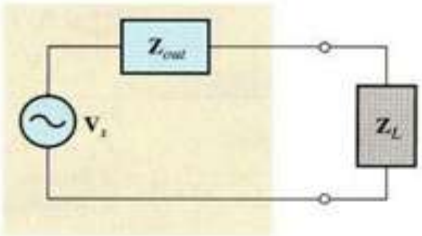
كيف يتم تطبيق نظرية اعظم قدرة في دوائر تيار المستمر ؟

5- المحتوى العلمي

MAXIMUM POWER TRANSFER THEOREM

When a load is connected to a circuit, maximum power is transferred to the load when the loud impedance is the complex conjugate of the circuit's output impedance.

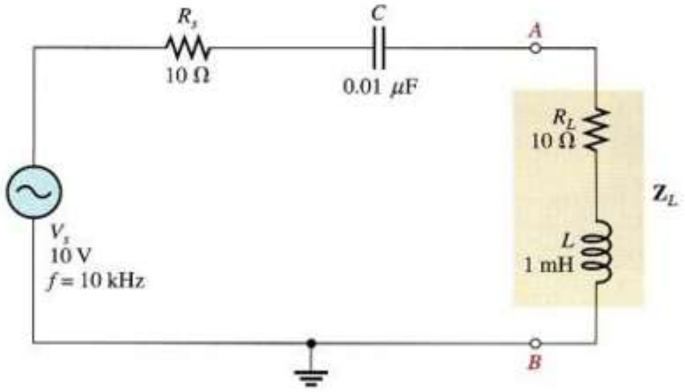
The complex conjugate of $R - jX_C$ is $R + jX_L$, where the resistances and the reactance's are equal in magnitude. The output impedance is effectively Thevenin's equivalent impedance viewed from the output terminals. When Z_L is the complex conjugate of Z_{out}, maximum power is transferred from the circuit to the load with a power factor of 1. An equivalent circuit with its output impedance and load is shown in Figure.



Equivalent circuit with load.

Example shows that maximum power occurs when the impedances are conjugate matched.

EXAMPLE The circuit to the left of terminals A and B in Figure provides power to the load $\mathbf{Z}_L$. This can be viewed as simulating a power amplifier delivering power to a complex load. It is the Thevenin equivalent of a more complex circuit. Calculate and plot a graph of the power delivered to the load for each of the following frequencies: 10 kHz, 30 kHz, 50 kHz, 80 kHz, and 100 kHz.



Solution For $f = 10$ kHz,

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(10\text{ kHz})(0.01\ \mu\text{F})} = 1.59\text{ k}\Omega$$

$$X_L = 2\pi fL = 2\pi(10\text{ kHz})(1\text{ mH}) = 62.8\ \Omega$$

The magnitude of the total impedance is

$$Z_{tot} = \sqrt{(R_s + R_L)^2 + (X_L - X_C)^2} = \sqrt{(20\ \Omega)^2 + (1.53\text{ k}\Omega)^2} = 1.53\text{ k}\Omega$$

The current is

$$I = \frac{V_s}{Z_{tot}} = \frac{10\text{ V}}{1.53\text{ k}\Omega} = 6.54\text{ mA}$$

The load power is

$$P_L = I^2R_L = (6.54\text{ mA})^2(10\ \Omega) = \mathbf{428\ \mu W}$$

For $f = 30$ kHz,

$$X_C = \frac{1}{2\pi(30\text{ kHz})(0.01\ \mu\text{F})} = 531\ \Omega$$

$$X_L = 2\pi(30\text{ kHz})(1\text{ mH}) = 189\ \Omega$$

$$Z_{tot} = \sqrt{(20\ \Omega)^2 + (342\ \Omega)^2} = 343\ \Omega$$

$$I = \frac{V_s}{Z_{tot}} = \frac{10\text{ V}}{343\ \Omega} = 29.2\text{ mA}$$

$$P_L = I^2R_L = (29.2\text{ mA})^2(10\ \Omega) = \mathbf{8.53\ mW}$$

For $f = 50$ kHz,

$$X_C = \frac{1}{2\pi(50\text{ kHz})(0.01\ \mu\text{F})} = 318\ \Omega$$

$$X_L = 2\pi(50\text{ kHz})(1\text{ mH}) = 314\ \Omega$$

Note that X_C and X_L are very close to being equal which makes the impedances approximately complex conjugates. The exact frequency at which $X_L = X_C$ is 50.3 kHz.

$$Z_{tot} = \sqrt{(20\ \Omega)^2 + (4\ \Omega)^2} = 20.4\ \Omega$$

$$I = \frac{V_s}{Z_{tot}} = \frac{10\text{ V}}{20.4\ \Omega} = 490\text{ mA}$$

$$P_L = I^2R_L = (490\text{ mA})^2(10\ \Omega) = \mathbf{2.40\ W}$$

For $f = 80$ kHz,

$$X_C = \frac{1}{2\pi(80\text{ kHz})(0.01\ \mu\text{F})} = 199\ \Omega$$

$$X_L = 2\pi(80\text{ kHz})(1\text{ mH}) = 503\ \Omega$$

$$Z_{tot} = \sqrt{(20\ \Omega)^2 + (304\ \Omega)^2} = 305\ \Omega$$

$$I = \frac{V_s}{Z_{tot}} = \frac{10\text{ V}}{305\ \Omega} = 32.8\text{ mA}$$

$$P_L = I^2R_L = (32.8\text{ mA})^2(10\ \Omega) = \mathbf{10.8\ mW}$$

For $f = 100$ kHz,

$$X_C = \frac{1}{2\pi(100\text{ kHz})(0.01\ \mu\text{F})} = 159\ \Omega$$

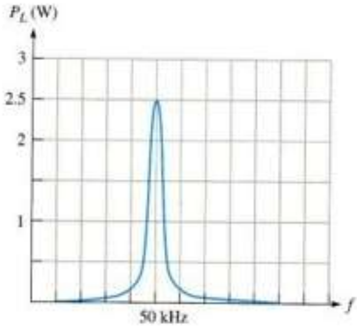
$$X_L = 2\pi(100\text{ kHz})(1\text{ mH}) = 628\ \Omega$$

$$Z_{tot} = \sqrt{(20\ \Omega)^2 + (469\ \Omega)^2} = 469\ \Omega$$

$$I = \frac{V_s}{Z_{tot}} = \frac{10\text{ V}}{469\ \Omega} = 21.3\text{ mA}$$

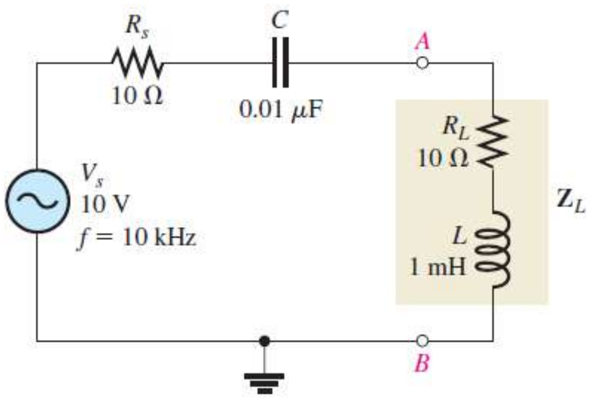
$$P_L = I^2R_L = (21.3\text{ mA})^2(10\ \Omega) = \mathbf{4.54\ mW}$$

As you can see from the results, the power to the load peaks at the frequency(50 kHz) for which the load impedance is the complex conjugate of the output impedance (when the reactances are equal in magnitude). A graph of the load power versus frequency is shown in Figure . Since the maximum power is so much larger than the other values, an accurate plot is difficult to achieve without intermediate values.



6- الاسئلة البعدية

The circuit to the left of terminals A and B in Figure 19–39 provides power to the load $\mathbf{Z}_L$. This can be viewed as simulating a power amplifier delivering power to a complex load. It is the Thevenin equivalent of a more complex circuit. Calculate and plot a graph of the power delivered to the load at 10 kHz intervals starting at 10 kHz going to 100 kHz.



Solution For the first frequency (10 kHz), the solution is shown in detail. Then the TI-84 Plus CE calculator is used to solve the other frequencies.

For $f = 10$ kHz,

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(10\text{ kHz})(0.01\ \mu\text{F})} = 1.59\text{ k}\Omega$$

$$X_L = 2\pi fL = 2\pi(10\text{ kHz})(1\text{ mH}) = 62.8\ \Omega$$

The magnitude of the total impedance is

$$Z_{tot} = \sqrt{(R_s + R_L)^2 + (X_L - X_C)^2} = \sqrt{(20\ \Omega)^2 + (1.53\text{ k}\Omega)^2} = 1.53\text{ k}\Omega$$

The current is

$$I = \frac{V_s}{Z_{tot}} = \frac{10\text{ V}}{1.53\text{ k}\Omega} = 6.54\text{ mA}$$

The load power is

$$P_L = I^2R_L = (6.54\text{ mA})^2(10\ \Omega) = \mathbf{428\ \mu W}$$

في نهاية الحقيبة

- **المصادر الاساسية :**

- **1. Electrical Technology (Edward Hughes)**

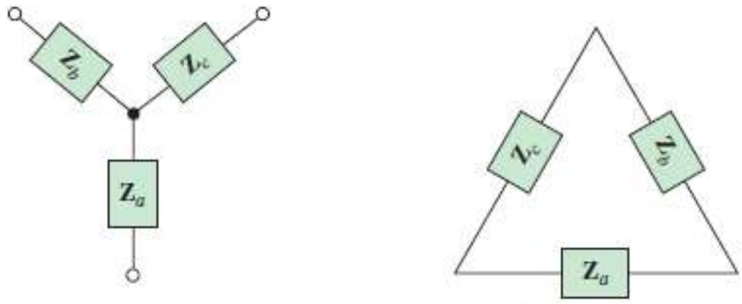
- 2 .Basic Circuits(A-M-F Brooks) pergaman press
- **المصادر المقترحة:**
- **Principles of Electric Circuits Tenth Edition by Thomas L. Floyd**
- **Introductory Circuit Analysis-Prentice Hall by Robert L. Boylestad**

رقم المحاضرة:	**15**
عنوان المحاضرة	نظام ثلاثي الطور
اسـم المدرس:	زيد خلف
الفئة المستهدفة :	طلبة معهد
الهدف العام من المحاضرة	تحليل نظام ثلاثي الطور
الأهداف السلوكية او مخرجات التعلم:	ايجاد فولتيات والتيارات والاحمال خاصة بنظام ثلاثي الطور
استراتيجيات التيسير المستخدمة	عرض التقديمي وامثلة محلولة
المهارات المكتسبة	تحليل نظام ثلاثي الطور
طرق القياس المعتمدة	امتحان التحريري ومناقشة

4 - الاسئلة القبلية

- هل لديك فكرة عن تكامل الدوال الجبرية ؟

5- المحتوى العلمي



(a) Y-connected load (b) Δ-connected load

The Y-Y System

Figure 21–20 shows a Y-connected source driving a Y-connected load. The load can be a balanced load, such as a three-phase motor where $\mathbf{Z}_a = \mathbf{Z}_b = \mathbf{Z}_c$, or it can be three independent single-phase loads where, for example, $\mathbf{Z}_a$ is a lighting circuit, $\mathbf{Z}_b$ is a heater, and $\mathbf{Z}_c$ is an air-conditioning compressor.

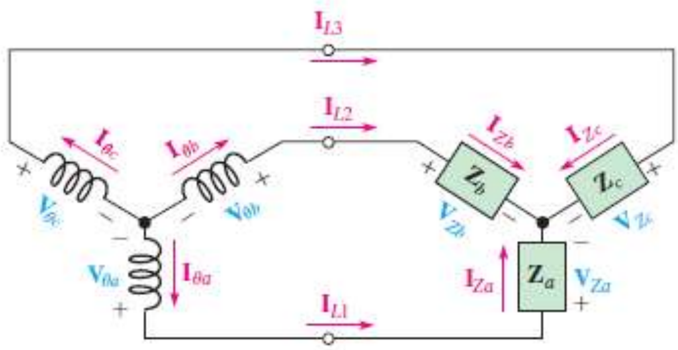


FIGURE 21–20

A Y-connected source driving a Y-connected load.

An important feature of a Y-connected source is that two different values of three-phase voltage are available: the phase voltage and the line voltage. For example, in the standard power distribution system, a three-phase transformer can be considered a source of three-phase voltage supplying 120 V and 208 V. In order to utilize a phase voltage of 120 V, the loads are connected in the Y configuration. A Δ-connected load is used for the 208 V line voltages.

Notice in the Y-Y system in Figure 21–20 that the phase current, the line current, and the load current are all equal in each phase. Also, each load voltage equals the corresponding phase voltage. These relationships are expressed as follows and are true for either a balanced or an unbalanced load.

$$I_\theta = I_L = I_Z$$

$$V_\theta = V_Z$$

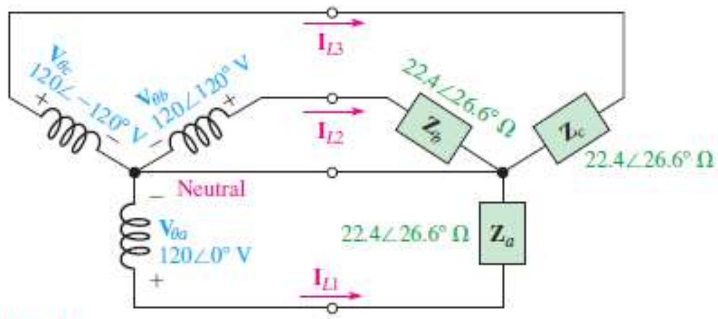
where V_Z and I_Z are the load voltage and current, respectively.

For a balanced load, all the phase currents are equal, and the neutral current is zero. For an unbalanced load, each phase current is different, and the neutral current is, therefore, nonzero. Although a small imbalance in loads is common, a large imbalance sacrifices the advantages of a three-phase system.

In the Y-Y system of Figure 21–21, determine the following:

(a) Each load current **(b)** Each line current **(c)** Each phase current

(d) Neutral current **(e)** Each load voltage



▲ FIGURE 21–21

Solution This system has a balanced load. $\mathbf{Z}_a = \mathbf{Z}_b = \mathbf{Z}_c = 22.4\angle 26.6^\circ\ \Omega$.

(a) The load currents are

$$\mathbf{I}_{Za} = \frac{\mathbf{V}_{\theta a}}{\mathbf{Z}_a} = \frac{120\angle 0^\circ\ \text{V}}{22.4\angle 26.6^\circ\ \Omega} = \mathbf{5.36\angle -26.6^\circ\ A}$$

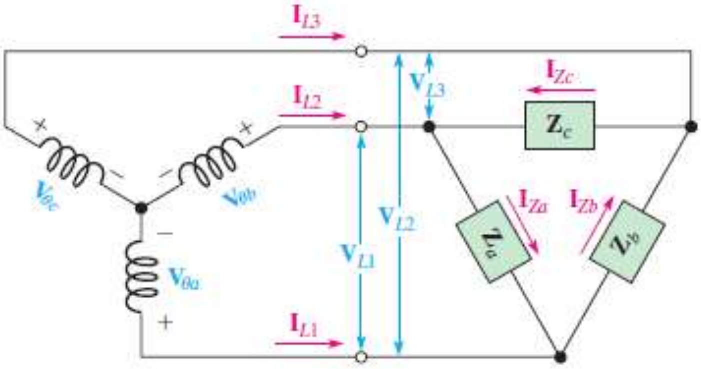
The Y-Δ System

Figure 21–22 shows a Y-connected source driving a Δ-connected load. An important feature of this configuration is that each phase of the load has the full line voltage across it.

$$V_Z = V_L$$

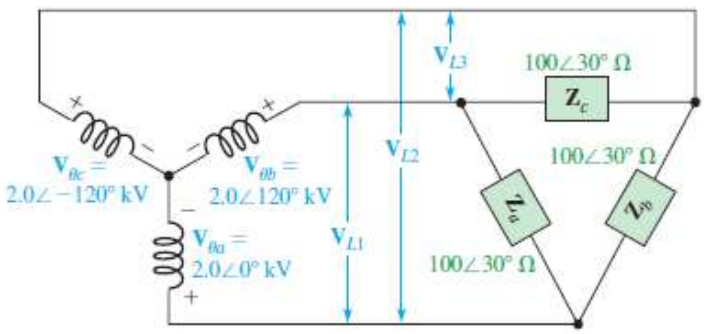
The line currents equal the corresponding phase currents, and each line current divides into two load currents, as indicated. For a balanced load ($Z_a = Z_b = Z_c$), the expression for the current in each load is

$$I_L = \sqrt{3} I_Z$$



You might wonder about the $\sqrt{3}$ in Equation 21–8. It occurs with a balanced load as a consequence of applying Kirchhoff's Current Law to any of the three junctions on the delta.

Determine the load voltages and load currents in Figure 21–23, and show their relationship in a phasor diagram.



▲ FIGURE 21–23

Solution Using $V_L = \sqrt{3}V_\theta$ (Equation 21–2) and the fact that there is 30° between each line voltage and the nearest phase voltage, the load voltages are

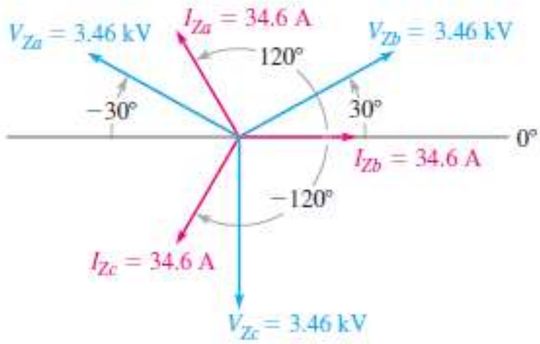
$$\mathbf{V}_{Za} = \mathbf{V}_{L1} = 2.0\sqrt{3}\angle 150° \text{ kV} = \mathbf{3.46\angle 150° \text{ kV}}$$
$$\mathbf{V}_{Zb} = \mathbf{V}_{L2} = 2.0\sqrt{3}\angle 30° \text{ kV} = \mathbf{3.46\angle 30° \text{ kV}}$$
$$\mathbf{V}_{Zc} = \mathbf{V}_{L3} = 2.0\sqrt{3}\angle -90° \text{ kV} = \mathbf{3.46\angle -90° \text{ kV}}$$

The load currents are

$$\mathbf{I}_{Za} = \frac{\mathbf{V}_{Za}}{\mathbf{Z}_a} = \frac{3.46\angle 150° \text{ kV}}{100\angle 30° \ \Omega} = \mathbf{34.6\angle 120° \text{ A}}$$
$$\mathbf{I}_{Zb} = \frac{\mathbf{V}_{Zb}}{\mathbf{Z}_b} = \frac{3.46\angle 30° \text{ kV}}{100\angle 30° \ \Omega} = \mathbf{34.6\angle 0° \text{ A}}$$
$$\mathbf{I}_{Zc} = \frac{\mathbf{V}_{Zc}}{\mathbf{Z}_c} = \frac{3.46\angle -90° \text{ kV}}{100\angle 30° \ \Omega} = \mathbf{34.6\angle -120° \text{ A}}$$

The phasor diagram is shown in Figure 21–24.

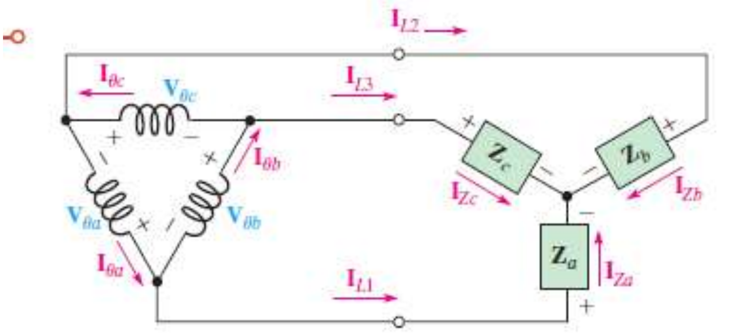
▶ FIGURE 21–24



The Δ-Y System

Figure 21–25 shows a Δ-connected source driving a Y-connected balanced load. By examination of the figure, you can see that the line voltages are equal to the corresponding phase voltages of the source. Also, each phase voltage equals the difference of the corresponding load voltages, as you can see by the polarities.

Each load current equals the corresponding line current. The sum of the load currents is zero because the load is balanced; thus, there is no need for a neutral return.



The relationship between the load voltages and the corresponding phase voltages (and line voltages) is

$$V_\theta = \sqrt{3}V_Z$$

The line currents and corresponding load currents are equal, and for a balanced load, the sum of the load currents is zero.

$$\mathbf{I}_L = \mathbf{I}_Z$$

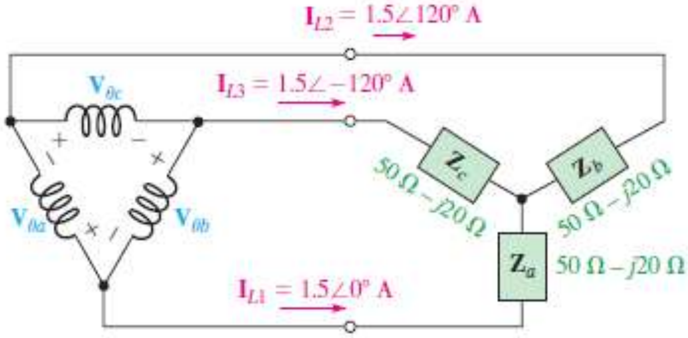
As you can see in Figure 21–25, each line current is the difference of two phase currents.

$$\mathbf{I}_{L1} = \mathbf{I}_{\theta a} - \mathbf{I}_{\theta b}$$

$$\mathbf{I}_{L2} = \mathbf{I}_{\theta c} - \mathbf{I}_{\theta a}$$

$$\mathbf{I}_{L3} = \mathbf{I}_{\theta b} - \mathbf{I}_{\theta c}$$

Determine the currents and voltages in the balanced load and the magnitude of the line voltages in Figure 21–26.



▲ FIGURE 21–26

Solution The load currents equal the specified line currents.

$$\mathbf{I}_{Za} = \mathbf{I}_{L1} = \mathbf{1.5\angle 0^\circ\ A}$$
$$\mathbf{I}_{Zb} = \mathbf{I}_{L2} = \mathbf{1.5\angle 120^\circ\ A}$$
$$\mathbf{I}_{Zc} = \mathbf{I}_{L3} = \mathbf{1.5\angle -120^\circ\ A}$$

The load voltages are

$$\mathbf{V}_{Za} = \mathbf{I}_{Za}\mathbf{Z}_a$$
$$= (1.5\angle 0^\circ\ \text{A})(50\ \Omega - j20\ \Omega)$$
$$= (1.5\angle 0^\circ\ \text{A})(53.9\angle -21.8^\circ\ \Omega) = \mathbf{80.9\angle -21.8^\circ\ V}$$
$$\mathbf{V}_{Zb} = \mathbf{I}_{Zb}\mathbf{Z}_b$$
$$= (1.5\angle 120^\circ\ \text{A})(53.9\angle -21.8^\circ\ \Omega) = \mathbf{80.9\angle 98.2^\circ\ V}$$
$$\mathbf{V}_{Zc} = \mathbf{I}_{Zc}\mathbf{Z}_c$$
$$= (1.5\angle -120^\circ\ \text{A})(53.9\angle -21.8^\circ\ \Omega) = \mathbf{80.9\angle -142^\circ\ V}$$

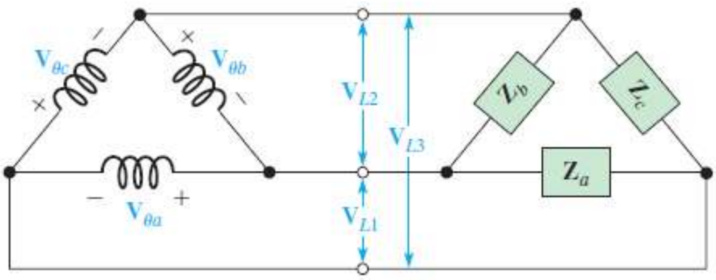
The magnitude of the line voltages is

$$V_L = V_\theta = \sqrt{3}V_Z = \sqrt{3}(80.9\ \text{V}) = \mathbf{140\ V}$$

The Δ-Δ System

Figure 21–27 shows a Δ-connected source driving a Δ-connected load. Notice that the load voltage, line voltage, and source phase voltage are all equal for a given phase.

$$V_{\theta a} = V_{L1} = V_{Za}$$
$$V_{\theta b} = V_{L2} = V_{Zb}$$
$$V_{\theta c} = V_{L3} = V_{Zc}$$



Of course, when the load is balanced, all the voltages are equal, and a general expression can be written

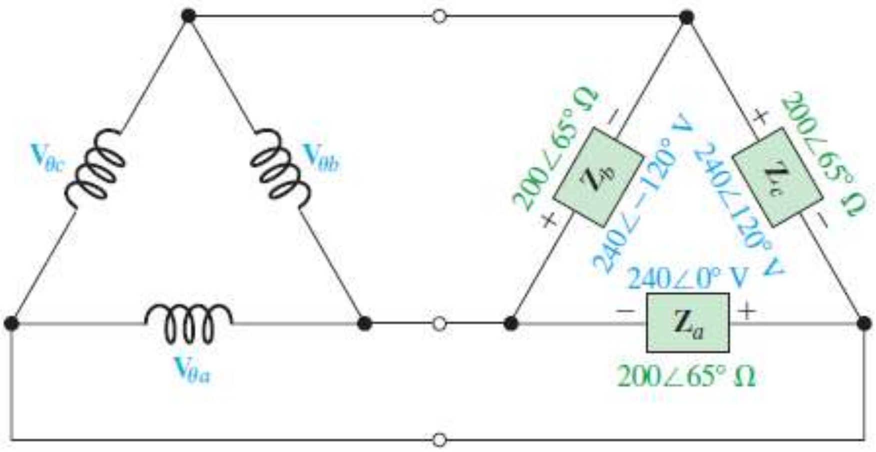
$$V_{\theta} = V_L = V_Z$$

For a balanced load and equal source phase voltages, it can be shown that

$$I_L = \sqrt{3}I_Z$$

6- الاسئلة البعدية

Determine the magnitude of the load currents and the line currents in Figure



$$V_{Za} = V_{Zb} = V_{Zc} = 240 \text{ V}$$

The magnitude of the load currents is

$$I_{Za} = I_{Zb} = I_{Zc} = \frac{V_{Za}}{Z_a} = \frac{240 \text{ V}}{200 \ \Omega} = \mathbf{1.20 \ A}$$

The magnitude of the line currents is

$$I_L = \sqrt{3} I_Z = \sqrt{3}(1.20 \text{ A}) = \mathbf{2.08 \ A}$$

في نهاية الحقيبة

- **المصادر الاساسية :**
- **1 .Electrical Technology (Edward Hughes)**
- **2 .Basic Circuits(A-M-F Brooks) pergaman press**
- **المصادر المقترحة:**
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