BERZIET UNIVERSITY

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ENEE2101

Basic Electrical Engineering Lab

Experiment 8

Impedance and Sinusoidal Steady State

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Abstract :

- We have three aims:

the frequency-dependent behavior of impedance, the sinusoidal steady-state response of RL and RC circuits, and the measurement of self-inductance and capacitance, and how impedance changes with frequency.

- We use :

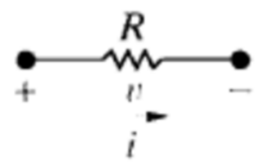
Function generator , Digital Multimeter , Oscilloscope , Board , wires, capacitors, inductor box, and resistances. DC Power Supply.

Theory :

- The function for sinusoidal source voltage and current as function of time :

$$V = Vm \cos(\omega t + \theta)$$
$$I = Im \cos(\omega t + \theta)$$

1. The V-I Relationship for a Resistor:



Where Im is the maximum amplitude of the current in amperes and θis the phase angle of the current. The phasor transform of this voltage is

V=IR

$$\mathbf{V} = RI_m e^{j\theta_i} = RI_m \angle \theta_i.$$

. There is no phase shift between the current and voltage. Fig2 depicts this phase relationship, where the phase angle of both the voltage and the current waveforms is 60°. The signals are said to be in phase because they both reach corresponding values on their respective curves at the same time.

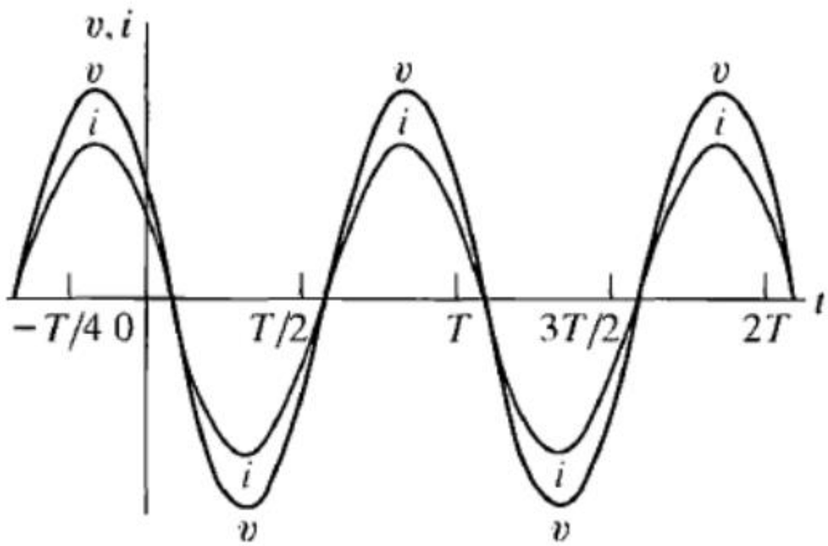
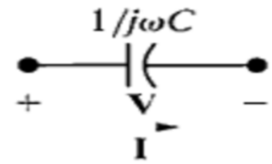


Fig1.2

2. The V-I Relationship for a Capacitor:

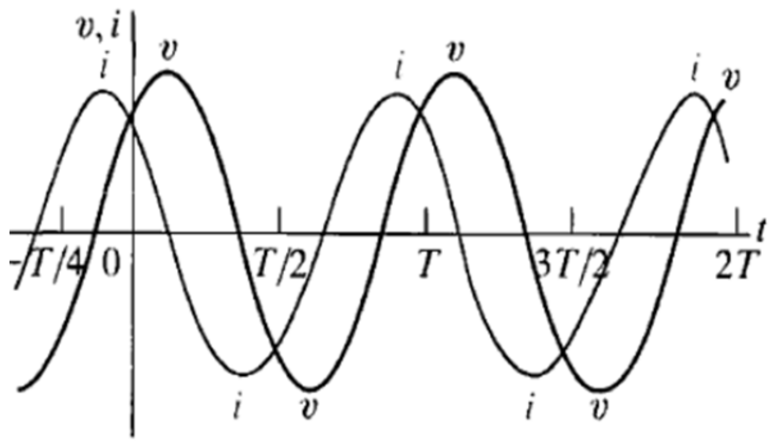


The relationship between the phasor current and phasor voltage at the terminals of a capacitor I = c dv/dt ,and v = Vm cos (ωt+ θv), then I = jωCv The voltage as a function of the current V=1/jω

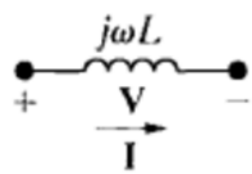
V=1/ωc∠-90 Im∠θi
V= Im /ωc ∠(θi-90)

- The current leads the voltage by 90°. Figure 4 shows the phase relationship between the current and voltage at the terminals of a capacitor.

Fig1.4



3. The V-I Relationship for an Inductor:



The relationship between the phasor current and phasor voltage at the terminals of an inductor by assuming a sinusoidal current and using Ldi/dt to establish the corresponding voltage. Thus, for I =Im cos (ωt+θi), the expression for the voltage is V = L di/dt = -ω L Im sin (ωt + θi) The phasor representation of the voltage givenV= jωLI

v = (ωL∠90)Im∠θi
v = ωL Im ∠(90+θi)

The voltage leads the current by 90 Fig 6 illustrates this concept of voltage leading current or current lagging voltage

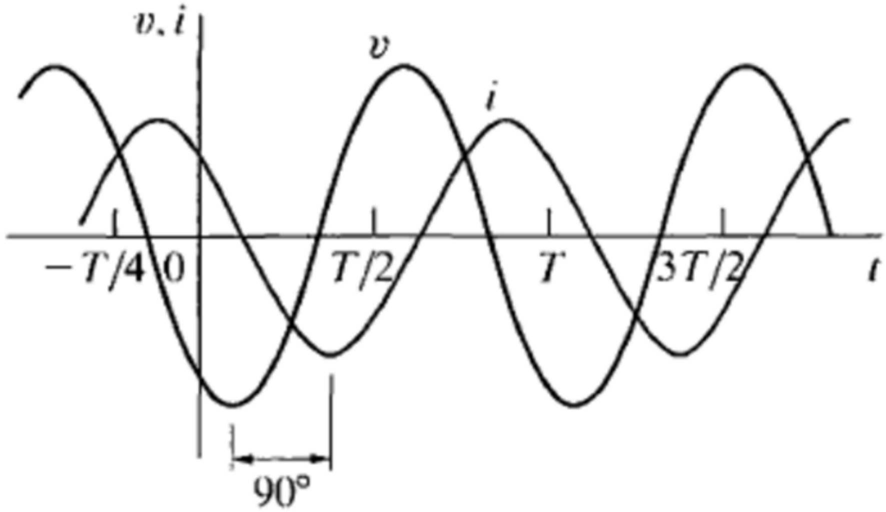


Fig1.6

4. Impedance and Reactance:

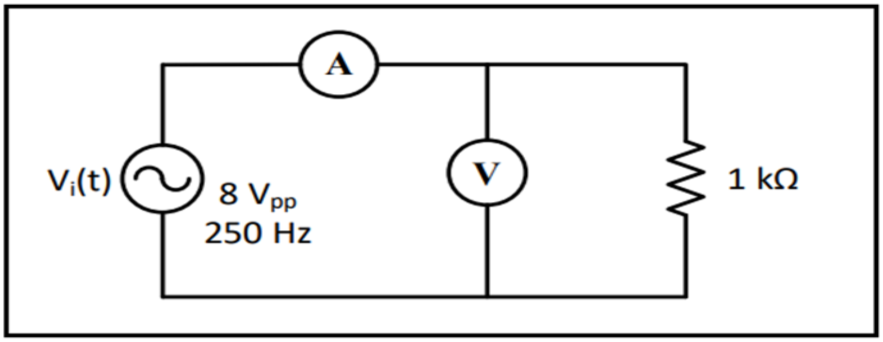
V = ZI Where Z represents the impedance of the circuit element it shows how voltage relates to current in a circuit element. For resistors, impedance equals resistance (R), for inductors, it's $j\omega L$ and for capacitors 1/ ωC . Impedance is measured in ohms and is a complex number**.** not a phasor like $e\ jt$. In the frequency domain, impedance acts like resistance, inductance, and capacitance in the time domain. Reactance, the imaginary part of impedance, is also important.

Circuit Element	Impedance	Reactance
Resistor	R	—
Inductor	$j\omega L$	ωL
Capacitor	$j(-1/\omega C)$	$-1/\omega C$

Procedure:

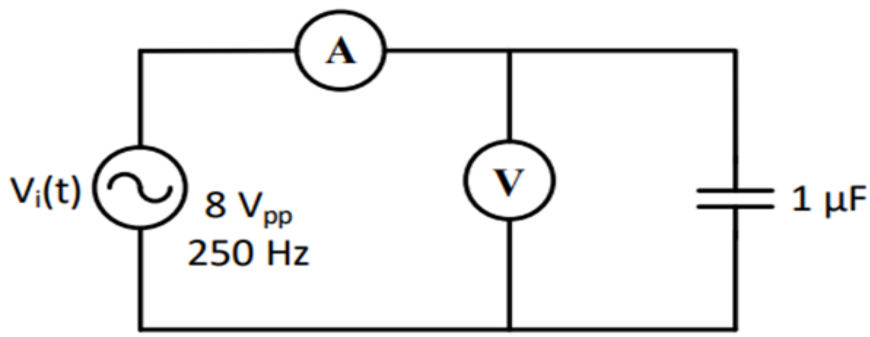
- Part A: Impedance Measurement:

1.



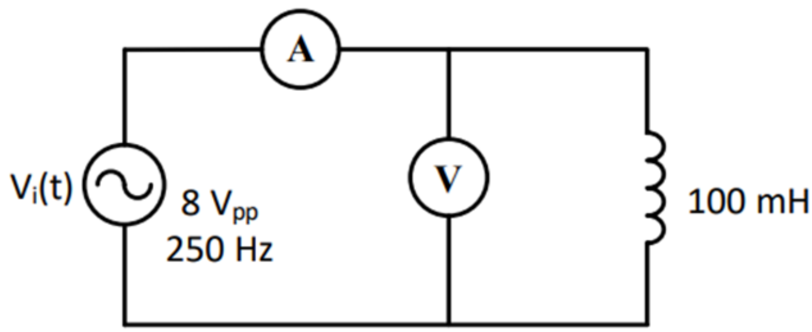
sinusoidal voltage input=8Vpp with a frequency of 250 Hz. the current and voltage across the resistor must be measured and recorded in Tab 8.1. This process should then be repeated for frequencies of 500 Hz, 1000 Hz, and 2000 Hz, with the corresponding results documented in tab8.1

2.



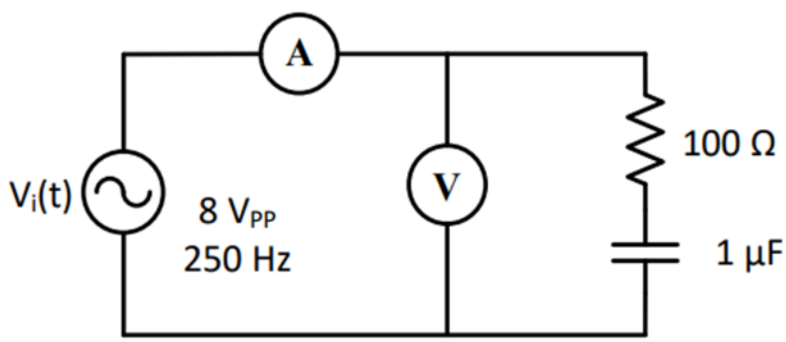
sinusoidal voltage input=8Vpp with a frequency of 250 Hz. the current and voltage across the capacitor must be measured and recorded in Tab 8.2. This process should then be repeated for frequencies of 500 Hz, 1000 Hz, and 2000 Hz, with the corresponding results documented in tab8.2

3.



sinusoidal voltage input=8Vpp with a frequency of 250 Hz. the current and voltage across the Inductor must be measured and recorded in Tab 8.3. This process should then be repeated for frequencies of 500 Hz, 1000 Hz, and 2000 Hz, with the corresponding results documented in tab8.3

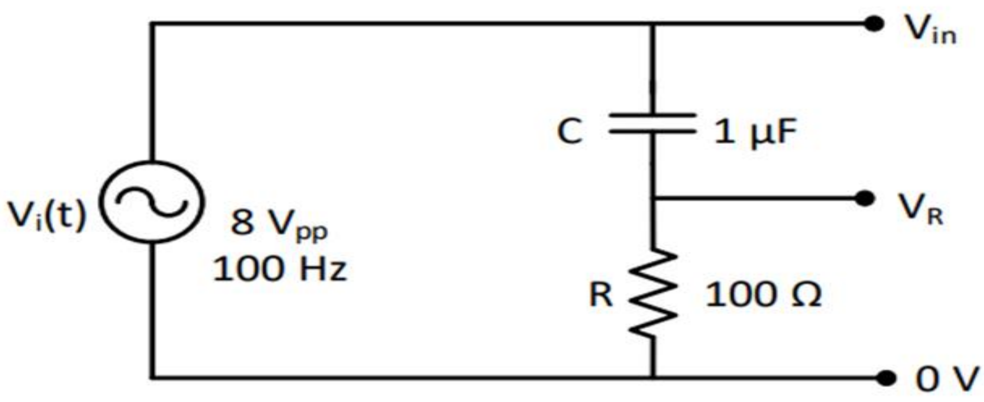
4.



The voltage was set to 8 volts peak-to-peak, with a frequency 250 Hz, and was added a resistor in series with a capacitor, the measures must be added and recorded to the Tab 8.4

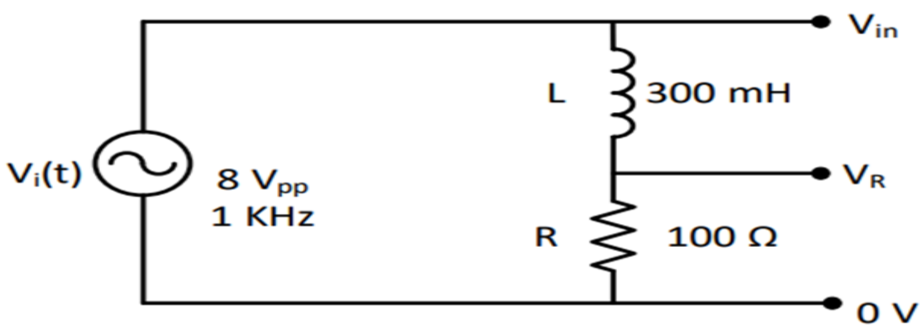
Part B: Phase shift measurement

1.



The voltage should be set to 8 (VPP) with a frequency of 100 Hz connect channel 1 across Vin and channel 2 across VR. Measure the time difference (Δt) between Vin(t) and VR(t) using cursors, and record the result in Tab 8.5.

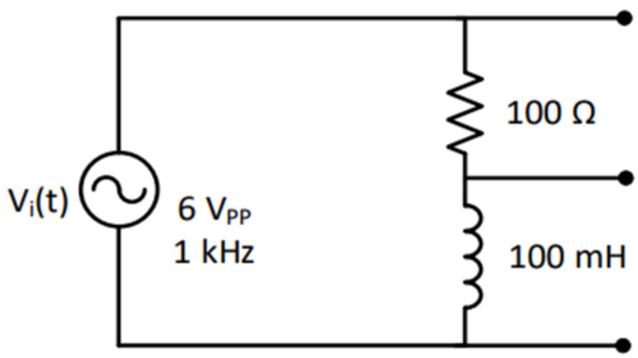
2.



The sinusoidal voltage input to 8 (VPP) with a frequency of 1 KHz., connect channel 1 across Vin and channel 2 across VR. Measure the time difference (Δt) between Vin(t) and VR(t) using cursors, and record the result in Tab8.6

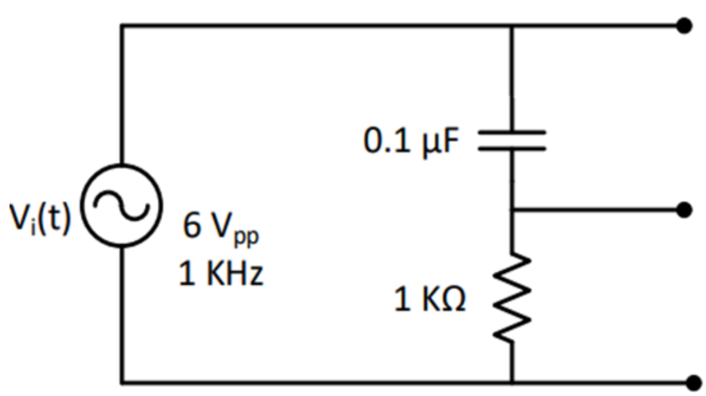
Part C: Inductance and Capacitance Measurement

1.



The voltage be set to 6 volts (VPP), with frequency of 1KHz, the measures of this part is to measure the current ‘I’ and the voltage across the resistor ‘VR’, also the voltage across the inductor ‘VL’ using the Digital Multimeter (DMM), and all the measures was recorded in Tab8.7

2.



The voltage set to 6 volts (VPP), with frequency of 1KHz, the measures of this part is to measure the current ‘I’ and the voltage across the resistor ‘VR’, also the voltage across the capacitor ‘VC’ .all the measures was recorded in Tab 8.8

Simulation and Data analysis and Calculations:

- Part A:

1.

Table 8.1

f [Hz]	250	500	1000	2000
|V|	~~[illegible]~~ 2.66	2.67	2.67	2.67
|I|	2.70	2.71	2.70	2.70
|Z_R|	1k	1k	1k	1k

$VR = I * R$, the resistor doesn't depend on the frequency

2.

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Table 8.2

f [Hz]	250	500	1000	2000
|V|	2.70	2.68	2.73	2.73
|I|	4.23	8.48	17.25	35.3
|Zc| (ohm)	636.9	318.47	159.23	79.62

$\hookrightarrow = \frac{1}{j\omega c}$, $c = 1\mu F$

$Zc = 1/j\omega C$, as the frequency increase, the Zc decrease

3.

Table 8.3

f [Hz]	250	500	1000	2000
|V|	2.51	2.75	2.78	3.26
|I|	17.2	8.4	4.2	2.3
$\|Z_L\|$ (ohm)	157	314	628	1256

$= j\omega L$, $L = 100\,mH$

$ZL = j\omega$L. frequency increases, ZL increases

4.

Table 8.4

f [Hz]	250	500	1000	2000
|V|	2.78	2.71	2.74	2.74
|I|	4.2	8.0	14.3	21.6
$\|Z_{RC}\|$ (ohm)	644.7	333.8	187.9	127.7

100 Ω
1 μF

$Z_{RC} = \sqrt{Z_R^2 + Z_C^2}$

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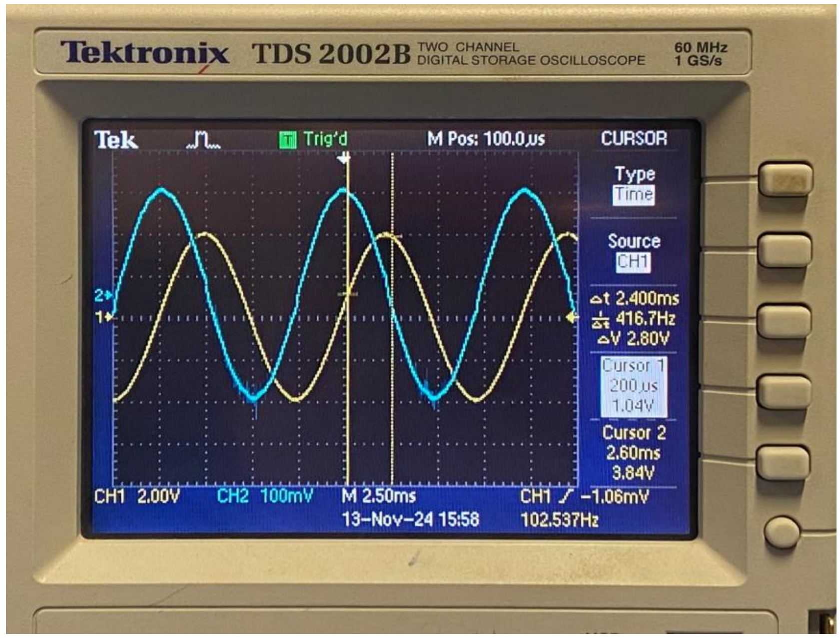
ZRC=(ZR^2+ZC^2)^0.5 , frequency increases, ZRC decrease.

- Part B :

1.



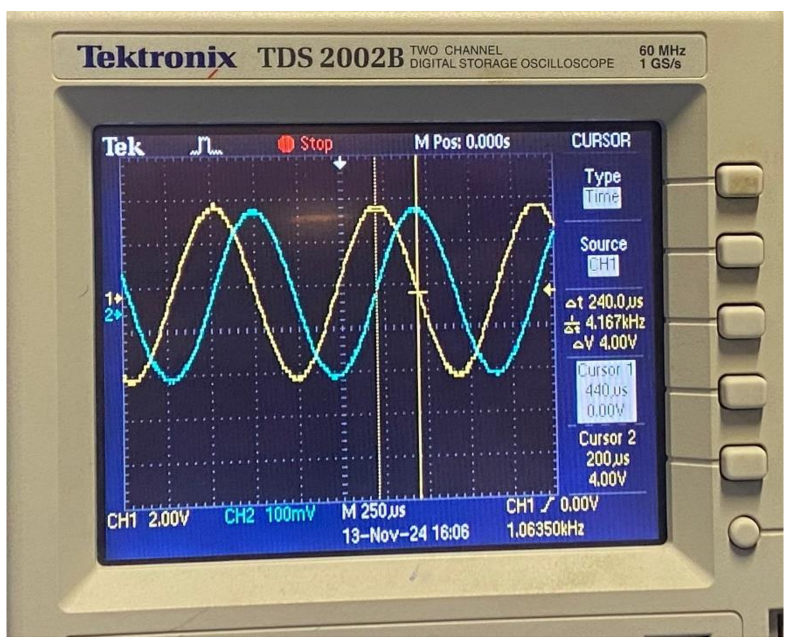
Δt = 2.400ms

Δ Θ = 360*100*Δt

= 360*100*2.400*10^-3

= 86.4

2.



Δt = 240.0

Δ Θ = 360*100*Δt

= 360*100*240.0*10^-6

= 8.64

- Part C :

1. L_{exp}?

Part C: Inductance and Capacitance Measurement

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1.

Table 8.7

f [Hz]	$\lvert V_R \rvert$	$\lvert V_L \rvert$	$\lvert I \rvert$	L
1 kHz	0.34V	2.30V	3.54mA	103.4mH

ZL = VL/I

= 2.30 / (3.54*10^-3) = 649.7

649.7=2*3.14*1000*L

L=103.4mH

2. C_{exp}?

2.

Table 8.8

F	$\lvert V_R \rvert$	$\lvert V_C \rvert$	$\lvert I \rvert$	C
1 kHz	1.09 V	1.69V	1.11 mA.	0.1045μF

Zc = Vc/I

= 1.69 / (1.11 *10^-3) =1522.5

C = 1/1522.5*2*1000*3.14

C =0.1045Uf

Conclusion:

The V-I relationship for a resistor is defined by a direct relationship between voltage and current.in capacitor The current leads the voltage.in inductor the voltage leads the current by 90. resistance for resistors, increasing with frequency for inductors and decreasing with frequency for capacitors.