جامعة بيرزيت

BIRZEIT UNIVERSITY

EXPERIMENT 8

Impedance and Reactance

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Data:

$c = 0.1\ \mu F$

$L = 10\ mH$

$R = 1\ K\Omega$

Frequancy (KHZ)	Δt (s)	w =2* PI * f (rad)	Ø = Δt * w
0.1	0.00248	0.628	0.00155744
0.3	0.00068	1.884	0.00128112
0.5	0.00037	3.14	0.0011618
0.7	0.00025	4.396	0.001099
1	0.00015	6.28	0.000942
3	0.000016	18.84	0.00030144
4	0.000008	25.12	0.00020096
4.5	0.000006	28.26	0.00016956
4.8	0.000003	30.144	0.000090432
5	0	31.4	0
5.2	-0.000005	32.656	-0.00016328
5.5	-0.000006	34.54	-0.00020724
7	-0.000008	43.96	-0.00035168
20	-0.0000076	125.6	-0.00095456
50	-0.000004	314	-0.001256
70	-0.00000332	439.6	-0.00145947
100	-0.00000248	628	-0.00155744

Note: The original datasheet signed by Dr.Khalid
is attached to the end of report

Abstract:

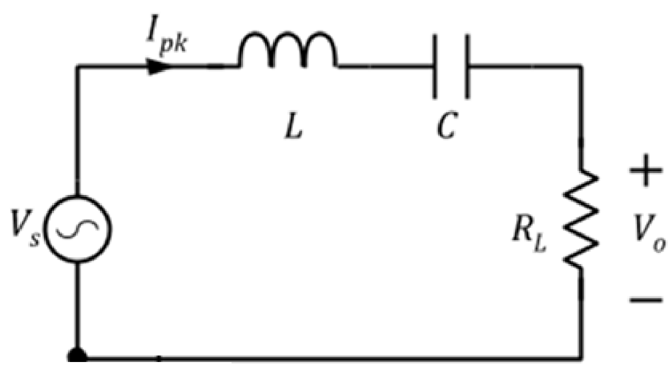
Define The phase shifts between the voltages across the different circuit elements (Voltage source, resister) are also related to Φ which is a function of ω. and define the capacitive impedance and the inductive impedance ZC, ZL, and ZR for the resister.

Introduction:

Apparatus:

1kΩ resistor, 0.1μF capacitor, 10 mH inductor, signal generator, oscilloscope, circuit board.

In this experiment will build this circuit:



The current in this circuit is equal:

$$I = \frac{V_s}{Z_{eq}}$$

And the impedance:

$$Z_{eq} = Z_R + Z_C + Z_L$$

But $Z_R = R$, $Z_C = -\frac{i}{\omega c}$, $Z_L = i\omega L$

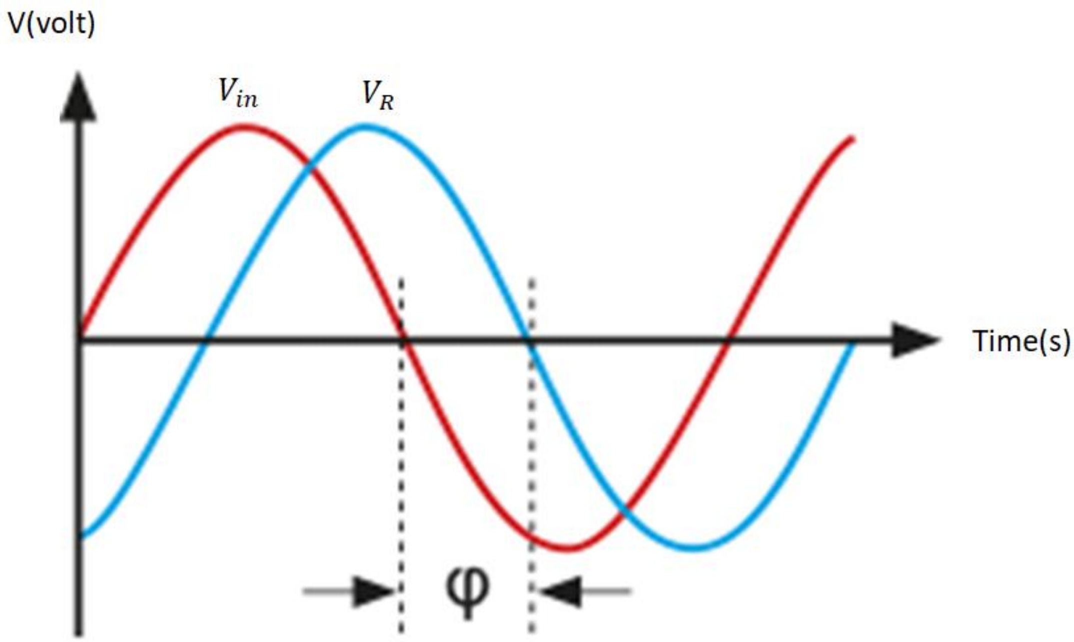
The impedance is a complex numbers that needs special mathematical treatment but the equation will be :

$$I(t) = I_0 \cos(\omega t + \varphi)$$

Then:

$$\varphi = tan^{-1}(\frac{-\omega L + \frac{1}{\omega c}}{R})$$

When plot of both the voltage for voltage source and the voltage on the resistor in this circuit on a common time scale, will exists a phase shift $\varphi = \omega * \Delta t$ between them, As shown in the following graph.



The voltage across the inductor & capacitor & resistor:

$$V_L = -\omega L I_0 \sin(\omega t + \varphi)$$

$$V_R = R I_0 \, \text{Cos}\,(\omega t + \varphi)$$

$$V_c = \frac{I_0}{\omega c}\sin(\omega t + \varphi)$$

$$all\ of\ the\ voltages\ has\ a\ phase\ shifts$$

Data & Analysis:

Theoretically:

$$\varphi = tan^{-1}\left(\frac{-\omega L + \frac{1}{\omega c}}{R}\right)$$

Let $\varphi = zero$

$$zero = tan^{-1}\left(\frac{-\omega L + \frac{1}{\omega c}}{R}\right)$$

$$\tan(0) = \frac{-\omega L + \frac{1}{\omega c}}{R}$$

$$0 = \frac{-\omega * 0.01 + \frac{1}{\omega * 0.1 * 10^{-6}}}{1000}$$

$$-\omega * 0.01 + \frac{1}{\omega * 0.1 * 10^{-6}} = 0$$

$$\omega * 0.01 = \frac{1}{\omega * 0.1 * 10^{-6}}$$

$$\omega^2 = \frac{1}{10^{-9}}$$

$$\omega = 31622.7766 \quad rad$$

Then: $$f = \frac{\omega}{2\pi}$$

$$f = \frac{31622.7766}{2\pi}$$

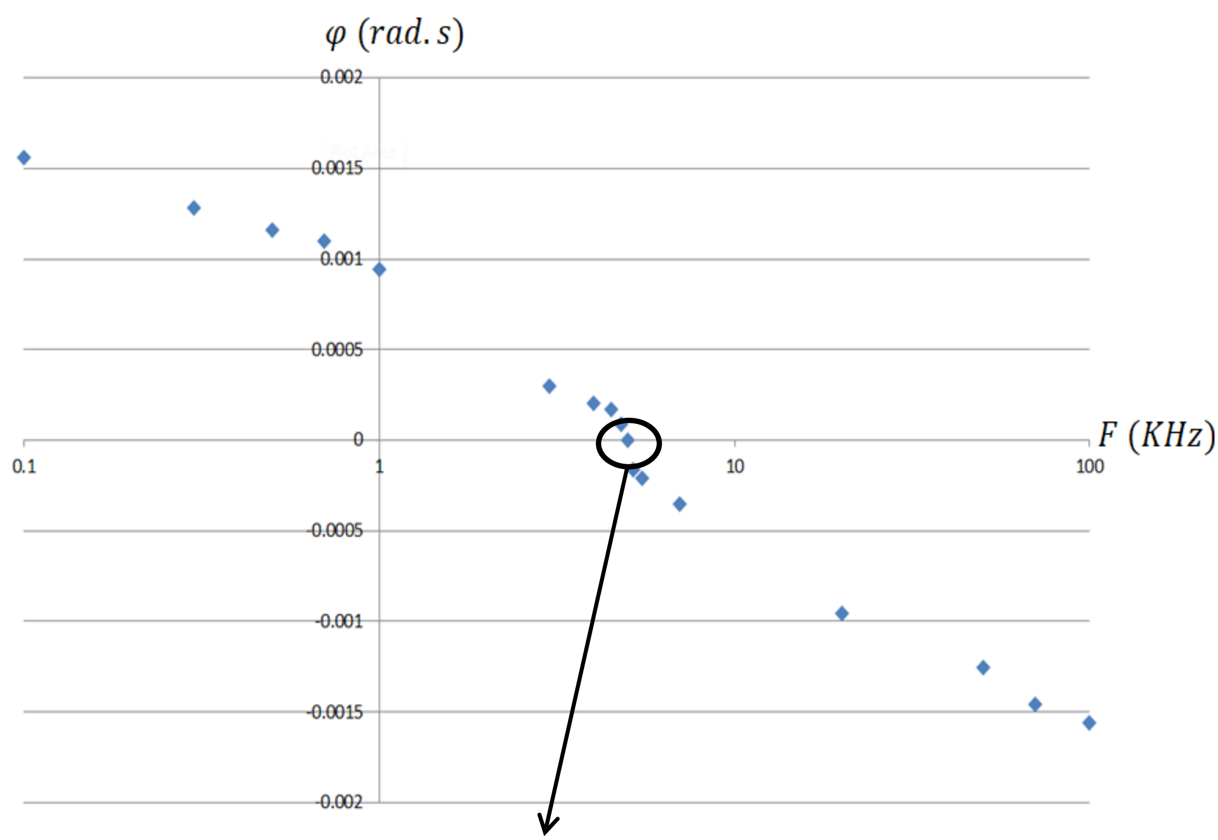
$$f = 5035.47 \quad Hz$$

Then:

$$f = 5 \quad KHz$$

Experimentally:

$$\varphi\ (rad.s)\ VS\ f\ (KHz)\ with\ logaritmic\ scale\ for\ f:$$



At this point f = 5 KHz

The value of (f) Theoretically equal 5 KHz and the value of (f) Experimentally equal 5 KHz

Then the curve of V_R and V_{in} match when $\varphi = 0$

Conclusion:

The phase shift of a sine wave can be defined as “The time interval by which a wave leads by or lags by another wave” and the phase shift is not a property of only one wave, it’s the relative property to two or more waves. The phase difference is represented Phi (φ). The complete phase of a waveform can be defined as 2π rad, and the leading phase means, a waveform is ahead of another wave with the same frequency and the Lagging phase means, a waveform is behind another wave with the same frequency, This phase shift exists because of the impedance for capacitors and Inductors.