Expt.No. 9: Passive components

Aim:

1. To identify different passive components through their response to the variable frequency applied.
2. Comment on the variation of the response.

Apparatus:

Experimental setup consisting of a digital wide band ac voltmeter, impedance $Z_{x,}$ sine wave oscillator (1KHz-10KHz), & load resistance $R_L \approx 1k\Omega$.

Theory:

Introduction:

In this expt three unknown passive electric components are to be identified by studying their behavior in ac circuits. Further, from the impedance variation, unknown inductance, capacitance & resistance values are determined.

Impedance:

Impedance is the opposition offered by a passive component to current flow. The opposition is measured in ohms. If the component offers opposition that is independent of input frequency of the current then the opposition is called resistive (R).If the opposition varies with the input frequency of the current passing through it, and then the opposition is called reactive impedence (Z). Further if the impedence increases with the frequency then it is called +ve or inductive impedence (X_L). And if the impedance decreases with frequency then it is called –ve or capacitive impedence (X_C). Reactive impedence is represented graphically in X-Y axis with Y-axis as impedance& the x- axis represent the freq of the current flowing through the impedence
(fig 3). The inductive impedance is written as

$$X_L = \omega L = 2\pi fL$$

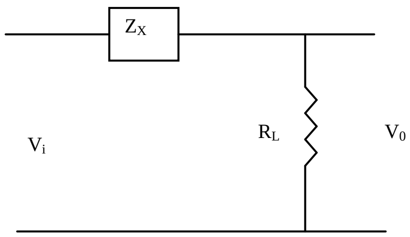
where $\omega = 2\pi f$ is angular frequency.

The resistance appearing in the negative impedance is due to dielectric material of the capacitor, which is very high. Hence this resistance appears parallel to capacitor, hence $1/R_c = 0$ or in practice a negative impedance or a capacitive impedance is written as

$$X_c = \frac{1}{\omega C} = \frac{1}{2\pi fC}$$

where f is the frequency of the current passing through it and C is the capacitance value.

There are various ways one can identify these impedances. But in each case one has to use different voltage sources and meter. The simplest method is using a multimeter one can identify these components. Another simplest method with minimum number of instruments and more accurate is presented here. The unknown impedance is in the black box is termed as Z_1, Z_2 and Z_3. One at a time these impedances are connected to a known resistance to form a voltage divider and the behavior of the impedance is studied at different input frequency. By noting input and output voltages using a digital wide band ac voltmeter, voltage gain and impedance are calculated at various frequencies. From the behavior of the impedance variation, the components are identified.



(Fig-1 Impedance Z_X is connected R_L to form a voltage divider network.)

Fig 1 shows any one of the impedance (Z_X) in the black box connected to a known resistance (R_L). The voltage gain of the circuit is given by

$$\frac{V_O}{V_i} = \frac{R_L}{R_L + Z_X} = A_V$$

$$A_V (R_L+Z_X) = R_L$$

$$A_V R_L + A_V Z_X = R_L$$

$$A_V Z_X = R_L (1 - A_V)$$

Therefore, $Z_X = \dfrac{R_L(1 - A_V)}{A_V}$

The impedance Z_X is calculated by measuring voltage gain A_V. R_L is known quantity it is our choice. In this manner connecting Z_1, Z_2 and Z_3 in place of Z_X one can determine the impedances of various components in the black box. To measure input and output voltages a digital voltmeter is used and sine wave oscillator is used as an input source.

If Z_X increases with the frequency then it is positive or inductive. If Z_X decreases with frequency then it is –ve or capacitive. If Z_X is independent of frequency then is a resistive component.

Measuring impedance at a fixed frequency the L, C & R values are calculated.

L = Indicative impedance at 1 KHz / 2πf = $Z_L / 2\pi f$

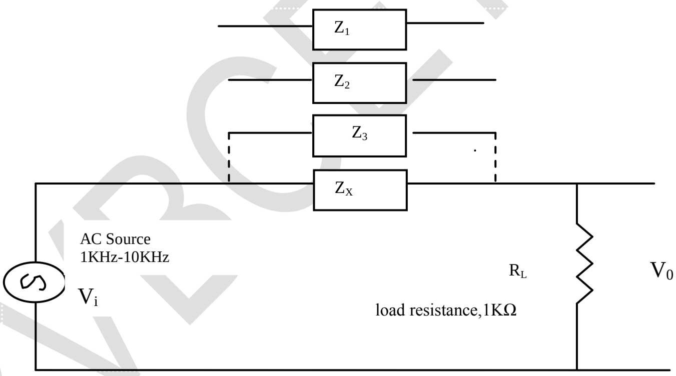
C = 1/Capacitor Impedance at 1 KHz × 2πf = $Z_C / 2\pi f$

R= $\dfrac{R_L(1 - A_V)}{A_V}$ where A_V is the voltage gain obtained with R =Z_X

Experimental Procedure:

- The circuit connections are made as shown in figure-2. A Sine wave oscillator is connected to the input and its amplitude is set to 1000Hz. The amplitude knob of the oscillator once adjusted to 1 volt should not be disturbed throughout the expt.
- Any one impedance say Z_1 is selected and formed voltage divider with load resistance R_L and output voltage is measured using digital ac voltmeter and the readings obtained are tabulated.
  - If V_i=1Volt, V_0=0.7Volts, hence voltage gain
  - $A_V = V_0/ V_i = 0.7/1 = 0.7$.
  - $Z_1 = \frac{R_L(1-A_V)}{A_V} = \frac{1K(1-0.7)}{0.7} = 428\Omega$
- Trial is repeated by varying the frequency to up to 10 KHz, the corresponding readings are tabulated.
- Expt. is repeated by connecting Z_2 & Z_3, and the corresponding gain is noted and impedance is calculated and presented in table.
- A graph is drawn taking impedance on Y-axis and frequency along X-axis as shown in fig- 3.
- From the graph for inductor, capacitor the impedance (Z_L, Z_C) at 2 KHz is noted and hence inductance and capacitance is calculated, using $L=Z_L/2\pi f$ & $C=1 / 2\pi f Z_C$.

Circuit Diagram.



(FIG – 2)

<u>Nature Of Graph</u>:

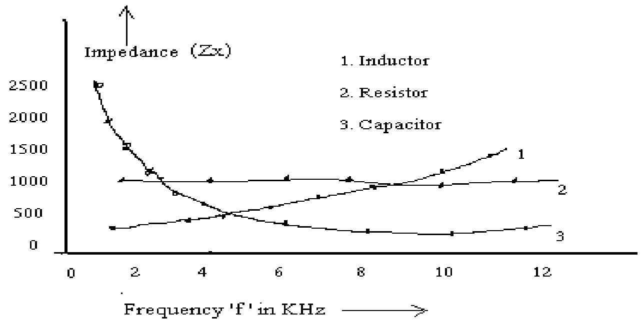


Fig 3 , Graph shows variation with frequency.

Record of Observations:

V_i = 1 ± volts

R_L = Load resistance =1 ± KΩ (Given)

Tabulation:

Frequency 'f' in KHz	**Z_1**		**Z_2**		**Z_3**	
	Gain $A_V = \frac{V_o}{V_i}$	**Impedance** $Z_1 = \frac{R_L(1-A_V)}{A_V}$	**Gain** $A_V = \frac{V_o}{V_i}$	**Impedance** $Z_2 = \frac{R_L(1-A_V)}{A_V}$	**Gain** $A_V = \frac{V_o}{V_i}$	**Impedance** $Z_3 = \frac{R_L(1-A_V)}{A_V}$
Error ± 1 2 3 . . .						

Calculations:

From graph (fig 3) it is clear that,

1. As frequency increases, impedance increases which indicates Z_1 is INDUCTOR.
2. As frequency increases, impedance remains same, indicates Z_2 is. RESISTOR
3. As frequency increases, impedance decreses which indicates Z_3 is CAPACITOR

From Graph, 1) At 2KHz Z_L =………Ω

Therefore, Inductance $L = \dfrac{Z_L}{2\pi\ f}$ =…………Henry. =……..mH

2) At 2KHz Z_C =………Ω

Therefore, Capacitance $C = \dfrac{1}{2\pi\ f\ Z_C}$ =………Farad. =…….μF

3) Resistance =R=………….Ω