Q-2(H), Paper IV

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A.C circuit : Reactance

An inductance offers no resistance in a steady current but when the current is varying as in a.c circuit, a back e.m.f is set up in the inductance. This reduces the current and thus is equivalent to a resistance.

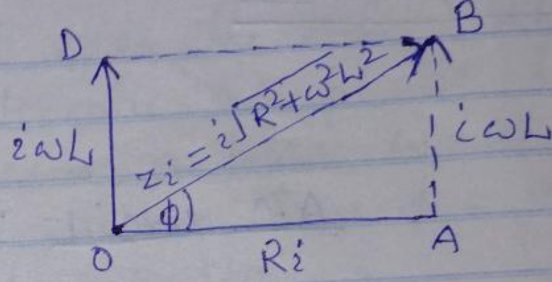
The resistance due to inductance in an a.c circuit is called its reactance and is expressed in ohms. It is denoted by X_L.

$$\text{Reactance} = \omega L = 2\pi f L$$

Thus reactance is not a const. quantity but is directly proportional to the freq. of the applied e.m.f.

vector diagram :- The voltage across the resistance is in phase with the current through it, the voltage across the inductance leads the current in phase by 90°. We thus may represent these voltages by vectors. The P.D across the resistance is represented by the vector $\vec{OA}$. The vector $\vec{AB}$ represents the magnitude and direction of the P.D across the inductance and is drawn 90° to the vector $\vec{OA}$.

The resultant vector OB will represent the combined P.D across the inductance and resistance in series,



$$\vec{OB} = \vec{OA} + \vec{AB}$$

$$OB = \sqrt{(OA^2+OB^2)}$$

$$\text{or } Z = \sqrt{R^2+\omega^2L^2}$$

$$\text{and } \tan\phi = \frac{\omega L}{R}$$

<u>By the use of operator j</u> : In cartesian co-ordinates a unit vector is taken along the +ve x-axis. The multiplication by the imaginary quantity j denotes the rotation of the positive unit vector counter clock wise through 90°. Thus j is along the Y-axis. Thus

$$e = Ri + j\omega Li$$

$$\therefore \quad i = \frac{e}{R+j\omega L} = \frac{e}{Z}$$

where $Z = R+j\omega L$ is known as complex impedance. The real part is called the ~~resistance~~ resistive or inphase component and the imaginary part as the reactive or quadrature component.

$$Z = R + j\omega L = Ze^{j\phi} = Z(\cos\phi + j\sin\phi)$$

$$\therefore Z = \sqrt{R^2+\omega^2L^2} \text{ and } \tan\phi = \omega L/R.$$