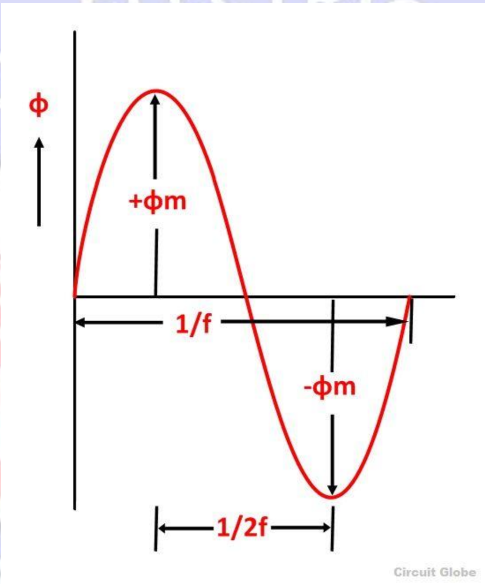
4-4 E.M.F Equation of a Transformer:

Suppose the maximum value of the flux to be $\emptyset_m$ Webbers and the frequency to be f hertz (or cycles /second).From fig(2) is seen that the flux has to change from $+\emptyset_m$ to $-\emptyset_m$ in half cycle , namely in $\frac{1}{2}$ F second. Average rate of change of

flux $=2\emptyset_m \div \frac{1}{2\,f}$

$=4f\emptyset_m$ weber/second……...

And average e.m.f induced turn $=4\ f\ \emptyset_m$ volts



For a sinusoidal wave the r.m.s or effective value is 1.11 times the average value. r.m.s value of e.m.f induced /turn $=1.11 \times 4\ f\ \emptyset_m$

Hence r.m.s value of e.m.f induced in primary $=E_1$.

$$E_1 = 4.44\ N_1\ f\ \emptyset_m\ \ volts$$

And r.m.s value of e.m.f induced in secondary = E_2

$$E_2 = 4.44\ N_2\ f\ \emptyset_m\ \ \ volts$$

$$\emptyset_m\ = B_m \times A$$

B_m= maximum flux density

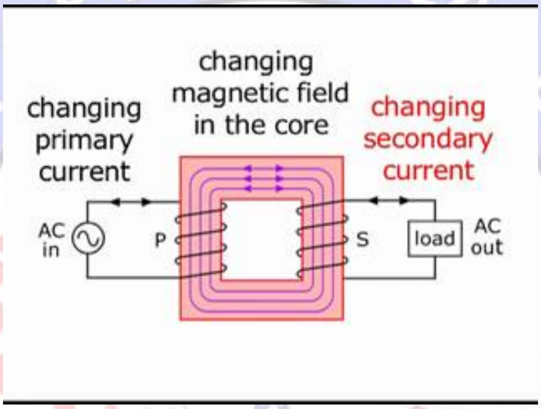
A=area of the core .

K=voltage transformation ratio

K=$\frac{N_2}{N_1}$

$\frac{E_2}{E_1}=\frac{N_2}{N_1}=K$

$V_1 I_1 = V_2\, I_2 \rightarrow \frac{I_2}{I_1}=\frac{V_1}{V_2}=\frac{1}{K}$



4-5 Windings the Ideal Transformer P And S:

R_1 and R_2 are resistance equal to the resistance of the primary and secondary windings of the actual transformer. Similarly, inductive reactance X_1 and X_2 represent the reactance of the windings due to leakage flux in the actual transformer. The inductive reactor X is that it takes a reactive current equal the magnetizing current I_{mag} of the actual transformer. The core losses due to hysteresis and eddy currents are allowed for by a resistor R of such value that it takes a current to equal to the core loss of the actual transformer.

4-6 Phasor Diagram for Transformer On no load:

It is most convenient to the commence the phasor diagram with the phasor representing the quantity that is common to the two windings, namely the flux ∅. This phasor can be convenient length and may be regarded merely as reference phasor, relative to which another phasor has to be drawn. The e.m.f induced by sinusoidal flux lags the flux by a quarter if a cycle. Consequently the e.m.f E_2 and E_1 induced in the secondary and primary winding are represented by phasor drawn 90° behind $\emptyset$, as in fig(3) .The values of E_2 and E_1 are proportion to the number of turns on the secondary and primary windings, since practically the whole of the flux set up by the primary is linked with the secondary when the latter is on open cct. For convenience in drawing phasor diagram for transformer, it will be assume that N_1 and N_2 are equal , so that $E_2 = E_1$, as shown in fig(3).Since the difference between the value of the applied voltage V_1 and that of the induced e.m.f E_1 is only about 0.05 per cent when the transformer is on no load , the phasor representing V_1 can be drawn equal and opposite to that representing E_1 .

The no-load current Io taken by the primary consist of two components: a reactive or magnetizing component (I_{mag}) producing the flux and therefore in phasor with the the latter, and an active or power component (I_c) supplying the hysteresis and eddy current losses in the iron core and the negligible (I_2R) loss in the primary winding. Components I_c in phase with the applied voltage (I_c V_1=core losses) this component is usually very small compared with I_{mag} , so that the no-load power factor is very small.

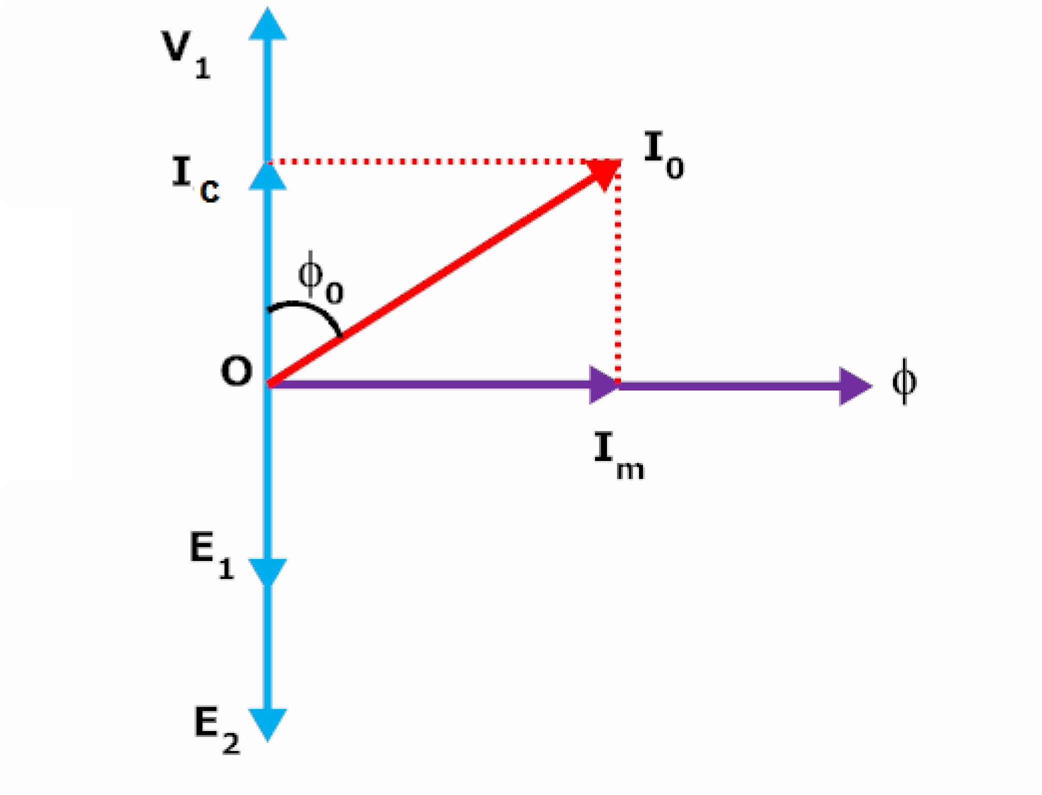


Figure 3 : Phasor diagram of practical transformer on no load

From (fig 3) it will see that:

No-load current $=I_o=\sqrt{i_c^2+i_{mag}^2}$

At power factor on no load$=\cos\emptyset_o=\frac{I_C}{I_O}$

$I_c=I_o\cos\emptyset_o$

$I_{mag}=I_o\sin\emptyset_o$

4-7 Phasor Diagram for A Loaded Transformer:

Assuming the voltage drop in the winding to be negligible with this assumption, it follows that the secondary voltage V_2 is the same as the e.m.f E_1 induced in the secondary, and the primary applied voltage V_1 is equal and opposite in phase to the e.m.f . E_1 induced in primary winding, also, if we again assume equal number of turns on the primary and secondary winding then $E_1=E_2$. Let us consider the general case of a load having lagging power factor $\cos\emptyset_1$, hence the phasor representing the secondary current I_2 lags V_2 by angle $\emptyset_2$, as shown in fig (4), phasor I_1 represents the component of the primary current to neutralize the demagnetizing effect of the secondary current and is drawn equal and opposite to I_2 . Io is the no-load current of the transformer, the phasor sum of I_1 and is gives the total current I_1 taken from the supply, and the power factor on the primary side is cos $\emptyset_1$, where $\emptyset_1$ is phase difference between V_1 and I_1 .