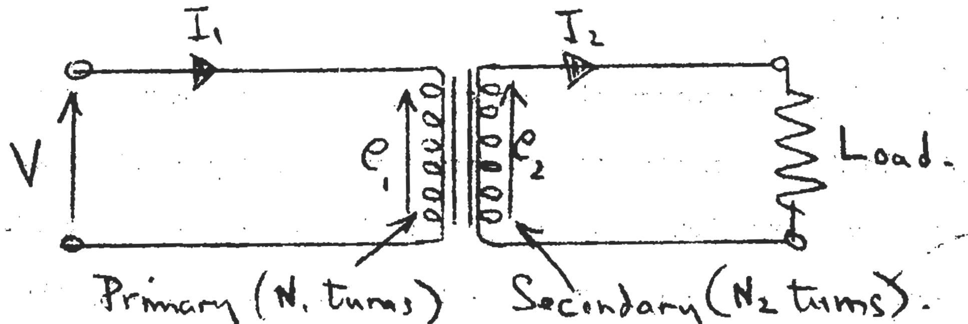
Fundamentals Section

T.O.

## THE TRANSFORMER (Introduction)

The transformer consists of two electrically separate coils which are arranged so that a varying current in one (the primary winding) produces a magnetic flux which links with the other (the secondary winding) to induce an e.m.f. in it. Thus power may be transmitted to a load connected in series with the secondary winding. The two coils are usually wound on an iron core so that the magnetic linkage between them is most effective.




The transformer may be used to step up or down a voltage, current or apparent load impedance, or to separate the a.c. and d.c. components of current or voltage in a circuit.

Usually the powers supplied to, and delivered by, a transformer are approximately equal so that an introductory study of the transformer as a perfect device is fairly will justified. The relationships derived in this paper on the assumption of perfection are approximately true for most transformers which are intended to be used at 50c/s.

A perfect transformer is one in which each of the two windings has no resistance but very high inductance. These windings are linked by a magnetic flux entirely produced within a perfect core material.

If a voltage V is applied to the primary of such a transformer it must be balanced by the e.m.f. $e_1$, induced in the primary ($v = e_1$),

$$e_1 = N_1 \frac{d\phi}{dt} \text{ volts.}$$

The e.m.f. induced in the secondary winding ($e_2$) is due to the same flux so that:

$$e_2 = N_2 \frac{d\phi}{dt} \text{ volts.}$$

Taking the ratio of these e.m.f.'s,

$$\frac{e_1}{e_2} = \frac{N_1}{N_2}.$$

Thus voltage transformation depends on the turns ratio of the transformer.

If a load is connected to the secondary a load current flows to produce a secondary flux in opposition to that to which the e.m.f.'s $e_1$ and $e_2$ are due. The applied voltage is no longer balanced by the primary e.m.f. ($e_1$) and consequently the primary current increases to regain this essential balance by producing sufficient additional primary flux to cancel the effect of the secondary flux. Changes of secondary and primary current produce equal and opposite changes of core flux. Now the assumption of a perfect transformer implies that the primary current on no load is negligible so that to a close approximation the primary and secondary magnetising forces are equal.

$$N_1 I_1 = N_2 I_2$$

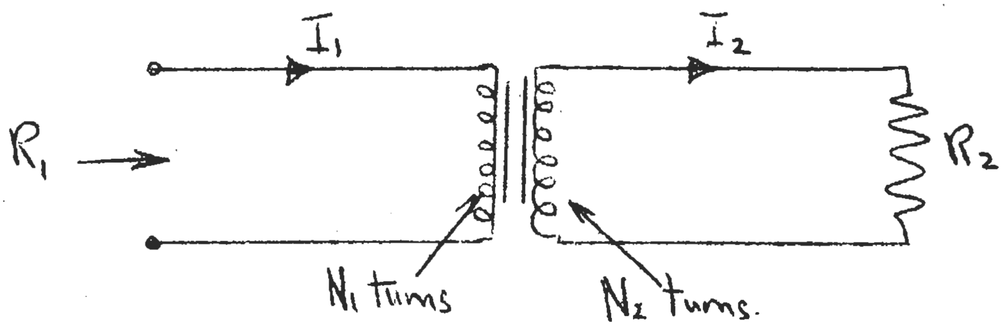
$$\therefore \frac{I_1}{I_2} = \frac{N_2}{N_1}.$$

Thus current transformation also depends on the turns ratio of the transformer.

If voltage is stepped up current is stepped down. This is obviosly necessary if the input and output powers of the transformer are to be equal.

Since these powers are equal

$$I_1^2 R_1 = I_2^2 R_2$$




$$\left(\frac{I_1}{I_2}\right)^2 = \frac{R_2}{R_1} \quad \therefore \quad \left(\frac{N_2}{N_1}\right)^2 = \frac{R_2}{R_1} \quad \therefore \quad R_1 = R_2 \left(\frac{N_1}{N_2}\right)^2$$

Thus the load ($R_2$) on the secondary winding may be stepped up or down to appear as a different load ($R_1$) at the input terminals of the transformer.

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