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Problem 39.41 (RHK)

We have to show that $i_p(t)$ *the current in the primary circuit remains unchanged if a resistance* $R'\left[=R\left(N_p/N_s\right)^2\right]$ *is connected directly across the generator, the transformer and the secondary circuit being removed. That is*

$$i_p(t)=\frac{\mathrm{E}(t)}{R'} .$$

In this sense we see that a transformer not only "transforms" potential differences and currents but also resistances.

Solution:

In an ideal transformer the secondary emf (secondary circuit being open) and the primary emf are related to each other through N_s (number of turns in the secondary coil) and N_p (number of turns in the primary coil) as

$$\frac{E_s}{E} = \frac{N_s}{N_p},$$

or

$$E_s = \frac{N_s}{N_p} E.$$

When a resistive load R is connected across the secondary windings, there will be a current flow in the secondary given by

$$i_s = \frac{N_s}{N_p} \frac{E}{R}.$$

The power dissipation in the secondary will be

$$P = i_s^2 R = \left(\frac{N_s}{N_p} \frac{E}{R} \right)^2 R = \left(\frac{N_s}{N_p} \right)^2 \frac{E^2}{R}.$$

This power will be drawn from the generator feeding the primary coil of the transformer. A current i_p will begin to flow in the primary, which can be determined from the relation

$$i_p E = P = \left(\frac{N_s}{N_p} \right)^2 \frac{E^2}{R},$$

or

$$i_p = \left(\frac{N_s}{N_p} \right)^2 \frac{E}{R} = \frac{E}{R'},$$

where

$$R' = R\left(\frac{N_p}{N_s}\right)^2 .$$

Thus if the transformer and the secondary circuits are removed and a resistive load $R'\left[= R\left(N_p/N_s\right)^2\right]$ is applied across the generator the same amount of current equal to i_p will be drawn from the generator.