

Electrical Machinery – Part 4

Some Ideal Machines

Transformers

Let us now add a second winding to an inductor to make a transformer (*fig 4.1*) – the *primary* winding has N_p turns and the *secondary* winding has N_s turns. The battery voltage is V_p and when it is connected to the *primary* winding, it produces a magnetic flux Φ in the core:

$$\Phi = (V_p \cdot t) / N_p$$

The flux rises at a rate that induces a voltage \mathcal{E} in every turn of *both* windings such that the total voltage induced in the *primary* winding is equal to the battery voltage V_p and opposing it:

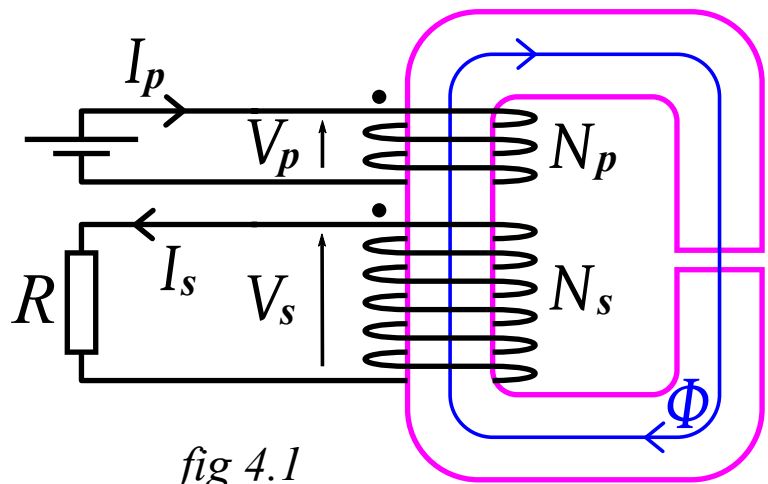
$$V_p = \mathcal{E} \cdot N_p$$

Similarly, the total voltage V_s induced in the *secondary* winding is:

$$V_s = \mathcal{E} \cdot N_s = V_p (N_s / N_p)$$

If we now connect a load resistor R to the *secondary* – a current I_s flows in accordance with *Ohm's Law*:

$$I_s = V_s / R$$



Energy is now flowing from the transformer to the load – but where is it coming from?

When the load R is connected, the flux Φ must continue to rise at its original rate to maintain the induced voltage that balances the supply voltage V_p – thus the *total* current encircling the flux in the core must also continue to rise at its original rate.

Before the load is connected, the only current flowing is that in the *primary* winding – so the *total* current encircling the flux is: $I_p \cdot N_p$

After the load is connected, there is also a current flowing in the *secondary* – the *total* current encircling the flux due to this is: $I_s \cdot N_s$

The *primary* current automatically adjusts itself to leave the *total* current encircling the flux in the core unaffected by the current in the *secondary* winding.

The *primary* and *secondary* currents encircle the core in opposite directions – thus the *primary* current I_p has to **increase** by an amount:

$$I_s (N_s / N_p)$$

Fig 4.2 shows graphically how the primary current increases.

We can therefore say:

The primary voltage controls the secondary voltage.

The secondary current controls the primary current.

