DO PHYSICS ONLINE

MOTORS AND GENERATORS

TRANSFORMERS

A transformer is a device for either increasing or decreasing an ac voltage. Transformers are used everywhere. Our electrical supply from our power points is 240 V\textsubscript{rms}, 50 Hz. Many electrical circuits in home devices operate at much lower voltages. So, transformers are used to produce smaller ac voltages.

A transformer is made of a two coils called the **primary** and **secondary** (figure 1). They are usually wound onto a **soft iron core** (iron does not remain magnetised when current falls to zero). The iron core is laminated to reduce energy losses due to eddy currents.

The changing magnetic flux produced by the ac current in the primary coil windings induces a changing magnetic flux at the secondary coil. This changing magnetic flux the induces an emf in the windings of the secondary coil.

![Fig. 1. A transformer.](image)

**Transformer operates only on ac voltages – DC current in primary does not produce a changing magnetic flux.**

Fig. 2. When DC voltage is switched on/off ⇒ current induced in secondary circuit e.g. spark plug in a car: high voltage created across a gap to produce a spark ⇒ ignition coil switches 12 Vdc to produce voltage spike ~ 25 kV).
Conservation of energy (assume zero energy losses in this simple model)

\[ \text{energy input} = \text{energy output} \]
\[ \text{power input (primary)} = \text{power output (secondary)} \]

Changing magnetic flux in primary = Changing magnetic flux in secondary

\[ V_p = N_p \left[ \frac{d\phi_p}{dt} \right]_{p} = N_p \frac{d\phi_p}{dt} \]
\[ V_s = N_s \left[ \frac{d\phi_s}{dt} \right]_{s} = N_s \frac{d\phi_s}{dt} \]

\[ \frac{V_p}{V_s} = \frac{N_p}{N_s} \quad P_p = P_s \quad \frac{I_p}{I_s} = \frac{N_s}{N_p} \]

\( V \) represents in rms (root mean square) or peak values of the ac voltages

**step-up transformer:**
*increase in secondary voltage (decrease in secondary current)*

\( N_S > N_P \quad V_S > V_P \quad I_S < I_P \)

**step-down transformer:**
*decrease in secondary voltage (increase in secondary current)*

\( N_S < N_P \quad V_S < V_P \quad I_S > I_P \)

The ferromagnetic core used in transformers is laminated to reduce ohmic heating caused by induced eddy currents.

![Diagram of induced eddy currents](image-url)

**Laminations reduce magnitude of eddy currents**

\[ \Rightarrow \text{less ohmic heating (} I^2R \text{)} \]

Fig. 3. Laminations reduce the magnitude of eddy currents. This reduces the ohmic heating of the metal core.
Questions and problems

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