4.6 Electric Generators, Back EMF, Transformers


Now THAT'S a generator!

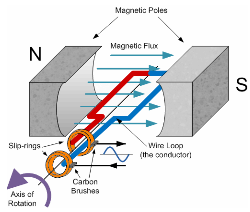
Alternating Current (AC) Generators

Convert mechanical energy into electrical energy.

Different types of input energy: fuel burning engine, hydroelectric, nuclear/coal driven steam turbine, etc.

Loops are forced to turn in a B-field; the resulting electron movement powers your lives!
(Hand-generator demo./ race cars!)

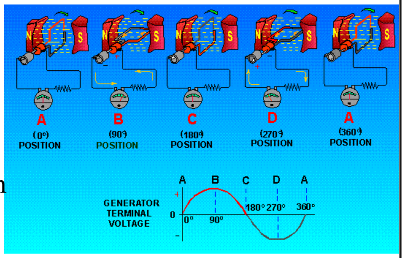
As the loop turns, the electron direction continuously reverses.



Max AC Generator Voltage

Since the loops (called an armature) of an AC generator constantly change direction, the B-field through them are in constant flux.

Generators turn at some frequency; the voltage at any point is a function of the armature's position vs. B-field.



Maximum Voltage Calculation

The maximum emf of a generator is:

$\varepsilon_0 = NBA \bullet 2\pi f$	N = loops B = magnetic Field (T) A = loop area (m^2) f = frequency (Hz)

Note: max. emf only occurs when A is parallel to B, at 90^{O} and 270^{O} (maximum flux).

1. Voltage Example

What maximum voltage will a 60 Hz generator produce if it has 250 turns (A = 0.055 m^2) in a 0.024 T field?

$$\varepsilon_0 = NBA \bullet 2\pi f$$
$$= 250 \bullet 0.024\,T \bullet 0.055\,m^2 \bullet 2\pi \bullet 60\,Hz$$
$$= 124\,V$$

Back EMF

As motors turn, their coils generate emf opposite that of their line voltage, called back emf (ε_b).

This is zero when the motor first starts (and current is maximum), and increases with rotational speed.

When back emf is large enough to almost equal line voltage, the motor goes no faster (current is limited).

Ex: Your lights dim when a motor turns on, but return to full intensity after a brief time.

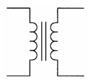
$\varepsilon_b = V - IR$	ε_b = back emf (V) V = line voltage (V) I = motor current (A) R = armature resistance (Ω)

Transformers

Convert one AC voltage to another for transmission, or to power devices requiring less voltage than provided.

Step-up transformers increase voltage; step-down transformers decrease voltage.

Circuit Symbol:



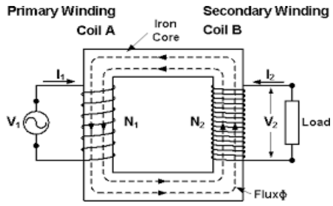
Wall Wart.

Power Station Transformer (Do NOT Lick!)

Transformer Theory

Induction changes voltage according to the ratio of windings around an iron core: the primary (supply side) vs. the secondary (output side) (hand out transformers).

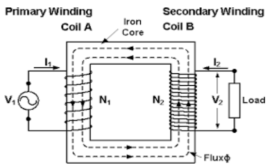
The core enhances the primary's B-field, and as polarity changes the decaying magnetic field (and newly forming one) propagates through the core and establishes voltage in the secondary.



Transformer Math

Primary power = secondary power: $P_1 = P_2 = IV$.
Since voltage and current are inversely proportional:

$V_s = \left(\frac{N_s}{N_p}\right) V_p$	V = Voltage (V) N = Number of Windings p = primary (supply side) s = secondary (output side) I = Current (A)
$I_s = \left(\frac{N_p}{N_s}\right) I_p$	



2. Transformer Example

A step-up transformer provides 2,280 V to a circuit, drawn from a 120 V supply.
What ratio of turns would be needed to achieve this?

$$V_s = \left(\frac{N_s}{N_p}\right) V_p$$

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\frac{2,280V}{120V} = 19$$

A ratio of 19 turns on the secondary to every 1 turn on the primary coils.

Cool Motors

Homopolar motor.

Li'l blue

Homework 4.6

4.6 Booklet Problems
Due: Next Class

Finish Review Scan