

### Common conversions:

RMS to PEAK  $\times \sqrt{2}$   
 PEAK to PEAK-PEAK  $\times 2$   
 RMS to PEAK-PEAK  $\times 2\sqrt{2}$

PEAK to RMS  $\div \sqrt{2}$   
 PEAK-PEAK to RMS  $\div 2$   
 PEAK-PEAK to RMS  $\div 2\sqrt{2}$

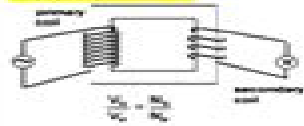
### Voltage stepping:

Input power = Output power  
 Current goes up  $\rightarrow$  Voltage goes up  
 Current and Voltage = Opposite

### Voltage stepping:

$P_{in} = P_{out}$	$\rightarrow$	$\frac{V_s}{V_p} = \frac{N_s}{N_p}$
$P_{in} = P_{out}$		

### Transformers:



An alternating current within the primary coil generates an alternating current in the iron core. The alternating field passes through the secondary coil induces an EMF in the secondary coil.

Peak Max  $\rightarrow$  Peak Min

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

To generate electricity, we must have a change in magnetic flux in relation to magnetic field. A transformer needs AC to create the changing magnetic field.

Step up = Primary (lower)  $\rightarrow$  Secondary (higher)  
 Step down = Primary (higher)  $\rightarrow$  Secondary (lower)

### Power loss equations:

$$P_{loss} = V_{loss} \times I_{transmission}$$

But,  $V_{loss} = I_{transmission} \times R$   
 $\rightarrow P_{loss} = I_{transmission}^2 \times R$

Current is inversely proportional to voltage if the power stays the same. Which is why it is best to reduce the current during transmission rather than resistance.

### Magnetic flux:

The measure of the amount of magnetic field passing through an area. A constant magnetic flux does not produce an electric current, but a changing magnetic flux does.

To change a magnetic flux: move a wire through a constant field, or, rotate a loop of wire in a constant field, or, change the strength of the magnetic field.

$$\Phi_B = \mathbf{B} \cdot \mathbf{A}$$

$$\therefore B = \frac{\Phi_B}{A}$$

$\Phi$  is the magnetic flux (Wb - Weber)  
 $B$  is the magnetic field strength (T)  
 $A$  is the area (m<sup>2</sup>)

Hence, field strength can be defined as the flux density, or the number of field lines per square metre.

### EMF:

EMF = Potential Difference (V) - (The electrical pressure).  
 The magnitude of the induced EMF is directly proportional to the rate of change of magnetic flux.

The change in flux induces the EMF.

Induced EMF will oppose change in flux.

### EMF induced:

For a single loop of wire, the induced EMF can be calculated as

$$\mathcal{E} = - \frac{\Delta \Phi_B}{\Delta t}$$

The minus sign is important, but is ignored in simple calculations

$$\text{as } \Phi_B = \mathbf{B} \cdot \mathbf{A} \quad \left\{ \begin{array}{l} \mathcal{E} = -A \frac{\Delta B}{\Delta t} \\ \mathcal{E} = -B \frac{\Delta A}{\Delta t} \end{array} \right.$$

### Size of the EMF induced:

Where the magnetic field is constant, the rate of change in flux is created by the rate of change of area.

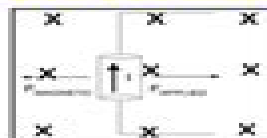
$$\mathcal{E} = -B \frac{\Delta A}{\Delta t} \quad \text{where } \frac{\Delta A}{\Delta t} \text{ represents the rate at which the conductor sweeps out area.}$$

### EMF and more loops:

$$\mathcal{E} = -N \frac{\Delta \Phi_B}{\Delta t}$$

**Lenz's law:** the direction of the induced EMF is the same as the current which opposes the change in flux that created it.

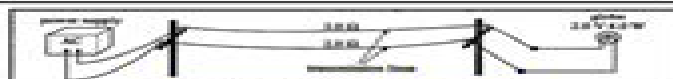
### Changing the flux by moving a wire through area:



Induced current creates a magnetic field and force that will oppose the applied force. Using the right-hand rule, when:

- the current flows up, and
  - the field acts into the page
- then the force due to the magnetic field around the wire is to the **left**.

This  $F_{magnetic}$  force acts to oppose the applied force - (motion)



Calculate the current in the wires:

$$I = \frac{V}{R} = \frac{4}{2} = 2A$$

Voltage output of the power supply:

$$R_{total} = 4\Omega, I_{globe} = \frac{12V}{2\Omega} = 2A, R_{globe} = \frac{2V}{2A} = 1\Omega$$

$$V = 2 \times (4 + 1) = 10V$$

Total power loss:

$$P_{loss} = I^2 R = 2^2 \times 4 = 16W$$



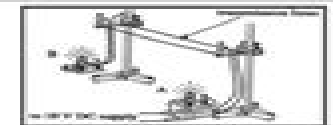
Current in wires:

$$P=IV, 4=2I, I=2A, R_{coil} = 1\Omega, \text{ Line current} = 0.2A$$

Power loss during transmission:

$$P_{loss} = I^2 R = 0.2^2 \times 4 = 0.16W$$

Over long-distance transmission of electricity, transformers are used to step up the voltage and consequently step down the current as they are inversely proportional if power stays the same as per:  $P=IV$ .



Total R of transmission line = 30  
 R of globe = 90, Supply = 12V DC

Power in globe A:

$$I = V/R = 2A, P = IV = 2 \times 18 = 36W$$

Voltage loss in transmission lines:

$$V=IR, I = 18/12 = 1.5A \text{ (lines)}$$

$$V=IR = 1.5 \times 3 = 4.5V$$

Power delivered to point B:

$$P=IV = 1.5^2 \times 9 = 20.25W$$

Transformers reduce power loss as they allow voltage to be stepped up and current to be stepped down as they are inversely proportional where power remains the same:  $P=IV$ , (reducing power loss in the form of heat or excess sound energy from buzzing).

### Ohms Law:



Frequency = 1/period



Primary coil = 100 turns so, secondary = 24/2400 = 100 = 24 turns.

Step lights = 5V so, resistance of wires = 5-4V = 1/1.5 = 0.67Ω

Power dissipated in wires = power loss  
 $P_{loss} = I^2 R = 1.5^2 \times 0.67 = 1.5W$

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