## Alternating Current

An alternating current source creates an electrical current that varies in magnitude and direction with time, as opposed to direct current source where the direction of current stays constant.

The root-mean-square value of an alternating current/ voltage is the value of steady direct current/ voltage that would produce the same average power in a given resistor.

Rectification is the process of converting an alternating current or voltage source into direct current or voltage supply.

Formulas:

$$P = (I_{rms})^2 R$$

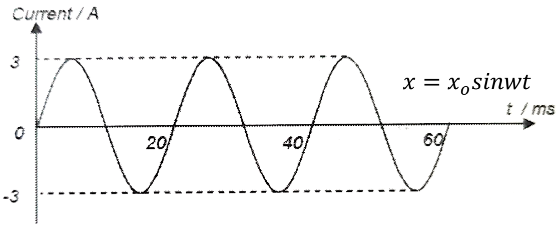
$$V_{rms} \text{ or } I_{rms} = \frac{V_o \text{ or } I_o}{\sqrt{2}}$$

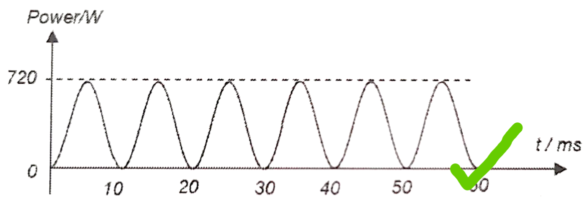
$$< P > = \frac{1}{2} P_O$$

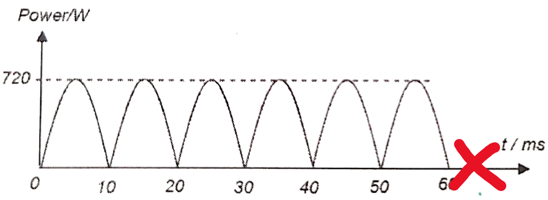
$$\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}$$

- Assume sinusoidal ac source, unless otherwise stated

- Thereafter, given sinusoidal ac source and told to sketch the appropriate power-time graph, not that power-time graph should also (somewhat) follow sine curve, with smooth (not sharp) troughs to the curve.

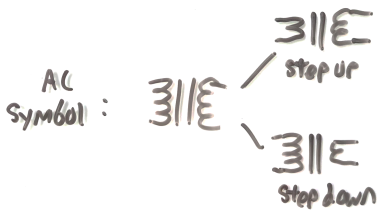



- **AC equations (e.g. $V_{rms}$ or $I_{rms} = \frac{V_o \text{ or } I_o}{\sqrt{2}}$) only work for sinusoidal ac source**. If it is not ac source, to find rms value: square the I-t or V-t graph, then mean squared value can be obtained by dividing the area under $I^2 - t$ graph or $V^2 - t$ graph within one period by the value of one period, lastly square root the mean square value.

- All voltmeter and ammeter readings are **rms value**.
- Effective value of the ac is the rms value
- For **full-wave** sinusoidal ac source:
  - mean value of current is zero
  - $< P > = \frac{1}{2} P_O$




- Assume ideal transformer, unless otherwise stated.
- Note that **for all transformers**[1], $\frac{V_S}{V_P} = \frac{N_S}{N_P}$ **holds**. But, for non-ideal transformers there could be power loss in transformer[2] and $I_s V_s \neq I_P V_P$, **thus** $\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}$ **does not hold**.

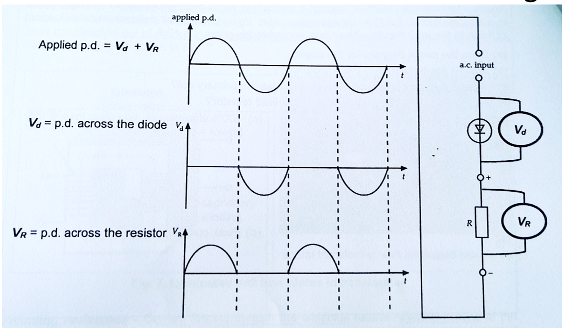
[1] Iron Core strengthens and links the flux through the secondary coil
[2] Energy loss in transformer: Eddy current causes heating of core→ mitigated by constructing the core out of stack of laminated soft iron plates perpendicular to the eddy currents circulation plane OR energy dissipated in primary and secondary coils as heat

N.B. Turns ratio may not always be $N_S/N_P$, varies based on context.

- Rectification:

| Half-wave rectification | Full-wave rectification |
|---|---|
| A half-wave rectification converts only half of the ac into dc by allowing current flow in only one direction. | A full wave rectification converts all of the ac into dc by inverting the negative current flow into positive current flow. |

- Use of single diode for half wave rectification of an alternating current:




| Half cycle with positive V and I | Half cycle with negative V and I |
|---|---|
| The diode is **forward biased** and has **almost zero resistance**, which **allows a current to flow through the circuit**. There is **negligible pd across the diode** as its **resistance is negligible**. Thus, **pd across R is equal to ac input voltage**.<br>→ When forward is forward biased, pd across R follows ac supply | The diode is now **reversed biased** and has almost **infinite resistance**, such that only a **negligible current** flow through it. **The pd across the diode is equal to the ac input voltage** as its **resistance is very much larger than R**. Thus, **pd across R is zero**.<br>→ When diode is reversed biased, pd across R is 0. |

- If sinusoidal current of peak value $I_o$ is passed through a resistor, average power dissipated in the resistor= $\frac{I_o}{\sqrt{2}}^2 \boldsymbol{R}$.
- If sinusoidal current of peak value $I_o$ is passed through a resistor with **a** diode connected in series with it, average power dissipated in the resistor= $(\frac{I_o}{\sqrt{2}}^2 \boldsymbol{R})/\boldsymbol{2}$

- Disadvantage of half wave rectification:
  For half the duration, there is no pd across the resistor. Hence, half the power supplied is not transferred to the resistor.

- Check your understanding:

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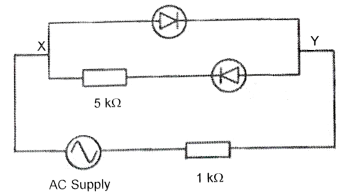
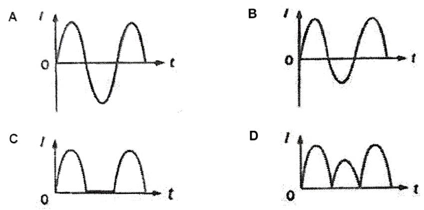



Which of the following graphs below represents the variation of current $I$ with time $t$ through XY of the circuit in the diagram above?

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- Power-time graph is always in the positive region

- Selecting appropriate fuse for an appliance:
  For ac, current and voltages alternates in direction and magnitude. This means that energy (heat) must be dissipated in wire for a **sufficiently long duration** to melt fuse (i.e. fuse).

  Example: Given $I_{peak} = 12A$, $I_{rms} = 8.33A$, and 6A, 10A, 13A fuse to choose from, 10A fuse should be chosen.
  - rms value represents effective current value
  - 6A is too low → fuse will blow with normal usage
  - 13A higher than peak current → heater might be damaged by 12.5A current but fuse does not blow

- Rationale of stepping up:
  For given power supplied, higher voltage → lower current in transmission cable → less power loss as heat in transmission cable since $P = I^2R$

- Usefulness of AC:
  AC voltage is required to transmit electrical energy, because it allows for voltages to be step up before transmission and step down after transmission through transformers, by means of changing magnetic flux.