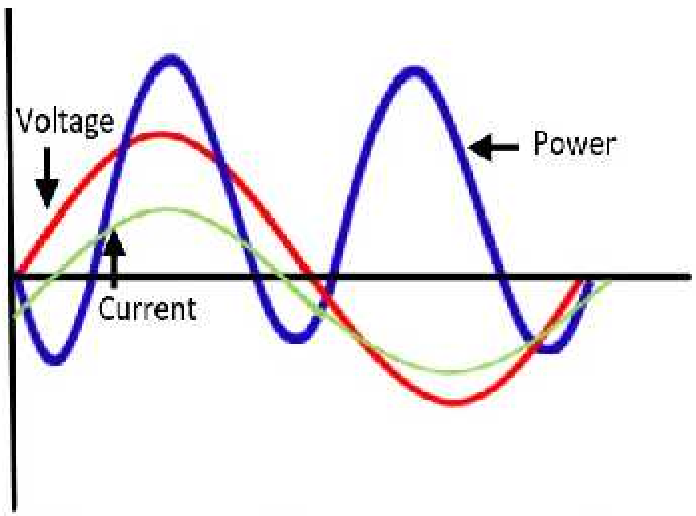
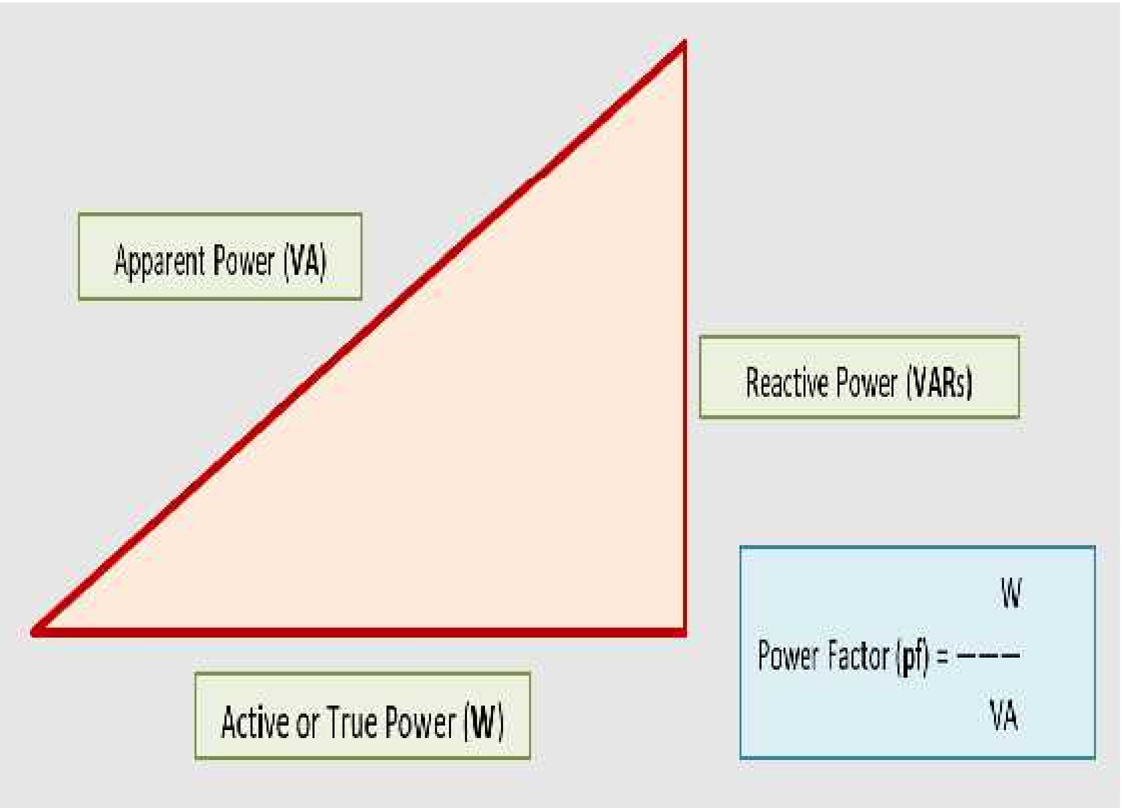
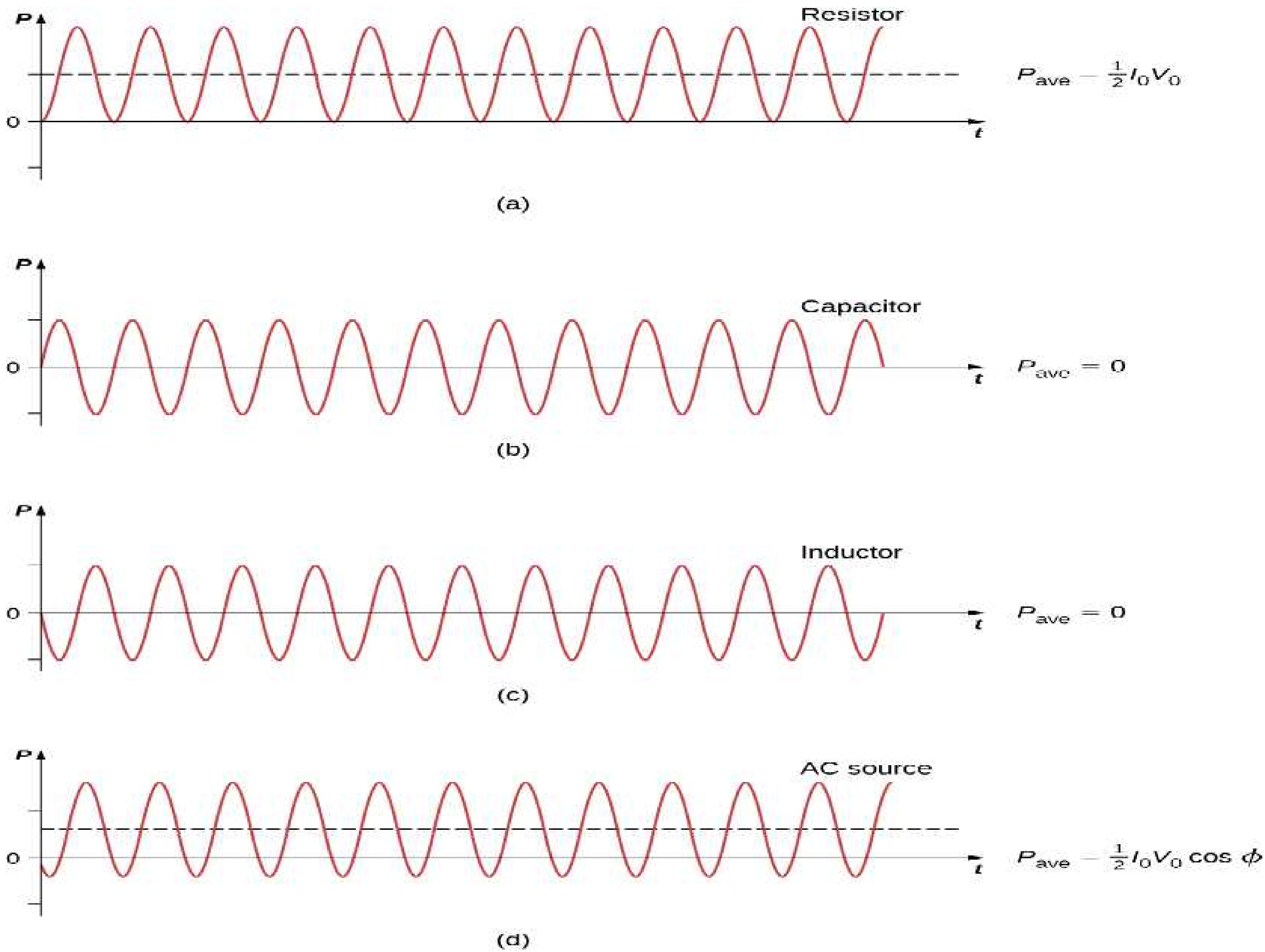
Power in AC circuits

Power factor



Plot of the Power of Instantaneous Voltage, Current & Power




P
Resistor
$P_{ave} = \frac{1}{2} I_0 V_0$
0
t
(a)
P
Capacitor
0
t
$P_{ave} = 0$
(b)
P
Inductor
0
t
$P_{ave} = 0$
(c)
P
AC source
0
t
$P_{ave} = \frac{1}{2} I_0 V_0 \cos \phi$
(d)

Power in AC circuits: Power Factor

$$P = \frac{V_m I_m}{2} \cos \theta \qquad \text{(watts, W)}$$

- When the load is a combination of resistive and reactive elements,

  Power factor will vary between 0 and 1
- More resistive the total impedance, the closer the power factor is to 1
- More reactive the total impedance, the closer the power factor is to 0

In terms of the average power and the terminal voltage and current

$$F_p = \cos \theta = \frac{P}{V_{eff} I_{eff}}$$

leading and lagging power factor:

- **If the current leads the voltage across a load, the load has a leading PF**
- **If the current lags the voltage across the load, the load has a lagging PF**

capacitive networks have leading power factors, and inductive networks have lagging power factors.

$$\text{Power Factor} = \frac{\text{watts}}{\text{volt-amperes}}$$

$$= \frac{P}{S} = \frac{VI\cos\phi}{VI} = \cos\phi$$

$$\text{Power factor} = \frac{P}{S}$$

$$\text{Power factor} = \frac{1.5\text{kW}}{2.308\text{kVA}}$$

$$\text{Power factor} = 0.65$$

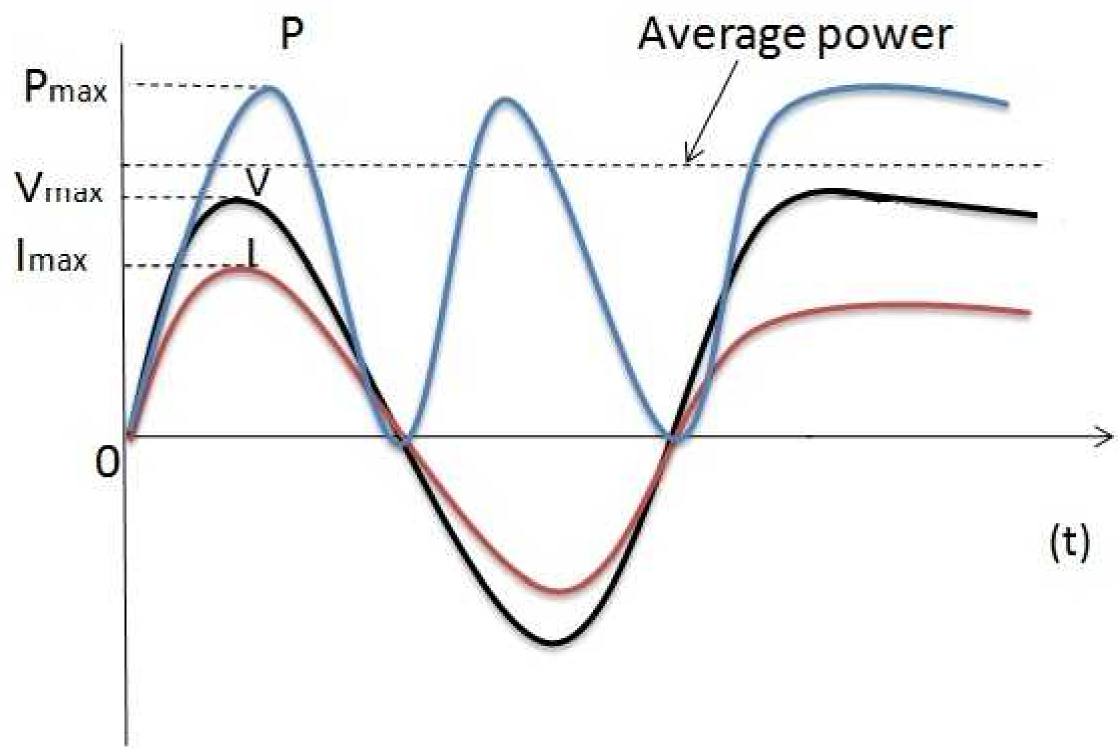
The average **ac power** is found by multiplying the **rms** values of current and **voltage**. Ohm's law for the **rms ac** is found by dividing the **rms voltage** by the impedance. In an **ac circuit**, there is a phase angle between the source **voltage** and the current, which can be found by dividing the resistance by the impedance.

RMS value is equal to the **value** of the direct current that would produce the same average power dissipation in a resistive load.
RMS value of **AC** = 0.707 times its instantaneous **value**

Then the **RMS** voltage (V_{RMS}) of a sinusoidal waveform is determined by multiplying the peak voltage value by 0.7071, which is the same as one divided by the square root of two ($1/\sqrt{2}$).

Power in AC Circuits

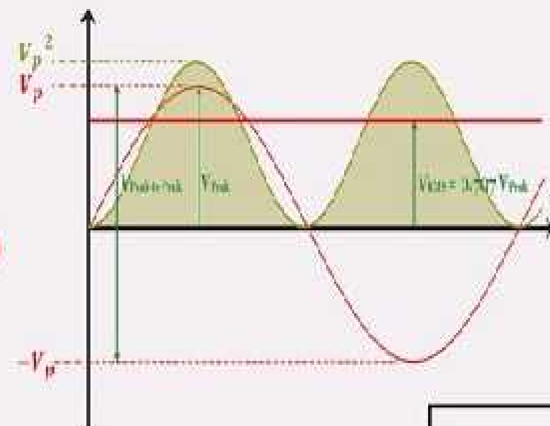
Electrical **power** is the “rate” at which **energy** is being consumed in a **circuit** and as such all electrical and electronic components and devices have a limit to the amount of electrical **power** that they can safely handle. For example, a 1/4 watt resistor or a 20 watt amplifier.



What is RMS voltage and current?
Why do we use RMS values?

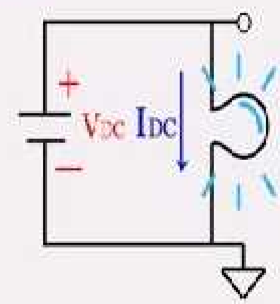
$$v_{RMS} = \sqrt{\frac{1}{T_2 - T_1}\int_{T_1}^{T_2} (V_p sin(wt))^2 dt}$$

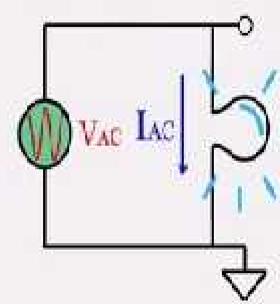
Waveform		RMS
DC	$y = A_0$	A_0
Sine wave	$y = A_1 Sin(xt)$	$\frac{A_1}{\sqrt{2}}$
Square wave	$y = A_1 \quad 0 < t < 0.5T$ $y = -A_1 \quad 0.5T < t < T$	A_1
Triangle Sawtooth		$\frac{A_1}{\sqrt{3}}$
DC shifted sine wave	$y = A_0 + A_1 Sin(xt)$	$\sqrt{A_0^2 + \frac{A_1^2}{2}}$
DC shifted square wave	$y = A_0 + A_1 \quad 0 < t < 0.5T$ $y = A_0 - A_1 \quad 0.5T < t < T$	$\sqrt{A_0^2 + A_1^2}$
Sine wave + Square wave	$y = A_0 + A_1 sin(xt) \quad 0 < t < 0.5T$ $y = -A_0 + A_1 sin(xt) \quad 0.5T < t < T$	$\sqrt{A_0^2 + \frac{A_1^2}{2}}$
Pulse train	$y = 0 \quad 0 < t < t_1$ $y = A_1 \quad t_1 < t < T$	$A_1 \sqrt{\frac{T - t_1}{T}}$

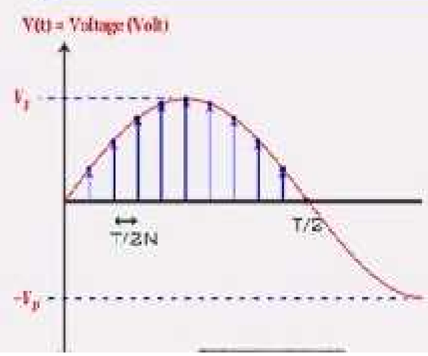


$$120\, Volts_{RMS} = 340\, Volts_{pp}$$

$$RMS\ Value_{sine\ wave} = \frac{v_{peak}}{\sqrt{2}} \approx 0.707\ v_{peak}$$







$$RMS_{Wave} = \sqrt{\frac{\sum_{i=1}^{n} v_i^2}{n}} = \sqrt{\frac{v_1^2 + v_2^2 + ... + n^2}{n}}$$