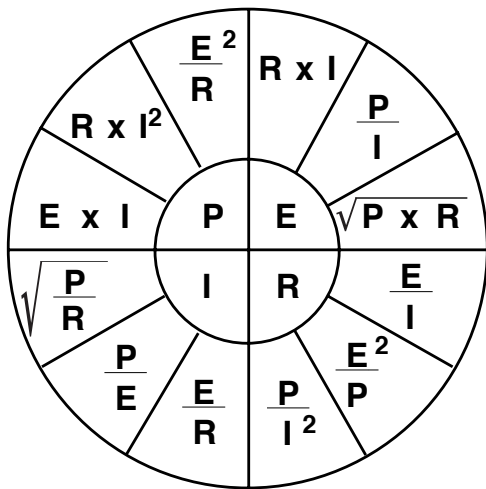


# CHAPTER 1

## ELECTRICAL FORMULAS

### OHM'S LAW/POWER FORMULAS



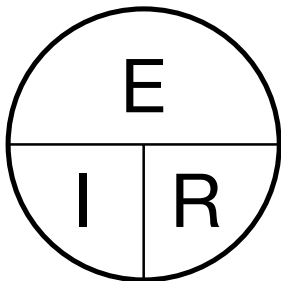
P = Power = Watts

R = Resistance = Ohms

I = Current = Amperes

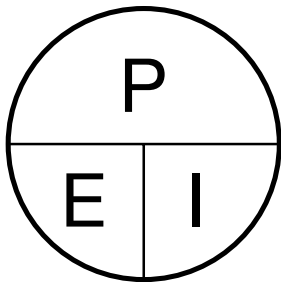
E = Force = Volts

## OHM'S LAW DIAGRAM AND FORMULAS



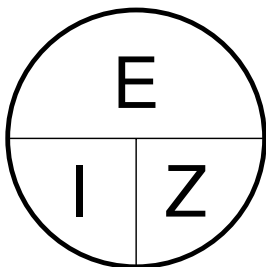
$E = I \times R$	Voltage = Current x Resistance
$I = E \div R$	Current = Voltage $\div$ Resistance
$R = E \div I$	Resistance = Voltage $\div$ Current

## POWER DIAGRAM AND FORMULAS



$I = P \div E$	Current = Power $\div$ Voltage
$E = P \div I$	Voltage = Power $\div$ Current
$P = I \times E$	Power = Current x Voltage

## OHM'S LAW AND IMPEDANCE



E = VOLTAGE (IN V)  
I = CURRENT (IN A)  
Z = IMPEDANCE (IN  $\Omega$ )

$$E = I \times Z$$

$$I = \frac{E}{Z}$$

$$Z = \frac{E}{I}$$

Ohm's law and the power formula are limited to circuits in which electrical resistance is the only significant opposition to current flow including all DC circuits and AC circuits that do not contain a significant amount of inductance and/or capacitance. AC circuits that include inductance are any circuits that include a coil as the load such as motors, transformers, and solenoids. AC circuits that include capacitance are any circuits that include a capacitor(s).

In DC and AC circuits that do not contain a significant amount of inductance and /or capacitance, the opposition to current flow is resistance (R). In circuits that contain inductance ( $X_L$ ) or capacitance ( $X_C$ ), the opposition to the flow of current is reactance (X). In circuits that contain resistance (R) and reactance (X), the combined opposition to the flow of current is impedance (Z). Resistance and Impedance are both measured in Ohms.

Ohm's law is used in circuits that contain impedance, however, and Z is substituted for R in the formula. Z represents the total resistive force (resistance and reactance) opposing current flow.

## OHM'S LAW FOR ALTERNATING CURRENT

For the following Ohms Law formulas for AC current,  $\theta$  is the phase angle in degrees where current lags voltage (in inductive circuit) or by which current leads voltage (in a capacitive circuit). In a resonant circuit (such as 120VAC) the phase angle is  $0^\circ$  and Impedance = Resistance

$$\text{Current in amps} = \frac{\text{Voltage in volts}}{\text{Impedance in ohms}}$$

$$\text{Current in amps} = \sqrt{\frac{\text{Power in watts}}{\text{Impedance in ohms} \times \cos \theta}}$$

$$\text{Current in amps} = \frac{\text{Power in watts}}{\text{Voltage in volts} \times \cos \theta}$$

$$\text{Voltage in volts} = \text{Current in amps} \times \text{Impedance in ohms}$$

$$\text{Voltage in volts} = \frac{\text{Power in watts}}{\text{Current in amps} \times \cos \theta}$$

$$\text{Voltage in volts} = \sqrt{\frac{\text{Power in watts} \times \text{Impedance in ohms}}{\cos \theta}}$$

$$\text{Impedance in ohms} = \text{Voltage in volts} / \text{Current in amps}$$

$$\text{Impedance in ohms} = \text{Power in watts} / (\text{Current in amps}^2 \times \cos \theta)$$

$$\text{Impedance in ohms} = (\text{Voltage in volts}^2 \times \cos \theta) / \text{Power in watts}$$

$$\text{Power in watts} = \text{Current in amps}^2 \times \text{Impedance in ohms} \times \cos \theta$$

$$\text{Power in watts} = \text{Current in amps} \times \text{Voltage in volts} \times \cos \theta$$

$$\text{Power in watts} = \frac{(\text{Voltage in volts})^2 \times \cos \theta}{\text{Impedance in ohms}}$$

## OHM'S LAW FOR DIRECT CURRENT

$$\text{Current in amps} = \frac{\text{Voltage in volts}}{\text{Resistance in ohms}} = \frac{\text{Power in watts}}{\text{Voltage in volts}}$$

$$\text{Current in amps} = \sqrt{\frac{\text{Power in watts}}{\text{Resistance in ohms}}}$$

$$\text{Voltage in volts} = \text{Current in amps} \times \text{Resistance in ohms}$$

$$\text{Voltage in volts} = \text{Power in watts} / \text{Current in amps}$$

$$\text{Voltage in volts} = \sqrt{\text{Power in watts} \times \text{Resistance in ohms}}$$

$$\text{Power in watts} = (\text{Current in amps})^2 \times \text{Resistance in ohms}$$

$$\text{Power in watts} = \text{Voltage in volts} \times \text{Current in amps}$$

$$\text{Power in watts} = (\text{Voltage in volts})^2 / \text{Resistance in ohms}$$

$$\text{Resistance in ohms} = \text{Voltage in volts} / \text{Current in amps}$$

$$\text{Resistance in ohms} = \text{Power in watts} / (\text{Current in amps})^2$$

## POWER FACTOR

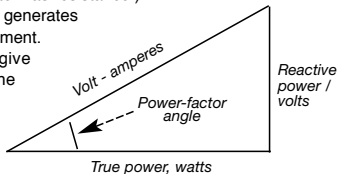
An AC electrical system carries two types of power:

(1) true power, watts, that pulls the load (Note: Mechanical load reflects back into an AC system as resistance.)

and (2) reactive power, vars, that generates magnetism within inductive equipment.

The vector sum of these two will give actual volt-amperes flowing in the circuit (see diagram right).

Power factor is the cosine of the angle between true power and volt-amperes.



## SINGLE-PHASE POWER

Power of a single-phase AC circuit equals voltage times current times power factor:

$$P_{\text{watts}} = E_{\text{volts}} \times I_{\text{amps}} \times \text{PF.}$$

To figure reactive power, vars squared equals volt-amperes squared minus power squared, or

$$\text{VARs} = \sqrt{(\text{VA})^2 - (\text{P})^2}$$