Electrical Formulas

Commonly used electrical formulas like Ohms Law and more.

Common electrical units used in formulas and equations are:

- **Volt** - unit of electrical potential or motive force - potential is required to send one ampere of current through one ohm of resistance
- **Ohm** - unit of resistance - one ohm is the resistance offered to the passage of one ampere when impelled by one volt
- **Ampere** - units of current - one ampere is the current which one volt can send through a resistance of one ohm
- **Watt** - unit of electrical energy or power - one watt is the product of one ampere and one volt - one ampere of current flowing under the force of one volt gives one watt of energy
- **Volt Ampere** - product of volts and amperes as shown by a voltmeter and ammeter - in direct current systems the volt ampere is the same as watts or the energy delivered - in alternating current systems - the volts and amperes may or may not be 100% synchronous - when synchronous the volt amperes equals the watts on a wattmeter - when not synchronous volt amperes exceed watts - reactive power
- **kiloVolt Ampere** - one kilovolt ampere - kVA - is equal to 1000 volt amperes
- **Power Factor** - ratio of watts to volt amperes

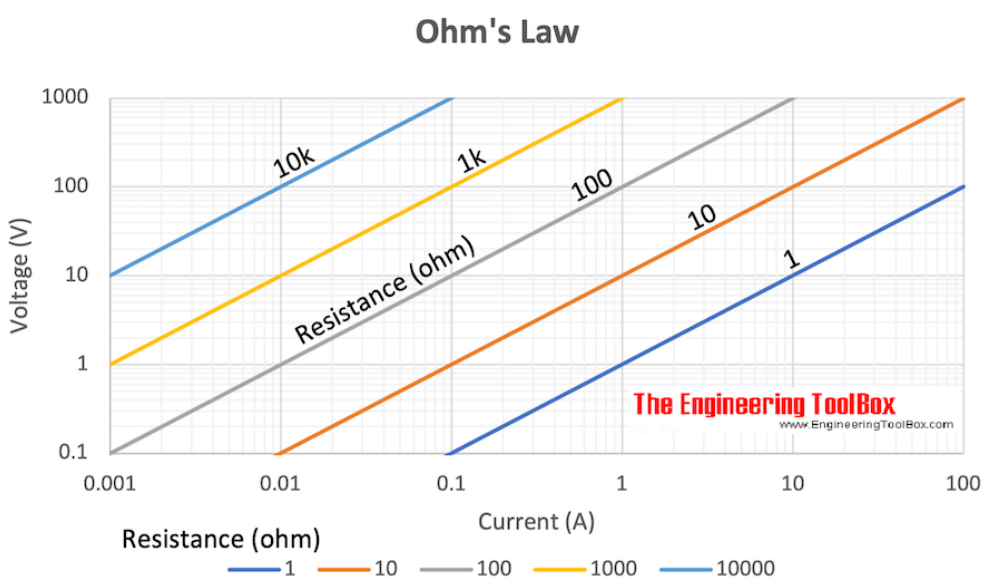
Electrical Potential - Ohm's Law

Ohm's law can be expressed as:

$$U = R\ I \qquad (1a)$$

$$U = P / I \qquad (1b)$$

$$U = (P\ R)^{1/2} \qquad (1c)$$



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Electric Current - Ohm's Law

$$I = U / R \qquad (2a)$$

$$I = P / U \qquad (2b)$$

$$I = (P / R)^{1/2} \qquad (2c)$$

Electric Resistance - Ohm's Law

$$R = U / I \qquad (3a)$$

$$R = U^2 / P \qquad (3b)$$

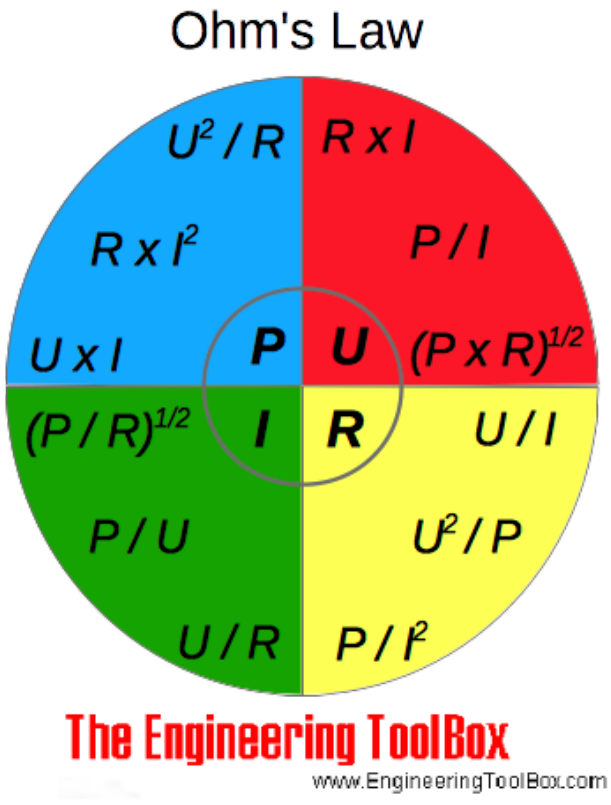
$$R = P / I^2 \qquad (3c)$$

Example - Ohm's law

A *12 volt* battery supplies power to a resistance of *18 ohms*.

$$I = (12\ V) / (18\ \Omega)$$

= 0.67 (A)



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Electric Power

$P = U I$ (4a)

$P = R I^2$ (4b)

$P = U^2 / R$ (4c)

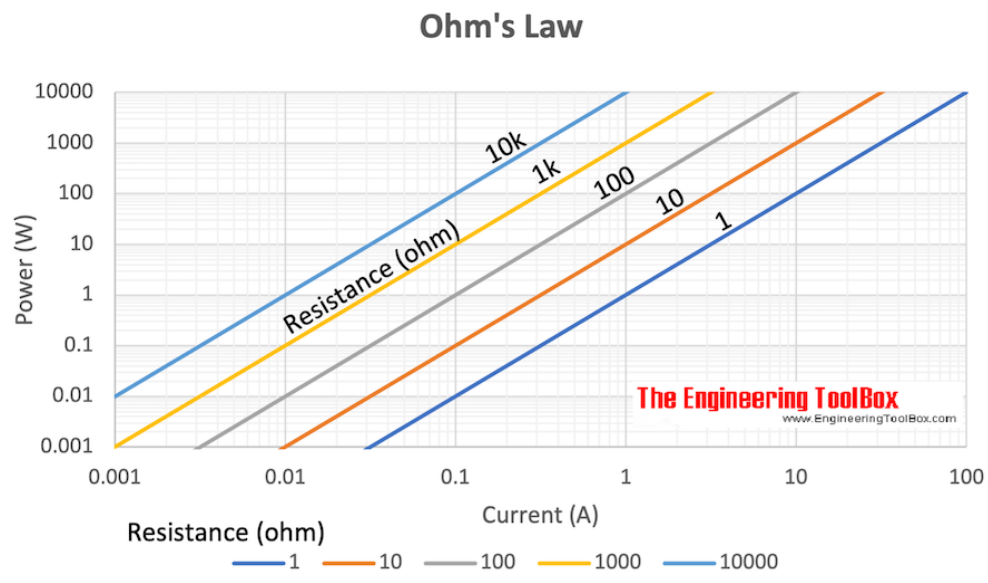
where

P = power (watts, W, J/s)

U = voltage (volts, V)

I = current (amperes, A)

R = resistance (ohms, Ω)



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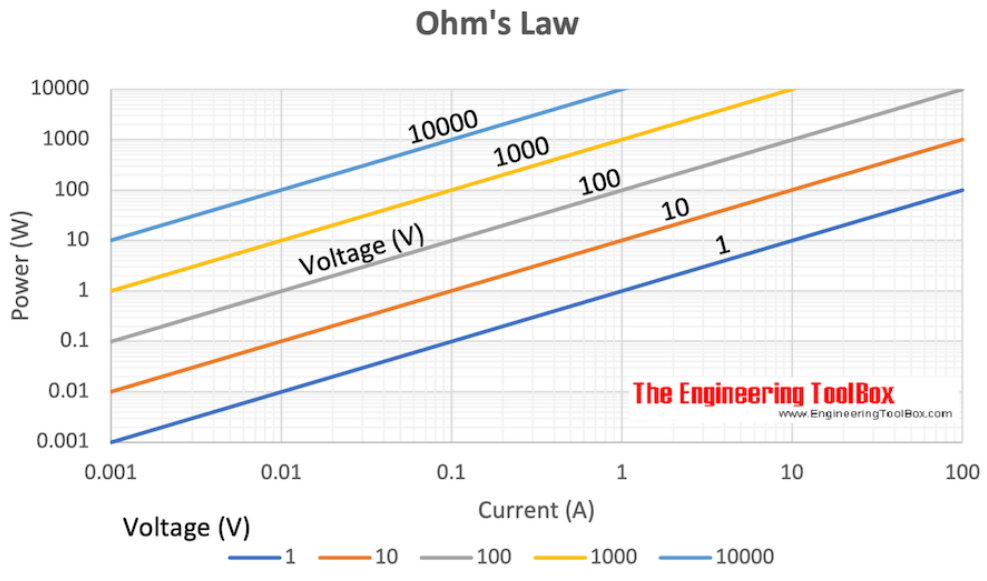

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Electric Energy

Electric energy is power multiplied with time:

$W = P\ t$ (5)

where

W = energy (Ws, J)

t = time (s)

Alternative - power can be expressed

$P = W / t$ (5b)

Power is consumption of energy by consumption of time.

Example - Energy lost in a Resistor

A *12 V* battery is connected in series with a resistance of *50 ohm*. The power consumed in the resistor can be calculated as

$P = (12\ V)^2 / (50\ ohm)$

$= \underline{2.9}\ W$

The energy dissipated in *60 seconds* can be calculated

$W = (2.9\ W)\ (60\ s)$

$= \underline{174}\ Ws, J$

$= \underline{0.174}\ kWs$

$= \underline{4.8\ 10}^{-5}\ kWh$

Example - Electric Stove

An electric stove consumes *5 MJ* of energy from a *230 V* power supply when turned on in *60 minutes*.

- energy to heat water

The power rating - energy per unit time - of the stove can be calculated as

$P = (5\ MJ)\ (10^6\ J/MJ) / ((60\ min)\ (60\ s/min))$

$= \underline{1389}\ W$

$= \underline{1.39}\ kW$

The current can be calculated

$I = (1389\ W) / (230\ V)$

$= \underline{6}\ ampere$

Electrical Motors

Electrical Motor Efficiency

$\mu = 746\ P_{hp} / P_{input\_w}$ (6)

where

μ = efficiency

P_{hp} = output horsepower (hp)

P_{input_w} = input electrical power (watts)

or alternatively

$\mu = 746\ P_{hp} / (1.732\ V\ I\ PF)$ (6b)

Electrical Motor - Power

$P_{3\text{-}phase} = (U\ I\ PF\ 1.732) / 1{,}000$ (7)

where

$P_{3\text{-}phase}$ = electrical power 3-phase motor (kW)

PF = power factor electrical motor

Electrical Motor - Amps

$I_{3\text{-}phase} = (746\ P_{hp}) / (1.732\ V\ \mu\ PF)$ (8)

where

$I_{3\text{-}phase}$ = electrical current 3-phase motor (amps)

PF = power factor electrical motor