Technical Information

Electrical Fundamentals & Three Phase Calculations

Ohm's Law

The relationship between Wattage (heat) output and the applied Voltage of electric resistance heating elements is determined by a precise physical rule defined as Ohm's Law which states that the current in a resistance heating element is directly proportional to the applied Voltage. Ohm's Law is traditionally expressed as:

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

Where: I = Amperes (Current)
E = Voltage
R = Ohms (Resistance)

The same equation using the conventional abbreviation for voltage is:

$$I = \frac{V}{R}$$

Where: I = Amperes (Current)
V = Voltage
R = Ohms (Resistance)

An unknown electrical value can be derived by using any two known values in one of the variations of Ohm's Law shown at the right.

OHM'S LAW

VOLTS

VOLTS = $\sqrt{\text{WATTS X OHMS}}$

VOLTS = $\frac{\text{WATTS}}{\text{AMPERES}}$

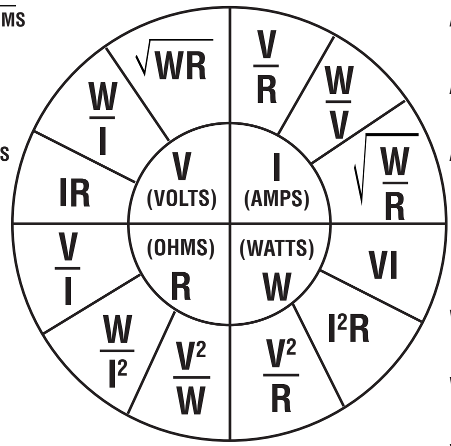
VOLTS = AMPERES X OHMS

OHMS

OHMS = $\frac{\text{VOLTS}}{\text{AMPERES}}$

OHMS = $\frac{\text{WATTS}}{\text{AMPERES}^2}$

OHMS = $\frac{\text{VOLTS}^2}{\text{WATTS}}$



AMPERES

AMPERES = $\frac{\text{VOLTS}}{\text{OHMS}}$

AMPERES = $\frac{\text{WATTS}}{\text{VOLTS}}$

AMPERES = $\sqrt{\frac{\text{WATTS}}{\text{OHMS}}}$

WATTS

WATTS = VOLTS x AMPERES

WATTS = AMPERES² x OHMS

WATTS = $\frac{\text{VOLTS}^2}{\text{OHMS}}$

Voltage & Wattage Relationships

An electric resistance element only produces rated Wattage at rated Voltage. It is common for electric heating elements and assemblies to be connected to a wide range of operating Voltages. Since the Wattage output varies directly with the ratio of the square of the Voltages, the actual Wattage can be calculated for any applied Voltage. The relationship is expressed by the equation below,

$$W_A = W_R \times \left(\frac{V_A^2}{V_R^2}\right)$$

Where: W_A = Actual Wattage
W_R = Rated Wattage
V_A = Applied Voltage
V_R = Rated Voltage

Percent of Rated Wattage for Various Applied Voltages

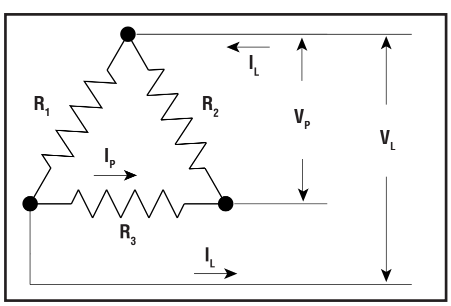
Applied Voltage	Rated Voltage 110	115	120	208	220	230	240	277	380	415	440	460	480	575
110	100	91	84	28	25	23	21	16	8.4	7.0	6.2	5.7	5.2	3.7
115	109	100	92	31	27	25	23	17	9.0	7.6	6.7	6.2	5.7	4.0
120	119	109	100	33	30	27	25	19	10	8.4	7.4	6.8	6.3	4.3
208	—	—	300	100	89	82	75	56	30	25	22	20	19	13
220	—	—	—	112	100	91	84	63	34	28	25	23	21	15
230	—	—	—	122	109	100	92	69	37	31	27	25	23	16
240	—	—	—	133	119	109	100	75	40	33	30	27	25	17
277	—	—	—	—	—	—	133	100	53	45	40	36	33	23
380	—	—	—	—	—	—	—	188	100	84	74	68	63	44
415	—	—	—	—	—	—	—	—	119	100	89	81	75	52
440	—	—	—	—	—	—	—	—	—	112	100	91	84	58
460	—	—	—	—	—	—	—	—	—	123	109	100	92	64
480	—	—	—	—	—	—	—	—	—	—	119	109	100	70
550	—	—	—	—	—	—	—	—	—	—	156	143	131	91
575	—	—	—	—	—	—	—	—	—	—	171	156	144	100
600	—	—	—	—	—	—	—	—	—	—	186	170	156	109

Three Phase Equations (Balanced)

Ohm's Law, as stated above, applies to electrical resistance elements operated on single phase circuits. Ohm's Law can be modifed to calculate three phase values by adding a correction factor for the phase Voltage relationships. The three phase equations shown can be applied to any balanced Delta or Wye circuit. The terms used in the equations are identified below:

- V_L = Line Voltage
- V_P = Phase Voltage
- I_L = Line Current (Amps)
- I_P = Phase Current (Amps)
- W_T = Total Watts
- R_1 = R_2 = R_3 = Element Resistance
- W_C = Wattage per Circuit (Equal Circuits)
- R_C = Circuit Resistance in Ohms Measured Phase to Phase

3Ø Delta



$V_P = V_L$

$W_T = 1.73\ I_L \times V_L$

$I_P = I_L \div 1.73$

$W_C = 1.73\ I_L \times V_L \div \#\ \text{Circuits}$

$R_C = (2 \times V_L^2) \div W_C$

$V_L = V_P$

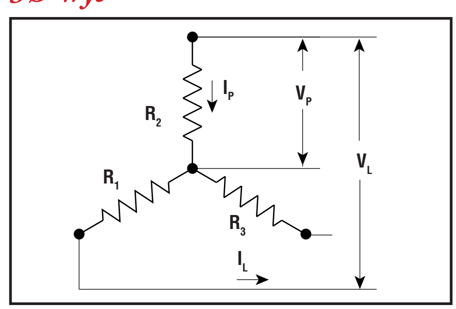
$W_T = 3\ (V_L^2 \div R_1)$

$I_L = I_P \times 1.73$

$R_C = V_L^2 \div 0.5 W_C$

Note — For Open Delta connections, see next page.

3Ø Wye



$V_P = V_L \div 1.73$

$W_T = 1.73\ I_L \times V_L$

$I_P = I_L$

$W_C = 1.73\ I_L \times V_L \div \#\ \text{Circuits}$

$R_C = (2 \times V_L^2) \div W_C$

$V_L = V_P \times 1.73$

$W_T = V_L^2 \div R_1$

$I_L = I_P$

$R_C = V_L^2 \div 0.5\ W_C$

Note — For Open Wye connections, see next page.

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