BASIC ELECTRICAL CALCULATIONS

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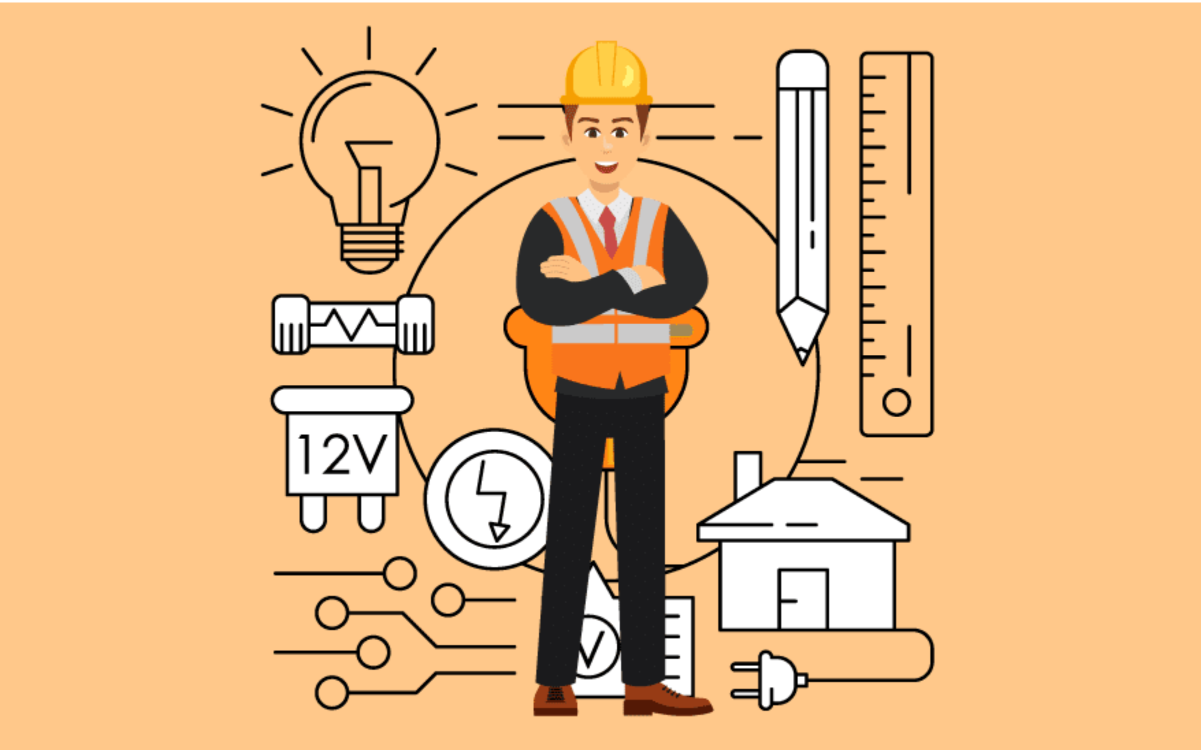

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Computing Watts When Volts and Amps are Known

POWER (WATTS) = Volts x Amps

- For example, a small computer has a nameplate that shows 2.5 amps. Given a normal 120 Volt, 60 Hz power source and the ampere reading from equipment, make the following calculation:

POWER (WATTS) = 2.5Amps x 120Volts = 300 WATTS

Generally: P=IE

P= Power(WATTS)

I = Current(Amps)

E = Voltage(Volts)

So: I = P/E and E = P/I
Therefore: 1 Watt = 1 Ampere x 1 Volt

Computing Kilovolt-Amps (kVA)

kVA stands for "Thousand Volt-Amps".

A 2-Pole Single Phase 208-240 power source requires 2 hot wires from 2 different circuits (referred to as poles) from a power distribution panel.

<u>SINGLE PHASE</u>

KILOVOLT-Amps (kVA) = Volts x Amps / 1000

Using the previous example: 120 x 2.5 = 300 VA 300 Va / 1000 = .3 kVA

<u>208-240 SINGLE-PHASE (2-POLE SINGLE-PHASE)</u>

- Example: An enterprise computer bvserver with a 4.7 amp rating and requiring a 208-240 power source. Use 220 volts for our calculations.

kilovolt-Amps (kVA) = Volts x Amps /1000

220 x 4.7 = 1034 1034 / 1000 = 1.034 kVA

THREE-PHASE

- Example: A large disk storage system loaded with disks. The equipment documentation shows a requirement for a 50-amp 208-240 VAC power source. Do not calculate any value for the plug or receptacle. Use 220 volts for the calculation.

kilovolt-Amps (kVA) = Volts x Amps x 1.73 / 1000

220 x 50 x 1.73 = 19,030   19,030 / 1000 = 19.030 kVA   This would be rounded to 19

To Convert Between kW and kVA

- The only difference between kW and kVA is the power factor. The power factor, unless taken from the manufacturer's specifications, is an approximation. For this example, we use a power factor of .95. The kVA value will always be larger than the value for kW.

kW to kVA	kW / .95 = kVA
kVA TO kW	kVA x .95 = kW

To Convert Between kW-Hours and kVA

- There is NO conversion from kWH to kVA. These are two different measures. kWH is *energy* and kVA is *power* (not necessarily dissipated). If you look at kW (power) and kVA (power), then there is a relationship. That relationship is the power factor of the load.

Computing BTUs

- Known Standard: 1 kW = 3413 BTUs (or 3.413 kBTUs)
- If you divide the electrical nameplate BTU value by 3413 you may not get the published kW value. If the BTU information is provided by the manufacturer, use it, otherwise use the above formula.

Shotgun Section

Here are conversions, short and sweet:

To convert kVA to Amps:
Multiply kVA by 1000/voltage [(kVA x 1000) / E]
For 3 Phase power divide by 1.73 [(kVA x 1000) / E x 1.73]

- To convert Watts to Volts when amps are known:
  Voltage = Watts / Amps
  E = P / I
- To convert Watts to Amps when volts are known:
  Amps = Watts / Voltage
  I = P / E
  For 3 Phase power divide by 1.73
- To convert Amps to Watts when volts are known:
  Watts = Voltage x Amps
  P = E x I
  For 3 Phase power multiply by 1.73
- To convert Horsepower to Amps:
  Horsepower = (E x I x EFF) / 746
  Efficiency = (746 x HP) / (V x A)

  Multiply Horsepower by 746W (1 HP = 746 Watts)
  Find Circuit Voltage and Phase

  Example:
  40 HP at 480 (3 Phase) 746 multiplied by 40 = 29,840
  29,840 divided by 480 (3 Phase) = 62.2
  62.2 divided by 1.73 = 35.95Amps
- To convert kW to Amps:
  Multiply kW by 1000/voltage and then by Power Factor [(kW x 1000) / E x PF]
  for 3 Phase power divide by 1.73 [(kW x 1000) / E x PF x 1.73]

Shotgun Table of Formulae

HOW TO FIND Amps (I)	
Direct Current	
When HP, E and EFF are known:	**HP x 746 / E x EFF**
When kW and E are known:	**kW x 1000 / E**
SINGLE PHASE	
When P, E and PF are known:	**P / E x PF**
When HP, E, EFF and PF are known:	**HP x 746 / E x EFF x PF**
When kW, E and PF are known:	**kW x 1000 / E x PF**
When kVA and E are known:	**kVA x 1000 / E**
THREE PHASE	
When P, E and PF are known:	**P / E x PF x 1.73**
When HP, E, EFF and PF are known:	**HP x 746 / E x EFF x PF x 1.73**
When kW, E and PF are known:	**kW x 1000 / E x PF x 1.73**
When kVA and E are known:	**kVA x 1000 / E x 1.73**
(See abbreviations explained below)	

HOW TO FIND WATTS (P)	
When E and I are known:	**I x E**
When R and I are known:	**R x I^2**
When E and R are known:	**E^2 / R**
(See abbreviations explained below)	

HOW TO FIND KILOWATTS (kW)	
Direct Current	
E and I must be known:	**E x I / 1000**
SINGLE PHASE	
E, I and PF must be known:	**E x I x PF / 1000**
THREE PHASE	
E, I and PF must be known:	**E x I x PF x 1.73 / 1000**
(See abbreviations explained below)	

HOW TO FIND KILOVOLT-Amps (kVA)	
SINGLE PHASE	
E and I must be known:	**E x I / 1000**
THREE PHASE	
E and I must be known:	**E x I x 1.73 / 1000**
(See abbreviations explained below)	

HOW TO FIND HORSEPOWER (HP)	
Direct Current	
E, I and EFF must be known:	**E x I x EFF / 746**
SINGLE PHASE	
E, I, PF and EFF must be known:	**E x I x PF x EFF / 746**
THREE PHASE	
E, I, PF and EFF must be known:	**E x I x PF x EFF x 1.73 / 746**
(See abbreviations explained below)	

HOW TO FIND KILOWATT-HOUR (KwH)
BTU * $(2.9307 * 10^{-4})$
FtLb * $(3.7661 * 10^{-7})$
Joule * $(2.7777 * 10^{-7})$

WHERE:

E = VOLTS

P = WATTS

R = OHMS

I = AMPS

HP = HORSEPOWER
PF = POWER FACTOR
kW = KILOWATTS
kVA = KILOVOLT-AMPS
EFF = EFFICIENCY (decimal)

Basic Horsepower Calculations

Horsepower is work done per unit of time. One HP equals 33,000 ft-lb of work per minute. When work is done by a source of torque (T) to produce (M) rotations about an axis, the work done is:

radius x 2π x rpm x lb. or 2π TM

When rotation is at the rate N rpm, the HP delivered is:

HP = radius x 2π x rpm x lb. / 33,000 = TN / 5,250

For vertical or hoisting motion:

HP = W x S / 33,000 x E

Where:

W = total weight in lbs. to be raised by motor
S = hoisting speed in feet per minute
E = overall mechanical efficiency of hoist and gearing. For purposes of estimating
E = .65 for eff. of hoist and "connected gear."

Energy measurement with Joules and Dynes

Energy is measured in joules (Watt-seconds) or kiloWatt-hours. A power level of one Watt that continues for one second equals one joule. The integrated energy from a 100-Watt light that runs for 60 seconds equals 6000 joules.

4.18 joules equal 1 calorie, which is enough energy to raise the temperature of one gram of water by one degree Celsius (or Centigrade).

When it comes to energy density (Watts per liter or Watts per kilogram) it is difficult to beat gasoline. A lead-acid battery is good for about 125 thousand joules per kilogram. Lithium batteries can provide as much as 1.5 million joules per kilogram. Gasoline tends to run about 45 million joules per kilogram.

Joules:

1 joule is exactly 10^7 ergs.

1 joule is approximately equal to:

- 6.2415×10^{18} eV (Electron Volts)
- 0.2390 cal (calorie) (small calories, lower case c)
- 2.3901×10^{-4} kilocalorie, Calories (food energy, upper case C)
- 9.4782×10^{-4} BTU (British thermal unit)
- 0.7376 ft-lb (foot-pound force)2.7778×10^{-7} kiloWatt hour
- 2.7778×10^{-4} Watt hour

Units defined in terms of the joule include:

- 1 thermo chemical calorie = 4.184 J
- 1 International Table calorie = 4.1868 J
- 1 Watt hour = 3600 J
- 1 kiloWatt hour = 3.6×10^6 J (or 3.6 MJ)
- 1 ton TNT = 4.184 GJ

Useful to remember:

- 1 joule = 1 Newton meter = 1 Watt second

Dynes:

In physics, the dyne (symbol "dyn", from Greek δύναμις (dynamis) meaning power, force) is a unit of force specified in the centimeter-gram-second (CGS) system of units, a predecessor of the modern SI. One dyne is equal to exactly 10 micronewtons. Equivalently, the dyne is defined as "the force required to accelerate a mass of one gram at a rate of one centimeter per second squared":

$1 \text{ dyn} = 1 \text{ g} \times \text{cm/s}^2 = 10 - 5 \text{ kg} \times \text{m/s}^2 = 10\ \mu\text{N}$

The dyne per centimeter is the unit usually associated with measuring surface tension. For example, the surface tension of distilled water is 72 dyn/cm at 25°C (77°F).

Units of force					
	newton (SI unit)	**dyne**	**kilogram-force, kilopond**	**pound-force**	**poundal**
1 N	= 1 kg x m/s^2	= 10^5 dyn	≈ 0.10197 kp	≈ 0.22481 lb_f	≈ 7.2330 pdl
1 dyn	= 10^{-5} N	= 1 g x cm/s^2	≈ 1.0197 x 10^{-6} kp	≈ 2.2481 x 10^{-6} lb_f	≈ 7.2330 x 10^{-5} pdl
1 kp	= 9.80665 N	= 980665 dyn	= g_n x (1 kg)	≈ 2.2046 lb_f	≈ 70.932 pdl
1 lb_f	≈ 4.448222 N	≈ 444822 dyn	≈ 0.45359 kp	= g_n x (1 lb)	≈ 32.174 pdl
1 pdl	≈ 0.138255 N	≈ 13825 dyn	≈ 0.014098 kp	≈ 0.031081 lb_f	= 1 lb x ft/s^2
The value of g_n as used in the official definition of the kilogram-force is used here for all gravitational units.					

Mechanical

General Approximations - RULES OF THUMB

Use these in the field for fast approximations:

At 3600 rpm, a motor develops a 1.5 lb-ft of torque per HP at rated HP output
At 1800 rpm, a motor develops a 3 lb-ft of torque per HP at rated HP output
At 1200 rpm, a motor develops a 4.5 lb-ft of torque per HP at rated HP output
At 900 rpm, a motor develops a 6 lb-ft of torque per HP at rated HP output

At 575 volts, a 3-phase motor draws 1 AMP per HP at rated HP output
At 460 volts, a 3-phase motor draws 1.25 AMP per HP at rated HP output
At 230 volts a 3-phase motor draws 2.5 AMP per HP at rated HP output

At 230 volts, a single-phase motor draws 5 AMP per HP at rated HP output
At 115 volts, a single-phase motor draws 10 AMP per HP at rated HP output