Electrical Formulas

Amperes, Horsepower, Kilowatts and KVA

To find	Single phase	Three phase	Direct current
Kilowatts	$\frac{I \times E \times PF}{1000}$	$\frac{I \times E \times 1.73 \times PF}{1000}$	$\frac{I \times E}{1000}$
KVA	$\frac{I \times E}{1000}$	$\frac{I \times E \times 1.73}{1000}$	–
Horsepower	$\frac{I \times E \times \%\ Eff \times PF}{746}$	$\frac{I \times E \times 1.73 \times \%\ Eff \times PF}{746}$	$\frac{I \times E \times \%\ Eff}{746}$
Amperes when Horsepower is known	$\frac{HP \times 746}{E \times \%\ Eff \times PF}$	$\frac{HP \times 746}{1.73 \times E \times \%\ Eff \times PF}$	$\frac{HP \times 746}{E \times \%\ Eff}$
Amperes when Kilowatts is known	$\frac{kW \times 1000}{E \times PF}$	$\frac{kW \times 1000}{1.73 \times E \times PF}$	$\frac{kW \times 1000}{E}$
Amperes when KVA is known	$\frac{KVA \times 1000}{E}$	$\frac{KVA \times 1000}{1.73 \times E}$	
E=Volts	I = Amperes	% Eff = Per cent efficiency	PF = Power factor

$\text{Amperage} = \frac{\text{Wattage (W)}}{\text{Voltage (V)}}$	Amperage (AMP) x Resistance (Ω) = Voltage

Average efficiency and power factor values of motors:
When the actual efficiencies and power factors of the motors to be controlled are not known, the following approximations may be used.

Efficiencies:
- DC motors, 35 horsepower and less .... 80% to 85%
- DC motors, above 35 horsepower .... 85% to 90%
- Synchronous motors (at 100% Power factor) .... 92% to 95%

"Apparent" efficiencies (= Efficiency x Power factor):
- Three phase induction motors, 25 horsepower and less 70%
- Three phase induction motors, above 25 horsepower 80%

These figures may be decreased slightly for single phase induction motors.

Approximate Motor Full-Load Current Rating

Ampères

Three Phase Induction motors
60 cycles
Full load current

HP	RPM	230V	460V	575V
1/4	1800	.96	.48	.38
1/3	1800	1.16	.58	.47
1/2	1800	1.68	.84	.67
3/4	1800	2.33	1.17	.93
1	3600	2.75	1.38	1.10
	1800	3.05	1.53	1.22
1-1/2	3600	4.17	2.09	1.67
	1800	4.28	2.14	1.71
2	3600	5.56	2.78	2.22
	1800	5.76	2.88	2.30
3	3600	7.87	3.94	3.14
	1800	8.29	4.14	3.32
5	3600	12.7	6.34	5.08
	1800	13.2	6.60	5.28
7-1/2	3600	19.2	9.6	7.68
	1800	19.3	9.7	7.72
10	3600	24.5	12.3	9.8
	1800	25.2	12.6	10.1
15	3600	36.7	18.4	14.7
	1800	50.5	25.3	20.2
25	3600	59.2	29.6	23.6
	1800	62.7	31.3	25.0
30	1800	72.8	36.4	29.2
	1200	77.1	38.6	30.8
40	1800	98	49.0	39.2
	1200	99	49.5	39.6
50	1800	121	60.5	48.4
	1200	122	61.0	48.8
60	1800	143	71.5	57.2
	1200	148	74.0	59.2
75	1800	178	89.0	71.2
	1200	181	90.5	72.4
100	1800	233	116	93.2
	1200	239	120	95.6
125	1800	289	144	115
	1200	298	149	119
150	1800	346	173	138
	1200	350	175	140
200	1800	460	230	184
	1200	466	233	186
250	1800	572	286	229
	1200	580	290	232
300	1800	685	343	274
	1200	696	348	278

Single phase induction motors
60 cycles
Full load current

HP	RPM	115V	230V
1/8	3600	2.52	1.26
	1800	2.80	1.40
1/6	3600	2.88	1.44
	1800	3.20	1.60
1/4	3600	4.00	2.00
	1800	4.60	2.30
1/3	3600	4.70	2.35
	1800	5.20	2.60
1/2	3600	6.50	3.25
	1800	7.40	3.70
3/4	3600	9.05	4.52
	1800	10.20	5.10
1	3600	11.70	5.85
	1800	13.00	6.50
1-1/2	3600	17.80	8.90
	1800	18.40	9.20
2	3600	23.00	11.50
	1800	24.00	12.00
3	3600	32.30	16.15
	1800	34.00	17.00
5	3600	54.00	27.00
	1800	56.00	28.00
7-1/2	3600	79.20	39.60
	1800	80.00	40.00
10	3600	97.50	48.75
	1800	100.00	50.00

Variations of Ohm's Law

Volts

$$\text{Volts} = \sqrt{\text{Watts X Ohms}}$$

$$\text{Volts} = \frac{\text{Watts}}{\text{Amperes}}$$

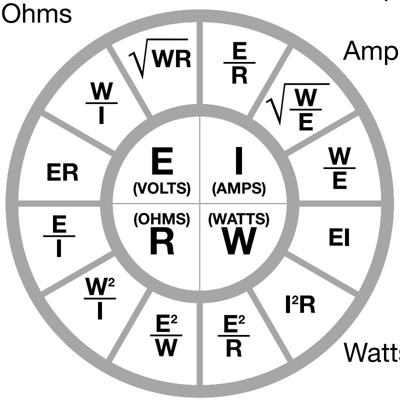
$$\text{Volts} = \text{Amperes X Ohms}$$

Amperes

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

$$\text{Amperes} = \frac{\text{Watts}}{\text{Volts}}$$

$$\text{Amperes} = \sqrt{\frac{\text{Watts}}{\text{Ohms}}}$$



Ohms

$$\text{Ohms} = \frac{\text{Volts}}{\text{Amperes}}$$

$$\text{Ohms} = \frac{\text{Volts}}{\text{Watts}}$$

$$\text{Ohms} = \frac{\text{Volts}}{\text{Amperes}^2}$$

Watts

$$\text{Watts} = \frac{\text{Volts}^2}{\text{Ohms}}$$

$$\text{Watts} = \text{Amperes}^2 \text{ X Ohms}$$

$$\text{Watts} = \text{Volts X Amperes}$$

Wattage varies directly as ratio of voltages squared

$$W_2 = W_1 \text{ X } \left(\frac{E^2}{E^1}\right)$$

$$\text{3 Phase Amperes} = \frac{\text{Total Watts}}{\text{Volts X 1.732}}$$

Useful Physical Constants

ACCELERATION OF GRAVITY (STANDARD)
G=32.17 ft./sec^2 = 980.6 cm./sec^2

VELOCITY OF SOUND IN DRY AIR @ 0˚C AND 1 atm
33,136 cm./sec = 1,089 ft./sec

HEAT OF VAPORIZATION OF WATER @ 1.0 atm
540 cal./g = 970 Btu/lb.

DENSITY OF DRY AIR @ 0˚C AND 760 mm Hg
0.001293 g/cm^3

Useful Motor Formulas

Nominal Input Power

The nominal power of an electric motor is that given to the shaft at nominal voltage and frequency in continuous duty (S1[2]). The unit of power is kW or HP and they are related as follows:

1 HP = 0.736 kW (at 50Hz)
1 HP = 0.746 kW (at 60Hz)

Continuous Duty S1

Constant load running with life at least sufficient to reach the thermic equilibrium. Running with a continuous overload is not scheduled in the specifications. With correct voltage and frequency an overload capacity of 106% (min.) of the nominal torque for 2 minutes is permitted. If the overload is higher then the time must be reduced proportionally.

Voltage and Supply Frequency

CEI 2-3 and IEC 34-1 specifications allow a nominal voltage change of ±5% and a max. temperature rise of 10°C higher than the permissible values of the different insulation classes.

The motors wound at 50 Hz for a certain voltage, can be used without modifications at 60 Hz but the characteristics will change according to the table below.

Example:

		Tensione *Tension*	Potenza *Power*	Potenza *Power*	Corrente *Current*	Ca/Cn	Velocitá *Speed*
Dati a *Data at*	50 Hz	380 V	11 kW	15 HP	23 A	2	1450
Fattore di Conversione *Conversion ratio*		–	1.15	1.15	1.0	0.95	1.20
Dati a *Data at*	60 Hz	440 V	12.6 kW	17.3 HP	23 A	1.9	1740

Note: A motor wound for use at 60 Hz <u>cannot</u> be used at 50 Hz. The current increase can damage the motor and become a fire hazard.

Useful Motor Formulas (at 60 Hz)

Kgm = (Pound Feet) Lbf • ft x 0.1383

$$\text{(Pound Feet) Lbf • ft} = \frac{\text{Kgm}}{0.1383}$$

$$\text{Kgm - (Pound Inches) Lbf • in} = \frac{\text{Kgm}}{0.011525}$$

$$HP_1 = \frac{M_1\ (\text{Kgm}) \times n}{726.4 \times \eta}$$

$$HP_2 = \frac{M_2\ (\text{daNm}) \times n_2}{712.6 \times \eta}$$

$$HP = \frac{\text{kW}}{0.746}$$

kW = HP x 0.746

Speed In The Rotary Motion

$V = \pi \times d \times n$

V = speed m/min
d = diameter in m
n = RPM

Torque

M = F x r

$$M = \frac{955 \times P}{n}$$

M = torque in daNm
r = lever arm
P = power in kW
n = RPM
F = force in daN

Power

Lifting

$$P = \frac{m \times g \times V}{\eta \times 1000}$$

Translation

P = Fr x V

$Fr = \mu \times m \times g$

Rotation

$$P = \frac{M \times n}{955}$$

P = power (kW)
Fr = frictional resistance (daN)
m = Mass (Kg.)
V = speed (m/sec)
η = efficiency
μ = friction coefficient
M = torque in daNm
n = RPM
g = 9.81

Absorbed current
Pr in kW

$$In = \frac{Pr \bullet 1000}{\sqrt{3} \bullet V \bullet \cos\psi \bullet \eta}\ [A]$$

Absorbed current
Pr in HP

$$In = \frac{Pr \bullet 746}{\sqrt{3} \bullet V \bullet \cos\psi \bullet \eta}\ [A]$$

Nominal torque
Pr in kW

$$Cn = \frac{Pr \bullet 1000}{1.027 \bullet n}\ [kgm]$$

Nominal torque
Pr in HP

$$Cn = \frac{Pr \bullet 746}{1.027 \bullet n}\ [kgm]$$

Synchronous speed

$$n_1 = \frac{7200}{\text{nr. poles}}$$

Electrical Formulas

Ratings for three-phase single-speed full-voltage magnetic controllers for nonplugging and nonjogging duty

Continuous Size of controller	Horsepower* at current rating, Amperes	60 Hz 200 Volts	230 Volts	50 Hz 380 Volts	60 Hz 460 or 575 Volts	Service-limit current rating Amperes
00	9	1 1/2	1	1	2	11
0	18	3	3	5	5	21
1	27	7 1/2	7 1/2	10	10	32
2	45	10	15	25	25	52
3	90	25	30	50	50	104
4	135	40	50	75	100	156
5	270	75	100	150	200	311
6	540	150	200	300	400	621
7	810	—	300	—	600	932
8	1215	—	450	—	900	1400
9	2250	—	800	—	1600	2590

*These horsepower ratings are based on typical locked-rotor current ratings. For motors having higher locked-rotor currents, a larger controller should be used so that its locked-rotor current rating is not exceeded.

Ratings for three-phase single-speed full-voltage magnetic controllers for plug-stop or jogging duty

Size of controller	Continuous current rating, Amperes	Horsepower* at 60 Hz 200 Volts	230 Volts	50 Hz 380 Volts	60 Hz 460 or 575 Volts	Service-limit current rating Amperes
0	18	1 1/2	1	1	2	21
1	27	3	3	5	5	32
2	45	7	10	15	15	52
3	90	15	20	30	30	104
4	135	25	30	50	60	156
5	270	60	75	125	150	311
6	540	125	150	250	300	621

*These horsepower ratings are based on typical locked-rotor current ratings. For motors having higher locked-rotor currents, a larger controller should be used so that its locked-rotor current rating is not exceeded.

Power

From	Kw	PS	hp	ft-lb/s
1kW (kilowatt) =	1	1.360	1.341	737.6
1 PS (metric horsepower)	0.7355	1	0.9863	542.5
1 hp (horsepower)	0.7457	1.014	1	550.0
1 ft-lb/x (foot-pound per sec.)	1.356×10^{-3}	1.356×10^{-3}	1.356×10^{-3}	1