E = Voltage / I = Amps /W = Watts / PF = Power Factor / Eff = Efficiency / HP = Horsepower

AC/DC Formulas

To Find	Direct Current	AC / 1phase 115v or 120v	AC / 1phase 208,230, or 240v	AC 3 phase All Voltages
Amps when Horsepower is Known	HP x 746 E x Eff	HP x 746 E x Eff X PF	HP x 746 E x Eff x PF	HP x 746 1.73 x E x Eff x PF
Amps when Kilowatts is known	kW x 1000 E	kW x 1000 E x PF	kW x 1000 E x PF	kW x 1000 1.73 x E x PF
Amps when kVA is known		kVA x 1000 E	kVA x 1000 E	kVA x 1000 1.73 x E
Kilowatts	I x E 1000	I x E x PF 1000	I x E x PF 1000	I x E x 1.73 PF 1000
Kilovolt-Amps		I x E 1000	I x E 1000	I x E x 1.73 1000
Horsepower (output)	I x E x Eff 746	I x E x Eff x PF 746	I x E x Eff x PF 746	I x E x Eff x 1.73 x PF 746

Three Phase Values

For 208 volts x 1.732, use 360
For 230 volts x 1.732, use 398
For 240 volts x 1.732, use 416
For 440 volts x 1.732, use 762
For 460 volts x 1.732, use 797
For 480 Volts x 1.732, use 831

E = Voltage / I = Amps /W = Watts / PF = Power Factor / Eff = Efficiency / HP = Horsepower

AC Efficiency and Power Factor Formulas

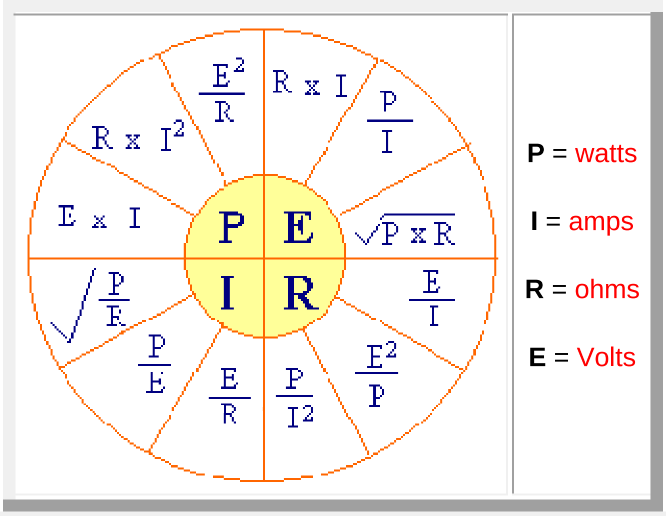
To Find	Single Phase	Three Phase
Efficiency	746 x HP E x I x PF	746 x HP E x I x PF x 1.732
Power Factor	Input Watts V x A	Input Watts E x I x 1.732

Power - DC Circuits

Watts = E xI

Amps = W / E

Ohm's Law / Power Formulas



Voltage Drop Formulas			
Single Phase (2 or 3 wire)	VD =	$\frac{2 \times K \times I \times L}{CM}$	**K** = ohms per mil foot
	CM=	$\frac{2K \times L \times I}{VD}$	**(Copper = 12.9 at 75°)**
Three Phase	VD=	$\frac{1.73 \times K \times I \times L}{CM}$	**(Alum = 21.2 at 75°)** **Note: K** value changes with temperature. See Code chapter 9, Table 8
	CM=	$\frac{1.73 \times K \times L \times I}{VD}$	**L** = Length of conductor in feet **I** = Current in conductor (amperes) **CM** = Circular mil area of conductor

Calculating Motor Speed:

A squirrel cage induction motor is a constant speed device. It cannot operate for any length of time at speeds below those shown on the nameplate without danger of burning out.

To Calculate the *speed of a induction motor*, apply this formula:

$$Srpm = \frac{120 \times F}{P}$$

Srpm = synchronous revolutions per minute.
120 = constant
F = supply frequency (in cycles/sec)
P = number of motor winding poles

Example: What is the synchronous of a motor having 4 poles connected to a 60 hz power supply?

$$Srpm = \frac{120 \times F}{P}$$

$$Srpm = \frac{120 \times 60}{4}$$

$$Srpm = 7200$$

$$Srpm = \frac{}{4} = 1800 \text{ rpm}$$

Calculating Braking Torque:

Full-load motor torque is calculated to determine the required braking torque of a motor.
To Determine *braking torque* of a motor, apply this formula:

$$T = \frac{5252 \times HP}{rpm}$$

T = full-load motor torque (in lb-ft)
5252 = constant (33,000 divided by 3.14 x 2 = 5252)
HP = motor horsepower
rpm = speed of motor shaft

Example: What is the braking torque of a 60 HP, 240V motor rotating at 1725 rpm?

$$T = \frac{5252 \times HP}{rpm}$$
$$T = \frac{5252 \times 60}{1725}$$
$$T = \frac{315{,}120}{1725}$$
$$T = 182.7 \text{ lb-ft}$$

Calculating Work:

Work is applying a force over a distance. Force is any cause that changes the position, motion, direction, or shape of an object. Work is done when a force overcomes a resistance. Resistance is any force that tends to hinder the movement of an object.If an applied force does not cause motion the no work is produced.

To calculate the amount of work produced, apply this formula:

$$W = F \times D$$

W = work (in lb-ft)
F = force (in lb)
D = distance (in ft)

Example: How much work is required to carry a 25 lb bag of groceries vertically from street level to the 4th floor of a building 30' above street level?

$$W = F \times D$$
$$W = 25 \times 30$$
$$W = 750 \text{ -lb}$$

Calculating Torque:

Torque is the force that produces rotation. It causes an object to rotate. Torque consist of a force acting on distance. Torque, like work, is measured is pound-feet (lb-ft). However, torque, unlike work, may exist even though no movement occurs.

To calculate torque, apply this formula:

$$T = F \times D$$

T = torque (in lb-ft)
F = force (in lb)
D = distance (in ft)

Example: What is the torque produced by a 60 lb force pushing on a 3' lever arm?

$$T = F \times D$$
$$T = 60 \times 3$$
$$T = 180 \text{ lb ft}$$

Calculating Full-load Torque:

Full-load torque is the torque to produce the rated power at full speed of the motor. The amount of torque a motor produces at rated power and full speed can be found by using a horsepower-to-torque conversion chart. When using the conversion chart, place a straight edge along the two known quantities and read the unknown quantity on the third line.

To calculate motor full-load torque, apply this formula:

$$T = \frac{HP \times 5252}{rpm}$$

T = torque (in lb-ft)
HP = horsepower
5252 = constant
rpm = revolutions per minute

Example: What is the FLT (Full-load torque) of a 30HP motor operating at 1725 rpm?

$$T = \frac{HP \times 5252}{rpm}$$
$$T = \frac{30 \times 5252}{1725}$$
$$T = \frac{157{,}560}{1725}$$
$$T = 91.34 \text{ lb-ft}$$

Calculating Horsepower:

Electrical power is rated in horsepower or watts. A horsepower is a unit of power equal to 746 watts or 33,0000 lb-ft per minute (550 lb-ft per second). A watt is a unit of measure equal to the power produced by a current of 1 amp across the potential difference of 1 volt. It is 1/746 of 1 horsepower. The watt is the base unit of electrical power. Motor power is rated in horsepower and watts. Horsepower is used to measure the energy produced by an electric motor while doing work.

To calculate the horsepower of a motor when current and efficiency, and voltage are known, apply this formula:

$$HP = \frac{V \times I \times Eff}{746}$$

HP = horsepower
V = voltage
I = curent (amps)
Eff. = efficiency

Example: What is the horsepower of a 230v motor pulling 4 amps and having 82% efficiency?

$$HP = \frac{V \times I \times Eff}{746}$$
$$HP = \frac{230 \times 4 \times .82}{746}$$
$$HP = \frac{754.4}{746}$$
$$HP = 1\ Hp$$

Eff = efficiency / HP = horsepower / V = volts / A = amps / PF = power factor

Horsepower Formulas					
To Find	Use Formula	Example			
		Given	Find	**Solution**	
HP	$HP = \frac{I \times E \times Eff.}{746}$	240V, 20A, 85% Eff.	HP	$HP = \frac{240V \times 20A \times 85\%}{746}$ **HP=5.5**	
I	$I = \frac{HP \times 746}{E \times Eff \times PF}$	10HP, 240V, 90% Eff., 88% PF	I	$I = \frac{10HP \times 746}{240V \times 90\% \times 88\%}$ **I = 39 A**	

To calculate the horsepower of a motor when the speed and torque are known, apply this formula:

$$HP = \frac{rpm \times T(torque)}{5252(constant)}$$

Example: What is the horsepower of a 1725 rpm motor with a FLT 3.1 lb-ft?

$$HP = \frac{rpm \times T}{5252}$$
$$HP = \frac{1725 \times 3.1}{5252}$$

$$HP = \frac{5347.5}{5252}$$

$$HP = 1\ hp$$

Calculating Synchronous Speed:

AC motors are considered constant speed motors. This is because the synchronous speed of an induction motor is based on the supply frequency and the number of poles in the motor winding. Motor are designed for 60 hz use have synchronous speeds of 3600, 1800, 1200, 900, 720, 600, 514, and 450 rpm.

To calculate synchronous speed of an induction motor, apply this formula:

$$rpmsyn = \frac{120 \times f}{Np}$$

rpmsyn = synchronous speed (in rpm)
f = supply frequency in (cycles/sec)
Np = number of motor poles

Example: What is the synchronous speed of a four pole motor operating at 50 hz.?

$$rpmsyn = \frac{120 \times f}{Np}$$

$$rpmsyn = \frac{120 \times 50}{4}$$

$$rpmsyn = \frac{6000}{4}$$

$$rpmsyn = 1500\ rpm$$

To better understand the following formulas review the rule of transposition in equations.
A multiplier may be removed from one side of an equation by making it a division on the other side, or a division may be removed from one side of an equation by making it a multiplier on the other side.

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1. **Voltage and Current: Primary (p) secondary (s) Power(p) = power (s) or Ep x Ip = Es x Is**

A. $Ep = \frac{Es \times Is}{Ip}$ B. $Ip = \frac{Es \times Is}{Ep}$

C. $Is = \frac{Ep \times Ip}{Es}$ D. $Es = \frac{Ep \times Ip}{Is}$

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2. Voltage and Turns in Coil:
Voltage (p) x Turns (s) = Voltage (s) x Turns (p)
or Ep x Ts = Es x Ip

A. $Ep = \frac{Es \times Ip}{Ts}$ **B.** $Ts = \frac{Es \times Tp}{Ep}$

C. $Tp = \frac{Ep \times Ts}{Es}$ **D.** $Es = \frac{Ep \times Ts}{Tp}$

3. Amperes and Turns in Coil:
Amperes (p) x Turns (p) = Amperes (s) x Turns (s)
or Ip x Tp = Is x Ts

A. $Ip = \frac{Is \times Ts}{Tp}$ **B.** $Tp = \frac{Is \times Ts}{Ip}$

C. $Ts = \frac{Ip \times Tp}{Is}$ **D.** $Is = \frac{Ip \times Tp}{Ts}$

DC Motors

Horse-power	90v	120v	180v	240v	500v	550v
	Amperes					
1/4	4.0	3.1	2.0	1.6	--	--
1/3	5.2	4.1	2.6	2.0	--	--
1/2	6.8	5.4	3.4	2.7	--	--
3/4	9.6	7.6	4.8	3.8	--	--
1	12.2	9.5	6.1	4.7	--	--
1-1/2	--	13.2	8.3	6.6	--	--
2	--	17	10.8	8.5	--	--
3	--	25	16	12.2	--	--
5	--	40	27	20	--	--
7-1/2	--	58	--	29	13.6	12.2
Horse-power	90v	120v	180v	240v	500v	550v
	Amperes					
10	--	76	--	38	18	16
15	--	--	--	38	18	16
20	--	--	--	55	27	24
25	--	--	--	89	43	38
30	--	--	--	106	51	46
40	--	--	--	140	67	61
Horse-power	90v	120v	180v	240v	500v	550v

	Amperes					
50	--	--	--	173	83	75
60	--	--	--	206	99	90
75	--	--	--	255	123	111
100	--	--	--	341	164	148
125	--	--	--	425	205	185
150	--	--	--	506	246	222
200	--	--	--	675	330	294

AC Single Phase Motors

Horse-power	115v	200v	208v	230v
	Amperes			
1/6	4.4	2.5	2.4	2.2
1/4	5.8	3.3	3.2	2.9
1/3	7.2	4.1	4.0	3.6
1/2	9.8	5.6	5.4	4.9
3/4	13.8	7.9	7.6	6.9
1	16	9.2	8.8	8.0
1-1/2	20	11.5	11	10
2	24	13.8	13.2	12
3	34	19.6	18.7	17
5	56	32.2	30.8	28
7-1/2	80	46	44	40
10	100	57.5	55	50
Horse-power	**115v**	**200v**	**208v**	**230v**

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2 Phase (4 wire) AC Induction Type
Squirrel Cage and Wound Rotor

Horse-power	115v	230v	460v	575v	2300v
	Amperes				
1/2	4.0	2.0	1.0	0.8	--
3/4	4.8	2.4	1.2	1.0	--
1	6.4	3.2	1.6	1.3	--
1-1/2	9.0	4.5	2.3	1.8	--
2	11.8	5.9	3.0	2.4	--
3	--	8.3	4.2	3.3	--
5	--	13.2	6.6	5.3	--
10	--	24	12	10	--
15	--	36	18	14	--

20	--	47	23	19	--
25	--	59	29	24	--
30	--	69	35	28	--
40	--	90	45	36	--
Horse-power	115v	230v	460v	575v	2300v
	Amperes				
50	--	113	56	45	--
60	--	133	67	53	14
75	--	166	83	66	18
100	--	218	109	87	23
125	--	270	135	108	28
150	--	312	156	125	32
200	--	416	208	167	43

AC 3 Phase Induction Type Squirrel Cage and Wound Rotor

Horse-power	115V	200V	208V	230V	460V	575V	2300V
	Amperes						
1/2	4.4	2.5	2.4	2.2	1.1	0.9	--
3/4	6.4	3.7	3.5	3.2	1.6	1.3	--
1	8.4	4.8	4.6	4.2	2.1	1.7	--
1-1/2	12.0	6.9	6.6	6.0	3.0	2.4	--
2	13.6	7.8	7.5	6.8	3.4	2.7	--
3	--	11.0	10.6	9.6	4.8	3.9	--
5	--	17.5	16.7	15.2	7.6	6.1	--
7-1/2	--	25.3	24.2	22	11	9	--
Horse-power	115v	200v	208v	230v	460v	575v	2300v
10	--	32.2	30.8	28	14	11	--
15	--	48.3	46.2	42	21	17	--
20	--	62.1	59.4	54	27	22	--
25	--	78.2	74.8	68	34	27	--
30	--	92	88	80	40	32	--
40	--	120	114	104	52	41	--
Horse-power	115v	200v	208v	230v	460v	575v	2300v
50	--	150	143	130	65	52	--
60	--	177	169	154	77	62	16
75	--	221	211	192	96	77	20
100	--	285	273	248	124	99	26

125	--	359	343	312	156	125	31
150	--	414	396	360	180	144	37
200	--	552	528	480	240	192	49
Horse-power	115v	200v	208v	230v	460v	575v	2300v
	Amperes						
250	--	--	--	--	302	242	60
300	--	--	--	--	361	289	72
350	--	--	--	--	414	336	83
400	--	--	--	--	477	382	95
450	--	--	--	--	515	412	103
500	--	--	--	--	590	472	118

AC 3 Phase Synchronous Type Unity Power Factor

Horse-power	**230v**	**460v**	**575v**	**2300v**
	Amperes			
25	53	26	21	--
30	63	32	26	--
40	83	41	33	--
50	104	52	42	--
60	123	61	49	12
75	155	78	62	15
100	202	101	81	20
125	253	126	101	25
150	302	151	121	30
200	400	201	161	40
Horse-power	**230v**	**460v**	**575v**	**2300v**
