BASIC ELECTRICAL FUNDAMENTALS, EQUATIONS & FORMULAS

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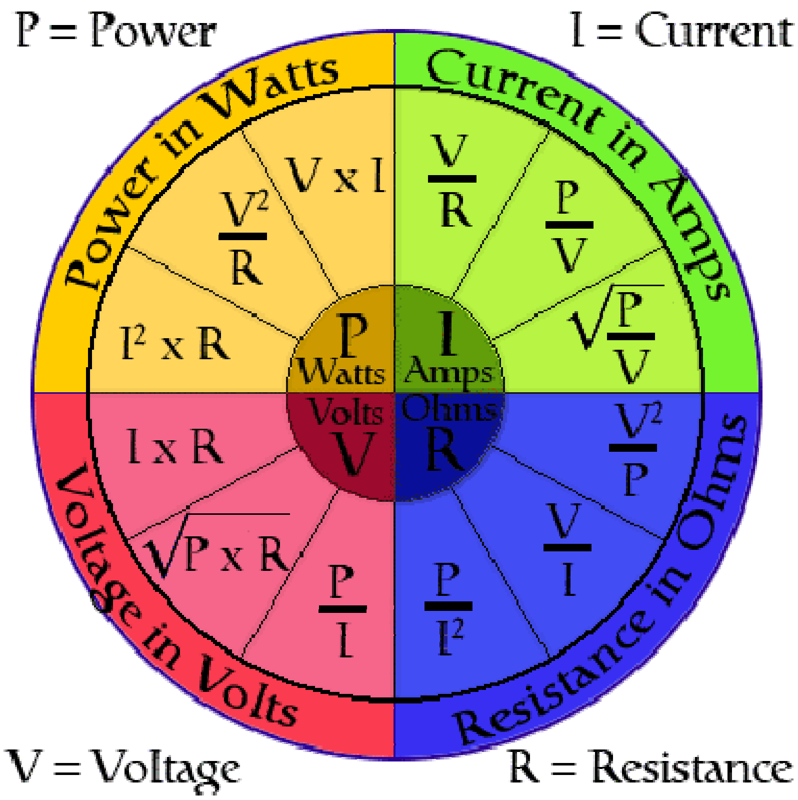
ELECTRICAL EQUATIONS

1KW = 1000 WATTS	1HP = 746WATTS	1000mA = 1 Ampere
1MW = 1000 KW	1HP = 0.746 KW	1KA = 1000 Ampere
1MVA = 1000 KVA	1KV = 1000 VOLTS	1mA = 100 Ampere
1KVA = 1/1000 MVA	1KW = 1.34102 HP	1MillionµA = 1 Ampere



Electric Power Formulas: $P = VxI$ $P = RxI^2$ $P = V^2/R$

Electric Current Formulas: $I = V/R$ $I = P/V$ $I = (P/R)$ ½

Electric Resistance Formulas: $R = V/I$ $R = V^2/P$ $R = P/I^2$

Electric Voltage Formulas: $V = RxI$ $V = P/I$ $V = (PxR)$ ½

FORMULAS EQUATIONS & LAWS

E = Volt or (V = Volts)
P = Watts or (W = Watts)
R = Ohms or (R = Resistance)
I = Amperes or (A = Amperes)
HP = Horse Power
KW = Kilowatts
KWH = Kilo Watt Hour
VA = Volt Ampere
KVA = Kilo Volt Ampere
C = Capacitance
PF = Power Factor (use 0.8 unless otherwise indicated)
Eff. = Efficiency (expressed as a decimal) (use 0.9 unless otherwise indicated)

ELECTRICAL FORMULAS

Several basic electrical formulas, which are listed below, are related to Ohm's law. (See definition on previous page.) Variables used in these formulas are as follows:

- I = Intensity of current = Amperes
- E = Electromotive Force = Volts
- R = Resistance = Ohms
- P = Power = Watts

Current (Ampere) Formulas

$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{Watts}{Ohms}}$ $\quad I = \frac{P}{E} = \frac{Watts}{Volts}$ $\quad I = \frac{E}{R} = \frac{Volts}{Ohms}$

Voltage Formulas

$E = \sqrt{P \times R} = \sqrt{Watts \times Ohms}$ $\quad E = \frac{P}{I} = \frac{Watts}{Amps}$

$E = R \times I = Ohms \times Amps$

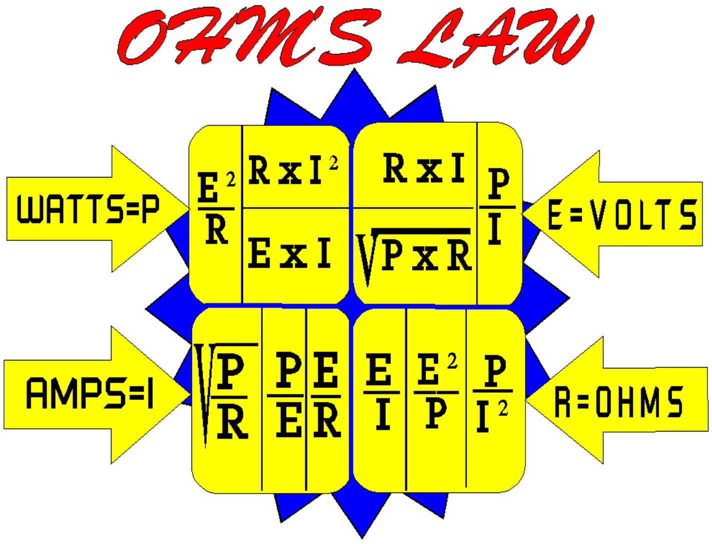
Power (Watt) Formulas

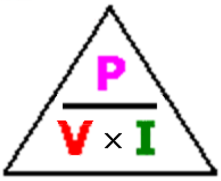
$P = E \times I = Volts \times Amps$ $\quad P = \frac{E^2}{R} = \frac{Volts^2}{Ohms}$

$P = R \times I^2 = Ohms \times Amps^2$

Resistance (Ohms) Formulas

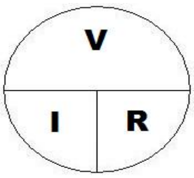
$R = \frac{E}{I} = \frac{Volts}{Amps}$ $\quad R = \frac{E^2}{P} = \frac{Volts^2}{Watts}$ $\quad R = \frac{P}{I^2} = \frac{Watts}{Amps^2}$



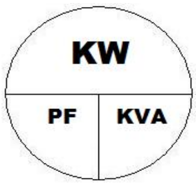


$V = \frac{P}{I}$ or $P = VI$ or $I = \frac{P}{V}$

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



$PF = \frac{KW}{KVA}$ or $KW = PF x KVA$ or $KVA = \frac{KW}{PF}$



PREFIX	NAME	MEANING	EXAMPLE
T	Tera	multiply by 1,000,000,000,000 (i.e. $x10^{12}$)	2TΩ = 2,000,000,000,000 Ohms
G	Giga	Multiply by 1,000,000,000 (i.e. $\div 10^{9}$)	2GΩ = 2,000,000,000 Ohms
M	Mega	multiply by 1,000,000 (i.e. $x10^{6}$)	2 MΩ = 2,000,000 Ohms
K	Kilo	multiply by 1,000 (i.e. $x10^{3}$)	10 kV = 10,000 Volts
m	milli	divide by 1,000 (i.e. $\div 10^{-3}$)	25mAΩ = 25/1000 A = 0.025Amperes
µ	micro	divide by 1,000,000 (i.e. $\div 10^{-6}$)	50µV = 50/1,000,000 V = 0.00005 Volts
n	nano	divide by 1,000,000,000 (i.e. $\div 10^{-9}$)	100nV = 100/1,000,000,000 V = 0.0000001 Volts
p	pico	divide by 1,000,000,000,000 (i.e. $\div 10^{-12}$)	25pV =25/1,000,000,000,000 V = 0.000000000025 Volts

VOLTAGE DROP FORMULAS			
Single Phase (2 or 3 wire)	VD =	$\frac{2 \times K \times I \times L}{CM}$	**K** = ohms per mil foot (Copper = 12.9 at 75°C) Note: K value changes with temperature.
	CM =	$\frac{2K \times L \times I}{VD}$	
Three Phase	VD =	$\frac{\sqrt{3} \times K \times I \times L}{CM}$	**L** = Length of conductor in feet
	CM =	$\frac{\sqrt{3} \times K \times L \times I}{VD}$	**I** = Current in conductor (amps) **CM** = Circular mil area of conductor

A.C. / D.C. EQUATIONS

DIRECT CURRENT			
AMPS =	WATTS ÷ VOLTS	I = P ÷ E	A = W ÷ V
WATTS =	VOLTS x AMPS	P = E x I	W = V x A
VOLTS =	WATTS ÷ AMPS	E = P ÷ I	V = W ÷ A
HORSEPOWER =	WATTS ÷ 746		
EFFICIENCY =	(746 x HP) ÷ (V x A)		
A.C. SINGLE PHASE ~ 1Ø			
AMPS =	WATTS ÷ (VOLTS x PF)	I = P ÷ (E x PF)	A = W ÷ (V x PF)
WATTS =	VOLTS x AMPS x PF	P = E x I x PF	W = V x A x PF
VOLTS =	WATTS ÷ (AMPS x PF)	E = P ÷ I	V = W ÷ (A x PF)
VOLT AMPS =	VOLTS x AMPS	VA = E x I	VA = V x A
HORSEPOWER =	(V x A x PF) ÷ 746		
POWER FACTOR =	INPUT WATTS ÷ (V x A)		
EFFICIENCY =	(746 x HP) ÷ (V x A x PF)		
A.C. THREE PHASE ~ 3Ø			
AMPS =	WATTS ÷ (√3 x VOLTS x PF)	I = P ÷ (√3 x E x PF)	
WATTS =	√3 x VOLTS x AMPS x PF	P = √3 x E x I x PF	
VOLTS =	WATTS ÷ (√3 x AMPS x PF)	E = P ÷ (√3 x I x PF)	
VOLT AMPS =	√3 x VOLTS x AMPS	VA = √3 x E x I	
HORSEPOWER =	(√3 x V x A x PF) ÷ 746		
POWER FACTOR =	INPUT WATTS ÷ (√3 x V x A)		
EFFICIENCY =	(746 x HP) ÷ (√3 x V x A x PF)		
CONVERSION FORMULAS			
EFFICIENCY (percent) = (OUTPUT ÷ INPUT) x 100			
EFFICIENCY = OUTPUT ÷ INPUT			
INPUT = OUTPUT ÷ EFFICIENCY			
OUTPUT = INPUT x EFFICIENCY			
HORSEPOWER = WATTS ÷ 746			

A.C. / D.C. FORMULAS

DESIRED DATA	SINGLE PHASE	TWO PHASE	THREE PHASE	DIRECT CURRENT
Ampere when KVA is shown	$\frac{KVA \times 1000}{V}$	$\frac{KVA \times 1000}{2 \times V}$	$\frac{KVA \times 1000}{\sqrt{3} \times V}$	$\frac{KVA \times 1000}{V}$
Ampere when Kilowatt are shown	$\frac{KW \times 1000}{V \times PF}$	$\frac{KW \times 1000}{2 \times V \times PF}$	$\frac{KW \times 1000}{\sqrt{3} \times V \times PF}$	$\frac{KW \times 1000}{V}$
Ampere when HP is shown	$\frac{HP \times 746}{V \times Eff \times PF}$	$\frac{HP \times 746}{2 \times V \times Eff \times PF}$	$\frac{HP \times 746}{\sqrt{3} \times V \times Eff \times PF}$	$\frac{HP \times 746}{V \times Eff}$
Kilowatts	$\frac{I \times V \times PF}{1000}$	$\frac{2 \times I \times V \times PF}{1000}$	$\frac{\sqrt{3} \times I \times V \times PF}{1000}$	$\frac{I \times V}{1000}$
Kilo Volt Ampere	$\frac{I \times V}{1000}$	$\frac{2 \times I \times V}{1000}$	$\frac{\sqrt{3} \times I \times V}{1000}$	$\frac{I \times V}{1000}$
Horse Power	$\frac{I \times V \times PF}{746}$	$\frac{2 \times I \times V \times PF}{746}$	$\frac{\sqrt{3} \times I \times V \times PF}{746}$	$\frac{KW \times 1000}{746}$
Efficiency	$\frac{HP \times 746}{V \times I \times PF}$	$\frac{HP \times 746}{2 \times V \times I \times PF}$	$\frac{HP \times 746}{\sqrt{3} \times V \times I \times PF}$	$\frac{HP \times 746}{V \times I}$
Power Factor	$\frac{INPUT\ WATTS}{V \times A}$	$\frac{INPUT\ WATTS}{2 \times V \times A}$	$\frac{INPUT\ WATTS}{\sqrt{3} \times V \times A}$	$\frac{INPUT\ WATTS}{V \times A}$

ALL EQUATIONS OF D.C. MOTOR ARE GIVEN BELOW AS PER THIS NAME PLATE

M/C No.	OASH6077	**REF.**	JBA00080	**K.W.**	30
FRAME	AFS260H	**R.P.M.**	1500	**INS. CL.**	F
EXTN.	SEP	**ARM. V**	125	**DUTY**	S1
TYPE	SHUNT	**ARM. A**	273	**MTG.**	B3
BRG CE	6316 2RS	**FIELD V**	125	**AMB.**	65°C
BFG NCE	6316 2RS	**FIELD A**	2.2	**Wt.**	1000kg
PROTN.	IP55	**COOLING**	1C0141	**GD²**	7.50kgm²

CE

CROMPTON GREAVES LTD

DC MOTOR

MADE IN INDIA

1. AMPS = (WATTS x 1000) ÷ VOLTS

   $$\text{AMPS} = \frac{30 \times 1000}{125} = \frac{30000}{125} = 240$$

   AMPS = 240

2. VOLTS = (WATTS x 1000) ÷ AMPS

   $$\text{VOLTS} = \frac{30 \times 1000}{273} = \frac{30000}{273} = 109.89$$

   VOLTS = 109.89

3. KILOWATTS = (VOLTS x AMPS) ÷ 1000

   $$\text{KILOWATTS} = \frac{125 \times 273}{1000} = \frac{34125}{1000} = 34.125$$

   KILOWATTS = 34.125

4. HORSEPOWER = (WATTS x 1000) ÷ 746

   $$\text{HORSEPOWER} = \frac{30 \times 1000}{746} = \frac{30000}{746} = 40.21$$

   HORSEPOWER = 40.21

5. EFFICIENCY = (746 x HP) ÷ (V x A)

   $$\text{EFFICIENCY} = \frac{746 \times 440.21}{125 \times 273} = \frac{29996.66}{34125} = 0.879$$

   EFFICIENCY = 0.879

6. $$\text{POLE} = \frac{F120}{N(\text{RPM})}$$

   $$\text{POLE} = \frac{50 \times 120}{1500} = \frac{6000}{1500} = 4$$

   POLE = 4

ALL EQUATIONS OF A.C. SINGLE PHASE MOTOR ARE GIVEN BELOW AS PER THIS NAME PLATE

ABB

<table>
<tr><td colspan="2">MODEL 500</td><td colspan="2">SPLIT PHASE</td><td colspan="2">TOTALLY ENCLOSED</td></tr>
<tr><td colspan="2">FRAME</td><td>TYPE</td><td>INS. CL.</td><td colspan="2">IDENTIFICATION NO.</td></tr>
<tr><td colspan="2">145</td><td>KC</td><td>B</td><td colspan="2">2538094990298209</td></tr>
<tr><td>KW (HP)</td><td>RPM</td><td colspan="2">VOLTS</td><td>AMPS</td><td>CYC</td><td>S.F.</td></tr>
<tr><td>1.3 (1.73)</td><td>1725</td><td colspan="2">115/230</td><td>15/7.5</td><td>60</td><td>1.25</td></tr>
<tr><td colspan="4">DESIGN CODE: B</td><td>PHASE</td><td>EFF</td><td>P.F.</td></tr>
<tr><td colspan="4">DRIVE END BEARING BBD 116</td><td>1</td><td>99%</td><td>75%</td></tr>
<tr><td colspan="4">OPP. END BEARING B0B 117</td><td colspan="3">DUTY: CONTINUOUS</td></tr>
<tr><td colspan="3">AMB 40°C</td><td colspan="4">NO THERMAL PROTECTION</td></tr>
</table>

A.C. SINGLE PHASE MOTOR MADE IN FRANCE

1. AMPS = (WATTS x 1000) ÷ (VOLTS x PF)

   $$\text{AMPS} = \frac{1.3 \times 1000}{230 \times 0.75} = \frac{1300}{172.5} = 7.536$$

   AMPS = 7.536

2. VOLTS = (WATTS x 1000) ÷ (AMPS x PF)

   $$\text{VOLTS} = \frac{1.293 \times 1000}{7.5 \times 0.75} = \frac{1293}{5.625} = 231.11$$

   VOLTS = 231.11

3. KILOWATTS = (VOLTS x AMPS x PF) ÷ 1000

   $$\text{KILOWATTS} = \frac{230 \times 7.5 \times 0.75}{1000} = \frac{1293.75}{1000} = 1.293$$

   KILOWATTS = 1.293

4. HORSEPOWER = (V x A x PF) ÷ 746

   $$\text{HORSEPOWER} = \frac{230 \times 7.5 \times 0.75}{746} = \frac{1293.75}{746} = 1.734$$

   HORSEPOWER = 1.734

5. P.F. = (INPUT WATTS x 1000) ÷ (V x A)

   $$\text{P.F.} = \frac{1.3 \times 1000}{230 \times 7.5} = \frac{1300}{1725} = 0.75$$

   P.F. = 0. 75

6. EFFICIENCY = (746 x HP) ÷ (V x A x PF)

   $$\text{EFFICIENCY} = \frac{746 \times 1.734}{230 \times 7.5 \times 0.75} = \frac{1293.564}{1293.75} = 0.999$$

   EFFICIENCY = 0.999

7. K.V.A. = (V x A) ÷ 1000

   $$\text{K.V.A.} = \frac{230 \times 7.5}{1000} = \frac{1725}{1000} = 1.725$$

   K.V.A. = 1.725

8. $$\text{POLE} = \frac{F120}{N(RPM)}$$

   $$\text{POLE} = \frac{50 \times 120}{1725} = \frac{6000}{1725} = 3.478$$

   POLE = 3.378

ALL EQUATIONS OF A.C. THREE PHASE MOTOR ARE GIVEN BELOW AS PER THIS NAME PLATE

BHARAT HEAVY ELECTRICALS LTD

INDUCTION MOTOR

SERIAL NO.	47259P421-91-01		
FRAME	1R7716-4		
DUTY	CONTINUOUS		
K.W.	4000		
STATOR VOLTS	6600		
STATOR AMPS	405		
R.P.M.	1493		
PHASE	3	Hz	50
INSULATION CL.	F		

SPECIFICATION	IS : 325	
CONNECTION	ST - Y	RT --
ROTOR VOLTS	---	
ROTOR AMPS	---	
POWER FACTOR	0.87	
EFFICIENCY	97%	
AMBIENT TEMP.	50°C	
TEMPERATURE RISE	70°C	

ROTOR TYPE	CAGE ROTOR		
DEG OF PROTECTION	IP55		
COOLING CODE	IC 81 W		
DE BEARING	SLEEVE BRG Ø160X140		
NDE BEARING	SLEEVE BRG Ø125X115		
YEAR	2009	WEIGHT	13360KG
DIVISION	BHOPAL		

MADE IN INDIA

1. AMPS = (WATTS x 1000) ÷ (√3 x VOLTS x PF)

   $$\text{AMPS} = \frac{4000 \times 1000}{1.732 \times 6600 \times 0.87} = \frac{4000000}{9945.144} = 402.20$$

   AMPS = 402.20

2. VOLTS = (WATTS x 1000) ÷ (√3 x AMPS x PF)

   $$\text{VOLTS} = \frac{4000 \times 1000}{\sqrt{3} \times 405 \times 0.87} = \frac{4000000}{610.2702} = 6554.47$$

   VOLTS = 6554.47

3. KILOWATTS = (√3 x VOLTS x AMPS x PF) ÷ 1000

   $$\text{KILOWATTS} = \frac{1.732 \times 6600 \times 405 \times 0.87}{1000} = \frac{4027783.3}{1000} = 4027.78$$

   KILOWATTS = 4027.78

4. HORSEPOWER = (√3 x V x A x PF) ÷ 746

   $$\text{HORSEPOWER} = \frac{1.732 \times 6600 \times 405 \times 0.87}{746} = \frac{4027783.3}{746} = 5399.17$$

   HORSEPOWER = 5399.17

5. P.F. = (INPUT WATTS x 1000) ÷ (√3 x V x A)

$$P.F. = \frac{4000 \times 1000}{1.732 \times 6600 \times 405} = \frac{4000000}{4629636} = 0.863$$

P.F. = 0.863

6. EFFICIENCY = (746 x HP) ÷ (√3 x V x A x PF)

$$EFFICIENCY = \frac{746 \times 5399.17}{1.732 \times 6600 \times 405 \times 0.87} = \frac{4027780.8}{4027783.3} = 0.99$$

EFFICIENCY = 0.99

7. K.V.A. = (√3 x V x A) ÷ 1000

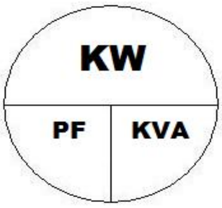
$$K.V.A. = \frac{1.732 \times 6600 \times 405}{1000} = \frac{4629636}{1000} = 4629.63$$

K.V.A. = 4629.63

8. $$POLE = \frac{F120}{N(RPM)}$$

$$POLE = \frac{50 \times 120}{1493} = \frac{6000}{1493} = 4.018$$

POLE = 4.018



How to find Power & P.F.

P.F. = KW / KVA *or* ***KW = P.F. x KVA*** *or* ***KVA = KW / P.F.***

KW = Active Power
KVA = Apparent Power (**Note: Apparent Power is Greater than Active Power**)
Example's are given as per above mentioned name plate.

P.F. = K.W. / K.V.A. Or KW = P.F. x K.V.A. Or K.V.A. = K.W. / P.F. **(Note: KVA is always greater than KW)**

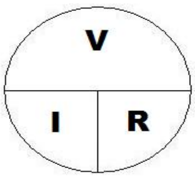
$$P.F. = \frac{4000}{4629.63}$$

P.F. = 0.863

KW = 0.87 x 4629.63
KW = 4027.77

$$K.V.A. = \frac{4000}{0.87}$$

K.V.A. = 4597.70



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

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

$$I = \frac{12}{18} \qquad V = 0.666 \times 18 \qquad R = \frac{12}{0.666}$$

I = 0.666 V = 11.988 R = 18.01

Motor Formulas:

Speed VS Poles Formulas.

The magnetic field created in stator rotates at a synchronous speed (Ns)

$F = \frac{NP}{120}$ $N = \frac{F\ 120}{P}$ $P = \frac{F\ 120}{N}$

where: N = speed of rotation (RPM)
P = the number of poles on the stator.
F = the supply frequency in Hertz.
120 = time constant

$F = \frac{3000 \times 2}{120} = 50Hz$ $N = \frac{50 \times 120}{2} = 3000\ RPM$ $P = \frac{50 \times 120}{3000} = 2\ Pole$

The difference between Ns and Nb is called the slip. The slip varies with the load. An increase in load will cause the rotor to slow down or increase slip. A decrease in load will cause the rotor to speed up or decrease slip. The slip is expressed as a percentage and can be determined with the following formula:

$$\%\ slip = \frac{Ns - Nb}{Ns} \times 100$$

$$Slip = \frac{(Synchronous\ speed) - (Rotor\ Speed)}{(Synchronous\ speed)} \times 100$$

Where: Ns = the synchronous speed in RPM
Nb = the base speed in RPM

TORQUE (lb-ft):

To determine braking torque of a motor or to calculate motor full load torque apply this formula.

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

Where T = Full load motor torque in (lb-ft)
5252 = Constant (33,000 divided by 3.14 x 2)
HP = Motor Horsepower
RPM = Speed of Shaft

E.g. What is the FLT (full load torque) of a 30 HP motor operating at 1725 RPM?

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

To calculate the horsepower of a motor when the speed & torque are known apply this formula.

$HP = \frac{RPM \times T\ (torque)}{5252}$ $HP = \frac{1725 \times 3.1}{5252}$ $HP = \frac{5347.5}{5252} = 1HP$

For H.T. or L.T. Motors IR value always more than its capacity.

IR=KV +1 = MΩ

IR=11KV Motor + 1

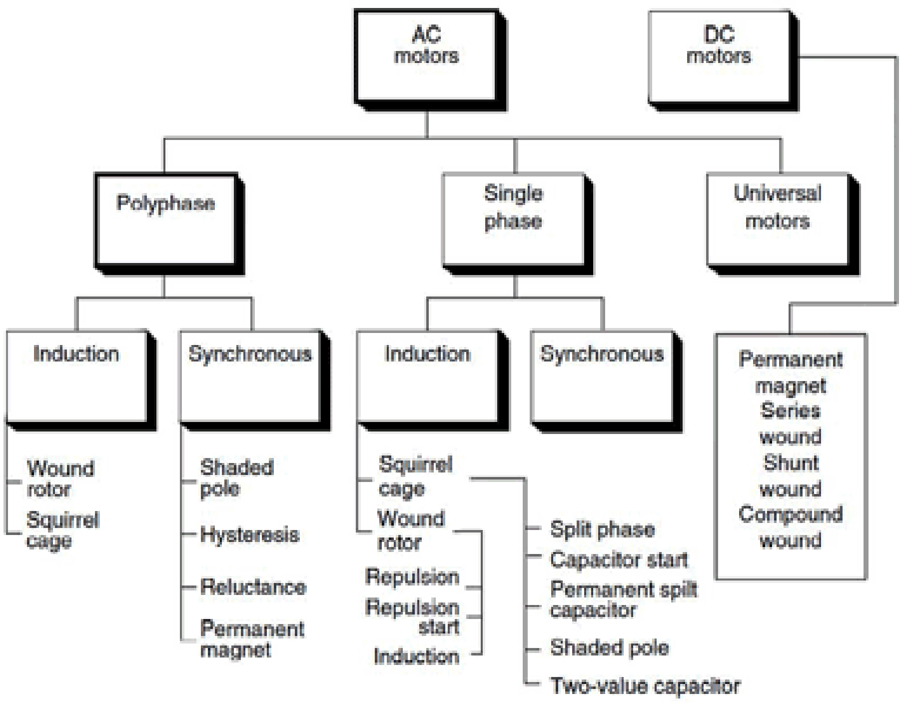
IR=12 MΩ

∴ 440V Motor = 440÷1000 = 0.440KV

IR =0.440 + 1 = 1.4 MΩ

Note:

- Always earthing should be less than 1Ω and use better quality heavy copper wire.
- D.O.L. starter is used in A.C. Motors up to 7.5 KW & above Star/Delta Starter
- H.T. Motor is to feed with more than 415V & all other operated below 415V are L.T. Motor.
- The L.T. cables are up to 1000 volts, H.T. cables are from 1000V to 23KV & Extra High Voltage Cables is from 23KV upwards.
- Cables for 220KV lines are always oil compressed gas insulated.
- In ball bearing to find O.D. of shaft multiply the last two digit of bearing No. with 5
  e.g. 6310 bearing No. 6310 = 10 x 5 = 50mm O.D. of shaft.
- To find outer diameter of the ball bearing 6310 = (10x10) +10 = 110mm outer diameter of ball bearing.
- To find voltage from megawatt MW = √3 x I x P.F. = Answer, ∴ MW ÷ Answer = Voltage



Application of Duty & Insulation Class of All Induction Motors

MOTOR DUTY CYCLE TYPES AS PER IEC STANDARDS

No.	Ref.	Duty Cycle Type	Description
1	S1	Continuous running	Operation at constant load of sufficient duration to reach the thermal equilibrium.
2	S2	Short-time duty	Operation at constant load during a given time, less than required to reach the thermal equilibrium, followed by a rest enabling the machine to reach a temperature similar to that of the coolant (2 Kelvin tolerance)
3	S3	Intermittent periodic duty.	A sequence of identical duty cycles, each including a period of operation at constant load and a rest (without connection to the mains). For this type of duty, the starting current does not significantly affect the temperature rise.
4	S4	Intermittent periodic duty with starting	A sequence of identical duty cycles, each consisting of a significant period of starting, a period under constant load and a rest period.
5	S5	Intermittent periodic duty with electric braking	A sequence of identical cycles, each consisting of a period of starting, a period of operation at constant load, followed by rapid electric braking and a rest period
6	S6	Continuous operation periodic duty	A sequence of identical duty cycles, each consisting of a period of operation at constant load and a period of operation at no-load. There is no rest period.
7	S7	Continuous operation periodic duty with electric braking	A sequence of identical duty cycles, each consisting of a period of starting, a period of operation at constant load, followed by an electric braking. There is no rest period.
8	S8	Continuous operation periodic duty with related load and speed changes	A sequence of identical duty cycles, each consisting of a period of operation at constant load corresponding to a predetermined speed of rotation, followed by one or more periods of operation at another constant load corresponding to the different speeds of rotation (e.g., duty). There is no rest period. The period of duty is too short to reach the thermal equilibrium.
9	S9	Duty with non-periodic load and speed variations	Duty in which, generally, the load and the speed vary non-periodically within the permissible range. This duty includes frequent overloads that may exceed the full loads.

APPLICATION OF THE DUTY TYPE, RATED MOTORS		
No.	**Duty Class Type**	**Use Of Motor**
1	S1 : Continuous Duty	Pump, Blowers, Fans, and Compressors.
2	S2 : Short Time Duty	Operation of Gates of Dams, Sirens, Capstan.
3	S3 : Intermittent Periodic Duty	Valve Actuators, Wire Drawing Machine.
4	S4 : Intermittent Periodic Duty With Starting	Hoist, Cranes, Lift.
5	S5 : Intermittent Periodic Duty With Starting	Hoist, Cranes, Rolling Mills.
6	S6 : Continuous Duty With Intermittent Periodic Loading	Conveyors, Machine Tools.
7	S7 : Continuous Duty With Starting & Breaking	Machine Tools.
8	S8 : Continuous Duty With Periodic Speed Charges	Special Application where the motor is required to run at different speeds & different loads.
9	S9 : Duty With Non-Periodic Load & Speed Variations	Special Application where the motor is required to run at different speeds & different loads.

Insulation Class Of All Induction Motors						
Y	A	E	B	F	H	C
90°c	105°c	120°c	130°c	155°c	180°c	Above 180°c

Types of Mounting	
Horizontal Mounting (Foot Mounting)	B3, B6, B7, B8, V5, V6
Vertical Mounting (Flange Mounting)	B5, V1, V3
Face Mounting	B14, V18, V19

TYPES D.C. MOTOR		
Sr.No.	MOTOR	USE
1	D.C. Shunt Motor	Lathes, Fans, Pumps Disc and Band Saw Drive requiring moderate torques.
2	D.C. Series Motor	Electric Traction, Train, Cranes & High Speed Tools.
3	D.C. Compound Motor	Rolling mills and other loads requiring large momentary torques.

TYPES OF SINGLE PHASE A.C. INDUCTION MOTOR		
Sr.No.	MOTOR	USE
1	Split Phase Induction Motor	Small Grinders, Fans & Blowers and other low starting torque applications with power needs from 1/20 to 1/3 HP.
2	Capacitor Start Induction Motor	Belt-Drive applications like small conveyors, large blowers & pumps.
3	Capacitor Run Induction Motor	Fans, Blowers with low starting torque needs & intermittent cycling uses, such as adjusting mechanisms, gates operators & garage door openers.
4	Capacitor Start Capacitor Run Ind. Motor	Air Compressors, High Pressure Water Pumps & other High Torque applications requiring 1 to 10 HP.
5	Shaded Pole Induction Motor	Starting Torque is weak so it is use in Fans, Small Blowers, Electric Razors
6	Universal Induction Motor	It is use in house hold appliances like Mixture, Hand Grinder, Table Fan, etc.
7	Repulsion Start Induction Motor	This type of motor can start very heavy loads without drawing too much current. They are made from q/2 to 20 HP. This motors are used in large air compressors, refrigeration equipment and large hoist, and particularly useful in locations where low line voltage is a problem.

TYPES OF THREE PHASE A.C. INDUCTION MOTOR & THERE DIFFERENCE	
SQUIRREL CAGE INDUCTION MOTOR	***SLIP RING INDUCTION MOTOR***
Copper losses are low.	Copper losses are high.
Starting torque is low but running torque is good.	Starting torque is higher than Squirrel Cage.
Starting current is high.	Starting current is low.
Speed is nearly constant but slightly falls with load.	More speed falls with load.
Speed can be varied by changing poles.	Speed can be varied very slightly by changing rotor's extra resistance.
Rotor resistance is low so, copper losses are less and efficiency is high	Efficiency is low.
App.: It is used where low power is needed & speed control is not needed such as Printing Machinery, Flour Mills, Saw Mills, Lathe Machine, Blower Mills.	App.: It is only used where high starting torque is required such as Rolling Mills, Flour Mills, Lifts, Cranes etc.

CIRCUITS BREAKERS:

RESIDUAL CURRENT CIRCUIT BREAKER: It is used in range from 16A to 63A. It trips the circuit when there is earth fault current. It is extremely effective from of shock protection. It may be used where only fire protection is required.

MINIATURE CIRCUIT BREAKER: It is used in range from 80A to 125A to A and 25KA Max. MCB used for domestic, light commercial and light industrial applications. MCB is thermal operated and use for short circuit protection in small current rating circuit. It is used where load is low and used for outgoing.

MOULED CASE CIRCUIT BREAKER: It is used in range from 25A to 6300A and 250KA Max. MCCB is used in heavy commercial and heavy industrial applications. MCCB is thermal operated for over load current and magnetic operation for instant trip in short circuit condition. Under voltage and under frequency may be inbuilt. Normally it is used where normal current is more than 100A where load is high and use as incomer.

VACUUM CIRCUIT BREAKER: It is used in range from 7.2KV to 36KV. In VCB arc extinguishing and insulating is carried out in low vacuum. Vacuum can sustain high voltage (not ionizes) and does not losses its dielectric properties which makes the VCB suitable for HT. Since VCB is costlier and require more maintenance compared ACB.

MINIMUM OIL CIRCUIT BREAKER: It uses Dielectric oil (Transformer Oil) for the purpose of arc extinction. The arc extinction takes places in an insulating housing enclosed in ceramic enclosures. The various voltages rating of MOCB developed is 3.6KV, 7.2KV, 12KV, 30KV, 72.5KV, 145KV, 245KV and 420KV.

SF6 CIRCUIT BREAKER: Sulphur Hexafluoride circuit breaker is used for rated voltage in range of 3.6 KV to 760 KV. This type of circuit breaker offers advantage of compactness requiring only 10% of spaces of conventional substation, protection from moisture, pollution & dust, low maintenance reduced installation time and increased safety.

AIR BLAST CIRCUIT BREAKER: It is used in the range from 11KV to 1100KV. Since it is fast and suitable for repeated operation. It is the most popular circuit breaker for outdoor UHV and HV traction system.

AIR CIRCUIT BREAKER: It is used in range from 400A, 630A, 800A & 1250A. In ACB arc extinguishing and insulating is carried out in air. At high voltages, air ionizes and losses its dielectric properties which makes the ACB unsuitable at HT. That's why ACB is used at LT not at HT.

EQUATION'S OF TRANSFORMERS:

Equation for finding the ratio of Transformer

$$\frac{V1}{V2} \times \sqrt{3} = \frac{I2}{I1} \times \sqrt{3} = \frac{N1}{N2} = K \text{ (Ratio)}$$

where V = Voltage
I = Current
N = No. of Turns   So as per 25KVA Transformer

$$\frac{11000}{433} \times \sqrt{3} = \frac{33.33}{1.312} \times \sqrt{3} = \frac{7656}{174} = 44 \text{ Ratio}$$

To find Phase Current of any Transformer the equation is given bellow.

$$\frac{\text{Rating} \times 1000}{\text{H.V. Voltage}} \div \sqrt{3} = \text{H.V. Phase Current}$$

H.V. Phase Current ÷ √3 = H.V. per Phase Current

$$\frac{\text{Rating} \times 1000}{\text{L.V. Voltage}} \div \sqrt{3} = \text{L.V. Phase Current}$$

L.V. Phase Current ÷ √3 = L.V. per Phase Current

For E.g. 25KVA Transformer

$$\frac{25 \times 1000}{11000} \div \sqrt{3} = 1.312 \text{ H.V. Phase Current}$$

1.312 ÷ √3 = 0.7575 H.V. per Phase Current

$$\frac{25 \times 1000}{433} \div \sqrt{3} = 33.33 \text{ L.V. Phase Current}$$

33.33 ÷ √3 = 19.24 L.V. per Phase Current

For No Load Test of 25 KVA or any other rating Transformer

For No Load test apply the rated L.V. Voltage to secondary side (L.V.) & primary side (H.V.) open.
E.g. for 25kva 11000/433 we have to apply 433 voltages to L.V. side and measure Amps & Watts at 3% accept. So we apply 250 volts 250 x √3 = 433.
For 3% it means that current should not go above 0.999Amp.

$$\text{Equation} = \frac{\text{L.V. Phase Current} \times 3\%}{100} \qquad \frac{33.33 \times 3}{100} = 0.999$$

For Load Loss Test apply Phase Current of rated H.V. voltage of transformer & measure voltage & watts L.V. short.

Magnetic Balance Test: - Measurement of magnetic balance of 10kva 11kv distribution transformer. Magnetic balance test is always measured in L.V. side by applying 100volt to each phase with neutral and measured other two phase with neutral and total of both measurement should be applied voltage.

E.G. Voltage Measured Between

2U2N	2V2N	2W2N	Result
104.6	77.0	27.6	2V2N + 2W2N = 2U2N
51.9	**103.9**	52.0	2U2N + 2W2N = 2V2N
28.2	76.1	**104.3**	2U2N + 2V2N = 2W2N

Winding Resistance Test:- On HV side apply in Ω for 10-16 KVA apply 2000 Ω, 25-63 KVA apply 200 Ω, 100KVA apply 20 Ω. On LV side apply in mΩ for 10-16 KVA apply 2000m Ω, 25-63 KVA apply 200m Ω, 100KVA apply 20mΩ.

A FORMULA TO CALCULATE THE ELECTRICITY COST OF HOUSEHOLD ELECTRIC APPLIANCES

When a person operates any electric appliance in their home it gets measured at the Electric Meter. Those units of measurements are known as kilo-watt hour (KWh). Each electric utility company charges a different rate for each KWh used. In Gujarat the cost of KWh per unit is approximately 6.52 Rs.

The first thing a person needs to know is how many watts the appliance in question uses. That can usually be found on any e volts, amps and watts. If the watts are not listed just multiply the volts times the amps and the result will be the watts. ***Example: 120 volts X 10 amps = 1200 watts.*** Once a person knows the watts of an appliance they can easily figure out how many KWh that particular appliance is using.

1KW = 1000 watts. A 1000 watts appliance that is turned on for one hour equals 1 kilo watt hour. That means 1000 watts appliance used for 1 hour its cost 1 unit (6.52 Rs) for every hour.

EQUATION: $\frac{\text{Watts x Hours}}{1000} = \text{Kwh}$

Kwh x No. Days = Total Kwh. Total Kwh x Rs/unit = Total Monthly cost.

HERE ARE SIMPLE EXAMPLES:

- I have a 100 watt light bulb that is turned on approximately 5 hours every evening. Its cost about 98 Rs a month on my electric bill.

  100w X 5hrs = 500w divided by 1000 = 0.5 KWh every evening. Multiply by 30 days/month.
  0.5 X 30 = 15KWh a month.
  15KWh X 1 unit (6.52 Rs) = 97.80 Rs a month on my bill.

- I have an electric water heater for water heating that is on 30minute every morning. The label on the heater reads 7.5 amps, 120 volt. To find the watts you multiply amps X volts, 7.5 X 120 = 900 watts. Its cost about 88 Rs a month on my electric bill.

  30 minute for 30 days. 0.30min X 30Days = 15 Hrs
  900w X 15hrs = 13500W divided by 1000 = 13.5 KWh every month.
  13.5KWh X 1 unit (6.52 Rs) = 88.02 Rs a month on my bill.

- I have an electric hot plate for cooking that is on for 2 hours every day. The label on the appliance is 1500 watts, 230 volts. To find amps you divide watt X volts, 1500 X 230 = 6.5 amps. Its cost about 586 Rs a month on my electric bill.

  1500w X 2hrs = 3000w divided by 1000 = 3 KWh every day. Multiply by 30 days/month.
  3 X 30 = 90KWh a month.
  90KWh X 1 unit (6.52 Rs) = 586.8 Rs a month on my bill.

- I have an electric motor of 1.3 KW that runs for daily 1 hour. Its cost about 254 Rs a month on my electric bill. So we have to first convert it KW to watts. Simply KW X 1000, 1.3 X 1000 = 1300 watts.

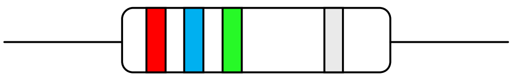
  1300w X 1hrs = 1300w divided by 1000 = 1.3 KWh per hour every day. Multiply by 30 days/month.
  1.3 X 30 = 39KWh per month.
  39KWh X 1 unit (6.52 Rs) = 254.28 Rs per month on my bill.

You can use this formula on every appliance in your home as long as you can find the appliance label. The most important things to remember is that ***amps X volts = watts, 1000 watts an hour is a kilo-watt hour (KWh)*** and that's how your local electric utility.

TABLE OF RESISTOR COLOUR CODE

COLOUR CODE	SIGNIFICANT DIGITS			MULTIPLIER		TOLERANCE	
	1ST BAND	2ND BAND	3RD BAND				
BLACK	0	0	0	1	1Ω		
BROWN	1	1	1	10	10Ω	±1%	F
RED	2	2	2	100	100Ω	±2%	G
ORANGE	3	3	3	1000	1KΩ		
YELLOW	4	4	4	10000	10KΩ		
GREEN	5	5	5	100000	100KΩ	±0.5%	D
BLUE	6	6	6	1000000	1MΩ	±0.25%	C
VIOLET	7	7	7	10000000	10MΩ	±0.10%	B
GREY	8	8	8	100000000	100MΩ	±0.05%	A
WHITE	9	9	9	1000000000	1GΩ		
GOLD	-	-	-	0.1		±5%	J
SILVER	-	-	-	0.01		±10%	K
NONE	-	-	-	-		±20%	M

EXAMPLE:



1. Red = 2
2. Blue = 6
3. Green = x 100000
4. Silver = ±10% Tolerance

2, 6 x 100000 = 2600000Ω
2600000 Ω ÷ 1000000 Ω = 2.6MΩ
This Resistor is 2.6MΩ ±10%

PREFIX	NAME	CONVERSATION
T	Tera	1TΩ = 1,000,000,000,000 Ω
G	Giga	1GΩ = 1,000,000,000 Ω
M	Mega	1MΩ = 1,000,000 Ω
K	Kilo	1KΩ = 1,000Ω
m	milli	1,000 mΩ = 1Ω
μ	micro	1,000,000 μΩ = 1Ω
n	nano	1,000,000,000 nΩ = 1Ω
p	pico	1,000,000,000,000 pΩ = 1Ω