



## Electrical Formulas and Grounding Requirements

1  
Application  
Data

### Electrical Formulas for Finding Amperes, Horsepower, Kilowatts and kVA

To Find	Single-Phase	Alternating Current Two-Phase <sup>①</sup> , Four-Wire	Three-Phase	Direct Current
Kilowatts	$\frac{I \times E \times pf}{1000}$	$\frac{I \times E \times 2 \times pf}{1000}$	$\frac{I \times E \times 1.73 \times pf}{1000}$	$\frac{I \times E}{1000}$
kVA	$\frac{I \times E}{1000}$	$\frac{I \times E \times 2}{1000}$	$\frac{I \times E \times 1.73}{1000}$	—
Horsepower (Output)	$\frac{I \times E \times \% \text{ EFF} \times pf}{746}$	$\frac{I \times E \times 2 \times \% \text{ EFF} \times pf}{746}$	$\frac{I \times E \times 1.73 \times \% \text{ EFF} \times pf}{746}$	$\frac{I \times E \times \% \text{ EFF}}{746}$
Amperes when Horsepower is Known	$\frac{HP \times 746}{E \times \% \text{ EFF} \times pf}$	$\frac{HP \times 746}{2 \times E \times \% \text{ EFF} \times pf}$	$\frac{HP \times 746}{1.73 \times E \times \% \text{ EFF} \times pf}$	$\frac{HP \times 746}{E \times \% \text{ EFF}}$
Amperes when Kilowatts is Known	$\frac{KW \times 1000}{E \times pf}$	$\frac{KW \times 1000}{2 \times E \times pf}$	$\frac{KW \times 1000}{1.73 \times E \times pf}$	$\frac{KW \times 1000}{E}$
Amperes when kVA is Known	$\frac{kVA \times 1000}{E}$	$\frac{kVA \times 1000}{2 \times E}$	$\frac{kVA \times 1000}{1.73 \times E}$	—

### 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<sup>③</sup>

Type	Power Factor
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 × Power Factor); Three-phase induction motors, 25 horsepower and less	70%
Three-phase induction motors above 25 horsepower	80%

### Fault-Current Calculation on Low-Voltage AC Systems

In order to determine the maximum interrupting rate of the circuit breakers in a distribution system, it is necessary to calculate the current which could flow under a three-phase bolted short circuit condition. For a three-phase system the maximum available fault current at the secondary side of the transformer can be obtained by use of the formula:

$$I_{sc} = \frac{kVA \times 100}{KV \times \sqrt{3} \times \% Z}$$

where:

$I_{sc}$  = Symmetrical RMS amperes of fault current.

kVA = Kilovolt-ampere rating of transformers.

KV = Secondary voltage in kilovolts.

% Z = Percent impedance of primary line and transformer.

### Minimum Size Grounding Conductors for Grounding Raceways and Equipment (From NEC Table 250-95)<sup>②</sup>

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit etc., Not Exceeding (Amperes)	Size	
	Copper Wire Number	Aluminum or Copper Clad Aluminum Wire Number
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250 kcmil
1600	4/0	350 kcmil
2000	250 kcmil	400 kcmil
2500	350 kcmil	600 kcmil
3000	400 kcmil	600 kcmil
4000	500 kcmil	800 kcmil
5000	700 kcmil	1200 kcmil
6000	800 kcmil	1200 kcmil

### Grounding Electrode Conductor for AC Systems (From NEC Table 250-94)<sup>②</sup>

Size of Largest Service Entrance Conductor or Equivalent Area for Parallel Conductors		Size of Grounding Electrode Conductor	
Copper	Aluminum or Copper Clad Aluminum	Copper	Aluminum or Copper Clad Aluminum
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250 kcmil	4	2
Over 3/0 to 350 kcmil	Over 250 kcmil to 500 kcmil	2	1/0
Over 350 kcmil to 600 kcmil	Over 500 kcmil to 900 kcmil	1/0	3/0
Over 600 kcmil to 1100 kcmil	Over 900 kcmil to 1750 kcmil	2/0	4/0
Over 1100 kcmil	Over 1750 kcmil	3/0	250 kcmil

① In three-wire, two-phase circuits the current in the common conductor is 1.41 times that in either other conductor.

② Additional information and exceptions are stated in Article 250—Grounding, National Electric Code.

③ These figures may be decreased slightly for single-phase and two-phase induction motors.

E = Volts I = Amperes  
% EFF = Percent Efficiency pf = Power Factor