Electrical Formulae

Electrical Quantities

Quantity	Symbol	Unit Name	Unit Symbol
Electromotive force	E, e*	Volt	V
Potential difference	V, v*	Volt	V
Current	I, i*	Ampere	A
Magnetic flux	Φ	Weber	Weber
Frequency	f	Hertz	Hz
Flux linkage	λ	Weber-turns	-
Resistance	R	Ohm	Ω
Inductance	L	Henry	H
Capacitance	C	Farad	F
Impedance	Z	Ohm	Ω
Reactance	X	Ohm	Ω
Power,dc,or active	P	Watt	W
Power, reactive	Q	Volt-ampere reactive	VAr, var
Power, total or apparent	S	Volt-ampere	VA
Power factor angle	φ	-	°, deg.
Angular velocity	ω	Radians per second	rads^{-1}
Rotational velocity	n	Revolutions per second	s^{-1} ,rev s^{-1}
		Revolutions per minute	min^{-1}, rpm
Efficiency	η	-	
Number of pairs of poles	p	-	

** Capital and small letters designate rms and instantaneous value respectively.*

AC Single-Phase

All quantities r.m.s. values:

V = I Z

Total or apparent power in VA = $V_l = I^2Z = V^2/Z$

Active power in watts, W = V_l cos φ

Reactive power in VAr = V_l sin φ

AC Three-Phase

(Assuming Balanced Symmetrical Waveform)

All quantities r.m.s values:

V_l = Line-to-line voltage

V_p = Phase voltage (line-to-neutral)

I_l = line current (wye)

I_p = Phase current (delta)

In a WYE connected circuit, $V_p = V_l/\sqrt{3}$, $V_l = \sqrt{3}V_p$, $I_l = I_p$

In a DELTA connected circuit: $I_p = I_l/\sqrt{3}$, $I_l = \sqrt{3}\,I_p$ $V_l = V_p$

Total of apparent power in VA = $\sqrt{3}\,V_l I_l$

Active power in watts,W = $\sqrt{3}\,V_l I_l \cos\varphi$

Reactive power in VAr = $\sqrt{3}\,V_l I_l \sin\varphi$

Power factor (pf) = cos φ

= Active power / Apparent power

= W / VAr

Three-Phase Induction Motors

All quantities rms values:

kW_{mech} = horsepower x 0.746

$kW_{elec} = \sqrt{3}\,V_l\,I_l \cos\varphi$ at rated speed and load

where V_l = supply voltage I_l = rated full load current

cos φ = rated full load power factor

Efficiency, η = (kW_{mech}/ kW_{elec}) x 100 per cent

Phase current $I_p = I_l$ for wye connection

$I_p = I_l/\sqrt{3}$ for delta connection

Loads (phase values)

Resistance R, measured in Ohms (no energy storage)

Inductive reactance, $X_L = \omega L = 2\pi f L$ Ohms (stores energy)

Where f = frequency (Hz), L = Inductance (H)

Capacitative reactance, $X_C = 1/(\omega C) = 1/(2\pi f C)$

Where f = frequency (Hz), C = Capacitance (F)

Impedance

Impedance is the algebraic sum of the separate load values thus:

$$Z = \sqrt{(R^2 + X_L^2)} \text{ or } \sqrt{(R^2 + X_C^2)}$$

If R, X_L and X_C are present in series in the same circuit then X_L and X_C may be summated, treating X_C as negative, thus

$$Z = \sqrt{(R^2 + (X_L - X_C)^2)}$$

Symbols & Formulae

CONTROL TECHNIQUES

Symbols & Formulae

Electrical Formulae

Ohms Law

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

or $\text{Volts} = \text{Amperes} \times \text{Ohms}$

Power in DC Circuits

$$\text{Horsepower} = \frac{\text{Volts} \times \text{Amperes}}{746}$$

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

$$\text{Kilowatts} = \frac{\text{Volts} \times \text{Amperes}}{1{,}000}$$

$$\text{Kilowatts-Hours} = \frac{\text{Volts} \times \text{Amperes} \times \text{Hours}}{1{,}000}$$

Power in AC Circuits

Kilovolt-Amperes (KVA):

$$\text{kVA (1Ø)} = \frac{\text{Volts} \times \text{Amperes}}{1{,}000}$$

$$\text{kVA (3Ø)} = \frac{\text{Volts} \times \text{Amperes} \times 1.73}{1{,}000}$$

Kilowatts (Kw)

$$\text{kW (1Ø)} = \frac{\text{Volts} \times \text{Amperes} \times \text{Power Factor}}{1{,}000}$$

$$\text{kW (3Ø)} = \frac{\text{Volts} \times \text{Amperes} \times \text{Power Factor} \times 1.73}{1{,}000}$$

$$\text{Power Factor} = \frac{\text{Kilowatts}}{\text{Kilovolts} \times \text{Amperes}}$$

Other Useful Formulae

Three-Phase (3Ø) Circuits

$$\text{HP} = \frac{E \times I \times \sqrt{3} \times \text{Eff} \times \text{PF}}{746}$$

$$\text{Motor Amps} = \frac{\text{HP} \times 746}{E \times \sqrt{3} \times \text{Eff} \times \text{PF}}$$

$$\text{Motor Amps} = \frac{\text{kVA} \times 1000}{\sqrt{3} \times E}$$

$$\text{Motor Amps} = \frac{\text{kW} \times 1000}{\sqrt{3} \times E \times \text{PF}}$$

$$\text{Power Factor} = \frac{\text{kW} \times 1000}{E \times I \times \sqrt{3}}$$

$$\text{Kilowatt Hours} = \frac{E \times I \times \text{Hours} \times \sqrt{3} \times \text{PF}}{1000}$$

$$\text{Power (Watts)} = E \times I \times \sqrt{3} \times \text{PF}$$

Mechanical Variables

Material Densities		
Materials	lb/in^3	gm/cm^3
Aluminum	0.096	2.66
Brass	0.299	8.3
Bronze	0.295	8.17
Copper	0.322	8.91
Hard Wood	0.029	0.8
Soft Wood	0.018	0.48
Plastic	0.04	1.11
Glass	0.079-0.090	2.2-2.5
Titanium	0.163	4.51
Paper	0.025-0.043	0.7-1.2
Polyvinyl chloride	0.047-0.050	1.3-1.4
Rubber	0.033-0.036	0.92-0.99
Silicone Rubber, without filler	0.043	1.2
Cast Iron, gray	0.274	7.6
Steel	0.28	7.75

Friction Coefficients	Ffr=μWL
Materials	μ
Steel on Steel (greased)	~0.15
Plastic on Steel	~0.15-0.25
Copper on Steel	~0.30
Brass on Steel	~0.35
Aluminum on Steel	~0.45
Steel on Steel	~0.58
Mechanism	μ
Ball Bushings	<0.001
Linear Bearings	<0.001
Dove-tail Slides	~0.2++
Gibb Ways	~0.5++

Mechanism Efficiencies	
Acme screw with brass nut	~0.35-0.65
Acme screw with plastic nut	~0.50-0.85
Ballscrew	~0.85-0.95
Chain and Sprocket	~0.95-0.98
Preloaded Ballscrew	~0.75-0.85
Spur or Bevel gears	~0.90
Timing Belts	~0.96-0.98
Worm Gears	~0.45-0.85
Helical Gear (1 reduction)	~0.92