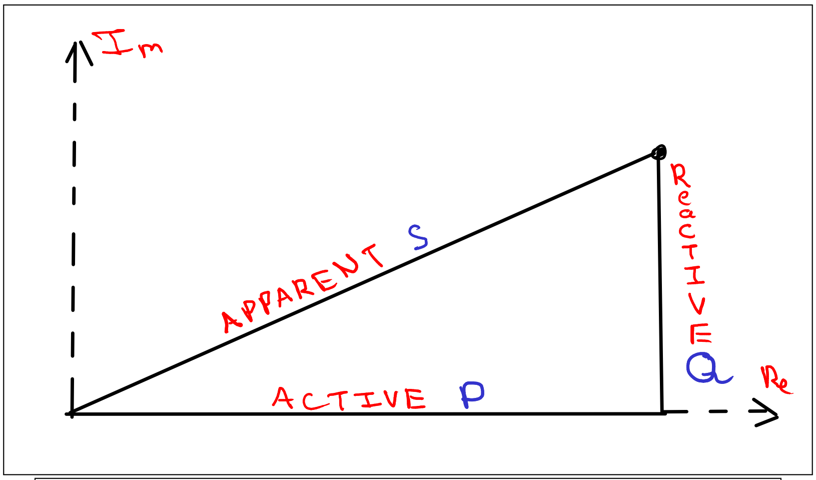
Formula Sheet EE2E11

MaybE_Tree

2022-09-07

1 Power



Name	Type	Symbol	Unit
Complex Power	Complex Value	S	VA
Active Power	$\mathrm{Re}(S)$	P	W
Reactive Power	$\mathrm{Im}(S)$	Q	VAr
Apparent Power	$\lvert S\rvert$	$\lvert S\rvert$	VA

1.1 Factors

$$\text{Power Factor} \quad \frac{\text{Active Power}}{\text{Apparent Power}} = \text{Distortion Factor} * \text{Displacement Factor}$$

$$\text{Distortion Factor} \quad \frac{\text{RMS of fundamental}}{\text{RMS of total}} = 1 \quad \text{(when no harmonics)}$$

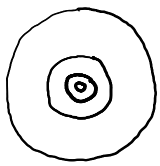
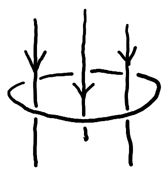
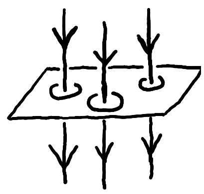
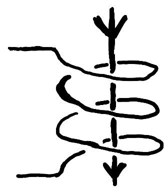
$$\text{Displacement Factor} \quad \cos\phi, \text{ where } \phi \text{ is phase difference between voltage and current}$$

2 Three-phase

Property	**Y**	**Δ**
Voltage	$V_{LL} = \sqrt{3}V_\phi$	$V_{LL} = V_\phi$
Current	$I_L = I_\phi$	$I_L = \sqrt{3}I_\phi$
Phase	V_{ab} leads V_a by $30°$	I_a lags I_{ab} by $30°$
Active Power	$P = \sqrt{3}V_{LL}I_L\cos\phi$	
Reactive Power	$Q = \sqrt{3}V_{LL}I_L\sin\phi$	
Apparent Power	$\lvert S\rvert = \sqrt{3}V_\phi I_\phi$	

- All powers are given as total power ($3 *$ Power of single load/coil)
- V_ϕ is voltage across one coil.
- I_ϕ is current through one coil.
- ϕ is phase difference between voltage and current (conventionally, voltage has 0 phase offset).

3 Magnetic Concepts

Field Strength	Flux Density	Magnetic Flux	Flux Linkage
H	$\vec{B}$	Φ	λ
$[\mathrm{A\,m^{-1}}]$	$[\mathrm{T}] = [\mathrm{V\,s\,m^{-2}}]$	$[\mathrm{Wb}]$	$[\mathrm{Wb}]$
-	$B = \mu_0\mu_r H$	$\Phi = \vec{B}\cdot\vec{A}$	$\lambda = N\Phi$
			

4 General Equations

Speed	$[\mathrm{m\,s^{-1}}] = \dfrac{5}{18}[\mathrm{km\,h^{-1}}]$	
Angular Speed	$v = \omega R$	R is radius, v is linear speed.
Revolutions per Minute	$[\mathrm{rad\,s^{-1}}] = \dfrac{2\pi}{60}[\mathrm{rpm}]$	
Power	$P_{\mathrm{mech}} = T\omega$	
Turns Ratio: Voltage	$\dfrac{V_1}{V_2} = \dfrac{N_1}{N_2}$	
Turns Ratio: Current	$\dfrac{i_1}{i_2} = \dfrac{N_2}{N_1}$	

5 Converters

- Glavanic isolation (flyback converter only) isolates high-voltage from low-voltage, more safe.
- Higher duty cycle = higher efficiency

Value	Symbol	Unit	Notes
Duty Cycle	D	-	$0 < D < 1$

5.1 Buck

$$\text{Duty Cycle} \quad \frac{V_c}{V_s} = D$$

$$\text{Current} \quad I_B = \frac{V_s(D - D^2}{2Lf_s}$$

- Peak diode current = peak inductor current
- Peak inductor current = average inductor current * 2

5.2 Flyback

$$\text{Duty Cycle} \quad \frac{V_c}{V_s} = \frac{N_2}{N_1}\frac{D}{1-D}$$

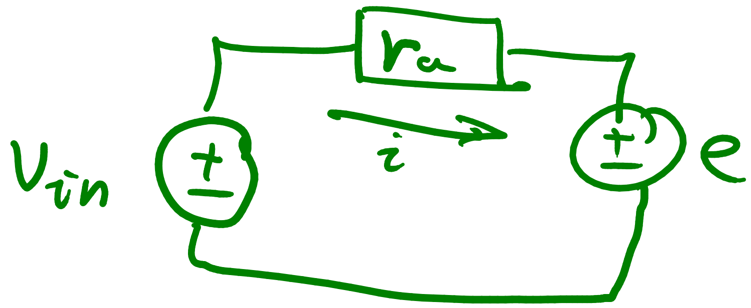
6 DC Machines

Value	Symbol	Unit	Notes
Machine Constant	K_m	???	Determined by geometry
Field Constant	K_ϕ	???	Determined by geometry
Pole Field	ϕ_p	Wb	-
Torque	T	N m	-
Induced Voltage	e	V	-
Armature Voltage	r_a	V	-

$$\text{Induced Voltage} \quad e = K_m \phi_p \omega$$

$$\text{Torque} \quad T = K_m \phi_p i_a$$

$$\text{Field per pole from Field Winding} \quad \phi_P = K_\phi i_f$$



7 AC Machines

Value	Symbol	Unit	Notes
Angular Speed	n	rpm [revolutions per minute]	-
Poles	P	-	Always even
Pole Pairs	p	-	$p = {}^{P}/_{2}$
Slip	s	ratio of angular speeds	$0 \leq s \leq 1$

Synchronous Speed	$n_s[\text{rpm}] = \dfrac{120f[\text{Hz}]}{P} = \dfrac{60f[\text{Hz}]}{p}$
Rotor Speed	$n_r = (1 - s)n_s$
Synchronous Speed	$\omega_{\text{mech}} = \dfrac{2\pi f_{\text{elec}}}{p}$
Rotor Current Frequency	$f_r = sf_s$

Parama's equation $P = \dfrac{V}{I}$ *V is voltage, I is current, P is power.*