Chapter 16 – SYNCHRONOUS GENERATORS

$120f = pn$

$X_S = \dfrac{E_{OC}}{I_{SC}}$ $\qquad Z_{BASE} = \dfrac{E_{BASE}^2}{S_{BASE}}$

$$\% \text{ Regulation} = \frac{(E_{NL} - E_B)}{E_B} * 100\%$$

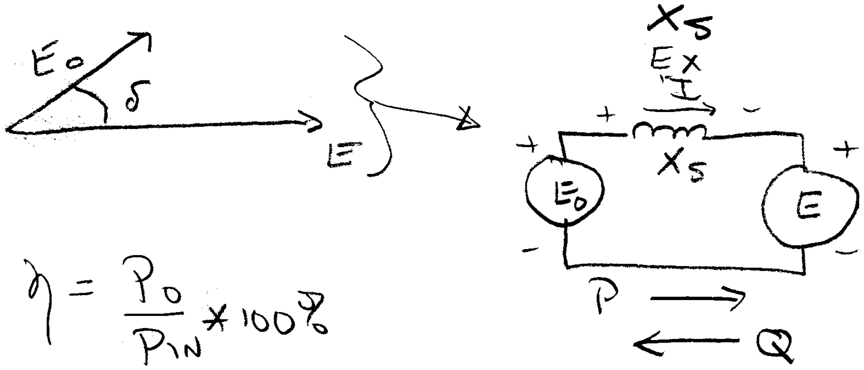
$\delta = p\dfrac{\alpha}{2}$ $\qquad P = \dfrac{E_0 E}{X_S} \sin\delta$

$$Q = \frac{(E_0^2 - EE_0)}{X_S} \cos\delta$$

NOTE – if E, E_0 Line to Neutral P is Per Phase $P_{1\phi}$

$P_{3\phi} = 3 P_{1\phi}$

if E, E_0 Line to Line P is Already 3 Phase Value.

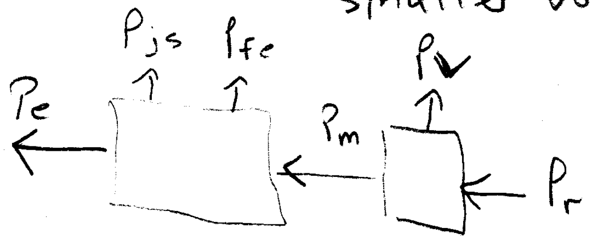


$\vec{E}_X = \vec{I}\vec{Z}_{XS} = \vec{E}_0 - \vec{E}$

$\eta = \dfrac{P_O}{P_{IN}} * 100\%$

P flows from Leading voltage to Lagging voltage

Q flows from Largest voltage source magnitude to smaller voltage source magnitude



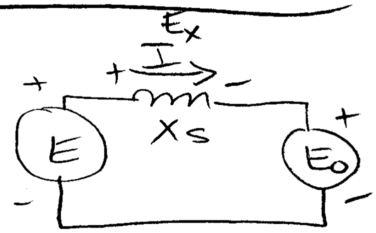
$\eta = \dfrac{P_e}{P_r} * 100\%$

δ controlled By P_r (turbine/Engine Power)

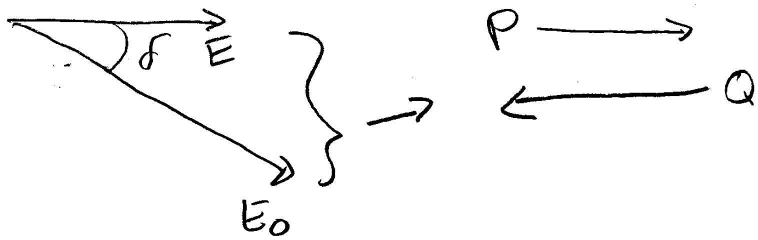
E_0 controlled By ϕ $\left[E_0 = \dfrac{Zn\phi}{60}\right]$, ϕ controlled by field current.

Chapter 17 - SYNCHRONOUS MOTORS

$$n_s = \frac{120f}{p}$$



$$E_x = I Z_{xs} = \vec{E} - \vec{E}_0$$

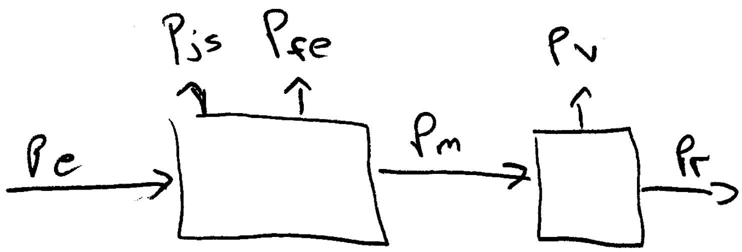


$$P = \frac{E_0 E}{X_s} \sin\delta \qquad Q = \frac{(E_0^2 - EE_0)}{X_s} \cos\delta$$

$$9.55\, P = T \cdot n_s \qquad \delta = \frac{p\alpha}{2}$$

P flows from Leading Voltage to Lagging Voltage

Q flows From Largest Voltage Source magnitude to Smaller voltage source magnitude.



$$\eta = \frac{P_r}{P_e} * 100\%$$

CHAPTER 18 - Single Phase Motors

$n_s = \frac{120f}{p}$ $T = K \, I_a I_s \sin\alpha$ (split phase motor)

$\eta = \frac{P_o}{P_i} * 100\%$ $9.55P = T \cdot n$

(Hysteresis motor) → $T = E_h / 6.28$ { E_h = Energy per turn

$W = n E_h$ W = Energy per min }

$E_K = 5.48 \times 10^{-3} J (n_s)^2$

Universal motor → Series DC motor with brushes & commutating section

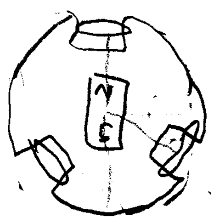
$n = \frac{60E}{Z\phi}$ or $n \propto E$ (not frequency)

Chapter 19 - STEPPER MOTORS

Pull out Torque corresponds to slewing characteristics
Pull in torque corresponds to step without error

$$T_0 = \frac{L}{R}$$

time to final current $\approx 3T_0$



SPR or PPR $= \frac{360^\circ}{rev} \Big| \frac{step}{Degree}$ = STEPS Per Revolution = Pulse Per Revolution

→ UNIPolar

Degree Per Step $= \frac{(360)(2)}{P_s P_r} = \frac{(360)(2)}{(3)(2)} = 120^\circ/\text{step}$

→ BiPolar

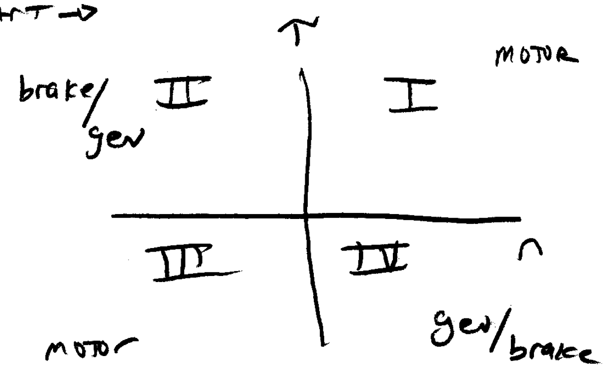
Degree per step $= \frac{(360)}{P_s P_r} = \frac{360}{(3)(2)} = 60^\circ/\text{step}$

chapter 20 - Industrial Motor control

TABLE 20A (Page 452) - symbols for elements

@ Given slip, under Reduced Voltage start →

$I_2 = I_1 \left(\frac{E_2}{E_1}\right)$ $T_2 \approx T_1 \left(\frac{E_2}{E_1}\right)^2$



Variable frequency

SLIP (in RPM) has to be same for same torque and current

for constant torque / variable freq.

$V_2 = V_B \left(\frac{f_2}{f_B}\right)$

LADDer Logic for Across the Line start
Reduced Voltage start

Chapter 21 – Power electronics

$E_L = L \frac{di}{dt} \rightarrow A_{(+)} = E \cdot dt = L\,di$

$I_{max} = \frac{A_{(+)}}{L}$

2pulse, single Phase Rectifier

$E_d = 0.9\,E$ $\quad I_d = E_d / R$ $\quad I_{diode\,Avg} = \frac{I_d}{2}$

$E_{max} = \sqrt{2}E$, $E_{MIN} = 0$, $E_{pp} = \sqrt{2}E$

$\text{ripple} = \frac{5.5\,P_L}{f\,W_L}$ $\quad P_L = I_d E_d$ $\quad \beta = 180^\circ$

$W_L = \frac{1}{2} L I^2$ $\quad f_p = 2 * f$

6Pulse, Three Phase Rectifier

$E_d = 1.35\,E$ $\quad \beta = 120^\circ$ $\quad f_p = 6 * f$

$E_{max} = \sqrt{2}E$ $\quad E_{MIN} = 1.225E$, $E_{pp} = 0.189E$

$\text{ripple} = \frac{0.17\,P_L}{f\,W_L}$ $\quad I_d = \frac{E_d}{R}$ $\quad I_{diode\,Avg} = \frac{I_d}{3}$

$P_L = I_d E_d$ $\quad I_{LINE} = 0.816\,I_d$

$W_L = \frac{1}{2} L I^2$ $\quad I_F = 0.955\,I_{LINE}$

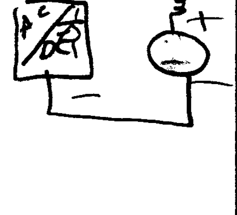
Phase Controlled 6 Pulse, 3 Phase Rectifier

$E_d = 1.35\,E \cos\alpha$ (where $0^\circ < \alpha < 90^\circ$)

$I_{Line} = 0.816\,I_d$

$Q = P \tan\alpha$ $\quad I_{diode\,Avg} = I_d/3$

$P = E_d I_d$



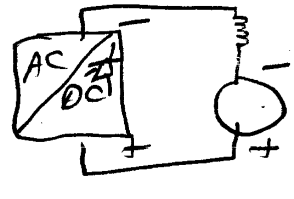
Phase Controlled, 6Pulse, 3Phase inverter

$E_d = 1.35\,E \cos\alpha$ (where $90^\circ < \alpha < 180^\circ$)

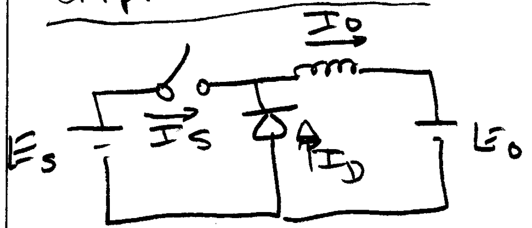
$I_{LINE} = 0.816\,I_d$

$Q = P \tan\alpha$ $\quad I_{diode\,Avg} = I_d/3$

$P = E_d I_d$



Chapter 21 continued



$D = t_a/T$, $f = \frac{1}{T}$

$I_0 = I_D + I_s$

$E_0 = D E_s$

$I_s = D I_0$

$R_s = \frac{R_0}{D^2} = \frac{E_0}{D^2 I_0} = \frac{E_s}{I_s}$