North South University

Assignment 03

Power Systems

Course Code: EEE362

Section: 02

Course Instructor

Hafiz Abdur Rahman (HZR)

Prepared By

Mohammed Mahmudur Rahman **ID #** 152 0386 043

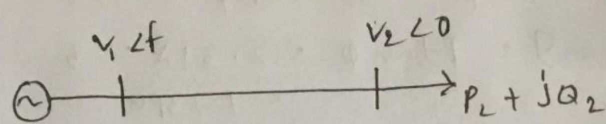
Mohammed Mahmudur Rahman (1)

ID: 1520386043

Course: EEE 362

Section: 02

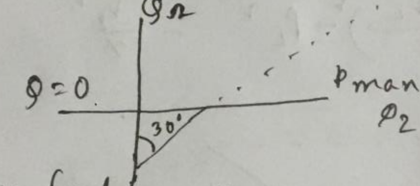
Answer to the question no. 1



$$x = 82.66 (K.m) \times .4 (\Omega / Km)$$
$$= 33.064 \Omega$$

$$Z_{base} = \frac{115 \times 10^3}{100 \times 10^6} = 132.25 \Omega$$

$$X_{p.u} = \frac{X}{Z_{base}} = \frac{33.064}{132.25}$$
$$= .25 pu$$



Power factor = 0

$$Q_2 = 0$$

$$\tan(30) = \frac{P_{max}}{\frac{V_2^2}{X}}$$

$$P_{max} = \frac{V_2^2}{X} \times \tan(30)$$
$$= 2.31 pu$$

$$P_2 = \frac{V_1 V_2}{X} \sin\delta$$

$$V_1 = \frac{X P_2}{V_2 \sin\delta} = \frac{.25 \times 2.31}{1.0 \times \sin 30°}$$

$$V_1 = 1.155 pu$$

(2)

(2) power factor = .8

$\cos\phi = .8, \quad \tan\phi = 3/4$

$Q = P\tan\phi = 2.31 \times .75$

$= 1.73pu$

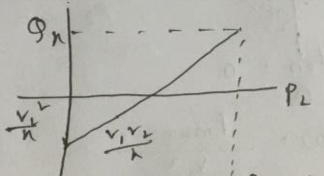
Here, we assume that

$V_2 = 120$

So we have a total reactive power consum-ption of $Q = Q_2 - Q_c$

$$\left(\frac{V_x^2}{x} + Q_x\right)^2 + P_2^2 = \left(\frac{V_1 V_2}{x}\right)^2$$

$$Q_x = \sqrt{\left(\frac{V_1 V_2}{x}\right)^2 - P_2^2} - \frac{V_2^2}{x}$$



$P_2 = 2.3\ pu$

$$Q_x = \sqrt{\left(\frac{1.05 \times 1.0}{.25}\right)^2 - 2.31^2} - \frac{1.0^2}{.25}$$

$= -0.5$

$Q_c = Q_2 - Q_x = 1.73$

$= 2.23$

$Q_{ph} = \frac{Q_3}{3} = .744pu$

$Q_{ph} = \frac{V_{ph}^2}{X_c} = 2\pi f c V_{ph}^2$

$$C = \frac{Q_{ph}}{2\pi f \left(V_{in}/\sqrt{3}\right)^2}$$

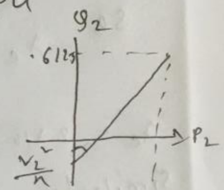
$$= \frac{74.42\times10^6}{120\pi \times (115)^2 \times \left(10^3/\sqrt{3}\right)^2}$$

$$= 4.47\times10^{-5}\,F$$

$$= 44.78\,\mu F$$

(3) $\frac{Q_c}{2} = 1.11\,pu$

$$Q_2 = Q_2 - \frac{Q_c}{2} = .61\,pu$$



$$\frac{V_2^2}{x} = \frac{(1.0)^2}{.25}$$

$$= 4\,pu$$

$$\tan\delta = \frac{P_2}{\frac{V_2^2}{x} + Q_2} = \frac{2.31}{4+.6125}$$

$$\delta = 26.3$$

$$V_1 = \frac{x P_1}{V_2 \sin\delta} = \frac{.25\times2.31}{1\times\sin(26.58)}$$

$$= 1.290\,pu$$

Chapter–4

(2) we know that,

$$R_{dc} = \frac{17.0\times1000}{1,033,500}$$

$$= .01645$$

Corrected for stranding

$$R_{dc} = 1.02\times.01645$$

$$= .01678\,\Omega/1000 \text{ at } 20^\circ c$$

At $50^\circ c$, $R_{dc} = \frac{228+50}{228+20}\times.01678\times5.28$

$$= .09932\,\Omega.$$

The value does not for skin effect and is less than 60HZ value.

(6) (a) Let,

current a-b carry the current θ I,

$I_a = -I_b$

$= I_A \quad (\because I_c = I_f = 0)$

Hence,

$\Sigma I = 0$ for the group remains valid

So, $\lambda_c = 2\times10^{-7}\left(I_a \ln\frac{1}{D_{ac}} + I_b \ln\frac{1}{D_{bc}} + I_c \ln\frac{1}{r_c} + I_a \ln\frac{1}{D_{fc}}\right)$

$\lambda_c = 2\times10^{-7} \times \ln\frac{D_{bc}}{D_{ac}}$ wb-t/m

Similarly,

$\lambda_d = 2\times10^{-7} \times \ln\frac{D_{bd}}{D_{ad}}$ wb-t/m

λ_{c-d} is given by;

So, $\lambda_c - \lambda_d = 20\times10^{-7} \times \ln\frac{D_{bc}D_{ad}}{D_{ac}D_{bd}}$

$\therefore$ Mutual Inductance $= \frac{\lambda_{c-d}}{I}$

~~$4\times10^{-7}\times\ln\sqrt{D_{bc}}$~~

$= 4\times10^{-7}\times\ln\sqrt{\frac{D_{bc}D_{ad}}{D_{ac}D_{bd}}}$ (Am)

(b) $D_{ac} = \sqrt{(1.25-.5)^2+1.8^2}$

$= 1.95m$

$D_{ad} = \sqrt{(1.25+.5)^2+1.8^2}$

$= 2.51m$

Flux linkages, with c-d

Due to I_a $\phi_{cd} = 2\times10^{-7} I_a \ln \frac{2.51}{1.95}$

" " I_b $\phi_{cd} = -2\times10^{-7} I_a \ln \frac{2.51}{1.95}$

Here,

I_a and I_b are 180° out of Phase,

$\phi_{cd} = 4\times10^{-7} I_a \ln \frac{2.51}{1.95}$

$m = 4\times10^{-7} \ln \frac{2.51}{1.95}$

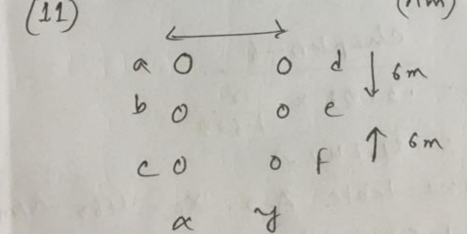
$= 1.01\times10^{-7}$ H/m

(c) $V_{cd} = \omega m I$

$= 377\times1.01\times10^{-7}\times10^{3}\times150$

$= 5.71$ V/Km

(11) (Am)



$D_m = \sqrt[9]{D_{ad}\,D_{ae}\,D_{af}\,D_{bd}\,D_{be}\,D_{bf}\,D_{cd}\,D_{ce}\,D_{cf}}$

$D_{ad} = D_{be} = D_{cf} = 9m$

$D_{ae} = D_{bd} = D_{bf} = D_{ce} = \sqrt{117}\,m$

$D_{af} = D_{cd} = \sqrt{12^2+9^2} = 15m$

$D_m = \sqrt[9]{9\times\sqrt{117}\times15\times\sqrt{117}\times9\times\sqrt{117}\times15\times\sqrt{117}\times9}$

$= 10.940m$

$D_a = .481$

$L_x = L_y = 2\times10^{-7} \ln \frac{10.940}{.481}$ H/m

$= 6.249\times10^{-7}$ H/m

$L = L_x + L_y = 12.497\times10^{-7}$ H/m

(12) from the table A.1 for rail at 1 ft spacing.

$D_3 = .0386$ ft

$1ft = 2.54\times12/100$

$= .3048$ m

$D_s = .3048\times.0386$

$= .01177$ ft

$X_L = 2\times10^{-7} (\ln \frac{1}{.01177}) \times 377 \times 1000$

$= .335\ \Omega$/km .

Chapter-6

(1) (a) $R = .3792\times\frac{18}{1.609}$

$= 4.242\ \Omega$

from the table A.3. $X_a = .465\ \Omega$/m

and $1.6\ m = (1.6\times100)/(2.54\times12)$

$= 5.25$ ft

$X_d = .2012$

$X = .465 + .2012$

$= .6668\ \Omega$/mi

18 km, $X = 18\times\frac{.666}{1.609}$

$= 7.451\ \Omega$

$Z = 4.242 + j7.451$

$= 8.57 \angle 60.35^\circ\ \Omega$

(b) For power factor,

$$I_R = \frac{2500}{\sqrt{3} \times 11}$$

$$= 131.2159 \text{ A} \qquad \frac{11000}{\sqrt{3}}$$

$$= 6305 \text{ V}$$

$$V_3 = 6350 + 131.215\,(4.24 + j7.451)$$

$$= 6906 + j977.6$$

$$= 6975 \angle 8.06^\circ$$

Scending end line voltage $= \sqrt{3} V_3$

$$= \sqrt{3} \times 6975$$

$$= 12.681 \text{V}$$

For power factor $= .8$ lagging

$$|I_R| = \frac{2500}{\sqrt{3} \times 11 \times .8}$$

$$= 160 \text{A}$$

$$V_3 = 6350 + 164 \angle .36.87^\circ \times 8.37 \angle 60.35$$

$$= 7639 + j5.60$$

$$= 7660 \angle 4.19^\circ$$

Sepending end line voltage $= \sqrt{3} V_3$

$$= \sqrt{3} \times 6533$$

$$= 11.350 \text{V}$$

(c) % regulation $= \frac{|V_3| - |V_R|}{|V_R|} \times 100\%$

P.f = .8 lagging % Reg

$$= \frac{7660 - 6350}{6350} \times 100\%$$

$$= 20.63\%$$

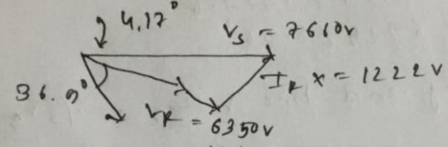
at unity p.f % Regulation = $\frac{6975-6350}{6350} \times 100\%$

$= 9.84\%$

at p.f = .9 leading % Reg = $\frac{6553-6350}{6350}$

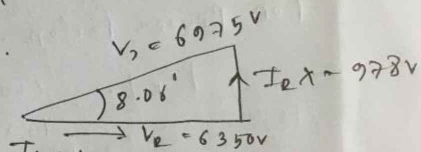
$= 3.201$

(d) p.f = .8 lagging

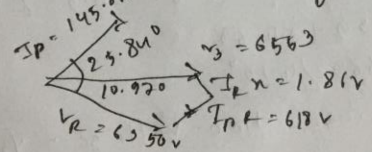


$I_R = 131.2A$

For unity p.f



for p.f = .9 leading



(14) $z = (.2 + j0.8) \times 250 = 206.1 \angle 75.96°$

$Y = 250 \times 5.3 \times 10^{-6} = 1.325 \times 10^{-3} \angle 90°$

$V_L = \sqrt{ZY} = \sqrt{206.1 \times 1.325 \times 10^{-3} \angle 165.96°}$

$= .5226 \angle 82.98°$

$= .0639 + j$

$= .5187$

(8) (9)

$$Z_c = \sqrt{Z/Y} = \sqrt{\frac{206.1\angle 75.96^\circ}{1.325\times10^{-3}\angle 90^\circ}}$$
$$= 394.\angle -7.02^\circ \Omega$$

$$I_R = 0$$

$$I_S = \left(\frac{V_3}{Z_c}\right)\frac{\sinh \gamma l}{\cosh \gamma l}$$

$$\beta l = .5187 \text{ rad} = 29.72^\circ$$

$$\varepsilon^{\alpha l}\varepsilon^{-j\beta l} = .8147 - j0.4651$$

$$\sinh \gamma l = \frac{1}{2}[.9258 - .8147 + j(.5285 + 4.651)]$$
$$= .499\angle 83.61^\circ$$

$$I_3 = \frac{220.00/\sqrt{3}}{394\angle .702} \times \frac{.499\angle 83.61^\circ}{8709\angle 2.086^\circ}$$
$$= 1.85\angle 88.54^\circ A$$

(15) $$V_R = \frac{220}{\sqrt{3}}$$
$$= 127 kV$$

$$I_R = \frac{80.000}{\sqrt{3}\times220} = 209.93A$$

$$V_S = 127.017(0.8703 + j0.0317) + 209.95 \times 3.94\angle -7.02^\circ \times .4999\angle 83.61^\circ$$

$$= 110.528 + j4.021 + 9.592 + j40.23$$
$$= 128.014\angle 20.23^\circ V$$

$$|V_S| = \sqrt{3} \times 128.04$$
$$= 221.7 \text{ kV}$$

$$I_S = 260.95\,(.8703 + j\,.0317) + \frac{127.000}{394\angle -7.02^\circ} \times .4009\angle 83.61^\circ$$
$$= 128.79 + j66.66 - 1.77 + j161.13$$
$$= 246.8\angle 42.84^\circ \text{ A}$$

$$P_S = \sqrt{3} \times 221.7 \times 246.8 \cos(20.3^\circ - 42.84^\circ)$$
$$= 87.486$$

$$I_R = 0$$

$$|V_R| = \frac{127,000}{.8709} = 145,826 \text{ V}$$

$$\% \text{ Reg} = \frac{145.8 - 127}{127}$$
$$= 14.8\,\%$$

(22) The diagram from problem (21) draw a new load line the fourth quardant at $\cos^{-1} 0.9$ with horizontal axis.

Here, power circles at radi

$|V_S|, |V_R| / |B| = 311, 327, 342, 358, 373$ and 380

And $|V_S| = 200, 210, 220, 230, 240$ and 250 kV.

For, p.f = 0.9 leading and $|V_S| = 202$ kV the vertical line through 40MW on the load line in the fourth quadrant. The vertical distance between the two lines at 40 MW represents the capacitor needed. The value is 38.6 kvar

p.f = 1.0 read $|V_s|$ = 214 kV at 40MW which is the horizontal axis. The vertical distance between the horizontal axis in the lead line. The value is 19.3 kvar

—x—