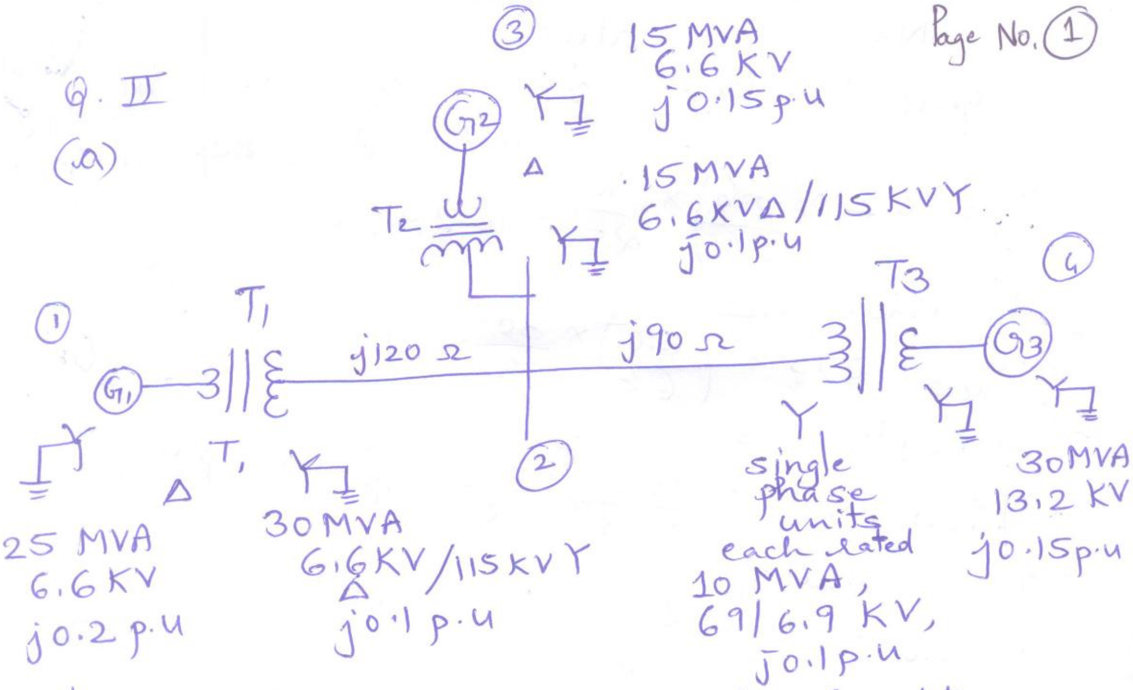
Q. II

(a)



New base
30 MVA, 6.6 KV in Generator G1 ckt.

Solution - Base power = 30 MVA.

Base voltages in 4 sections.

Section (1) Generator G1

Base volt. = 6.6 KV

section (2), ~~Generator G2~~ Transmission line

Base volt. = 115 KV

Section (3), Generator G2

Base volt. = 6.6 KV

Section (4). Generator G3

Transformer 3, 3-φ transformer 30 MVA,

line volt. ratio. $\sqrt{3} \times 69 / \sqrt{3} \times 6.9$

$119.508 / 11.9508$ KV.

Base volt. for section (4), $(x = ?)$

$$\frac{115}{x} = \frac{119.508}{11.9508} \qquad x = 11.5 \text{ KV}$$

(2)

New p.u. values.

(1) Generator G_1, $Z_{pu_{new}} = Z_{p.u_{old}} \times \left(\frac{\text{Base KV}_{old}}{\text{Base KV}_{new}}\right)^2 \times \frac{\text{Base MVA}_{new}}{\text{Base MVA}_{old}}$

$$X_{pu_{new}} = 0.2 \times \left(\frac{6.6}{6.6}\right)^2 \times \frac{30}{25} = j0.24 \text{ p.u.}$$

(2) Generator G_2

$$X_{pu_{new}} = 0.15 \times \left(\frac{6.6}{6.6}\right)^2 \times \frac{30}{15} = j0.3 \text{ p.u.}$$

(3) Generator G_3

$$X_{pu_{new}} = 0.15 \times \left(\frac{13.2}{11.5}\right)^2 \times \frac{30}{30} = j0.1976 \text{ p.u.}$$

(4) Transformer T_1

$$X_{pu_{new}} = 0.1 \times \left(\frac{6.6}{6.6}\right)^2 \times \frac{30}{30} = j0.1 \text{ p.u.}$$

(5) Transformer T_2

$$X_{pu_{new}} = 0.1 \times \left(\frac{6.6}{6.6}\right)^2 \times \frac{30}{15} = j0.2 \text{ p.u.}$$

(6) Transformer T_3

$$X_{pu_{new}} = 0.1 \times \left(\frac{119.508}{115}\right)^2 \times \frac{30}{30} = j0.1079 \text{ p.u.}$$

(7) Base impedance for transmission lines

$$Z_{base} = \frac{(\text{Base KV})^2}{\text{Base MVA}} = \frac{(115)^2}{30} = 440.83\,\Omega$$

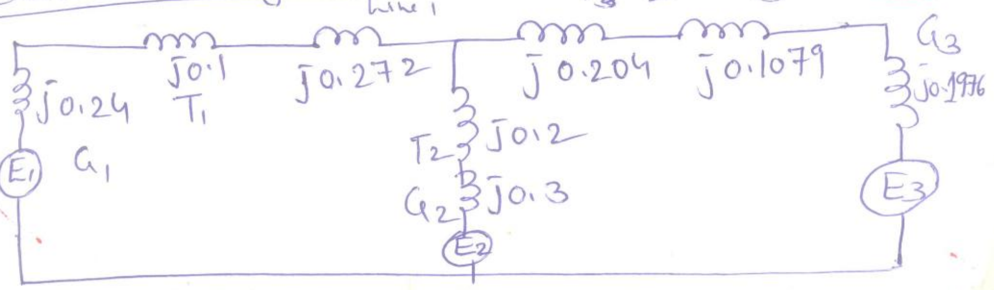
$$X_{pu_{line_1}} = \frac{j120}{440.83} = j0.272 \text{ p.u.}$$

$$X_{pu_{line_2}} = \frac{j90}{440.83} = j0.204 \text{ p.u.}$$

(06)

(02)

p.u. impedance diagram



Q. III (b) 3-ϕ, 66 KV, 50 Hz $R = 9.6\,\Omega$ per phase

$L = 0.097\,H$, $C = 0.765\,\mu F$ per phase

$P_r = 24\,MVA$, $V_r = 66\,KV$ (line) $\cos\phi_r = 0.8$ p.f. (lag)

$V.R^n = ?$ Nominal T(π) ckt.

$\eta = ?$ $I_r = \dfrac{24 \times 10^6}{(\sqrt{3} \times 66 \times 10^3)} = 209.95\angle -36.87^\circ$

(14.7%, 93.6%)

$X = 2\pi \times 50 \times 0.097$

$= 30.47\ \Omega/ph$

$Y = j\omega C = 2\pi \times 50 \times 0.765 \times 10^{-6}\angle 90^\circ$

$= 2.403 \times 10^{-4}\angle 90^\circ\ \mho/ph$

$Z = R + jX_L = 9.6 + j30.47$

$= 31.94\angle 72.51\ \Omega/ph$

$V_r = \dfrac{66 \times 10^3}{\sqrt{3}} = 38.105 \times 10^3 V$ (phase voltage)

$A = D = 1 + \dfrac{ZY}{2} = 1 + \dfrac{31.94\angle 72.51 \times 2.403 \times 10^{-4}\angle 90^\circ}{2}$ (05)

$= 0.996\angle 0.066^c$

$B = Z\left(1 + \dfrac{ZY}{4}\right) = 31.88\angle 72.54$ (03)

$C = Y = 2.403 \times 10^{-4}\angle 90^\circ$

$V_S = AV_r + BI_r = 0.996\angle 0.066 \times 38.105 \times 10^3\angle 0 + 31.88\angle 72.54 \times 209.95\angle -36.87^\circ$

$V_S = 43.57\,kV\angle 5.19$ $V_S(\text{line}) = \sqrt{3} \times 43.57\,kV = 75.47\,kV$

$I_S = CV_r + DI_r = 2.40 \times 10^{-4} \times 38.105 \times 10^3\angle 0 + 0.996\angle 0.066 \times 209.95\angle -36.87$

$= 203.76\angle -34.74^\circ$

$\cos\phi_S$ = Sending end p.f. $= \cos(5.19 + 34.74)$

$= 0.7669$

$V_{r(NL)} = \dfrac{|V_S|}{|A|} = \dfrac{75.47 \times 10^3}{0.996}$ (01)

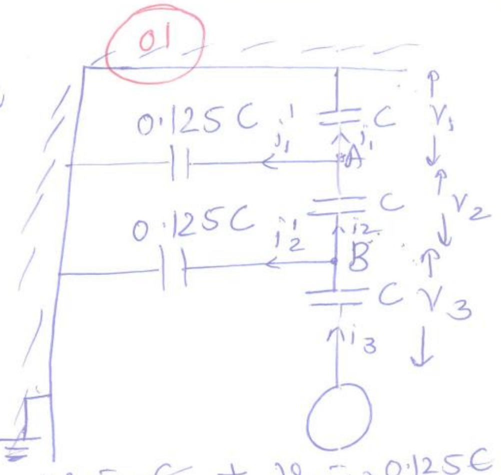
$= 75.77\,kV$

$\%V.R = \dfrac{V_{r(NL)} - V_{r(FL)}}{V_{r(FL)}} \times 100 = \dfrac{75.77 - 66}{66} \times 100 = 14.81\%$

Trans^n. $\eta = \dfrac{P_r \times \cos\phi_r}{\sqrt{3} V_S I_S \cos\phi_S} = \dfrac{24 \times 10^6 \times 0.8}{20.45 \times 10^6} \times 100 = 93.88\%$ (01)

Q. IV (b)

Consider a string insulator with 3 units.



Cap^n. from each jt. to the tower is 12.5% of cap^n. of each unit.

(01)

$K = 0.125$.

$V_3 = 11$ KV. (max^m value)

Applying KCL at 'A',

$i_2 = i_1 + i_1'$ $\therefore$ $V_2 j\omega C = V_1 j\omega C + V_1 j\omega 0.125C$

$V_2 = V_1 + 0.125 V_1 = 1.125 V_1$

Applying KCL at 'B',

$i_3 = i_2 + i_2'$ $\therefore$ $V_3 j\omega C = V_2 j\omega C + (V_1 + V_2) \times j\omega 0.125C$

$\therefore$ $V_3 = V_2 + (V_1 + V_2) 0.125$

$= V_2 + V_1 . 0.125 + V_2 . 0.125$

$= V_2 + V_1 0.125$ (05)

$= (1 + 0.125) V_2 + V_1 0.125 = (1.125)^2 V_1 + V_1 . 0.125$

$= 1.125 V_2 + V_1 . 0.125$

$= 1.265 V_1 + V_1 0.125$

$V_3 = 1.39 V_1$ $\therefore$ $V_1 = \frac{11 \text{ KV}}{1.39} = 7.913$ KV

Now, $V_3 = 11$ KV

$V_2 = 1.125 \times 7.913$

$= 8.902$ KV (02)

$\therefore$ Max^m volt. across the string for which it can be used $= V_1 + V_2 + V_3$

$= 7.913 + 8.902 + 11$

$= \underline{27.815 \text{ KV}}$ (phase volt.)

(01)

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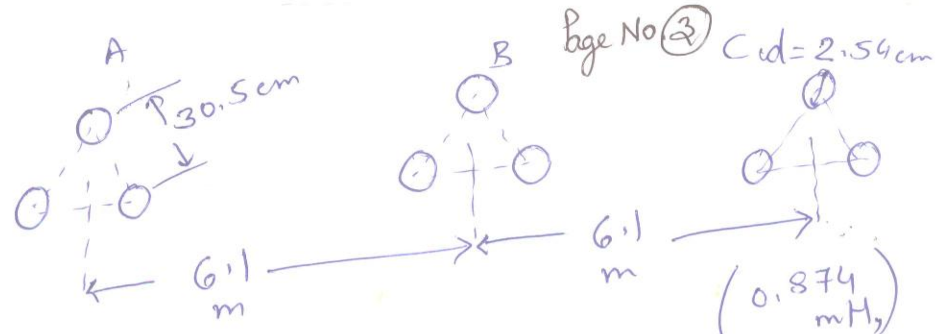
Q.(V)



02

(0.874 mH)

(0.01296 uF)

$L = 2\times10^{-7} \ln \frac{D_{eq}}{D_{sb}}$

* $D_{eq} = \sqrt[3]{D_{ab}\, D_{bc}\, D_{ca}}$

01 $= \sqrt[3]{6.1 \times 6.1 \times 12.2} = 7.685\ m$

$D_{sb} = \sqrt[9]{(r' \times 30.5 \times 30.5)^3} = \sqrt[3]{0.7788 \times 1.27 \times 30.5 \times 30.5}$

01 $= 9.726\ cm = 0.09726\ m$

$L/ph = 2\times10^{-7} \ln \frac{7.685}{9.726\times10^{-2}}$ H/m

02 $= 0.2 \times 4.3696 = 0.8739$ mH/km/phase

$C = \frac{2\pi\varepsilon_0}{\ln\left(\frac{D_{eq}}{D_{sb}}\right)}$ F/m $= \frac{2\pi \times 8.854\times10^{-12}}{\ln\left(\frac{7.685}{10.57\times10^{-2}}\right)}$ 02

$D_{sb} = \sqrt[3]{1.27 \times 30.5 \times 30.5}$

01 $= 10.57$ cm

$= \frac{55.6 \times 10^{-12+9}}{4.286}$ uF/km

$= 12.972 \times 10^{-3}$

$C/ph = 0.012972$ uF/km per phase

01 or find mutual GMD.

* Since the distance between the subconductors per phase is very less as compared to the distance between the adjacent phases.