Ques (1.)

$V = 11KV$

MVAR Rating = 1 MVAr

$Q_C = 1$ MVAr

$Q_L = 0.3$ MVAr

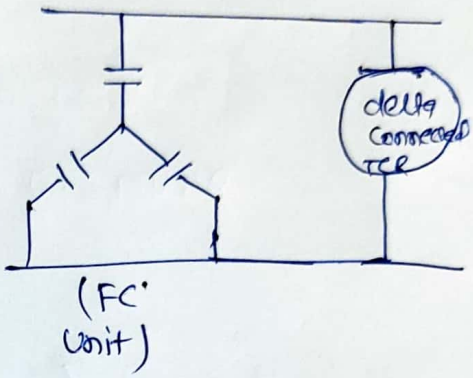
S.C. Capacity = 20 MVA @ 0 PF lagg.

(a.)

$$S = \frac{V^2}{Z}$$

$$Z = \frac{V^2}{S} = \frac{\left(\frac{11}{\sqrt{3}}\right)^2 * 10^6}{20 MVA}$$

$$Z = 2.0167\ \Omega$$



(FC Unit)

So; at 0 PF

$$X_L = Z = j2.0167\ \Omega$$

Now;

(a.)

$$\sqrt{3} V_L I_L = 1 MVAR$$

$$\sqrt{3} * 11 * 10^3 * I_L = 1 * 10^6$$

$$I_L = \frac{1 * 10^6}{\sqrt{3} * 11 * 10^3}$$

$$I_L = 52.4863\ A.$$

for delta connection

$$I_{ph} = \left(\frac{I_L}{\sqrt{3}}\right) = 30.303\ A.$$

So; $$X_{Cph} = \left(\frac{V_{ph}}{I_{ph}}\right) = \frac{11 * 10^3}{30.303}$$

(∵ delta connection ∴ $V_{ph} = V_L$)

$$\boxed{X_{Cph} = 363\ \Omega}$$

For TCR unit

$$Q_L = 0.3 \text{ MVAR}$$

$$\sqrt{3} V_L I_L = 0.3 \text{ MVAR}$$

$$I_L = \frac{0.3 * 10^6}{\sqrt{3} * 11 * 10^3}$$

$$I_L = 15.746 \text{ A} \Rightarrow I_{ph} = \left(\frac{15.746}{\sqrt{3}}\right) = 13.31 \text{ A}$$

So;

$$(X_L)_{ph} = \frac{V_{ph}}{(I_L)_{ph}}$$

$$= \frac{11 * 10^3}{13.31}$$

$$(X_L)_{ph} = 1210 \Omega$$

(b.) Let $(V)_{Base} = 11 \text{ KV}$

$$(S)_{Base} = 10 \text{ MVA}$$

$\therefore$ S.C. Capacity $= \left(\frac{20}{10}\right) = 2 \text{ PU}$

$$X = \frac{1}{\text{S.C. Capacity}}$$

$$X = 0.5 \text{ P.U}$$

$$\Delta V_L = 11 \text{ KV} - 11.4 \text{ KV}$$

$$= -0.4 \text{ KV}$$

$$= \frac{-0.4 * 10^3}{11 * 10^3} = -0.0364 \text{ PU.}$$

$$\Delta V_L = Q_L(V * X)$$

$$Q_{\text{①}} = \frac{\Delta V_L}{(V * X)}$$

$$Q_{\text{①}} = \frac{-0.0864}{1.04 * 0.5}$$

$$= -0.07 \text{ PU}$$

$Q \rightarrow -ve \Rightarrow$ (inductive)

$$V = \left(\frac{11.4}{11}\right) = 1.04$$

$$\simeq 1.0367$$

$$Q_L = (0.07) * 10$$

$$= 0.7 \text{ MVAR}.$$

max^m inductive compensation is = 0.3 MVAR

∴ max^m inductive/Reactive power drawn by the load = (0.7 - 0.3)

= 0.4 MVAR

~~So; Range of Reactive power ⇒ 1 MVAR Cap. to 0.4 MVAR inductive~~.

(c.) for V = 11 KV

Range of Reactive Power drawn by load ⇒ 1 MVAR Cap. to 0.3 MVAR inductive.

(d.) $\Delta V = 11 - 10.4$

$$= \left(\frac{0.6}{11}\right) = 0.0545 \text{ PU}$$

$$V_{PU} = \frac{10.4}{11}$$

$$= 0.945 \text{ PU}$$

$$Q_C = \frac{0.0545}{0.945 * 0.5}$$

$$= 1.153 \text{ MVAR}$$

max^m compensation available = 1 MVAR

∴ load should draw 0.153 MVAR Capacitive Reactive Power.

(e) $V_{oc} = 10.8$ KV

1 mVA load
PF = 0.8 lagg.

Bus voltage maintained at 11 KV.

$$\Delta V = \left(\frac{0.2}{11}\right) = 0.0182 \text{ PU} \qquad V_{bus} = \left(\frac{10.8}{11}\right) = 0.9818$$

$$Q_c = \frac{0.0182}{0.9818 * 0.5} = 0.0371 \text{ PU}$$

$$Q_c = 0.371 \text{ mVAR}.$$

inductive Reactive power req. $= 1 - 0.371 = 0.629$ mVAR

Reactive power drawn by load $= 1 * \{\sin(\cos^{-1}(0.8))\}$

$= 0.6$ mVAR

$\therefore$ Inductive power drawn by TCR $= 0.6 - 0.629$

$= 0.029$ mVAR

$= 0.0029$ PU

$$\therefore \quad 0.0029 = 0.0371\left(1 - \frac{2}{\pi}\alpha - \frac{1}{\pi}\sin 2\alpha\right)$$

$$\frac{2}{\pi}\alpha + \frac{1}{\pi}\sin 2\alpha = 0.9218$$

α —— ?

Ques ② Given : 11kV, 3-Φ TSC-TCR unit

Capacity = 1 MVAR (for 4 units)

∴ Capacity of one TSC unit

= 0.25 MVAR

for 5th harmonic compensation,
inductive Reactance used = 4%.

∴ Net capacitive power = (1-0.04) * 0.25

= 0.24 MVAR.

for TSC

$\sqrt{3} V_L I_L = 0.24$

$(I_L) = 12.6\ A$

$(I_L)_{ph} = 7.273\ A$

$X_C = \left(\frac{11\ KV}{7.273}\right) = 1512.44\ \Omega$

For TCR

inductive power = 0.3 MVAR

$\sqrt{3} V_L I_L = 0.3$ MVAR

$(I_L) = \frac{0.3 * 10^6}{\sqrt{3} * 11 * 10^3} = 15.746\ A$

$(I_L)_{ph} = 9.091\ A$

$X_L = \frac{11 * 10^3}{9.091} = 1210\ \Omega.$