EE 491 Homework 1

1.1 $v = 141.4\sin(\omega t + 30)$, $i = 11.31\cos(\omega t - 30)$

a) Maximum Value

$$\begin{cases} v_{max} = 141.4\ V \\ i_{max} = 11.31\ A \end{cases}$$

b) RMS values

$$\begin{cases} v_{rms} = \dfrac{141.4}{\sqrt{2}} = 100\ V \\ i_{rms} = \dfrac{11.31}{\sqrt{2}} = 8\ A \end{cases}$$

c) $v = 141.4\sin(\omega t + 30)$

$= 141.4\cos(\omega t + 30 - 90)$

if voltage is reference: $V = 100\angle 0 = 100 + j0\ V$

$I = 8\angle(-30 + 60)$

$= 8\angle +30^\circ = 6.93 + j4$

current leads the voltage $\Rightarrow$ capacitive

(1.4)

$R = 10\cos 60 = 5\ \Omega$

$X = 10\sin 60 = 8.66\ \Omega$

$I = \frac{240}{10\angle 60} = 24\angle -60^\circ$

$P = RI_1^2 = 5 \times 24^2 = 2880\ W$

$Q = XI_1^2 = 8.66 \times 24^2 = 4988\ VAr$

$P.f. = \cos\left(\tan^{-1}\frac{Q}{P}\right) = 0.5$

(1.10)

$S = EI^* = (-120\angle 210)(10\angle -60)$

$= -1200\angle 150^\circ = 1200\angle -30^\circ$

$= \underbrace{1039}_{P} \underbrace{-j600}_{Q}$

P → delivered

Q → received

(1.16)

$|I| = \frac{15 \times 746}{\sqrt{3} \times 460 \times 0.9 \times 0.8} = 20.39\ A$

$P = \sqrt{3} \times 460 \times 20.39 \times 0.8 = 12,431\ W$ drawn from line

$Q = \sqrt{3} \times 460 \times 20.39 \times 0.6 = 9,324\ VAr$ drawn from line

1.19

Load: $S_1 = 250 \angle \cos^{-1}(0.707) = 250 + j250$ kVA

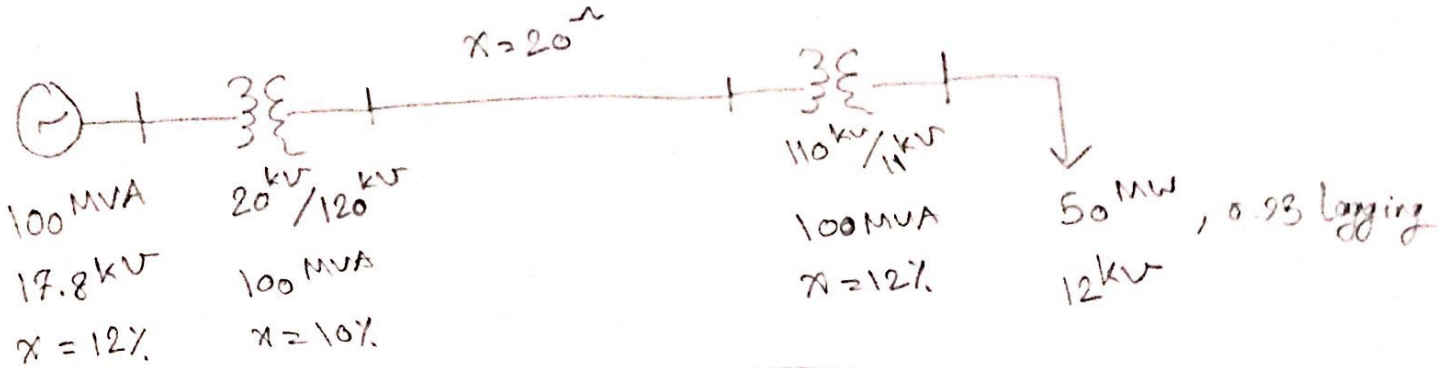
capacitor bank: $S_2 = 60 \angle -90^\circ = -j60$ kVA

$$S_1 + S_2 = 250 + j190 = 314 \angle 37^\circ$$

$$|\bar{I}| = \frac{314}{\sqrt{3} \times 440} = 412 \text{ A}$$

$$P.f. = \cos 37^\circ = 0.796 \text{ Lagging}$$

(2)



$S_{base} = 100\ MVA$

$V_{base_{Gen}} = 17.8\ kV \Rightarrow V_{base_{line}} = 17.8 \times \left(\frac{120}{20}\right) = 106.8\ kV$

$\Rightarrow V_{base_{Load}} = 106.8\ kV \times \left(\frac{11}{110}\right) = 10.68\ kV$

We know: $Z_{pu}^{new} = Z_{pu}^{old} \times \frac{S_{base}^{new}}{S_{base}^{old}} \times \left(\frac{V_{base}^{old}}{V_{base}^{new}}\right)^2$

$X_G = 0.12\ pu$ (no change)

$X_{T_1} = 0.1 \times \frac{100\ MVA}{100\ MVA} \times \left(\frac{20\ kV}{17.8\ kV}\right)^2 = 0.1263\ pu$

$Z_{base_{line}} = \frac{V_{base_{line}}^2}{S_{base}} = \frac{(106.8\ kV)^2}{100\ MVA} = 114.0624\ \Omega$

$X_{line} = \frac{20}{114.0624} = 0.1753\ pu$

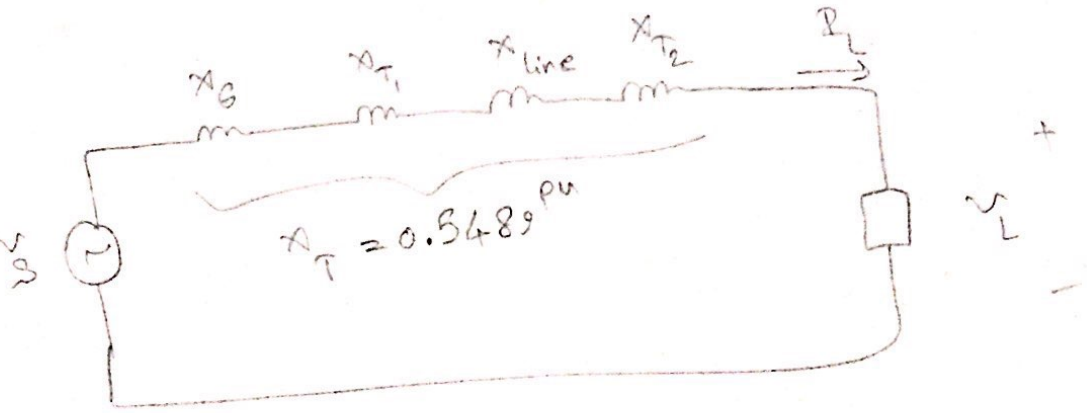
$X_{T_2} = 0.12 \times \frac{100\ MVA}{100\ MVA} \times \left(\frac{110\ kV}{106.8\ kV}\right)^2 = 0.1273\ pu$

Load: $|V_L| = \frac{12^{kv}}{10.68^{kv}} = 1.1236^{kv}$

$P_L = \frac{80^{MW}}{100^{MW}} = 0.8\,pu = |V_L||I_L|\cos\varphi$

$\Rightarrow |I_L| = \frac{0.8}{1.1236 \times 0.98} = 0.4684^{pu}$

$$\begin{cases} V_L = 1.1236 \angle 0 \\ I_L = 0.4684 \angle -\cos^{-1}(0.98) \end{cases}$$



$V_S = V_L + I_L \times j X_T$

$= 1.1236 + (0.4684 \angle -\cos^{-1}(0.98))(0.5489 \angle 90^\circ)$

$= 1.2039 + j0.2443 = 1.2284 \angle 11.47^\circ$

$|V_S| = 1.2284 \times 17.8^{kv} = 21.87^{kv}$