EEE 554 Assignment 3.

Question 1

a.) Contingency planning is the planning of a system outcome other than in the usual plan of the system.

b.) 4 Methods of voltage Control

i) Shunt reactors

ii) Shunt capacitors

iii) Static VAR systems.

iv) Synchronous phase modifiers.

c.) Steady state stability limit is the maximum power that can be transmitted through a system without loss of synchronous stability.

d.) 2 methods of ~~increasing~~ improving transient stability limit of power system are;

i) Increasing system voltage.

ii) Reduction of transfer reactance.

e) i) Prefault operation

$$X_I = j\left[0.28 + \frac{0.16 + 0.24 + 0.16}{2} + 0.16\right]$$

$$= 0.72 \text{ pu.}$$

$$P_{EI} = \frac{|E| \cdot V}{X_I} \sin \delta_0 = \frac{1.25 \times 1}{0.72} \sin \delta_0$$

$$= 1.736 \sin \delta_0$$

$$1 = 1.736 \sin \delta_0$$

$$\delta_0 = \sin^{-1}\left(\frac{1}{1.736}\right) = 35.2^\circ$$

$$\simeq 0.62 \text{ rad.}$$

ii) During fault

Since fault occurs at one end of the transmission line

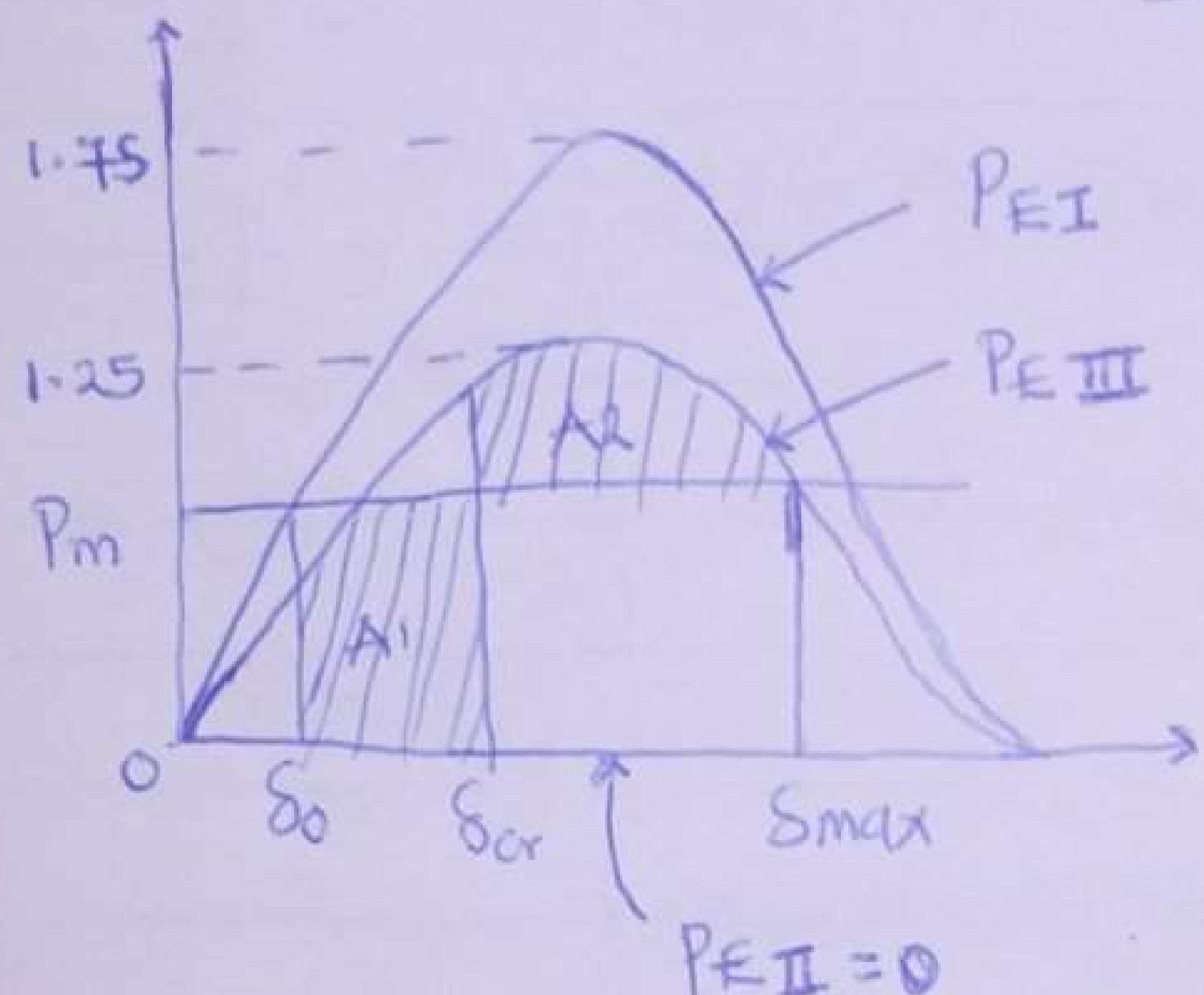
$$P_{EII} = 0$$

iii) Post fault

$$X_{III} = 0.28 + 0.16 + 0.24 + 0.16 + 0.16$$
$$= 1.0 \text{ pu}$$

$$P_{E III} = \frac{1.25 \times 1}{1} \sin \delta_0 = 1.25 \sin \delta_0$$

$$1 = 1.25 \sin \delta_0$$
$$\delta_0 = \sin^{-1}\left(\frac{1}{1.25}\right) = 53.1^\circ$$
$$\simeq 0.927 \text{ rad.}$$



δ_{max} for $A_1 = A_2$ is given by

$$\delta_{max} = \pi - \delta_0 = \pi - 0.927 = 2.21 \text{ rad}$$

$$A_1 = P_m(\delta_{cr} - \delta_0) = 1(\delta_{cr} - 0.62)$$
$$= \delta_{cr} - 0.62$$

$$A_2 = \int_{\delta_{cr}}^{\delta_{max}} (P_{E\,III} - P_m)\, d\delta$$

$$= \int_{\delta_{cr}}^{\delta_{max}} (1.25 \sin\delta - 1)\, d\delta$$

$$= \int_{\delta_{cr}}^{\delta_{max}} (1.25 \sin\delta)\, d\delta - \int_{\delta_{cr}}^{\delta_{max}} 1\, d\delta$$

$$= 1.25 \left[-\cos\delta\right]_{\delta_{cr}}^{\delta_{max}} - \left[\delta\right]_{\delta_{cr}}^{\delta_{max}}$$

$$= -1.25 \cos(\delta_{max} - \delta_{cr}) - (\delta_{max} - \delta_{cr})$$

$$= -1.25 \cos\delta_{max} + 1.25 \cos\delta_{cr} - \delta_{max} + \delta_{cr}$$

$$= -1.25 \cos(2.21) + 1.25 \cos\delta_{cr} - 2.21 + \delta_{cr}$$

$= 0.7457 + 1.25\cos\delta_{cr} - 2.21 + \delta_{cr}$

$A_2 = 1.25\cos\delta_{cr} + \delta_{cr} - 1.464$

$A_1 = A_2$

$\delta_{cr} - 0.62 = 1.25\cos\delta_{cr} + \delta_{cr} - 1.464$

$$\cos\delta_{cr} = \frac{1.464 - 0.62}{1.25} = 0.6752$$

$$\delta_{cr} = \cos^{-1}(0.6752) = 47.53^{0}$$

$\simeq 0.8296$ rad.

Question 2.

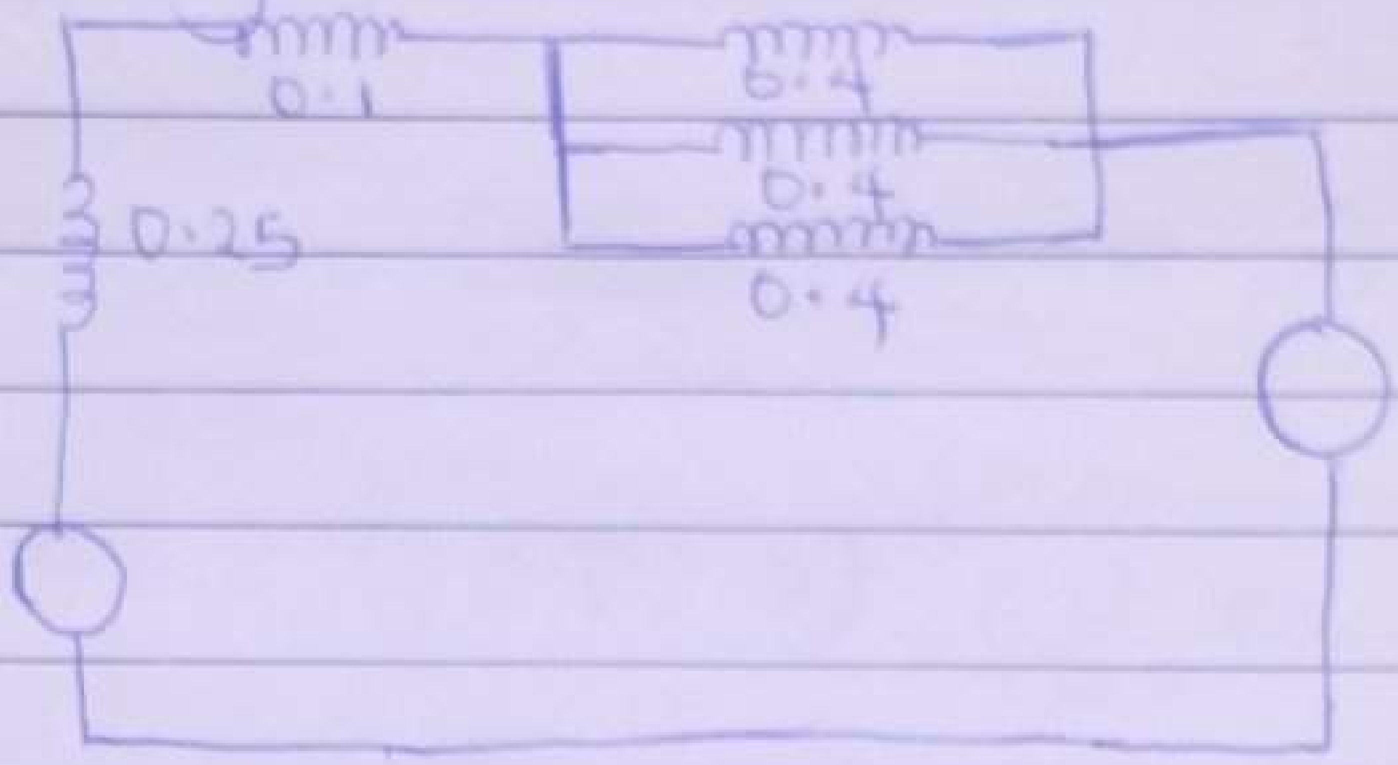
a) Classifications of power System stability are;

i) Steady state Stability.

ii) Dynamic Stability.

iii) Transient stability.

b) Drawing the close circuit diagram



i) $V_t = |V_t| \angle \alpha = 1 \angle \alpha$

$$P_E = \frac{|V_t||V|}{X} \sin \alpha$$

$$1 = \frac{1 \times 1}{(0.25 + 0.1)} \sin \alpha$$

$\sin \alpha = 0.35$

$\alpha = \sin^{-1} 0.35$

$\alpha = 20.5^\circ$

Current going into the infinite bus.

$$I = \frac{|V_t| \angle \alpha - |V| \angle 0}{X}$$

$$= \frac{1 \angle 20.5^\circ - 1 \angle 0^\circ}{j\,0.35}$$

recall that

$$A \angle \theta = A(\cos\theta + j\sin\theta)$$

$$\therefore I = \frac{1(\cos 20.5 + j\sin 20.5) - 1}{j0.35}$$

$$= 1.016 \angle 10.21^\circ$$

EMF behind transient X

$$E' = |V| \angle 0 + IX$$

$$X = 0.25 + 0.1 + \frac{0.4}{3} = j0.483$$

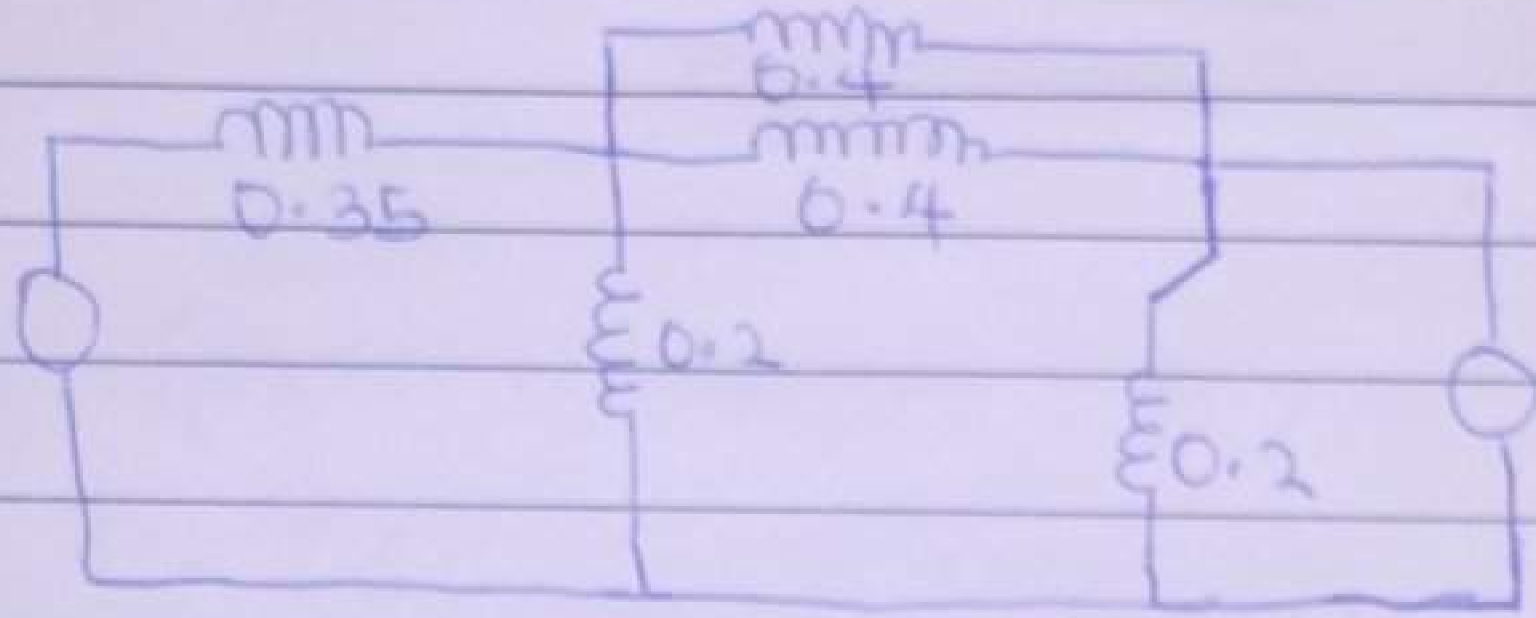
$$E' = 1 \angle 0 + j0.483(1 + j0.18)$$

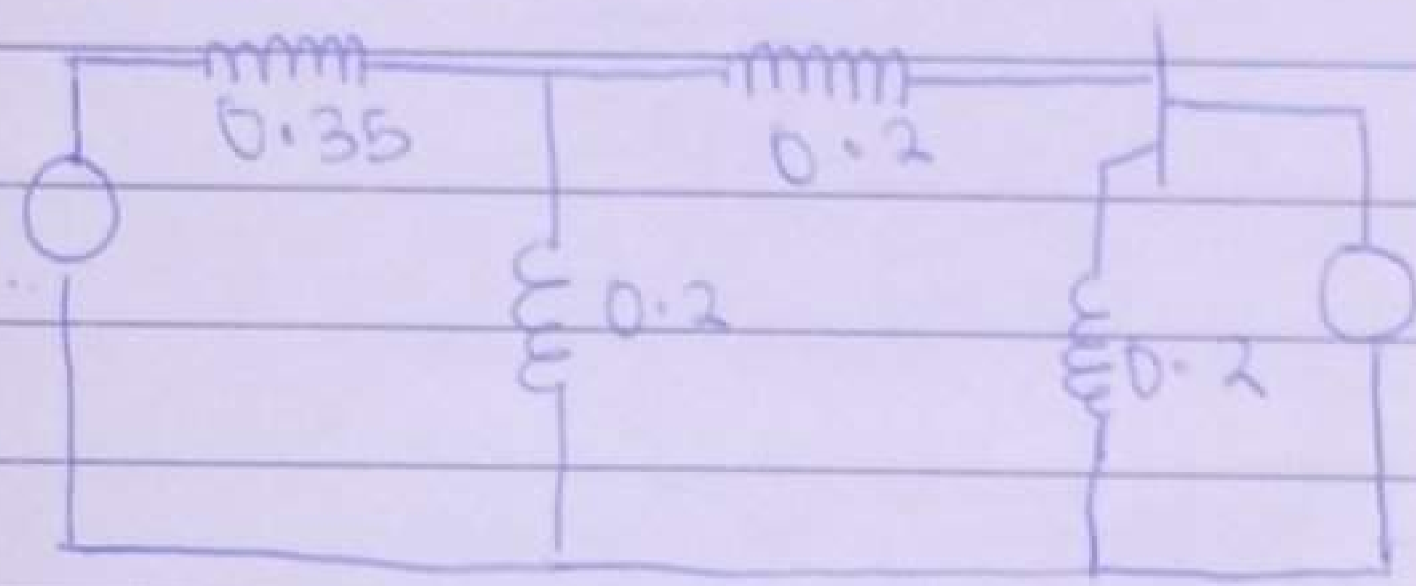
$$= 1 - 0.08694 + j0.483$$

$$= 0.9131 + j0.483$$

$= 1.033 \angle 27.85^\circ$

ii) When one line is shorted.

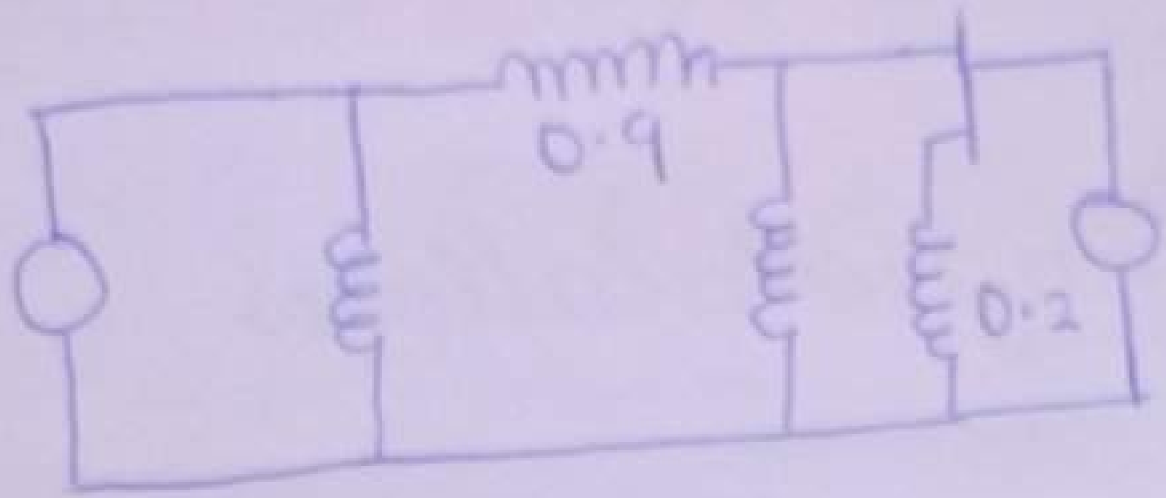




Using star-delta conversion.

$$X = \frac{0.35 \times 0.2 + 0.2 \times 0.2 + 0.35 \times 0.2}{0.2}$$

$= 0.9$



$$P_{max} = \frac{|E| \cdot V}{X} = \frac{1.033 \times 1}{0.9}$$

$P_{max} = 1.148$ Pu