EEE 554 Assignment 3 (1)

Q.1

(a) Contigency planning involves the itemisation of actions to be taken to bring into balance supply-demand equation.

(b) (i) Excitation Control

(ii) Regulating transformers

(iii) Line Reactance Compensators

(iv) Reactive power sinks or sources.

(c) Steady state stability limit is the maximum power that can be transmitted to the receiving end without loss of synchronism

(d) (i) Increase in system voltage

(ii) Reduction in transfer Reactance.

(e) (i) Prefault operation

$$X_I = j\left[0.28 + \frac{0.16 + 0.24 + 0.16}{2} + 0.16\right] = 0.72 \text{ pu}$$

$$P_{eI} = \frac{|E| \cdot V}{X_I} \sin\delta = \frac{1.25 \times 1}{0.72} \sin\delta = 1.736 \sin\delta$$

$$1 = 1.736 \sin\delta_0$$

$$\delta_0 = \sin^{-1}\left(\frac{1}{1.736}\right) = 35.2^\circ \cong 0.62 \text{ rad}$$

(ii) During fault: since fault occurs at one end of the line

$P_{eII} = 0$

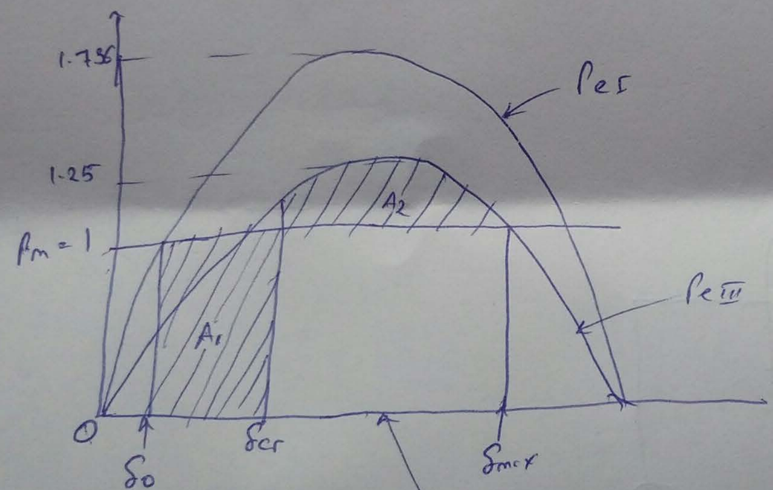
(iii) Post fault

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

$P_{eIII} = \frac{1.25 \times 1}{1} \sin\delta = 1.25 \sin\delta$

$1 = 1.25 \sin\delta_0$

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



max δ_{max} for $A_1 = A_2$ is given by

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

$P_m = P_{max} \sin\delta_0$

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

$A_1 = \delta_{cr} - 0.62$

$A_2 = \int_{\delta_{cr}}^{\delta_{max}} (P_{eIII} - P_m)\, d\delta = \int_{\delta_{cr}}^{\delta_{max}} (1.25 \sin\delta - 1)\, d\delta = \int_{\delta_{cr}}^{\delta_{max}} 1.25 \sin\delta\, d\delta - \int_{\delta_{cr}}^{\delta_{max}} 1\, d\delta$

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

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

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

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

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

$A_1 = A_2$

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

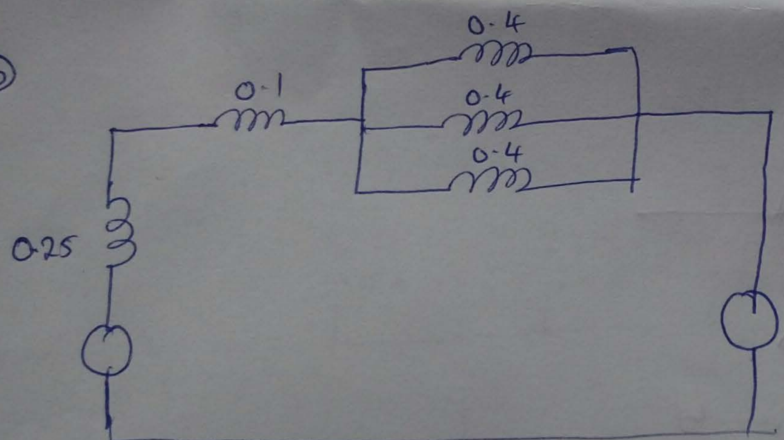
$\cos \delta_{cr} = \frac{0.844}{1.25}$ $\therefore$ $\delta_{cr} = \cos^{-1}\left(\frac{0.844}{1.25}\right) = 0.8296$ rad

or $\delta_{cr} = 47.53^\circ$

Q.2

(a) (i) Steady state
(ii) Dynamic
(iii) Transient

(b)



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

$P_e = \frac{|V_t|\,|V|}{X} \sin \alpha$ $\therefore$ $1 = \frac{1 \times 1}{(0.25 + 0.1)} \sin \alpha$

$\sin \alpha = 0.35$ $\quad \alpha = \sin^{-1} 0.35 = 20.5^\circ$

Current into infinite bus

$I = \frac{|V_t|\angle \alpha - |V|\angle 0}{X} = \frac{1\angle 20.5 - 1\angle 0}{j0.35}$

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

$$I = \frac{1[\cos 20.5 + j\sin 20.5] - 1}{j0.35} = \frac{-0.0633 + j0.350}{j0.35} = 1 + j0.18$$

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

EMF behind transient X

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

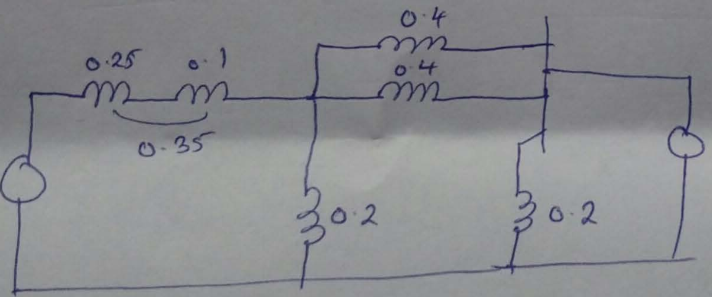
$$X = 0.25 + 0.1 + \frac{0.4}{3} = j0.483$$

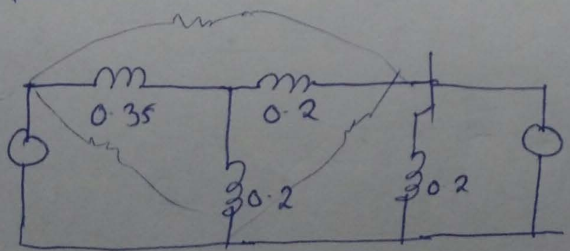
$E' = 1\angle 0 + j0.483(1 + j0.18)$

$= 1 - 0.08694 + j0.483 = 0.9131 + j0.483$

$= 1.033\angle 27.88^\circ$

(ii) when one line is shorted





Using star-delta

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

$$= 0.9$$

$$P_e = \frac{|E|.V}{X}\sin\delta = \frac{1.033\times 1}{0.9}\sin\delta = 1.148\sin\delta$$

$P_{max} = 1.148$ pu.