Assignment

(a) Contingency planning involves the itemization of actions to be taken to bring into balance supply - demand equation

(b) → Line resistance Compensation
→ Regulating transformers
→ Excitation Controls
→ Reactive power sink or Source

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

(d) → Reduction in transfer reactance
→ Increase in System Voltage

(e) Prefault Operation

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

$$P_{ex} = \frac{|E| \cdot V}{X_T} \sin\delta$$

$$= \frac{1.25 \times 1}{0.72} \sin\delta = 1.726 \sin\delta$$

$$I = 1.736 \sin\delta$$

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

$\simeq 0.62 \text{ rad}$

(ii) During fault.

$P_{eII} = 0$

Since the fault occurs at one end of the line

(iii) Post fault

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

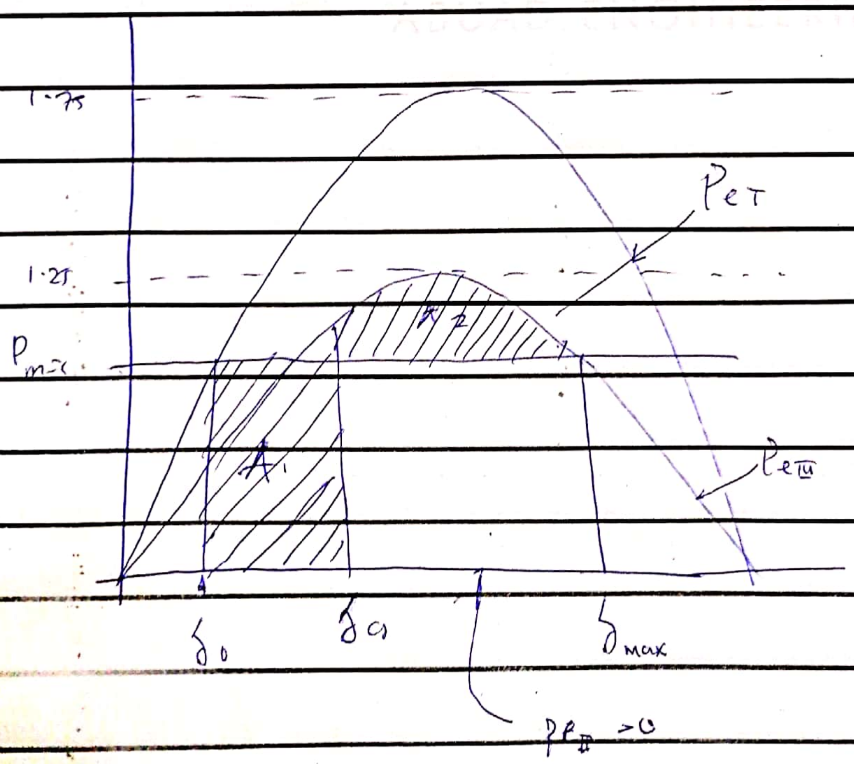
$= 1.0 pu$

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

$1 = 1.25 \sin\delta_0$

$\delta_0 = \sin^{-1}(1/1.25)$

$= 0.927 \text{ rad}$



δ_{max} for $A_1 = A_2$ is given by

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

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

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

$$A_1 = \delta_{cr} - 0.62$$

$$A_2 = \int_{\delta_{cm}}^{\delta_{max}} (P_{eIII} - P_m)\, d\delta$$

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

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

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

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

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

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

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

$$A_1 = A_2$$

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

$$\cos \delta_{cr} = \frac{0.8844}{1.2}$$

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

$$= 0.8296 \text{ rad}$$

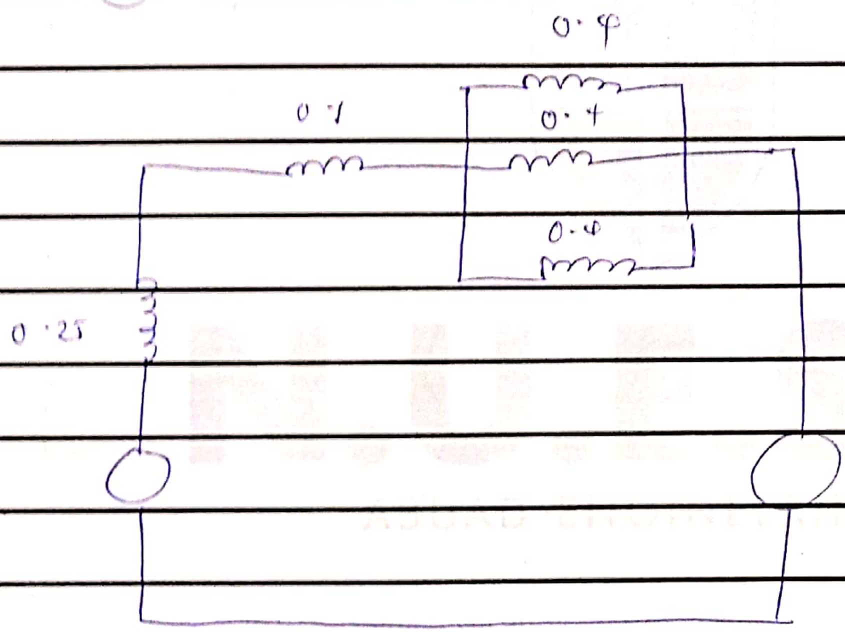
$$= 47.38^{\circ}$$

(2) (i) Steady State

(ii) Dynamic

(iii) Transient

(5)



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

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

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

$\sin \alpha = 0.35$

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

$\alpha = 20.5^\circ$

Current flow in to infinite bus

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

$$= \frac{1 \angle 20.5 - 1 \angle 0}{j0.35}$$

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

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

$$= \frac{-0.0633 + j0.352}{j0.35} = 1 + j0.18$$

$$= 1.016 \angle 10.20^\circ$$

EMF behind transient X

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

$X = 0.25 + 0.1 + 0.4/2 = j0.483$

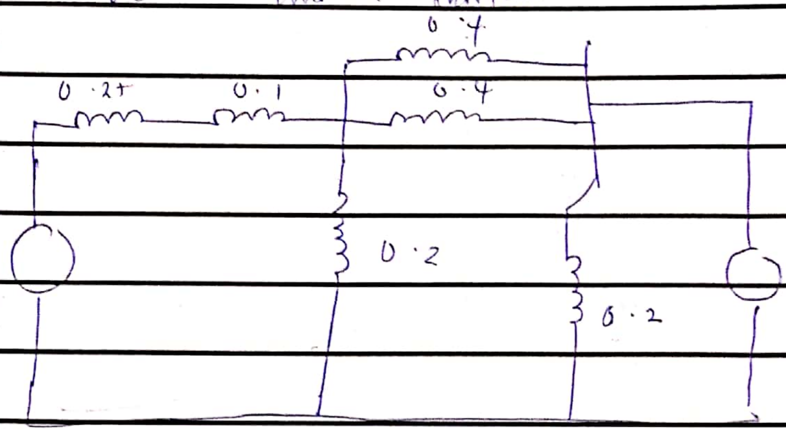
$E' = 1 \angle 0 + j0.483(1 + j0.18)$

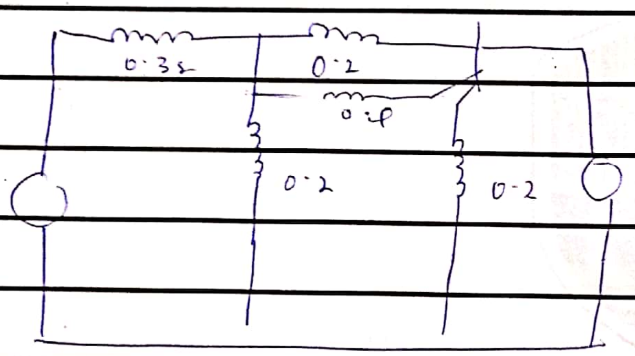
$= 1 - 0.08694 + j0.483)$

$= 0.9131 + j0.483$

$= 1.033 \angle 27.88^\circ$

(ii) When line is shorted





Using star – delta ($Y - \Delta$)

$$X = \frac{0.35 \times 0.2 + 0.2 \times 0.4 + 0.35 \times 0.2}{0.2}$$

$$= 0.9$$

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

$$= 1.148 \sin\delta$$

$$P_{max} = 1.148 \text{ PU}$$