Power Systems Assignment 2

Question 1

(a) Contingency Planning: This simply means the listing of actions to be carried out to balance the supply - demand equation.

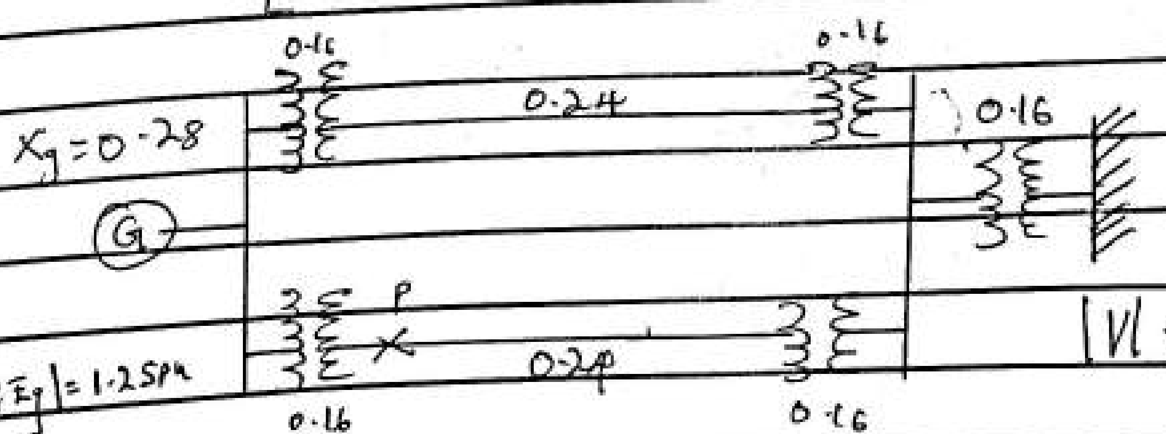
(b) 4 methods of voltage control
(i) Tap changing transformers
(ii) Shunt Capacitors
(iii) Series Capacitor
(iv) Shunt Reactors

(c) Steady state stability limits of a power system is the maximum power that can be transmitted to the recieving and without loss of synchronism.

(d) (i) System Voltage increase
(ii) Transfer Reactance Reduction.

(e) i Prefault Operation

$$X_1 = j\left[0.28 + \frac{0.16 + 0.24 + 0.16}{2} + 0.16\right] = 0.72\,pu$$



$$P_{eI} = \frac{|E| \cdot V}{X_I} \sin\delta$$

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

$P_{eI} = 1.736 \sin\delta$

$1 = 1.736 \sin\delta$

$\delta = \sin^{-1}(1/1.736)$

$\delta = 35.2° \approx 0.61 \text{ rad}$

(ii) During fault

Due to position of fault.

$P_{eII} = 0$

iii Post fault

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

$X_{III} = 1.0 \text{ pu.}$

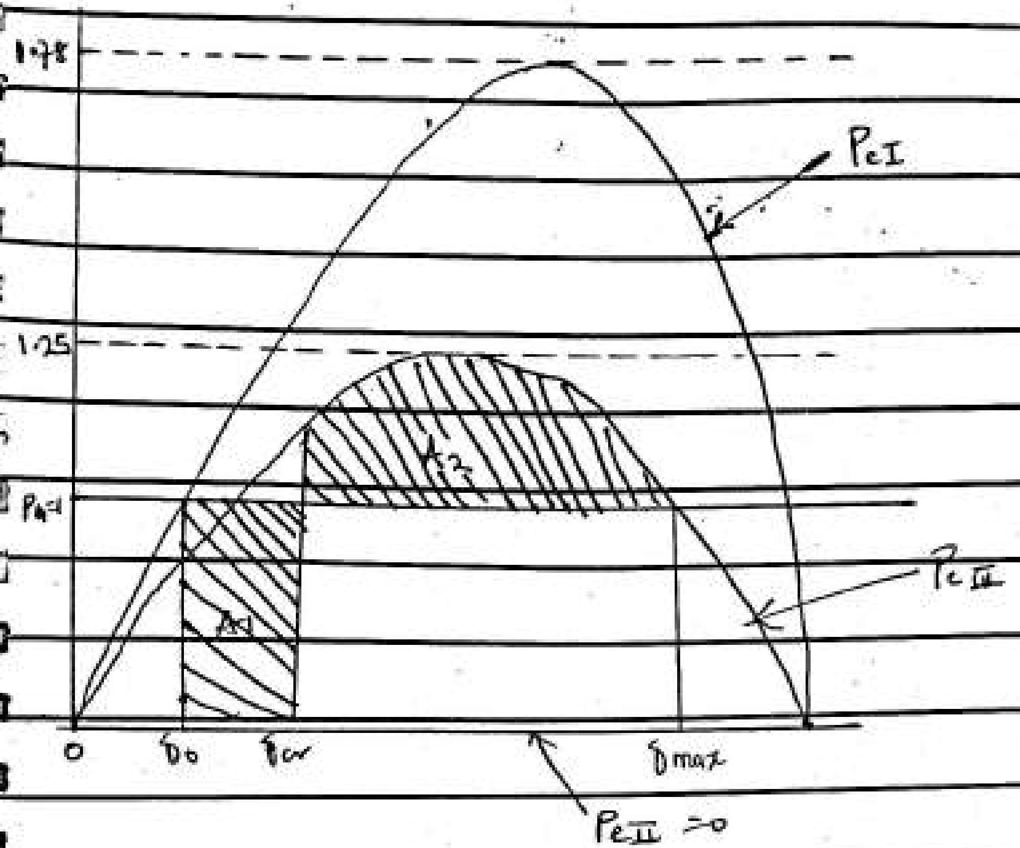
$$P_{eIII} = \frac{1.25 \times 1}{1} \sin\delta = 1.25 \sin\delta$$

~~$1 = \sin\delta\cdot 1$~~ $1 = 1.25 \sin\delta$

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

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

$\delta = 53.1° \approx 0.927 \text{ rad.}$



δ_{max} for A_1 & A_2 $= \pi - \delta_0$

$= \pi - 0.927 = 2.21\,rad$

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

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

$\Rightarrow 1(\delta_{cr} - \delta_0)$

$\Rightarrow 1(\delta_{cr} - 0.61)$

$A_1 \Rightarrow \delta_{cr} - 0.61$

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

$\Rightarrow \int_{\delta_{cr}}^{\delta_{max}} 1.25\sin\delta\, d\delta$

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

$\Rightarrow [-1.25\cos\delta] - [\delta]_{\delta_0}^{\delta_{max}}$

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

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

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

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

$A_1 = A_2$

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

$\cos\delta_{cr} = \dfrac{0.844}{1.25}$

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

$\delta_{cr} = 0.8296$ rad.

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

Question 2

(a) (i) Dynamic

(ii) Transient

(iii) Steady-state

(b)

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

$P_e = \dfrac{|V_t|\,|V|\sin\alpha}{X} \equiv 1 = \dfrac{1 \times 1 \sin\alpha}{(0.25+1)}$

Q2

$\sin\alpha = 0.35$

$\alpha = \sin^{-1} 0.35 = 20.5°$

Current going into infinite bus

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

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

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

$= 1.016\angle 10.21°$

Emf behind transient X.

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

$X = 0.25 + 0.1 + 0.4/3 = j0.483$

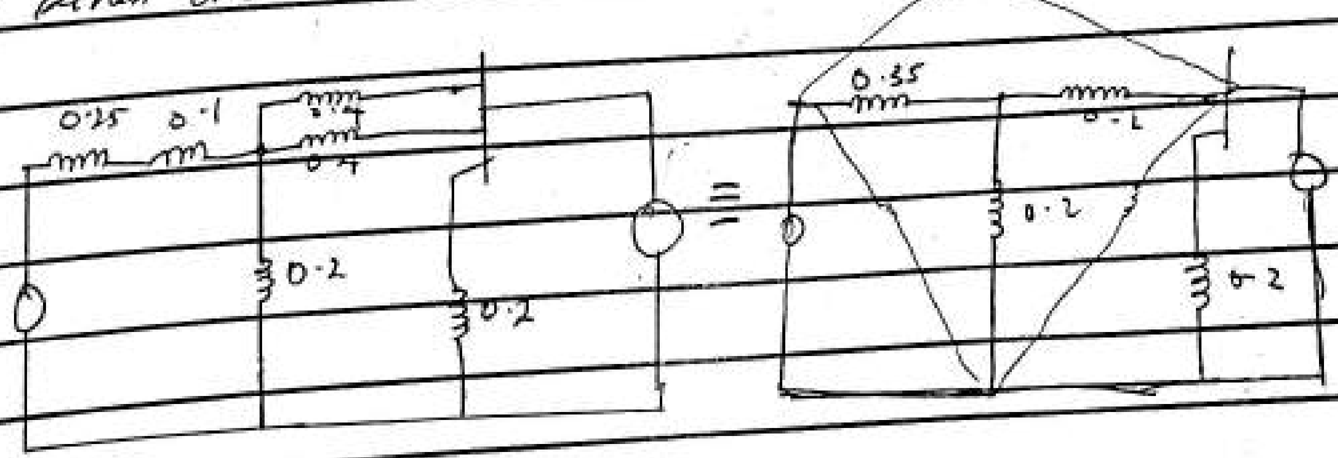
$E' = 1\angle 0 + j0.483(1 + j0.18)$

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

$= 0.9131 + j0.483$

$= 1.033\angle 27.58°$

(ii) When one line is shorted.



from Y − Δ

$$X = \frac{0.35 \times 0.2 + 0.35 \times 0.2 + 0.2 \times 0.2}{0.2} = 0.9$$

$P_e = |E||V|$

$$P_e = \frac{|E| V \sin\delta}{X}$$

$$P_e = \frac{1.033 \times 1 \sin\delta}{0.9} = 1.148 \sin\delta$$

$P_{max} = 1.148$ Pu