Q1

a- Contingency planning in power system is a form of analysis which evaluates the impact of faults or outages in a power system. It allows operators to be prepared for an outage using the pre-planned recovery scenario.

b- Voltage regulation Methods
i- Shunt Reactors
ii- Shunt Capacitors.
iii- Use of On-load / Off-load Transformers.
iv- Line Reactance Compensators.

c- Steady state limit is the maximum power that can be transmitted to the receiving end without loss of synchronism.

d- i- Use of bundled Conductors
ii- Increase system voltage.
iii- Operating lines in Parallel

Q2

a- Classification of Power System Stability

i- Steady-State Stability

ii- Transient-State Stability

iii- Dynamic-State Stability.

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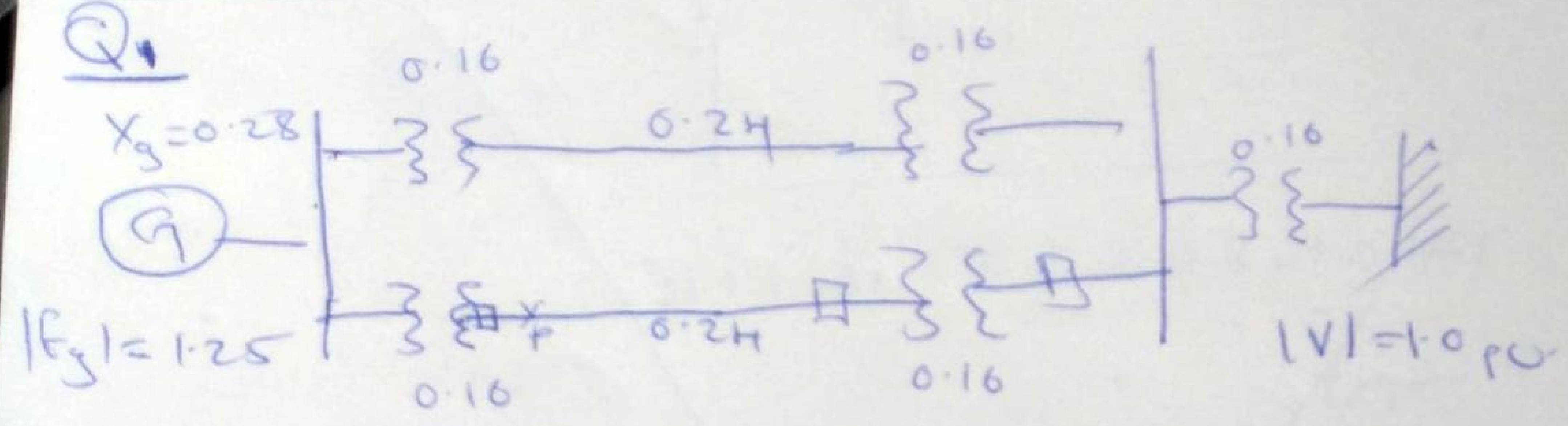
15/EMGO4/016.

Q1



delivered Power = 1.0 pu.

$$X_1 = 0.28 + \frac{0.16 + 0.24 + 0.16}{2} + 0.16$$

$= 0.72$ pu.

Pre fault.

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

$= 1.736 \sin\delta$

$V = 1.736 \sin\delta$

$1 = 1.736 \sin\delta$

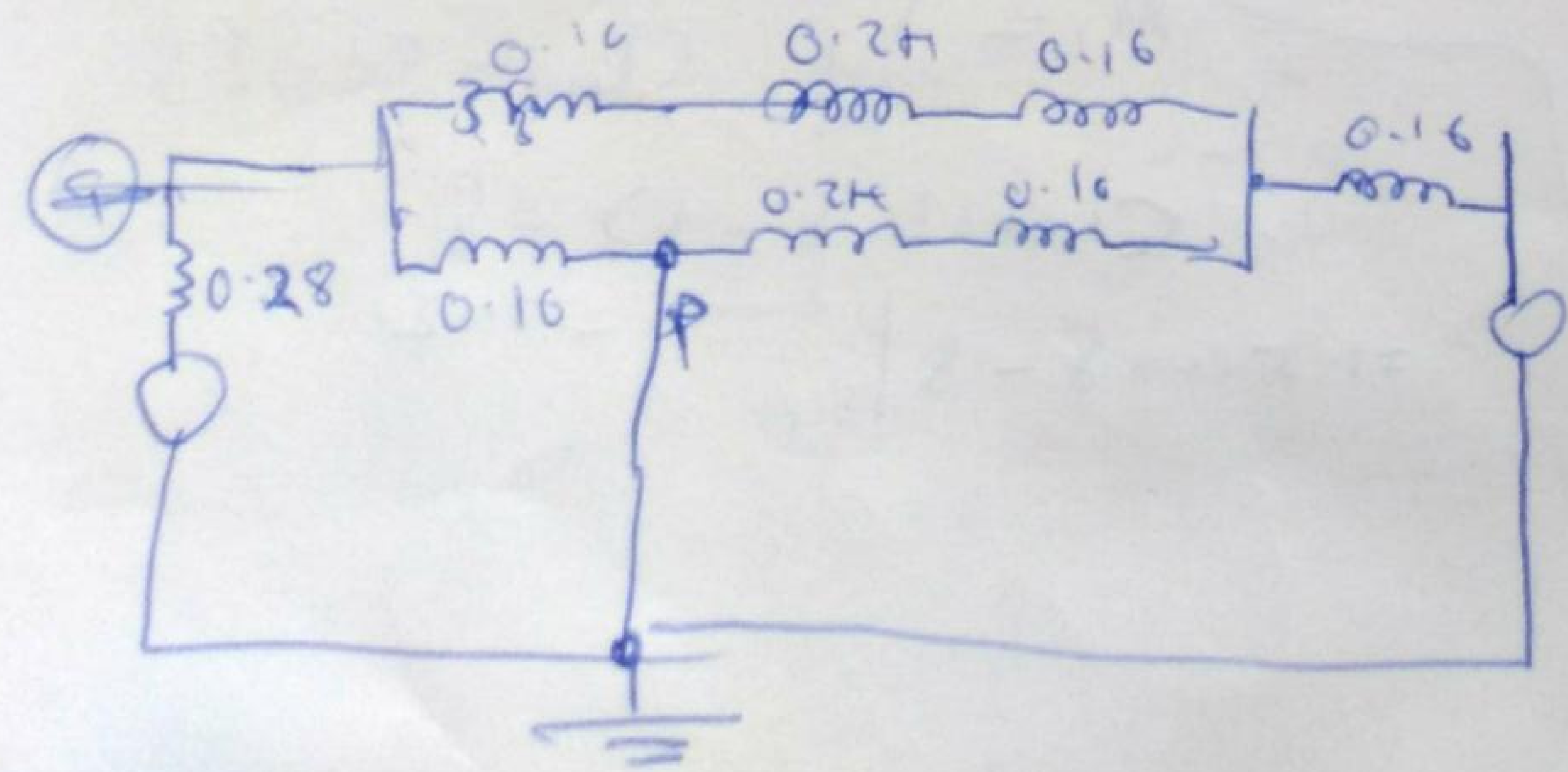
$\delta = \sin^{-1}(1/1.736) = 35°$

$\Rightarrow \delta_0 \Rightarrow 0.62$ rad

$\delta_{max} = 2.53$

(ii) During fault.

the power goes to GND since fault occurs at one end of the line



$P_{eII} = 0$

iii) Post fault.

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

$= \underline{1.0_{pu}}$

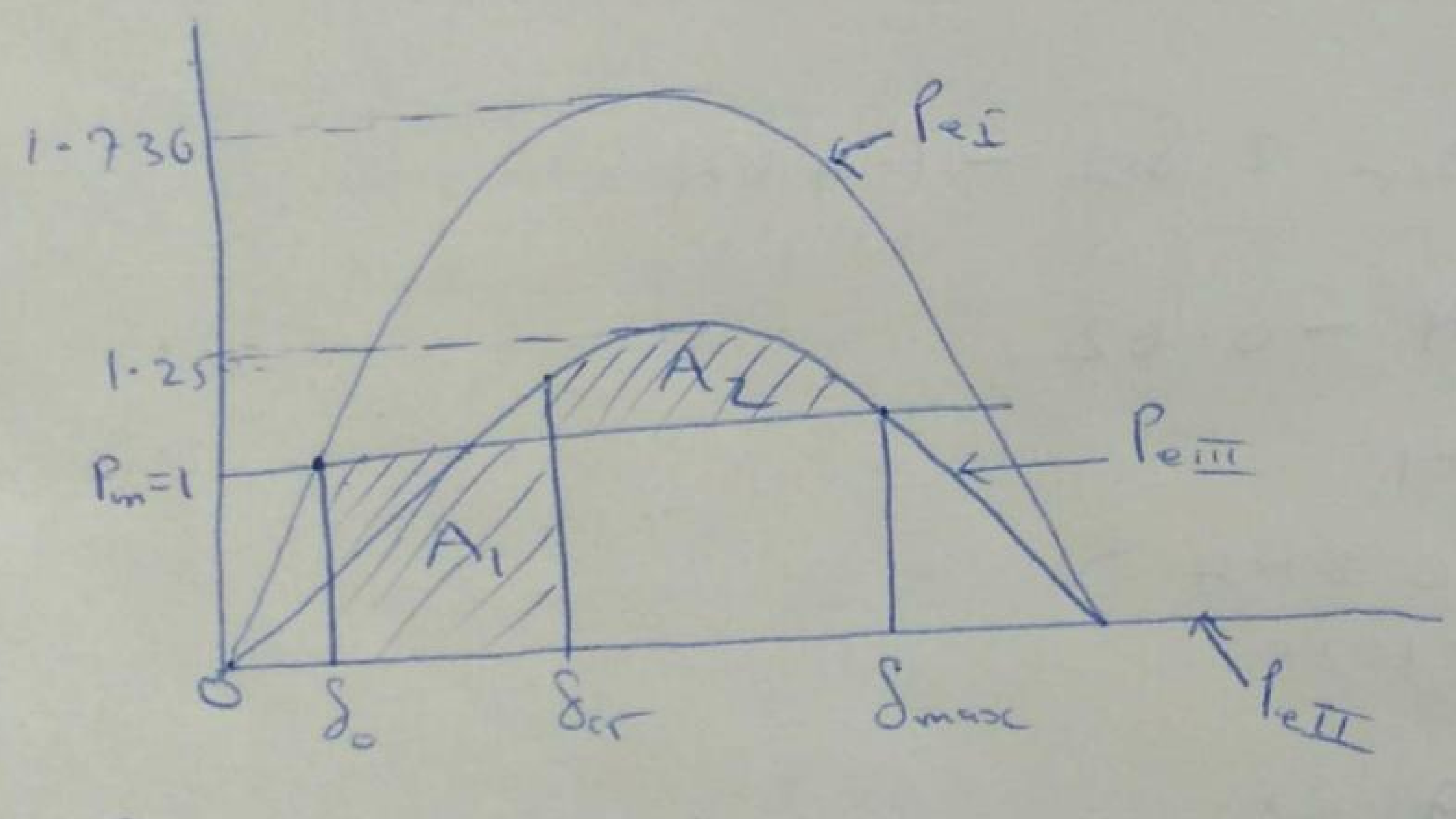
$P_{eIII} = \frac{1.25 \times 1}{1} \sin\delta$

$= 1.25 \sin\delta$

$\therefore \delta_0 = \sin^{-1}(1/1.25) = 0.927_{rad}$

Hence,

$P_{eI} = 1.736 \sin\delta \quad P_{eII} = 0 \quad P_{eIII} = 1.25 \sin\delta.$



For max δ_{max} $A_1 = A_2$ is

$\delta_{max} = \pi - \delta_0$

$= \pi - 0.927$

$= 2.21$ radians

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

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

$A_1 = \delta_{cr} - 0.62$

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

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

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

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

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

$$= -1.25(0.9992) + 1.25 \cos\delta_{cr} - 2.21 + \delta_{cr}$$

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

For $A_1 = A_2$

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

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

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

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

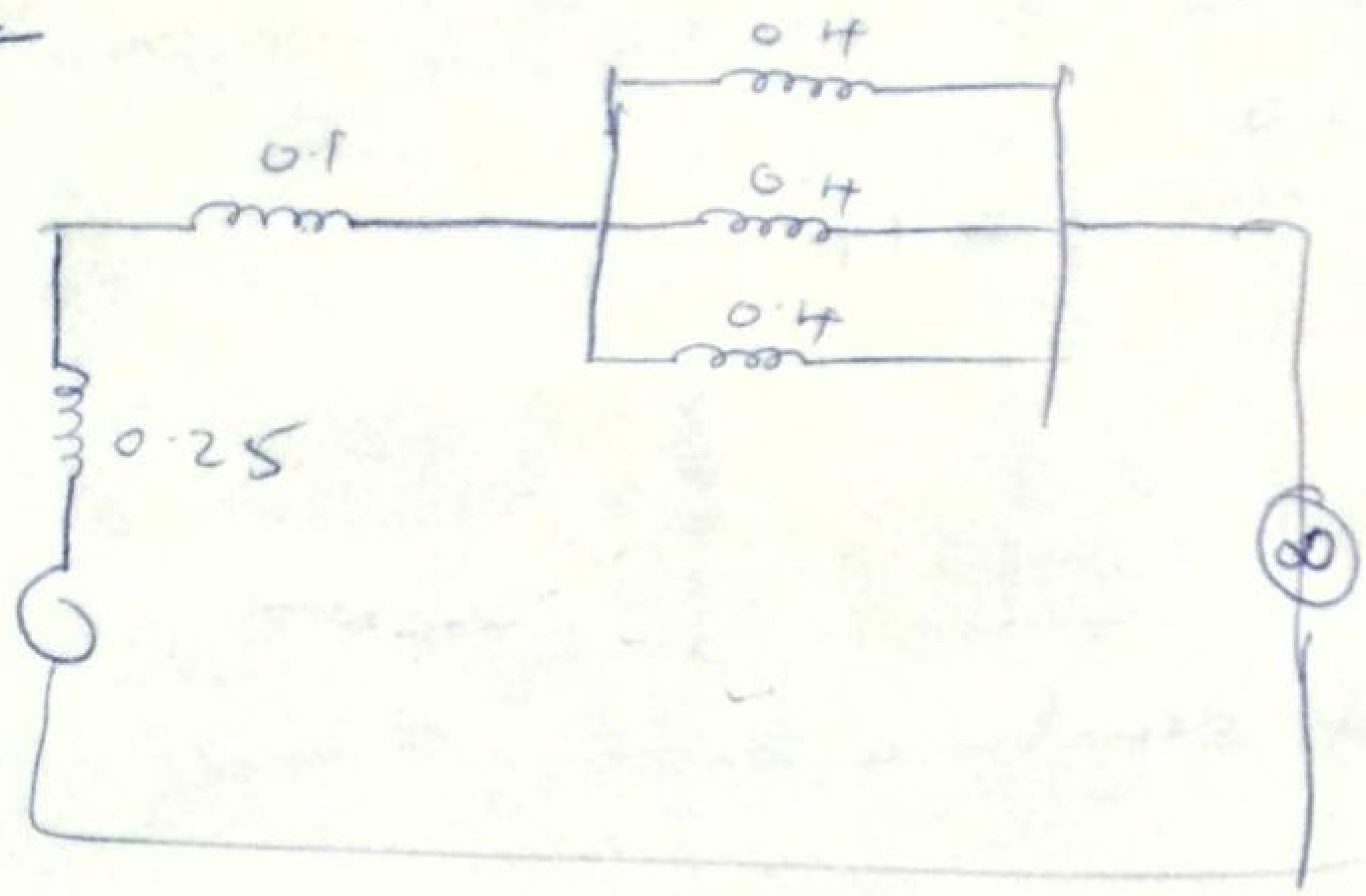
$\delta_{cr} = 0.829$ rad

or

$\delta_{cr} = 47.53°$

Q2

b.



$V_t = |V_t| < \alpha$

$= 1 < \alpha$

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

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

$(0.25 + 0.1) = \sin\alpha$

~~$\alpha = \sin^{-1}(0.025)$~~

$\alpha = \sin^{-1}(0.35) = 20.5°$

for amount of current flowing into infinite bus

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

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

Note

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

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

$= \frac{-0.0633 + j0.350}{j0.35} = 1 + j0.18$

or

$I \Rightarrow 1.016 \angle 0.21^\circ$

EMF behind transient reactance X

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

NB

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

$= 0.483$

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

$= 1 + j0.483 - 0.0869$

$= 1 - 0.0869 + j0.483$

$= 0.9131 + j0.483$

$= 1.033 \angle 27.88^\circ$

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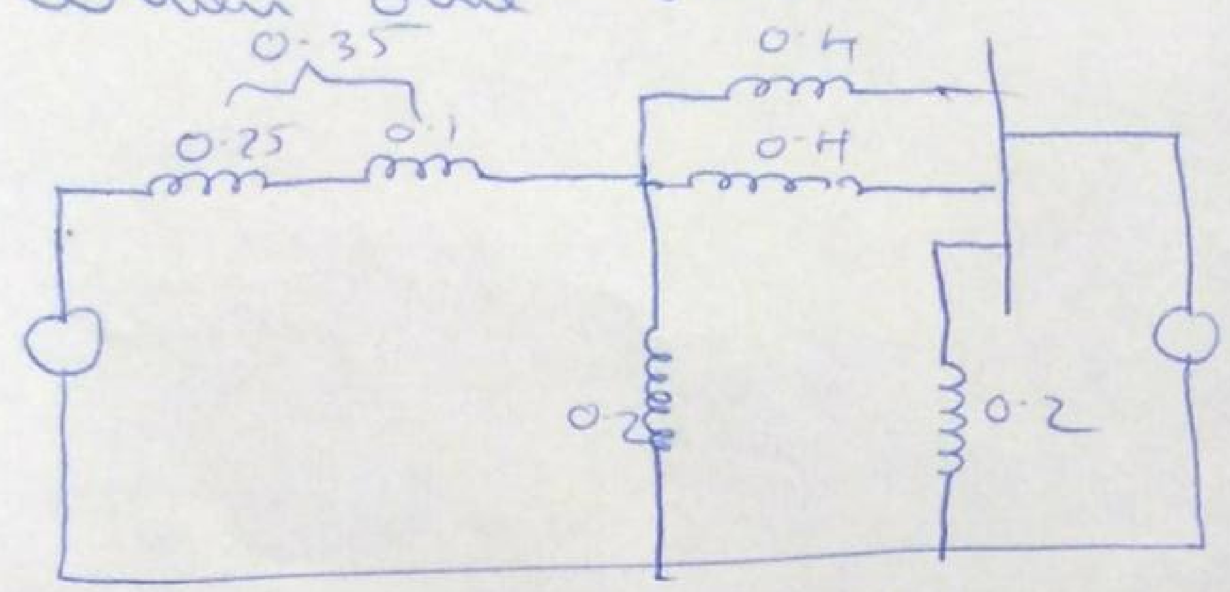
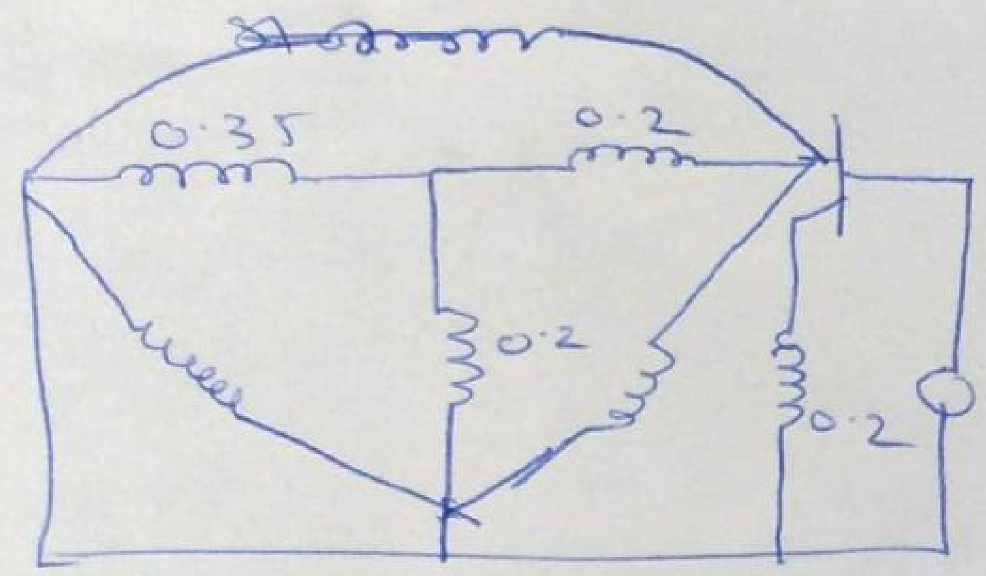
ii) When one line is shorted.



Series — Parallel



for Star-Delta :

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

$$= \frac{0.18}{0.2} = 0.9$$

$$P_e = \frac{|E| V}{X} \sin\delta = \frac{1.033 \times 1}{0.9} \sin\delta = 1.1477 \sin\delta$$

$$\cong 1.148 \sin\delta.$$

max Power is given as

$$\therefore P_{max} = 1.148 \, P_r$$