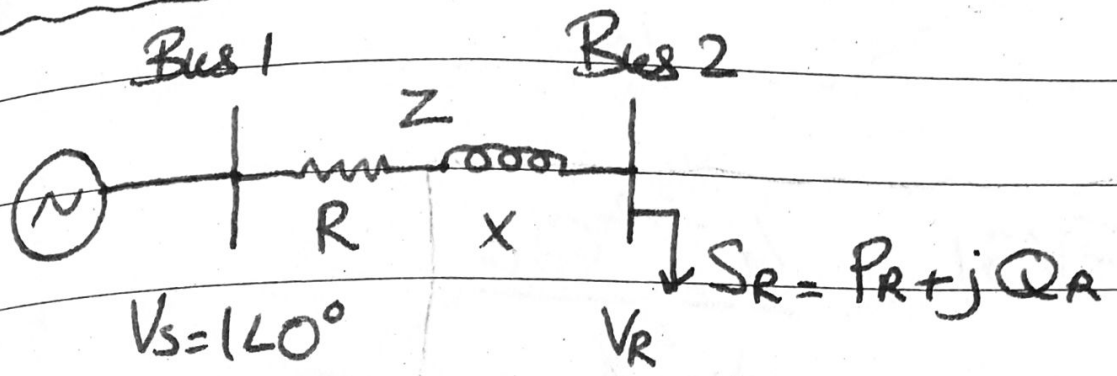
VSI Evaluations:



Note: Base values: $V_B = 20KV$; $S_B = 10\ MVA$

$Z = R + jX = 2 + j1$

S#	LL1	LL2	LL3
S_R	$5+j2.5$	$20+j10$	$40+j25$

$$I_B = S_B / V_B = 10\times10^6 / 20\times10^3 = 500A$$

$$Z_B = V_B^2 / S_B = (20\times10^3)^2 / 10\times10^6 = 40\Omega$$

$$Z_{pu} = \frac{Z}{Z_B} = \frac{2+j1}{40} = 0.05 + j0.025\ pu$$

$R(pu)$ $X(pu)$

$= 10.0559 / pu$

LL1: $S_{R(pu)} = \frac{5+j2.5}{10} = 0.5 + j0.25\ pu$

$= 10.559 / pu$

LL2: $S_{R(pu)} = \frac{20+j10}{10} = 2 + j1\ pu$

$= 12.23607 / pu$

LL3 : $S_R(pu) = \frac{40+j25}{10} = 4+j2.5 = 14.717\angle_{\theta}$

① $$FVSI = \frac{4Z^2Q_r}{V_s^2 X}$$

② LL1 : $$FVSI\_LL1 = \frac{4(0.0559)^2 \times 0.25}{(1)^2 \times 0.025}$$

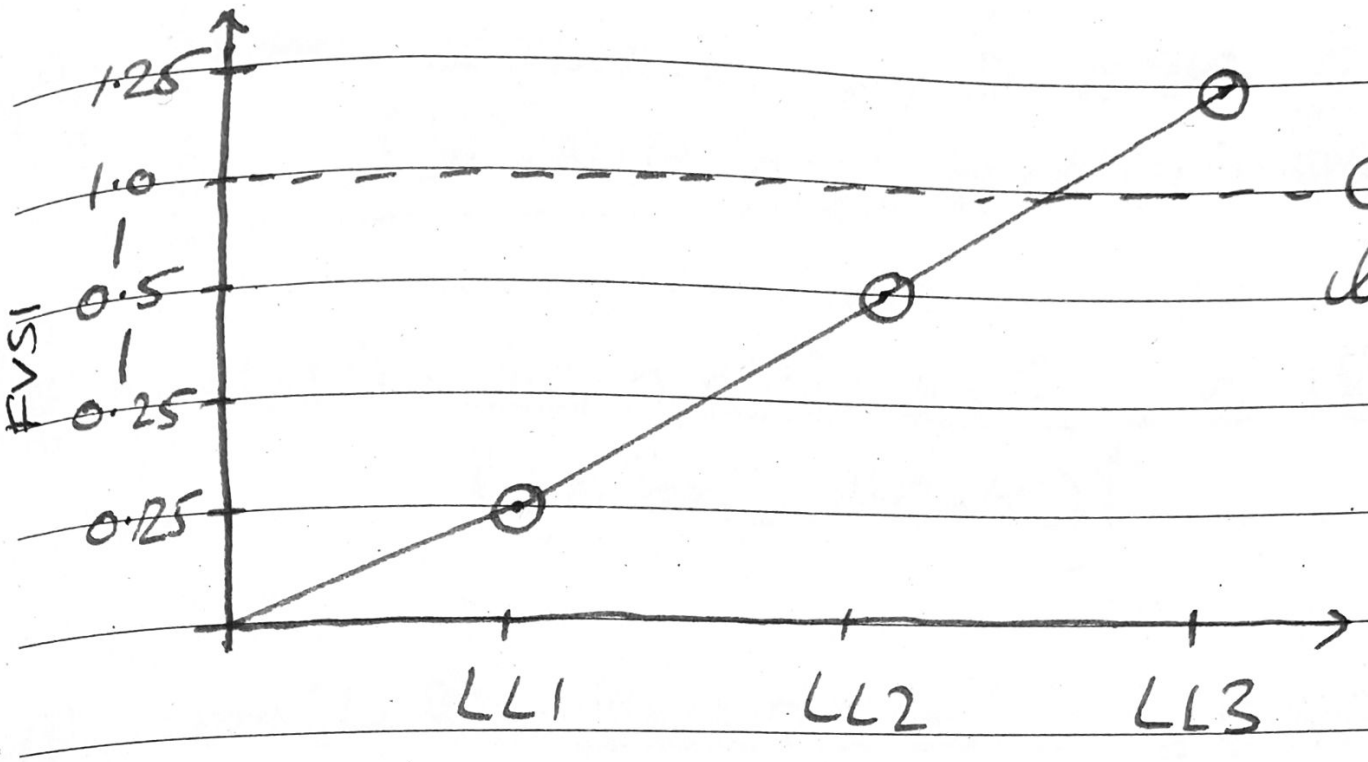
$$= 0.125 \text{ pu (stable)}$$

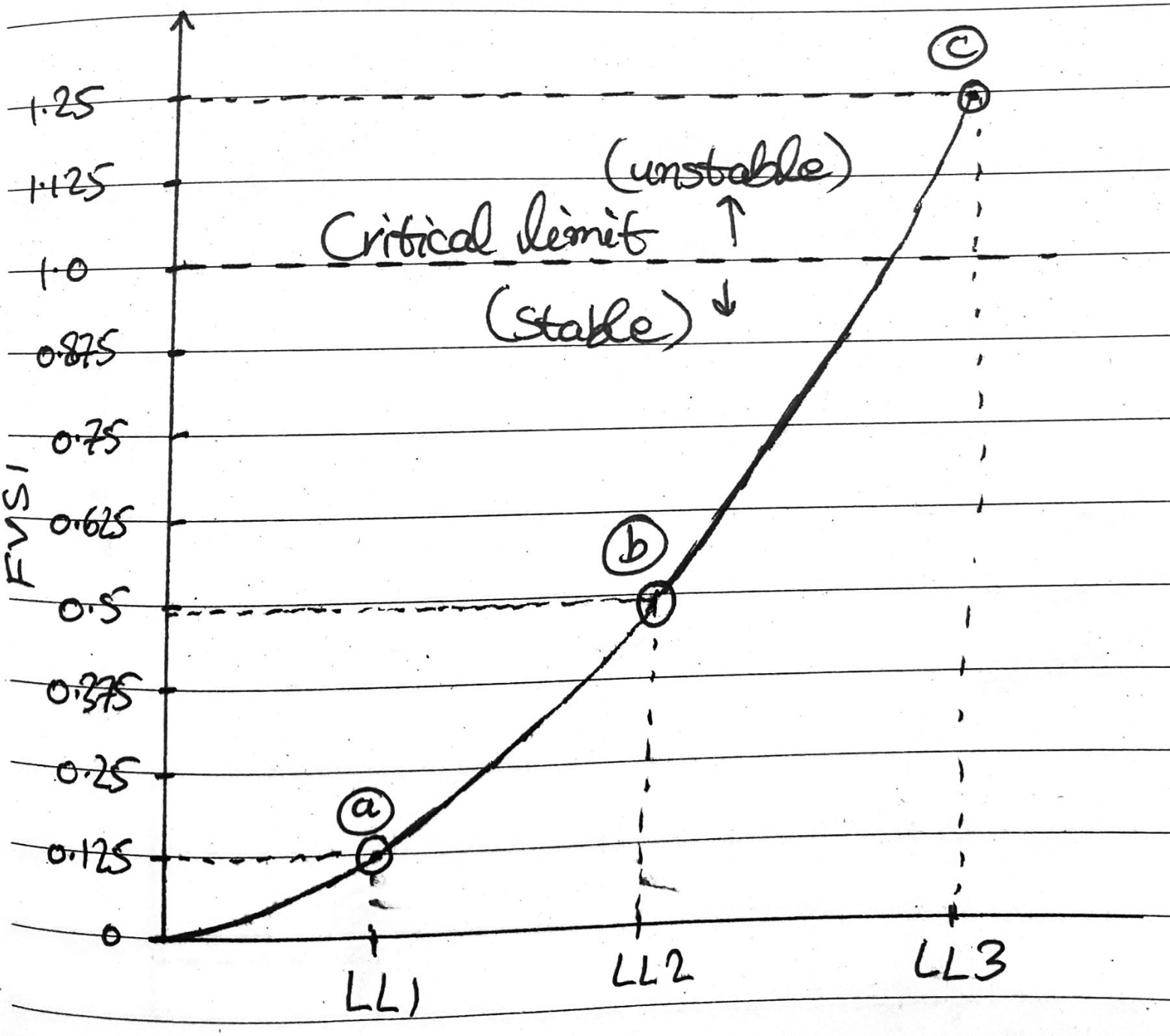
⑤ LL2 : $$FVSI\_LL2 = \frac{4 \times (0.0559)^2 \times 1}{(1)^2 \times 0.025}$$

$$= 0.49997 \text{ pu (stable)}$$

© LL3 : $$FVSI\_LL3 = \frac{4 \times (0.0559)^2 \times 2.5}{(1)^2 \times 0.25}$$

$$= 1.25 \text{ pu (unstable)}$$


1.25
1.0
0.5
0.25
0.125
FVSI
Critical limit
LL1
LL2
LL3


1.25
1.125
1.0
0.875
0.75
0.625
0.5
0.375
0.25
0.125
0
FVSI
(unstable)
Critical limit
(stable)
a
b
c
LL1
LL2
LL3

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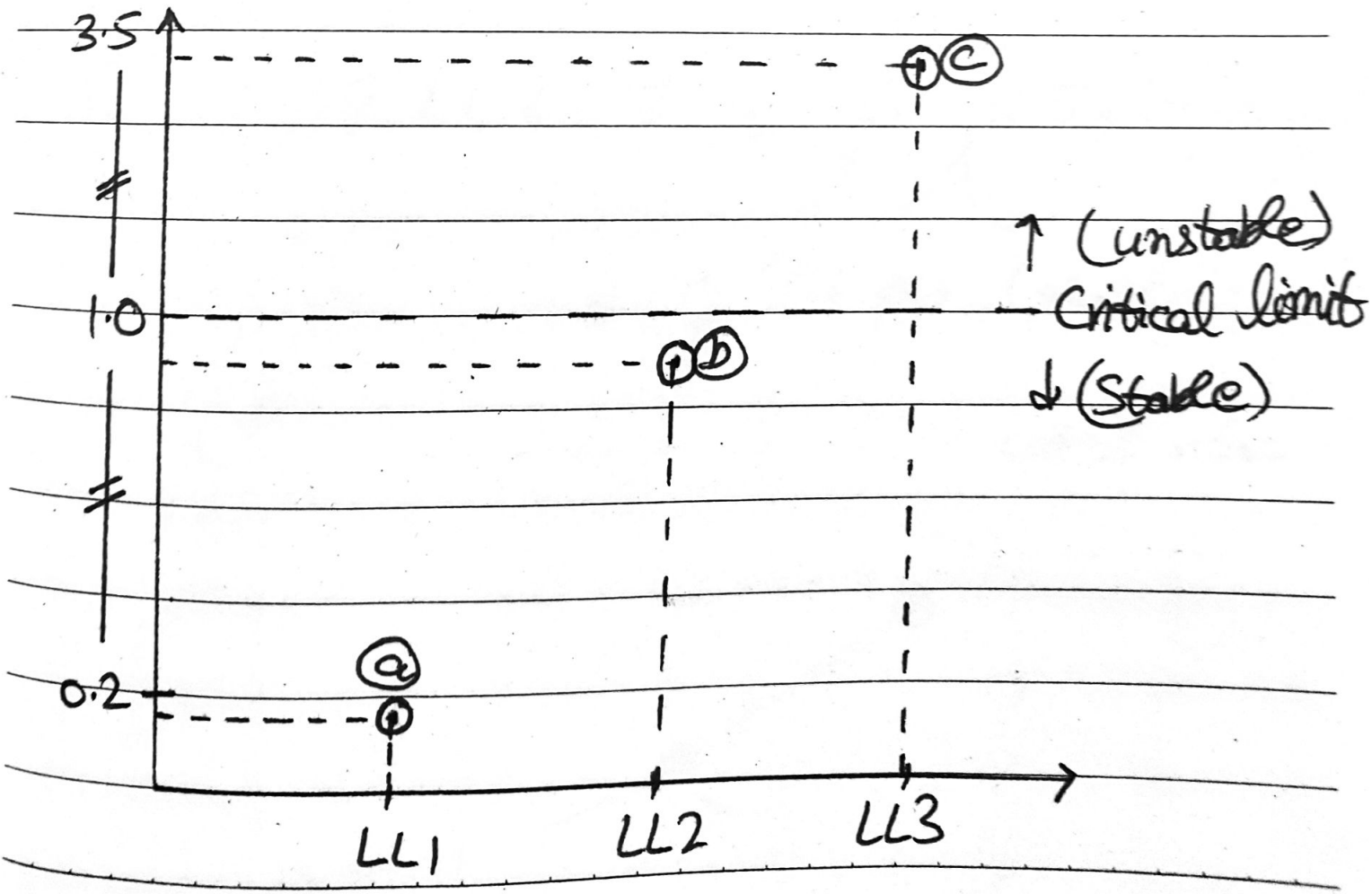
② $$L_{mn} = \frac{4 \times Q_r}{(V_s \sin(\theta - \delta))^2}$$; $\theta = 25.84°$; $G_{55} = 0.9$.

$\delta = 4°$ (LL1) : 7° (LL2) ; 10° (LL3)

ⓐ $$L_{mn}(LL1) = \frac{4 \times 0.025 \times 0.25}{(1.0 \sin(25.84° - 4°))^2} = 0.18064 \text{ pu}$$

ⓑ $$L_{mn}(LL2) = \frac{4 \times 0.025 \times 1}{(1 \sin(25.84° - 7°))^2} = 0.9589 \text{ pu}$$

ⓒ $$L_{mn}(LL3) = \frac{4 \times 0.025 \times 2.5}{((1 \sin(25.84° - 10°))^2} = 3.356 \text{ pu}.$$



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$(P_S = P_R)$.

③ $$LQP = 4\left(\frac{X}{V_S^2}\right)\left(Q_R + \frac{P_{RS}^2 X}{V_S^2}\right)$$

ⓐ $$LQP\_LL1 = 4\left(\frac{0.025}{1.0^2}\right)\left(0.25 + \frac{(0.5^2 \times 0.025)}{1.0^2}\right)$$

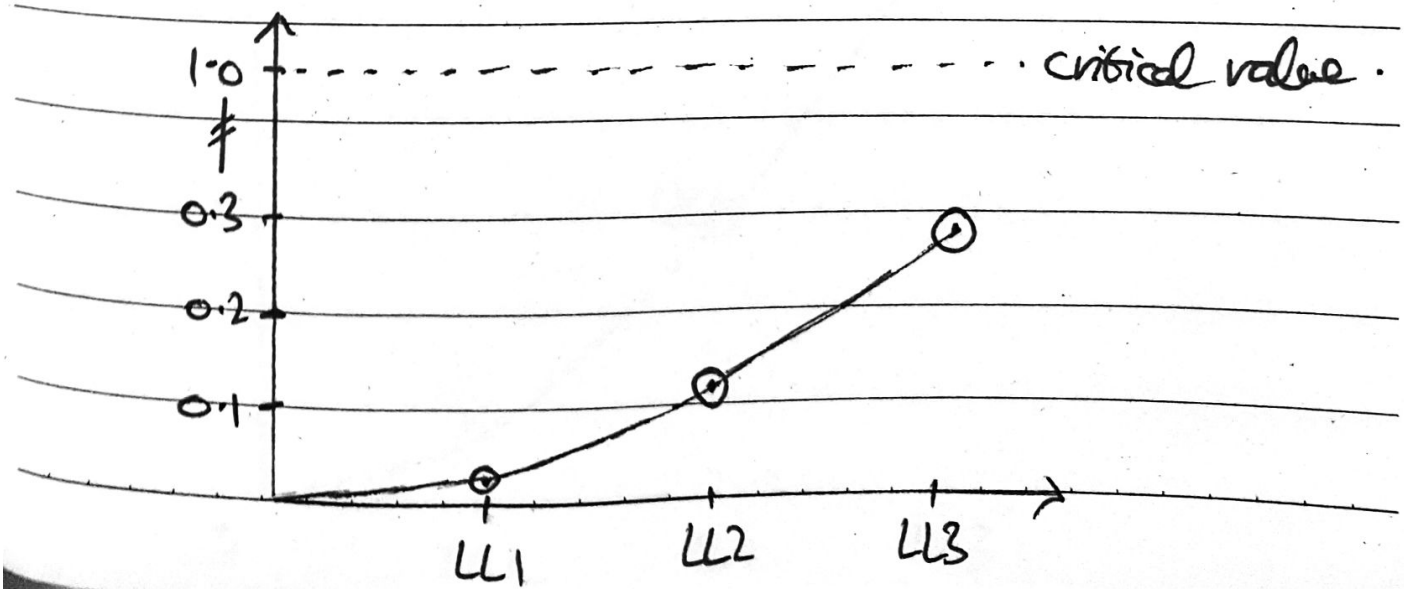
$$= 0.02625 \text{ pu (stable)}$$

ⓑ $$LQP\_LL2 = 4\left(\frac{0.025}{1^2}\right)\left(1 + \frac{(2^2 \times 0.025)}{1^2}\right)$$

$$= 0.11 \text{ pu (stable)}$$

ⓒ $$LQP\_LL3 = 4\left(\frac{0.025}{1^2}\right)\left(2.5 + \frac{(4^2 \times 0.025)}{1}\right)$$

$$= 0.29 \text{ pu (stable)}.$$



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(4) $$NLSI = \frac{P_r R + Q_r X}{0.25 V_s^2}$$

(a) $$NLSI\_LL1 = \frac{(0.5 \times 0.05) + (0.25 \times 0.025)}{0.25 \times 1^2}$$

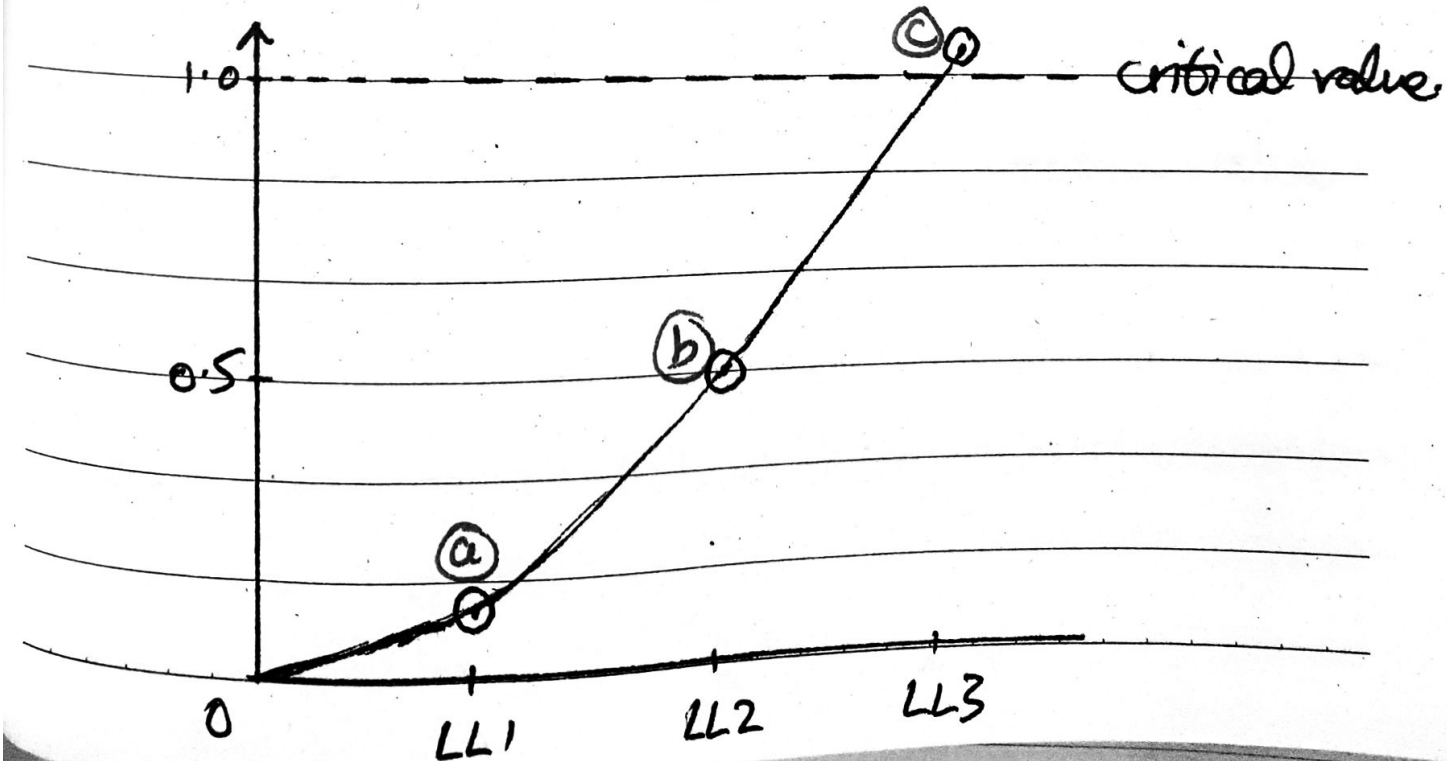
$$= 0.125$$

(b) $$NLSI\_LL2 = \frac{(2 \times 0.05) + (1 \times 0.025)}{0.25 \times 1^2}$$

$$= 0.5$$

(c) $$NLSI\_LL3 = \frac{(4 \times 0.05) + (2.5 \times 0.025)}{0.25 \times 1^2}$$

$$= 1.05$$



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(5) $$VSI\_2 = \frac{4Q_r(R+X)^2}{X(V_s^2 + 8RQ_r)}$$

(a) $$VSI\_2(LL1) = \frac{4 \times 0.25 \times (0.05+0.025)^2}{0.025(1^2 + 8 \times 0.05 \times 0.25)}$$

$$= 0.2045$$

(b) $$VSI\_2(LL2) = \frac{4 \times 1 \times (0.05+0.025)^2}{0.025(1^2 + 8 \times 0.05 \times 1)}$$

$$= 0.6429$$

(c) $$VSI\_2(LL3) = \frac{4 \times (2.5) \times (0.05+0.025)^2}{0.025(1^2 + 8 \times 0.05 \times 2.5)}$$

$$= 1.125$$