EE 460
Solution of Home Work #2b

5.26 (a) $\bar{Z}_C = \sqrt{\frac{\bar{z}}{\bar{y}}} = \sqrt{\frac{j0.34}{j4.5\times10^{-6}}} = 274.9\angle 0° = 274.9\ \Omega$

(b) $\bar{\gamma}l = \sqrt{\bar{z}\,\bar{y}}\,(l) = \sqrt{(j0.34)(j4.5\times10^{-6})}\,(300) = j0.3711\text{pu}$

(c) $\bar{\gamma}l = j(\beta l);\quad \beta l = 0.3711\text{pu}$

$$A = D = \cos\ (\beta l) = \cos\,(0.3711\text{ radians}) = 0.9319\angle 0°\text{ pu}$$

$$\bar{B} = j\,Z_C \sin\,(\beta l) = j\,(274.9)\sin\,(0.3711\text{ radians})$$
$$= j99.68\ \Omega$$

$$\bar{C} = j\left(\frac{1}{\bar{Z}_C}\right)\sin\,(\beta l) = j\left(\frac{1}{274.9}\right)\sin\,(0.3711\text{ radians})$$
$$= j1.319\times10^{-3}\text{ S}$$

(d) $\beta = 0.3711/300 = 1.237\times10^{-3}$ radians/ km

$\lambda = 2\pi/\beta = 5079$ km

(e) $\text{SIL} = \frac{V^2_{rated\ L-L}}{\bar{Z}_C} = \frac{(500)^2}{274.9} = 909.4\text{ MW}(3\phi)$

5.38 From Problem 5.14

$\bar{A} = 0.8794\angle 0.66°$ pu; $\quad A = 0.8794$ and $\theta_A = 0.66°$

$\bar{B} = \bar{Z}' = 134.8\angle 85.3°\ \Omega$; $\quad Z' = 134.8$ and $\theta_Z = 85.3°$

Using Eq. (5.5.6)

$$P_{R\max} = \frac{500\times 500}{134.8} - \frac{(0.8794)(500)^2}{134.8}\cos(85.3° - 0.66°)$$
$$= 1854.6 - 152.4 = 1702\ \text{MW}\ (3\phi)$$

For this loading at unity power factor,

$$I_R = \frac{P_{R\max}}{\sqrt{3}\, V_{RLL}(PF)} = \frac{1702}{\sqrt{3}(500)(1.0)} = 1.966\ \text{kA / Phase}$$

From Table A.4, the thermal limit for 3 ACSR 1113 kcmil conductors is $3\times 1.11 = 3.33$ kA/phase. The current 1.966 kA corresponding to the theoretical steady-state stability limit is well below the thermal limit of 3.33 kA.

5.45 (a) Using Eq. (5.5.3) with $\delta = 35°$

$$P_R = \frac{(500)(0.95\times 500)}{134.8}\cos(85.3° - 35°) - \frac{(0.8794)(0.95\times 500)^2}{134.8}\cos(85.3° - 0.66°)$$

$$= 1125.4 - 137.5 = 987.9 \text{ MW } (3\phi)$$

$P_R = 988$ MW is the practical line loadability provided that the voltage drop limit and thermal limits are not exceeded.

(b) $$I_{R\,FL} = \frac{P_R}{\sqrt{3}\, V_{R\,LL}\,(PF)} = \frac{987.9}{\sqrt{3}\,(0.95\times 500)(0.99)} = 1.213 \text{ kA}$$

(c) $\bar{V}_S = \bar{A}\bar{V}_{R\,FL} + \bar{B}\bar{I}_{R\,FL}$

$$\frac{500}{\sqrt{3}}\angle\delta = (0.8794\angle 0.66°)(V_{R\,FL}\angle 0°) + (134.8\angle 85.3°)(1.213\angle 8.109°)$$

$$288.68\angle\delta = 0.8794 V_{R\,FL}\angle 0.66° + 163.5\angle 93.41°$$

$$288.68\angle\delta = (0.8793 V_{R\,FL} - 9.725) + j(0.01013 V_{R\,FL} + 163.21)$$

Taking the squared magnitude of the above equation:

$$83333 = 0.7733 V_{R\,FL}^2 - 13.8 V_{R\,FL} + 26732$$

Solving the above quadratic equation:

$$V_{R\,FL} = \frac{13.8 + \sqrt{(13.8)^2 + 4(0.7733)(56601)}}{2(0.7733)} = 279.6 \text{ kV}_{\text{L-N}}$$

$$V_{R\,FL} = 279.6\sqrt{3} = 484.3 \text{ kV}_{\text{L-L}} = 0.969 \text{ pu}$$

(d) $V_{R\,NL} = V_S / A = 500/0.8794 = 568.6 \text{ kV}_{\text{L-L}}$

$$\%\,VR = \frac{568.6 - 484.3}{484.3}\times 100 = 17\%$$

(e) From Problem 5.38, thermal limit is 3.33 kA. Since $V_{R\,FL} / V_S = 484.3/500 = 0.969 > 0.95$, and the thermal limit of 3.33 kA is greater than 1.213 kA, the voltage drop it and thermal limits are not exceeded at $P_R = 987.9$ MW. Therefore, loadability is determined by stability.