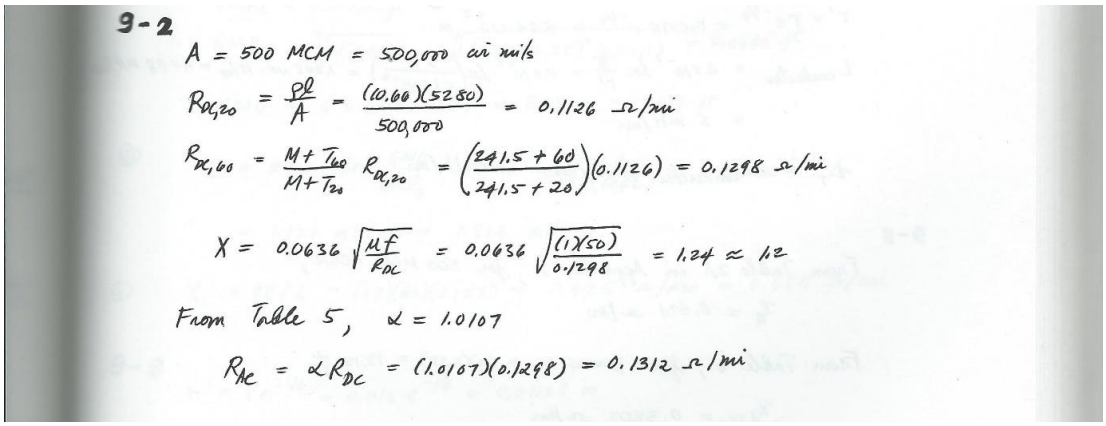
EE 360: Homework # 6

Problems 9-2, 9-6, 9-29, and 9-30



9-2

$A = 500\ MCM = 500{,}000\ cir\ mils$

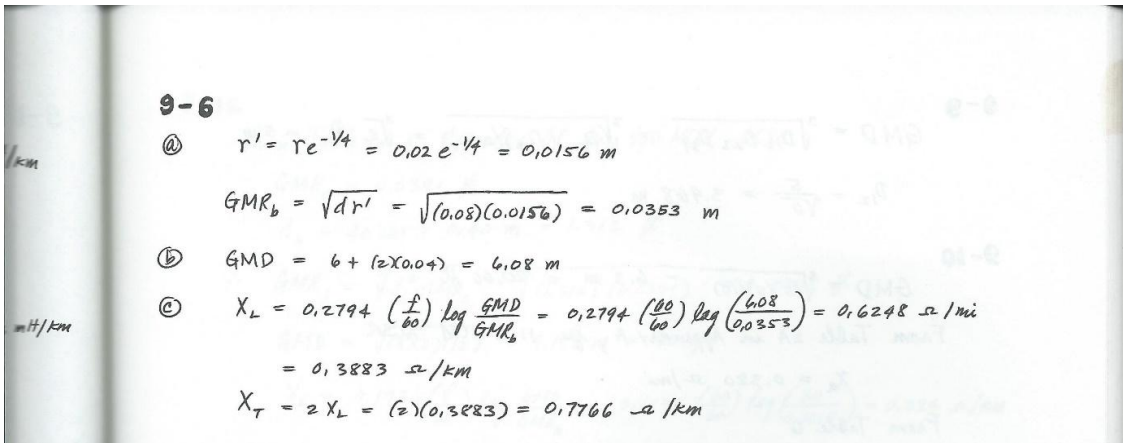
$R_{DC,20} = \frac{\rho l}{A} = \frac{(10.60)(5280)}{500{,}000} = 0.1126\ \Omega/mi$

$R_{DC,60} = \frac{M+T_{60}}{M+T_{20}} R_{DC,20} = \left(\frac{241.5+60}{241.5+20}\right)(0.1126) = 0.1298\ \Omega/mi$

$X = 0.0636\sqrt{\frac{\mu f}{R_{DC}}} = 0.0636\sqrt{\frac{(1)(50)}{0.1298}} = 1.24 \approx 1.2$

From Table 5, $\alpha = 1.0107$

$R_{AC} = \alpha R_{DC} = (1.0107)(0.1298) = 0.1312\ \Omega/mi$



9-6

/km

mH/km

ⓐ $r' = re^{-1/4} = 0.02e^{-1/4} = 0.0156\ m$

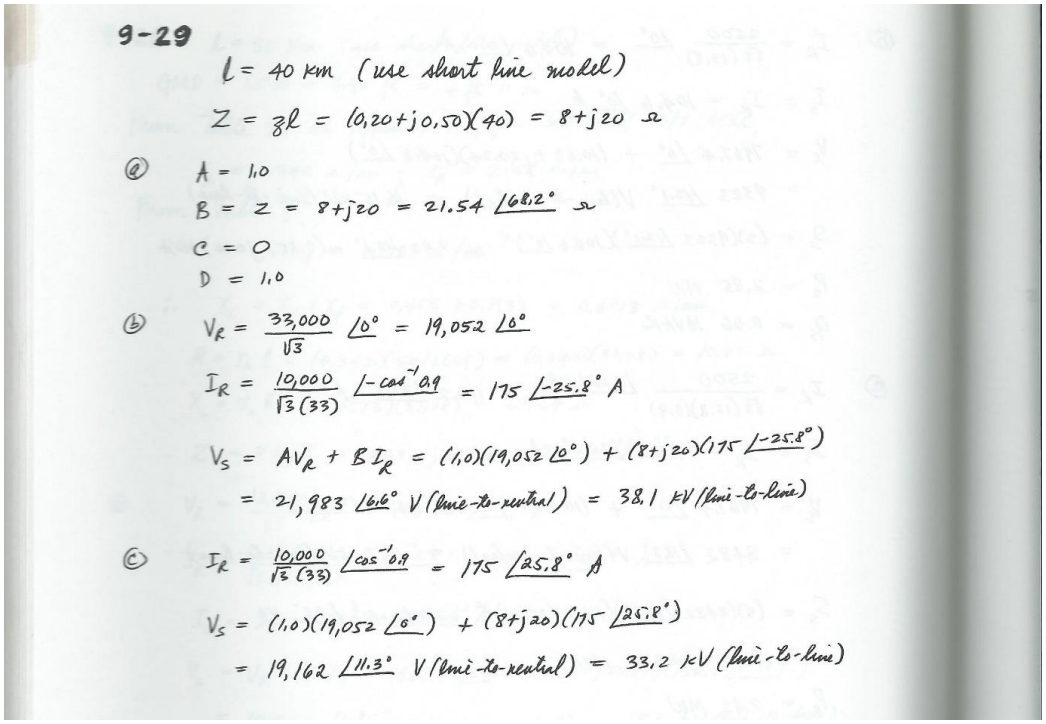
$GMR_b = \sqrt{dr'} = \sqrt{(0.08)(0.0156)} = 0.0353\ m$

ⓑ $GMD = 6 + (2)(0.04) = 6.08\ m$

ⓒ $X_L = 0.2794\left(\frac{f}{60}\right)\log\frac{GMD}{GMR_b} = 0.2794\left(\frac{60}{60}\right)\log\left(\frac{6.08}{0.0353}\right) = 0.6248\ \Omega/mi$

$= 0.3883\ \Omega/km$

$X_T = 2X_L = (2)(0.3883) = 0.7766\ \Omega/km$



9-29

$l = 40\ km$ (use short line model)

$Z = zl = (0.20+j0.50)(40) = 8+j20\ \Omega$

ⓐ $A = 1.0$

$B = Z = 8+j20 = 21.54\angle 68.2°\ \Omega$

$C = 0$

$D = 1.0$

ⓑ $V_R = \frac{33{,}000}{\sqrt{3}}\angle 0° = 19{,}052\angle 0°$

$I_R = \frac{10{,}000}{\sqrt{3}(33)}\angle -\cos^{-1}0.9 = 175\angle -25.8°\ A$

$V_S = AV_R + BI_R = (1.0)(19{,}052\angle 0°) + (8+j20)(175\angle -25.8°)$

$= 21{,}983\angle 6.6°\ V\ (line\text{-}to\text{-}neutral) = 38.1\ kV\ (line\text{-}to\text{-}line)$

ⓒ $I_R = \frac{10{,}000}{\sqrt{3}(33)}\angle \cos^{-1}0.9 = 175\angle 25.8°\ A$

$V_S = (1.0)(19{,}052\angle 0°) + (8+j20)(175\angle 25.8°)$

$= 19{,}162\angle 11.3°\ V\ (line\text{-}to\text{-}neutral) = 33.2\ kV\ (line\text{-}to\text{-}line)$

9-30

$l = 80$ mi (use medium length line model)

$$A = D = \frac{ZY}{2} + 1 = \frac{(10+j50)(j30\times10^{-5})}{2} + 1 = 0.9925\angle 0.1^\circ$$

$$B = Z = 10+j50 = 51\angle 78.7^\circ\ \Omega$$

$$C = Y\left(\frac{ZY}{4}+1\right) = (j30\times10^{-5})\left[\frac{(10+j50)(j30\times10^{-5})}{4}+1\right] = 2.99\times10^{-4}\angle 90^\circ$$

(a) $$V_R = \frac{230{,}000}{\sqrt{3}}\angle 0^\circ = 132{,}790\angle 0^\circ\ V$$

$$I_R = \frac{V_R}{Z_L} = \frac{132{,}790\angle 0^\circ}{150\angle 36.9^\circ} = 885.3\angle -36.9^\circ\ A$$

$$V_S = AV_R + BI_R = (0.9925\angle 0.1^\circ)(132{,}790\angle 0^\circ) + (51\angle 78.7^\circ)(885.3\angle -36.9^\circ)$$
$$= 168{,}208\angle 10.4^\circ\ V \text{ (line-to-neutral)} = 291.34\ kV \text{ (line-to-line)}$$

$$I_S = CV_R + DI_R = (2.99\times10^{-4}\angle 90^\circ)(132{,}790\angle 0^\circ) + (0.9925\angle 0.1^\circ)(885.3\angle -36.9^\circ)$$
$$= 855.5\angle -34.7^\circ\ A$$

(b) $$V.R. = \frac{V_S/A - V_R}{V_R} = \frac{(291.34/0.9925) - 230}{230}100\% = 27.6\%$$

(c) $$S_S = 3V_S I_S^* = (3)(168{,}208\angle 10.4^\circ)(855.5\angle -34.7^\circ)^* = 431.7\times10^6\angle 45.1^\circ\ VA$$
$$= (304.7 + j\,305.8)\ MVA$$

$P_S = 304.7$ MW

$Q_S = 305.8$ MVAR

(d) $$P_R = 3V_R I_R \cos\theta_R = (3)(132{,}790)(885.3)\cos 36.9 = 282\times10^6\ W = 282\ MW$$

$$\eta = \frac{P_R}{P_S} = \frac{282}{304.7}100\% = 92.6\%$$