

ECE 476 Homework 2 Solutions

4.10 From Eq. (4.5.10)

$$L_1 = 2 \times 10^{-7} \ln \left(\frac{D}{r'} \right) \frac{\text{H}}{\text{m}}$$

$$D = 4 \text{ ft}$$

$$L_1 = 2 \times 10^{-7} \ln \left(\frac{4}{1.6225 \times 10^{-2}} \right)$$

$$r' = e^{\frac{-1}{4}} \left(\frac{.5}{2} \right) \left(\frac{1 \text{ ft}}{12 \text{ in}} \right) \quad 4.4.20$$

$$L_1 = \underline{1.101 \times 10^{-6}} \frac{\text{H}}{\text{m}}$$

$$r' = 1.6225 \times 10^{-2} \text{ ft}$$

$$X_1 = \omega L_1 = (2\pi 60)(1.101 \times 10^{-6})(1000) = \underline{0.4153 \Omega / \text{km}}$$

4.18 $D_{eq} = \sqrt[3]{8 \times 8 \times 16} = 10.079 \text{ m}$ 4.6.17

From Table A.4, $D_s = \overset{\text{cm R}}{(0.0403 \text{ ft})} \frac{1 \text{ m}}{3.28 \text{ ft}} = 0.0123 \text{ m}$

$$L_1 = 2 \times 10^{-7} \ln(D_{eq} / D_s) = 2 \times 10^{-7} \ln \left(\frac{10.079}{0.0123} \right) = 1.342 \times 10^{-6} \text{ H/m}$$

$$X_1 = 2\pi(60)L_1 = 2\pi(60)1.342 \times 10^{-6} \frac{\Omega}{\text{m}} \times \frac{1000 \text{ m}}{1 \text{ km}} = 0.506 \Omega / \text{km}$$

4.19 (a) $L_1 = 2 \times 10^{-7} \ln \left(\frac{10.079 \times 1.1}{0.0123} \right) = 1.361 \times 10^{-6} \text{ H/m}$

$$X_1 = 2\pi(60)1.361 \times 10^{-6}(1000) = 0.513 \Omega / \text{km}$$

(b) $L_1 = 2 \times 10^{-7} \ln \left(\frac{10.079 \times 0.9}{0.0123} \right) = 1.321 \times 10^{-6} \text{ H/m}$

$$X_1 = 2\pi(60)1.321 \times 10^{-6}(1000) = 0.498 \Omega / \text{km}$$

The positive sequence inductances L_1 and inductive reactance X_1 increase 1.4% (decrease 1.6%) as the phase spacing increases 10% (decreases 10%).

4.23 (a) The geometric mean radius of each phase is calculated as

$$R = \sqrt[4]{(r')^2 (0.3)^2} \text{ where } r' = 0.7788 \times 0.0074 \quad 4.6.19 \\ = 0.0416 \text{ m}$$

The geometric mean distance between the conductors of phases A and B is given by

$$D_{AB} = \sqrt[4]{6^2 (6.3)(5.7)} = 5.996 \approx 6 \text{ m}$$

Similarly, $D_{BC} = \sqrt[4]{6^2 (6.3)(5.7)} = 5.996 \approx 6 \text{ m}$

and $D_{CA} = \sqrt[4]{12^2 (12.3)(11.7)} = 11.998 \approx 12 \text{ m}$

Can be neglected

The GMD between phases is given by the cube root of the product of the three-phase spacings.

$$D_{eq} = \sqrt[3]{6 \times 6 \times 12} = 7.56 \text{ m}$$

The inductance per phase is found as

$$L = 0.2 \ln \frac{7.56}{0.0416} = 1.041 \text{ mH/km}$$

or $L = 1.609 \times 1.041 = 1.674 \text{ mH/mi}$

(b) The line reactance for each phase then becomes

$$X = 2\pi f L = 2\pi (60) 1.674 \times 10^{-3} = 0.631 \Omega / \text{mi per phase}$$