EE504 Boise Bench Cloverdale Section #712-02 Single Circuit

Define transformation

$$a := 1 \cdot e^{j \cdot \frac{2 \cdot \pi}{3}} \qquad A1 := \begin{pmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{pmatrix} \qquad T := \begin{pmatrix} 1 & 1 & 1 \\ 1 & -2 & 1 \\ 1 & 1 & -2 \end{pmatrix}$$

Define Constants:

$\rho := 100 ohm \cdot m$ $freq := 60 Hz$

$\mu o := 4 \cdot \pi \cdot 10^{-7} \frac{H}{m}$ $Icons := \frac{\mu o}{2 \cdot \pi}$

$CarsonsResistConst := 9.869 \times 10^{-7} \frac{ohm}{m \cdot Hz}$ $De\_const := 2160 \cdot \frac{ft \cdot Hz^{0.5}}{(ohm \cdot m)^{0.5}}$

Compute the series impedance matrix for the line configuration of Tower V-30 where the conductor is 1272 MCM, 45/7 Strand ACSR (Bittern). Assume line is 3.2 miles long

Define heights relative to the earth

$Hgw := (0.0) \cdot ft$

$Ha := 55 ft$ $Ha = 55 ft$

$Hb := Ha - 12.5 ft$ $Hb = 42.5 ft$

$Hc := Hb - 12.5 ft$ $Hc = 30 ft$

Define horizontal position relative to center of the tower (some are negative).

$Xa := 0ft$ $Xb := 0ft$ $Xc := 0ft$

Now calculate distance between conductors (be careful of negative signs)

$Dab := \sqrt{(Ha - Hb)^2 + (Xb - Xa)^2}$ $Dab = 12.5\,ft$

$Dac := \sqrt{(Ha - Hc)^2 + (Xc - Xa)^2}$ $Dac = 25\,ft$

$Dbc := \sqrt{(Hb - Hc)^2 + (Xb - Xc)^2}$ $Dbc = 12.5\,ft$

GMR, diameter, and Rac from table for Bittern

$GMR := 0.0445ft$ $diameter := 1.345in$

$Rac := 0.0759\,\frac{ohm}{mi}$ at 25C and 60Hz

$Rd := CarsonsResistConst \cdot freq$

$$Rperlength := \begin{pmatrix} Rac + Rd & Rd & Rd \\ Rd & Rac + Rd & Rd \\ Rd & Rd & Rac + Rd \end{pmatrix}$$

$$Rperlength = \begin{pmatrix} 0.171 & 0.095 & 0.095 \\ 0.095 & 0.171 & 0.095 \\ 0.095 & 0.095 & 0.171 \end{pmatrix} \frac{ohm}{mi}$$

$De := De\_const \cdot \sqrt{\frac{\rho}{freq}}$ $De = 2788.55\,ft$

$$Lperlength := \begin{pmatrix} Icons \cdot \ln\left(\frac{De}{GMR}\right) & Icons \cdot \ln\left(\frac{De}{Dab}\right) & Icons \cdot \ln\left(\frac{De}{Dac}\right) \\ Icons \cdot \ln\left(\frac{De}{Dab}\right) & Icons \cdot \ln\left(\frac{De}{GMR}\right) & Icons \cdot \ln\left(\frac{De}{Dbc}\right) \\ Icons \cdot \ln\left(\frac{De}{Dac}\right) & Icons \cdot \ln\left(\frac{De}{Dbc}\right) & Icons \cdot \ln\left(\frac{De}{GMR}\right) \end{pmatrix}$$

$$Lperlength = \begin{pmatrix} 3.555 & 1.741 & 1.517 \\ 1.741 & 3.555 & 1.741 \\ 1.517 & 1.741 & 3.555 \end{pmatrix} \frac{mH}{mi}$$

$Zabc\_perlength := Rperlength + j \cdot 2 \cdot \pi \cdot freq \cdot Lperlength$ $Length := 3.2mi$

$Zabc := Zabc\_perlength \cdot Length$

$$Zabc = \begin{pmatrix} 0.548 + 4.289i & 0.305 + 2.1i & 0.305 + 1.831i \\ 0.305 + 2.1i & 0.548 + 4.289i & 0.305 + 2.1i \\ 0.305 + 1.831i & 0.305 + 2.1i & 0.548 + 4.289i \end{pmatrix} \Omega$$

$$Zm := \frac{(Zabc_{0,1} + Zabc_{0,2} + Zabc_{1,2})}{3} \qquad Zm = 0.305 + 2.01i\,\Omega$$

$$Zs := \frac{(Zabc_{0,0} + Zabc_{1,1} + Zabc_{2,2})}{3} \qquad Zs = 0.548 + 4.289i\,\Omega$$

$Z0 := Zs + 2 \cdot Zm$ $Z0 = 1.158 + 8.309i\,\Omega$

$Z1 := Zs - Zm$ $Z1 = 0.243 + 2.279i\,\Omega$

$Z012 := A1^{-1} \cdot Zabc \cdot A1$

$$Z012 = \begin{pmatrix} 1.158 + 8.309i & 0.078 - 0.045i & -0.078 - 0.045i \\ -0.078 - 0.045i & 0.243 + 2.279i & -0.155 + 0.09i \\ 0.078 - 0.045i & 0.155 + 0.09i & 0.243 + 2.279i \end{pmatrix} \Omega$$

$$Zmodal := T^{-1} \cdot Zabc \cdot T \qquad Zmodal = \begin{pmatrix} 1.158 + 8.309i & -0.179i & 0.09i \\ -0.09i & 0.243 + 2.099i & 0.179i \\ 0 & 0 & 0.243 + 2.458i \end{pmatrix} \Omega$$