EE504 Boise Bench Cloverdale Section #712-02 Double Circuit

Define transformation

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

Define Constants:

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

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

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

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

$$Hgw := (0.0) \cdot ft$$

$$Ha1 := 55 ft \qquad Ha1 = 55\,ft \qquad Ha2 := 55 ft \qquad Ha2 = 55\,ft$$

$$Hb1 := Ha1 - 12.5 ft \qquad Hb1 = 42.5\,ft \qquad Hb2 := Ha1 - 12.5 ft \qquad Hb2 = 42.5\,ft$$

$$Hc1 := Hb1 - 12.5 ft \qquad Hc1 = 30\,ft \qquad Hc2 := Hb2 - 12.5 ft \qquad Hc2 = 30\,ft$$

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

$Xa1 := 8ft$ $Xb1 := 8ft$ $Xc1 := 8ft$

$Xa2 := -8ft$ $Xb2 := -8ft$ $Xc2 := -8ft$

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

$$Dab11 := \sqrt{(Ha1 - Hb1)^2 + (Xb1 - Xa1)^2} \qquad Dab22 := \sqrt{(Ha2 - Hb2)^2 + (Xb2 - Xa2)^2}$$

$$Dac11 := \sqrt{(Ha1 - Hc1)^2 + (Xc1 - Xa1)^2} \qquad Dac22 := \sqrt{(Ha2 - Hc2)^2 + (Xc2 - Xa2)^2}$$

$$Dbc11 := \sqrt{(Hb1 - Hc1)^2 + (Xb1 - Xc1)^2} \qquad Dbc22 := \sqrt{(Hb2 - Hc2)^2 + (Xb2 - Xc2)^2}$$

$$Dab12 := \sqrt{(Ha1 - Hb2)^2 + (Xb1 - Xa2)^2} \qquad Daa12 := \sqrt{(Ha1 - Ha2)^2 + (Xa1 - Xa2)^2}$$

$$Dac12 := \sqrt{(Ha1 - Hc2)^2 + (Xc1 - Xa2)^2} \qquad Dbb12 := \sqrt{(Hb1 - Hb2)^2 + (Xb1 - Xb2)^2}$$

$$Dbc12 := \sqrt{(Hb1 - Hc2)^2 + (Xb1 - Xc2)^2} \qquad Dcc12 := \sqrt{(Hc1 - Hc2)^2 + (Xc1 - Xc2)^2}$$

GMR, diameter, and Rac from table for Bittern

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

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

$Rd := CarsonsResistConst \cdot freq$

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

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

$$Lperlength := \begin{pmatrix} Icons \cdot \ln\left(\frac{De}{GMR}\right) & Icons \cdot \ln\left(\frac{De}{Dab11}\right) & Icons \cdot \ln\left(\frac{De}{Dac11}\right) & Icons \cdot \ln\left(\frac{De}{Daa12}\right) & Icons \cdot \ln\left(\frac{De}{Dab12}\right) & Icons \cdot \ln\left(\frac{De}{Dac12}\right) \\ Icons \cdot \ln\left(\frac{De}{Dab11}\right) & Icons \cdot \ln\left(\frac{De}{GMR}\right) & Icons \cdot \ln\left(\frac{De}{Dbc11}\right) & Icons \cdot \ln\left(\frac{De}{Dab12}\right) & Icons \cdot \ln\left(\frac{De}{Dbb12}\right) & Icons \cdot \ln\left(\frac{De}{Dbc12}\right) \\ Icons \cdot \ln\left(\frac{De}{Dac11}\right) & Icons \cdot \ln\left(\frac{De}{Dbc11}\right) & Icons \cdot \ln\left(\frac{De}{GMR}\right) & Icons \cdot \ln\left(\frac{De}{Dac12}\right) & Icons \cdot \ln\left(\frac{De}{Dbc12}\right) & Icons \cdot \ln\left(\frac{De}{Dcc12}\right) \\ Icons \cdot \ln\left(\frac{De}{Daa12}\right) & Icons \cdot \ln\left(\frac{De}{Dab12}\right) & Icons \cdot \ln\left(\frac{De}{Dac12}\right) & Icons \cdot \ln\left(\frac{De}{GMR}\right) & Icons \cdot \ln\left(\frac{De}{Dab22}\right) & Icons \cdot \ln\left(\frac{De}{Dac22}\right) \\ Icons \cdot \ln\left(\frac{De}{Dab12}\right) & Icons \cdot \ln\left(\frac{De}{Dbb12}\right) & Icons \cdot \ln\left(\frac{De}{Dbc12}\right) & Icons \cdot \ln\left(\frac{De}{Dab22}\right) & Icons \cdot \ln\left(\frac{De}{GMR}\right) & Icons \cdot \ln\left(\frac{De}{Dbc22}\right) \\ Icons \cdot \ln\left(\frac{De}{Dac12}\right) & Icons \cdot \ln\left(\frac{De}{Dbc12}\right) & Icons \cdot \ln\left(\frac{De}{Dcc12}\right) & Icons \cdot \ln\left(\frac{De}{Dac12}\right) & Icons \cdot \ln\left(\frac{De}{Dbc22}\right) & Icons \cdot \ln\left(\frac{De}{GMR}\right) \end{pmatrix}$$

$$Lperlength = \begin{pmatrix} 3.555 & 1.741 & 1.517 & 1.661 & 1.584 & 1.462 \\ 1.741 & 3.555 & 1.741 & 1.584 & 1.661 & 1.584 \\ 1.517 & 1.741 & 3.555 & 1.462 & 1.584 & 1.661 \\ 1.661 & 1.584 & 1.462 & 3.555 & 1.741 & 1.517 \\ 1.584 & 1.661 & 1.584 & 1.741 & 3.555 & 1.741 \\ 1.462 & 1.584 & 1.661 & 1.462 & 1.741 & 3.555 \end{pmatrix} \frac{mH}{mi} \qquad Length := 3.2mi$$

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

$$Zabc = \begin{pmatrix} 0.548 + 4.289i & 0.305 + 2.1i & 0.305 + 1.831i & 0.305 + 2.004i & 0.305 + 1.911i & 0.305 + 1.764i \\ 0.305 + 2.1i & 0.548 + 4.289i & 0.305 + 2.1i & 0.305 + 1.911i & 0.305 + 2.004i & 0.305 + 1.911i \\ 0.305 + 1.831i & 0.305 + 2.1i & 0.548 + 4.289i & 0.305 + 1.764i & 0.305 + 1.911i & 0.305 + 2.004i \\ 0.305 + 2.004i & 0.305 + 1.911i & 0.305 + 1.764i & 0.548 + 4.289i & 0.305 + 2.1i & 0.305 + 1.831i \\ 0.305 + 1.911i & 0.305 + 2.004i & 0.305 + 1.911i & 0.305 + 2.1i & 0.548 + 4.289i & 0.305 + 2.1i \\ 0.305 + 1.764i & 0.305 + 1.911i & 0.305 + 2.004i & 0.305 + 1.764i & 0.305 + 2.1i & 0.548 + 4.289i \end{pmatrix} \Omega$$

$$Zm := \frac{(Zabc_{0,1} + Zabc_{0,2} + Zabc_{0,3} + Zabc_{0,4} + Zabc_{0,5} + Zabc_{1,2} + Zabc_{1,3} + Zabc_{1,4} + Zabc_{1,5} + Zabc_{2,3} + Zabc_{2,4} + Zabc_{2,5} + Zabc_{3}}{15}$$

$Zm = 0.305 + 1.95i\,\Omega$

$$Zs := \frac{(Zabc_{0,0} + Zabc_{1,1} + Zabc_{2,2} + Zabc_{3,3} + Zabc_{4,4} + Zabc_{5,5})}{6}$$

$Zs = 0.548 + 4.289i\,\Omega$

$Z0 := Zs + 2 \cdot Zm$ $Z0 = 1.158 + 8.188i\,\Omega$

$Z1 := Zs - Zm$ $Z1 = 0.243 + 2.339i\,\Omega$

$_{3,4} + \text{Zabc}_{3,5} + \text{Zabc}_{4,5})$