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$\mu_o := 4 \cdot \pi \cdot 10^{-7}$ H/m $\qquad \varepsilon_o := 8.854 \cdot 10^{-12}$ F/m $\qquad c := 2.998 \cdot 10^{8}$ m/s

$\rho := 1.7 \cdot 10^{-8}$ Ω m $\qquad l := 1$ m $\qquad h := 1 \cdot 10^{-3}$ m

$s := 4 \cdot 10^{-3}$ m $\qquad r := 0.5 \cdot 10^{-3}$ m $\qquad$ see figure 4.3.1

$$Rss_1 := \frac{\rho \cdot l}{\pi \cdot r^2} \qquad Rss_3 := Rss_1 \qquad Rss_2 := 0.005 \;\; \Omega$$ equation (2.5.11)

$$Fx := \frac{4 \cdot \rho}{\mu_o \cdot \pi \cdot r^2} = 6.89 \times 10^{4} \quad \text{Hz}$$ equation (2.5.14)

$$Lc_1 := \frac{\mu_o \cdot l}{2 \cdot \pi} \cdot \ln\left(\frac{2 \cdot h \cdot s}{r \cdot \sqrt{s^2 + 4 \cdot h^2}}\right) \quad \text{H}$$

$$Lc_2 := \frac{\mu_o \cdot l}{2 \cdot \pi} \cdot \ln\left(\frac{\sqrt{s^2 + 4 \cdot h^2}}{s}\right) \quad \text{H}$$ equation (2.11.3)

$$Lc_3 := Lc_1$$

$$Cc := \frac{1}{Lc} \cdot \left(\frac{l}{c}\right)^2 \quad \text{F}$$ equation (2.3.8)

$$Fq := \frac{1}{4 \cdot \sqrt{Lc_1 \cdot Cc_1}} = 7.495 \times 10^{7} \quad \text{Hz}$$ equation (2.3.9)

Component values for circuit model of figure 4.2.3:-

$$\frac{Rss}{2} = \begin{pmatrix} 0.011 \\ 2.5 \times 10^{-3} \\ 0.011 \end{pmatrix} \qquad \frac{Lc}{2} = \begin{pmatrix} 1.275 \times 10^{-7} \\ 1.116 \times 10^{-8} \\ 1.275 \times 10^{-7} \end{pmatrix} \qquad Cc = \begin{pmatrix} 4.364 \times 10^{-11} \\ 4.986 \times 10^{-10} \\ 4.364 \times 10^{-11} \end{pmatrix}$$

$$Zn := \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \;\Omega \qquad Zf := \begin{pmatrix} 10^{7} \\ 0 \\ 10^{7} \end{pmatrix} \;\Omega \qquad Gc := \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \;\text{S}$$

Figure 4.3.2 Deriving circuit parameters

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$$
\mathrm{Zbranch}(f) := \left|
\begin{array}{l}
\omega \leftarrow 2\cdot\pi\cdot f \\
\text{for } i \in 1..3 \\
\quad \left|
\begin{array}{l}
Rc_i \leftarrow Rss_i\cdot\sqrt{1+\dfrac{f}{Fx}} \\
\theta \leftarrow \sqrt{(Rc_i + j\cdot\omega\cdot Lc_i)\cdot(Gc_i + j\cdot\omega\cdot Cc_i)} \\
Zo \leftarrow \sqrt{\dfrac{Rc_i + j\cdot\omega\cdot Lc_i}{Gc_i + j\cdot\omega\cdot Cc_i}} \\
Z_{1,i} \leftarrow Zo\cdot\tanh\left(\dfrac{\theta}{2}\right) \\
Z_{2,i} \leftarrow Zo\cdot\mathrm{csch}(\theta)
\end{array}
\right. \\
Z
\end{array}
\right.
$$

equation (2.5.15)

equation (4.2.1)

equation (4.2.2)

equation (4.2.3)

equation (4.2.4)

$$
\mathrm{Zloop}(f, Zf) := \left|
\begin{array}{l}
Z \leftarrow \mathrm{Zbranch}(f) \\
Z11 \leftarrow Zn_1 + Z_{1,1} + Z_{2,1} + Z_{2,2} + Z_{1,2} + Zn_2 \\
Z12 \leftarrow -(Z_{1,2} + Z_{2,2} + Zn_2) \\
Z13 \leftarrow -(Z_{2,1} + Z_{2,2}) \\
Z14 \leftarrow Z_{2,2} \\
Z22 \leftarrow Zn_2 + Z_{1,2} + Z_{2,2} + Z_{2,3} + Z_{1,3} + Zn_3 \\
Z23 \leftarrow Z_{2,2} \\
Z24 \leftarrow -(Z_{2,2} + Z_{2,3}) \\
Z33 \leftarrow Zf_2 + Z_{1,2} + Z_{2,2} + Z_{2,1} + Z_{1,1} + Zf_1 \\
Z34 \leftarrow -(Z_{1,2} + Z_{2,2} + Zf_2) \\
Z44 \leftarrow Zf_3 + Z_{1,3} + Z_{2,3} + Z_{2,2} + Z_{1,2} + Zf_2 \\
\begin{pmatrix}
Z11 & Z12 & Z13 & Z14 \\
Z12 & Z22 & Z23 & Z24 \\
Z13 & Z23 & Z33 & Z34 \\
Z14 & Z24 & Z34 & Z44
\end{pmatrix}
\end{array}
\right.
$$

equation (4.2.6)

Figure 4.3.4 Calculating branch impedances and loop impedances

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$n := 100$ $\quad s := 1 .. 4 \cdot n$ $\quad F_s := s \cdot \frac{Fq}{n}$ $\quad$ defining the spot frequencies

$$V := \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \end{pmatrix} V$$

defining the voltage source

$$Yoc_s := \left| \begin{array}{l} f \leftarrow F_s \\ Z \leftarrow Zloop(f, Zf) \\ I \leftarrow lsolve(Z, V) \\ |I_2| \end{array} \right.$$

Main Program

Defining the current at the near end of the victim line when the far end is open-circuit. See figure 4.3.3.

Figure 4.3.5 Calculating frequency response of open-circuit transfer admittance

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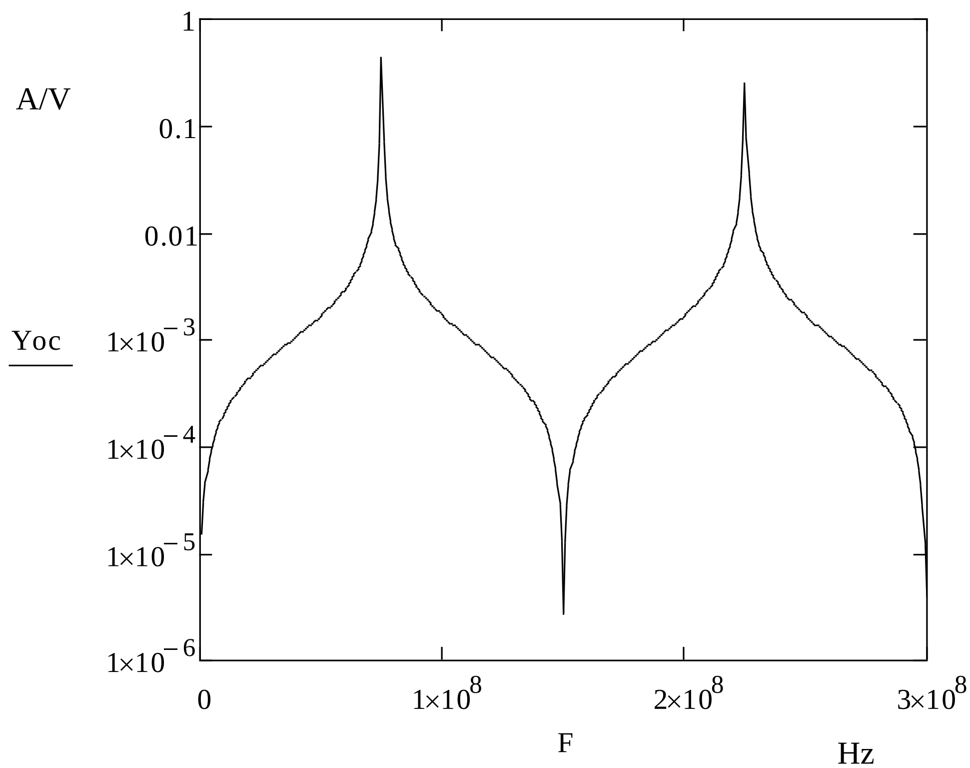

Figure 4.3.6 Transfer admittance with open circuit terminations

$$Zf := \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

$$Ysc_s := \left| \begin{array}{l} f \leftarrow F_s \\ Z \leftarrow Zloop(f, Zf) \\ I \leftarrow lsolve(Z, V) \\ \left|I_2\right| \end{array} \right.$$

Transfer admittance with short circuit terminations

$$Zf := \sqrt{\frac{Lc}{Cc}} \qquad Zf = \begin{pmatrix} 76.432 \\ 6.69 \\ 76.432 \end{pmatrix}$$

$$Ycrit_s := \left| \begin{array}{l} f \leftarrow F_s \\ Z \leftarrow Zloop(f, Zf) \\ I \leftarrow lsolve(Z, V) \\ \left|I_2\right| \end{array} \right.$$

Transfer admittance with critical damping

Figure 4.3.7 Calculating frequency response for short-circuited and critically damped lines

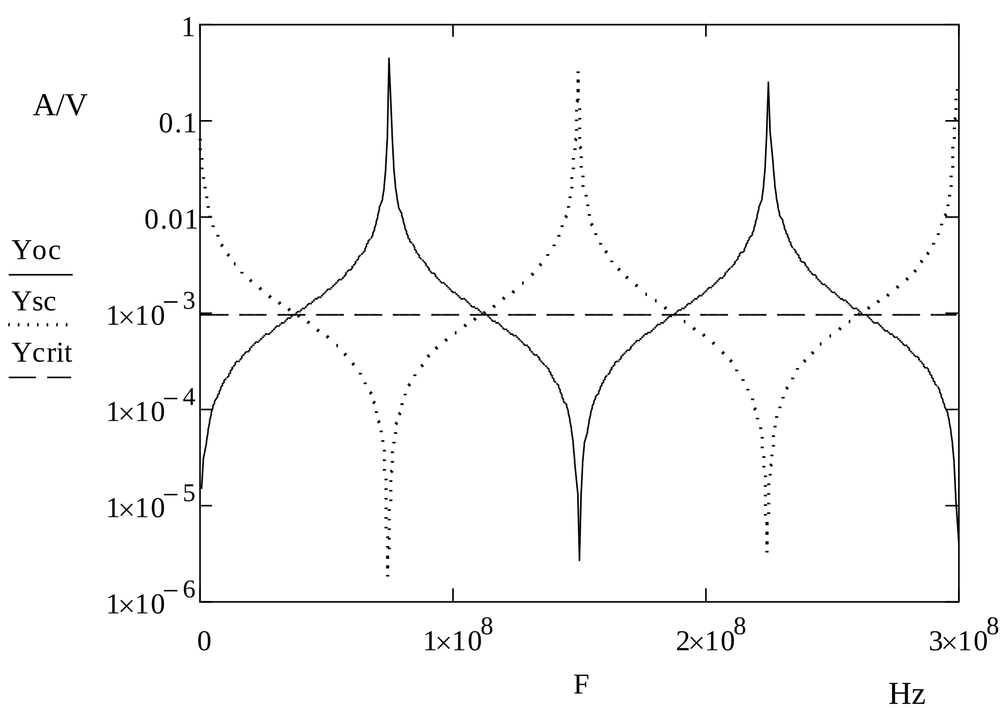

Figure 4.3.8 Transfer admittance for open circuit, short circuit, and critically damped lines.