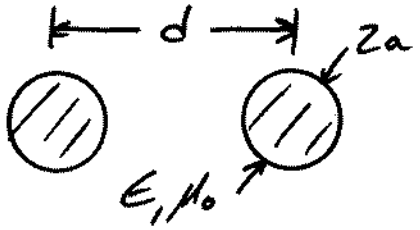
Twin-lead Transmission Line



@ 100MHz

$d = 2.6\,cm$ $\quad \sigma_{cu} = 5.8 \times 10^7\ S/m$ $\quad \epsilon = 1.9\epsilon_0$

$2a = 0.5\,cm$ $\quad \sigma_{ins} = 0.001\ S/m$ ← effective value

From Table 11.2

$$R = \frac{1}{\pi a \delta \sigma_{cu}} \quad \text{where} \quad \delta = \frac{1}{\sqrt{\pi f \mu \sigma_{cu}}}$$

$$\delta = \frac{1}{\sqrt{\pi (100\times10^6) 4\pi\times10^{-7} (5.8\times10^7)}} = 6.60855 \times 10^{-6}\ m$$

$$R = \frac{1}{\pi \left(\frac{0.5\times10^{-2}}{2}\right)(6.60855\times10^{-6})\,5.8\times10^7} = \underline{0.3322\ \Omega/m}$$

$$L = \frac{\mu}{\pi}\cosh^{-1}\left(\frac{d}{2a}\right) = \frac{4\pi\times10^{-7}}{\pi}\cosh^{-1}\left(\frac{2.6\times10^{-2}}{0.5\times10^{-2}}\right)$$

$$L = 932.972\ nH/m$$

$$G = \frac{\pi \sigma_{ins}}{\cosh^{-1}(d/2a)} = \frac{\pi (0.001)}{\cosh^{-1}\left(\frac{2.6\times10^{-2}}{0.5\times10^{-2}}\right)}$$

$$G = 1.3469\times10^{-3}\ S/m = 1.3469\ mS/m$$

$$C = \frac{\mu\epsilon}{L} = \frac{(4\pi\times10^{-7})(1.9)\,8.854\times10^{-12}}{932.972\times10^{-9}} = 22.6587\ pF/m$$

OR

$$C = \frac{\pi\epsilon}{\cosh^{-1}(d/2a)} = \frac{\pi(1.9)\,8.854\times10^{-12}}{\cosh^{-1}\left(\frac{2.6\times10^{-2}}{0.5\times10^{-2}}\right)} = 22.6587\ pF/m$$

$$\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} \quad (11.11)$$

$$= \sqrt{(0.3322 + j2\pi(100\times10^{6})932.97\times10^{-9})(1.3469\times10^{-3} + j2\pi(10^{8})22.66\times10^{-12})}$$

$$= \sqrt{(0.3322 + j586.2)(1.3469\times10^{-3} + j0.01424)}$$

$$\gamma = 0.13732 + j2.8921\ m^{-1}$$

α β

$\alpha = 0.13732\ Np/m = 20\log_{10} e^{0.1373} = 1.1927\ dB/m$

$\beta = 2.8921\ rad/m$

↖ or use $1\ Np = 8.686\ dB$

(11.19) $Z_0 = \sqrt{\frac{R+j\omega L}{G+j\omega C}} = \sqrt{\frac{0.3322 + j586.2}{1.3469\times10^{-3} + j0.01424}}$

$Z_0 = 202.22 + j9.485\ \Omega = 202.44\angle 2.685^\circ\ \Omega$

$\lambda = \frac{2\pi}{\beta} = \frac{2\pi}{2.8921} = 2.173\ m$ (11.13)

$u = \omega/\beta = \frac{2\pi(100\times10^6)}{2.8921} = 2.173\times10^8\ m/s$ (11.14)

Distortionless? Quick way $X_0 = 9.5\Omega \neq 0 \Rightarrow$ NO

(11.22) $\frac{R}{L} = 356{,}066 \neq \frac{G}{C} = 59{,}442{,}951$

Low-loss? $R \ll \omega L$?

yes → $0.3322\ \Omega/m \ll (2\pi\times10^8)(933\times10^{-9}) = 586.2\ \Omega/m$

$G \ll \omega C$?

YES yes → $1.347\times10^{-3}\ \frac{S}{m} \ll (2\pi\times10^8)(22.65\times10^{-12}) = 14.2\times10^{-3}\ S/m$