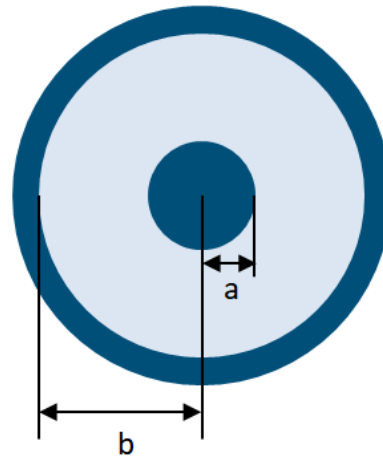


Coaxial Cable Transmission Line Design

▼ Introduction

An electrical engineer is asked to design a coaxial transmission line with a characteristic impedance of $50 \, \Omega$ and a phase velocity of at least $1.8 \times 10^8 \, \text{m s}^{-1}$

This application will calculate the outer radius of the line.



> restart :
with(Units[Simple]) :

▼ Governing Equations

Capacitance and inductance per unit length for a coaxial cable transmission line

$$> c := \frac{2 \cdot \pi \cdot \epsilon_r \cdot \epsilon_0}{\ln\left(\frac{b}{a}\right)} :$$

$$> l := \frac{\mu_0}{8 \cdot \pi} + \frac{\mu_0}{2 \cdot \pi} \cdot \ln\left(\frac{b}{a}\right) :$$

Phase velocity

$$> v_p := \frac{1}{\sqrt{l \cdot c}}$$

(2.1)

$$v_p := \frac{\sqrt{2}}{2 \sqrt{\left(\frac{\mu_0}{8\pi} + \frac{\mu_0 \ln\left(\frac{b}{a}\right)}{2\pi} \right) \pi \epsilon_r \epsilon_0 \ln\left(\frac{b}{a}\right)}} \quad (2.1)$$

Impedance of the coaxial cable transmission line

$$> Z_0 := \sqrt{\frac{l}{c}}$$

$$Z_0 := \frac{\sqrt{2}}{2} \sqrt{\left(\frac{\mu_0}{8\pi} + \frac{\mu_0 \ln\left(\frac{b}{a}\right)}{2\pi} \right) \ln\left(\frac{b}{a}\right) \pi \epsilon_r \epsilon_0} \quad (2.2)$$

▼ Parameters

Permittivity and permeability of free space

$$> \epsilon_0 := 8.854187817 \cdot 10^{-12} \text{ Fm}^{-1} :$$

$$\mu_0 := 4 \cdot \pi \cdot 10^{-7} \text{ NA}^{-2} :$$

Dielectric constant for Teflon

$$> \epsilon_r := 2.1 :$$

Set the radius of the center conductor to be 22 gauge wire

$$> Dia := 0.0253 \text{ inch} :$$

▼ Solution

$$> a := \frac{Dia}{2}$$

$$1.26 \times 10^{-2} \text{ in} \quad (4.1)$$

$$> eq := 50 \text{ ohm} = Z_0$$

$$eq := 50 \quad (4.2)$$

$$= 65420.07770 \sqrt{2}$$

$$\sqrt{\frac{\left(\frac{1}{20000000} \frac{\text{N}}{\text{A}^2} + \frac{\ln\left(\frac{79.05138340 b}{\text{in}}\right)}{5000000} \frac{\text{N}}{\text{A}^2} \right) \ln\left(\frac{79.05138340 b}{\text{in}}\right)}{\frac{\text{F}}{\text{m}}}} \text{ S}$$

> `res := fsolve(eq, {b = 2·a})`

$$\{b = 9.56 \times 10^{-4} \text{ m}\}$$

(4.3)

Hence the phase velocity is

> `evalf(eval(vp, res))`

$$1.87 \times 10^8 \frac{\text{m}}{\text{s}}$$

(4.4)

Legal Notice: © Maplesoft, a division of Waterloo Maple Inc. 2018. Maplesoft and Maple are trademarks of Waterloo Maple Inc. This application may contain errors and Maplesoft is not liable for any damages resulting from the use of this material. This application is intended for non-commercial, non-profit use only. Contact Maplesoft for permission if you wish to use this application in for-profit activities.