

**2.6** A coaxial line with inner and outer conductor diameters of 0.5 cm and 1 cm, respectively, is filled with an insulating material with  $\epsilon_r = 4.5$  and  $\sigma = 10^{-3}$  S/m. The conductors are made of copper.

- (a) Calculate the line parameters at 1 GHz.
- (b) Compare your results with those based on CD Module 2.2. Include a printout of the screen display.

**Solution:** (a) Given

$$a = (0.5/2) \text{ cm} = 0.25 \times 10^{-2} \text{ m},$$

$$b = (1.0/2) \text{ cm} = 0.50 \times 10^{-2} \text{ m},$$

combining Eqs. (2.5) and (2.6) gives

$$\begin{aligned} R' &= \frac{1}{2\pi} \sqrt{\frac{\pi f \mu_c}{\sigma_c}} \left( \frac{1}{a} + \frac{1}{b} \right) \\ &= \frac{1}{2\pi} \sqrt{\frac{\pi (10^9 \text{ Hz}) (4\pi \times 10^{-7} \text{ H/m})}{5.8 \times 10^7 \text{ S/m}}} \left( \frac{1}{0.25 \times 10^{-2} \text{ m}} + \frac{1}{0.50 \times 10^{-2} \text{ m}} \right) \\ &= 0.788 \text{ } \Omega/\text{m}. \end{aligned}$$

From Eq. (2.7),

$$L' = \frac{\mu}{2\pi} \ln \left( \frac{b}{a} \right) = \frac{4\pi \times 10^{-7} \text{ H/m}}{2\pi} \ln 2 = 139 \text{ nH/m}.$$

From Eq. (2.8),

$$G' = \frac{2\pi\sigma}{\ln(b/a)} = \frac{2\pi \times 10^{-3} \text{ S/m}}{\ln 2} = 9.1 \text{ mS/m}.$$

From Eq. (2.9),

$$C' = \frac{2\pi\epsilon}{\ln(b/a)} = \frac{2\pi\epsilon_r\epsilon_0}{\ln(b/a)} = \frac{2\pi \times 4.5 \times (8.854 \times 10^{-12} \text{ F/m})}{\ln 2} = 362 \text{ pF/m}.$$

(b) Solution via Module 2.2:

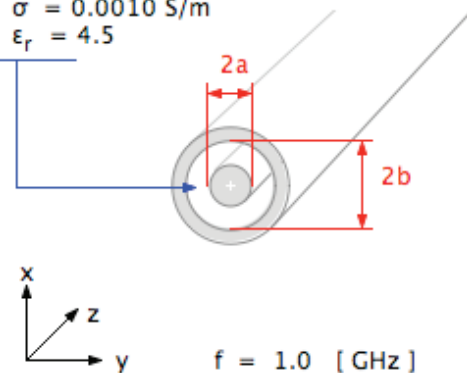
## Module 2.2

## Coaxial Cable

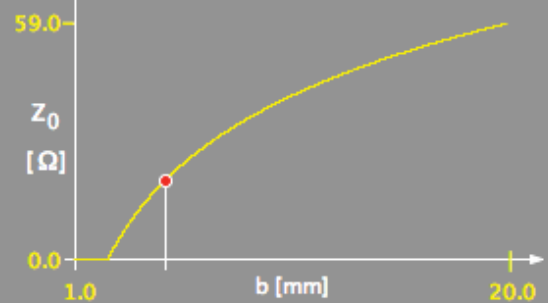
Select: Impedance vs. Radius b

$$\sigma = 0.0010 \text{ S/m}$$

$$\epsilon_r = 4.5$$



Real Part of Characteristic Impedance



### Input

Inner radius a = 2.5 [mm]

Range:

Shield radius b = 5 [mm]

Range:

Frequency f = 1.0E9 [Hz]

Range:

$\epsilon_r$

$\sigma \text{ [S/m]}$

$\sigma_c \text{ [S/m]}$

4.5

1E-3

5.8E7

Update

### Output

#### Structure Data

a = 2.5 [mm]

b / a = 2.0

b = 5.0 [mm]

$Z_0 = 19.605065 + j 0.03034369 \text{ [}\Omega\text{]}$

$C' = 360.67376 \text{ [pF/m]}$

$L' = 138.629436 \text{ [nH/m]}$

$R' = 0.787839 \text{ [}\Omega\text{/m]}$

$G' = 0.009065 \text{ [S/m]}$

$\lambda_0 = 0.3 \text{ [m]}$

in vacuum

$\lambda = 0.1414 \text{ [m]}$

in guide

$\alpha = 0.10895$

[Np/m]

$\beta = 44.428883$

[rad/m]