

**2.2** A two-wire copper transmission line is embedded in a dielectric material with  $\epsilon_r = 2.6$  and  $\sigma = 2 \times 10^{-6}$  S/m. Its wires are separated by 3 cm and their radii are 1 mm each.

- (a) Calculate the line parameters  $R'$ ,  $L'$ ,  $G'$ , and  $C'$  at 2 GHz.
- (b) Compare your results with those based on CD Module 2.1. Include a printout of the screen display.

**Solution:**

(a) Given:

$$\begin{aligned}
 f &= 2 \times 10^9 \text{ Hz}, \\
 d &= 2 \times 10^{-3} \text{ m}, \\
 D &= 3 \times 10^{-2} \text{ m}, \\
 \sigma_c &= 5.8 \times 10^7 \text{ S/m (copper)}, \\
 \epsilon_r &= 2.6, \\
 \sigma &= 2 \times 10^{-6} \text{ S/m}, \\
 \mu &= \mu_c = \mu_0.
 \end{aligned}$$

From Table 2-1:

$$\begin{aligned}
 R_s &= \sqrt{\pi f \mu_c / \sigma_c} \\
 &= [\pi \times 2 \times 10^9 \times 4\pi \times 10^{-7} / 5.8 \times 10^7]^{1/2} \\
 &= 1.17 \times 10^{-2} \Omega, \\
 R' &= \frac{2R_s}{\pi d} = \frac{2 \times 1.17 \times 10^{-2}}{2\pi \times 10^{-3}} = 3.71 \Omega/\text{m}, \\
 L' &= \frac{\mu}{\pi} \ln \left[ (D/d) + \sqrt{(D/d)^2 - 1} \right] \\
 &= 1.36 \times 10^{-6} \text{ H/m}, \\
 G' &= \frac{\pi \sigma}{\ln[(D/d) + \sqrt{(D/d)^2 - 1}]} \\
 &= 1.85 \times 10^{-6} \text{ S/m}, \\
 C' &= \frac{G' \epsilon}{\sigma} \\
 &= \frac{1.85 \times 10^{-6} \times 8.85 \times 10^{-12} \times 2.6}{2 \times 10^{-6}}
 \end{aligned}$$

$$= 2.13 \times 10^{-11} \text{ F/m.}$$

(b) Solution via Module 2.1:

