A coaxial transmission line, operating at 3.6 GHz, has the distributed parameters $R = 3.8\ \Omega/\text{m}$, $L = 248$ nH/m, $G = 6.4$ mS/m, and $C = 112$ pF/m. Calculate the a) propagation constant, b) attenuation constant (both Np/m and dB/m), c) phase constant, d) characteristic impedance (both polar & rectangular forms), e) wavelength, and f) phase velocity (m/s and fraction of c).

- Used MathCAD for precision in all calculations.

a) Per (2.5), the propagation constant is

$$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)} = \alpha + j\beta$$
$$= \sqrt{[3.8 + j(2\pi 3.6\times 10^9)248\times 10^{-9}][6.4\bullet 10^{-3} + j(2\pi 3.6\times 10^9)112\times 10^{-12}]}$$

$\Rightarrow$ **γ = 0.19096 + j 119.2113 1/m**

b) the attenuation constant is $\alpha = \text{Re}(\gamma)$ $\Rightarrow$ **α = 0.19096 Np/m**

$\alpha = 0.01568$ Np/m (8.6859 dB/Np) $\Rightarrow$ **α = 1.65863 dB/m**

c) the phase constant is $\beta = \text{Im}(\gamma)$ $\Rightarrow$ **β = 119.2113 rad/m**

d) Per (2.7), the characteristic impedance is

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}} = \sqrt{\frac{3.8 + j(2\pi 3.6\times 10^9)248\times 10^{-9}}{6.4\bullet 10^{-3} + j(2\pi 3.6\times 10^9)112\times 10^{-12}}}$$

$\Rightarrow$ **Z_0 = 47.0561 + j 0.435 Ω = 47.0561∠0.05297° Ω**

d) Per (2.10), the wavelength is

$$\lambda = \frac{2\pi}{\beta} = \frac{2\pi}{119.2113}$$ $\Rightarrow$ **λ = 0.052706 m = 5.2706 cm**

e) Per (2.11) and using $c = 2.9979\times 10^8$ m/s, the phase velocity is

$$v_p = \frac{\omega}{\beta} = \frac{2\pi(3.6\times 10^9)}{119.2113}$$ $\Rightarrow$ **$v_p = 1.89743\times 10^8$ m/s = 0.6329c**