EE 382 Applied EM Quiz #2 (Spring 2018)

Name Key A

Instructions: Closed book & notes. Show all work for full credit.

Equations: $\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} = \alpha + j\beta$, $u = f\lambda = \frac{\omega}{\beta}$, $Z_0 = \sqrt{\frac{(R+j\omega L)}{(G+j\omega C)}}$, $\lambda = \frac{2\pi}{\beta}$

A 150 m long coaxial transmission line has the per-unit-length parameters: R = 1.6 Ω/m, L = 310 nH/m, G = 3 mS/m, and C = 125 pF/m. If the transmission line is and carries a time-harmonic signal operating at 700 MHz, find the attenuation, phase, & propagation constants, wavelength, phase velocity, and characteristic impedance. **(EXPRESS COMPLEX NUMBERS IN RECTANGULAR FORMAT)**

$\omega = 2\pi f = 2\pi(700\times10^6) = 1.4\pi\times10^9$ rad/s $= 4.398\times10^9$ rad/s

(11.11) $\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} = \sqrt{(1.6+j\,1.4\pi\times10^9(310\times10^{-9}))(0.003+j\,1.4\pi\times10^9(125\times10^{-12}))}$

$\gamma = 0.090764 + j\,27.378822\ m^{-1}$ ← prop. constant

(α (atten.) β (phase))

(11.13) $\lambda = 2\pi/\beta = \frac{2\pi}{27.3788} = 0.229491$ m

(11.14) $u = \omega/\beta = \frac{1.4\pi\times10^9}{27.3788} = 1.60643\times10^8$ m/s

(11.19) $Z_0 = \sqrt{\frac{R+j\omega L}{G+j\omega C}} = \sqrt{\frac{1.6+j\,1.4\pi\times10^9(310\times10^{-9})}{0.003+j\,1.4\pi\times10^9(125\times10^{-12})}}$

$= 49.79913 + j\,0.10665\ \Omega$

attenuation constant = 0.090764 Np/m phase constant = 27.378822 rad/m

propagation constant = 0.09076 + j 27.3788 1/m wavelength = 0.229491 m

phase velocity = 1.60643×10^8 m/s characteristic impedance = $49.79913 + j\,0.10665\ \Omega$

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Name Key B

Instructions: Closed book & notes. Show all work for full credit.

Equations: $\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} = \alpha + j\beta$, $u = f\lambda = \frac{\omega}{\beta}$, $Z_0 = \sqrt{\frac{(R+j\omega L)}{(G+j\omega C)}}$, $\lambda = \frac{2\pi}{\beta}$

A 250 m long coaxial transmission line has the per-unit-length parameters: R = 2.7 Ω/m, L = 450 nH/m, G = 2 mS/m and C = 90 nF/m. If the transmission line is and carries a time-harmonic signal operating at characteristic impedance. **(EXPRESS COMPLEX NUMBERS IN RECTANGULAR FORMAT)**

$\omega = 2\pi f = 2\pi \times 900\times10^6 = 1.8\pi \times 10^9$ rad/s $= 5.655 \times 10^9$ rad/s

(11.11) $\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} = \sqrt{(2.7+j1.8\pi\times10^9(450\times10^{-9}))(0.002+j1.8\pi\times10^9(90\times10^{-12}))}$

$\gamma = 0.089802 + j35.987389\ m^{-1}$ ← prop. constant

α (atten. constant) $\quad \beta$ (phase constant)

(11.13) $\lambda = 2\pi/\beta = \frac{2\pi}{35.987} = 0.174594$ m

(11.14) $u = \omega/\beta = \frac{2\pi(900\times10^6)}{35.987} = 1.57135 \times 10^8$ m/s

(11.19) $Z_0 = \sqrt{\frac{R+j\omega L}{G+j\omega C}} = \sqrt{\frac{2.7+j1.8\pi\times10^9(450\times10^{-9})}{0.002+j1.8\pi\times10^9(90\times10^{-12})}}$

$= 70.71035 + j0.10142\ \Omega$

attenuation constant = 0.089802 Np/m phase constant = 35.98739 rad/m

propagation constant = 0.0898 + j35.9874 m^{-1} wavelength = 0.174594 m

phase velocity = 1.57135×10^8 m/s characteristic impedance = 70.71035 + j0.1014 Ω