Assuming a frequency of 90 MHz, is the transmission line of problem 11.18 low loss? Why or why not? Regardless, in a table, compare the exact values of α, β, $u$, and $Z_0$ from 11.18 to those calculated using the low loss approximations. Table format: Column 1 variable, column 2 exact value, column 3 low loss approximate value, column 4 percent difference.

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From 11.18, **$u$ = 50,000 m/s = $5*10^4$ m/s, $\alpha$ = 0.1 dB/m = 0.006907755 Np/m**

**$L$ = 0.0012 H/m = 1.2 mH/m, $C$ = $3.333*10^{-7}$ F/m = 333.333 nF/m**

**$G$ = $1.1513*10^{-4}$ S/m = 115.13 μS/m, $R$ = 0.41445 Ω/m**

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From notes, a transmission line must have $R << \omega L$ and $G << \omega C$ to be low loss.

**Check-**

**Is $R$ = 0.41445 Ω/m much less than $\omega L = (2\pi)90*10^6(0.0012) = 678584$ Ω/m? YES**

**Is $G$ = $1.1513*10^{-4}$ S/m much less than $\omega C = (2\pi)90*10^6(3.333*10^{-7}) = 188.5$ S/m? YES**

**⇒ TL of 11.18 is low loss at 90 MHz**

Assuming **low loss**-

$$\alpha_{LL} \approx 0.5\left[R\sqrt{\frac{C}{L}} + G\sqrt{\frac{L}{C}}\right] = 0.5\left[0.41445\sqrt{\frac{3.33333\bullet10^{-7}}{0.0012}} + 1.1513\bullet10^{-4}\sqrt{\frac{0.0012}{3.33333\bullet10^{-7}}}\right].$$

**⇒ $\alpha_{LL}$ = 0.00690765 Np/m**

$$\beta_{LL} \approx \omega\sqrt{LC} = 2\pi 90\bullet10^6\sqrt{0.0012(3.3333333\bullet10^{-7})}$$ **⇒ $\beta_{LL}$ = 11309.73355 rad/m**

**Note that the low loss equation for the phase constant $\beta_{LL}$ is the same as the exact equation (11.23a) for the phase constant $\beta$ of a distortionless TL.**

$$u_{LL} \approx 1/\sqrt{LC} = 1/\sqrt{0.0012(3.3333333\bullet10^{-7})}$$ **⇒ $u_{LL}$ = 50,000 m/s**

**Note that the low loss equation for the phase velocity $u_{LL}$ is the same as the exact equation (11.23c) for the phase velocity $u$ of a distortionless TL.**

$$Z_{0,LL} = \sqrt{\frac{L}{C}\left[1+\frac{1}{2j\omega}\left(\frac{R}{L}-\frac{G}{C}\right)\right]} = \sqrt{\frac{L}{C}} \text{ since } \frac{R}{L}=\frac{G}{C} \text{ for distortionless TL}$$

$$= \sqrt{\frac{0.0012}{3.3333333\bullet10^{-7}}}$$

**⇒ $Z_{0,LL}$ = 60 Ω**

**Note that the low loss equation for the characteristic impedance $Z_{0,LL}$ is the same as the exact equation (11.23b) for the characteristic impedance $Z_0$ of a distortionless TL.**

| **Variable** | **Exact** | **Low loss approximation** | **% difference** |
|---|---|---|---|
| $\alpha$ | **0.006907755 Np/m** | **0.00690765 Np/m** | **0.0015** |
| $\beta$ | **11309.73355 rad/m** | **11309.73355 rad/m** | **0** |
| $u$ | **50,000 m/s** | **50,000 m/s** | **0** |
| $Z_0$ | **60 Ω** | **60 Ω** | **0** |

- Virtually no difference for all the quantities for this low loss distortionless TL.