11.18 A distortionless cable is 4 m long and has a characteristic impedance of 60 Ω. An attenuation of 0.24 dB is observed at the receiving end. Also, a signal applied to the cable is delayed by 80 μs before it is measured at the receiving end. Find *R*, *G*, *L*, and *C* for the cable.

- First, find the phase velocity u and attenuation constant α (Np/m & dB/m).

****

From physics, $d = u*t$, $u = d/t = 4\text{ m}/80*10^{-6}\text{ s}$ $\Rightarrow$ **$u = 50{,}000\text{ m/s} = 5*10^4\text{ m/s}$**

From given info, $\alpha = 0.24\text{ dB}/4\text{ m}$ $\Rightarrow$ **$\alpha = 0.1\text{ dB/m}$**

$\alpha = 0.24\text{ dB}/4\text{ m}\ (1\text{ Np}/8.6858896\text{ dB})$ $\Rightarrow$ **$\alpha = 0.006907755\text{ Np/m}$**

****

Per (11.22), $\frac{R}{L} = \frac{G}{C} \Rightarrow RC = GL$. Per (11.23a), $\alpha = \sqrt{RG} \Rightarrow \alpha^2 = RG$.

Per (11.23b), $Z_0 = \sqrt{\frac{L}{C}}$. Per (11.23c), $u = \frac{1}{\sqrt{LC}}$.

Note, $Z_0 / u = \sqrt{\frac{L}{C}}\sqrt{LC} = L$. $L = Z_0 / u = 60 / 50000$ $\Rightarrow$ **$L = 0.0012\text{ H/m} = 1.2\text{ mH/m}$**

Per (11.23c), $u^2 = \frac{1}{LC} \Rightarrow C = \frac{1}{Lu^2} = \frac{1}{0.0012(5\cdot 10^4)^2}$

$\Rightarrow$ **$C = 3.333*10^{-7}\text{ F/m} = 333.3\text{ nF/m}$**

Note, $\alpha / Z_0 = \sqrt{RG} / \sqrt{\frac{L}{C}} = \sqrt{\frac{RGC}{L}}$. Substitute $RC = GL$ to get $\alpha / Z_0 = \sqrt{\frac{(GL)G}{L}} = G$.

$G = \alpha / Z_0 = 0.006907755/60$ $\Rightarrow$ **$G = 1.1513*10^{-4}\text{ S/m} = 115.13\ \mu\text{S/m}$**

From (11.23a), $R = \alpha^2 / G = 0.006907755^2/1.1513*10^{-4}$ $\Rightarrow$ **$R = 0.41445\ \Omega\text{/m}$**