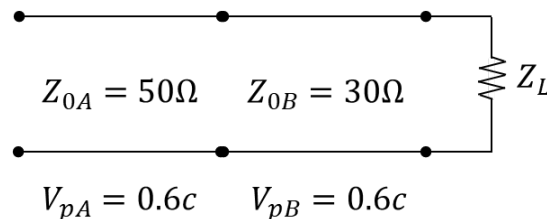


EE3109 Applied Electromagnetics
2022/23 Semester B
Assignment 3

1. A low loss transmission line has the following properties: $R' \ll j\omega L'$; $G' \ll j\omega C'$. Find expressions for α , β , v_p and Z_0 for the low loss transmission line; show that these expressions approach the lossless counterparts when R' and $G' \rightarrow 0$.
2. (Adapted from a previous test question) A microwave network analyzer with a port impedance of 50Ω measures the input reflection coefficient of a microwave circuit as $\Gamma = 0.1\angle -60^\circ$ at a frequency of 2 GHz. The circuit being measured is pictured below. Both transmission lines are lossless. A time domain measurement with a 5 GHz voltage wave input shows the arrival times of the first two reflection signals at 7.25 ns and 13.5 ns respectively. Answer the following for the frequency of 2 GHz.
 - (a) What are the electrical lengths of transmission line sections A and B?
 - (b) What is the reflection coefficient at junction between transmission lines A and B?
 - (c) What is the load impedance?
 - (d) What percentage of the incident power is delivered to the load?
 - (e) Write the current as a function of position along transmission line B.
 - (f) Where does the first voltage minimum appear relative to the load?



3. A 30Ω lowloss transmission line is terminated with a microwave device, whose load can be modelled by a series connection of a resistor $R = 15\Omega$ and a capacitor $C = 50\text{ pF}$. The line length is 25cm. The phase velocity for a 500 MHz wave along this line is $1.5 \times 10^8\text{ [m/s]}$. A voltage wave taking a round trip along the transmission line experiences a loss of 0.1 dB.
 - (a) Find the load impedance.
 - (b) Find the phase constant, attenuation constant and wavelength of a voltage wave along this TL.
 - (c) Design an L-section matching circuit that matches this load impedance to the transmission line.
 - (d) Design a single stub tuner that matches this load impedance to the transmission line. Choose the solution that leads to the shortest stub length for an open-circuited shunt stub.
 - (e) Use a shunt reactive load and a quarter-wave transformer to match the load impedance to the transmission line. What is the length and impedance of the quarter-wave transformer?
4. The goal of this question is to design a co-axial transmission line, with an inner and outer conductor radii of a and b respectively.
 - (a) Derive the per-unit-length capacitance and inductance of the co-axial transmission line. (Most of this is done for you in the course notes.)
 - (b) Find the characteristic impedance and phase velocity of the lossless co-axial transmission line.
 - (c) For a dielectric material with $\epsilon_r = 2.2$, design a co-axial TL with $Z_0 = 75\Omega$. Choose the outer conductor radius to be the same as that for an RG-59 cable.
5. **(10% BONUS)** Prove that one can find the admittance point on the Smith Chart at a location diametrically opposite (same distance from the origin, but in the opposite direction) to the impedance point. Hint: remember the Smith Chart's relationship with the reflection coefficient.