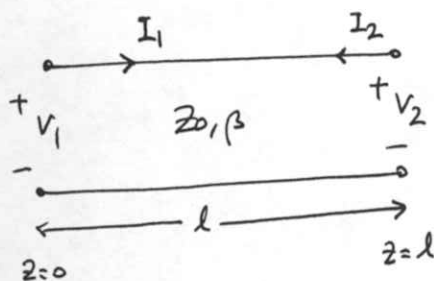


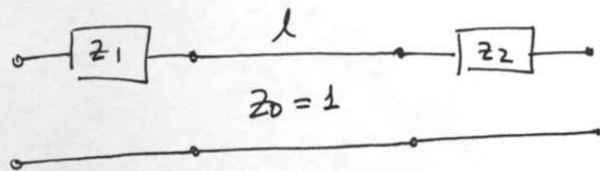
① A microstrip antenna is supposed to be matched to a source having a generator impedance of 50Ω . The input impedance of this antenna is also 50Ω , and the connection is to be made with a microstrip line. The thickness (d) of the substrate is 0.127 cm and $\epsilon_r = 2.2$. Determine the width and length of this microstrip line such that its characteristic impedance is $Z_0 = 50\Omega$ and it will supply a 90° phase shift at 2.5 GHz .

② Consider a waveguide mode propagating in an air-filled waveguide. Calculate the group velocity, and compare it to the phase velocity and speed of light.

③ Find the Z and Y parameters of the following transmission line segment.



④ Use the result of problem ③ to find the Z -parameters of the following lossless 2 port junction.



(b) What happens to the Z -parameters

if $\beta l = \frac{\pi}{2}$