Exam-01

1. Consider a 1st 50 Ω transmission line (T-line), transmitting a sinusoidal signal with wavelength λ, having a length of $\ell = 2\lambda$, with an impedance-matched transmitter at one end and an impedance-matched receiver at the other end. Next we connect a 2nd 50 Ω T-line to the middle point of the 1st T-line. The 2nd T-line has various lengths and terminations.
   (a) Draw the experimental setup and label all objects appropriately.
   (b) Assume that the 2nd T-line is lossless, has a length of $\ell = (1/4)\,\lambda$, and is terminated by an OC (open circuit). Describe how the signal at the receiver changes when connecting the 2nd T-line.
   (c) Assume that the 2nd T-line is lossy (so that the signal strength is negligible after having propagated for a length of $\ell = 10\,\lambda$), has a length of $\ell = 20\,\lambda$, and terminated by an SC (short circuit). Describe how the receiver signal changes when connecting the 2nd T-line.
   (d) Assume that the 2nd T-line is lossless, has a length of $\ell = (1/100)\,\lambda$, and is terminated by an SC. Describe how the receiver signal changes when connecting the 2nd T-line.

2. A sinusoidal 1 GHz wave propagating on a transmission line (T-line) has a wavelength of $\lambda = 10$ cm. Assume that the T-line is lossless and has a capacitance per unit length of $C' =$ 150 pF/m.
   (a) Calculate the phase velocity v_{phase}, attenuation constant α, phase constant β, and propagation constant γ?
   (b) Calculate the inductance per unit length, L', of the T-line.
   (c) Next, consider a different coaxial T-line; it is found to be too lossy for a certain application. You are charged with re-designing the T-line. Which specific design changes would you propose in order to improve the T-line?

3. The termination of a 50 Ω transmission line (T-line) consists of a capacitor (C = 10 nF) in a parallel circuit to an inductor (L = 10 nH).
   (a) Draw the electrical circuit of the termination. Calculate the impedance of the termination (symbolic expression).
   (b) Determine the voltage reflection coefficient Γ at the angular frequencies $\omega = 2\pi f$ = 0 Hz, 100 MHz, and ∞ Hz. Explain the results in your own words.
   (c) Assume that a resistor R, in parallel to C and L, is added to the load. For ω = 100 MHz, qualitatively describe how the voltage reflection coefficient Γ changes.

4. Are the following statements (***i***) true, (***ii***) false, or (***iii***) impossible to determine due to lack of information?
   (a) A lossless transmission line with length of 7/4 λ that is terminated by an open circuit has a voltage node at its front end that acts like a short circuit.
   (b) For very long lossy T-lines, there is no or little effect of the termination (Z_{Load}) on the input side of the T-line.