ECE 3317
Fall 2023

Homework #6

Assigned: Thursday, Oct. 5
Due: Tuesday, Oct. 17

Note: In this homework set we are in the sinusoidal steady-state (phasor domain). Please use the Smith chart and turn in Smith charts for each problem, clearly showing your work on the charts.

1) From the Smith chart, find the complex load reflection coefficient Γ_L for the following values of Z_L^N listed below. Do this by measuring distances and angles on the Smith chart. Note: One of the scales on the outside of the Smith chart should give you the phase angle of the reflection coefficient (or you can just use a protractor to measure the angle). Put your answers in polar form.

   (a) $0.6 - j0.4$

   (b) 0

   (c) ∞

   (d) $3.5 + j2.0$

2) From the Smith chart, find the normalized input admittances corresponding to the following normalized input impedances:

   (a) $Z_{in}^N = 0.7 - j0.3$

   (b) $Z_{in}^N = 4 + j3$

   (c) $Z_{in}^N = j\infty$

3) A transmission line is terminated in a normalized load impedance of $Z_L^N = 2.0 - j\,(1.5)$.

   a) Use the Smith chart to find the reflection coefficient at the load (both magnitude and phase). What percent of the incident power is reflected back from the load?

   b) Sketch $|V(z)|$, assuming $|V^+(z)| = 1$. Do this by using the Smith chart as a crank diagram. The sketch does not have to be an accurate plot, but indicate clearly on your diagram the values of $V_{\max}$ and $V_{\min}$ and their positions.

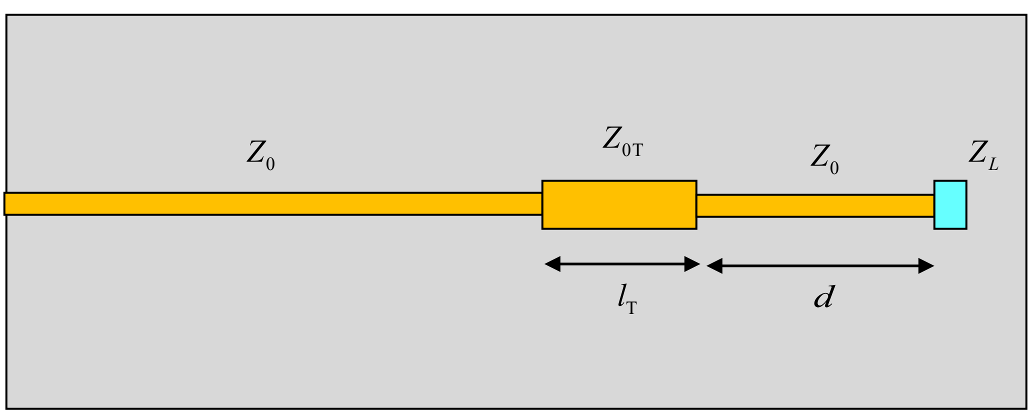
4) A 50 [Ω] transmission line (i.e., the characteristic impedance is 50 [Ω]) has an unknown load impedance Z_L. The SWR is 1.8 and a voltage minimum occurs at $z = -0.15\lambda_d$. Find Z_L using the Smith chart.

5) A 50 [Ω] transmission line (i.e., the characteristic impedance is 50 [Ω]) has an unknown load impedance Z_L. A voltage minimum occurs at $z = -0.30\lambda_d$. At $z = -0.10\lambda_d$ the real part of the impedance is 60 [Ω]. Find Z_L using the Smith chart.

6) A 50 [Ω] transmission line (i.e., the characteristic impedance is 50 [Ω] has a load impedance of $Z_L = 30 + j\,(75)$ [Ω]. Find the normalized load admittance at a distance of $0.4\lambda_d$ from the load, using the Smith chart.

7) A transmission line has a normalized load impedance of $Z_L^N = 0.5 - j\,(0.2)$. The transmission line has a characteristic impedance of 50 [Ω]. Find: (a) the stub length l_s (in terms of λ_d on the stub line) of a short-circuited stub to be placed in parallel with the load, and (b) the characteristic impedance Z_{0T} of a quarter-wave transmission line connected to the load, which will provide a quarter-wave transformer matching system for the line. Assume that the characteristic impedance of the stub line is also 50 [Ω]. Use the Smith chart to do all of the calculations necessary to find the stub length, and compare with what you get by using exact equations.

8) A microstrip line on a circuit board with $Z_0 = 50$ [Ω] is connected to a load impedance $Z_L = 100 - j(100)$ [Ω]. In order to match the line to the load, a quarter-wave transformer with characteristic impedance Z_{0T} is inserted a distance d from the load, where the input impedance is real. Determine: (a) the length l_T of the microstrip transformer line, and (b) the characteristic impedance Z_{0T} of the microstrip transformer line. Assume that the frequency is 2.0 GHz and the effective permittivity of the microstrip line is 2.0. Use the Smith chart to determine the distance d. Use the shortest possible distance d that you can in your solution. A top view of the circuit board is shown below.



9) A transmission line has a normalized load impedance of $Z_L^N = 0.5 - j\,(0.2)$. Find: (a) the stub position d and (b) the stub length l_s (in terms of λ_d on the stub line) in order to provide a single stub matching system for the line, using a shorted stub. Use the Smith chart. (Show both possible solutions.) Assume that both the main line and the stub line have the same characteristic impedance (but you do not need to know what this value is, since the load impedance was given as a normalized value).