THIS IS A CLOSED BOOK QUIZ

Electromagnetic Fields and Waves -- EE117. Quiz 1. SPRING 2021

Instructor: Prof. Boubacar Kanté 9:40am-11:00am 02/18/2021

- The solution should be scanned (if written on paper) and submitted to Gradescope "Quiz 1", similar to previous homework submissions.
- The submission deadline is 11am at the end of the class, with additional 5 mins grace period for scanning & submission.
- The quiz is closed book, but one-page cheat sheet is allowed. No online resource is allowed.
- Partial credits will be given if the derivation is correct but the answer is wrong.
- Please keep camera on during the quiz.
- If you have questions during the quiz, please post it in Zoom chat.

Honor Pledge: I have neither given nor received any aid on this quiz.

Signature: _____

Problem 1 **[Transmission lines]. (50 points)**

Consider a system in Fig. 1(a) that operates under the frequency $f = 3\,GHz$. The system comprises a feeding transmission line (TL1) of characteristic impedance $Z_{01} = 50\,\Omega$ that is connected to two identical transmission lines (TL3a and TL3b) through a transmission line TL2 of impedance Z_{02}. The length of TL2 is $l_2 = \lambda/4$ and the length of TL3(a) and TL3(b) is $l_3 = 5\lambda/2$. The transmission lines TL3a and TL3b are terminated by load impedance Z_L. The system is excited by an incident wave of voltage amplitude of $1V$ in TL1.

1) The load impedances are given by $Z_L = 70\,\Omega$. The characteristic impedance of TL2 is $Z_{02} = 50\,\Omega$. Find the input impedance and reflection coefficient at port AA'. Give expressions for the phasor and instantaneous voltage and current in TL1.

2) The load impedances are again $Z_L = 70\,\Omega$. Find a value of the characteristic impedance Z_{02} that leads to no reflected wave in TL1 (i.e. perfect matching between TL1 and the rest of the system).

3) With the matching conditions in item 2 in place, is there a standing wave in TL1? Is there a standing wave in TL2?

4) Now, the load impedances are replaced with complex impedances $Z_L = 70\,\Omega - j20\,\Omega$ and the characteristic impedance Z_{02} is given by $Z_{02} = 50\,\Omega$. A matching circuit is inserted at the port AA'. It consists of a reactive (imaginary) impedance jX and resistive (real) impedance R connected as shown in Fig. 1(b). Find the values of the reactance (X) and resistance (R) leading to matching between TL1 and the rest of the system (on the right).

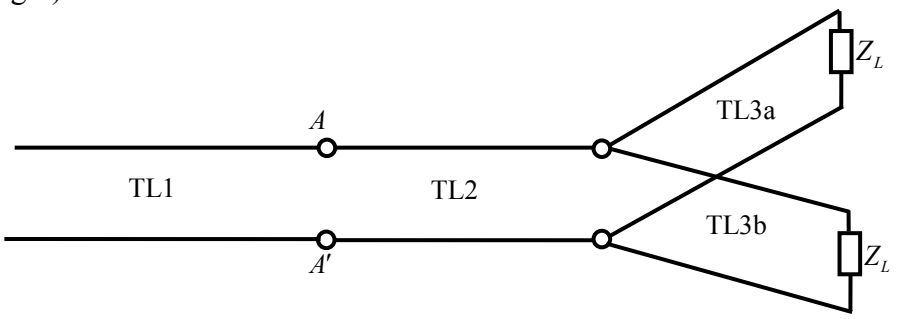

Fig. 1(a)

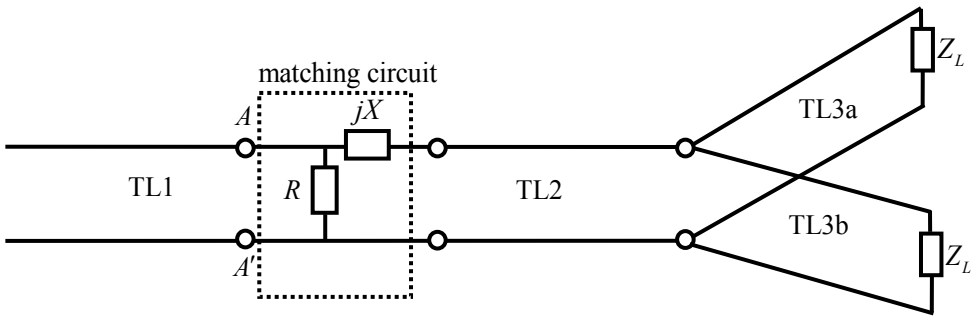

Fig. 1(b)

<u>Problem 2</u> [electrostatic]. (50 points)

Consider a sphere of radius R, and total charge Q. The total charge is uniformly distributed through the volume of the sphere.

1) Establish an expression of the electric field inside the sphere.
2) Establish an expression of the electric field outside the sphere
3) Plot the electric field E as a function of r with r<R and r>R on the same plot. Is E(r) continuous at r=R? Plot the potential V(r).
4) Same questions 1-3 with the charge Q only on the surface of the sphere with a uniform surface charge density.