Electromagnetics Spring 2020

Homework 8

Deadline:

说明：全用英文作答；

每道题要对所有小问作答，要给出全部必要的推导过程，计算题要算出最终的数值结果，比如开根号之类的；

所有计算出来的结果如果是有单位的物理量，一定要写明单位；

每题的分数在括号中给出；

可以互相讨论，也可以上网查，但是不能抄袭，也不能找别人代做；

可以在电脑敲字解答，也可以手写解答，最后统一转换为 PDF 格式，按分组信息邮件 或 BB 上提交；

邮件主题&附件命名规范:姓名_章节，不按规范发送扣除一半分数；

请在作业 PDF 的第一行写上姓名和学号；

有问题请给老师或助教发邮件；

Textbook: Fundamentals of Applied Electromagnetics, 7th edition

Part I. Problems in textbook. (320)

2.6 (10 points) Do not need to do (b).

2.13 (20 points)

2.20 (30 points)

2.26 (20 points)

2.32 (30 points) Do not need to do (f).

2.33 (30 points)

2.34 (30 points)

2.38 (30 points)

2.41 (30 points) Do not need to use the CD Module.

2.42 (40 points)

2.43 (10 points)

2.45 (20 points)

2.46 (20 points)

PART II. Problems in quiz (156)

1. (**19 points**)

(a) (**3 points**) When we analyze a circuit, in what condition do we need to use the transmission line theory?

(b) (**8 points**) For a piece of TEM transmission line, draw its lumped element model and label all elements properly. You also need to give the units of all the symbols (except Δz) you use in this model.

(c) (**2 points**) Write out the wave equation of the total voltage $V(z)$ on a transmission line using $V(z)$ and the propagation constant γ.

(d) (**2 points**) Write out the general solution of the wave equation you got in (c).

(e) (**2 points**) Write out the expression of the propagation constant γ in terms of the symbols you used in (b).

(f) (**2 points**) Write out the expression of the characteristic impedance Z_0 in terms of the symbols you used in (b).

2. (**16 points**)
(a) (**2 points**) Write out the reflection coefficient Γ at the load by Z_{L} and Z_0.

(b) (**2 points**) What is Γ if the line is short-circuited?

(c) (**2 points**) What is Γ if the line is open circuited?

(d) (**2 points**) Besides the short-circuited and open-circuited cases, what other kinds of load can also cause a total reflection on a transmission line?

(e) (**2 points**) Write out the total voltage on a transmission line in terms of V_0^+ and Γ.

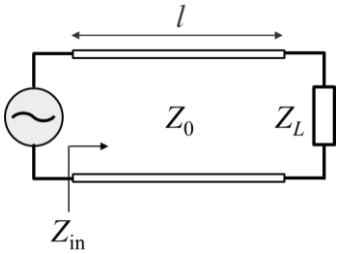
(f) (**2 points**) Write out the total current on a transmission line in terms of V_0^+, Γ and Z_0.

(g) (**2 points**) When the total voltage on the transmission line gets minimum at a location, does the total current get maximum or minimum at the same location?

(h) (**2 points**) For a transmission line terminated with a load having inductive reactance, the first voltage maxima is closer to the load or the first voltage minima is closer to the load?

3. (**9 points**)

(a) (**3 points**) For the transmission line shown below, write out Z_{in} in terms of Z_L and Z_0.



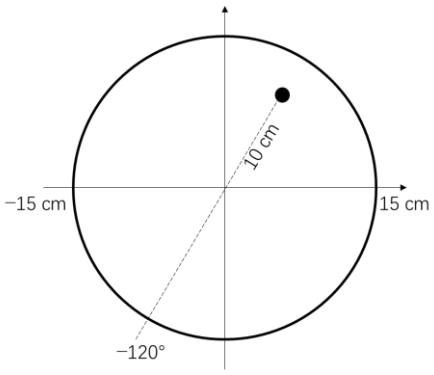
(b) (**2 points**) How much is the total voltage on the input of the transmission line if the source voltage is V_g and the internal impedance of the source is Z_g?

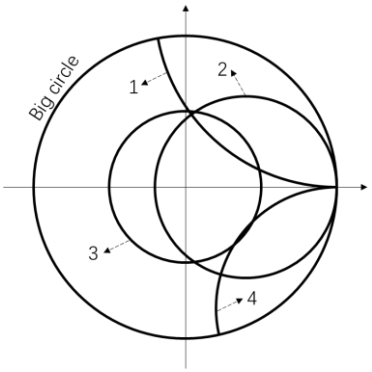
(c) (**2 points**) If the transmission line is half-wavelength long, what is Z_{in}?

(d) (**2 points**) If we want to get an open circuit ($Z_{in} = \infty$) by a short-circuited transmission line, how long should the transmission line be?

4. (**19 points**)

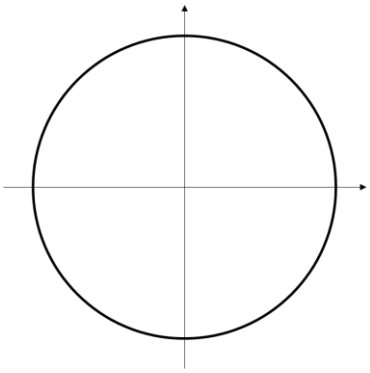
(a) (**2 points**) Calculate the reflection coefficient of the point marked by a black spot in the first simplified Smith chart shown below. The circle is the big circle in Smith chart.

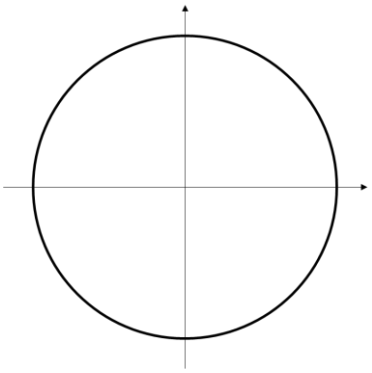




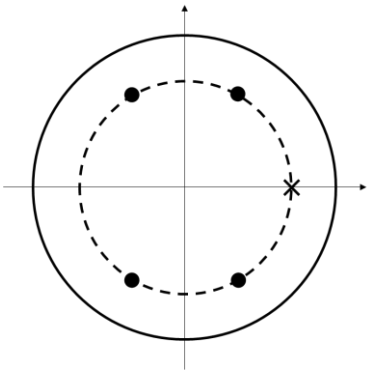
(b) (**4 points**) Write out the names of the four circles in the second Smith chart shown above.

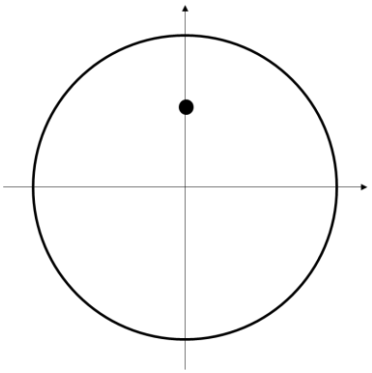
(c) (**5 points**) Label the matching point, open-circuited point and short-circuited point in the first Smith chart shown below. Label the pure reactance curve and pure resistance curve in the second Smith chart shown below.





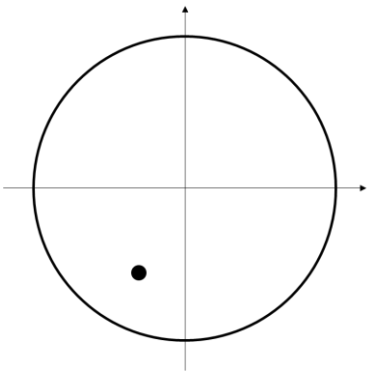
(d) (**2 points**) A load is marked as the black cross in the first Smith chart shown below. After connecting a $\lambda/6$-long transmission line, where should the input impedance be? Circle one dot.





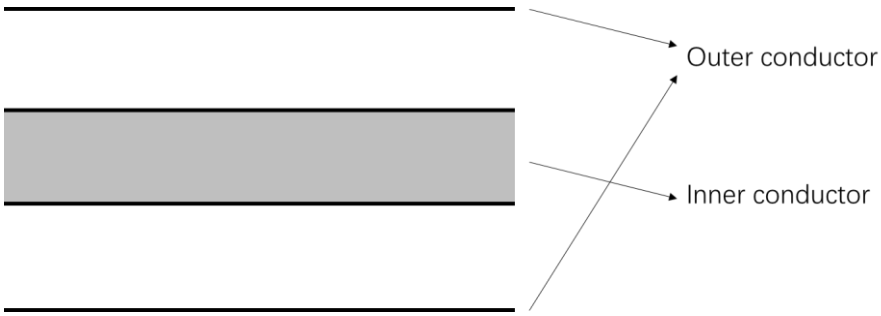
(e) (**4 points**) A load terminating a transmission line is marked as the black spot in the second Smith chart shown above. How long is the distance between the first voltage maxima to the load? How long is the distance between the first voltage minima to the load?

(f) (**2 points**) Describe the simple way to obtain the SWR value of a load marked as the black spot shown in the first Smith chart shown below.



5. (**14 points**)

(a) (**8 points**) Draw the voltage, current, electric field intensity and magnetic field intensity distributions on a piece of coaxial transmission line shown below. Need to specify all the directions of the four quantities. Also need to use some way to illustrate the variation of the magnitude of the four quantities.

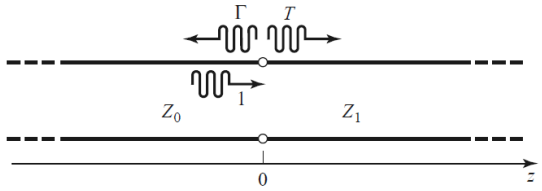


(b) (**4 points**) What is the direction of the current on the inner conductor, along z or φ? Assume the central axis of the inner conductor is on the z axis. Is there any current flowing on the outer conductor?

(c) (**2 points**) In which region is the electromagnetic wave travelling?

6. (**8 points**)

(a) (**2 points**) Write out the transmission coefficient T of the following case in terms of Z_0 and Z_1 if the Z_1 line is terminated with a matched load.

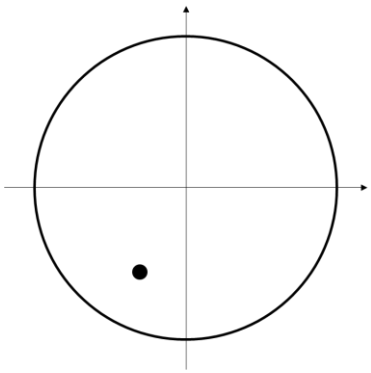


(b) (**2 points**) Write out the definition of insertion loss.

(c) (**4 points**) If the second transmission line is terminated with Z_L (Z_L is real) and we want to match Z_L to the Z_0 line by the Z_1 line, what is the relationship between these three impedances value and how long should the Z_1 line be?

7. (**7 points**)

(a) (**3 points**) Describe how to get the admittance of the load whose impedance is marked as a black spot in the Smith chart shown below.

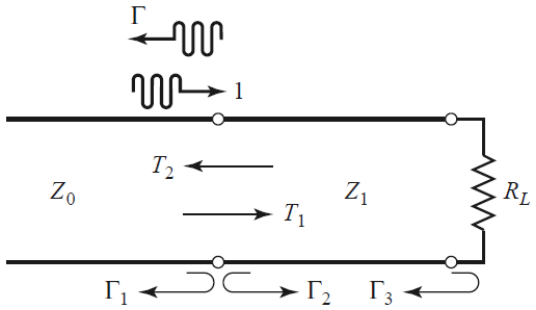


(b) (**2 points**) The imaginary part of the admittance of this load is positive or negative?

(c) (**2 points**) Is this load an inductive one or capacitive one?

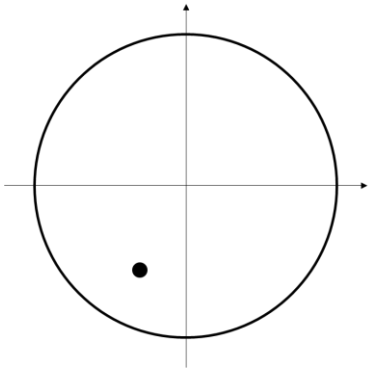
8. (**15 points**)

(a) (**2 points**) For a quarter-wave transformer (matching the load R_L to the Z_0 line through the Z_1line) shown below, if the lowest frequency that can achieve a matched condition is f_0, what is the next frequency that can achieve a matched condition using the same matching network?



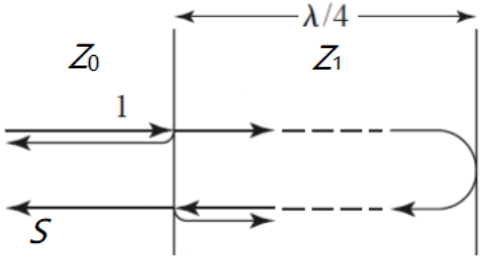
(b) (**2 points**) Under the matching condition, is there any standing wave on the Z_0 line? Is there any standing wave on the Z_1 line?

(c) (**2 points**) If the load has a reactive part (marked as the black spot in the simplified Smith chart shown below), what should be done first before using a quarter-wave transformer?



(d) (**5 points**) Express Γ_1, Γ_2, Γ_3, T_1, and T_1 in terms of the given impedance values.

(e) (**4 points**) As shown in the following schematic of the circuit given in (a), if the incident wave amplitude is 1, how much is the reflected coefficient *S* after the wave travelling a round trip in the Z_1 line? Express *S* in terms of Γ_1, Γ_2, Γ_3, T_1, and T_2.

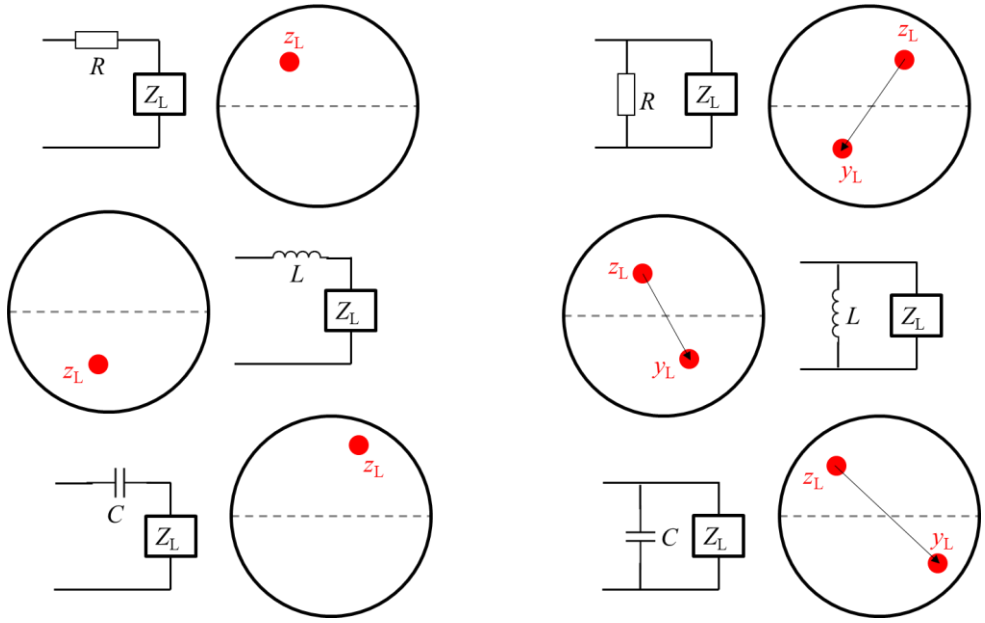


9. (**4 points**)

(a) (**2 points**) On a transmission line with characteristic impedance of Z_0, the incident voltage on the line is V_0^+. Write out the time-average power of the incident wave.

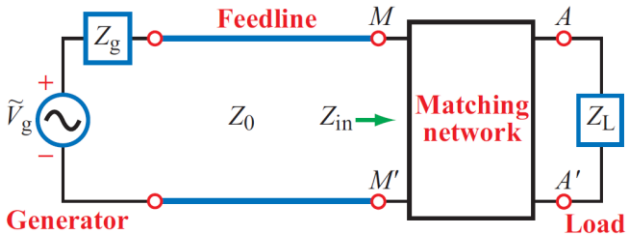
(b) (**2 points**) Write out the time-average power of the reflected wave if the reflection coefficient is Γ.

10. (**12 points**) For the six different cases shown below (adding a series or shunt component to a load Z_L), use the corresponding Smith chart to show how does the resulting input impedance z_{in} (for the left three cases) and input admittance y_{in} (for the right three cases) change.



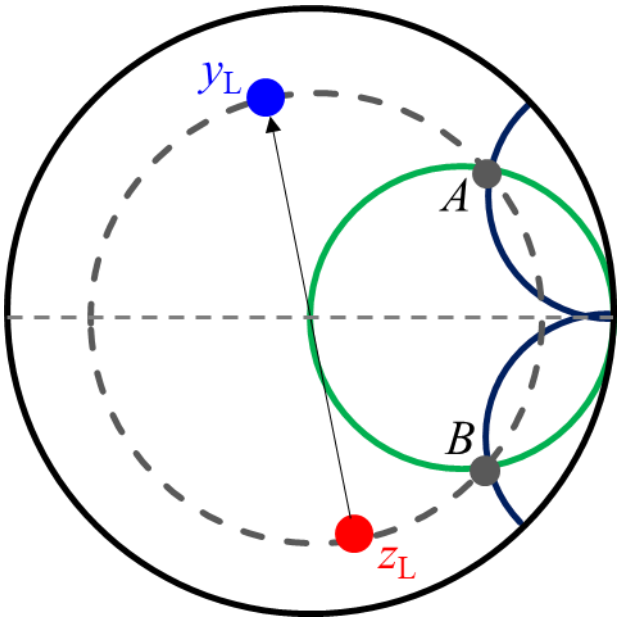
11. (**8 points**)

(a) (**2 points**) For the circuit shown below, what is the purpose of the matching network?



(b) (**6 points**) Draw the configurations of the two cases of the *L*-section matching network. Also use Smith chart to label the region where each of them can be used.

12. (**10 points**) A single-stub matching network using an open-circuited stub is applied to match a load Z_L to a line. Use the Smith chart shown below to find the length *d* (distance from the load the stub) and *l* (length of the stub). Need to give two sets of solutions. Need to label clearly on the chart how to find *d* and *l*.



PART III. Homemade (110)

1. (60 points) If a quarter wave transformer is used to match a load of $3Z_0$ to a transmission line with characteristic impedance of Z_0 at the frequency f_0, calculate the characteristic impedance of the transformer. Calculate the frequency range (should be around f_0) within which the magnitude of the reflection coefficient on the Z_0 line is less than 1/3.

2. (20 points) Use terminated transmission line theory to recalculate the reflection coefficient you found for problem 8.9.

3. (30 points) Calculate the input impedance of the following circuit.