ECE 329 Fields and Waves I
Homework 14

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Due May 4, 2023, 11:59 PM

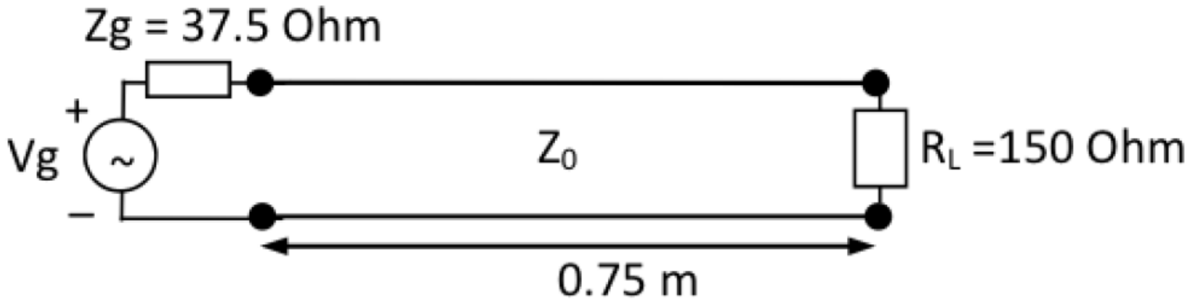
Homework Policy:

- Write your name and NetID on top of every page. This habit will help you in exams in the event of having loose page(s).
- Tag all the questions in Gradescope. Failure to do so results in a 5 points deduction.
- Cheating results in ZERO and 50% reduction in HW average on first offense. A 100% reduction in HW average on second offense.
- Please show detailed process for each problem instead of just an answer. No partial credits would be given otherwise. All answers should include units wherever appropriate.
- No late HW is accepted.
- Regrade requests are available one week following grade release.

You are allowed to work with anyone else, but the work you submit should only belong to you. Note that if you have knowledge of a violation of the Honor Code, then you are obligated to report it. By submitting this homework, you are agreeing to the Honor Code: "I have neither given nor received unauthorized aid on this homework, nor have I concealed any violations of the Honor Code."

Question	Points	Score
1	8	
2	12	
3	10	
4	5	
5	15	
6	10	
7	10	
8	5	
Total:	75	

1. In the transmission-line circuit shown below the voltage at the load is $V_L = j15$ V. The operating frequency is 300 MHz. Given that the line is lossless of characteristic impedance of 75 Ohm with wave velocity 3×10^8 m/s, calculate the following:
   (a) (3 points) The time-average power dissipated at the load;
   (b) (5 points) The time-average power delivered by the generator.



2. A TL with characteristic impedance $Z_o = 25\,\Omega$ and length $l = 0.45\lambda$ is terminated with a load $Z_L = 100\,\Omega$.
   (a) (5 points) Using a SC, determine (i) the load reflection coefficient Γ_L, (ii) the generalized reflection coefficient $\Gamma(d)$ at $d = l$, and (iii) the input impedance $Z(l)$ at the generator end. Hand in your S.C.

      Hint: you start by entering $z_L = \frac{Z_L}{Z_o}$ in the SC. Express Γ_L and $\Gamma(l)$ as complex numbers in polar form — i.e, as $|\Gamma|\angle\theta$.
   (b) (2 points) Using $Z(l)$ from part (a), determine the voltage phasor $V(l)$ at the generator end if the generator has an open circuit voltage phasor $V_g = 10$ V and a Thevenin impedance $Z_g = 50\,\Omega$.
   (c) (2 points) Given the result of (b), determine V^+ such that $V(d) = V^+(e^{j\beta d} + \Gamma_L e^{-j\beta d})$.
   (d) (2 points) What is the load voltage phasor $V(0)$ given the result of (c)?
   (e) (1 point) What is the corresponding load current $I(0)$?

3. (10 points) A TL with characteristic impedance $Z_o = 50\,\Omega$ and length $l = 0.4\lambda$ has an *open* termination at $d = 0$ *and* a $50\,\Omega$ resistor connected between the TL conductors (a "shunt" connection) at $d = 0.2\lambda$. Use a SC to determine the input impedance and admittance of the line at the generator end, i.e., $Z(l)$ and $Y(l)$. Hand in your marked SC.

   Hint: first move by 0.2λ from the load point (where you enter $z(0)$ or $y(0)$) toward generator on the SC, read off the corresponding $y(d)$, combine it in parallel with the shunt element, go back onto the SC with the normalized combined admittance, and move another 0.2λ toward the generator...

4. (5 points) Two TL stubs of equal lengths $l = 0.3\lambda$ and identical short terminations have unequal characteristic impedances of $Z_o = 50\,\Omega$ and $100\,\Omega$. If the two stubs are connected in parallel at their input ports, what is the input admittance of the combined network. Use a SC to solve this problem and hand in your marked SC.

5. A transmission line having a characteristic impedance of 50 Ω is terminated by a load of unknown impedance Z_L. Measurements of the voltage amplitude $|V(d)|$ along the line reveal a "standing wave pattern" with a maximum voltage of 8.4 V and a minimum voltage of 2.1 V.
   (a) (2 points) What is the voltage standing wave ratio (SWR or VSWR) on the line?
   (b) (2 points) A voltage minimum is observed at distance $d = 2.592\lambda$ from the load. What is then the distance d_{min} between the load and the first voltage minimum (closest to the load)? Hint: successive voltage minima are $\frac{\lambda}{2}$ apart.
   (c) (3 points) Determine the magnitude and and phase angle of the load reflection coefficient Γ_L using the S.C. and the results of parts (a) and (b). **Hint:** Given the VSWR, constant-Γ circle passes through $z = \text{VSWR} + j0$ on the S.C. The same location on the S.C. also correspond to the location of a voltage maximum on the line.
   (d) (2 points) Determine z_L using the S.C. and the value Z_L in Ω's.
   (e) (4 points) Determine $|V^+|$ and $|V^-|$, the travelling wave amplitudes on the line.
   (f) (2 points) What is the average power (in W) delivered to the load?

6. We want to use a quarter-wave transformer to match a load Z_L to a T.L. with a characteristic impedance $Z_o = 50\,\Omega$. The quarter wave transformer is to be inserted at a distance d_1 away from the load.
   (a) Determine d_1 (in units of λ) and the characteristic impedance Z_{qo} of the quarter wave transformer if
      i. (2 points) $Z_L = 100\,\Omega$,
      ii. (2 points) $Z_L = 100 + j100\,\Omega$.
   (b) For $Z_L = 100 + j100\,\Omega$, what is VSWR in the region
      i. (3 points) $0 < d < d_1$,
      ii. (3 points) $d_1 < d < d_1 + \frac{\lambda}{4}$.

7. We want to use a single-stub tuner to match a load Z_L to a T.L. with a characteristic impedance $Z_o = 50\,\Omega$. A shorted-stub is to be connected at a distance $d_1$away from the load.
   (a) (6 points) Determine d_1 (in units of λ) and the length d_s of the shorted stub if $Z_L = 100 + j100\,\Omega$ and the characteristic impedance of the stub is $50\,\Omega$.
   (b) (4 points) Repeat (a) if the characteristic impedance of the stub is $100\,\Omega$.

8. (5 points) Please go to https://tinyurl.com/33zam9rc to fill out the informal early feedback form. Please take a screenshot that looks like the following picture and submit the screenshot as the solution.