Electromagnetics II

<u>Second Exam</u> (10:10am–12:10m) 5/14/01

1. (10%) Consider a lossless transmission line, with characteristic impedance Z_0 and propagation constant β, that is open circuited at the far end $d = 0$, as shown in Fig. P1. Assume that a sinusoidally time-varying voltage wave, $V_0 \sin(\omega t + \beta d)$, is traveling along the line due to a source that is not shown in the figure and that conditions have reached steady state, where ω is the angular frequency. (a) Write the expression for the total voltage phasor $\overline{V}(d)$. (b) Write the expression for the real (instantaneous) total voltage $V(d, t)$.

2. (10%) Consider the low-loss line system shown in Fig. P2. (a) Determine the reflcetion coefficient at the input end $d = l$. (b) Determine the input impedance of the line at $d = l$. Use the notation shown in the figure.

3. (15%) Consider the structure of two parallel perfectly conducting plates separated by a lossy medium characterized by conductivity σ, permittivity ϵ, and permeability μ, and driven by a voltage source $V_0 \cos \omega t$ at one end, as shown in Fig. P3, where V_0 is real. Using the quasistatic-field approach, please derive an expression for the magnetic field intensity correct to the first power in the frequency ω.

4. (10%) Fig. P4 shows a magnetic circuit of square cross section with area $A = W^2$ and with air gaps. The magnetic core has permeability μ. Find the relectance of this circuit as seen by the current turns.

5. (10%) Consider an electromagnet as shown in Fig. P5. When current is passed through the coil, the armature is pulled upward to close the air gaps. The mechanical force $\mathbf{F}_e$ can be found by assuming a constant magnetic flux ψ in the core. (a) Is there electrical energy input to the system? Please explain. (b) Drive an expression for $\mathbf{F}_e$ in terms of ψ.

6. (15%) Fig. P6 shows a hybrid arrangement of a series short-circuited sub and a parallel short-circuited stub connected at a fixed distance d_1 from the load in order to achieve a match between the line and the load. (a) (10%) With the notation shown in the figure, where $\bar{z}_1 = r' + jx'$, express x_1 and b_2 in terms of r' and x' for the match to be achieved. (b) (5%) Discuss the condition for which a solution does not exist for a fixed value of d_1, and a remedy to get around the problem.

7. (15%) Fig. P7 shows the configuration of a typical problem that may be met in practice. Say a generator feeds an antenna by means of a coaxial transmission line 1.72 m long (with air medium); for measurement purposes a slotted section has been inserted between the generator and the transmission line, and is tied to the line by means of a connector. The line, the connector, and the slotted section all have a common characteristic impedance of 50 Ω. A minimum in the standing wave on the slotted section is observed 9 cm from the connector. The generator frequency is 750 MHz, and a voltage standing wave ratio of 3 is obtained along the slotted section. What impedance does the antenna present to the line at this frequency? (Use the provided Smith chart to find the solution.)

8. (15%) In the system shown in Fig. P8, two $\lambda/4$ line sections of characteristic impedance $50\sqrt{2}\ \Omega$ and $50\ \Omega$, respectively, are employed. You are asked to use the Smith chart provided to find the locations of the two $\lambda/4$ sections, that is, the values of l_1 and l_2 to achieve a match between the 100-Ω line and the load. Use the notation shown in the figure.

(a) Mark on the Smith chart the two locations representing the two solutions for $\bar{z}_2$ as P_1 and P_2.

(b) Mark the corresponding locations as P_1' and P_2' representing the two solutions for $\bar{z}_1$.

(c) Determine the corresponding values of l_1 and l_2.

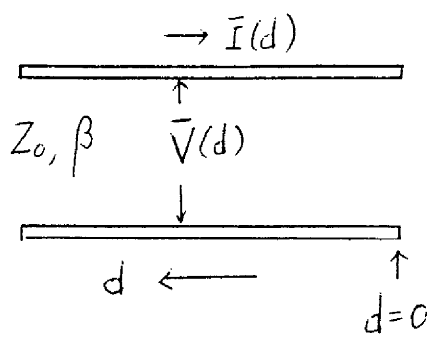

Fig. P1

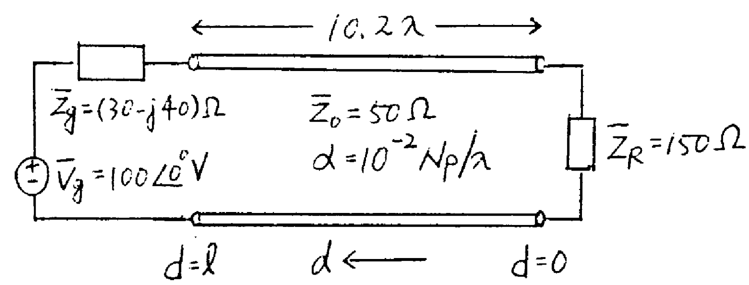

Fig. P2

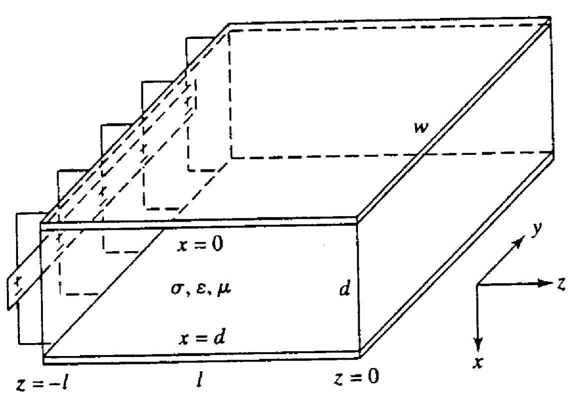

Fig. P3

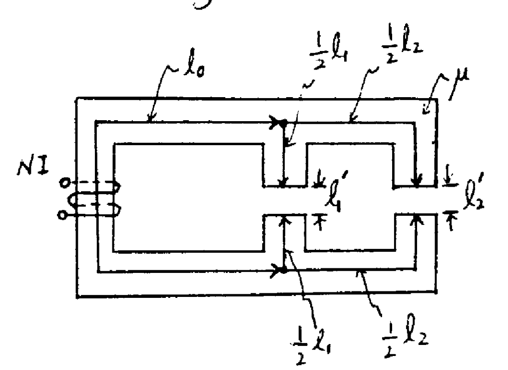

Fig. P4

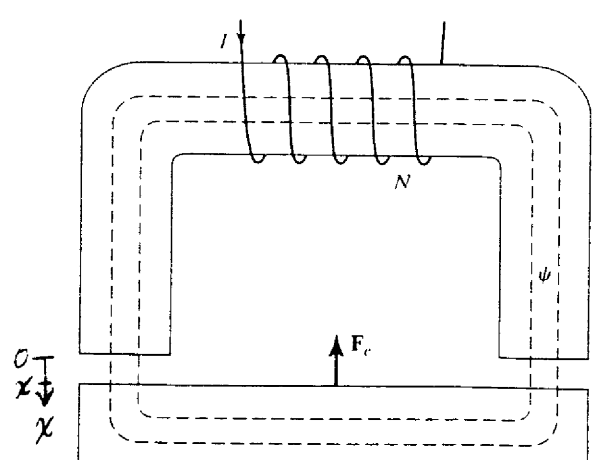

Fig. P5

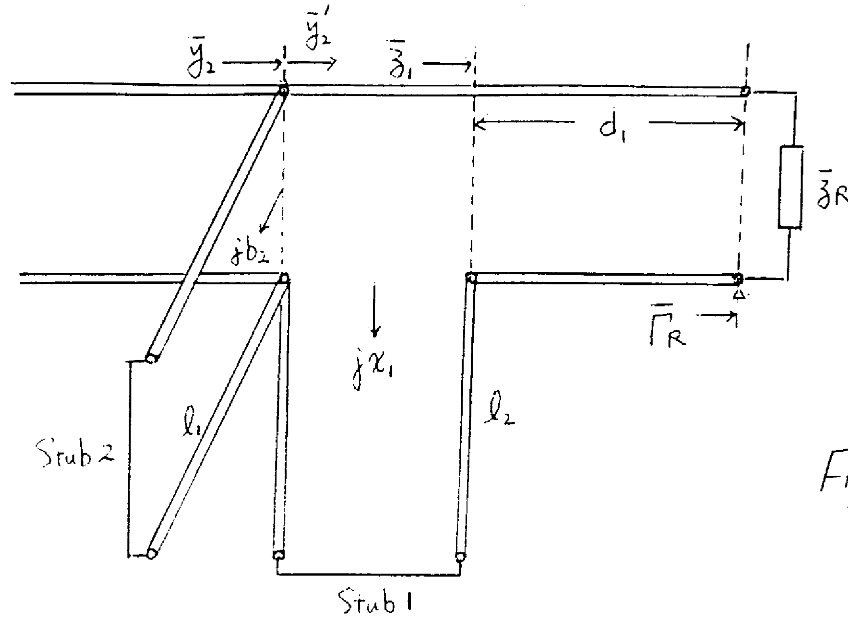

Fig. P6

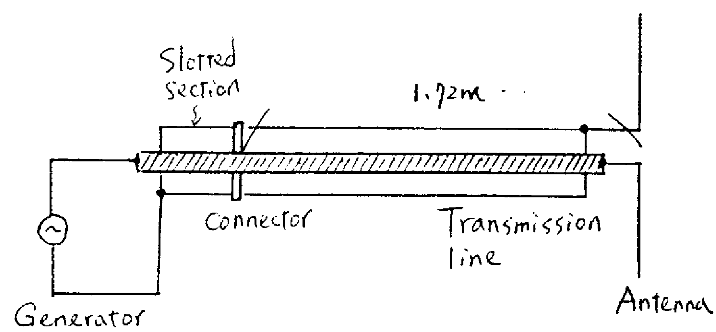

Fig. P7

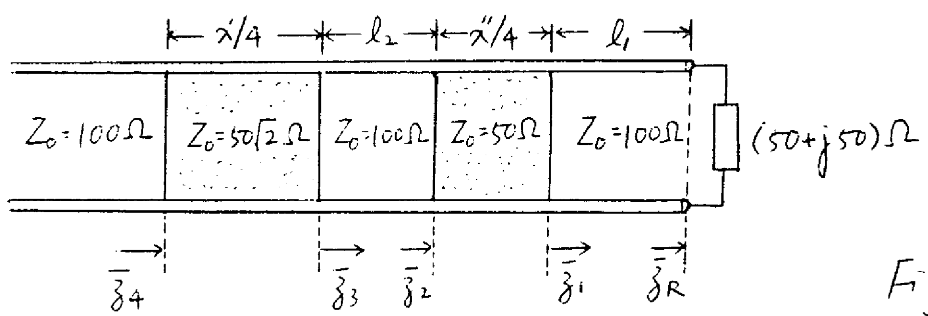

Fig. P8