Microwave Physics and Techniques

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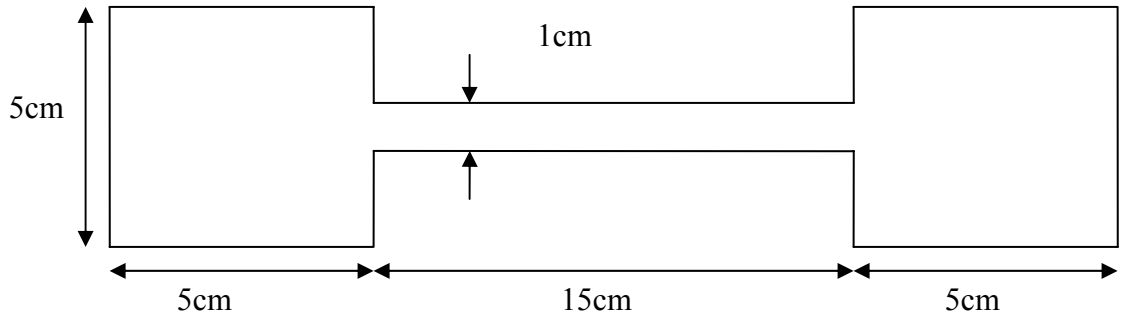
IU/UPSAS P671D
Final Exam
June 20, 2003

1. You may use your textbook and class lectures.
2. Provide full answer along with complete explanation.
3. This exam is limited to two hours only.

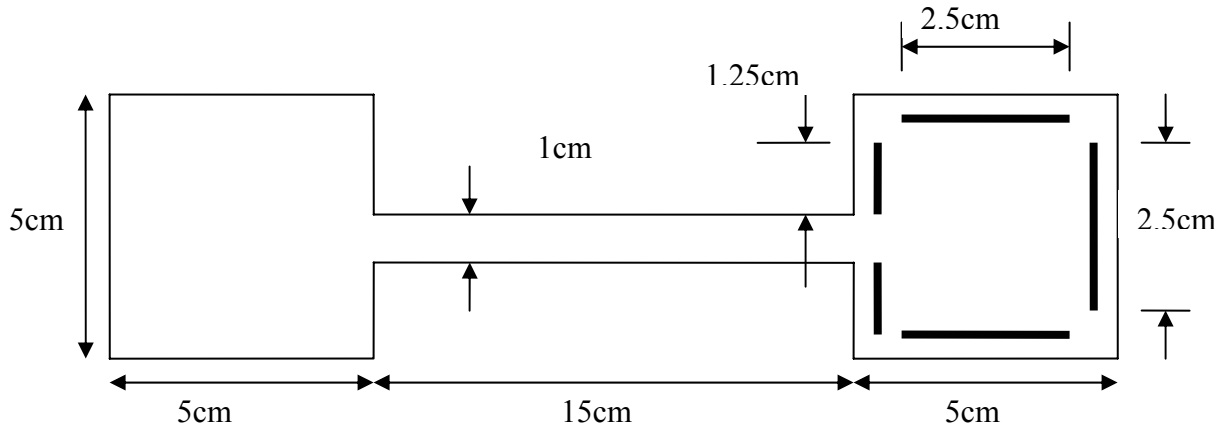
Problem1. Before submitting your technical drawings of the proposed storage ring beam chamber at your facility, you decide to check and verify the RF properties of the chamber. The cross section of the aluminum chamber is shown below. The chamber is 5 meters long and both ends are covered with aluminum plates.



1) Find the cutoff frequency of the lowest order mode in the chamber.
2) Find the frequencies and wavelengths of the first five harmonic resonances in the waveguide. Compare the results with the wavelengths in the free space and rectangular waveguide with a width a=25cm.

Assume that all the electrical field is concentrated in the ridge area and all the magnetic field is concentrated in the square chambers.

3) If NEG strips ($\sigma=3.5\times10^{6}$S/m) are inserted as shown below (for pumping) for the whole length, estimate the increased loss factor of the chamber compared to the chamber with no NEG strip. NEG strips have thickness much greater than the skin depth of the material.

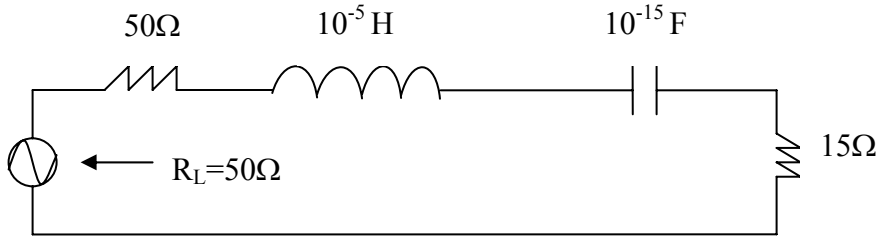


Problem2. A 2-port network is characterized by the following S-matrix parameters:

$$S_{11} = \frac{1+j}{2},\ S_{12} = \frac{1+j}{2},\ S_{21} = \frac{1-j}{2},\ S_{22} = \frac{1+j}{2}$$

a) Is the network reciprocal?
b) Is the network lossless?

Problem3. A cylindrical cavity is excited by a probe that is connected to a 50-Ohms generator by a length of 50-Ohms coaxial cable. At resonance, the cavity looks like the following load at the end of the transmission line.

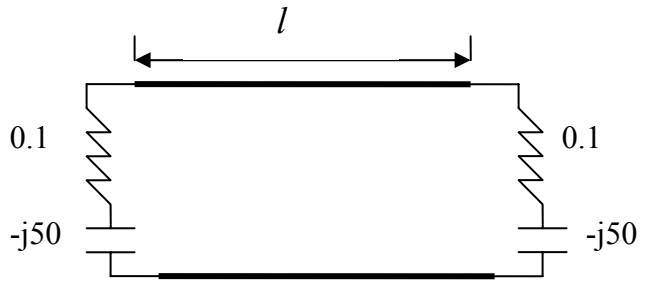


Find

a) Unloaded Q, Q_u
b) External Q, Q_e
c) Loaded Q, Q_L
d) Coupling constant, K

Problem4. Design a circular air waveguide to operate at 6.4 GHz such that the cutoff frequency of the dominate mode is at least 20% lower than the operating frequency, the cutoff frequency of the TE_{01} mode is at least 10% higher than the operating frequency, and the waveguide has maximum power-carrying capability. Find all the possible propagating modes in this waveguide at 6.4GHz. Find all the possible propagating modes if this waveguide is operated at 9.4 GHz.

Problem5. A transmission line resonator is made from a length *l* of lossless line of characteristic impedance Z_0=100-Ohms. If the line is terminated at both ends, find *l*/λ for the first resonance, and the Q of this resonator.



Problem6. Calculate the skin depth and surface resistivity in copper for 1MHz, 100MHz, and 1GHz.

(σ=5.8×1010^{-7}S/m)