INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date.....FN/AN Time: **2** Hrs., Full Marks: 30, Deptt: **E & ECE**

No. of Students: **98.** Mid Autumn Semester Exam. **Sep.: 2011**

Subject No.: **EC31005** Subject: **RF & Microwave Engineering**

3rd Yr. B.Tech(H)/M.Tech(Dual) **INSTRUCTIONS:** Answer ALL Questions

All symbols and variables have their usual meaning.

Note 1: The numbers in square brackets at the right-hand side of the text indicate the provisional allocation of maximum marks per question or sub-section of a question.

Note2: **You may need:** $\varepsilon_0 = 8.854 \times 10^{-12}\, F/m, \mu_0 = 4\pi \times 10^{-7}\, H/m$.

Q.1 In the following indicate clearly the correct/best answer. Note. No marks will be given in cases where the proper reason asked for is not provided.

i) The TM_{10} mode can exist in a rectangular waveguide.
(a) True. Why? (b) False. Why? **[02]**

ii) For the TE_{30} mode which of the following field components exist?

(a) E_x (b) E_y (c) E_z (d) H_x (e) H_y **[02]**

iii) If in a rectangular waveguide for which a = 2b, the cutoff frequency for TE_{02} mode is 12 GHz , the cutoff frequency for TM_{11} mode is
(a) 3 GHz (b) $3\sqrt{5}$ GHz (c) 12 GHz
(d) $6\sqrt{5}$ GHz (e) None of these. **[02]**

iv) If a tunnel is 4 by 7 m in cross section, a car in the tunnel will not receive a 10 MHz AM radio signal.
(a) True. Why? (b) False. Why? **[02]**

v) When the electric field is at its maximum value, the magnetic energy of a cavity is
(a) at its maximum value (b) at $\sqrt{2}$ of its maximum value
(c) at $1/\sqrt{2}$ of its maximum value (d) at 1/2 of its maximum value
(e) zero (f) None of these. **[02]**

Q.2 A rectangular w/g, with a=2.5 cm, b=1 cm is to operate below 10 GHz. How many TE and TM modes can the w/g transmit if the guide is filled with a medium characterized by σ=0, ε=3.5, μr=1? Calculate the cutoff frequencies of the modes.

[05]

Q.3 A rectangular w/g, has a=2 cm, b=1 cm. The guide is filled with a air and transports energy in the dominant mode at a rate of 0.5 hp (1hp=746 Watts). If the frequency of operation is 30 GHz, Determine, the peak value of the electric field in the waveguide.

Also calculate the phase constant in guide (β), wavelength in guide, wave impedance, phase velocity and the group velocity for the dominant mode

[05]

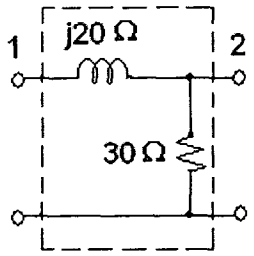
P.T.O.

(Contd.)

Q.4 An air filled circular waveguide has a radius of 2 cm and the operating frequency is 10 GHz. Find all the TE_{np} and the TM_{np} modes for which energy transmission is possible. Also determine λg and the wave impedance for the dominant mode.

[05]

Q.5 **(a)** Calculate the s-parameters for the two-port network shown in the adjacent figure for the case where Z_0=50 Ω.



(b) Find the return loss at the input with $Z_L = Z_0$.

(c) Determine the insertion loss for the two-port network when the generator and the termination are both 50 Ω.

[05]

Note 3: You may need:

$$E_y = E_0 \sin(k_c x) e^{-\gamma z} \qquad H_x = -E_0 / Z_{TE}$$

$$\gamma = \sqrt{k_c^2 - k^2} \qquad \beta = k\sqrt{1-(f_c/f)^2} \qquad \lambda_g = \lambda \Big/ \sqrt{1-(f_c/f)^2} \qquad Z_{TE} = \frac{j\omega\mu}{\gamma}$$

$$\langle P_f \rangle = \frac{|E_0|^2 ab}{4Z_{TE}^*}$$

p^{th} zero of $J_n(ka)$

p	n=0	n=1
1	2.4048	3.8317
2	5.5201	7.0156
3	8.645	10.173

p^{th} zero of $J_n'(ka)$

p	n=0	n=1	n=2
1	3.832	1.841	3.054
2	7.016	5.331	6.706