TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
# Examination Control Division
**2080 Baishakh**

| Exam. | Back | | |
|---|---|---|---|
| Level | BE | Full Marks | 80 |
| Programme | BEI | Pass Marks | 32 |
| Year / Part | IV / I | Time | 3 hrs. |

## *Subject:* - RF and Microwave Engineering (*EX 716*)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary formulas and Smith Charts are attached herewith.***
- ✓ *Assume suitable data if necessary.*



1. How is microwave frequency band classified by the IEEE? Enumerate the basic advantages and disadvantages of microwaves compared to lower frequencies. [2+4]
2. Design a double stub shunt tuner to match a load impedance of $Z_L$ = 60-j80Ω to a 50 Ω line. The stubs are to be open circuited stubs and are spaced 3λ/8 apart. Assume the first is 0.4 λ from the load. Formulate the S-matrix for your design. [8+2]
3. Why are S-parameters used in microwave network analysis? Derive the S-parameters for a two port network. [2+6]
4. For an air-filled rectangular waveguide with a width of 3 cm and a desired frequency of operation of 6 GHz (for dominant mode), determine cut-off frequency, cut-off wavelength, group velocity, phase velocity, propagation wavelength in the waveguide and the characteristic impedance. Explain the four basic parameters used to describe the performance of a directional coupler. [6+4]
5. Sketch a cross-sectional view of a magnetron having 45 degrees of phase shifts among the adjacent cavities, and explain its functioning as a power amplifier. Explain the bunching effect. [6+2]
6. Investigate the stability of a transistor having following S-parameters at 6GHz. [5+5]

$$[S] = \begin{bmatrix} 0.894\angle -60.6^\circ & 0.020\angle 62.4^\circ \\ 3.122\angle 123.6^\circ & 0.781\angle -27.6^\circ \end{bmatrix}$$

7. Explain why insertion loss technique is used to design microwave filters. With proper labeling sketch microwave double-section shunt – arm types microwave LPF using micro strips. [3+5]
8. Discuss the possible RF radiation fields to the public exposers. Explain, what are the international standards and recommended (SARPs) practices to safe from such radiation. [3+3]
9. Explain power measurement using calorimeter wattmeter. What are the limitations of using single bridge bolometer? [6+2]
10. Write short notes on: [2×3]
    a) MASER
    b) E-plane Tee

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**Supplied Formulas:**

$$\Delta = S_{11}S_{22} - S_{12}S_{21}$$

$$K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2|S_{12}S_{21}|}$$

$$\mu = \frac{1 - |S_{11}|^2}{|S_{22} - \Delta S_{11}^*| + |S_{12}S_{21}|}$$

$$\Gamma_s = \frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2C_1}$$

$$\Gamma_L = \frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2C_2}$$

$$B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2$$

$$B_2 = 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2$$

$$C_1 = S_{11} - \Delta S_{22}^*$$

$$C_2 = S_{22} - \Delta S_{11}^*$$

$$C_s = \frac{(S_{11} - \Delta S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2}$$

$$C_L = \frac{(S_{22} - \Delta S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2}$$

$$R_s = \frac{|S_{12}S_{21}|}{|S_{11}|^2 - |\Delta|^2}$$

$$R_L = \frac{|S_{12}S_{21}|}{|S_{22}|^2 - |\Delta|^2}$$

$$G_{T\,Max} = \frac{1}{1 - |\Gamma_s|^2} \cdot |S_{21}|^2 \cdot \frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2}$$

$$G_{TU\,Max} = \frac{1}{1 - |S_{11}|^2} \cdot |S_{21}|^2 \cdot \frac{1}{1 - |S_{22}|^2}$$

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1. Compare the behavior of circuits for Low frequency/ Conventional and RF/ Microwave bands. Classify microwave frequency band and its application in major areas. [3+3]
2. A 50 Ω lossless transmission line is required to be matched with the load admittance 0.00813 + j0.0065 ℧, by a double-stub shunt tuner with separation of 3λ/8 and the distance of the first stub from the load is 0.01λ. Calculate the length of each stub by using the smith chart. Write the s-parameter for the matched network. [8+2]
3. Why S-parameters are used in high frequencies? The S-matrix of certain microwave network is given as [3+1+1+1+2]

$$S = \begin{bmatrix} 0.4 + j0.5 & j0.6 \\ j0.6 & 0.4 - j0.5 \end{bmatrix}$$

   a) Is the network reciprocal?
   b) Is the network lossless?
   c) What is the return loss at the input?
   d) If the input power to the network is 5 watts. What is the reflected power?
4. Provide the fundamental field and characteristic equations of a circular waveguide for TE mode. [10]
5. How is the output of conventional tubes reduced at microwaves due to inter-electrode capacitance, lead inductance and transit time effect? Explain about the construction and working principle of TWT. [2+6]
6. For transistor having following S-parameter $S_{11} = 0.894 \angle -60.6°$, $S_{21} = 3.122 \angle 123.6°$, $S_{12} = 0.020 \angle 62.4°$, $S_{22} = 0.781 \angle -27.6°$. Determine the stability and compare maximum power gains for bilateral and unilateral modes. [5+5]
7. How is a low pass filter prototype based on Butterworth approximation designed using insertion loss method? Implement a low pass filter π section using microstrips. [6+2]
8. Explain the RF/MW radiation hazards and its safety practices. [3+3]
9. List out the major RF/MW measurement parameters. How the VSWR of any microwave transmitter (In case of VSWR > 10) can be measured? Explain. [2+6]
10. Write short notes on: [2×3]
    a) Microwave Magic Tee
    b) Gunn-diode

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