

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX 752)

- ✓ 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 formula and Smith chart are attached herewith.
- ✓ Assume suitable data if necessary.



1. Explain how microwave systems are different from conventional low frequency devices. [8]
2. Define SAR and discuss microwave radiation hazards based on the SAR exposures. [10]
3. Define EM field equations and its characteristic parameters of a rectangular waveguide working on TE mode. [10]
4. Compare h-parameters with S-parameter. Using a two-port network describe S-parameters. [5+5]
5. Assuming a load of $110 + j110$ ohm is connected to a 100-ohm transmission line, find the lengths and spacing for a double-stub impedance matching system using three-eighths wavelength separation between the stubs. [12]
6. Check the stability and find the unilateral gain of a transistor having following S-parameters: $S_{11}=0.45\angle-160^\circ$, $S_{12}=0.04\angle20^\circ$, $S_{21}=3.12\angle180^\circ$ and $S_{22}=0.35\angle-40^\circ$. [7+8]
7. Write short notes (Any Three) [3×5]
 - a) Microwave magic tee
 - b) Bolometry
 - c) Multi-cavity klystron
 - d) Immittance Chart
 - e) Spectrum Analyzer

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2079 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX 752)

- ✓ 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 Equations and Smith Charts are attached herewith.
- ✓ Assume suitable data if necessary.



1. Differentiate the behavior of a transmission line at conventional low frequency and microwave bands. [10]
2. List and describe five major RF safety practices. Differentiate among microwave reactive, near - and far- field radiations with necessary illustrations. [5+5]
3. Explain the working principle of bolometry used in microwave measurements. [10]
4. A lossless 50 Ohm transmission line is terminated by an impedance of $75 + j100$ Ohm. Using Smith Chart, find (a) Γ_L , (b) VSWR, (c) Z_{in} at a distance of 0.375λ from the load, (d) the shortest length of line for which impedance is purely resistive, and (e) the value of this resistance. [10]
5. With self -defined line and load impedances and mentioning the steps, design a single short- circuited matching stub. [10]
6. A GaAs power FET has the S - parameters at 5 GHz with 50 - ohm line measured as $S_{11} = 0.45 \angle 163^\circ$, $S_{12} = 0.04 \angle 40^\circ$, $S_{21} = 2.55 \angle -106^\circ$ and $S_{22} = 0.46 \angle -65^\circ$. Using these parameters, design an amplifier and find the total gain power gain. [10]
7. Write the basic field equations of a rectangular waveguide working at TE mode. [10]
8. Write short notes on (Any Two) [2x5]
 - a) Magnetron
 - b) Directional coupler
 - c) Magic Tee
 - d) S-parameters

Supplied Formulas:

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

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

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

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

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

$$G_T = \left(\frac{1 - \Gamma_s^2}{|1 - \Gamma_m \Gamma_s|^2} \right) |S_{21}|^2 \left(\frac{1 - \Gamma_L^2}{|1 - S_{22} \Gamma_L|^2} \right)$$

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX 752)

- ✓ 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 chart and formula are attached herewith.
- ✓ Assume suitable data if necessary.



1. Based on operational principles, compare microwave systems with conventional low frequency systems. Lists the areas of application of microwave system. [10]
2. Illustrate different impedance matching techniques. What will be a resulting S-matrix, if you are asked to prepare a double-stub matching network of having perfect matching? [4+6]
3. Elaborate the importance of S-parameters for microwave frequencies. Evaluate the S-matrix of an Amplitude Modulator. [3+7]
4. Identify and explain the properties of a microwave passive device having following S-Matrix with necessary diagram. [10]

$$\begin{bmatrix} 0 & .0 & 1 & 1 \\ 0 & 0 & -1 & 1 \\ 1 & -1 & 0 & 0 \\ 1 & 1 & 0 & 0 \end{bmatrix}$$
5. What is cross-field effect? Describe the construction and principle of operation of a multi cavity klystron amplifier. [2+8]
6. Assuming suitable S-parameters calculate maximum gain of an amplifier working in an unilateral model. Also illustrate a flow chart showing the designing steps. [10]
7. Justify and describe how a double-section series-arm type micro strip filter is designed using insertion loss method. [10]
8. Write short notes on: (Any Two) [2×5]
 - a) Combinational effect of two magic tees connected in H-plane
 - b) VNA type Network analyzer
 - c) Microwave radiation hazards

Supplied Formulas:

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

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

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

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

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

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

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

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

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

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

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

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

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

$$G_{T_{\max}} = \left(\frac{1}{1 - |\Gamma_S|^2} \right) |S_{21}|^2 \left(\frac{1 - |\Gamma_L|^2}{1 - |S_{22}\Gamma_L|^2} \right)$$

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2077 Chaitra

Exam.	Regular	
Level	BE	Full Marks 80
Programme	BEX	Pass Marks 32
Year / Part	IV / II	Time 3 hrs.

Subject: - RF and Microwave Engineering (EX 752)

- ✓ 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 are attached herewith.
- ✓ Assume suitable data if necessary.

1. Explain the behavior of microwave circuits. Also discuss the advantages and disadvantages of using microwave frequency. [4+4]
2. Sketch a double-stub perfectly matched network using microstrip and prepare its s-matrix. [2+8]
3. For a rectangular waveguide, with suitably assumed breadth, width and frequency, (for dominant mode), determine cut-off frequency, phase velocity, propagation wavelength in the waveguide and the characteristic impedance. [6]
4. Explain the properties of two Magic Tees if one connects their E-arms and derive its S-matrix. [10]
5. Derive explicitly the field equations of Rectangular waveguides for TE modes. [8]
6. What is transit time effect? State the working principles of a magtron having phase difference of 45° of adjacent cavities. [2+6]
7. A microwave amplifier operates in Ku-Band for satellite transmit system uses a High Electron Mobility GaAs MOSFET transistor having following S-parameters at 4 GHz with 50Ω line impedance as, $S_{11} = 0.72 \angle -116^\circ$, $S_{12} = 0.03 \angle 57^\circ$, $S_{21} = 2.60 \angle 76^\circ$ and $S_{22} = 0.73 \angle -54^\circ$. Check the stability of the given transistor and compare maximum power gain for bilateral and unilateral mode. [5+5]
8. Describe in detail the procedures for prototyping Butterworth LPF using insertion loss method. [8]
9. How are microwaves hazardous to humans? Define different radiation zones of a microwave oven. [3+3]
10. Explain how microwave power is measured with static calorimeter. [6]

Supplied Formulas:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Bhadra

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX 752)

- ✓ 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.
- How is microwave frequency band classified by the IEEE? Enumerate the basic advantages and disadvantages of microwaves compared to lower frequencies. [5+5]
 - A single-stub tuner is to match a lossless line to a load of an antenna. Design the stub with any assumed placement and length and derive its S-matrix. [10]
 - A radar installation engineer is given a responsibility to install an Airport Surveillance Radar that requires half input power to the antenna than the transmitter that can deliver using a duplexer. Prepare its S-matrix. [10]
 - Explain field and characteristics equations of a rectangular wave guide working in TM mode. [10]
 - A microwave transistor has the following scattering parameters at 1.0GHz, with a 50Ω line impedance:
 $S_{11}=0.38\angle -158^\circ$
 $S_{12}=0.11\angle 54^\circ$
 $S_{21}=3.50\angle 80^\circ$
 $S_{22}=0.40\angle -43^\circ$
 The source impedance is $Z_s=25\Omega$ and load impedance is $Z_L=40\Omega$. Compute the gains of input and output matching networks. Also, draw a design a flowchart. [6+4]
 - How is a low pass filter prototype based on Butterworth and Chebyshev approximations designed using insertion loss method? Implement a low pass filter double π -sections using microstrips. [8+2]
 - Name and explain different microwave radiation fields. Describe different international EMR safety standards and practices. [5+5]
 - Explain power measurement using static and dry calorimeters. [10]

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

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

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

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

$$GT_{\max} = \frac{1}{1 - |\Gamma_S|^2} |S_{21}|^2 \frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2}$$

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

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

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

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX752)

- ✓ 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 provided herewith.
- ✓ Assume suitable data if necessary.

- How the circuit at seismic band is different from its RF/Microwave counterparts? Explain. [8]
- A 75-ohm, coaxial line is terminated with a normalized complex load of $0.4 + j0.85$ ohms. Design a double-stub matching system using short-circuited coaxial line of 75-ohm characteristic impedance. Sketch the network using micro strip. [10+2]
- Analyze a three-port directional coupler using S-parameters. [4]
 - Which of the passive microwave device is explained by this S-matrix. Judge the condition and explain its characteristics.

$$[S] = \begin{bmatrix} S_{11} & 0 & S_{13} & S_{14} \\ 0 & S_{22} & -S_{13} & S_{14} \\ S_{13} & -S_{13} & 0 & 0 \\ S_{14} & S_{14} & 0 & 0 \end{bmatrix} \quad [6]$$

- Derive the expression for the field strength for TM waves for a air-filled circular waveguide. Check the dominant mode in TE and TM modes. [8+2]
- With neat circuit diagrams and relevant equations, explain the velocity modulation process and bunching in a multicavity reflex klystron. [10]
- Refer the sketched smith chart (Fig.Q6) and analyze/synthesize the stabilities. Assume necessary parameters as desired. Mention all the steps. [5]
 - Describe the insertion loss method used for the filter designing. [5]
- Discuss in detail the power measurement using circulating calorimeter. [5]
 - How microwave radiation becomes hazardous to human body? [5]
- What do you understand by immittance chart? Sketch it. List out all duality parameters vital to designing microwave networks. [10]

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

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

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

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

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

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

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

$$G_{TU_{\max}} = \frac{1}{1 - |S_{11}|^2} |S_{21}|^2 \frac{1}{1 - |S_{22}|^2}.$$

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX752)

- ✓ 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 figures and Chart are attached herewith.**
- ✓ Assume suitable data if necessary.

1. Design a single short and open-circuited shunt matching network for a transmission line using Smith Chart by considering an output reflection coefficient $\Gamma_L = 0.5 \angle 51^\circ$ Ohm and surge impedance $Z_0 = 50$ Ohm. [8]
2. Identify and explain the properties of a microwave passive device having following S-Matrix. [8]

$$\begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & 13 & -S_{14} \\ S_{13} & S_{13} & 0 & 0 \\ S_{14} & -S_{14} & 0 & 0 \end{bmatrix}$$

3. Sketch a flowchart for designing a microwave amplifier using a GaAsFET. Consider the following S-parameters and find maximum gain for both bilateral and unilateral model. Also using the calculated value of Γ_{in} and Γ_{out} trace Z_{in} and Z_{out} in the smith chart. [4+4+4+4]

$$[S] = \begin{bmatrix} 0.656 \angle 146.7^\circ & 0.122 \angle 46.1^\circ \\ 2.30 \angle 44.7^\circ & 0.172 \angle -117.1^\circ \end{bmatrix}$$

4. Synthesize stability parameters of input matching network for the attached sketched smith chart. [8]
5. Choose a proper microwave measurement tool to test an antenna as a DUT; and explain its working principles. [8]
6. Explain in detail the designing steps of microwave filters. Illustrate an example of passive HPF using microstrips. [6+4]
7. Express field equations of a rectangular waveguide for TM mode. [10]
8. Write short notes on: (any two) [6×2]
 - i) Effect of SAR as microwave radiation hazards
 - ii) Features of microwave frequency band
 - iii) Backward Wave Oscillator
 - iv) Microwave Cavity Resonators

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

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

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

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

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

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

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

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

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

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

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

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

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

$$G_{Tmax} = \left(\frac{1}{|1 - S_{11}\Gamma_S|^2} \right) |S_{21}|^2 \left(\frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2} \right)$$

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX752)

- ✓ 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 formula and Chart are attached herewith.
- ✓ Assume suitable data if necessary.

1. What are the advantages of using double stub matching over single stub matching? Explain the necessary steps for impedance matching of a load to a transmission line using double-stub matching network with an appropriate example. Use provided Smith Chart. [2+8]
2. Why are S-parameters used in microwave network analysis? Analyze three port network using S-parameters. [2+6]
3. Suppose there are two identical radar transmitters in equipment stock. A particular application required twice more input power to an antenna than either transmitter can deliver. Give your appropriate solution for the given problem with explanation using S-matrix. [6]
4. Describe the working principle and applications of cavity magnetron having phase shift of 45° between the cavities. [8]
5. Given S-parameters for microwave transistor amplifier: [12]

$$S_{11} = 0.78 \angle -113^\circ \quad S_{12} = 0.028 \angle 247^\circ$$

$$S_{21} = 2.60 \angle 76^\circ \quad S_{22} = 0.81 \angle -54^\circ$$

Determine the stability and compare maximum power gain for unilateral and bilateral modes using supplied formulas.
6. How is low pass filter implemented using microstrip? How are the low pass filter prototyped? [5+3]
7. What are the different types of electromagnetic radiation hazard? Illustrate radiation fields of a microwave oven. [4+4]
8. Choose a proper power measurement tool to measure power of a Airport Surveillance Radar. [8]
9. Write short notes on: [4×3]
 - i) Behavior of microwave bands
 - ii) Field equation of rectangular wave guide for TE mode
 - iii) Cavity Resonators

Supplied Formulas:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

34 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX752)

- ✓ 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 formula, graph and figures are attached herewith.
- ✓ Assume suitable data if necessary.

1. Classify signal frequency in different bands of waves and rays. What are the advantages and disadvantages of using microwave signal? [3+5]
2. By assuming a complex inductive load of an antenna which is mismatched with the line impedance of 78.0 ohm, design a double-stub short-circuited matching network. Show both electrical and physical connections. [8+2]
3. Why S-parameter is important in microwave network analysis? Write down the properties of a 3-port network. [4+4]
4. Suppose there are two identical radar transmitters and few passive devices in equipment stock. A particular application requires twice more input power to an antenna than either transmitter can deliver. As a RF engineer, give your appropriate solution for the above problem with necessary figures, mathematics and sufficient explanation. [8]
5. What do you mean by slow backward wave structure? Explain the construction and working principle of a LNA. [2+6]
6. Show a flow diagram that explain designing of an amplifier using a FET transistor. With self-defined parameters and the help of a smith chart define conditional stability of a microwave amplifier. [10]
7. Justify and describe how a microwave filter is designed using insertion loss method. [2+6]
8. Define major microwave measurement parameters and explain the working principle of a low microwave power measurement device. [8]
9. Write short notes on: (any two) [2×6]
 - a) RF/MW radiation hazards and safety practices
 - b) Directional Couplers
 - c) TE mode circular wave guide

Supplied Formulas:

$$B_1 = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2|S_{12}||S_{21}|}$$

$$A = (S_{11}S_{22} - S_{12}S_{21})$$

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

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

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

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

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

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

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

$$|C_1|^2 = \frac{(S_{22} - \Delta S_{11}^*)}{|S_{22}|^2 - |\Delta|^2}$$

$$|C_2|^2 = \frac{(S_{11} - \Delta S_{22}^*)}{|S_{11}|^2 - |\Delta|^2}$$

$$R_1 = \frac{|S_{12}S_{21}|}{|S_{22}|^2 - |\Delta|^2}$$

$$R_2 = \frac{|S_{12}S_{21}|}{|S_{11}|^2 - |\Delta|^2}$$

$$G_{\text{max}} = \left(\frac{1}{1 - |\Gamma_S|^2} \right) |S_{21}|^2 \left(\frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2} \right)$$

For unilateral mode $S_{12} = 0$, $\Gamma_S = S_{11}^*$ and $\Gamma_L = S_{22}^*$

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX 752)

- ✓ 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. Differentiate between lumped and distributed circuit analysis. What are the uses of microwave bands? [4+2]
2. Assume an inductive load impedance is connected to a mismatched 50Ω transmission line. Find the size and placement of the matching stub that will remove all the standing waves and match load to the line. Use double stub shunt tuning short and open circuited stub. Draw its electrical diagram and physical connection. [8]
3. Why we use S-parameters for microwave analysis? Define S-matrix for 3 port network with appropriate example. [4+4]
4. Choose a suitable passive microwave device to split power into half and explain its properties. [8]
5. Explain what is bunching effect. Explain the working principle of BWO with neat diagrams. [2+8]
6. Check the stability and find the maximum gain a transistor amplifier having $S_{11} = 0.64\angle -169^\circ$, $S_{12} = 0.03\angle 50^\circ$, $S_{21} = 10.11\angle 91^\circ$, $S_{22} = 0.22\angle -82^\circ$. Consider both bilateral and unilateral model. Modify the S-parameters if necessary. [12]
7. Describe insertion loss method of microwave filter design. Illustrate an example of a passive LPF using μ -strip. [8+2]
8. Describe the working principle of a network analyzer. [8]
9. Write short notes on: (Any two) [2×5]
 - a) Microwave Circulators
 - b) TM mode for rectangular waveguides
 - c) Microwave radiation hazards

Supplied Formulas:

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

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

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

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

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

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

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

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

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

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

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

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

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

$$G_{T\max} = \left(\frac{1}{1 - |\Gamma_S|^2} \right) |S_{21}|^2 \left(\frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2} \right)$$

$$\text{For unilateral mode } S_{12} = 0, \Gamma_S = S_{11}^* \text{ and } \Gamma_L = S_{22}^*$$

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX752)

- ✓ 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. What are the advantages and disadvantages of microwaves over acoustic waves? [5]
2. What is admittance chart? A load impedance of $Z_L = 80 + j100$ is connected to a microstrip transmission line. Find the size and placement of the matching stub. Use single stub shunt tuning short and open stubs. [2+8]
3. Define the use of S-parameters for three-port analysis. Define the term return loss and insertion loss. [5+2]
4. What are waveguide junctions? Describe the operational principles of magic tee based on s-parameters. [3+3]
5. What is density modulation? Describe the working principle of a multi-cavity klystron oscillator. [2+7]
6. Justify that a transistor having following S-parameters $S_{11} = 0.894 \angle -60.6^\circ$, $S_{12} = 0.020 \angle 62.4^\circ$, $S_{21} = 3.122 \angle 123.6^\circ$ and $S_{22} = 0.781 \angle -27.6^\circ$ is conditionally stable while designing an amplifier. Considering unilateral model calculate maximum gain. [5+5]
7. How can you implement low pass filter using micro-strip? How they are prototyped? [3+5]
8. Describe how standing waves and microwave powers are measured with VSWR meter and low power measurement. [2+8]
9. Write short notes on: (any three) [3×5]
 - a) Dominant mode in waveguide
 - b) Circulators
 - c) LNA cavity device inserting loss method for filter designing
 - d) Insertion loss method for filter designing



Supplied Formula

$$\begin{aligned}
 K &= \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}S_{21}|} & \mu &= \frac{1 - |S_{11}|^2}{|S_{22} - S_{11}^* \Delta| + |S_{12}S_{21}|} \\
 \Delta &= S_{11}S_{22} - S_{12}S_{21} & \Gamma_s &= \frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2C_1} & \Gamma_L &= \frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2C_2} \\
 R_L &= \left| \frac{S_{12}S_{21}}{|S_{22}|^2 - |\Delta|^2} \right| & B_1 &= 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2 & C_1 &= S_{11} - \Delta S_{22}^* \\
 & & B_2 &= 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2 & C_2 &= S_{22} - \Delta S_{11}^* \\
 C_L &= \frac{(S_{22} - \Delta S_{11}^*)^*}{|S_{22}|^2 - |\Delta|^2} & G_{TU} &= \frac{|S_{21}|^2 (1 - |\Gamma_s|^2)(1 - |\Gamma_L|^2)}{|1 - S_{11}\Gamma_s|^2 |1 - S_{22}\Gamma_L|^2} \\
 R_s &= \left| \frac{S_{12}S_{21}}{|S_{11}|^2 - |\Delta|^2} \right| & G_T &= \frac{|S_{21}|^2 (1 - |\Gamma_s|^2)(1 - |\Gamma_L|^2)}{|1 - \Gamma_s\Gamma_{in}|^2 |1 - S_{22}\Gamma_L|^2} \\
 C_s &= \frac{(S_{11} - \Delta S_{22}^*)^*}{|S_{11}|^2 - |\Delta|^2}
 \end{aligned}$$

Supplied Formula

Design For Maximum Gain (Conjugate Matching)

$$\Gamma_{in} = \Gamma_s^*$$

$$\Gamma_{out} = \Gamma_L^*$$

$$G_{Tmax} = \frac{1}{1 - |\Gamma_s|^2} |S_{21}|^2 \frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2}$$

$$\Gamma_s = \frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2C_1} \quad \Gamma_L = \frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2C_2}$$

$$B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2 \quad C_1 = S_{11} - \Delta S_{22}^*$$

$$B_2 = 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2 \quad C_2 = S_{22} - \Delta S_{11}^*$$

For Unilateral $S_{12} = 0$, $\Gamma_s = S_{11}^*$ and $\Gamma_L = S_{22}^*$

$$G_{TUmaz} = \frac{1}{1 - |S_{11}|^2} |S_{21}|^2 \frac{1}{1 - |S_{22}|^2}$$

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

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

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX752)

- ✓ 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. What are the merits and demerits of microwaves compared to seismic wave? [5]
2. Compare RF radiation fields and explain how they are hazardous to living body. [5]
3. Sketch an immittance chart and compare the scales. [5]
4. Design a signal shunt and open matching networks using Smith Chart for a transmission line having surge impedance of 75 Ohm and load impedance of $78.27 + j60.93$ Ohm. Sketch the physical diagram considering microstrips. [4+4+2]
5. You are supposed to measure about 7.5 mW of microwave power. Choose a proper power measuring device and explain its working principle. [10]
6. What is cross-field effect? Design and describe the working principle of a cross field cavity device for power amplifier. Consider a 90° phase shift between adjacent cavities. [3+7]
7. Describe magic Tee based on S-parameters. Differentiate between dominant and degenerate modes. Consider a rectangular waveguide having dimension of $a = 3b$ and find the dominant mode among TM_{01} , TM_{10} , TM_{11} , TM_{21} , TM_{12} , TM_{02} and TM_{20} . [6+2+2]
8. A GaAs FET transistor has the S-Parameters at 5 GHz with 50 Ohm line measured as $S_{11} = 0.45\angle 163^\circ$, $S_{12} = 0.04\angle 40^\circ$, $S_{21} = 2.55\angle -106^\circ$ and $S_{22} = 0.46\angle -65^\circ$. Check the stability and find the maximum power gain using this transistor. [10]
9. Write short note on: (any three) [3×5]
 - a) Microwave filter parameters and LPF prototyping
 - b) TM mode rectangular wave guide
 - c) Bunching effect in reflex klystron
 - d) Microwave mixer



Supplied Formula

$$\begin{aligned}
 K &= \frac{1 - |S_{11}|^2 - |S_{22}|^2 + |\Delta|^2}{2|S_{12}S_{21}|} & \mu &= \frac{1 - |S_{11}|^2}{|S_{22} - S_{11}^* \Delta| + |S_{12}S_{21}|} \\
 \Delta &= S_{11}S_{22} - S_{12}S_{21} & \Gamma_s &= \frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2C_1} & \Gamma_L &= \frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2C_2} \\
 R_L &= \left| \frac{S_{12}S_{21}}{|S_{22}|^2 - |\Delta|^2} \right| & B_1 &= 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2 & C_1 &= S_{11} - \Delta S_{22}^* \\
 & & B_2 &= 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2 & C_2 &= S_{22} - \Delta S_{11}^* \\
 C_L &= \frac{(S_{22} - \Delta S_{11}^*)}{|S_{22}|^2 - |\Delta|^2} & G_{TU} &= \frac{|S_{21}|^2 (1 - |\Gamma_s|^2) (1 - |\Gamma_L|^2)}{|1 - S_{11}\Gamma_s|^2 |1 - S_{22}\Gamma_L|^2} \\
 R_s &= \left| \frac{S_{12}S_{21}}{|S_{11}|^2 - |\Delta|^2} \right| & G_T &= \frac{|S_{21}|^2 (1 - |\Gamma_s|^2) (1 - |\Gamma_L|^2)}{|1 - \Gamma_s\Gamma_{in}|^2 |1 - S_{22}\Gamma_L|^2} \\
 C_s &= \frac{(S_{11} - \Delta S_{22}^*)}{|S_{11}|^2 - |\Delta|^2}
 \end{aligned}$$

Supplied Formula

Design For Maximum Gain (Conjugate Matching)

$$\Gamma_{in} = \Gamma_s^*$$

$$\Gamma_{out} = \Gamma_L^*$$

$$G_{Tmax} = \frac{1}{1 - |\Gamma_s|^2} |S_{21}|^2 \frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2}$$

$$\Gamma_s = \frac{B_1 \pm \sqrt{B_1^2 - 4|C_1|^2}}{2C_1} \quad \Gamma_L = \frac{B_2 \pm \sqrt{B_2^2 - 4|C_2|^2}}{2C_2}$$

$$B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2 \quad C_1 = S_{11} - \Delta S_{22}^*$$

$$B_2 = 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2 \quad C_2 = S_{22} - \Delta S_{11}^*$$

For Unilateral $S_{12} = 0$, $\Gamma_s = S_{11}^*$ and $\Gamma_L = S_{22}^*$

$$G_{TUmax} = \frac{1}{1 - |S_{11}|^2} |S_{21}|^2 \frac{1}{1 - |S_{22}|^2}$$

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

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

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX752)

- ✓ 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.

- Describe field equations and other related parameters of a rectangular waveguide in TM mode. Compare TE₁₀ and TE₂₀ in terms of cut-off frequency and dominant mode. [8+2]
- Design a double stub matching network using three-eighths wavelength $\left(\frac{3\lambda}{8}\right)$ separation that match an antenna having load of 300+j300 Ohm connected to a 300 Ohm transmission line. Justify your design. [10]
- What is bunching effect? Describe the working principle of a klystron oscillator. [2+8]
- Using the given S-parameters $S_{11}=0.55\angle 150^\circ, S_{12}=0.04\angle 20^\circ, S_{21}=2.82\angle 180^\circ, S_{22}=0.45\angle -30^\circ$ and required assumptions, calculate maximum gains of this transistor amplifier for bilateral and unilateral modes. [10]
- Draw a flow diagram to describe the design procedure of a microwave amplifier. Define the stability of an amplifier having $C_S=1.15\angle 10^\circ, R_S=0.85, C_L=1.10\angle 80^\circ, R_L=1.10$. [5+5]
- How microwave measurements are different to low frequency measurements? Describe how static calorimeter works to measure power. [3+7]
- Design a two-port network model and derive the required parameters. [10]
- Write short notes (Any TWO) [2x5]
 - Design procedures of microwave filters
 - Microwave radiation hazards and safety practices
 - Backward Wave Oscillator
 - Merits of S-parameters in microwaves

Supplied Formulas:

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

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

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

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

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

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

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

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

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

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

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

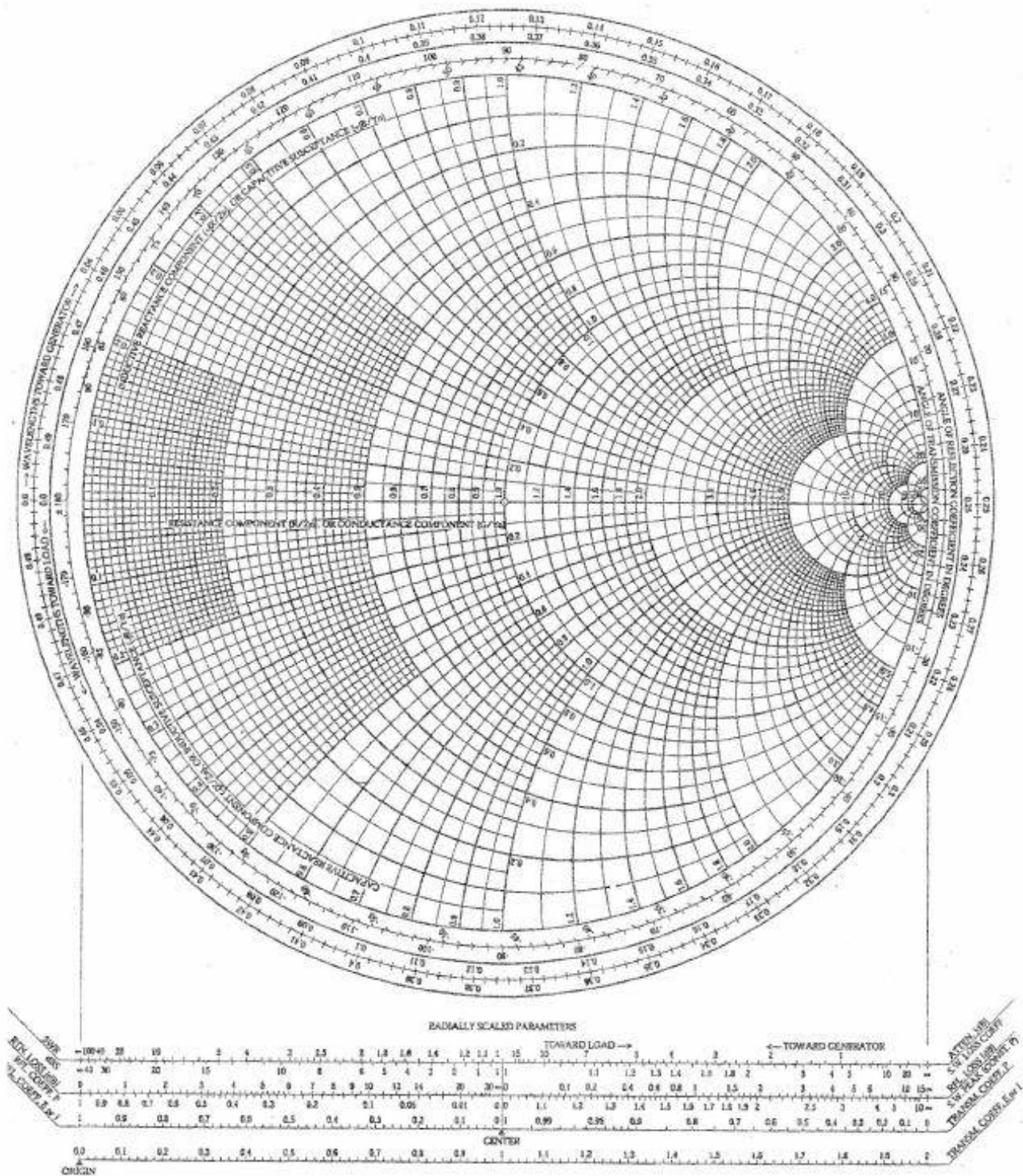
$$R_L = \frac{|S_{12}S_{21}|}{|S_{22}|^2 - |\Delta|^2}$$

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

$$G_{rmax} = \left(\frac{1 - |\Gamma_S|^2}{|1 - S_{11}\Gamma_S|^2} \right) |S_{21}|^2 \left(\frac{1 - |\Gamma_L|^2}{|1 - S_{22}\Gamma_L|^2} \right)$$

The Complete Smith Chart

Black Magic Design



Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX752)

- ✓ 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 figures and Smith Charts are attached herewith.
- ✓ Assume suitable data if necessary.

1. Differentiate the behaviors of the systems at microwave and conventional low frequency bands. [6]
2. Describe how TE mode is different from TM mode in a circular waveguide. [10]
3. Describe the working principle of a cavity magnetron. [10]
4. Why S-parameter is important in microwave network analysis? Define S-parameters for a two-port network. [4+5]
5. By arbitrarily assuming a suitable load that connects to a 50-ohm transmission line find the lengths and spacing for a two-stub impedance matching system. Assume also a suitable separation between the stubs. [10]
6. Using the following S-parameters of $S_{11}=0.55\angle-150^\circ$, $S_{12}=0.04\angle20^\circ$, $S_{21}=2.82\angle180^\circ$ and $S_{22}=0.45\angle-30^\circ$, calculate and compare maximum power gain for unilateral and bilateral modes. [15]
7. Discuss the difference between an amplifier circuit and an oscillator circuit in terms of stability factor. [5]
8. Write short notes (Any THREE) [3 x 5]
 - a. Microwave magic tee
 - b. Microwave radiation fields
 - c. Microwave strip-lines against micro-strips
 - d. Static calorimeter

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF and Microwave Engineering (EX752)

- ✓ 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.

- Based on operational principles, compare microwave systems with conventional low frequency systems. Lists the areas of application of microwave systems. [4+4]
- What makes S-parameters useful in microwave network analysis? Define S-parameters for a two-port network. Justify that the Butterworth and Chebyshev filter responses are common to prototype microwave two-port filter network using insertion loss method. [4+4+4]
- Design a double-stub impedance matching network for a given load of $80 + j180$ Ohm connected to a 100-Ohm transmission line at 3 GHz with a three-eighths wavelength separation between the stubs. Illustrate necessary diagrams to show physical connections. [8+2]
- Define expressions for various field components of a rectangular waveguide in TE mode. Show that a 1 GHz signal cannot propagate in TE₁₀ mode in a rectangular waveguide with a wall separation of 5 cm. [7+3]
- Find the maximum gain for a microwave transistor amplifier with $S_{11} = 0.656 \angle 146.7^\circ$, $S_{12} = 0.122 \angle 46.1^\circ$, $S_{21} = 2.3 \angle 44.7^\circ$, $S_{22} = 0.172 \angle -117.1^\circ$. [10]
- What is bunching effect? Briefly describe the construction and operational features of a cavity magnetron. [2+8]
- Describe how standing waves and microwave powers are measured with VSWR meter and bolometry respectively. [4+6]
- Write short notes on: (any two) [2x5]
 - Mixer theory
 - Circulators
 - Microwave radiation hazards and safety practices

Supplied Formulas:

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

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

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

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

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

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

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

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

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

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

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

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

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

$$G_{\text{max}} = \left(\frac{1}{1 - |\Gamma_s|^2} \right) |S_{21}|^2 \left(\frac{1 - |\Gamma_L|^2}{1 - S_{22}\Gamma_L^*} \right)$$

36T TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Bhadra

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEX	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - RF & Microwave Circuits, Systems & Devices (EG785EX) (Elective II)

- ✓ 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 chart are attached herewith.
- ✓ Assume suitable data if necessary.

1. Classify microwave frequency bands and state their major applications. Describe how microwave transmission lines are different from the conventional low frequency transmission lines. [4+4]
2. Describe microwave radiation hazards based on the radiation fields. [8]
3. Describe rectangular waveguide based on modes on propagation and other critical parameters. [8]
4. Describe why S-parameter is important in microwave network analysis. Using a two-port network derive S-parameters. [4+6]
5. What is double-stub tuner? Assuming a load of $75 + j75$ ohm is connected to a 50-ohm transmission line, find the lengths and spacing for a two-stub impedance matching system with three-eighths wavelength separation between the stubs. [3+15]
6. Design an amplifier to attain maximum gain at 4.0 GHz using a GaAs FET having following S-parameters: $S_{11} = 0.72\angle -116^\circ$, $S_{12} = 0.03\angle 57^\circ$, $S_{21} = 2.60\angle 76^\circ$ and $S_{22} = 0.73\angle -54^\circ$. Consider the characteristic impedance, $Z_0 = 50$ Ohm. [18]
7. Write short notes (Any TWO)
 - a. E-plane tee against H-plane tee
 - b. PROBE-coupling against LOOP-coupling
 - c. Microstrips
 - d. Two-cavity klystron

[2 x 5]
