SHRI ANGALAMMAN COLLEGE OF ENGINEERING & TECHNOLOGY
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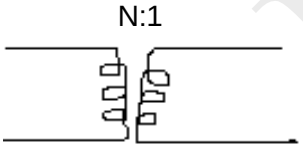
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

EC 1402 **Microwave Engineering**

UNIT I Microwave Network Theory

Two marks questions

1. Find the ABCD matrix of a transformer with N : 1 Turns



2. What do you mean by symmetry of scattering matrix?
3. State the properties of S-matrix of a two port lossless, reciprocal, perfectly matched network.
4. Find S- matrix of a length l of a lossless transmission line terminated by matched impedance

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Extra questions taken from Unit I

5. What are S parameters? Why are S parameters used in microwave network analysis?
6. Give the relationship between Y and S parameters
7. Give the relationship between Z and S parameters
8. Give the relationship between ABCD and Y parameters
9. Write down the S matrix of a two port network
10. Write briefly how S matrix for an multi-port network can be obtained from a two port analysis?

Part B questions

1. State and prove the properties of scattering matrices. (16)

2. i. What is scattering matrix? Derive scattering matrix formulation for n-port network. (12)
   ii. What are the advantages of S-parameters over 'Z' or 'Y' parameters (4)

3. i. Explain why Z or Y or ABCD parameters are not preferred in microwave circuit analysis but S-parameters are used. (4)
   ii. With the help of a 3 port network, establish relationship between S and Z matrices (12)

4. i. A two port network is terminated by mismatch generator and load. Derive an expression of input reflection coefficient Γ_1 in terms of load reflection coefficient Γ_2 and S-parameters of the network when it is lossless and reciprocal. (16)

   ii. The S-parameters of a two-port network are $S_{11} = 0.2 \angle 0°$, $S_{22} = 0.1 \angle 0°$, $S_{12} = 0.6 \angle 90°$, $S_{21} = 0.6 \angle 90°$. Prove that the network is reciprocal but not lossless.

If Γ_2 for a short circuit, find Γ_1 and return loss in dB (16)

UNIT II Microwave Passive Devices

Two marks questions

1. Give the X-band frequency range.
2. State the principal advantage of microwave frequencies over lower frequency
3. What are co-axial connectors and adapters?
4. What is the use of waveguide choke flange? How is it designed?
5. Draw the various types of terminations.
6. What is the use of waveguide transition?
7. Distinguish between windows and tuning screws?
8. What are the impedances offered by a tuning screw on the broad wall of rectangular waveguide, when depth of penetration varies?
9. What are waveguide corners, bends and twists? Where are they used?
10. Write down the need for coupling loops and aperture.
11. What are the different types of attenuators? Why are they required?
12. Write the S matrices of various attenuators.
13. What is the effect of phase shifter? Give the S matrix.
14. What are the basic types of directional couplers?
15. Define the basic parameters to measure the performance of a directional coupler?
16. What do you mean by Faraday rotation isolator? Write its S matrix.
17. Draw a 3-port circulator and give its S matrix.
18. Compare the E and H plane Tee junctions by their structure, operation and S matrix.
19. Why is Magic Tee called so? Write down the applications.
20. Compare three and four port devices with two examples for each.

Part B questions

1. Write information on the following: Waveguide matched terminations, Shorts, Coupling loop & Aperture and Attenuators (16)
2. Write notes on the following: Waveguide tuning screws, corners, twists and bends. (16)
3. Describe the working of E- and H-plane Tee junctions and obtain the S-matrices. (16)

4. i. Explain the operation of Hybrid Tee junction and list its characteristics, when all the ports are terminated with matched load. (10)
   ii. Discuss briefly on Faraday rotation isolator. (6)

5. i. Explain the working of a circulator and obtain its S matrix. (10)
   ii. Prove that it is impossible to construct a perfectly matched, lossless, reciprocal three port junction. (6)
6. Explain the working and list out the characteristics of the Magic T when all the ports are terminated with matched load. (16)
7. Describe the operation and derive the S-matrix of a 2-hole Directional Coupler. (8)
8. Explain the operation of Hybrid Ring and obtain its S matrix. (16)

9. A three port circulator has an insertion loss of 1 dB, an isolation of 20 dB, and VSWR of 1.2 when all ports are matched terminated. Find the S matrix of the junction and the output power at ports 2 and 3 for an input power of 100mW at port 1. (16)

UNIT III Microwave Vacuum Tube Devices

Two marks questions.

1. Why the conventional tubes like triode, tetrode cannot generate microwave power?
2. What are the limitations of conventional tubes?
3. Distinguish between O-type tubes and M-type tubes with examples.
4. What is the other name for O-type tubes?
5. What are re-entrant cavities?
6. What are modulations occurring in Klystron?
7. What is mode of operation in Klystron?
8. Write down the performances of Klystron.
9. Distinguish between Klystron and Reflex Klystron with diagrams.
10. Write the assumptions to calculate the RF power using reflex Klystron oscillator.
11. Define beam loading.
12. What is electronic admittance?
13. Draw the structure of TWTA.
14. What is the need for slow wave structure? Name some types of slow wave structures.
15. Explain why optimum RF power output from reflex klystron is more at higher magnitude of repeller voltage and lower mode.
16. Explain why TWTA has a broader bandwidth than two cavity klystron amplifier?
17. Draw the Magnetron oscillator structure.
18. What is phase focusing?
19. What are frequency pushing and pulling?
20. Give the Hull cut-off equations.
21. List out the various tube version oscillators and amplifiers.

Part B questions:

1.i. Discuss briefly on reflex Klystron tuning. (8)

ii.Compare the features of velocity modulation and density modulation. (8)

2.i. Describe the gain characteristics of TWT amplifier. (8)

ii.Derive the Hull cut-off magnetic and voltage equations. (8)

3. A two cavity Klystron amplifier has the following parameters:
   Beam voltage (V_{dc})=900V, Beam current (I_o)=30mA, frequency = 8GHz, gap spacing in either cavity (d)=1mm. Spacing between centre of cavities (s) = 4 cm. Effective shunt impedance (R_{sh}) = 40KΩ.
   Calculate:
   i. electron velocity (5)
   ii. d.c electron time (5)
   iii. input voltage for maximum output voltage (6)

Or

b. i. Explain with a neat figure, how TWT is used as an microwave oscillator? (10)

ii. List and explain various applications of TWT. (6)

4.i.A reflex klystron is operated at 8 GHz with dc beam voltage of 600V for 1.75 mode, repeller space length of 1 mm, and dc beam current of 9mA. The beam coupling coefficient is assumed to be 1. Calculate the repeller voltage, electronic efficiency and output power. (8)

ii. With the applegate diagram, describe the mechanism of operation of two cavity klystron amplifier. Write the assumptions on which the analysis for RF amplification by this amplifier is based. (8)

5. i. How can you analyze a TWTA circuit that uses a helix slow-wave non-resonant microwave guiding structure? (8)

ii. Explain the oscillation mechanism and the electron trajectory concept of magnetron oscillator. (8)

4. i. Draw a neat sketch showing the constructional features of a cavity magnetron and explain why Magnetron is called as crossed field device. (4)

ii. Derive an expression for cut off magnetic field for a cylindrical magnetron. (8)

iii. Explain how 'strapping' enables the separation of II mode from other modes. (4)

5. i. Write down RWH theory of Gunn diode. (6)

ii. Explain the various modes of operation of Gunn diode (10)

6. i. Describe with the neat sketch the constructional details and principle of operation of a Reflex Klystron tube. With the help of Applegate diagram illustrate the phenomenon of bunching. (8)

ii. Derive expressions for bunched beam current and efficiency. (8)

7. A reflex klystron is operated at 5GHz with dc beam voltage 1000V, beam current 20mA, repeller space Lcm for 1 ¾ mode, cavity gap 2 mm, repeller voltage - 500V. Calculate optimum repeller space, rf power output, efficiency and the bandwidth over ΔV_R =1V. (16)

8. A cylindrical magnetron is operated at 5GHz with cathode radius 3cm, anode radius 5cm, 16 resonate cavities, anode voltae 20 kV, dc magnetic flux density 0.05 T. Calculate cut-off voltage, cut-off magnetic flux density, Hartee voltage.

UNIT IV Microwave Solid State Devices and Circuits

Two marks questions

1. List out the high frequency limitations of bipolar devices.
2. Give the major disadvantages of IMPATT diodes.
3. What is Gunn effect?
4. What do the Acronyms IMPATT, TRAPATT and BARITT stand for?
5. State the transferred electron effect.
6. What are the major disadvantages of IMPATT diodes?
7. State Gunn effect.
8. Distinguish between ATD's and TED's.
9. What is transferred electron effect?
10. What are the differences between Transferred Electron Devices and Avalanche Transit-time Devices?

22. What are the advantages and disadvantages of parametric amplifiers?
23. What are HEMTs?
24. What is MESFET?

Part B questions

1. i. With equivalent circuits, describe the power frequency limitations of microwave bipolar transistor. (8)
   ii. Describe the various modes of operation in Gunn diode. (8)

2. i. Distinguish between IMPATT, TRAPATT and BARITT diodes. (8)
   ii. List the advantages and limitations of parametric amplifiers and the advantages of parametric up converter. (8)

3. i. Draw the microwave equivalent circuit of a bipolar transistor. (8)
   ii. Explain the operation of a tunnel diode. (8)

4. i. Discuss the differences between transferred electron devices and avalanche transit time devices. (8)
   ii. Describe the modes of operation of a Gunn diode. (8)

5. i. Draw the geometrical of GaAsFET and explain. (8)
   ii. What are the modes of operation that result in microwave oscillations in a Gunn diode? Explain. (8)

6. i. Describe the principle of operation, the cases of input resistance at signal frequency and the circuit performance of parametric amplifier. (8)
   ii. Explain the construction and DC operating principle of IMPATT diode. (8)

7. Enumerate with appropriate equations the power frequency limitations of BJT's at high frequencies. (6)

8. Write short notes on :
   i. Microwave FET's (8)
   ii. HEMT (8)

9. i. Give the principle of parametric amplifier. (4)
   ii. Derive Manley – Rowe power relations and hence explain the parametric up convener. (12)

10. Explain the constructional details and principle of operation of GaAs MESFET with neat diagrams and characteristic curves. (16)

11. i. What are avalanche transit time devices? (2)
    ii. With neat diagram explain the construction and operating principle of IMPATT diode. (12)
    iii. Mention any two applications of IMPATT diode. (2)

12. i. Explain using multivalley energy diagram, the I-V characteristics of gunn diodes. Draw and explain electrical equivalent circuit. Explain LSA mode of operation. (8)

ii. A GaAs Gunn diode oscillator operates at 10GHz with drift velocity of electrons 10^5 m/s. Determine the effective length of the active region. What is the required dc voltage for oscillation? Critical field is 3uv/cm. (8)

13. Explain the I-V characteristics of Tunnel diode and its electrical equivalent circuit. Obtain an expression of resonant frequency. With the help of a diagram explain operation and obtain power gain expression for a reflection amplifier. What are the advantages of tunnel diode?

UNIT V Microwave Measurements

Two marks questions

1. What does VSWR determine?
2. List any two sensors used to measure the power.
3. Draw a setup to measure the frequency.
4. Mention two methods to measure microwave power.
5. Write the main demerits of single bridge power meter.
6. What does the accuracy of phase measurement depend on while measuring the impedance using reflectometer method?
7. What is the principle by which high power measurements could be done by calorimetric method?
8. Name two methods to measure the dielectric constant of a solid.
9. Mention two methods to measure impedance.
10. Define return loss and write its expression.
11. Why reflex klystron is square wave 1KHz pulse amplitude modulated while microwave measurements are done using VSWR meter?
12. What are the source of error in return loss measurement using a w/g reflectometer and reflex klystron source?

Part B questions

1.i.How do you measure VSWR through return loss measurement. (8)
ii. Explain the slotted line method to measure the impedance. (8)

2. i. How do you measure the dielectric constant of a solid using waveguide? (8)
ii. Draw the experimental set-up for S-parameter measurement of magic tee, and explain. (8)

3.i.Explain the basic principle of operation of a bolometer. (8)
ii. Describe a technique of measuring the phase shift provided by a network. (8)

4. Explain with a block diagram how frequency of an unknown microwave signal can be Measured directly and indirectly (16)
5. i. Draw the block diagram for the slotted line method of VSWR measurement and

explain. (8)

ii. Explain a method for high power measurement. (8)

6. i. Draw the experimental set-up for the measurement of impedance of a discontinuity and explain. (8)

ii. Draw the experimental set-up for S-parameter measurement of Magic Tee and explain. (8)

7. i. With neat block diagram explain the Insertion loss and Attenuation measurements. (8)

ii. Explain the measurement of load Impedance by slotted line method. (8)

8. i. Describe with neat diagram and mathematical formulation the measurement of dielectric constant of a solid using rectangular waveguide. (8)

ii. Explain the measurement of cavity 'Q' by slotted line method. (8)

9. Describe in detail with block diagram the measurement of VSWR through return loss measurement. (16)

10. Explain in detail the measurement of load impedance through slotted line method. (16)

11. i.Describe the operation of tunable probe detector used in slotted line with the help of a neat diagram. What are the possible sources of error in low VSWR measurements using slotted line? (8)

ii. A Crystal detector generates a signal of 10mV for an incident microwave power of -25dBm. What is the detector sensitivity in mV/mW? (8)

12. i. Describe with neat diagram and mathematical formulation how dielectric constant of a solid material is determined/measured using rectangular waveguide as sample holder.(8)

ii. Explain how gain of an antenna is measured using three antenna method. What care should be taken for accuracy in measurements? (8)

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