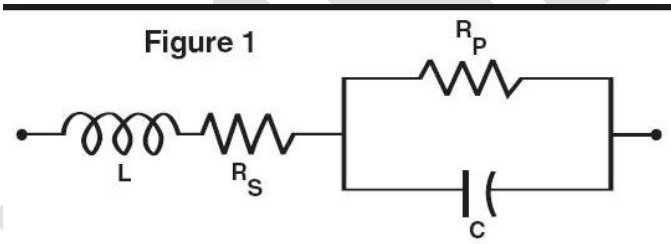
PART A

UNIT I

TWO PORT RF NETWORKS – CIRCUIT REPRESENTATION

1. **Mention the limitations in measuring Z, Y and ABCD parameters at microwave frequencies. (Nov/Dec 2011)**
   (i) Equipment is not readily available to measure total voltage and current at the ports of the network.
   (ii) Short circuit and open circuit are difficult to achieve over a wide range of frequencies.
   (iii) Presence of active devices such as power transistors and tunnel diodes, makes the circuit unstable.
2. **A 5dB attenuator is specified as having VSWR of 1.2. Assuming the device is reciprocal finding the S parameters. (Nov/Dec 2011)**
   Attenuators are normally reciprocal devices, therefore
   $|S21| = |S12| = 0$
   $|S11|$ or $|S22| = (VSWR-1)/ (VSWR+1)$
   $= (1.2-1)/ (1.2+1)$
   $= 0.09$
3. **State the properties of S parameter.(Nov/Dec 2012)**
   (i) |S| is always a square matrix of order (n*n).
   (ii) |S| is a symmetric matrix.
   (iii) |S| is a unitary matrix.
   (iv) Under perfect matched conditions, the diagonal elements of |S| are zero.
4. **Give the X-band frequency range. (Nov/Dec 2007)**
   Frequency range: 8 – 12.5 GHz
   Wavelength : 3.75cm – 2.4cm
5. **Draw the equivalent circuit of a practical capacitor. (Nov/Dec 2012)**

Figure 1



C = Capacitance R_S = Equivalent Series Resistance (ESR)
L = Inductance R_P = Insulation Resistance (IR)

6. **What do you mean by symmetry of scattering matrix? (April/May 2008)**
   |S| is a symmetric matrix when the microwave device has the same transmission characteristics in either direction of a pair of ports.
   $$S_{ij} = S_{ji}$$
7. **Write down the ABCD parameters of a lossless transmission line. (Nov/Dec 2005)**
   $V_1 = AV_2 – BI_2$
   $I_1 = CV_2 - DI_2$
8. **Give the K-band frequency range. (May/June 2007)**
   Frequency range: 18 – 26.5 GHz
   Wavelength : 1.67 – 1.13 cm

9. Define Scattering matrix.

Scattering matrix is a square matrix which gives all the combinations of the power relationships between the various input and output port of a microwave junction.

10. State the reciprocity theorem.

The theorem states that when some amount of electromotive force (or voltage) is applied at one point (e.g., in branch k, v_k) in a passive linear network, that will produce the current at any other point (e.g., in branch m, i_m). The same amount of current (in branch k, v_k) is produced when the same electromotive force (or voltage) is applied in the new location(in branch m, i_m).

$$v_k/i_m = i_m/v_k$$

11. Define lossless network.

In lossless passive network, the power entering the circuit is always equal to power leaving network which leads to the conservation of power.

12. List the different types of high frequency capacitors.

(i) Parallel plate capacitor
(ii) Leaded capacitor
(iii) Perfect capacitor

13. List the different types of high frequency resistors.

(i) Carbon composite resistors
(ii) Metal film resistors
(iii) Thin-film chip resistors

14. List the different types of high frequency inductors.

(i) Simple wire inductor
(ii) Coiled wire inductor

15. Define straight wire inductance.

In a wire medium, if the current is AC, the magnetic field is alternately expanding and contracting. This produces an induced voltage in the wire that opposes any change in the current flow. This opposition to change is called 'Self Inductance'.

16. Define skin effect.

As frequency increases, the electrical signals propagate less and less inside the conductor. As a result the current density increases near the outside perimeter of the wire and causes higher impedance for the signal. This effect is known as skin effect.

17. Why the S parameters are used in microwaves?

(i) Increased stability at higher frequencies
(ii) Mismatch loss is less
(iii) Attenuation loss is less

18. What is insertion loss?

Insertion loss is measure of the loss of the energy in transmission through a line or device compared to direct delivery of energy without the line or device.

19. Define Q factor of a capacitor.

The measure of ability of an element to store energy, equal to 2π times the average energy store divided by the energy dissipated per cycle.

UNIT II

RF TRANSISTOR AMPLIFIER DESIGN AND MATCHING NETWORKS

1. What is the need for impedance matching network? (Nov/Dec 2011)

(i) To stabilize the amplifier by keeping the source and load impedances in the appropriate range.
(ii) To reduce undesired reflections.
(iii) To improve the power flow capabilities.

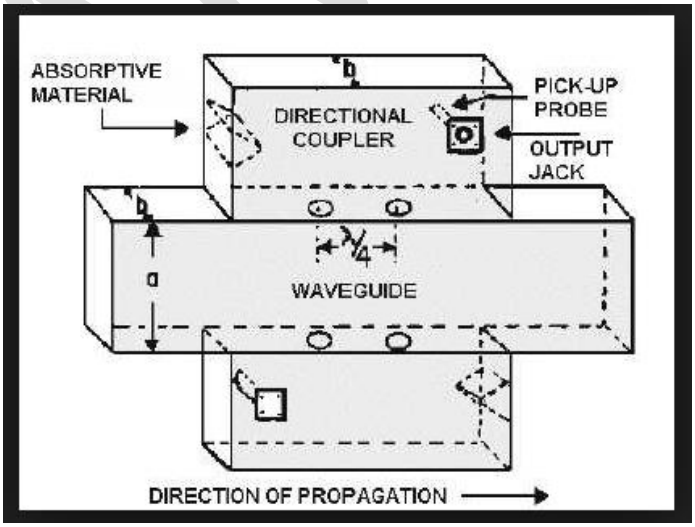
2. Write the expression for noise figure of a two port amplifier. (Nov/Dec 2011)

$$F = F_{min} + (G_n/R_s)\,|Z_s - Z_{opt}|^2$$

3. **What are the considerations in selecting a matching network?(Nov/Dec 2012)**
   (i) Gain and gain flatness
   (ii) Operating frequency and bandwidth
   (iii) Output power
   (iv) Power supply requirements
   (v) Input and output reflection coefficients
   (vi) Noise figure
4. **Define power gain of an amplifier in terms of S parameters and reflection coefficients. (Nov/Dec 2012)**
   Transducer power gain defined as the ratio of power delivered to the load to that of the power available from the source.
5. **Define unilateral power gain.**
   When feedback effect of the amplifier is neglected (i.e. $S_{12} = 0$), the amplifier power gain is known as unilateral power gain.
6. **Define operating power gain.**
   Operating power gain is defined as the power delivered to the load to that of the power supplied to the amplifier.
7. **Define available power gain from load.**
   Available power gain is defined as the power available from the network to that of the power available from the source.
8. **Define unconditional stability.**
   Unconditional stability refers to the situation where the amplifier remains stable for any passive source and load at the selected frequencies and bias conditions.
9. **Define noise figure.**
   Noise figure is defined as the ratio of input SNR to the output SNR.
   $$F = (SNR)_O/(SNR)_I$$
10. **List the various types of waveguide stub.**
    (i) E stub
    (ii) H stub
    (iii) E-H tuner
11. **Define positive and negative feedback of RF circuit.**
    (i) If $|\Gamma| > 1$, then the magnitude of the return voltage wave increases and causes instability. This is known as positive feedback.
    (ii) If $|\Gamma| < 1$, the return voltage is totally avoided. This is known as negative feedback.

UNIT III
MICROWAVE PASSIVE COMPONENTS

1. **Draw a structure of two hole directional coupler. (Nov/Dec 2011)**



2. **Find the resonant frequency of TE $_{101}$ mode of an air filled rectangular cavity of dimensions 5 cm * 4 cm * 2.5cm. (Nov/Dec 2011)**

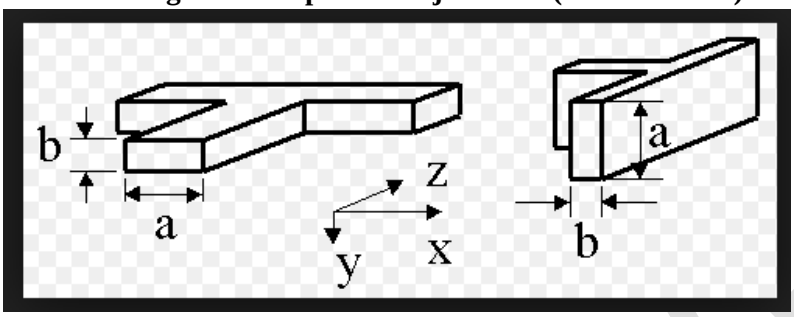
Given

a = 5cm
b = 4cm
d = 2.5cm
m = 1
n = 0
p = 1

$$f_r = \frac{1}{2}(\mu\epsilon)^{1/2}\left[(m/a)^2 + (n/b)^2 + (p/d)^2\right]^{1/2}$$

$$= 6.71 \text{ GHz}$$

3. **Draw the diagram of H-plane Tee junction. (Nov/Dec 2012)**



4. **State Faraday's rotation law.**

If a circularly polarized wave is made to pass through a ferrite rod which has been influenced by an axial magnetic field B, then the axis of polarization gets tilted in clockwise direction and amount of tilt depends upon the strength of magnetic field and geometry of the ferrite.

5. **Define directivity of directional coupler.(April/May 2008)**

The directivity of directional coupler is defined as the ratio of forward power P_r to that of the back power P_b expressed in dB.

6. **What are the basic parameters to measure the performance of a directional coupler? (Nov/Dec 2008)**

(i) Coupling co-efficient
(ii) Directivity
(iii) Insertion loss
(iv) Isolation

7. **What do you mean by Faraday rotation isolator? (Nov/Dec 2008)**

Isolators can be made by inserting ferrite rod along the axis of a rectangular waveguide. This isolator is known as Faraday rotation isolator.

8. **What are the basic types of directional couplers?(Nov/Dec 2009)**

(i) Two hole directional coupler
(ii) Four hole directional coupler
(iii) Reverse coupling directional coupler
(iv) Bethe hole directional coupler

9. **What is the need for waveguide twist?**

Waveguide twists are used to change the plane of polarization of a propagating wave.

10. **Why is a magic tee referred to as E-H tee?**

Magic tee is constructed by E plane tee and H plane tee perpendicular to each other. Therefore magic tee is referred as E-H tee.

11. **What are scattering coefficients?**

The elements representing various ports of a n*n matrix are known as scattering coefficients or scattering parameters.

12. What is hybrid ring?

Hybrid ring consists of an annular line of proper electrical length to sustain standing waves, to which four arms are connected at proper intervals by means of series or parallel junctions.

13. Define coupling factor(C).

Coupling factor is measure of how much of the incident power is being sampled.

14. Define isolator.

An isolator is a two port non-reciprocal device which produces a minimum attenuation to wave in one direction and very high attenuation in the opposite direction.

15. What is the need for circulator in microwave applications?

(i) Circulator used as duplexer in radar antenna system
(ii) Three port circulator used in tunnel diode and parametric amplifiers
(iii) Circulators are also used in low power applications

16. Define non-reciprocal devices.

The devices having different forward and reverse propagating characteristics are known as non-reciprocal devices.

17. State the properties of ferrites.

(i) Ferrites exhibits strong magnetic ability
(ii) Ferrites exhibits high resistivity
(iii) Ferrites exhibits non-reciprocal property

18. What is meant by hybrid junction?

A hybrid junction is a four-port network in which a signal incident on any one of the ports divides between two output ports with the remaining port being isolated.

UNIT IV
MICROWAVE SEMICONDUCTOR DEVICES

1. Compare tunnel diode and normal P-N diode.(Nov/Dec 2011)

TUNNEL DIODE	p-n DIODE
Doping levels at p and n sides are very high.	Doping levels at p and n sides are very normal.
It exhibits negative resistance characteristics.	It does not exhibits negative resistance characteristics.
Used as reflection amplifiers and oscillators.	Used as detectors and mixers.
Preferred semiconductors – Ge and GaAs.	Preferred semiconductors – Ge.
Low noise.	Moderate noise.

2. List the advantages of parametric amplifier. (Nov/Dec 2011)

(i) Thermal noise in parametric amplifiers is less.
(ii) Stability is high at higher frequencies.
(iii) Typical noise figure of 1-2dB

3. State transferred electron effect. (Nov/Dec 2012)

When GaAs is biased above a threshold value of the electric field, it exhibits a negative differential mobility. The electrons in the lower energy band will be transferred into the higher energy band. This behavior is called transferred electron effect.

4. What are HEMT's? (Nov/Dec 2011)

(i) The Field Effect Transistor (FET) which is made using a heterojunction is called High Electron Mobility Transistor (HEMT).
(ii) HEMT has higher frequency of operation.
(iii) HEMT has lower noise figure.

5. What is MESFET? (Nov/Dec 2007)

When the Field Effect Transistor is constructed with a metal-semiconductor Schottky-barrier diode, the device is called a Metal Semiconductor Field Effect Transistor (MESFET).

6. State Gunn Effect. (April/May 2008)

When the electric field is varied from zero to threshold value, the carrier drift velocity is increased from zero to maximum. When the electric field is beyond the threshold value of 3000V/cm, the drift velocity is decreased and the diode exhibits negative resistance.

7. What are M-type tubes? (April/May 2008)

M type tubes are crossed field devices where the static magnetic field is perpendicular to the electric field. Here the electrons travel in curved path.

8. List the advantages for microwave IC's. (April/May 2008)

(i) Low package density
(ii) Small size and less weight
(iii) High reliability
(iv) Different transmission structures (micro strip lines, lumped circuit elements, thin film circuits) are possible

9. What are the major disadvantages of IMPATT diodes? (Nov/Dec 2008)

(i) Avalanche process makes the IMPATT diode noisy
(ii) Poor noise figure of 30dB
(iii) Low efficiency due to induced electron current

10. List the high frequency limitations of bipolar devices. (Nov/Dec 2009)

(i) Unstable beyond K band frequency.
(ii) Higher noise level
(iii) Voltage gain is less compared to other transistors

11. What is the other name of O-type? (Nov/Dec 2007)

Linear tube or rectilinear beam tube.

12. Mention the basic materials required for microwave integrated circuit. (Nov/Dec 2007)

(i) Substrate materials
(ii) Conductor materials
(iii) Dielectric materials
(iv) Resistive materials

13. State any two applications of parametric amplifier. (May/June 2007)

(i) Space communication systems
(ii) Radio telescopes
(iii) Tropo-receivers

14. Name the different types of lithography. (April/May 2008)

(i) Electron-beam lithography
(ii) Ion-beam lithography
(iii) Optical lithography
(iv) X-ray lithography

15. Define bilateral negative-resistance parametric amplifier.

When the negative resistance parametric amplifier operates below the oscillation threshold, the device is known as bilateral negative-resistance parametric amplifier.

16. List the various MMIC fabrication techniques.

(i) Diffusion and ion implementation
(ii) Oxidation and film deposition
(iii) Epitaxial growth
(iv) Lithography
(v) Etching and photo resist
(vi) deposition

17. What are the elements that exhibit Gunn Effect?

(i) Gallium arsenide
(ii) Indium phosphide
(iii) Cadmium telluride

(iv) Indium arsenide

18. What are the modes available in negative resistance devices?

(i) Voltage controlled mode

(ii) Current controlled mode

UNIT V

MICROWAVE TUBES AND MEASUREMENTS

1. State any four high frequency limitations. (Nov/Dec 2011)

(i) Lead inductance effects

(ii) Interelectrode capacitance effects

(iii) Transmit angle effects

(iv) Gain bandwidth product limitation

2. **A helix travelling wave tube operates at 4 GHz, under a beam voltage of 10 KV and beam current of 500mA. If the helix is 25Ω and interaction length is 20cm, find the gain parameter. (Nov/Dec 2011)**

Given

$V_0 = 10KV$

$I_0 = 500mA$

$Z_0 = 25ohm$

$F = 4$ GHz

$l = 20cm$

Gain parameter $C = [I_0Z_0/4V_0]^{1/3}$

$= 0.068$

3. What are the possible errors in standing wave ratio measurements? (Nov/Dec 2012)

(i) V_{max} and V_{min} may not be measured in the square law region of the crystal detector.

(ii) Probe thickness and depth may produce reflections in the line.

(iii) Residual VSWR arises due to mismatch impedance.

(iv) Harmonics and spurious signals from source causes measurement errors.

4. State two methods to measure impedance. (Nov/Dec 2012)

(i) Slotted line method

(ii) Reflectometer method

5. Define return loss and write its expression. (Nov/Dec 2007)

The return loss is a measure of the power reflected by a line or network or device.

Return loss (dB) = 10 log [input energy to the device / reflected energy at the input of the device]

Return loss (dB) = $10 \log [P_i/P_r]$

6. What is the principle by which high power measurements could be done by calorimetric method? (April/May 2008)

(i) Direct heating method

(ii) Indirect heating method

7. State the demerits of single bridge power meter. (Nov/Dec 2008)

(i) The change of resistance due to a mismatch at the microwave input ports results in incorrect reading.

(ii) The themistor is sensitive to changes in the ambient temperature resulting in false reading.

8. List any two sensors used to measure the power. (Nov/Dec 2009)

(i) Barretter

(ii) Thermistor

9. What is bolometer? Give two examples. (May/June 2007)

Bolometer is a power sensor whose resistance changes with temperature as it absorbs microwave power. Examples: Barretter, Thermistor.

10. Define reflection loss.

Reflection loss is a measure of power loss during transmission due to the reflection of the signal as a result of impedance mismatch.

11. Define insertion loss.

Insertion loss is a measure of loss of energy in transmission through a line or device compared to direct delivery of energy without the line or device.

12. What is a VSWR meter?

VSWR meter is a highly sensitive, high gain, low noise voltage amplifier tuned normally at fixed frequency of 1KHZ at which microwave signals are modulated. This meter indicates calibrated VSWR reading for any loads.

13. How do you measure microwave frequencies?

(i) Wave meter method
(ii) Slotted line method
(iii) Down conversion method

14. What is calorimeter?

It is convenient device setup for measuring the high power at microwave which involves conversion of microwave energy in to heat, absorbing the heat in a fluid and determine the temperature.

15. What is tunable detector?

The tunable detectors are used to demodulate the signal and couple the required output to high frequency scope analyzer. The low frequency demodulated output is detected using non reciprocal detector diode mounted in the microwave transmission line.

16. What is calorimetric direct heating method?

In calorimetric direct heating method, the rate of production of heat can be measured by observing the rise in temperature of the dissipating medium.

17. What is calorimetric indirect heating method?

In calorimetric indirect heating method, heat is transferred to another medium before measurement.

UNIT I

1. Explain the properties of S-parameters. (8)
2. Prove that the S-Matrix for a reciprocal network is symmetric. (8)
3. Write Short notes on High Frequency resistors, inductors & capacitors. (16)
4. Discuss about the various losses available in microwave. (16)
5. Explain in detail about low frequency parameters (16)
6. Write the need for S-parameters and define S-parameters for a two port network. (16)

UNIT II

1. Derive the derivations for power gain, available gain and transducer gain of a Microwave amplifier using S-parameters. (16)
2. Derive the expression for input and output stability circle equation (16)
3. Draw the double stub matching network and explain it in detail (16)
4. Discuss the smith chart approach to design the L-section and T-section matching Networks. (16)

UNIT III

1. From the first principles derive the Scattering matrix of an ideal Directional Coupler. (16)
2. Derive scattering matrix for Hybrid Tee using 'S' parameter theory. (16)
3. Explain the properties of E-plane Tee and H-plane Tee. (16)
4. Derive the coupling parameters for directional couplers and explain its types. (16)
5. With neat diagram explain the operation of attenuator and phase shifter (16)

UNIT IV

1. Describe the principle of operation and the circuit performance of Parametric up and down converter. (16)
2. Explain the principle of operation of MESFET with necessary curves and Diagrams. (16)
3. With the help of two valley theory, explain how negative resistance is created in Gunn diodes (16)
4. Explain the operation of MOSFET with neat diagram and characteristic curves. (16)
5. With neat diagrams, explain the operation of Tunnel diode and varactor diode.
6. With a neat diagram, explain how negative resistance is created in Gunn diodes and draw the Equivalent circuit of Gunn diode. (16)

UNIT V

1. Explain the oscillation mechanism and the electron trajectory concept of Magnetron oscillator. (16)
2. Explain LOW VSWR and HIGH VSWR measurement method. (16)
3. With the Applegate diagram, describe the mechanism of operation of two cavity klystron Amplifier.
4. Explain the principle of operation of Reflex Klystron Oscillator with a neat diagram. (16)
5. Explain the oscillation mechanism and the electron trajectory Concept of Magnetron oscillator. (16)