UNIT-I TWO PORT NETWORK THEORY

1. What is the Scattering matrix for N port device?

[S]= S11 S12 S13..... S1n
S21 S22 .....S2n
S31 S32 .....S3n
. .
. .
Sm1 Sm2 .....Sm

2. State phase shifting property of S-parameters. Dec 2006

If the microwave network is shifted from its reference plane by the electrical distance 'l', its S parameters of the shifted network gets changed by multiplying its coefficient by $e^{-j\varphi l}$.

3. Define s-matrix

In a microwave junction there is intersection of three or more components. There will be an output port, in addition there may be reflection from the junction of other ports. Totally there may be many combinations, these are represented easily using a matrix called S matrix.

4. What are the properties of scattering matrix for a lossless junction?

1. The product of any column of the S-matrix with conjugate of this column equals unity.
2. The product of any column of the scattering matrix with the complex conjugate of any other column is zero.

5. Give two examples for two port junctions.

1. The junction of two rectangular guides of unequal height
2. A symmetrical junction consisting of two similar rectangular guides joined by an Intermediate guide of greater width.

6. **Define microwave**.

Microwaves are electromagnetic waves (EM) with wavelength ranging from 1cm to 1mm.The corresponding frequency range is 1 GHZ (=10^9 Hz) to 300GHz (=10^{11}Hz). Therefore signals, because of their inherently high frequencies, have relatively short wavelengths, hence the name micro" waves.

7. What are the major bands available in microwave frequencies?

The microwave frequencies span the following three major bands at the highest end of RF spectrum.

Ultra High Frequency (UHF) 0.3 to 3 GHz.
I. Super High Frequency (SHF) 3 to 30 GHz.
II. Extra High Frequency (EHF) 30 to 300 GHz.

8. Enumerate the basic advantage of microwaves.

Fewer repeaters are necessary for amplification.

- Minimal cross talk exists between voice channels.
- Increased reliability and less maintenance are important factors.
- Increased bandwidth availability.

9. Write the applications of microwaves.

- Microwave becomes a very powerful tool in microwave radio spectroscopy for analysis.
- Microwave landing system (MLS), used to guide aircraft to land safety at airports.
- Special microwave equipment known as diathermy machines are used in medicine for heating body muscles and tissues without hurting the skin.
- Microwave ovens are a common appliance in most kitchens today.

10. **Why are S parameters used in microwaves?**

The S parameters are used in microwaves because of the following characteristics

Increased stability at higher frequencies
Mismatch loss is less
Attenuation loss is less.

11. Specify the x- and frequency range and wavelength (N/ D 2007)

The X- band frequency range : 8 – 12.5 GHz
The X-band wavelength : 3.7 – 2.4 cm
Specify the k-band frequency range and wavelength (M / J 07)
The k-band frequency range : 18 – 26.5 GHz
The k-band wavelength 1.67- 1.13 cm
What is meant by symmetry of scattering matrix? (a/ M 08)
Matrix of S is a symmetric matrix when the microwave device has the same transmission characteristics in either direction of a pairs of ports.
Sij= Sji

12. Define – Scattering matrix

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

13. **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.

14. **Define- Straight Wire Inductance**

When alternating current is applied in a wire medium, the magnetic field is alternatively 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 ‘ Straight Wire Inductance’.

15. **Define – skin effect**

As frequency increases, the electrical signals propagate loss inside the conductor. Because of the current density increases to the perimeter of the wire and causes higher impedance for the signal. This effect is known as skin effect.

16. **State the different types of high frequency capacitors.**

The different types of high frequency capacitors are

Parallel plate capacitor
Leaded capacitor
- Perfect capacitor
-

17. **State the different types of high frequency resistors.**
The different types of high frequency resistors are
Carbon composite resistors
- Metal film resistors
- Thin film resistors

18. **Define – Q factor**
It is the measure of ability of an element to store energy and is equal to 2π times the average energy stored to that of the energy dissipated per cycle.

19. **Define – Two Port Network**
A two port network has only two access ports, one for input or excitation and one for output or response.

20. **What are scattering coefficients?**
The elements of scattering matrix are called scattering coefficients or scattering parameters.

21. **Which one is called junction?**
The point of interconnection of two or more devices is called a junction.

22. **Define- Reflection Loss**
The reflection loss is a measure of power loss during transmission due to the reflection of the signal as a result of impedance mismatch.

23. **What is the Zero property of S matrix?**
It states that, " for a passive lossless N- port network, the sum of the products of each term of any row or any column multiplied by the complex conjugate of the corresponding terms of any row or column is zero.

16 MARK QUESTIONS

1. i) Formulate scattering matrix for a n-port microwave network (8)
   ii) Give the [ABCD] matrix for a two port network and derive its [S] matrix. (8)
2. The S-parameter of a two port network are given by
   $S_{11}=0.2\angle 90$ $S_{12}=0.5\angle 90$ $S_{21}=0.5\angle 0$ $S_{22}=0.2\angle 90$
   i) Determine whether the network is lossy or not (8)
   ii) Is the network symmetrical and reciprocal? Find the insertion loss of network.(8)
3. State and explain the properties of S-parameters. (16)
4. i) Write a detailed not on ABCD parameters (8)
   iii) The input of an amplifier has a VSWR of 2 and the output has a VSWR of 3.Find the magnitude of the S parameters S_{11} and S_{12} under matched conditions.(8)
5. A four port network has the scattering matrix shown below.

[S] = $0.1\angle 90$ $0.6\angle -45$ $0.6\angle 45$ 0

$0.6\angle -45$	0	0	$0.6\angle 45$
$0.6\angle 45$	0	0	$0.6\angle -45$
0	$0.6\angle 45$	$0.6\angle -45$	0

i) Is this network lossless?

ii) Is this network reciprocal?

iii) What is the return loss at port 1 when all other ports are matched? Justify your answer. (16)

6. i) Discuss the importance of low frequency and high frequency parameters of RF two port network (6)

ii) The two port devices represented by the following matrices are cascaded. Find the scattering matrix of the resulting device. Determine the properties (symmetric, reciprocity, losses and match) (`10)

(1) [0.1 0.8
0.8 0.1]

(2) [0.4 068
0.6 0.4]

7. Verify the lossless and reciprocity properties of any two port network using scattering matrix. (16)

8. i) Derive the Z and Y matrix formulation of multi port network. (8)

ii) State and prove the symmetry of S matrix for a reciprocal network.(8)

9. Explain the scattering matrix for lossless junction(16)

10. Explain the concept of N port scattering matrix representation (6**) Dec'14 & April'15**

11. Discuss the properties of scattering matrix. Determine the scattering matrix representation of E plane tee junction (10) **Dec'14**

12. A four port network has the scattering matrix shown below.

$$[S] = \begin{matrix} 0.1\angle 90 & 0.6\angle -45 & 0.6\angle 45 & 0 \\ 0.6\angle -45 & 0 & 0 & 0.6\angle 45 \\ 0.6\angle 45 & 0 & 0 & 0.6\angle -45 \\ 0 & 0.6\angle 45 & 0.6\angle -45 & 0 \end{matrix}$$

i) Is this network lossless?

ii) Is this network reciprocal?

iii) What is the return loss at port 1 when all other ports are matched?

iv) What is the insertion loss and phase dialog between ports2 and 4 when all other ports are terminated with matched loads?

v) What is the reflection coefficient seen at port 1 in a short circuit is placed at the terminal plane of port 3 and all other ports are terminated with matched loads? (16) **Dec'11**

UNIT –II RF AMPLIFIER DESIGN & MATCHING NETWORKS

1. Define – Unilateral Power Gain
When feedback effect of the amplifer is neglected (i.e S12 = 0), the amplifier power gain is known as unilateral power gain.

2. What is the function of input and output matching networks?
Input and output matching networks are needed to reduce undesired reflections and improve the power flow capabilities.

3. Define - Unconditional Stability
Unconditional stability refers to the situation where amplifier remains stable for any passive source and load at the selected frequencies and bias conditions.
Define- Available power gain

Available power gain is defined as the power available from the microwave network to that of the poer from the source.

5. What is meant by power gain of an amplifier? (N / D 12)
Transducer power gain is defined as the ratio of power delivered to the load to that of the power from the source.

6. Define – Noise Figure
Noise figure F is defined as the ratio of the input SNR to the output SNR

8.What is the need for impedance matching networks? (N / D 11)
Matching networks can help stabilize the amplifier by keeping the source and load impedances in the appropriate range. Input and output matching networks are needed to reduce undesired reflections and improve the power flow capabilities.

9. Write the expression for noise figure of a two port amplifier (N / D 11)
The generated noise of a two port network can be determined from the signal to noise ratio (SNR) from the input to the output.

10. What are the considerations in selecting a matching network? (N / D 12)
Factors in the selection of matching networks are
- Complexity of the system
- Bandwidth requirement
- Adjustability
- Implementation
- Maximum power delivery or transfer
- Optimal efficiency

11. Why impedance matching is required? What are the other constraints required? (M / J 13)
Matching networks can help stabilize the amplifier by keeping the source and load impedances in the appropriate range. Matching network is important for the following reasons.
- Maximum power loss is in the feed line

 Maximum power delivery or transfer
 Improving the S/N ratio of the system

12. Define Transducer Power Gain
Transducer power gain is nothing but the gain of the amplifier when placed between source and load.

13. What are the parameters used to evaluate its performance of an amplifier? (N / D 12)
 Gain and gainflatness (in dB)
 Operating frequency and bandwidth (in Hz)
 Output power (in dB)
 Power supply requirements (in V and A)
 Noise figure (in dB)

14. Define – Operating Power Gain
The operating power gain is defined as the ratio of the power delivered to the load (Pl) to the power supplied to the amplifier.

15. State the various types of waveguide stub.
The various types of waveguide stub are
 E – Stub
 H- Stub
 E-H tuner

16.Write the function of matching networks?
Matching networks can help stabilize the amplifier by keeping the source and load impedanc es in the appropriate range.

17. What is function of input and output matching networks?
Input and output matching networks are needed to reduce undesired reflections and improve the power flow capabilities.

18.What are the parameters used to evaluate the performance of an amplifier?
Key parameters of amplifier, to evaluate the performance are

i. Gain and gain flatness(in dB)
ii. Operating frequency and bandwidth (in Hz)
iii. Output power (in dB)
iv. Power supply requirements (in V and A)
v. Input and output reflection coefficients (VSWR)
vi. Noise figure (in dB)

20. Define transducer power gain.
Transducer power gain is nothing but the gain of the amplifier when placed between source and load.

$$GT = \frac{\text{Power delivered to the load}}{\text{Available power from the source}}$$

21. Define unilateral power gain.
It is the amplifier power gain, when feedback effect of amplifier is neglected i.e.S12=0.

16 MARKS QUESTIONS

1. Discuss various aspects of amplifier-power relations' for RF transistor amplifier design.
2. Explain stability considerations for RF transistor amplifier design.
3. Explain various stabilization methods.
4. Discuss gain considerations for RF amplifier.
5. Design a Microwave Amplifier for Maximum transducer power gain (8)
6. Show that the noise figure of a three stage amplifier is F= F1 + F2-1 /GA1 + F3-1/GA2. Where F1, F2 and F3 are noise figures and GA1 and GA2 are power gains. (8)
7. Show that the noise figure of a three stage amplifier is F= F1 + F2-1 /GA1 + F3-1/GA2. Where F1, F2 and F3 are noise figures and GA1 and GA2 are power gains. (8)
8. Explain in detail the concept of T and Microstripline matching networks (8)
9. A microwave amplifier is characterized by its S-parameters. Derive equations for power gain, Available gain and transducer gain. (8)
10. Derive the expressions for the following of a micro stripline matching network (a) W/h ratio (b) Total Q factor (QT) (8)
11. A MESFET operated at 5.7 GHz has the following S-parameters:S11 = 0.5 ∟-600 , S12 = 0.02∟00 , S21 = 6.5∟1150, S22 = 0.6∟-350. Verify the circuit, whether it is unconditionally stable or not? (16)

$$GA = \frac{\text{Power available from the network}}{\text{Power available from the source}} = \frac{PN}{PA}$$

7) Define Operating Power Gain.

The operating power gain is defined as "the ratio of power delivered to the load to the power supplied to the amplifier".

$$G = \frac{\text{Power delivered to the load}}{\text{Power supplied to the amplifier}} = \frac{PL}{Pin}$$

8) Write a short note on feedback of RF circuit.

i.

If |□|>1, then the magnitude of the return voltage wave increases called *positive feedback,* which causes instability (oscillator).

ii.

If |□|<1, then the return voltage wave is totally avoided (amplifier). It's called as *negative feedback.*

9) Define unconditional stability.

Unconditional stability refers to the situation where the amplifier remains stable for any passive source and load at the selected frequency and bias conditions.

10) Define noise figure.

Noise figure F is defined as "the ratio of the input SNR to the output SNR".

$$F = \frac{\text{Input SNR}}{\text{Output SNR}}$$

3) Describe IEEE microwave frequency bands.

Frequency	Microwave band designation
3-30MHz	HF
30-300MHz	VHF

UNIT III MICROWAVE PASSIVE & ACTIVE COMPONENTS

PART A

1) **Name any two microwave passive devices which make use of Faraday rotation May 2015**

The two devices which make use of Faraday rotation are i) Circulator ii) Isolator.

2) **What are matched terminators? May 2014**

Matched Terminations are useful for USWR measurement of various waveguide components. These are also employed as dummy and as a precise reference loads with Tee junctions, directional couplers and other similar dividing devices.

3) **What are ferrites? Why is it needed in circulators? May 2014**

Ferrites are non metallic materials with resistivity's nearly 10^{14} times greater than metalsand also the d ielectric constants (□r) is in between 10-15 and relative permeability of the order of 1000. It is needed forcirculators because of following properties:

1. Ferrites possess strong magnetic properties.
2. Ferrites are most suitable for use in microwave device in order to reduce the reflected power.
3. Ferrites possess high resistivity, hence they can be used up to 100 GHz
4. Ferrites also exhibit non-reciprocal property.

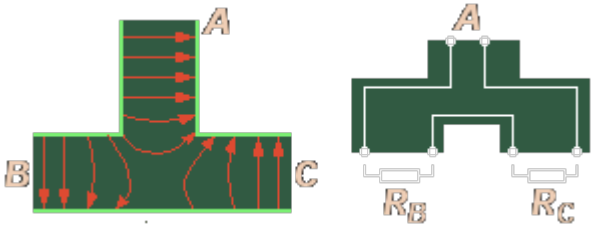
4) **What are the compositions of ferrite? Dec 2013**

A **ferrite** is a type of ceramic compound composed of iron oxide (Fe_2O_3) combined chemically with one or more additional metallic elements. Ferrites are usually non-conductive ferrimagnetic ceramic compounds derived from iron oxides such as hematite (Fe_2O_3) or magnetite (Fe_3O_4) as well as oxides of other metals.

5) **Give the significance of Rat-race junctions**. **May 2013**

A **rat-race coupler** (also known as a **hybrid ring coupler**) is a type of coupler used in RF and Microwave systems. In its simplest form it is a 3dB coupler and is thus an alternative to a magic tee. Compared to the magic tee, it has the advantage of being easy to realize in planar technologies such as microstrip and stripline, although waveguide rat races are also practical. Unlike magic tees, a rat-race needs no matching structure to achieve correct operation.

6) Draw the diagram of H-plane Tee junction. Dec 2012



7) **What are the differences between Gyrator and phase changer? May 2012**

Gyrator is a two port device which provides a relative phase shift of 180 degree for transmission from port 1 to port 2 as compared to the phase for transmission from Port2 to port 1.

Phase changer is a two port device which provides a certain amount of phase shift for transmission from port 1 to port 2 as compared to the phase for transmission from Port2 to port 1.

8) **Draw a structure of two hole direction coupler. Nov 2011**

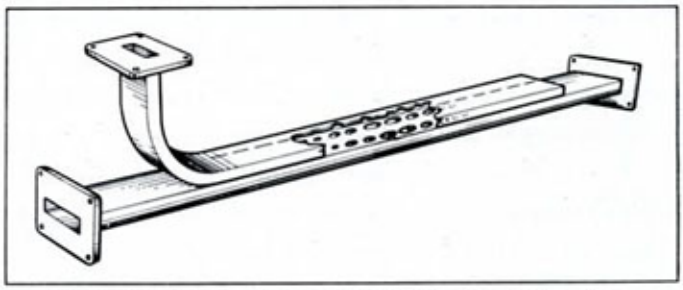


Figure 1. Construction, -*hp*- 752 Directional Couplers.

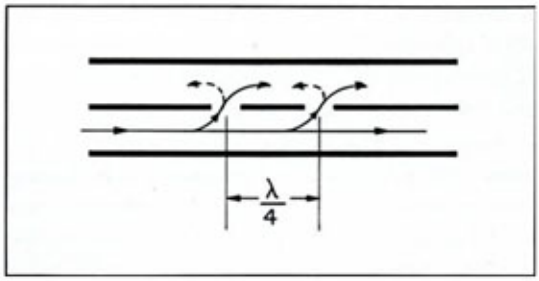


Figure 2. Cross-section, two-aperture coupler.

8) What are the basic types of directional coupler? Dec 09

The basic types of directional coupler are
Two- hole directional coupler
Four-hole directional coupler
Reverse coupling directional coupler
Bethe coupler.

9) State the two parameters that describe a directional coupler and define them. Dec2006

Coupling factor :

The coupling factor of a directional coupler is defined as the ratio of the incident power 'pi' to the forward power 'pi' measured in dB

Coupling factor (dB) = 10log10Pi/Pf

The coupling factor is a measure of how much of the incident power is being sampled.

Directivity :

The directivity of a directional coupler is defined as the ratio of forward power 'p' to the back power 'p' expressed in dB

D (dB) = 10log10Pf/Pb

Directivity is a measure of how well the directional coupler distinguishes between the forward and reverse traveling powers.

10) Give the applications of directional coupler

1. Unidirectional power measurement 2. SWR measurement
3. Unidirectional wave launching 4. Reflect meter 5. Balanced duplexer

11) Write the applications of magic tee.

A magic tee has several applications,

i. Measurement of impedance
ii. As duplexer
iii. As mixer
iv. As an isolator

12) Write the characteristics of a three port tee junction.

a) A short circuit may always be placed in one of the arms of a three port junction in such a way that no power can be transferred through the other two arms.
b) If the junction is symmetric about of its arms, a short circuit can always be placed in that arm so that no reflections occur in power transmission between the other two arms.
c) It is impossible for a general three port junction of arbitrary to present matched impedances at all three arms.

13) Define Isolator & circulator.

An isolator or uniline 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.

A circulator is a multiport junction in which the wave can travel from one port to next immediate port in one direction only. They are useful in parametric amplifiers, tunnel diode, amplifiers and duplexer in radar.

14) What is Faraday's rotation law?

It states that, " when a circularly polarised wave3 is passed through the ferrite material imposed by the magnetic field , the anlge of circular polarizaion gets titled. The angle of titling depend son the strength of magmteci field and the dimension of ferrite material.

15) What are the applications of isolator & gyrator?

Isolators are typically used to protect active components from distorting or potentially damaging reflective power. It is used to shield equipment on its input side, from the effects of conditions on its output side; for example, to prevent a microwave source being detuned by a mismatched load.
Gyrator is primarily used in active filter design and miniaturization.

16) A directional coupler is having coupling factor of 20 dB and directivity of 40 dB. If the incident power is 100 mW, What is the coupled power?

17) Power at the input port is 900 mW. If this power is incident on 20 dB coupler and directivity of 40 dB. What is the coupled and transmitted power?

18) State Gunn effect. (A / M 08)

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 3000 V/ cm , the drift velocity is decreased and the diode exhibits negative resistance.

19). State the transferred electron effect. (N / D 12)

Some materials like GaAs exhibit a –ive differential mobility when biased above a threshold value of the electric field. The electrons in the lower energy band will be transferred into the higher-energy band. The behavior is called transferred electron effect and the device is called transferred electron device or Gunn diode.

4.Differentiate tunnel diode from normal P-N diode

Tunnel diode	PN 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 exhibits positive resistance characteristics
Low noise	Moderate noise
Preferred semi conductor – GaAs	Preferred semiconductor – Ge and Si

21) What are the materials that exhibit Gunn effect?
The materials exhibiting Gunn effect are
- Gallium Arsenide
- Indium phosphide
- Cadmium telluride
- Indium arsenide.

22) What are the modes available in negative resistance devices?
The modes available in negative resistance devices are
- Voltage controlled mode
- Current controlled mode

23) What are the major disadvantages of IMPATT diodes? (N / D 08)
The major disadvantages of IMPATT diodes are
- Avalanche process makes the IMPATT diode noisy
- Poor noise figure of 30 dB
- Low efficiency due to induced electron current

24) Define - Varactor Diode
Varactor diodes are p-n junction diodes which provide a voltage variable junction in microwave circuits when reverse biased.

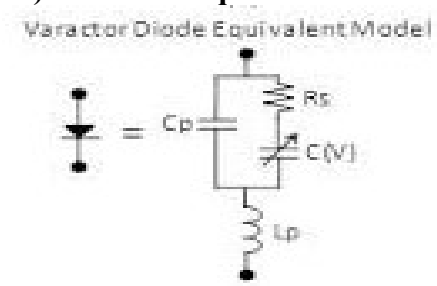
25) Mention the applications of IMPATT diodes.
The applications of IMPATT diodes are
- Microwave generators
- Modulated output oscillators
- Receiver local oscillators
- Parametric amplifier pumps
- IMPATT diodes are also suitable for negative resistance amplification.

26) Explain plasma function in TRAPATT diode.
During the operation of the diode, a high field avalanche zone propagates through the depletion region and fills the layer with dense plasma of electrons and holes which get trapped in the low field region behind the zone.

27) Mention the applications of Gunn diode amplifier.
Gunn diodes have been used in conjunction with circulator coupled networks in the design of high level wideband transferred electron amplifiers that have a voltage gain bandwidth product in excess of 10dB for frequencies from 4 to 16 GHz.

28) Why monolithic technology is not well suitable for microwave integrated circuits?
Monolithic technology is not well suited for microwave integrated circuits, because the processing difficulties, low yields and the performance have seriously limited their applications.

29). Draw the equivalent circuit of varactor diode? May 2015



30) What are the applications of varactor diode?
i.The varactor diode is used in TV receivers, HFC circuit adjustable, band pass filters.
ii.Used in phase locked loop (PLL) and frequency locked loop (FLL).
iii.In frequency modulation.
iv.In high frequency multipliers.

31) What is –ive resistance in Gunn diode?
The carrier drift velocity is linearly increased from zero to a maximum when the electric field is varied from zero to a threshold value. When the electric field is beyond the threshold value of 3000V/cm, the drift velocity is decreased and the diode exhibits –ive resistance.

32) What are the various modes of operation of Gunn diode?

1) Gunn oscillation mode.
2) Stable amplification mode.
3) LSA oscillation mode.
4) Bias circuit oscillation mode.

33) What are the elements that exhibit Gunn Effect?
The elements are

- Gallium arsenide
- Indium phosephide
- Cadmium telluride

34) Mention the applications of Gunn diode amplifier.
Gunn diodes have been used in conjunction with circulator coupled networks in the design of high level wideband transferred electron amplifiers that have a voltage gain bandwidth product in excess of 10dB for frequencies from 4 to about 16GHz.

35) Define avalanche transit time devices.

Avalanche transit – time devices are p –n junction diode with the highly doped p and n regions. They could produce a negative resistance at microwave frequencies by using carrier impact ionization.Av alanche breakdown and carriers drift in the high field intensity region under reverse biased condition.

36) What are modes available in avalanche device?

There are modes of avalanche device

(1) IMPATT – Impact Ionization Avalanche Transit Timed Device
(2) TRAPATT – Trapped Plasma Avalanche Triggered Transit Device and
(3) BARITT – Barrier Injected Transit Time Device.

37) What are the factors exhibit differential –ive resistances in IMPATT?

The IMPATT diodes exhibit a differential –ive resistance by two effects.

(1)The impact ionization avalanche effect, which causes the carrier current I0 (t) and the ac voltage to be out of phase by 90^0.

(2) The transit- time effect, which further delays the external current Ie(t) relative to the ac voltage by 90^0.

38) Mention the applications of IMPATTI diodes.

a) Microwave generators
b) Modulated output oscillators
c) Receiver local oscillators
d) Parametric amplifier pumps
e) IMPATT diodes are also suitable for negative resistance amplification.

39) Write the classification of electronic circuits.

Electronic circuits are broadly classified into three categories based on the circuit technology.

(1)Discrete circuit
(2)Integrated circuit
(3)Monolithic Microwave Integrated circuit (MMIC)

40) Write the classification of ICs

Due to components availability within chip, the integrated circuits' are categorized as follows

- Small Scale Integration (SSI) circuit
- Medium Scale Integration (MSI) circuit
- Large Scale Integration(LSI) circuit
- Very Large Scale Integration (VLSI) circuit
- Ultra Large Scale Integration(ULSI) circuit

41) What are the advantages of MMICs over discrete circuits?

MMICs offer the following advantage over discrete circuits

- Small in size& weight
- High reliability
- Improved reproducibility

- Improved performance
- Eventual cost reduction when produced in large quantities

42) Name the difference between MMICs and conventional ICs.

MMICs are quire different from the conventional ICs

I. The conventional IC's contain very high packing densities; whereas the packing density of a MMIC is typically low.

II. Hybrid Integrated Circuit: An MMIC consists of two or more integrated circuit types together with discrete elements and is referred to as a hybrid integrated circuit

III. Film Integrated Circuit: An MMIC whose elements are formed on an insulating substrate, such as glass or ceramic, is called a film integrated circuit.

43) What are the applications of MMICs?

- MMICs are currently being used for variety of applications including space and military because they meet the requirements for shock, temperature conditions and severe vibration.
- MMICs have been the advances in the development of microwave solid-state devices.

44) Name the circuits used in hybrid MMICs.

Three general types of circuits can be utilized for hybrid MMICs

I. Distributed micro strip lines.
II. Lumped-element
III. Thin-film circuits

45) Mention the materials used in MMICs.

The basic materials for monolithic microwave integrated circuits are broadly divided into four categories.

i. Substrate materials
ii. Conductor materials
iii. Dielectric materials
iv. Resistive materials

46) What are hybrid integrated circuits?

An MMIC consists of two or more integrated circuit types together with discrete elements and is referred to as hybrid integrated circuit.

47) Write the ideal characteristics of substrate material.

The ideal characteristics of substrate material are,

- High dielectric constant
- Low dissipation factor or loss tangent.
- High purity and constant thickness.
- High surface smoothness High resistivity
- High thermal conductivity
- Dielectric strength.

48) Write the ideal characteristics of conductor material.

The ideal characteristics of conductor material,

- High conductivity
- Low temperature coefficient of resistance
- Good adhesion to the substrate
- Good etch ability and solder ability
- Easily deposited or electroplated.

49) What is the need for dielectric materials?

Dielectric materials are use in monolithic microwave integrated circuits for blockers, capacitors and some-couple-line structures.

50) Mention some of the properties of dielectric materials.

The properties of dielectric materials are,

i. Good reproductivity
ii. Capability of handling high voltages
iii. Ability to undergo processes with developing pin holes
iv. Low RF dielectric loss.

51) What is the need of resistive materials?

Resistive materials are used in monolithic microwave integrated circuits for bias networks, terminations and attenuators.

52) Write some of the properties of resistive materials

i. Good stability
ii. Low temperature coefficient of resistance
iii. Adequate dissipation capability
iv. Sheet resistivity's in the range of 10 to 1000ohm per square.

53) Name the commonly used dielectric substrates for fabricating micro strip.

The commonly used dielectric substrates for fabricating micro strip are Al_2O_3, SiO, SiO_2,Si_3N_4 and Ta_2O_5.

54) What are the different techniques used to fabricate MMIC?

i. Diffusion and ion implantation
ii. Oxidation and film deposition
iii. Epitaxial growth
iv. Lithography
v. Etching and photo resist
vi. Deposition

55) Write the difficulties of MMICs.

1. Once MMICs fabricated, there is no provision for adjusting any device parameters such as tuning screws variable short ect.
2. Accurate design of circuit is complex.
3. Low value of Q, the high frequency stability are very difficult
4. Low power handling capacity than waveguides.

56) State the various MMIC fabrication techniques.

The various MMIC fabrication techniques are

- Diffusion and ion implementation
- Oxidation and film deposition
- Epitaxial growth
- Lithography
- Etching and photo resist deposition

PART-B

1. Explain how the directional coupler can be used to measure reflected power.(8) **Nov'12**
2. Explain the properties of H plane tee and give reasons why it is called shunt tee.(8) **Nov'12**
3. Explain the properties of Magic tee? Derive the scattering matrix of magic tee. **(16) May'13, Nov'12 & Dec'13**
4. Differentiate between circulator and isolators.(8) **Nov'12**
5. Explain the properties of E plane tee? Derive the expression of scattering matrix of directional coupler (16) **May'13 & Dec'13**
6. Explain the operation of i) Circulator ii) Isolator (16) **Dec'13 & April'15**
7. Draw and explain the operation of Magic tee. Explain the application in the construction of a 4-port circulator (8) **April '14**
8. Find the directivity in dB for a coupler if same power is applied in turn to input and output of the coupler with output terminated in each case in matched impedance. The auxiliary output readings are 450 mW and 0.710 µW. (8) **April '14**
9. Explain the various types of attenuators and phase shifters .What is gyrator (16) **April '14**
10. Explain the operating principle of microwave circulator with neat schematic diagram (8) **Dec'14**
11. An air filled rectangular cavity resonator has dimensions of a=5 cm, b=2 cm and d=15 cm. Compute the resonant frequency of the dominant mode for an air filled cavity. The resonant frequency of the dominant mode for a dielectric filled cavity is 2.56.(8) **Dec'14**
12. A four port network has the scattering matrix shown below.

$$[S] = \begin{matrix} 0.1\angle 90 & 0.6\angle -45 & 0.6\angle 45 & 0 \\ 0.6\angle -45 & 0 & 0 & 0.6\angle 45 \\ 0.6\angle 45 & 0 & 0 & 0.6\angle -45 \\ 0 & 0.6\angle 45 & 0.6\angle -45 & 0 \end{matrix}$$

   i) Is this network lossless?
   ii) Is this network reciprocal?
   iii) What is the return loss at port 1 when all other ports are matched?
   iv) What is the insertion loss and phase dialog between ports2 and 4 when all other ports are terminated with matched loads?
   v) What is the reflection coefficient seen at port 1 in a short circuit is placed at the terminal plane of port 3 and all other ports are terminated with matched loads? (16) **Dec'11**
13. Explain with neat diagram explain the operation of Phase shifter and show its phase change is $2\Pi + 4\,\beta l$. (8) **April'15**
14. With neat diagram explain the operation of the following devices : i) Gyrator (8) (ii) Two hole Directional Coupler **April'15**
15. a) i)Explain the operating principles of varactor and step recovery diode.(8)

(ii)Write the properties of Magic tee (4)

(iii)Draw the equivalent circuit of i) Tunnel diode ii) Gunn Diode (4)

16. What are the materials used for MMIC fabrication? Explain with properties of materials with example for the fabrication (8)

ii) a) With neat diagram explain the operation of Gyrator (8)

17. With the help of two-valley, explain how negative resistance can be created in Gunn diode. Mention its applications. (8)
18. With neat diagram, explain the working principle of Gunn diode. Mention its application. (8)
19. What are avalanche transit time devices? Explain the operation and construction of IMPATT diode (8)

UNIT IV MICROWAVE GENERATION

1) What is transit time?

The time taken by an electron to travel from the cathode to the anode plate of an electron tube is known as transit time

2) Write the classification of microwave tubes.

They are classified into two types

1) O – type microwave tube or linear beam
2) M – type microwave tube

3) Name the two configuration of klystron

There are two basic configurations of Klystron tubes

1) Reflex Klystron – It is used as low power microwave oscillator
2) Two cavity (or) Multicavity Klystron – It is used as low power microwave amplifier.

4) What is drift space?

The separation between buncher and catcher girds is called as drift space.

5) Define velocity modulation.

The variation in electron velocity in the drift space is known as velocity modulation.

6) Define bunching.

The electrons passing the first cavity gap at zeros of the gap voltage pass thro ugh with unchanged velocity, those passing through the +ive half cycles of gap voltage undergo an inc rease in velocity, those passing through the –ive half cycles of gap voltage undergo an decrease in velocity, As a result of these, electron bunch together in drift space. This is called bunching.

7) State the power gain, power output and efficiency of two – cavity klystron amplifier.

a. EFFICIENCY: about 40%
b. POWER OUTPUT: Average power is up to 500KW and pulsed power is up to 30 MW at 10GHz
c. POWER GAIN: about 30 Db.

8) Why the output cavity is called as catcher cavity?

The output cavity catches energy from the bunched electron beam. Therefore, it also ca lled as catcher cavity.

9) Mention the application of two – cavity.

a. Used in Troposphere scatter transmitters.
b. Satellite communication ground stations.
c. Used in UHF TV transmitters.

d. Rader transmitters.

10) Define electronic efficiency.

The electronic efficiency of the klystron amplifier is defined as the ratio of the output p ower to the input power.

Efficiency=Pout /PIN

= □□ I2 V2 / 2I0 V0

11) Define reflex klystron.

The reflex klystron is an oscillator with a built in feedback mechanism. It uses the cavity for bunching and for the output cavity.

12) What do you meant by applegate diagram?

The electrons passing through the buncher grids are accelerated / retarded / passed thr ough

with unchanged initial dc velocity depending upon when they encounter the RF signal fie ld at thebuncher cavity gap at positive / negative / zero crossing phase of the cycle, respective ly, as shown by distance-time plot. This is called the applegate diagram.

13) Mention the same characteristics of reflex klystrons.

- Frequency range: 1 to 25GHz
- Power output: It is a low-power generator of 10 to 500mW
- Efficiency: About 20 to 3o%

14) State the applications of reflex klystrons.

1. This type is widely used in the laboratory for microwave measurements.
2. In microwave receivers as local oscillators in commercial and military applications.
3. Also plays a role in airborne Doppler radars as well as missiles.

15) Write a short note on i. O – type tubes and ii. M – type tubes.

O – type tubes:

Klystrons ant TWTs are liner beam tubes in which the accelerating electric field is in the Samedirection as the static magnetic field used to focus the electron beam. Here the electron bea m travel in astraight line.

M – type tubes:

Magnetrons are crossed field devices where the static magnetic field is perpendicular to The electric field. In this tube, the electrons beam travel in a curved path.

16) Define electronic efficiency.

The electronic efficiency of a reflex klystron oscillator is defined as □□Pac / P dc

17) What is meant by microwave resonators?

Microwave resonators are tunable circuits used in microwave oscillators, amplifie rs, wavemeters and filters. At the tuned frequency the circuit resonates where the average ene rgies stored inthe electric field, We and magnetic field, Wm are equal and the circuit impedance purely real.

18) Define resonant frequency.

Resonant frequency fr, at which the energy in the cavity attains maximum value.

fr =2We or 2Wm

19) What are drawbacks available in klystrons?

i. Klystrons are essentially narrowband devices.

ii.In klystrons and magnetrons, the microwave circuit consists of a resonant struc ture which limits the bandwidth of the tube.

20) What is TWTA?

A traveling wave tube amplifier (TWTA) circuit uses a helix slow – wave non resonant microwave guiding structure. It is a broadband device.

21) What is the need of slow – wave structures?

Slow wave structures are special circuits that are used in microwave tubes to reduce the wave velocity in a certain direction so that the electron beam and the signal wave can interact.

22) Give the comparison between TWTA and klystron amplifier.

Sl.No	Klystron amplifier	TWTA
1.	Linear beam or 'O' type device.	Linear beam or 'O' type device.
2.	Uses cavities for input and output Circuits.	Uses non – resonant wave circuit.
3.	Narrow band device due to use of resona	Wide band device because use of non

23) State the characteristics of TWTA.

Frequency range	:	3GHz and higher
Bandwidth	:	about 0.8GHz
Efficiency	:	20 to 40%
Power output	:	up to 10kW average
Power gain	:	up to 60dB

24) Write the applications of TWT.

Medium power satellite
Higher power satellite transponder output
Radar transmitters.

25) What are the advantages of TWT?

Bandwidth is large
High reliability
High gain
Higher duty cycle

26) What is the use of attenuator in TWT?

Attenuator is used to prevent oscillations.

27) Name four types of slow wave structures.

Helical line
Folded back line
Inter digital line
Zigzag line

28) What is the need of Quality factor Q?

Quality factor Q which is a measure of the frequency selectivity of a cavity.

29) Why magnetron is called as cross field devices?

In a magnetron, the dc magnetic field and dc electric field are perpendicular to each other and hence magnetron is called as a cross field device.

30) What are the types of magnetron?

There are three types of magnetrons:

i. Spilt anode magnetron
ii. Cyclotron – frequency magnetrons
iii. Traveling wave magnetrons.

31) Write short notes on negative resistance magnetron.

Negative – resistance magnetrons ordinarily operate at frequencies below the microwave region. This type of magnetron uses a static negative resistance between two anode segments b ut haslow efficiency and is useful only at low frequencies.

32) Write the different configurations available in traveling wave magnetrons.

a) Cylindrical magnetron
b) Linear magnetron
c) Coaxial magnetron
d) Voltage – tunable magnetron
e) Inverted coaxial magnetron
f) Frequency-agile magnetron

33) Write short notes on

a) Coaxial magnetron
b) Voltage – tunable magnetron

a) Coaxial magnetron:The coaxial magnetron is composed of an anode resonator structu re surrounded by an inner –single, high-Q cavity operating in the TE011.

b) Voltage tunable magnetron:The voltage tunable magnetron is a broadband oscillator w ith frequency changed by varying theapplied voltage between the anode and sole.

34) State the characteristics of coaxial magnetron.

i. Minimum peak power of 400kW at a frequency range from 8.9 to 9.6GHz.
ii. Its duty cycle is 0.0013.
iii. Nominal anode voltage is 32kV.
iv. Peak anode current is 32A.

35) State the power output and efficiency of magnetron.

- A magnetron can deliver a peak power output of up to 40MW with the dc voltage of 50KV at 10GHz.
- The average power output is 800KW.
- The magnetron possesses a very high efficiency ranging from 40 to 70%.
- Magnetrons are commercially available for peak power output from 3KW and higher.

36) Write the applications of magnetron.

The magnetron are widely used on,

Radar transmitters
Industrial heating
Microwave ovens.

37) What is - mode of operation?

In the mode of operation, the successive cavities in anode have opposite phase, excitat ion is maximum in the cavities.

24. Give the comparison between TWTA and klystron amplifier.

TWTA	Klystron Amplifier
It is a non resonant wave circuit	It is a resonant wave circuit (Linear O type device)
Waveband band device due to traveling wave structures	Narrow band device
Traveling wave structures are used throughout the system.	Using cavities for input and output circuits.

PART B QUETSIONS

1. Explain with a neat figure, how TWT is used as an microwave oscillator? (8)
2. Describe with a neat sketch the constructional details and principle of operation of a Reflex klystron. With the help of Applegate diagram illustrate the phenomenon of bunching. Derive expression for beam current and efficiency. (8)
3. A 250kW pulsed cylindrical magnetron has the following parameters. Anode voltage = 25 KV, Peak anode current = 25A, magnetic field B = 0.35Wb/m2, Radius of cathode = 4cm, Radius of cylinder = 8cm.Calculate efficiency of the magnetron, cyclotron frequency, cut-off magnetic field. (8)
4. How can you analyze a TWTA circuit that uses a helix slow-wave non-resonant guiding structure?(8)
5. Explain the oscillation mechanism and the electron trajectory concept of magnetron oscillator.(8)
6. Explain the working principle of Reflex Klystron and derive the expression of Bunching parameter. (8)
7. Explain the bunching process of a two cavity klystron and derive expression for its Optimum bunching distance L_{opt}. (8)

8. Derive the equation of velocity modulated wave and discuss the concept of bunching effect in two cavity Klystron (16)
9. Explain the Π mode of operation of Magnetron. Mention few high frequency limitations.(16)
10. Explain the working principle of Reflex Klystron and derive the expression of bunching parameter (8)
11. A two cavity Klystron has the following parameters. V0 = 1000 V, R0= 40 kΩ , I0 = 25 mA, f = 3 GHz Gap spacing in either cavity (d) = 1 mm, Spacing between two cavities L = 4 cm Effective shunt impedance Rth = 30 kΩ .Calculate input gap voltage, voltage gain and efficiency.(8)
12. With neat circuit diagrams and relevant equations, explain the velocity modulation process and bunching in a klystron amplifier?(16)
13. Explain in detail about 2-cavity klystron amplifier.(16)
14. Explain in detail about multicavity klystron amplifiers. (16)
15. Derive the equation for power output and efficiency of two cavities and four cavity kl ystron amplifiers. (16)
16. With neat diagrams and relevant equations, explain about helix traveling wave tube.(16)
17. With neat diagrams and relevant equations, explain about cylindrical and coaxial magnetron. (16)
18. Discuss in detail about tunable magnetron and also explain in brief regarding Ricke diagram. (16)

UNIT V MICROWAVE MEASUREMENTS

1. **What do you meant by slotted line?**

Slotted line is a fundamental tool for microwave measurements. Slotted line consists of a section of waveguide or coaxial line with a longitudinal slot. The slot is roughly 1mm wide and allows an lectric field probe to enter the waveguide for measurement of the relative magnitude of field at location of the probe.

2. **Name two methods to measure impedance.**

i. Slotted line
ii. Reflecto meter

3. **Define power.**

a. Power is defined as the quantity of energy dissipated or stored per unit time.

4. **What are the methods to detect microwave power?**

a. Bolometer
b. Calorimeter method

5. **Define microwave sensor.**

The microwave power meter consists of a power sensor, which converts the microwave power into heat energy. The corresponding temperature rise provides a change in the electrical parameters resulting in an output current in low frequency circuitry and indicates the power.

6. **Mention the sensors used for microwave power measurements.**

The sensors used for microwave power measurements are the schottky barrier diode, bolometer and the thermocouples whose resistance changes with the applied power.

7. **Define bolometer.**

A bolometer is a power sensor whose resistance changes with temperature as it absorbs microwave power. The types of bolometer are, the barretter and the thermistor.

8. **What are drawbacks of using power meter with single bridge?**

i. The change of resistance due to a mismatch at the microwave input port results in
ii. incorrect reading
iii. The thermistor is sensitive to changes in the ambient temperature resulting in false
iv. reading.

9. **What do you meant by thermocouple sensor?**

A thermocouple sensor is a junction of two dissimilar metals or semiconductors. It generates an emf when two ends are heated up differently by absorption of microwaves in a thin film tantalum – nitride resistive load deposited on a Si substrate which forms one electrode of the thermocouple. This emf is proportional to the incident microwave power to be measured.

10. **Name the method used for high power microwave measurements.**

High power microwave measurements can be conveniently done by the calorimetric method which involves conversion of the microwave energy into heat, absorbing this heat in a fluid and then measuring the temperature rise of the fluid.

11. **What is calorimetric direct heating method?**

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

12. **What is calorimetric indirect heating method?**

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

13. **Mention the drawbacks in calorimeter measurements.**

The main disadvantage in calorimeter measurements are the thermal inertia caused by the lag between the application of microwave power and the parameter readings.

14. What are the classifications of power measurements?

a. The classifications of power measurements are
a. Low power (less than 10mW)
b. Medium power (from 10mW to 10W)
c. High power(>10W)

17.Distinguish between low frequency measurements and microwave measurements.

Low frequency measurements	Microwave measurements
At low frequency it is convenient to measure voltage and current and use them to calculate power	At microwave frequencies the amplitudes of the voltage the amplitudes of the voltages and current on a transmission line are the functions of a distance and are not easily measurable
At low frequency, circuits are lumped elements.	At microwave frequencies, the circuit elements are distributed.

8. Distinguish between thermistor and barretter.

Barretter	Thermistor
Barretter has a positive temperature coefficient. i e resistance increases with temperature.	Thermistor has negative temperature coefficient
They are less sensitive	They are more sensitive
They need less bias current	They need more bias current
Barretters are usually operated at 100 ohms.	Thermistors are operated at 100 ohm to 200 ohms.

PART B QUETSIONS

1. Explain with block diagram how frequency of an unknown microwave signal can be measured.(8)
2. Explain the principle of microwave power measurements. (8)
3. Describe a technique of measuring the phase shift provided by a network.(8)
4. Explain the procedure for measuring impedance at microwave frequency with the aid of slotted line.(8)
5. Describe in detail with block diagram the measurement of VSWR through return loss measurement. (8)
6. With neat block diagram explain the Insertion loss and Attenuation measurements.
7. Explain the measurement of cavity "Q" by slotted line method.(8)

8.Explain in detail the measurement of VSWR through return loss measurements.(16)

9. Discuss in detail the power measurement using microwave devices.(16)
10. Write a brief note on insertion loss and attenuation measurements.(16)
11. Explain in detail about the dielectric constant measurement of a solid using waveguide.(16)