EC73 -RF AND MICROWAVE ENGINEERING

UNIT: 1

TWO PORT RF NETWORKS- CIRCUIT REPRESENTATION

2 Marks Questions and Answers:

1) Define two-port network.

A two-port network has only two access ports, one for input or excitation and one for output or response.

2) Which one is called junction?

The point of interconnection of two or more devices is called a junction.

3) Define scattering matrix.

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

4) What are scattering coefficients?

The elements of scattering matrix are called scattering coefficients or scattering parameters.

5) What is waveguide?

A waveguide is a hollow metal tube designed to carry microwave energy from one place to another.

6) Why the S-parameters are used in microwaves?

The H, Y, Z and ABCD parameters are difficult at microwave frequencies due to following reasons.

- Equipment is not readily available to measure total voltage and total current at the ports of the networks.
- Short circuit and open circuit are difficult to achieve over a wide range of frequencies.
- Presence of active devices makes the circuit unstable for short (or) open circuit.

Therefore, microwave circuits are analyses using scattering (or) S parameters which linearly relate the reflected wave's amplitude with those of incident waves.

7) Write the properties of [S] matrix.

1. [s] is always a square matrix of order (nxn) .
2. [s] is a symmetric matrix i.e. $S_{ij}=S_{ji}$
3. [s] is a unitary matrix i.e. [S][S*]=[I]
4. Under perfect matched conditions, the diagonal elements of [s] are zero.

8) State the reciprocity theorem.

The theorem state 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., branch m, i_m). The same amount of current (in branch k, i_k) is produced when the same electromotive force (or voltage) is applied in the new location (branch m, v_m); that is

$$V_k/i_m = v_m/i_k$$

9) Define lossless network.

In any lossless passive network, its containing no resistive elements, always the power entering the circuit will be equal to the power leaving the network which leads to the conserved in power.

10) 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 other row or column is zero”.

11) Write the unitary property for a lossless junction.

For any lossless network the sum of the products of each term of any one row or of any column of the S-matrix multiplied by its complex conjugate is unity.

12) Define non-reciprocal devices.

A non-reciprocal device does not have same electrical characteristics in all direction.

13) What is wire?

A wire is the simplest element having zero resistance, which makes it appear as a short circuit at DC and low AC frequencies.

14) Mention the many forms of wire.

Wire in a circuit can takes on many forms,

I. Wire wound resistors
II. Wire wound inductors
III. Leaded capacitors
IV. Elements-to- element interconnection applications

15) Write about the skin effect in a wire.

As frequency increases, the electrical signal propagates less and less in the inside of the conductor. The current density increases near the outside perimeter of the wire and causes higher impedance for the signal. This will act as resistance of the wire.

$$R=\rho\ell/A$$

Where,

A-Effective cross-sectional area. When area (A) decreases, the resistance of the wire will be increases.

16) Give a short note on straight-wire Inductance in wire.

In the wire medium, surrounding any current carrying conductor, there exists a magnetic field. If the current (I) is AC, this 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”.

17) Define a resistor.

A resistor whose purpose is simply to produce a voltage drop by converting some of the electric energy into thermal energy (heat), when an electric current passes through it.

18) Mention the purpose of resistors.

Purpose of Resistors:

i. In transistor bias networks, to establish an operating point.
ii. In attenuators, to control the flow of power.
iii. In signal combiners, to produce a higher output power.
iv. In transmission lines, to create matched conditions.

19) Name the types of resistors.

Types of resistors:

i. Carbon composition resistors, which have a high capacitance due to carbon granules parasitic capacitance.
ii. Wire wound resistors, which have high lead inductance.
iii. Metal film resistors of temperature-stable materials.
iv. Thin-film chip resistors of aluminum or beryllium-based materials.

20) What do you meant by capacitors?

A capacitor that consists of two conducting surfaces separated by an insulating material or dielectric. The dielectric is usually ceramic, air, paper, mica, or plastic. The capacitance is the property that permits the storage of charge when a potential difference exists between the conductors. It is measured in farads.

21) Define Quality-factor (Q) of Capacitor.

It is defined as "the measure of the ability of an element to store energy, equal to 2π times the average energy stored divided by the energy dissipated per cycle".

22) What is an Inductor?

A wire that is wound (or coiled) in such a manner as to increase the magnetic flux linkage between the turns of the coil. The increased flux linkage increases the wire's self inductance.

23) Write the applications of inductors.

Inductors have a variety of applications in RF circuits such as,

- Resonance circuits
- Filters
- Phase shifters
- Delay networks
- RF chokes

UNIT-2

RF TRANSISTOR AMPLIFIER DESIGN AND MATCHING NETWORKS

2 Marks Questions and Answers:

1) Write the function of matching networks?

Matching networks can help stabilize the amplifier by keeping the source and load impedances in the appropriate range.

2) 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.

3) 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)

4) Define transducer power gain.

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

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

5) Define unilateral power gain.

It is the amplifier power gain, when feedback effect of amplifier is neglected i.e.S_{12}=0.

6) What is available Power Gain (G_A) at Load?

The available power gain for load side matching ($\Gamma_L = \Gamma^*_{Out}$) is given as,

$$G_A = \frac{\text{Power available from the network}}{\text{Power available from the source}} = \frac{P_N}{P_A}$$

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".

$$G = \frac{\text{Power delivered to the load}}{\text{Power supplied to the amplifier}} = \frac{P_L}{P_{in}}$$

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

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

ii. If $|T|<1$, 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".

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

UNIT-3

MICROWAVE PASSIVE COMPONENTS

2 Marks Questions and Answers:

1) 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.

2) 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.

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

3) Describe IEEE microwave frequency bands.

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

0.3-1GHz	UHF
1-2GHz	L
2-4GHz	S
4-8GHz	C
8-12GHz	X
12-18GHz	Ku
18-27GHz	K
27-40GHz	Ka
40-300GHz	Millimeter
>300GHz	Sub millimeter

4) 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.

5) 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.

6) Define a microwave junction.

The point of interconnection of two or more microwave devices is called microwave junction.

7) Why is magic tee referred to as E-H tee?

The magic tee is a combination of the E-plane tee and H-plane tee. It is a four port hybrid circuit. It is also known as hybrid tee.

8) Define scattering matrix.

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

9) What are scattering coefficients?

The elements of scattering matrix are called scattering confidents or scattering parameters.

10) What is waveguide?

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- [s] is a symmetric matrix i.e. $S_{ij}=S_{ji}$
- [s] is a unitary matrix i.e. [S][S*]=[I]
- Under perfect matched conditions, the diagonal elements of [s] are zero.

13) Write the unitary property for a lossless junction.

For any lossless network the sum of the products of each term of any one row or of any column of the s-matrix multiplied by its complex conjugate is unity.

14) What is H-plane Tee?

An H-plane tee is a waveguide tee in which the axis of its side arm is shunting the E yield or parallel to the H-field of the main guide.

15) What is E-plane Tee?

An E-plane tee is a waveguide tee in which the axis of its side arm is parallel to the E-field of the main guide.

16) Define tee junction.

In microwave circuits a waveguide or co-axial line with three independent ports is commonly referred to as a tee junction.

12) Name some uses of waveguide tees.

It is used to connect a branch or section of the waveguide in series or parallel with the main waveguide transmission line for providing means of splitting and also of combining power in a waveguide system.

13) What are the types of waveguide tees?

The two types of waveguide are

i. E-plane Tee(series)
ii. H-plane Tee(shunt)

14) Define difference arm.

In E-plane tee, the power out of port 3 is proportional to the difference between instantaneous powers entering from port 1 and port 2. Therefore, this third port is called as difference arm.

15) What is sum arm?

In a H=plane tee, if two input waves are fed into port1 and port2 of the collinear arm, the output wave at port3 will be in phase and additive. Because of this, the third port is called as sum arm.

16) 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

17) What is hybrid ring?

The hybrid ring is a 4-port junction. The 4-ports are connected in the form of an angular ring at proper intervals by means of series junctions. It also called Rat-Race circuits.

18) What do you meant by hybrid junction?

A hybrid junction is a 4-port network in which a signal incident on any one of the ports divides between two output ports with the remaining port being isolated.

19) Why bends are used?

- Bends are used to alter the direction of propagation in a waveguide system.
- The reflection due to the bend is a function of its radius.

20) Name some uses of waveguide twists.

- Waveguide twists are used to change the plane of polarization of a propagating wave.
- Waveguide twists are helpful in converting vertical to horizontal polarizations or vice versa.

21) Define gradual twists.

The gradual twists changes the plane of polarizations in a continuous fashion.

22) Give a note on directional couplers.

Directional couplers are transmission line devices that couple together two circuits in one direction, while providing a great degree of isolation in the opposite direction.

23) Define coupling factor(C).

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

$$\text{Coupling factor (dB)} = 10\log 10Pi/Pf$$

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

24) Define directivity of directional coupler.

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

$$D\ (dB) = 10\log 10Pf/Pb$$

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

25) What do you meant by isolation?

Isolation is defined as the ratio of the incident power 'P_i' to the back power 'P_b' expressed in dB.

$$\text{Isolation (dB)} = 10 \log_{10} P_i/P_b$$

Isolation (dB) equals coupling plus directivity.

26) Define Isolator.

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.

27) What is circulator?

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.

28) 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.

29) Mention the different types of directional couplers.

a. Two-hole directional coupler
b. Four-hole directional coupler
c. Reverse- coupling directional coupler(Schwinger coupler)
d. Bethe- hole directional coupler

30 Define non-reciprocal devices?

A non-reciprocal device does not have same electrical characteristics in all direction.

31) Define Isolator.

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.

32) What is circulator?

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.

33) Write the properties of ferrites.

Properties of ferrites:

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.

34) Write the types of ferrite device.

Types of ferrite device:

Three types of non-reciprocal ferrite devices which make use of Faraday rotation in microwave system are

I. Gyrator
II. Isolator
III. Circulators

35) What is gyrator?

It is a two port device that has a relative phase difference of 180^0 for transmission from port 1 to port 2 and no phase shift for transmission from port 2 to port 1.

36) What do you meant by Faraday rotation?

The rotation of the direction of E field of a linearly polarized wave passing through a magnetized ferrite medium is known as Faraday rotation.

37) Define 4-port circulator.

A 4-port circulator which is a non-reciprocal component very similar to the 3-port circulator. All the four ports are matched and transmission of power takes place in cyclic order only, that is, from port 1 to port2, port 2 to port 3, port 3 to port 4 and from port 4 to port 1.

38) Derive the [S] matrix for 3 port circulator.

For a perfectly matched, lossless, non-reciprocal three-port circulator, the S-matrix is

$$[S] = \begin{matrix} 0 & 0 & S_{13} \\ S_{21} & 0 & 0 \\ 0 & S_{32} & 0 \end{matrix}$$

If the terminal planes are properly chosen to make the phase angles of S_{13}, S_{21} and S_{32} zero,

$$S_{13}=S_{21}=S_{32}=1$$

Therefore, [S] matrix for 3 port circulator is

$$[S] = \begin{matrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{matrix}$$

39) Write the applications of circulator.

i. A circulator can be used as a duplexer for a radar antenna system.
ii. Two three port circulators can be used in tunnel diode or parametric amplifiers.
iii. Circulators can be used as low power devices as they can handle low powers only.

40) Name some uses of isolators.

Isolators are generally used to improve the frequency stability of microwave generators, such as Klystrons and magnetrons, in which the reflection from the load affects the generating frequency.

41) Define Faraday rotation isolator.

Isolators can be made by inserting a ferrite rod along the axis of a rectangular waveguide. Here the isolator is called as faraday-rotation isolator.

42) Define ferrites.

Ferrites are non – metallic materials with resistivity's (ρ) nearly 10^{14} times greater than metals and also the dielectric constants (ε_r) is in between 10-15 and relative permeability of the order of 1000.

UNIT-4

MICROWAVE SEMICONDUCTOR DEVICES

2 Marks Questions and Answers:

1) What are the advantages of microwave transistors?

Microwave transistors are miniaturized designs to reduce device and package parasitic capacitances and inductances and to overcome the finite transit time of the charge carriers in the semiconductor materials.

2) What is bipolar transistor?

Bipolar is three-semiconductor (pnp or npn) region structure where charge carriers of both negative (electrons) and positive (holes) polarities are involved in transistor operation.

3) Name the advantages Si bipolar over GaAs.

Compared to GaAs devices Si bipolar transistors are inexpensive, durable have higher gain and moderate noise figure.

4) Name the surface geometries available in microwave power transistors.

Three geometries are available

- Interdigitated
- Overlay
- Matrix

5) Write the applications of bipolar transistors.

Bipolar transistors are suitable for oscillator and power amplifier applications in addition to small-signal amplifiers.

6) What are the configurations available in bipolar transistors?

A transistor can be connected as three different configurations

1. Common Base (CB)
2. Common Emitter (CE)
3. Common Collector (CC)

It is depending on the polarities of the bias voltages connected to its terminals.

7) What are the different modes of bipolar transistor?

A bipolar transistor can operate in four different modes depending on the voltage polarities across the two junctions,

1. Normal (active) mode
2. Saturation mode
3. Cutoff mode
4. Inverse (inverted)

8) Define saturated drift velocity.

Maximum velocity of charge carriers in a semiconductor is called saturated drift velocity (v_s).

9) What is referred as unipolar transistor?

In a field-effect transistors, the current flow is carried by majority carriers either electrons or holes, this type is referred to as a unipolar transistor.

10) Write the advantages of unipolar transistor?

i. It may have voltage gain in addition to current gain.
ii. Efficiency is higher.
iii. Noise Figure is low.

iv. Its operating frequency is up to X band.

v. Its input resistance is very high, up to several mega ohms.

11) Define homo junction transistor.

When the transistor junction is joined by two similar materials such as silicon-to-silicon or germanium-to-germanium, it is a homo junction transistor.

12) What do you meant by hetero junction transistor?

The transistor junction formed by two different materials, such as GE to GaAs, is called a hetero junction transistor.

13) What are MESFET?

Field Effect Transistors (FETs) at microwave frequencies are mostly fabricated in GaAs and use a Metal semiconductor (MES) schottky junction for gate contact. This device is referred to as MESFET or Metal- semiconductor Field Effect Transistors.

14) Define n-channel JFET.

The n-type material is sandwiched between two highly doped layers of p-type material that is designated p^+. This type of device is called as n-channel JFET.

15) What is called as p-channel JFET?

The p-type material is sandwiched between two highly doped layers of n-type material that is designated n^+. This type of device is called as p-channel JFET.

16) What is called as pinch off?

When drain voltage V_d is increased, in JFET the space charge regions expand and join together, so that all free electron carriers are completely depleted in the joined region. This condition is called pinch off.

17) Write the expression for pinch off voltage in JFET.

As the drain voltage V_d is further increased, the space charge regions expand and join together, so that all free electron carriers are completely depleted in the joined region. This condition is called pinch off.

Pinch off voltage, $V_p = q\, N_d\, a^2/2\, \varepsilon_s$

18) Define ON JFET.

The JFET has a conducting channel between the source and the drain electrodes when the gate bias voltage is zero. This is the ON state and the transistor is called a normally ON JFET.

19) Which one is called depletion mode JFET?

A gate voltage must be applied to deplete all carriers in the channel. This device is referred to as depletion mode JFET or D-JFET.

20) What is the amplification factor for JFET?

The amplification factor for a JFET is,

$$\mu = r_d\, g_m$$

21) What is break down voltage in JFET?

As the drain voltage V_d increases for a constant gate voltage V_g, the bias voltage causes avalanche breakdown across the gate junction and the drain current I_d increases sharply

$$V_b = V_d + |V_g|$$

22) Write the applications of GaAs MESFET.

i. The GaAs MESFETs the substrate is doped with chromium (Cr), which has an energy level near the center of the GaAs band gap. This is a very high resistivity substrate and it is commonly called the semi-insulator GaAs structure.

ii. Used in broad band amplifier applications.

23) Write the applications of GaAs MESFET.

1. The GaAs MESFETs are very commonly used in microwave integrated circuits for high power, low noise applications.

2. Used in broad band amplifier applications.

24) Which one is called semi-insulator GaAs structure?

In GaAs MESFETs the substrate is doped with chromium (Cr), which has an energy level near the center of the GaAs band gap. This is a very high resistivity substrate and it is commonly called the semi-insulator GaAs structure.

25) Define pinch off voltage.

The pinch off voltage is the gate reverse voltage that removes all the free charge from the channel.

26) What is called high electron mobility transistor?

The field effect transistor which is made using a hetero junction is called high electron mobility transistor.

27) Define threshold voltage V_{th}.

A minimum gate voltage is required to induce the channel, and it is called the threshold voltage V_{th}.

28) Name the modes of operation for n-channel and p-channel.

There are basically four modes of operation for n-channel and p-channel MOSFETs,

a) n-channel enhancement mode (normally OFF)
b) n-channel depletion mode (normally ON)
c) p-channel enhancement mode (normally OFF)
d) p-channel depletion mode (normally ON)

29) Write the advantages of MOSFETs over MESFETs, and JFETs.

- In the active region of an enhancement-mode MOSFET, the input capacitance and the transconductance are almost independent of gate voltage, and output capacitance is independence of the drain voltage. This leads to very linear (Class A) power amplification.
- The active gate-voltage range can be larger because n-channel depletion-type MOSFETs can be operated from the depletion - mode region ($-V_g$) to the enhancement - mode region ($+V_g$).

  Due to these two advantages, MOSFETs are often used as power amplifiers.

30) Describe tunneling phenomenon.

When the doping level is increased the depletion region reduces. Due to thin depletion region, even for very small forward bias many carriers penetrate through the junction and appear at the other side. This phenomenon of penetration of carriers through the depletion region is known as tunneling.

31) What are the key characteristics of a tunnel diode?

The key characteristics of a tunnel diode are its negative resistance region.

32) What are the applications of tunnel diode?

i. Relaxation oscillator
ii. Microwave oscillator
iii. Storage device
iv. Pulse generator
v. High speed switching networks

33) Draw the symbol of tunnel diode.

34) What are the advantages and disadvantages of tunnel diode?

Advantage:

- Low cost
- Low noise
- High speed
- Low power consumption

Disadvantages:

- Low output voltage swing
- No isolation between input and output.

35) Explain how a reverse biased pn junction exhibits a capacitor?

The width of the depletion layer can be controlled using reverse bias voltage. Since the depletion layer is an insulator, the pn junction can be thought of a parallel plate capacitor, the p and n regions acts like plates of a capacitor.

36) Discuss how the capacitor varies with reverse bias voltage.

The depletion region increases as reverse voltage applied to diode increases. Since capacitance varies inversely with dielectric thickness.

The junction capacitance will decrease as the voltage across pn junction increase.

37) 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.

38) What is microwave resonant?

Microwave resonators are tunable circuits used in microwave oscillators, amplifiers, wave meters and filters.

39) Define varactor diode.

Varactor diodes are p-n junction diodes which provide a voltage variable junction capacitance in microwave circuits when reverse biased.

40) What is resonant frequency?

Resonant frequency f_r at which the energy in the cavity attains maximum value=$2W_e$ or $2W_m$.

The total energy is therefore twice the electric or magnetic energy stored in the resonator.

41) Define Quality factor.

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

$$Q = \frac{2\pi \times \text{maximum energy stored}}{\text{Energy dissipated per cycle}}$$

42) Write the types of waveguide cavity resonators.

i. Rectangular cavity resonator.
ii. Circular cavity resonator.

43) What is transferred electron effect?

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.

44) 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.

43) 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.

44) What are the elements that exhibit Gunn Effect?

The elements are

- Gallium arsenide
- Indium phosephide
- Cadmium telluride
- Indium aresenide

45) Compare voltage and current controlled modes.

S.No.	Voltage controlled	Current controlled
1.	The current density can be Multivalued.	The voltage value can multivalued.
2.	High field domains are formed, Separating two low field regions.	It splits the sample results in high current filaments running along the field directly.

46) What are the available in negative resistance device?

Two modes are available in negative resistance devices. They are

- Voltage- controlled modes
- Current controlled modes

47) Write disadvantages of the source generation of solid-state microwave devices.

- Low efficiency at frequencies above 10GHz
- Small tuning range
- Large dependence of frequency on temperature
- High noise

48) Why Gunn diode amplifier is called travelling domain amplifier?

In the Gunn-diode amplifier, the value of n_0L must be larger than $10^{12}/cm^2$ in order to establish traveling domain oscillations, due to this larger output power can be obtained. Because of the presence of high field domains, this amplifier is called a travelling domain amplifier (TDA).

49) 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.

50) Define Gunn oscillation mode.

This mode is defined in the region when the product of frequency multiplied by length is about 10^7cm/s and the product of doping multiplied by length is greater than 10^{12}cm^2. In this region the device is unstable because of the cyclic formation of either the accumulation layer or the high field domain.

51) What is meant by stable amplification mode?

This mode is defined in the region where the product of frequency time's length is about 10^7cm/s and the product of doping time length is between 10^{11} and 10^{12}/cm^2.

52) Define LSA mode.

This mode is defined in the region where the product of frequency time's length is about 10^7cm/s and the quotient of doping divided by frequency is between 2×10^4 and 2×10^5.

53) Mention the name of domain modes available in Gunn oscillation mode.

Transit-time domain mode ($fL = 10^7$cm/s)

Delayed domain mode (10^6cm/s$<fL<10^7$cm/s)

Quenched domain mode ($fL>2 \times 10^7$cm/s)

54) Define inhibited mode.

When the transit time is chosen so that the domain collected while $E<E_{th}$. A new domain cannot form until the field rises above threshold again. The oscillation field is greater than the transit time i.e.$\tau_0>\tau_\tau$.This delayed mode is called inhibited mode. The efficiency is about 20%.

55) 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 Avalanche breakdown and carriers drift in the high field intensity region under reverse biased condition.

56) 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.

57) 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 I_0 (t) and the ac voltage to be out of phase by 90^0.

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

58) Mention the disadvantage of IMPATT diodes.

The major disadvantages of the IMPATT diodes are

(1) Dc power is drawn due to induced electron current in the external circuit, IMPATT diodes have low efficiency.

(2)Tend to be noisy due to the avalanche process and to the high level of operating current.

(3)A typical noise figure is 30dB which is worse than that of Gunn diodes.

59) Write down the applications of TRAPATT diodes

a) Used in low power Doppler radars.

b) Used as local oscillators for radars, microwave beacon landing system, radio altimeter, phased array radar etc.

60) Define the reactance.

A reactance is defined as a circuit element that stores and releases electromagnetic energy as opposed to a resistance, which dissipates energy.

61) 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.

62) Define inductive.

If the stored energy is predominantly in the magnetic field, the reactance is said to be inductive.

63) Explain plasma formation 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.

64) What is meant by capacitive?

If the stored energy is predominantly in the electric field, the reactance is said to be capacitance.

65) What is meant by degenerate parametric amplifier?

The degenerate parametric amplifier or oscillator is defined as a –ive resistance amplifier with the frequency equal to the idler frequency.

66) Write down the condition for parametric up converter and parametric down convertor.

The output frequency f_0 in the idler circuit is expressed as the sum and difference of the signal frequency f_s and pump frequency f_p .ie $f_o = mf_p \pm n f_s$

If $f_0 > f_s$, the device is called parametric up – converter (PUC)

If $f_o < f_s$, the device is called parametric down – converter (PDC)

67) Name the properties of parametric up converter.

a) The output frequency is equal to the sum of the signal frequency and the pump frequency.

b) There is no power flow in the parametric device at frequencies other than the signal, pump and output frequencies.

68) What are the advantages of parametric up converter over –ive resistance parametric amplifier?

a) A positive input impedance
b) Unconditionally stable and unilateral
c) Power gain independent of source impedance
d) No circulator required
e) Larger bandwidth.

69) Define parametric device.

A parametric device is one that uses a nonlinear reactance or time – varying reactance. The word parametric is derived from the parametric excitation, which is a reactive parameter, can be used to produce capacitance or inductive excitation.

70) Give the application of M/R power relation.

The main application of M/R power relation is to predict whether power gain is possible in a parametric amplifier.

71) Define bilateral –ive-resistance parametric amplifier.

When the –ive resistance parametric amplifier operates below the oscillation threshold, the device behaves as bilateral negative – resistance parametric amplifier.

72) What do you meant by idler frequency?

The idler frequency is defined as the difference between the pump frequency and the signal frequency, $f_i = f_p - f_s$.

73) What is idler circuit?

The output circuit which does not require external excitation is called idler circuit.

74) Give the application of parametric amplifier.

a) Space communication systems.

b) Radio telescopes

c) Tropo-receivers.

75) 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)

76) What do you meant by discrete circuit?

The circuit elements are separately manufactured and then interconnected by conducting wires is now referred to as discrete circuit.

77) Define IC.

The IC consists of a single – crystal chip of semiconductor typically 50*50 miles in cross section containing both active and passive elements and their interconnection.

78) 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

79) 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

80) 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.

81) 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.

82) 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

83) 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

84) Define substrate.

A substrate of MMIC is a piece of substance on which electronic devices are built. Alumina, beryllium, ferrite, GaAs, glass, rutile and sapphire are used as substrate material.

85) What are hybrid integrated circuits?

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

86) What is called as film integrated circuit?

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

87) 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.

88) 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.

89) What is the need for dielectric materials?

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

90) 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.

91) What is the need of resistive materials?

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

92) 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.

93) 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 poor performance have seriously limited their applications.

94) 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.

95) 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

96) What is the need of diffusion and ion-implantation?

Diffusion and ion implantation are the two processes used in controlling amounts of dopants in semiconductor fabrications.

97) Write the advantages of ion-implantation method?

i. Precise control of the total amount of dopants
ii. The improvement of reproducibility
iii. Reduced processing temperature

98) Mention the group's thing films.

- Thermal oxides
- Dielectric layers
- Polycrystalline silicon
- Metal films

99) Write the types of epitaxy.

- Vapor-phase epitaxy (VPE)
- Molecular-beam epitaxy (MBE)
- Liquid-phase epitaxy.

100) What is lithography?

Lithography is the process of transferring patterns of geometric shapes on a mask to a thin layer of radiation sensitive material, which is known as resist, for covering the surface of a semiconductor wafer.

101) Name the different types of lithography.

- Electron beam lithography
- Ion-beam lithography
- Optical lithography
- X-ray lithography

102) 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.

UNIT-5

MICROWAVE TUBES AND MEASUREMENTS

2 Marks Questions and Answers:

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 through with unchanged velocity, those passing through the +ive half cycles of gap voltage undergo an increase 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 called 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 power to the input power.

$$\text{Efficiency} = P_{out} / P_{IN}$$
$$= \beta_0 I_2 V_2 / 2 I_0 V_0$$

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 through with unchanged initial dc velocity depending upon when they encounter the RF signal field at the

buncher cavity gap at positive / negative / zero crossing phase of the cycle, respectively, 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 same direction as the static magnetic field used to focus the electron beam. Here the electron beam travel in a straight 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

$$\eta = P_{ac} / P_{dc}$$

17) What is meant by microwave resonators?

Microwave resonators are tunable circuits used in microwave oscillators, amplifiers, wave meters and filters. At the tuned frequency the circuit resonates where the average energies stored in the electric field, W_e and magnetic field, W_m are equal and the circuit impedance purely real.

18) Define resonant frequency.

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

$$f_r = 2W_e \text{ or } 2W_m$$

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 structure 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.

Comparison between TWTA and klystron amplifier is,

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	Wide band device because use of

	resonant cavities.	non – resonant wave circuit

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 but has low 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 structure surrounded by an inner – single, high-Q cavity operating in the TE_{011}.

b) Voltage tunable magnetron:

The voltage tunable magnetron is a broadband oscillator with frequency changed by varying the applied 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 π - mode of operation?

In the π - mode of operation, the successive cavities in anode have opposite phase, excitation is maximum in the cavities.

$$\varphi = \pi$$

38) What is the formula for cyclotron angular frequency?

$$\omega_c = eB / m$$

Where,

e -Charge of the electron
m-Mass of the electron
B -Magnetic flux density.

39) 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 electric field probe to enter the waveguide for measurement of the relative magnitude of field at location of the probe.

40) Name two methods to measure impedance.

- Slotted line
- Reflecto meter

41) Define power.

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

42) What are the methods to detect microwave power?

a. Bolometer
b. Calorimeter method

43) 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.

44) 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.

45) 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.

46) What are drawbacks of using power meter with single bridge?

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

47) 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.

48) 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.

49) 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.

50) What is calorimetric indirect heating method?

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

51) 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.

52) What are the classifications of power measurements?

The classifications of power measurements are

a. Low power (less than 10mW)
b. Medium power (from 10mW to 10W)
c. High power(>10W)

53) Distinguish between thermistor and barretter?

Sl.No	Barretter	Thermistor
1.	Barretter has a positive temperature coefficient, i.e., resistance increases with temperature.	Thermistor has negative temperature coefficient.
2.	They are less sensitive.	They are more sensitive.
3.	They need less bias current.	Thermistors need more bias current.
4.	Barretters are usually operated at 100 ohm	Thermistors are operated at 100 ohm to 200ohm.

54) Distinguish between low frequency measurements and microwave measurements.

Sl.No	Low frequency measurements	Microwave measurements
1.	At low frequency it is convenient to measure voltage and current and use them to calculate power.	At microwave frequencies the amplitudes of the voltages and current on a transmission line are the functions of a distance and are not easily measurable.
2.	At low frequency, circuits use *lumped elements.*	At microwave frequencies, the circuit elements are distributed.

UNIT-1

16 Marks Questions:

1. Explain in detail about low frequency parameters.
2. Discuss about high frequency parameters.
3. How microwave junction can be described by scattering matrix. Derive the scattering matrix relation between the input and output of an nxn junction?
4. Discuss about various losses available in microwave?
5. Explain the symmetry property in a reciprocal network.
6. Explain the unitary property in a lossless junction.
7. Explain the transmission matrix for 2-port networks.
8. State and explain the properties of S-parameters.
9. Discuss about behavior of wire at RF with neat diagrams.
10. Write in detail about resistors and its types.
11. Give a detailed note on Inductors.
12. Explain in detail about capacitors.

UNIT-2

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.

UNIT-3

16 Mark questions:

1. Discuss about microwave frequency bands.
2. Write the advantage and applications of microwave.
3. Explain a basic microwave system with neat diagram.
4. How microwave junction can be described by scattering matrix. Derive the scattering matrix relation between the input and output of a n x n junction?
5. What are waveguide tees? What are its applications? State different types.

1. Explain the operation of H-plane tee and derive the scattering matrix for it.
2. Explain the operation of E-plane tee and derive the scattering matrix for it.

3. Explain the operation of magic tee and derive the scattering matrix for it.
4. Write the properties of magic tee.
5. Discuss about various losses available in microwave?
6. Explain the symmetry property in a reciprocal network
7. Explain the unitary property in a lossless junction.
8. Discuss about phase shift property of S-matrix.
9. Write about the relation between [S] [Z] and [Y] matrix.
10. Describe in detail the operation of a 2-hole directional coupler.
11. With a neat sketch explain the following:
    ii. Corners
    iii. Bends
    iv. Twists

12. Explain about hybrid circuit. State its applications.
13. Explain directional coupler construction, principle of working and applications.
14. Drive the [S] matrix for directional coupler.
15. With neat diagrams explain different types of directional coupler.
16. What are performance parameters of directional coupler?
17. Explain S-matrix for 2-port networks.
18. State and explain the properties of S-parameters.
19. What are ferrite devices? What are its compositions and application?
20. Explain the construction and working of four port circulator with reference to Faraday rotation principle.
21. Explain the construction working and application of isolator based on Faraday rotation.
22. Explain the operation of gyrator with neat diagram.

UNIT-4

16 Mark questions:

1. Explain the constructional details and principle of operation of GaAs MESFET with neat diagrams and characteristic curves.
2. Give the physical structure and equivalent diagram of microwave field effect transistors.
3. Explain the operation of microwave bipolar transistor with neat diagrams.
4. Explain the operation of HEMT with neat diagrams and characteristic curves.
5. Explain the operation of MOSFET with neat diagrams and characteristic curves.
6. Explain the construction and working of tunnel diode.
7. Write advantages and applications of tunnel diode.
8. Explain the construction and working of varactor diode with neat diagram.
9. What are the applications of varactor diode?
10. Explain the field equations of circular waveguide resonator.
11. Explain in detail about Gunn diode with neat diagram?
12. Explain Ridley – Watkins – Hilsum (RHW) theory with the help of two – valley modal.
13. Explain in detail about high – field domain.
14. Describe the operating principles of LSA diode?
15. Describe the modes of operation for Gunn diode?
16. Explain the construction and operation of Read diode.
17. What are avalanche transit time device? Explain the operation, construction and applications of the following devices.

(1) IMPATT (2) TRAPATT

18. Explain the theory of a –ive resistance amplifier?
19. What are parametric devices? Explain the working of a parametric up converter and a down converter?
20. Derive the Manley – Rowe power relations. What are the conditions for parametric up converter and down converter?
21. Describe the applications of the parametric amplifiers
22. Explain (1) Degenerate paramp (2) Non – degenerate paramp.
23. Explain the fabrication techniques of a monolithic microwave integrated circuit.
24. List out the basic materials required for the manufactured of MMIC.
25. Discuss the discrete, integrated and monolithic microwave integrated circuits?
26. List the basic characteristics required for an ideal substrate material.
27. List the basic properties provided by ideal conductor, dielectric and resistive materials used in MMICs.
28. Describe the MMIC techniques.

UNIT-5

16 Mark questions:

1. What is velocity modulation? Explain how velocity modulation is utilized in klystron.
2. Derive an expression for the efficiency of a two cavity klystron amplifier.
3. What are the characteristics and applications of klystron amplifier?
4. What is klystron? Describe its operation and obtain an expression for its power output.
5. Derive the power output for two cavity klystron amplifier.
6. Derive the expression for optimum distance of klystron in bunching process.
7. Draw and explain the operation of klystron oscillator.
8. Derive the expression for velocity modulation in klystron oscillator.
9. What are the assumptions made when analysis a two-cavity klystron.
10. Explain the working of a TWT amplifier with neat sketch.
11. Write the advantages and applications of TWT.
12. Derive Hull – cutoff condition with respect to magnetron.
13. Explain the working of a magnetron with π - mode oscillation.
14. Explain the construction and working of cylindrical magnetron.
15. Derive the expression for cyclotron angular frequency of cylindrical magnetron.
16. Derive the expression for power output and efficiency of cylindrical magnetron.
17. Write short notes on
    a. Low VSWR
    b. High VSWR
18. Explain the attenuation loss measurement with neat diagram?
19. Explain about power meter using double bridge?
20. Explain high power measurements by calorimetric method?
21. Explain the method of measuring impedance of a given load, with suitable diagram?
22. Explain frequency and wavelength measurements with neat diagrams?
23. Write short notes on
    a. Average power
    b. Bolometer sensor
    c. Schottky Barrier Diode sensor

d. Thermocouple sensor