METHODIST
COLLEGE OF ENGINEERING AND TECHNOLOGY
Approved by AICTE New Delhi | Affiliated to Osmania University, Hyderabad
Estd : 2008 Address : King Koti Road, Abids, Hyderabad, Telangana, 500001 | Email : principal@methodist.edu.in

DEPARTMENT OF ECE

TWO MARKS QUESTION & ANSWERS

SUBJECT: MICROWAVE ENGINEERING

CODE: EC 401

FACULTY NAME: T. SRAVAN KUMAR

UNIT-I (GUIDED WAVES)

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.

i) Fewer repeaters are necessary for amplification.
ii) Minimal cross talk exists between voice channels.
iii) Increased reliability and less maintenance are important factors.
iv) 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) What are guided waves? Give examples

The electromagnetic waves that are guided along or over conducting or dielectric surface are called guided waves.

Examples: Parallel wire, transmission lines

7) What is TE wave or H wave?

Transverse electric (TE) wave is a wave in which the electric field strength E is entirely transverse. It has a magnetic field strength Hz in the direction of propagation and no component of electric field Ez in the same direction.

8) What is TH wave or E wave?

Transverse magnetic (TM) wave is a wave in which the magnetic field strength H is entirely transverse. It has a electric field strength Ez in the direction of propagation and no component of magnetic field Hz in the same
direction.

9) What is a TEM wave or principal wave?

TEM wave is a special type of TM wave in which an electric field E along the direction of propagation is also zero. The TEM waves are waves in which both electric and magnetic fields are transverse entirely but have no components of Ez and Hz. it is also referred to as the principal wave.

10) What is a dominant mode?

The modes that have the lowest cut off frequency is called the dominant mode.

11) Give the dominant mode for TE and TM waves?

Dominant mode: TE10 and TM10

12) What is cut off frequency or critical frequency (fc)?

The frequency at which the wave motion ceases is called cut-off frequency of the waveguide. (or) the frequency at which $\gamma=0$ is known as cutoff frequency.

13) What is cut-off wavelength(λ_C)?

It is the wavelength below which there is wave propagation and above which there is no wave propagation.

14) Define Guide wavelength(λ_g)?

It is defined as the distance travelled by the wave inorder to undergo a phase shift of 2π radians. $\lambda_g= 2\pi/\beta$

15) Define Phase Velocity(Vp)?

The velocity with which constant phase point travels is called phase velocity.i.e.$Vp=\omega/\beta$

16) Define Group Velocity(Vg)?

The velocity with which change in constant phase points travels is called group velocity.

i.e.$Vg= d\omega/d\beta$

17) Mention the characteristics of TEM waves.

a) It is a special type of TM wave
b) It doesn't have either E or H component
c) Its velocity is independent of frequency
d) Its cut-off frequency is zero.

18) Define attenuation factor?

Attenuation factor = (Power lost/ unit length)/(2 x power transmitted)

19) Define wave impedance?

Wave impedance is defined as the ratio of electric to magnetic field strength.

Zxy= Ex/ Hy in the positive direction

Zxy= -Ex/ Hy in the negative direction

20) What is a parallel plate wave guide?

Parallel plate wave guide consists of two conducting sheets separated by a dielectric material.

UNIT-II (WAVE GUIDES)

1) What is waveguide?

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

2) Mention the applications of wave guides

i) The wave guides are employed for transmission of energy at very high frequencies where the attenuation caused by wave guide is smaller.

ii) Waveguides are used in microwave transmission.

iii) Circular waveguides are used as attenuators and phase shifters.

3) Why is circular or rectangular form used as waveguide?

Waveguides usually take the form of rectangular or circular cylinders because of its simpler forms in use and less expensive to manufacture.

4) What is an evanescent mode?

When the operating frequency is lower than the cut-off frequency, the propagation constant becomes real i.e , $\gamma = \alpha$. The wave cannot be propagated. This non- propagating mode is known as evanescent mode.

5) What is the dominant mode for the TE waves in the rectangular waveguide?

The lowest mode for TE wave is TE10 (m=1 , n=0)

6) What is the dominant mode for the TM waves in the rectangular waveguide?

The lowest mode for TM wave is TM11 (m=1 , n=1)

7) What is the dominant mode for the rectangular waveguide?

The lowest mode for TE wave is TE10 (m=1 , n=0) whereas the lowest mode for TM wave is TM11(m=1 , n=1). The TE10 wave has the lowest cut off frequency compared to the TM11 mode. Hence the TE10 (m=1 , n=0) is the dominant mode of a rectangular waveguide. Because the TE10 mode has the lowest attenuation of all modes in a rectangular waveguide and its electric field is definitely polarized in one direction everywhere.

8) Define characteristic impedance in a waveguide

The characteristic impedance Zo can be defined in terms of the voltage current ratio or in terms of power transmitted for a given voltage or a given current.

$$Zo\ (V,I) = V/I$$

9) Why TEM mode is not possible in a rectangular waveguide?

Since TEM wave do not have axial component of either E or H ,it cannot Propagate within a single conductor waveguide

10) Explain why TM01 and TM10 modes in a rectangular waveguide do not exist.

For TM modes in rectangular waveguides, neither m or n can be zero because all the field equations vanish (i.e., Hx, Hy ,Ey. and Ez.=0). If m=0,n=1 or m=1,n=0 no fields are present. Hence TM01 and TM10 modes in a rectangular waveguide do not exist.

11) What are degenerate modes in a rectangular waveguide?

Some of the higher order modes, having the same cut off frequency , are called degenerate modes. In a rectangular waveguide, TEmn and TMmn modes (both $m \neq 0$ and $n \neq 0$) are always degenerate.

12) What is a circular waveguide?

A circular waveguide is a hollow metallic tube with circular cross-section for propagating the electromagnetic waves by continuous reflections from the surfaces or walls of the guide

13) Why are rectangular wave-guides preferred over circular wave-guides?

Rectangular wave-guides preferred over circular wave guides because of the following reasons.

a) Rectangular wave guide is smaller in size than a circular wave guide of the same operating frequency

b) It does not maintain its polarization through the circular wave guide

c) The frequency difference between the lowest frequency on dominant mode and the next mode of a rectangular wave-guide is bigger than in a circular wave guide.

14) Mention the applications of circular waveguide.

Circular waveguides are used as attenuators and phase-shifters

15) Which mode in a circular waveguide has attenuation effect decreasing with increase in frequency?

TE01

16) What are the possible modes for TM waves in a circular waveguide?

The possible TM modes in a circular waveguide are : TM01 , TM02 ,TM11, TM12

17) What are the root values for the TM modes?

The root values for the TM modes are:

(ha)01 = 2.405 for TM01

(ha)02 = 5.53 for TM02

(ha)11 = 3.85 for TM11

(ha)12 = 7.02 for TM12

18) What are the root values for the TE modes?

The root values for the TE modes are:

(ha)01 = 3.85 for TE01

(ha)02 = 7.02 for TE02

(ha)11 = 1.841 for TE11

(ha)12 = 5.53 for TE12

19) Define dominant mode for a circular waveguide.

The dominant mode for a circular waveguide is defined as the lowest order mode having the lowest root value.

20) What are the possible modes for TE waves in a circular waveguide?

The possible TE modes in a circular waveguide are : TE01 , TE02 ,TE11, TE12

21) What is the dominant mode in a circular waveguide

The dominant mode for TM waves in a circular waveguide is the TM01 because it has the root value of 2.405. The dominant mode for TE waves in a circular waveguide is the TE11 because it has the root value of 1.841 .Since the root value of TE11 is lower than TM01 , TE11 is the dominant or the lowest order mode for a circular waveguide.

21) Mention the dominant modes in rectangular and circular waveguides

For a rectangular waveguide, the dominant mode is TE01

For a circular waveguide, the dominant mode is TE11

22) Why is TM01 mode preferred to the TE01 mode in a circular waveguide?

TM01 mode is preferred to the TE01 mode in a circular waveguide, since it requires a smaller diameter for the same cut off wavelength.

23) What is a resonator?

Resonator is a tuned circuit which resonates at a particular frequency at which the energy stored in the electric field is equal to the energy stored in the magnetic field.

24) How the resonator is constructed at low frequencies?

At low frequencies upto VHF (300 MHz) , the resonator is made up of the reactive elements or the lumped elements like the capacitance and the inductance.

25) What are the methods used for constructing a resonator?

The resonators are built by

a) using lumped elements like L and C

b) using distributed elements like sections of coaxial lines

c) using rectangular or circular waveguide

26) What are the disadvantages if the resonator is made using lumped elements at high frequencies?

The inductance and the capacitance values are too small as the frequency is increased beyond the VHF range and hence difficult to realize .

27) What are the performance parameters of microwave resonator?

The performance parameters of microwave resonator are:

(i) Resonant frequency (ii) Quality factor (iii) Input impedance

28) What is resonant frequency of microwave resonator?

Resonant frequency of microwave resonator is the frequency at which the energy in the resonator attains maximum value. i.e., twice the electric energy or magnetic energy.

29) Define Quality factor(Q) of a resonator.

The quality factor Q is a measure of frequency selectivity of the resonator. It is defined as

$Q = 2\pi$ x Maximum energy stored / Energy dissipated per cycle

$=\omega$ W/ P ; Where W is the maximum stored energy,P is the average power loss

30) What is a transmission line resonator or coaxial resonator?

Transmission line resonator can be built using distributed elements like sections of coaxial lines. The coaxial lines are either opened or shunted at the end sections thus confining the electromagnetic energy within the section and acts as the resonant circuit having a natural resonant frequency.

31) Why transmission line resonator is not usually used as microwave resonator?

At very high frequencies transmission line resonator does not give very high quality factor Q due to skin effect and radiation loss. So, transmission line resonator is not used as microwave resonator

32) What are cavity resonators?

Cavity resonators are formed by placing the perfectly conducting sheets on the rectangular or circular waveguide on the two end sections and hence all the sides are surrounded by the conducting walls thus forming a cavity. The electromagnetic energy is confined within this metallic enclosure and they acts as resonant circuits .

33) What are the types of cavity resonators?

There are two types of cavity resonators. They are:

a) Rectangular cavity resonator

b) Circular cavity resonator

34) Why rectangular or circular cavities can be used as microwave resonators?

Rectangular or circular cavities can be used as microwave resonators because they have natural resonant frequency and behave like a LCR circuit.

35) What is the dominant mode for rectangular resonator?

The dominant mode of a rectangular resonator depends on the dimensions of the cavity.

For b<a<d, the dominant mode is TE101

36) What is the dominant mode for circular resonator?

The dominant mode of a circular resonator depends on the dimensions of the cavity. For d< 2a, the dominant mode is TM010.

UNIT-III (MICROWAVE CIRCUITS & COMPONENTS)

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) Define scattering matrix. What are scattering coefficients?

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.

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

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

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

i) Equipment is not readily available to measure total voltage and total current at the ports of the networks.

ii) Short circuit and open circuit are difficult to achieve over a wide range of frequencies.

iii) 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.

4) Write the properties of [S] matrix.

i) [s] is always a square matrix of order (nxn)

ii) [s] is a symmetric matrix i.e. $S_{ij}=S_{ji}$

iii) [s] is a unitary matrix i.e. [S][S*]=[I]

iv) Under perfect matched conditions, the diagonal elements of [s] are zero.

5) 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.

6) Define non-reciprocal devices.

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

7) What are junctions?Give some examples

A microwave circuit consists of several microwave devices connected in some way to achieve the desired transmission of MW signal.The interconnection of two or more microwave devices may be regarded as MW junction.

Eg:Magic Tee,Hybrid Ring

8) What is Tee junction?Give two examples

In MW circuits a wave guide or coaxial junction with three independent ports is referred to as tee junction.

Eg: E- Plane Tee,H-plane Tee

9) 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.

10) 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.

11) What are the types of waveguide tees? The two types of waveguide are

i. E-plane Tee(series)

ii. H-plane Tee(shunt)

12) 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.

13) 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.

14) 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

15) 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.

16) 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.

17) 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.

18) 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.

19) Define directivity(D) 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.

20) 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. i.e. I=C+D

21) 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.

22) 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.

23) 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.

24) 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

25) 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.

26) 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.

27) 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.

28) Define Faraday rotation in 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.

29) 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.

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

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

31) 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.

32) 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.

33) Give the differences between Isolator and Circulator

S.No.	Isolator	Circulator
1	It is a two port device	It is a three port device
2	It cannot be used as circulator	It is used as isolator by terminating on port
3	If input is given in port 1,ouput is obtained at port 2 and vice versa	Each terminal is connected only to the next terminal

34) Write the properties of ferrites. Properties of ferrites:

i) Ferrites possess strong magnetic properties.

ii) Ferrites are most suitable for use in microwave device in order to reduce the reflected power.

iii) Ferrites possess high resistivity; hence they can be used up to 100 GHz

iv) Ferrites also exhibit non-reciprocal property.

35) 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

36) 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.

UNIT-IV (MICROWAVE TUBES)

1) 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)

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

MMICs offer the following advantage over discrete circuits

i) Small in size& weight

ii) High reliability

iii) Improved reproducibility

iv) Improved performance

v) Eventual cost reduction when produced in large quantities.

3) Name the difference between MMICs and conventional ICs.

MMICs are require 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.

4) 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. (or) The time taken by the electron to travel into the repeller space and back to the gap.

T =n + ¾

5) What is the effect of transit time?

There are two effects.

1) At low frequencies, the grid and anode signals are no longer 180O out of phase, thus causing design problems with feedback in oscillators.

2) The grid begins to take power from the driving source and the power is absorbed even when the grid is negatively biased.

6) What are the high frequency effects in conventional tubes?

The high frequency effects in conventional tubes are

i) Circuit reactance

a)Inter electrode capacitance

b) Lead inductance

ii) Transit time effect

iii) Cathode emission

iv) Plate heat dissipation area

v) Power loss due to skin effect, radiation and dielectric loss.

7) 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

8) 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.

9) What is drift space?

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

10) Define velocity modulation.

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

11) 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.

12) Write the parameters on which bunching depend on?

i) Drift space should be properly adjusted.

ii) D.C anode voltage

iii) Signal amplitude should be such that proper bunching takes place.

13) 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.

14) 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.

15) 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.

16) Define electronic efficiency.

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

Efficiency (η)= Pout /PIN

= Pac / P dc

= $\beta_0 I_2 V_2 / 2 I_0 V_0$

17) How the klystron amplifier can act as klystron oscillator? What are the applications of klystron amplifier?

When the klystron amplifier is given a positive feedback such that the overall phase shift becomes zero 360° and $|A_V \beta| =$ I then klystron amplifier acts as an oscillator.

18) 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.

19) 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.

20) 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.

21) Mention the same characteristics of reflex klystrons.

i) Frequencyrange:1 to 25GHz

ii) Power output: It is a low-power generator of 10 to 500mW

ii) Efficiency: About 20 to 3o%

22) What are the applications of reflex klystron ?

i) Signal source in MW generator

ii) Local oscillators in receivers

iii) It is used in FM oscillator in low power MW links.

iv) In parametric amplifier as pump source.

23) 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.

24) What is the purpose of slow wave structures used in TWT amplifiers?

Slow wave structures are special circuits that are used in microwave tubes to reduce wave velocity in a certain direction so that the electron beam and the signal wave can interact. In TWT, since the beam can be accelerated only to velocities that are about a fraction of the velocity of light, slow wave structures are used.

25) Give the comparison between TWTA and klystron amplifier?

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

26) 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

27) State the applications of TWT.

i) Low power, low noise TWT's used in radar and microwave receivers
ii) Laboratory instruments
iii) Drivers for more powerful tubes
iv) Medium and high power CWTWT'S are used for communication and radar.

28) What are the advantages of TWT?

i) Bandwidth is large
ii) High reliability
iii) High gain
iv) Higher duty cycle

29) What are the types of magnetron?

There are three types of magnetrons:

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

30) 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.

31) Write the applications of magnetron.

The magnetron are widely used on,

Radar transmitters, Industrial heating, Microwave ovens.

32) What is BWO? State the applications of BWO.

A backward wave oscillator (BWO) is microwave cw oscillator with an enormous tuning and ever all frequency coverage range.

Applications:

(i) It can be used as signal source in instruments and transmitters.
(ii) It can be used as broad band noise sources which used to confuse enemy radar.

33) 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, We and magnetic field, Wm are equal and the circuit impedance purely real.

34) Define resonant frequency.

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

fr =2We or 2Wm

UNIT-V (MICROWAVE SOLID STATE DEVICES)

1) Define varactor diode.

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

2) 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.

3) What is negative resistance?

Negative resistance is defined as that property of a device which causes the current through it to be 180 degree out of phase with the voltage across it.

4) What is –ive resistance in Gunndiode?

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.

5) Define GUNN EFFECT.

Gunn effect was first observed by GUNN in n_type GaAs bulk diode. According to GUNN, above some critical voltage corresponding to an electric field of 2000-4000v/cm, the current in every specimen became a fluctuating function of time. The frequency of oscillation was determined mainly by the specimen and not by the external circuit.

6) 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.

7) What are the elements that exhibit Gunn Effect?

The elements are

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

8) What are the applications of Gunn Diode?

The applications are

a) Low and medium power oscillators

b) Used in high pump frequencies

c) Burglar alarms and aircraft rate-of-climb indicators.

9) 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.

10) What are the factors reducing efficiency of IMPATT diode?

1) Space charge effect

2) Reverse saturation current effect

3) High frequency skin effect

4) Ionization saturation effect.

11) 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.

12) Mention the applications of IMPATT 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.