SKP ENGINEERING COLLEGE
DEPARTMENT OF ECE
EC6701- RF & MICROWAVE ENGINEERING
ACADEMIC YEAR 2018

UNIT 1
TWO PORT NETWORK THEORY
PART A

1. Define s-matrix

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

2 What are the .Properties of s-matrix? [Nov/Dec2012, April /May 15]

1. It possess symmetric property sij =sji
2. It possess unitary property
3. [s][s]*=[i]

3. Why is s-matrix used in MW analysis? [Nov/Dec2011]

S matrix is used in MW analysis to overcome the problems which occurs when H,Y,&Z parameters are used in high frequencies.

1. Equipment is not readily available to measure total voltage &total current at the ports of the network.
2. Short and open circuits are difficult to achieve over a broad band of frequencies.
3. Active devices,such as power transistor &tunnel diodes,frequently won‟t have stability for a short or open circuit.

4. Give ABCD matrix for a two port network

V1= A B V2
I1= C D -I2

5. What is ABCD matrix?

ABCD matrix is a transmission matrix.these parameters express voltage and current at output in terms of those at input port.

V1=AV2-BI2
I1=CV2-DI2

6. What are the advantages of ABCD matrix?

1. They are used in power transmission lines.
2. They are very helpful in the case of cascade networks.

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

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

8. Give the S matrix of uniform transmission line.

$S = \begin{matrix} 0 & e^{-jbl} \\ e^{-jbl} & 0 \end{matrix}$

9. Give the properties of impedence [x] & admittance[y] matrix?

1. For a lossless junction y and z are symmetric.
2. $[y]=[z]^{-1}$
3. Elements of matix [Z] &matrix [Y] are Frequency dependent.

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

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

11. What is transmission matrix?

When a number of microwave devices are connected in cascade. Each junction is represented by a transmission matrix which gives the output quantities in terms of input quantities.

12. Express power input and power output under matched conditions for a two port network in terms of wave components. [May/June 2013]

Microwave circuits are analyzed using scattering(S) parameters, which linearly relate the reflected waves amplitude with those of incident waves.
The incident and reflected amplitudes of microwave at any port are used to characterize a microwave circuits.
Input power at n_{th} port P_{in} =
Reflected power at the n_{th} port P_{in} =

13. Write the voltage matrix for an N-port microwave circuits.

V1 Z11 Z12 ….. Z1N I1
V2 Z12 Z22 ….. Z2N I2
.=. . …… …. .
.
VN ZN1 ZN2….. ZNN IN
Where Zij=Elements of impedence matrix.
[Z]=Impedence martrix

14. Give two examples for two port junctions.

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

15. State the unique property of Scattering matrix?

Unitary Property: the row of a scattering matrix multiplied by the complex conjugate of the same

row of the scattering matrix is one.

16. Write the scattering matrix for a ideal waveguide section?

[S]=[0 11 0]

17. Define reciprocal and symmetrical networks. [May/June 2013]

A reciprocal network is defined to be a network that satisfies the reciprocity theorem. It states that when some amount of emf(or voltage) is applied at one point in a passive linear network, that will produce the current at any other point. The same amount of current is produced when the same emf is applied in the new location. In terms of S parameter,

$S_{ij} = S_{ji}$ (i not equal to j),where, i=1,2….N &j=1,2,…..N

Due to symmetry of the network topology, the input impedance at the input port is equal to the impedance in the output network. The equality of the input and output impedance leads to the equality of input and output reflection coefficients. In general, for any symmetrical passive n port network,

$S_{ij} = S_{ji}$

For any symmetrical and reciprocity networks, we can always write as $S_{11}=S_{22}$& $S_{12}=S_{21}$

18. What is ESR? [Nov/Dec2013]

Practical capacitors and inductors are used in electric circuit not ideal components with only capacitance or inductance. The ideal capacitances and inductors are in series with resistance. This type of resistance is called equivalent series resistance(ESR).

19. List any four reasons for the wide use of RF. [May/June 2014]

(i) RF is reusable
(ii) Wireless data transmission
(iii) Low cost, and
(iv) Bandwidth efficiency.

20. Give the relationship between S and Z. [May/June 2014]

$S = (Z-Z_0I) / (Z+Z_0I)$

Where, Z0 - Characteristic impedance
I - Circuit Current.

21. What are the high frequency limitations of conventional tubes?

Conventional vacuum triodes, tetrodes, and pentodes are less useful signal sources at the frequencies above 1FHz due to
(i) Lead – Inductance
(ii) Interelectrode – Capacitance effects
(iii) Transit – Angle effects
(iv) Gain – BW product limitation.

22. Write the applications of inductors.

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

(i) Resonance circuits
(ii) Filters
(iii) Phase shifters
(iv) Delay networks (v) RF Chokes.

23. Why the S-parameters are used in microwaves? [Nov/Dec 2011]

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.

24. 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.

25. 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".

PART B

1. **Discuss the importance of low frequency and high frequency parameters of two port networks. (16) [Nov/Dec 2014,April /May 15]**
2. **Write a detailed note on ABCD parameters. (8) [Nov/dec 2012, Nov/Dec 2013]**
3. **State and explain the properties of S-Parameters. (16) [May/June 2013, May/June 2014,April/May 2015]**
4. **Formulate S matrix and Compute transmission matrix for a T-network.(16) [May/June 2013, Nov/Dec 2012 april/ may 2017]**

5. Verify the lossless and reciprocity properties of any two port network using scattering matrix. (16) [Nov/Dec 2014]

6. The S parameters of a two port network are given by [Nov/Dec 2013, Nov/Dec 2012]

S11=0.2<90° S22=0.2<90°

S12=0.5<90° S21=0.5<0°

(a) Determine whether the network is lossy or not and

(b) Is the network symmetrical and reciprocal? Find the insertion loss of network.

7.Give a detailed note on resistor, inductor and capacitor. (16)

8. **Derive the overall network parameter for cascade connection of two port network. Discuss about short circuit,open circuit,h and ABCD low parameters(April/May 2017)**

9. state and prove the properties of s-matrix(april/may 2017)(NovDec/2017)

10.Explain the symmetry property in a reciprocal network. (April/May 2017)(Nov/Dec2016)

11. Discuss on the application of RF and microwave area. (April/May 2017) (Nov/Dec2016)

12.How microwave junction can be described by scattering matrix? Derive the scattering matrix relationbetween the input and output of ncrossn junction. (April/May 2018)

13.Describe the losses in microwave devices. (April/May 2018)

UNIT II
RF AMPLIFIERS AND MATCHING NETWORKS
PART A

1. Write the function of matching networks? [Nov/dec-11]

Matching networks can help stabilize the amplifier by keeping the source and load impedances in the appropriate range. Impedance matching (or tuning) is an important issue for - Maximum power is delivered when load is matched to line (assuming the generator is matched) - Power loss is minimized. S/N- ratio of receiver components is increased. - Amplitude and phase errors are reduced.

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. [Nov/dec-13]

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

G_T= Power delivered to the load/Available power from the source.

$G_T = P_L/P_{av}$

5. Define Unilateral Power gain. [Nov/Dec-14]

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

$$G_{TU} = S_{21}$$
$$_2 (1- \Gamma_{S\,2}) (1- \Gamma_{L\,2})$$
$$(1- \Gamma_S \Gamma_{in})_2 (1- S_{22} \Gamma_L)_2$$

6. What is available Power Gain (GA) at Load?

The available power gain for load side matching (TL = T*Out) is given as,

G_A= Power available from the network/power available from the source

$G_A = P_N/P_A$

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= Power delivered to the load/Power supplied to the amplifier

$G = P_L/P_{in}$

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

- If |T|>1, then the magnitude of the return voltage wave increases called positive feedback, which causes instability (oscillator).
- If |T|<1, then the return voltage wave is totally avoided (amplifier). It is called as negative feedback.

9. Define Stability factor (Rolette Factor) [May/June -14]

$$K = 1- S_{11}$$
$$_2- S_{22}$$
$$_2+ S_{11}S_{22}-S_{12}S_{21}$$
$$_2$$
$$2\ S12\| S21$$

10. Give the expression that relates nodal quality factor (Qn) with loaded quality factor (Q_L) [Nov/Dec-13,April/May 15]

Nodal quality factor (Qn) is defined as ratio of the absolute value of the reactance Xs to the corresponding Resistance R_s

$Q_n = [X_s] / R_s$

The nodel quality factor is $Q_L = Q_n / 2$

11. What are the need of Impedance Matching Network [May/June-13],[May/June-14]

- ✓ Minimal power loss in feed line
- ✓ Maximum power delivery
- ✓ Improving the S/N ratio of the system for sensitive receiver components
- ✓ Reducing amplitude & phase errors in a power distribution networks
- ✓ Minimum reflection in transmission line
- ✓ Optimal efficiency

12. Define power gain of amplifier in terms of S- parameter and reflection coefficient. [Nov/Dec-12, Nov/Dec13]

Transducer Power Gain

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

G_T =

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_T =

13. What are the considerations in selecting a matching network? [Nov/Dec12]

(i) Complexity of the system
(ii) Bandwidth requirement
(iii) Adjustability
(iv) Implementation
(v) Maximum power delivery
(vi) Optimal efficiency.

14. Define Stability [May/June-14]

Stability refers to the situation where the amplifier remains stable for any passive source and load at the selected frequency and bias condition.

15. State the significance of microstrip matching networks. [Nov/Dec-14]

(i) Distributed microstrip lines and lumped capacitors
(ii) Less susceptible to parasitic
(iii) Easy to tune
(iv) Efficient PCB implementation
(v) Small size for high frequency.

16. Define noise figure. [Nov/Dec 2011]

Noise figure F is defined as "the ratio of the input SNR to the output SNR".
F = Input SNR/Output SNR

17. Define unconditional stability

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

18. Mention the advantages of smith chart in the design of matching networks.

The smith chart allows immediately observing whether or not a particular impedance transformation is capable of achieving the desired matching. Moreover, the total number of possible network configurations can be readily be seen.

19. What is the advantage of T and Pi matching networks?

The addition of third element into the two element (L) matching network introduces an additional degree of freedom in the circuit and allows us to control the value of Q_L by choosing an appropriate intermediate impedance for wider (matching) bandwidth.

20. Why we go for double stub matching networks?

(i) They require a variable length transmission line between the stub and the input port, or between the stub and load impedance.
(ii) Usually this does not a problem for fixed networks, but may create difficulties for variable tuners.

PART B

1.Explain the micro strip matching network. (8) [Nov/Dec -2011,May/June 2014]

2.Microwave amplifier is characterized by its s parameters. Derive equations for power gain, available gain and transducer gain. (16)[NOV/DEC-11, Nov/Dec 12, May/June 2013,April/May 2015]

3.Explain conditional and un conditional stability. (16)[Nov/Dec2011,April/May 2015]

4. Derive the expression for various types of power gain in of RF amplifier.April/May2018.

5. Explain microstrip line matching network. April/May 2018.

6. Explain in detail noise figure in an amplifier. April/May 2018.

7. Derive the equation for power gain,available power gain and transducer power gain.[Nov/Dec2016]

8. Discuss the following single stub matching and double stub matching.[Nov/Dec2016]

9. Discuss about the design of t section and pi section matching network. [April/May 2017]

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UNIT III
PASSIVE AND ACTIVE MICROWAVE DEVICES
PART A

1. What are matched terminators [May/June-14]

- ✓ Low power co axial termination
- ✓ Resistance strip
- ✓ Standard mis matches

2. Name the microwave passive devices which make use of faraday rotation[Apr/May-15]

- ✓ Isolator
- ✓ Gyrator Circulator

3. What are ferrites? Why its needed in circulator [Nov/Dec-13], [May/June-14]

Ferrites are non metallic meterials with resistives nearly 10^{14} times greater than metals and also the dielectric constant is in between 10^{-15} and relative permeability of the order of 1000

4. Mention the application of gyrator and isolator [Nov/Dec-14]

Gyrator :
(i) In can be in radar antenna as a duplexer
(ii) It will handle a low power . hence they are used as low power devices
Isolator:
(i) Isolator 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.

5. Define isolator?

An isolator or uniline is two port non reciprocal devices, which produce a minimum attenuation to wave in one direction and very high attenuation in the opposite direction.

6. Draw the Structure of Two hole Directional coupler [Nov/Dec-11]

7. Draw the diagram for H – plan tee? [Nov/Dec-12]

8. What is H-Plane Tee?

It is a wave guide tee in which the axis of the slide arm is shunting the E- field or parallel to the H-field of the main guide.

9. Give the applications of directional coupler.

1. Unidirectional power measurement
2. SWR measurement
3. Unidirectional wave launching

4. Reflectometer
5. Balanced duplexer.

10. Define directivity of directional coupler.

It is defined as a ratio of forward power P_f to the back power P_b expressed in dB.

$D(dB)= 10\log_{10} P_f/P_b$

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

11. What is Gunn Effect? What are the elements that exhibit Gunn Effect? [May/june-13]

Gun 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 fuction of time. The frequency of oscillation was determined mainly by the specimen and not by the external circuit.

The elements are

a) Gallium arsenide
b)Indium phosphate
c) Cadmium telluride
d)Indium arsenide

12. What are the factors reducing efficiency of IMPATT diode? [Nov/Dec 2011]

1) Space charge effect
2) Reverse saturation current effect
3) High frequency skin effect
4) Ionization saturation effect.

13. What is Transferred electron effect? [Nov/Dec-12]

Some materials like GaAs exhibit negative differential mobility, when biased above a threshold value of the electric field. This behavior is called transferred electron effect. The electrons in the lower energy band will move to the higher energy ban d its called TED.

14. What are the factors reduces the efficiency in Impatt Diode

- Space charge effect
- Reverse saturation current effect
- High frequency skin effect
- Ionization saturation effect.

15. Mention the ideal characterize of dielectric material in MMIC? [Nov/Dec-13]

- Small size and Weight
- High reliability
- Improved reproducibility
- Improved performance
- Eventual cost reduction when produced in large quantities.

16. What are the necessary condition for Gunn diode
This mode is defined in the region when the fL value is about 10^7 cm/s and the n0/L > 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.

17. List the gunn modes of operations.
a. Transit time mode
b. LSA mode
c. Quenched time mode
d. Delayed mode

18. Draw the equivalent circuit for varactor diode [Apr/may-2015]

19. What are power dividers?
Power dividers are used to divide the input power into a number of smaller amounts of power for exciting the radiating elements in an array antenna.

20. What is the principle of Microwave phase shifter?
When a wave propagates on a line,a phase difference prevails between any two arbitary points along its paths.The phase difference between two points

21. 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 may be regarded as MW junction. Eg:Magic Tee,Hybrid Ring

22. 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.

23. What is negative resistance in gunn diode?
The carrier drift velocity increases linearly from 0 to maximum when the electric field is increased from 0 to threshold value in gunndiodes.When the electric field is beyond the threshold value of 3000v/cm the drift velocity is decreased and the diode exhibit negative resistance.
24. Write the applications of magic tee.
(i) Measurements of impedance
(ii) As duplexer,
(iii)As mixer
(iv) As an isolator

25. Define coupling factor(C)
It is defined as the ratio of incident power Pi to the forward power Pf measured in dB.
Coupling factor (dB) = 10log10 Pi/pf.
The coupling factor is a measure of how much of the incident power is being sampled.

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PART-B

1.Explain conditional and un conditional stability. (16)[Nov/Dec2011,April/May 2015]

2 .Discuss Structure and principle of operation of Isolator. (8) [Nov/dec-2011,12,13]

3. Discuss Structure and principle of operation of circulator. Nov/Dec 2017, (16)

4.Explain how directional coupler can be used to measure the reflected power. (16)

[Nov/Dec 2012, Nov/ Dec -13,Apr/May 15]

5.Explain the properties of H plane tee and give reasons and why it is called shunt tee.

(8) [NOV /DEC 2012]

6.Derive the equation for S matrix of magic TEE. (16) [NOV /DEC 2012, May / June - 13, 14, Nov/ Dec -13]

7. Explain the properties of E plane Tee? Derive the expression for scattering matrix. [May/June -2013,Nov/Dec 14]

8. With neat diagram , explain the working principle of Gunn diode mention its application. (16) [Nov/Dec 2011,2012,2013,14,May/June – 13,14,April/May 15]

9. Draw the construction and explain the working of IMPATT diode. (16)

[Nov/Dec - 12,May/June -13,April/May 15]

10. With neat diagram discuss the characteristics of series tee and shunt tee and derive the s matrix.[Apr/May -17]

11 .Discuss the principle of operation of any two non reciprocal devices and derive the s parameters. [Apr/May -17

12.Discuss the following quarter wave transformer and gunn diode oscillator. [Nov/Dec 2017]

13. Derive the s matrix of hybrid tee and the properties and applications. [Nov/Dec 2017]

14. Discuss briefly about working principle operation characteristics and application of varactor diode. [Nov/Dec 2017]

15. Derive the s matrix directional coupler and the properties and applications. [April/May18]

16. Explain the properties of E plane Tee? derive the expression for scattering matrix. [April/May 18].

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UNIT IV
MICROWAVE GENERATION
PART A

1. What is the role of slow wave structure in TWT? [May/June 2013, May/June 14]
Slow wave structure are a 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 were interact.

2. Compare M and O type tubes. [Nov/Dec-12]
M type Tubes O type Tubes
Static magnetic field is perpendicular
Static magnetic field is same
Direction to the electric field to the electric field
Magnetron is the M type Tube
Klystron and TWT are the O type tubes
Electron travel in curved path Electron travel in linear path

3. Compare TWT & Klystron.
[Nov/Dec 2011, Nov/Dec 2013]
Klystron Amplifier TWTA
Linear beam or O type tubes Linear beam or O type tubes
Uses a cavities for input and output Uses non resonant wave circuit
Circuits Narrow band device duo to use of Wide band device because use of
Nonresonant cavities resonant circuit.

4. What are the limitation in conventional vacuum tubes [Apr/May -15]
The conventional tubes such as triode, tetrodes, pentodes can be used as amplifiers and oscillators more efficiently. But these conventional tubes cannot used as amplifier or oscillator at high frequency (>1000MHZ) because at higher frequencies output drops off
The factors of contributing of output at UHF are
- ✓ Circuit resistance

a) Inter electrode capacitance
b) Lead inductance
- ✓ Transit time effects
- ✓ Cathode emission plate heat dissipation area
- ✓ Power loss due to skin effect, radiation and dielectric loss
- ✓ Gain band width product

5. Define convection current in TWT. [May/June-14]
The convection current induced in the electron beam is by the axial electric field. When the space charge effect is considered, the electron velocity, charge density, current density and the axial electric field will perturbate about their averages or DC values.

$I = j\beta_e I_0 E_1 / 2vo(j\beta_e - \gamma_2)$

6. Define resonant frequency.
Resonant frequency fr at which the energy in the cavity attains maximum value=2We or 2Wm.

7. What are the drawbacks available in klystron?
(i) Klystrons are essentially narrowband devices
(ii) In klystrons and magnetrons, the microwave circuit consists of a resonant structures which limits the BW of the tube.

8. What is TWTA?
A travelling wave tube amplifier (TWTA) circuit uses a helix slow wave non resonant microwave guiding structures. It is a boradband devices.

9. State the characteristics of TWTA.
Frequency range: 3GHz and higher
Bandwidth: about 0.8GHz
Efficiency: 20 to 40%
Power output: upto 10Kw average
Power gain: upto 60dB

10. State the applications of TWT.
(i) Microwave power satellite
(ii) Higher power satellite transponder output and
(iii) Radar transmitters.

11. What are the advantages of TWT.
(i) BW is large
(ii) High Reliability
(iii) High gain
(iv) Higher duty cycle.

12. Name four types of slow wave structures.
(i) Helical line
(ii) Folded back line
(iii) Zigzag line and
(iv) Inter digital line.

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

14. Define bunching.
The electrons passing the first cavity gap at zeros of the gap voltage pass through with unchanged velocity, those passing through the positive half cycles of gap voltage undergo

an increase in velocity; those passing through the negative half cycle of gap voltage undergo an increase in velocity. As a result of these, electrons bunch together in drift space. This is called bunching.

15. State the power gain, power output and efficiency of two cavity klystron amplifier.

(i) Efficiency: about 40%
(ii) Power output: Average power is upto 500KW and pulsed power is upto 30MW at10GHz.
(iii) Power gain: about 30dB.

16. What are the assumptions for calculation of RF power in Reflex Klystron?

i) Cavity grids and repeller are plane parallel and very large in extent.
ii) No RF field is excited in repeller space
iii) Electrons are not intercepted by the cavity anode grid.
iv) No debunching takes place in repeller space.
v) The cavity RF gap voltage amplitude V, is small compared to the dc beam voltage VO

17. What is the condition for oscillation in Reflex klystron?

The necessary condition for oscillation is that the magnitude of the negative real part of the electronic admittance should not be less than the total conductance of the cavity circuit i.e. $-Ge \geq G$.
Where $G=Gc + Gb + G1 = 1/ Rsh$
Rsh - effective shunt resistance
Gc - copper losses of cavity Gb- beam loading conductance G1 - load conductance

18. 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.

19. What are the applications of reflex klystron?

1) Signal source in MW generator
2) Local oscillators in receivers
3) It is used in FM oscillator in low power MW links.
4) In parametric amplifier as pump source

20. How the klystron amplifier can act as klystron oscillator?

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

21. Define Transit time in Reflex klystron.

The time taken by the electron to travel into the repeller space and back to the gap.
T =n + ¾

22. 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.

23. State the characteristics of magnetron and of 2-cavity klystron amplifier.
Magnetron:
Operating frequencies 70 GH z
Output power 40 MW
Efficiency 40 to 70%
2-cavity klystron:
Efficiency 40%
Power output average power 500 KW
Pulsed power 30 MW
Power gain about 30 db.

24. What is meant by strapping?
The magnetron has eight or more coupled cavity resonators and hence several modes of oscillation are possible. The oscillating frequency of different modes are not same and are quite close to each other which results in mode jumping. i.e., a 3 cm π mode oscillation which is normal for a particular magnetron Could become a 3.05 cm 3/4 mode oscillation. This result in oscillations of reduced power at wrong frequency. To prevent this. Strapping is used. It consists of two rings of heavy gauge wire connecting alternate anode poles. It provides a phase difference 0f 2 π radians for the modes other π-mode and thus preventing the occurrence of other modes, except the π-mode .

25. State the applications of magnetrons.
1) Pulse work in radar
2) Linear particle accelerators.
3) Radar transmitters
4)Microwave ovens

26. What is frequency pulling and frequency pushing in magnetrons?
Frequency pulling is caused by changes in the load impedance reflected into the cavity resonators. Frequency pushing is due to the change in anode voltage which alters the orbital velocity of electron clouds.

27. Define electronic efficiency.
The electronic efficiency of the klyston amplifier is defined as the ration of the output power to the input power.
Efficiency: $Pout/Pin = \beta_0 I_2 V_2 / 2 I_0 V_0$

28. What is hull cutoff condition?
In a magnetron, the electron will just graze the anode and return towards the cathode depends on Vo and Bo . The hull cut of magnetic equation is
Boc = (8Vo m / e) ½ / b(1- a 2 / b2)

29. What are the types of magnetron?

(i) Split anode magnetron
(ii) Cyclotron-frequency magnetron
(iii) Travelling wave magnetrons.

30. Why magnetron is called as cross filed device?

In cavity magnetron, there exists a radial electric field and an axial magnetic field perpendicular to each other and hence magnetron is called as a cross filed device.

PART B

1. **Explain the operation of two or multi cavity klystron amplifier and compare it with traveling wave tubes.(16)[Nov/Dec11,Nov/Dec12,May/June2013,may/June14, Nov/Dec14 Nov/Dec16]**
2. **Explain the working principle of reflex klystron and derive the expression of bunching parameters. (16) [Nov/ Dec -2013]**
3. **A two cavity klystron amplifier has the following parameters:**

   Beam voltage,V_0=1000v, Beam current I_0=25mA:

   Frequency f=3GHz,R_0=40KΩ

   Gap spacing in either cavity,d=1mm

   Spacing between the two cavities,L=4cm

   Effective shunt impedance, R_{sh}=30kΩ

   Calculate input gap voltage, voltage gain and efficiency. (16) [Nov/Dec 12]

3. With neat diagram, explain about Magnetron oscillator. (16) [April/May-2015]

4. A pulsed cylindrical magnetron is operated with following parameters:

Anode Voltage = 25KV (16) [May/June 2013, Nov/Dec 2014]
Beam current = 25A
Magnetic density = 0.35Wb/m2
Radius of cathode cylinder =4cm
Radius of anode cylinder = 8cm
Calculate a) The anguar frequency b) The cutoff voltage c) The cutoff magnetic flux density.

4. With neat diagrams and relevant equations, explain about helix traveling wave tube. (16)

Explain the principle of operation of the cavity klystron with the neat sketch.

A 250 kW pulsed cylindrical magnetration has the following parameters.

Anode voltage = 25 kV

Peak anode current = 25 A

Magnetic field B = 0.35 Wb/m^2

Radius of cathode = 4 CM

Radius of cylinder = 8 CM

Calculate efficiency of the magnetron, cyclotron frequency, cut-off magnetic field.

A travelling wave tube (TWT) operates under the following parameters :

Beam Voltage $V_0 = 3$ kV

Beam Current $I_0 = 30$ mA

Characteristic impedance of helix $= Z_0 = 10\ \Omega$

Circuit length $= N = 50$ m

Frequency $f = 10$ GHz

Determine :

(i) Gain parameters C.

(ii) Output power gain A_p in decibels.

(iii) All four propagation constants. (16)

UNIT V
MICROWAVE MEASUREMENTS
PART A

1. Name the possible errors VSWR measurements? [Nov/Dec-12,May/june-13]

✓ The signal source give a signal frequency. any spurious signals present leads to the shift in maxima and minima and hence error is resulted in the readings

✓ There should not be any undesired reflection. for this matched load can be used as shown. These undesiresd reflection cause peaks and nodes to shift position in the standing wave pattern and VSWR thus measured will not be accurate.

✓ For higher VSWR near 10, the minimum voltage will be small and there will be deformation in the pattern because of the high coupling at voltage maximum resulting in errors

✓ Depth of penetration of probe into slotted wave guide introduces errors

2. What are the errors in impendence measurements [May/june-14]

a. Scalar or sensitivity errors

b. Vector errors or phase errors

3. What is the significance of VSWR measurements [Nov/Dec-14][April/May 2018]
VSWR and the magnitude of voltage reflection coefficient (Γ) are very important parameters which determine the degree of impendence matching

a. VSWR and Γ are also used for measurement of load impendence by the slotted line method

b. When a load $Z_L \neq Z_o$ is connected to transmission line, standing waves are produced

4. What is Bolometer?
It is a power sensor whose resistance change with changed temperature as it absorb the microwave power. It is a short thin metallic wire sensor with positive temperature coefficient of reistance.

5. Define insertion loss?
It is defined as difference in power arriving at the terminating load .with or without The network in circuit
Insertion loss(db)=10 log(po/pi)

6. What is radiation pattern?
Radiation pattern is a representation of radiation characteristics of an antenna which is a function of elevation angle azimuth angle for a constant radial distance and frequency

7. What is spectrum analyzer?
Spectrum analyzer is a broad band super heterodyne receiver which is used to display a wave in frequency domain additionally, power measurements, side bands can also be observed
.

8. What is the principle by which high power measurements could be done by calorimetric method? (APRIL/MAY 2011)
The measurement involves conversion of microwave energy into heat, absorbing this heat in a fluid (usually water) and then measuring the temperature rice of the fluid.

9. Differentiate baretter and thermistor?

Baretter

1.baretter has positive
temperature coefficient.
2.it has thin wire.
3.less sensitive.
4.required less bias current

Thermistor

1.negative temp coefficient.
2.small bead of semi conductor material.
3.more sensitive.
4.require more sensitive.

10. What are tunable detector?
The tunable detectors are used to demodulate the signal and couple the required

output to high frequency scope analyzer. The low frequency demodulated output is detected using
non reciprocal detector diode mounted in the microwave transmission line.

11. What is slotted section with line carriage?

It is a microwave sectioned coaxial line connecting a coaxial E-field probe which penetrates inside a rectangular waveguide slotted section. The longitudinal slot is cut along the center of the waveguide broad walls. The probe is made to move along the slotted wall which samples the electric field propotional to probe voltage.

12. What is the main purpose of slotted section with line carriage?

1.For determination of location of voltage standing wave maxima and minima along the line.
2.Measure the VSWR and standing wave pattern.
3.Wavelength.
4.Impedence.
5.Reflection coeffient.
6.Return loss measurement.

13. What is a VSWR meter?

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

14. What is calorimeter?

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

15. Mention the disadvantages of single bridge circuit ?

1.Change in resistance due to mismatch at the microwave input port results in incorrect reading
2The thermistor is sensitive to change in the ambient temp resulting in false Readings.

16. Define insertion loss?

It is defined as difference in power arriving at the terminating load with or without the network in circuit Insertion loss(db)=10 log(po/pi)

17. How will you determine the VSWR and return loss in reflecto meter method?

The voltage ratio between port3 or port4 is known reflecting coefficient (T) determined we determine VSWR and return loss as
VSWR=(1+T)/(1-T)
Return loss=-20 log(T)

19. List the different types of Impedence measurement methods?

1.Slotted line method

2.Reflectometer method
3.Reactor discontructer method

20. How do you measure microwave frequency?
1.Wavemeter method
2.Slotted line method
3.Downconversion method.

21. What is a wavemeter?
It is a device used for frequency measurement in microwave.It has cylindrical cavity with a variable short circuit termination .It changes the resonant frequency of cavity by changing cavitylength.

22. Define dielectric constant?
It is defined by the ratio of permittivity of medium to permittivity of freespace.
xr=x/xo=((10^-9)/36p)

23. How the S-parameter of a microwave circuit measured?
S-parameters are conveniently measured using the deschamps method which utilizes the measured value of complex input reflection coefficient under a number of a reactive terminations.

24. List the methods for measuring dielectric constants?
1.Waveguide method 2.cavity pertubaration method

25. What is radiation pattern?
Radiation pattern is a representation of radiation characteristics of an antenna which is a function of elevation angle azimuth angle for a constant radial distance and frequency.

26. What is radiation efficiency?
Radiation efficiency is defined as the ratio of total power radiated to total power accepted at its input .

27. How do you measure the polarization?
The polarization of an antenna is measured using transmitting mode and probing the polarization by a dipole antenna in the which the dipole is rotated in the plane of polarization and the received voltage pattern is recorded.

28. What is spectrum analyzer?
Spectrum analyzer is a broad band super heterodyne receiver which is used to display a wave in frequency domain additionally, power measurements, side bands can also be observed.

29. List the types of spectrum analyzer
a) Real time spectrum analyzer
b) Swept tuned frequency spectrum analyzer

30. List some application of spectrum analyzer.

Identifying frequency terms and their power levels measuring harmonic distortion in a wave Determine type of wave modulation Signal to noise ratio for identifying wave distortion

31. What is network analyzer.[Nov/Dec 2016]

A Network analyzer measures both amplitude and phase of a signal over a wide frequency range. It requires accurate reference signal and a test signal

33. Define SWR. [Nov/Dec 2013]

Standing wave ratio is defined as the ratio of maximum voltage to the minimum voltage.

$S= E_{max}/E_{min}$

Or $S= 1+\Gamma$

1- Γ Where Γ= Reflection coefficient.

34. Name the errors possible in VSWR measurements. [Nov/Dec 2012, May/june 2013, May/june 2014]

(i) Vmax and Vmin may not be measured in the square law region of the crystal detector.
(ii) The probe thickness and depth of penetration may produce reflections in the line and also distortion in the field to be measured.
(iii) When VSWR is < 1.05, the associated VSWR of connector produces significant error in VSWR measurement. Very good low VSWR (<1.01) connectors should be used for very low VSWR measurements.

35. Distinguish between low frequency measurements and microwave measurements.

S.No Low frequency measuremerts Microwave measurements
1 At low frequency it is convenient to measure voltage and current and use them to calculate power.
At Microwave frequencies theamplitude of voltage andcurrents on a distribution line are the functions of a distance and are not easily measurable.

PART-B

1. Write a brief note on insertion loss and attenuation measurements (8)

2. Explain the procedure to measure the impedance of load using slotted line method (8) [May/June-14][Nov/Dec 2016]

3. Explain how low VSWR can be measured using microwave bench (16) [Nov/Dec – 2011, Nov/Dec 2012, Nov/Dec 2014] Nov/Dec 2017

4. Explain the principle of microwave power measurements (8) [Nov/Dec -11,May/June 2014,April/May15] Nov/Dec 2017

5. Explain how high VSWR can be measured with the help of block diagram.[Nov/Dec 2016].

6.Discuss the impedance,wavelength and frequency measurement using slotted line method.[April/May17] [Nov/Dec 2017]

7. Write short notes on power sensors used for microwave power measurements. [April/May17]

8. Explain impedance measurement technique using slotted line and reflectometer. [Nov/Dec 2016].

9. Explain the method of high power measurement (8) [April/May18]