EC6701- RF and Microwave Engineering

UNIT– I TWO PORT NETWORK THEORY
PART A- C401.1

1. What are the limitations in measuring Z,Y and ABCD parameters at microwave frequencies. (NOV 2017)

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

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

2. Give few applications of microwave frequencies.

Long distance communications such as repeaters, aircraft altimeters, vulcanization in rubber industries

Polymerization in the chemical industries

3. Explain the need of S parameters.

At microwave frequencies, ammeters and voltmeters do not exist and it is not possible to use h, y or z parameters. Hence the linear relationship between the incidents transmitted waves and reflected waves are measured in the form of s-parameters in order to study the behavior of s-matrix.

4. Define Two Port network?

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

5. Define S parameters.(Nov 2016)

S_{11}=Reflection coefficient $\Gamma_1$measured at port1 when port2 is terminated.

S_{12}= Attenuation of wave travel from port 2 to port 1

S_{21}=Attenuation of wave travel from port 1 to port 2

S_{22}=Reflection coefficient $\Gamma_2$measured at port2 when port1 is terminated.

6. What is the condition under which S parameters are equal to their corresponding transposes, $S=S^T$?

When a junction is said to be a reciprocal junction the s-matrix satisfies the symmetry property and the S-matrix is equal to its corresponding transposes, $S=S^{T.}$

7. Define Junction.

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

8. Write the properties of [S] matrix. (May 2015)

[S] is always a square matrix of order (n×n)

[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.

9. 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

10. 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.

11. Define one port circuit. Give two examples of one port circuit.
A one port circuit is a circuit for which power can enter or leave through a single wave guide or transmission line. **Examples:** 1. Short –circuited coaxial line2. Short –circuited wave guide with post

12. Define Lossless network. (Nov 2012)
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.

13. Define reciprocal and symmetrical Networks. (May 2013)
A reciprocal network is defined to be a network that satisfies the reciprocity theorem. It state that when some amount of electromotive force (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 electromotive force applied in the new location. In terms of S-parameter

$$S_{ij} = S_{ji} \ (i \neq j), \text{ where, } i=1,2,\ldots.N \ \& \ j=1,2,\ldots N$$

Due to symmetry of the network topology, the input impedance at the input port is equal to the impedance in the output port. In general, any symmetrical passive N-port network, $S_{ii} = S_{jj}$

14. What are the factors to influence the insertion loss?
Mismatch loss at the input, Attenuation loss through the device, Mismatch loss at the output

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

16. What is the unitary property for a lossless junction?
For any lossless network the sum of product of each term of any one row or column of the S matrix multiplied by its complex conjugate is unity.

17. What is wire? List out the different forms of wires.
A wire is the simplest element having zero resistance, which makes it appear as a short circuit at DC and low AC frequencies. Wire wound resistor, Wire wound inductors, leaded capacitors, Element to element interconnected applications

18. Write the applications of inductors. (Nov 2012)
Resonance circuits, filters, phase shifters, delay networks, RF chokes

19. What is an Inductor? (Nov 2013)
A wire that is wound 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.

20. Express power input and power output under matched conditions for a two-port networks in terms of wave components. (May 2013)
Input Power at nth port, $P_{in} = \frac{1}{2} |a_n|^2$ Reflected Power at nth port, $P_{rn} = \frac{1}{2} |b_n|^2$

21. Give the relationship between [S] and [ABCD]. (May 2014 & May 2017)

$$S_{11} = \frac{A-B-C+D}{A-B+C-D} \quad S_{22} = \frac{-A-B-C-D}{A-B+C-D} \quad S_{12} = \frac{-2(AD+BC)}{A-B+C-D} \quad S_{21} = \frac{2}{A-B+C-D}$$

$$A = \frac{Z_{11}}{Z_{21}} \quad B = \frac{-(Z_{11}Z_{22} - Z_{12}Z_{21})}{Z_{21}} \quad C = \frac{1}{Z_{21}} \quad D = \frac{-Z_{22}}{Z_{21}}$$

22. Given [y] = $\begin{bmatrix} 3.2 & 1 \\ 1 & 3.2 \end{bmatrix}$ find S parameters. (Nov 2014)

The S parametersS_{11}=3.2 S_{12}=1 S_{21}=1 S_{22}=3.2

23. What are the high frequency limitations of conventional tubes? (Nov 2014)

(i) Parasitic circuit elements such as inter electrode-capacitance and lead capacitance
(ii) Effects due to transit time of electrons between electrodes.
(iii) Increase of power loss (iv) Gain BW product limitation

24. List the radio frequency bands available in microwave and radio frequency ranges. (Nov 2016 & May 2017)

1 - 2 GHz	L band	8.2 - 12.4 GHz	X band
2 - 3.95 GHz	S band	12.4 - 18 GHz	Ku band
3.95 - 5.85 GHz	C band	18 -26.5 GHz	K band
5.85 - 8.2 GHz	J band	26.5 - 40 GHz	ka band

25. Write down the merits and demerits of microwave frequency over lower frequencies.
(NOV 2017)

Large bandwidth and hence large amount of information can be transmitted, better directivity, low power consumption, require low size antenna, minimizes the effect of fading by using line of sight propagation.

PART B - C401.1

1. Why we need S-matrix for Microwave analysis, derive the S-matrix for 2 port network; also discuss the losses associated with the 2 port network.
2. (i) Formulate [S]matrix for an N-port microwave network compute ABCD for a T network. (ii)Explain the various properties of a scattering matrix.**(May 2013, 2014 & 2015) (Nov 2017)**
3. (i) Explain the concept of N port scattering matrix representation**.(May 2015 & Nov 2017)**
(ii) Prove symmetry of reciprocal network. **(May 2015) (Dec 2015) (May 2017)**
4. (i)Explain the low frequency parameters and High frequency parameters.
(ii) Explain the scattering matrix for lossless junction. **(May 2015)**
5. The S parameters of at four port network are given by S_{11}=0.1∟90° S_{12}=0.6∟-45° S_{13}=0.6∟45°
S_{14}=0,S_{21}= 0.6∟-45° S_{22}=0 S_{23}=0 S_{24}=0.6∟45°S_{31}=0.6∟45° S_{32}=0.6∟45° S_{33}=0.6∟45°
S_{34}=0.6∟-45° S_{41}=0 S_{42}=0.6∟45° S_{43}=0.6∟-45° S_{44}=0. **(Nov2012) (Nov 2013)**
(i)Determine whether the network is lossy or not. (ii)Is the network symmetrical and reciprocal? Find the insertion loss of network.**(May2013)**
6. Give the [ABCD] matrix for a two port network and derive its matrix. **(Nov 2013)(May 2013)**
7.Draw the high frequency equivalent of i)Inductor ii)capacitor(iii)resistor(iv)wire &explain **(Dec 2015)**
8. (i) When do you prefer transmission matrix? Obtain the ABCD matrix of a transformer with turn's ratio of N: 1.(**May 2014)**
(ii) The impedance matrix of a certain lumped element network is given by $[z_{ij}] = \begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix}$.
Determine the equivalent scattering parameter matrix $[S_{ij}]=\begin{bmatrix} s11 & s12 \\ s21 & s22 \end{bmatrix}$for the $[z_{ij}]$.(**May 2014)**
9.(i) Verify the lossless and reciprocity properties of any two port network using scattering

matrix.

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

1. $\begin{bmatrix} 0.1 & 0.8 \\ 0.8 & 0.1 \end{bmatrix}$ 2. $\begin{bmatrix} 0.4 & 0.6 \\ 0.6 & 0.4 \end{bmatrix}$ **(Nov 2014)**

10. (i) What is transmission (T) matrix? Obtain and explain the relationship with [S] and vice versa.(ii) Compute the intrinsic wave impedance, phase velocity and wavelengths of an electromagnetic wave in free space and a printed circuit board(PCB) material whose dielectric constant is 4.6 for the frequency f=30MHz and 3 GHz. **(Nov 2016)**

11. (i) Explain and analyze any reciprocal lossless network with derivation.
(ii)Discuss on the application of RF and microwave area.**(Nov 2016)**

12. The S-parameters of a two-port network are given by $S_{11}=0.2\angle 90°$ $S_{22}=0.2\angle 90°$ $S_{12}=0.5\angle 90°$
$S21=0.5\angle 0°$ a) Determine whether the network is lossy or not. b) Is the network symmetrical and reciprocal c) Find the insertion loss of network d) Find the return loss at port l when port 2 is short circuited. **(Nov 2017)**

13. Derive the overall network parameters for cascade connection of two port network. Discuss about short circuit, open circuit, h and ABCD Low frequency parameters. **(May 2017)**

UNIT - II RF AMPLIFIER AND MATCHING NETWORKS
PART A – C401.2

1. List parameters of amplifier?
*Gain *Operating frequency *Output power *Noise figure

2. What is the need of matching networks? (May 2015)
Input & output matching networks are needed to reduce undesired reflections and thus improve the power flow capabilities

3. What is transducer power gain? (Nov 2013 & May 2017)
Transducer power gain G_T which quantifies the gain of the amplifier placed between source and load that is power delivered to the load to available power from the source

4. What is transducer power gain called?
Transducer power gain is so called unilateral power gain.

5. Define available gain. (Dec 2015)
It is defined as power available from the amplifier to power available from the source

6. Define operating power gain.
It is defined as power delivered to the load to power supplied to the amplifier

7. What is minimum noise figure?
Fmin =1

8. What are the approaches for designing matching networks?
1. To derive the values of the elements analytically
2. To rely on smith chart as a graphical design tool

9. What is optimum source admittance?
Yopt = Gopt + jBopt = 1/Zopt

10. What is matching networks? (May 2013) (Nov 2014)
To achieve maximum power transfer it need to match the impedance of the load to that of the source, this is accomplished by incorporating additional passive networks connected in between source and load. These networks are generically referred to as matching networks.

11. Design of Q.
To design a broad ban amplifier utilize networks with low Q in order to increase the bandwidth. To design oscillator high Q networks eliminate unwanted harmonics in output signal.

12. List types of network.
* L type network *T or Pi network

13 Why we are going to T network.
L network do not allow any flexibility in conditioning the frequency response and are therefore mostly used for narrow band RF design. To affect the frequency behavior a third element must added resulting in T and Pi network.

14. What are the factors affecting amplifier performance.
*Intermodular distortion, *Harmonics, *Feedback, *Heating effects

15. What are stabilization methods?
Stabilization of input port through series resistance or shunt conductance
Stabilization of output port through series resistance or shunt conductance

16. Define noise figure. (Nov 2016)
Noise figure F is defined as the ratio of the input SNR to the output SNR

17. Define unconditional stability? (May 2014 & NOV 2017)
Unconditional stability refers to the situation where the amplifier remains stable for any Passive source and load at the selected frequency and bias condition.

18. Define unilateral power gain. (Nov 2014)
It is the amplifier power gain, when feedback effect of amplifier is neglected i.e S_{12}=0.

19. Why input impedance is required. What are other constraints required? (May 2013,
Matching network can help stabilize the amplifier by keeping the source and load impedance in the appropriate range. It is important for the following reasons:
(i). Minimum power loss in the feed line. (ii). Maximum power transfer (iii). Improving the S/N ratio of the system for sensitive receiver components. (iv). Reducing amplitude & phase errors in the power distribution network.

20. Give the expression that relates Nodal quality factor loaded quality factor. (NOV 2013)
The nodal quality factor is defined as the ratio of the absolute value of the reactance X_s to the corresponding resistance R_s. $Q_n = |Bp|/Gp$. The loaded quality factor is defined as the ratio of the resonance frequency fo to the 3dB Bandwidth. Q_L = fo /BW

21.State the advantages of microstrip matching networks. (NOV 2014) (Dec 2015)
- Minimum power loss in feed line & maximum power delivery
- Linearizing the frequency response of the circuit
- Improving the S/N ratio of the system
- Reducing amplitude and phase errors in a power distribution network.

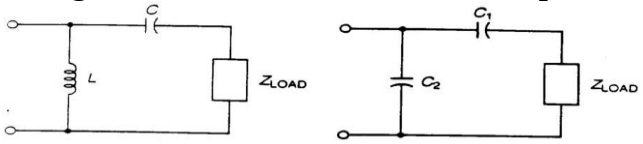
22.Define stability. (May2014)

The network is conditionally stable if only for a certain range of passive source and load impedance. This case is also referred to as potentially unstable.

23.Calculate VSWR of an amplifier ,if the amplifier has reflection coefficient 0.2533. (NOV 2016)

$$\text{VSWR} = \frac{1+K}{1-K} = \frac{1+0.253}{1-0.253} = 1.67$$

24. Draw any two matching networks used in microwave frequencies. (NOV 2017)



25. Define frequency compensated matching networks. (Nov 2012)

Frequency compensated matching network introduce a mismatch on either the Input or Output port of the device to compensate for the frequency variation introduced by the S-parameters.

PART B– C401.2

1. Discuss the following: i) Single stub impedance matching. ii) Double stub impedance matching.**(Nov 2017)**
2. What is a matching network? Why is this required? Briefly explain T &π matching networks. (**Nov 2012& 2013)**
3. Explain in detail about Micro stripline matching network with neat diagram. **(May 2017)**
4. (i) Write mathematical analysis of amplifier stability
(ii)A microwave amplifier is characterized by its S parameters. Derive equations for power gain, available gain and transducer gain. **(Nov 2012) (May 2015) (Nov 2016)**
5. Discuss the smith chart approach to design the L section and T section matching networks. **(Nov 2013)**
6. Design a matching network to match a Z_L= (10+j10) Ω to 50Ω line. Specify the values of L and C at frequency of 1Ghz. (use smith chart). (**May 2014)**
7. Derive expression for the following of a micro strip line matching network. (i) w/h ratio and (ii) Total Q factor (Q_T). (**May 2014)**
8. (i) With reference to RF transistor amplifier, discuss the considerations for stability and gain.
(ii) Show that the noise figure of a three stage amplifier is F=F1+ $\frac{F2-1}{GA1}+\frac{F3-1}{GA2}$ where F1, F2 and F3 are noise figures and GA1 and GA2 are power gains. **(Nov 2014)**
9. (i) Explain in detail the concept of T and Micro strip line matching networks. (ii) Describe the smith chart .How can it be used to determine unknown impedance. **(Nov 2014) (May 2017)**
10. Using smith chart design any two possible configuration of discrete two element matching networks to match the source impedance Z_s= (50+j25) Ω to the load Z_L = (25-j50) Ω. Assume Z_o= 50Ω, f=2Ghz. **(May 2015)**
11. Using smith chart design any two possible configuration of discrete two element matching networks to match the source impedance Z_s= (50+j25) Ω to the load Z_L = (25-j15) Ω. Assume Z_o= 75Ω, f=2Ghz. **(May 2015)**
12. Investigate the stability regions of a transistor whose S-parameters are recorded as follows:

S_{12}=0.2 ∟-10˚;S_{11}=0.7∟ -70 ˚;S_{21}=5.5 ∟85 ˚;S_{22}=0.7∟ -45 ˚; at 750 MHz. **(Nov 2016)**
13. An RF amplifier has the following S-parameters.S_{11}=0.3∟70˚; S_{21}=3.5∟85˚; S_{12}=0.2 ∟-10˚; S_{22}=0.4 -45 ˚ furthermore, the input side of the amplifier is connected to a voltage source with Vs = 5V< 0˚ and source impedance Zs=40Ω. The output is utilized to drive an antenna which has an amplifier of ZL=73Ω. Assuming that the S-parameters of the amplifier are measured with reference to a ZL=50Ω characteristics impedance. Find the transducer gain GT, unilateral transducer gain GTU, Available gain GA, Operating gain G. **(Nov 2017)**

UNIT - III PASSIVE AND ACTIVE MICROWAVEDEVICES
PART A - C401.3

1. Explain the significance of ferrite devices in microwave circuits.
Ferrite devices change the polarization of the waves that passes through them. This is useful for the construction of unidirectional devices such as isolators & circulators

2. Define any two performance factors of directional couplers. List out the different types of directional couplers.
The two performance factors of DC are the Coupling Factor and Directivity. Coupling Factor defines the ratio of the amount of power coupled in coupled port to that of power at input port in decibels. Directivity is defined as the ratio of powers at the isolated port and the incident ports at decibels.
Types: Bethe hole DC, 2 hole, crossed guide DC, coupled line couplers, branch line couplers, and Lange DC are the different types of directional couplers.

3. What is meant by circulator? Give any two applications of a circulator. (Nov 2014)
Circulator is a multiport junction (3port or 4 port) in which the wave can travel from one port to immediate port in one direction only. Applications: Multiple isolation in radars, parametric amplifiers.

4. What are ferrites & write its properties. Give some examples of ferrite devices(Nov 2012&2017)
Ferrites are ceramic like materials. These are made by sintering a mixture of metallic oxides.
Properties: Specific restivities may be used as much as $>10^{14}$ of metals, Dielectric constants around 10 to 15 or greater **Examples :** * Isolator, *Circulator, *Phase shifter, * Modulator, *Power limiters.

5. What do you meant by non reciprocal devices? Give two examples.
The devices which are having the property that, the forward characteristics are not equal to the reverse characteristics are called non reciprocal devices E.g. Isolator and circulator
6. Define Tee-Junction.
In microwave circuits a waveguide or co-axial-line with the independent ports is commonly referred to as a tee-junction.

7. Name some uses of waveguide Tees. What are the two different types 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.
Types: (i) E-plane tee (series) and (ii) H-plane tee (shunt).

8. Define difference arm.
In E-plane tee the power out of port3 (side or E-arm) is proportional to the difference between instantaneous powers entering from port 1 and 2 Therefore, this third port is called

as difference arm.

9. What is sum arm?

In H-plane tee if two input waves are fed into port 1 and port 2 of the collinear arm, the output wave at port 3 will be in-phase and additive .because of this, the third port is called as sum arm.

10. Write the application of magic Tee. (Nov 2012 & May 2017)

(i) Measurement of impedance, (ii) As duplexer,(iii) As mixer and (iv) As an isolator.

11. What is hybrid ring or Rat-Race junctions? (May 2013)

The hybrid ring is a four-port junction .The four ports are connected in the form of an angular ring at proper ring at proper intervals by means of series (or parallel) junction. It also called Rat-race circuits. It is mainly used to combining two signals (or) dividing a single signal into two equal halves.

12. What are waveguide bends? What are the two types of bends? (May 2017)

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.(i) E-plane Bend and (ii) H-plane Bend

13. What are the compositions of ferrite? (Nov 2013) (May 2014)

Ferrites are usually non-conductive ferromagnetic ceramic compounds derived from iron oxides such as hematite (Fe_2O_3) or magnetite (Fe_3O_4) as well as oxides of other metals.

14. What is negative resistance in Gunn diode? (May 2014)

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 negative resistance. The diode in the negative resistance will act as a source.

15. A Directional coupler is having coupling factor of 20dB and directivity of 40dB. If the incident power is 900mW, what is the coupled power? (May 2013)

Coupling power (C) = 10log10 (Pi/Pf) =20 Pi/Pf =10^2 = 100 Therefore, Pf=Pi/100 = 9mW
Directivity (D) = 10log10 (Pf/Pb) = 40 Pf/Pb =10^4 = 1000 Therefore, Pb=Pf/1000 = 0.9MW
Coupled Power Pr =Pi-Pr-Pb = 90.1mW

16. What are matched terminators? (May 2014)

Matched terminators are capable of absorbing the incident energy without appreciable reflection**.**

17. What are the various materials used for Gunn diodes? What are the four different modes of operation of GUNN diode?

GaAs, InP, CdTe, InAs are materials used in Gunn diode. Gunn oscillation mode, stable amplification mode, LSA oscillation and bias current oscillation mode.

18. Mention the applications of IMPATT diode.

Microwave generators, Receiver local oscillators, parametric amplifier pumps

19. Define Varactor diode. List out the applications of varactor diode?

Varactor diodes are p-n junction diodes which provides a voltage variable junction capacitance in microwave circuits when reverse biased.
Used in TV receivers, Used in PLL and FLL, In high frequency multiplier

20. Which has lesser coupling in the following?i) 3 dB coupler ii) 6 dB coupler iii) 10 dB coupler.

Answer: 10dB Coupler (couples out 10% of input power)

21. What is Gunn Effect? (May 2013) (Nov 2014)

Above some critical voltage corresponding to an electric field of 2000-4000 v/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. The length of the specimen is inversely proportional to the frequency of oscillation. Some of materials like GaAs, InP, CdTe exhibit a negative differential mobility when biased above a threshold value of the electric field.

22. Compare PIN and PN diode. (Nov 2016)

S.No	PIN Diode	PN Diode
1.	A PIN diode is a diode with a wide, undoped intrinsic semiconductor region between a p-type & an n-type semiconductor region.	P-N junction diode is the most fundamental and the simplest electronics device.
2.	The p-type and n-type regions are typically heavily doped because they are used for ohmic contacts.	When one side of an intrinsic semiconductor is doped with acceptor i.e, one side is made p-type by doping with n-type material; a p-n junction diode is formed. This is a two terminal device.

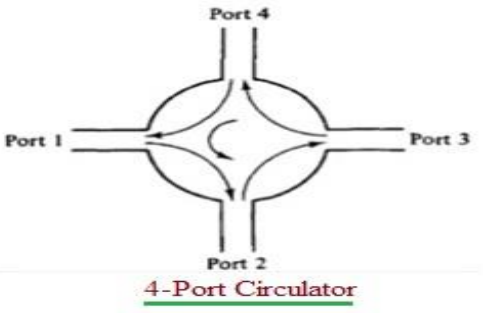
23. Mention the ideal characteristics of dielectric material in MMIC. (Nov 2013)

Good reproductivity, Capability of handling high voltages, Ability to undergo processes without developing pin holes, Low RF dielectric loss.

24. What is isolator? And why isolators are called uniline? (Nov 2016)

Isolator is a two port device which allows the signal in one direction and attenuate the signal in the Opposite direction so this device is called uniline.

25. Write the S matrix for 4 ports Circulator.



4-Port Circulator

$$S = \begin{bmatrix} 0 & S_{12} & S_{13} & S_{14} \\ S_{21} & 0 & S_{23} & S_{24} \\ S_{31} & S_{32} & 0 & S_{34} \\ S_{41} & S_{42} & S_{43} & 0 \end{bmatrix}$$

$$S = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

PART B- C401.3

1. Explain how Directional coupler can be used to measure reflected power. Also Derive scattering Matrix for Two hole Directional coupler. **(Nov2012) (May 2013 & 2015)**
2. What is circulator? With neat diagram explain the working principle construction, operation of four-port circulator using magic-tee. Verify the circulator theory with necessary S-parameter equations. **(Dec 2015) (Nov 2016)**
3. Discuss the principle of operation of any two non-reciprocal devices (Isolator and Circulator))and derive the S matrix.**(Dec 2015) (May 2017)**
4. Derive and explain the properties of H-plane tee and give reasons why it is called shunt Tee. **(Nov 2012) (May 2017)**
5. Derive and explain the properties of E-plane tee and give reasons why it is called series

Tee. **(Nov 2014) (Dec 2015) (May 2013) (May 2017)**
6. (i)Derive the equation for scattering matrix of magic Tee.**(Nov 2013) (Nov 2017)**
(ii) Find the directivity in db for a coupler if the same power is applied in turn to input and output of the coupler with output terminated in each case in matched impedance. The auxiliary output readings are 450mW and 0.710μW. **(May 2014)**
7. Explain the working of Attenuators and phase shifter with neat diagram. **(May 2014)(Dec 2015)**
8. Explain Physical structure, negative resistance, power output & efficiency of IMPATT Diode. **(Nov 2013) (May 2013) (Dec 2015) (May 2015)**
9. Explain the detailed fabrication steps for Monolithic Microwave integrated circuits.
10. Briefly Explain Gunn Effect & modes of operation of the Gunn Diode. Explain the working principle of Gunn diode with two valley model and plot its characteristics. **(Dec 2015) (May 2015)**
11. Discuss briefly about working principle, operation, characteristics and application of varactor diode. **(Nov 2016)**
12. Discuss the following: i) Quarter wave transformer ii) Gunn diode oscillator. **(Nov 2017)**
13. Give the comparison between Gunn, IMPATT, TRAPATT and BARITT. **(May 2017)**

Unit – IV MICROWAVE GENERATION
PART A - C401.4

1. List out the different types of Magnetrons.
Negative Resistance magnetrons, Cyclotron frequency magnetron, Travelling wave

2. Explain Hull Cut-off condition.
Hull cut-off condition gives the cut-off magnetic field in a magnetron such that the electron grazes the anode and returns back to the cathode.

3. What are slow wave structures? (May 2013 & Nov 2017 & May 2017)
Slow wave structures are used to reduce the phase velocity of the wave in certain direction so that the electron beam and signal wave can interact.

4. How a Helix structure is useful for SWS? (May 2013)
A helical structure is basically a slow wave structure which is used to reduce the phase velocity of the traveling wave. This enables a continuous interaction between RF field and the electron beam which in turn amplifies the input wave exponentially.

5. What is meant by 'Strapping' in magnetrons?
In order to prevent mode jumping in magnetrons, two rings of heavy gauge wire is used to connect alternate anode poles. This is called as strapping.

6. What is meant by pushing and pulling in magnetrons?
The change in resonant frequency of the magnetron due to changes in the anode voltage is called frequency pushing whereas the change in resonant frequency of the magnetron due to changes in load impedance is called frequency pulling.

7. List the advantages of Reflex klystron over multi-cavity klystrons.
Reflex klystrons can be used as an oscillator without any complex feedback circuitry as required in multi-cavity klystrons. As it is a narrow bandwidth device it can be tuned to operate at a single desired frequency in resonant circuits.

8. Why Π mode is preferred for magnetrons?
Π mode is preferred in magnetrons since it provides self-consistent oscillation and increased power output when compared to any other modes

9. Explain the need for attenuators in TWT.
Attenuators are used to attenuate the unwanted signal traveling towards the input end due to reflections arising from impedance mismatch.

10. What is meant by velocity modulation?
The change in the velocity of the electrons under the influence of an alternating field is termed as velocity modulation

11. Define transit time in a Reflex klystron.
The time taken by electron to travel into the repeller space and come back toward the cavity is called the transit time in Reflex klystron.

12. Bring out the differences between the TWT & Klystron (Nov 2013 & 2014)(May 2015 & 2017)

TWT	Klystron
• High BW • More gain • Use non-resonant structures • Continuous interaction between electron beam and RF voltage	• Narrow BW • Less gain • Use cavity resonators • Discontinuous interaction between electron beam and RF voltage

13. What do you meant by bunching?
The electrons traveling with different velocities join together at their transit towards the output end. This collection of different velocity modulated electrons is called bunching

14. Define: Convection current of TWT (May 2014)
It is due Continuous interaction between the velocity and density modulations.

15. Write the application of Reflex klystron
(i) Local oscillator in microwave receiver (ii) Microwave signal source (iii) pump oscillator for parametric amplifier (iv) as an oscillator, in frequency modulation of low power microwave link.

16. Name some conventional vacuum tubes
Triode, Tetrodes and Pentode

17. What are the classifications of Microwave tubes and explain the difference between them. (May 2017)

Linear beam tubes (O –type)	Cross field tubes (M- type)
• In O-Type tube , a magnetic field whose axis coincides with the electron beam is used to hold the beam together as it travels the length of the tube	• In M-Type tube, electric field is in the radial direction & magnetic field is in the axial direction.
• Reflex Klystron, TWT are Linear beam tubes	• Magnetron is M-type beam tubes
• Low power device	• Low power device

18. Write the application of backward wave oscillator.
(1) Signal source sources in instrument and transmitters. (2)Broad band noise source
(3)Noise less oscillator with good bandwidth in frequency range 3-9 GHz.

19. What are the several types of slow wave structures? (May 2017)

Helical, Feedback line, Zig-Zag, Interdigital line, corrugated wave guide.

20. Define Electronic Admittance.

It is defined by the ratio of induced bunch beam current and cavity gap voltage.

21. What is called reentrant cavity.

The reentrant cavity is one in which the metallic boundaries extend into the interior cavity and they are designed for the use of klystron and microwave triodes.

22. What is drift space?

The separation between buncher and catcher grids is called drift space.

23. What is magnetron? (NOV 2016)

Magnetron is an electron tube for amplifying or generating microwaves, with the flow of electrons controlled by an external magnetic field.

24. What are Tetrodes and Pentodes? (NOV 2016)

Tetrodes and pentodes are called as vacuum tubes. A pentode is an electronic device having five active electrodes. Tetrodes are a thermionic valve having four electrodes.

25. What do you mean by O type tube? Name some O type tubes.

In O-type tube a magnetic field whose axis coincides with the electron beam is used to hold the beam together as it travels the length of the tube. It's also called as linear beam tube. TYPES -Helix travelling wave tube and coupled cavity TWT.

PART B- C401.4

1. Explain the working principle and operation of multi-cavity Klystron amplifier and derive the expression for its output power. **(Nov 2016)**
2. Explain the working principle of Reflex klystron oscillator and derive output power & Efficiency. **(Nov 2013) (Dec 2015) (Nov 2017)**
3. Explain the operation of TWT Amplifier & write its characteristics. **(Dec 2015) (Nov & May 2017)**
4. Explain π mode of operation of Magnetron Oscillators mention few high frequency limitations. **(May 2015)**
5. A Reflex klystron is to be operated at frequency of 10 GHz, with dc beam voltage 300V, repeller space 0.1 cm for $1\frac{3}{4}$ mode. Calculate P_{RFmax} and corresponding repeller voltage for a beam current of 20 mA.
6. A Reflex klystron is to be operated at frequency of 9 GHz, with dc beam voltage 600V, repeller space 1 cm for $1\frac{3}{4}$ mode. Calculate electronic efficiency, output power and corresponding repeller voltage for a beam current of 10 mA. The beam coupling coefficient is assumed to be 1.
7. A two cavity klystron amplifier is tuned at 3 GHz. The drift space length is 2cm and beam current is 25mA. The catcher voltage is 0.3 times the beam voltage. It is assumed that the gap length of the cavity << the drift space so that the input and output voltages are in phase (β = 1). Compute (a) Power output and efficiency for N= $5\frac{1}{4}$ (b) Beam voltage, input voltage and output voltage for maximum power output of N= $5\frac{1}{4}$ mode.
8. A two cavity klystron amplifier operates at 5GHz with a dc beam voltage of 10KV and a 2 mm cavity gap. For a given input RF voltage, the magnitude of the gap voltage is 100 volts.

Calculate the transit time at the cavity gap, the transit angle, and the velocity of the electrons leaving the gap.

9. An X- band pulsed conventional magnetron has the following operating parameters: Anode Voltage Vo = 5.5 KV, Beam current is 4.5 mA, Operating frequency 9GHz, Resonator conductance 2×10^{-4} mho, Loaded conductance 2.5×10^{-4} mho, Vane capacitance is 2.5 PF, Duty cycle 0.002, Power loss is 18.5 KW. Compute 1) Angular resonant frequency, 2) Unloaded quality factor 3) loaded quality factor, 4) external quality factor 5) circuit efficiency 6) electronic efficiency

10. A 250kw pulsed cylindrical magnetron has the following parameters. Anode voltage = 25Kv, peak anode current = 25 A, Magnetic field = $0.35Wb/m^2$, Radius of the cathode = 4CM, Radius of the Anode = 8CM, Calculate efficiency of the magnetron, cyclotron angular frequency, Cutoff magnetic field. **(May 2013)**

11. Write a detailed note on cylindrical magnetron **(Nov 2013) (Nov 2017)**

12. A traveling wave tube (TWT) operates under the following parameters: Beam Voltage V_0=3Kv; Beam Current I_0=30ma; Characteristics impedance of helix =Z_0=10Ω; Circuit length =N=50m; Frequency f=10GHz. Determine: (i) gain parameters C (ii) Output power gain A_p in decibels. (iii) All four propagation constants. **(Nov 2016)**

13. With neat diagram explain the operation of two cavity Klystron amplifier and derive the equations for velocity modulation process. **(May 2017)**

Unit – V MICROWAVE MEASUREMENTS
PART A - C401.5

1. For which parameter measurement is the slotted line section used? (May 2013)
a. VSWR b. wavelength c. impedance d. reflection co-efficient & return loss.

2. What is a spectrum analyzer?
A spectrum analyzer is a broad band super heterodyne receiver which plots the amplitude versus freq of the received signal.

3. **What is a network analyzer? What are the types of network analyzer? (Nov 2012, 2016 & 2017)**
A network analyzer measures both the amplitude & phase of a signal over a wide freq range within a reasonable time. TYPES- scalar and vector network analyzer.

4. Mention the different types of sensors are used for power measurements?
1. Schottky barrier diode 2.Bolometer 3. Thermocouple

5. Define insertion loss & return loss. (Nov 2017)
Insertion loss = 10 log P_0/P_1.Return loss = 10 log Pr/Pi .

6. Name the possible errors sources in VSWR measurements? (May 2013 & 2014)
The possible sources of error in SWR measurements are (i). Vmax and Vmin may not be measured in the Square-law region of the crystal detector. (ii).When VSWR<1.05, the associated VSWR of connector produces significant error in VSWR measurement. Very good low VSWR (<1.01) connectors should be use d for very low VSWR measurements.

7. Define SWR. (Nov 2013)
It is defined as the ratio of maximum voltage to the minimum voltage. **S = Emax/Emin**

8. What are the errors in impedance measurement? (Nov 2014)
Significant Error, Measurement error

9. Define Bolometer.

It is a power sensor whose resistance changes with temperature as it absorbs microwave power.

10. Define power.

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

11. Name two methods to measure impedance.

(i) Slotted line and (ii) Reflectometer

12. What are the methods to detect microwave power?

(i) Bolometer (low power) (ii) Calorimetric technique (medium power)
(iii) Calorimeter – wavemeter (high power)

13. Name the methods of dielectric constant measurement.

Waveguide method and Cavity perturbation method

14. Distinguish between low frequency and microwave measurement.

S.No	Low frequency measurement	Microwave frequency measurement
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 currents on a transmission line are the functions of distance and are not easily measured
2	Circuits are limped elements	Circuits are distributed

15. What are the classifications of power measurement? (NOV 2016)

a) Low power (less than 10 mW) b) Medium power (10 mW to 10W) c) High power (greater than 10W)

16. Name three methods to measure frequency.

(i) Slotted line technique (ii) Wave meter or calibrated resonant cavity technique
(iii) Electronic Technique.

17. Define VSWR measurement.

Measurements of VSWR express the degree of mismatch between the load and transmission line.

18. What is the difference between reflectometer technique and slotted line?

In reflectometer technique only the magnitude of the impedance is calculated whereas a slotted line wave guide measurement gives both magnitude and phase angle of load impedance.

19. What are the types of bolometer?

1. Baretters: These are positive temperature coefficient and their resistance is increases with an increase in temperature

2. Thermistors: This is a semiconductor sensor which has a negative temperature coefficient of resistance, their resistance decrease as the temperature increases.

20. List out the different methods of Q measurement.
i) Transmission method ii) Impedance method iii) Decrement method

21. What do you meant by slotted line?
Slotted line consists of section of waveguide or coaxial line with longitudinal slot. This slot is roughly 1mm wide and allows an electric field probe to enter the waveguide for the measurement of the relative magnitude of field at the location of the probe.

22. What are the contributions of insertion loss?
(i) Mismatch loss at the input (ii) Attenuation loss through the device (iii) Mismatch loss at the output.

23. Define Attenuation loss & insertion loss.
The attenuation loss is a measure of power loss due to the signal absorption in the device
The insertion loss is a measure of energy in transmission through a line or device compared to direct delivery of energy without line or device.

24. What do you meant by reflection loss?
Reflection loss is a measure of power loss during transmission due to the reflection of the signal as a result of impedance mismatch

25. Define guide wavelength. (May 2017)
Guide wavelength is defined as the distance between two equal phase planes along the waveguide. The guide wavelength is a function of operating wavelength (or frequency) and the lower cutoff wavelength, and is always longer than the wavelength would be in free-space.

PART B- C401.5

1. Write short notes on power sensors used for Microwave power measurement. **(May 2015) (Nov 2017)**
2. Explain the impedance measurement technique using slotted line and reflectometer. **(Nov 2016 & 2017)**
3. Explain Insertion loss & Attenuation Measurement.
4. Describe how frequency of the given source is measured. **(May 2013)**
5. (i) Explain Measurement of scattering parameters.
(ii) Explain Dielectric constant Measurement of a solid using Waveguides.
6. Explain how high VSWR can be measured using a microwave bench**.(May 2013)(Nov 2016 & 2017)**
7. Describe the measurement of power at microwave frequencies in detail. **(Nov 2017)**
8. Explain the procedure to measure the impedance of a load. **(May 2014)**
9. Explain SWR measurement with neat block diagram. **(Nov 2014)**
10. Explain the impedance, wavelength and frequency measurement technique using slotted line method. **(May 2017)**