 **ST.ANNE’S**

**COLLEGE OF ENGINEERING AND TECHNOLOGY**

(Approved by AICTE,NewDelhi.Affiliated to Anna University,Chennai)

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**QUESTION BANK**

**PERIOD:** JULY - NOV 2018 **BATCH**: 2015 – 2019

**BRANCH:** ECE **YEAR/SEM:** IV/VII

**SUB CODE/NAME: EC6701 - RF AND MICROWAVE ENGINEERING**

**UNIT I -TWO PORT NETWORK THEORY**

**PART – A**

1. **Mention the frequency range of C and X Band?[D](April/May 2019)**

|  |  |
| --- | --- |
| The X-band frequency range | : 8 – 12.5 GHz |

1. **The S matrix of a reciprocal microwave junction is a symmetric matrix-justify[I.D](April/May 2019)**
2. **Write the frequency range for IEEE microwave bands?[D](April/May 2017)**
3. **L band----** 1-2GHz
4. **S band----** 2-4 GHz
5. **C band----** 4-8 GHz
6. **X band----** 8-12 GHz
7. **Give the relation between S and ABCD parameter.[I.D] (April/May 2017, Nov/Dec 2012)**
8. **List the radio frequency bands available in microwave and radio frequency ranges.[D] (Nov/Dec 2016**

|  |  |  |
| --- | --- | --- |
| **Letter designation** | **Frequency range** | **wavelength** |
| [L band](https://www.everythingrf.com/tech-resources/frequency-bands/l-band) | 1 to 2 GHz | 15 cm to 30 cm |
| [S band](https://www.everythingrf.com/tech-resources/frequency-bands/s-band) | 2 to 4 GHz | 7.5 cm to 15 cm |
| [C band](https://www.everythingrf.com/tech-resources/frequency-bands/c-band) | 4 to 8 GHz | 3.75 cm to 7.5 cm |
| [X band](https://www.everythingrf.com/tech-resources/frequency-bands/x-band) | 8 to 12 GHz | 25 mm to 37.5 cm |
| [Ku band](https://www.everythingrf.com/tech-resources/frequency-bands/ku-band) | 12 to 18 GHz | 16.7 mm to 25 mm |
| [K band](https://www.everythingrf.com/tech-resources/frequency-bands/k-band) | 18 to 26.5 GHz | 11.3 mm to 16.7 mm |
| [Ka band](https://www.everythingrf.com/tech-resources/frequency-bands/ka-band) | 26.5 to 40 GHz | 5.0 mm to 11.3 mm |
| [Q band](https://www.everythingrf.com/tech-resources/frequency-bands/q-band) | 33 to 50 GHz | 6.0 mm to 9.0 mm |
| [U band](https://www.everythingrf.com/tech-resources/frequency-bands/u-band) | 40 to 60 GHz | 5.0 mm to 7.5 mm |

1. **Define S parameters.[D] (Nov/Dec 2016)**

The element of scattering matrix is called scattering coefficients or scattering parameters.

1. **State the principle advantage of microwave frequency over lower frequency.[D](May/June 2009)**
   * Equipment is not readily available to measure total voltage and current at the ports of the network.
   * Short circuit and open circuit are difficult to achieve over a wide range of frequencies.
   * Presence of active devices such as power transistors and tunnel diodes makes the circuit unstable.
2. **Define reciprocal and symmetrical network.[D](May/June 2013)**

|S| is a symmetric matrix when the microwave device has the same transmission characteristics in either direction of a pair of ports.

* **Sij = Sji**

1. **Mention the limitation in measuring Z, Y and ABCD parameters at microwave frequencies.[I.D] (Nov/Dec 2011)**

The limitations in measuring Z, Y and ABCD parameters at microwave frequencies are,

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

network.

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

iii. Presence of active devices such as power transistors and tunnel diodes makes the circuit

unstable.

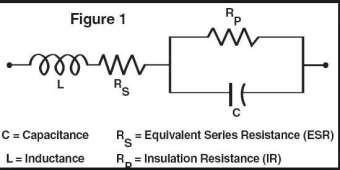
1. **List any four reason for the wide use of RF.(May/Jun 2014)**

* It can carry large quantities of information.
* Because of shorter wavelength, it requires small size of antenna.
* Fewer repeaters are necessary for amplification.
* Increased reliability and bandwidth availability.
* Less Maintenance.

1. **Name the properties of S parameters.[I.D] (Nov/Dec 2012)**

* Under perfect matched condition, the diagonal elements are zero.
* [S] is a Symmetry matrix.
* [S] is Unitary matrix.
* [S] is always a square matrix of order (nxn)

1. **Draw the equivalent circuit of a practical capacitor.[D] (Nov/Dec 2012)**

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1. **Draw the equivalent circuit of inductor at radio frequency.[D](May/June 2013)**
2. **Give the relationship between s and z.[D] (May/June 2014)**
3. **What are the advantages of S parameters?[D] (May/June 2012)**

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

1. Increased stability at higher frequencies
2. Mismatch loss is less
3. Attenuation loss is less
4. **Mention any 4 difference between low frequency and high frequency microwave circuits.[D] (April/May 2015)**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.NO** | **Low frequency Circuits** | **High Frequency Circuits** |  |
|  | Circuit elements are lumped | CIRCUITS elements are distributed |
|  | Analysis based on kirchoff’s and ohm’s law | Analysis based on electromagnetic field |
|  | Power handling capacity is less | Power handling capacity is high |
|  | Losses increases with frequency | Losses depends on other factor |

1. **Draw the high frequency equivalent circuit of resistor and inductor.[D] (April/May 2015)**
2. **Define 2 port network.[D]**

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

1. **Define a junction. (QB)[D]**

The Point of interconnection among two or more devices is called junctions.

1. **Why S matrix are used in microwave. [D](Nov/Dec 2011)**

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

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

1. **State reciprocity theorem.[D] (QB)**

The theorem states that when some amount of electromotive force (or voltage) is applied at one point (e.g., in branch k, vk) in a passive linear network, that will produce a current at any other point (e.g., in branch m, im). The same amount of current (in branch k, vk) is produced when the same electromotive force (or voltage) is applied in the new location (in branch m, im)

vk/i m = i m/vk

1. **Define quality factor of a capacitor.[D] (QB)**

It is the measure of ability of an element to store energy and is equal to 2π times the average energy stored to that of the energy dissipated per cycle.



1. **Write about the skin effect in a wire.[D] (QB)**

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

1. **Name the types of resistors.[D] (QB)**

The different types of high frequency resistors are,

* 1. Carbon composite resistors
  2. Metal film resistors
  3. Thin-film chip resistors

1. **Write the applications of inductors.[D] (QB)**

Inductors have a variety of application in RF circuits such as in resonance circuits, filters, phase shifter, delay network and RF chokes

1. **State zero property.[D]**

“For a passive lossless N-port network,the sum of the products of each term of any row or any column multiplied by the complex conjugate of the corresponding terms of any other row or column is zero”

Σ Ski Skj =0

1. **State few disadvantages of microwave.[D]**
2. **What are the Properties of s-matrix?[D]**

The properties of S parameter are,

* 1. |S| is always a square matrix of order (n\*n)
  2. |S| is a symmetric matrix
  3. |S| is a unitary matrix
  4. Under perfect matched conditions, the diagonal elements of |S| are zero

1. **Define one port circuit.Give two examples.[D]**

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 co-axial line

**PART – B**

**[First Half]**

**[Low frequency parameters]**

1. Write a detailed note on ABCD parameter. (8**)[D] (May/June 2013)**
2. Discuss the importance of low frequency and high frequency parameters of RF two port networks**.[D] (Nov/Dec 2014)**
3. Derive the overall network parameters for cascade connection of 2 port network. Discuss about short circuit, open circuit, H and ABCD low frequency parameters. **[D](16) (April/May 2017)**

**(OR)**

Explain in detail about low frequency parameters.

**[Formulation of S parameters]**

1. Derive the S parameter for a two port microwave network.discuss the physical significance of the four S parameter used to characterize the microwave circuit performance ?discuss the properties of S parameters?**[I.D](13) (April/May 2019)**
2. Formulate S parameter for n port network. Compute ABCD for a T network. (16**)[I.D] (May/June 2013, Nov/Dec 2012)**
3. Derive Z and Y matrix formulation of multi port network. (8) **[I.D](April/May 2015)**
4. Explain about the different types of interconnection of 2 port network. **[D](QB)**
5. Explain the scattering matrix for a lossless junction. (16) **[D](April/May 2015)**

**(OR)**

Explain the formulation of S matrix**.[D] (April/May 2015)**

**[Properties of S parameters]**

1. State and prove the properties of S matrix. (8**)[D] (April/May 2017)**

**(OR)**

List and explain the properties of S matrix. (8**)[D] (Nov/Dec 2011)**

**(OR)**

State and prove the properties of S matrix. (16) **[D](May/June 2009)**

**(OR)**

With the help of S matrix concept prove the S matrix properties. **[D](May/June 2014)**

1. Symmetry
2. Unity
3. Zero
4. Phase shift

**[Second Half]**

**[Reciprocal network]**

1. Explain the symmetry property in reciprocal network. (8)**[D] (April/May 2017, Nov/Dec 2011, April/May 2015)**
2. Explain and analyze any reciprocal lossless network with derivation. (10**)[D] (Nov/Dec 2016)**2016)

**[Transmission matrix]**

1. Explain the transmission matrix for 2 port network.**[D]** (8) **(Nov/Dec 2011)**

**(OR)**

Why do you prefer transmission matrix? Obtain ABCD matrix of a transformer with the turns ratio of N:1**. [I.D](May/June 2014)**

**(OR)**

What is T matrix? Obtain and explain its relationship with [S] and vice versa. (8) **[I.D](Nov/Dec 2016)**

**[RF behavior of Resistors, Capacitors and Inductors]**

1. Write in detail about types of resistors. (8) **[D](Nov/Dec 2011)**
2. Discuss on the application of RF and microwave area. (6) **[D](Nov/Dec 2016)**

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**UNIT II -RF AMPLIFIERS AND MATCHING NETWORKS**

**PART A**

1. **Write the necessary and sufficient conditions for an amplifier to be conditionally stable[I.D](April/May 2019)**

Key parameters of amplifier, to evaluate its performance are

1. Gain and gain flatness

2. Operating frequency and bandwidth

3. Output power

4. Power supply requirements

5. Input and output reflection coefficients

6. Noise figure

1. **What is meant by impedance matching?list the different impedance matching techniques?[D](April/May 2019)**

**Impedance matching** is the practice of designing the [input impedance](https://en.m.wikipedia.org/wiki/Input_impedance) of an [electrical load](https://en.m.wikipedia.org/wiki/Electrical_load)or the [output impedance](https://en.m.wikipedia.org/wiki/Output_impedance) of its corresponding signal source to [maximize the power transfer](https://en.m.wikipedia.org/wiki/Maximum_power_transfer_theorem) or minimize [signal reflection](https://en.m.wikipedia.org/wiki/Signal_reflection) from the load.

1. **Define transducer power gain.[D](Nov/Dec 2013)**

Transducer power gain is nothing but the gain of the amplifier when placed between

Source and load.

GT= Power delivered to the load / Available power from the source

1. **Define unilateral power gain.[D](Nov/Dec 2014)**

When feedback effect of the amplifier is neglected (i.e. S12 = 0), the amplifier power gain is known as unilateral power gain.

1. **Write the function of matching network? Or what is the need of matching network? [D](Nov/Dec 2011, Nov/Dec 2014, April/May 2015)**

Matching networks can help stabilize the amplifier by keeping the source and load impedances in the appropriate range. Input and output matching networks are needed to reduce undesired reflections and improve the power flow capabilities.

1. **Write notes on feedback of RF circuits.[D] (QB)**

i) If │Γ│>1, then the magnitude of the return voltage wave increases called

Positive feedback, which causes instability ( Oscillator).

(ii) If │Γ│<1, the return voltage wave is totally avoided (amplifier). It’s called as

Negative feedback.

1. **Define unconditional stability. [D](QB)**

Unconditional stability refers to the situation where the amplifier remains stable for

Any passive source and load at the selected frequency and bias conditions.

1. **Define noise figure.[D](Nov/Dec 2011)**

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

F = (SNR) O / (SNR) I

1. **Mention the importance of matching network.[I.D] (Nov/Dec 2012)**

1. Minimum power loss in the feed line

2. Maximum power delivers (or) Transfer

3. Improving the S/N ratio of the system for sensitive receiver components

4. Reducing amplitude & phase errors in a power distribution network

5. Minimum reflection in transmission line

6. Optimal efficiency

1. **What are the approaches used to a matching network?[I.D]**

(i) Derive the values of the elements analytically

(ii) Rely on the smith chart as a graphical design tool

1. **Define loaded quality factor.[D] (Rejinpaul)**

The loaded quality factor is equal to the ratio of the resonance frequency to the 3

dB bandwidth.

Ql=f0/BW

1. **Define nodal quality factor.[D]**

Nodal quality factor is defined as the ratio of the absolute value of the reactance to the

corresponding resistance.

Qn=Xs/Rs

1. **What are the advantage of T and Pi matching network?[D](Nov/Dec 2016)**

The addition of the third element into the two element matching network introduces an

addition degree of freedom in the circuit and allows us to control the value of ql by choosing

appropriate intermediate impedance for wider bandwidth.

1. **Why we go for double stub matching network?[I.D] (QB)**

One of the main drawbacks of single stub matching network is that they require a

variable length transmission line between the stub and the input port, or between the stub and the load impedance. Usually, this does not a problem for fixed networks, but may create

difficulties for variable tuners.

1. **Name the factors used for selecting a matching network.[D] (QB)**

1. Complexity

2. Bandwidth Requirement

3. Adjustability

4. Implementation

1. **Mention the advantage of smith chart. (Rejinpaul)**

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.

1. **Draw the typical output stability circle and input stability circle.[D](May/June 2013)**
2. **Why impedance matching is required. What are the other constraints?[I.D](May/June 2013)**

Matching networks can help stabilize the amplifier by keeping the source and load impedances in the appropriate range. Matching network is important for the following reasons.

* + 1. Maximum power loss is in the feed line
    2. Maximum power delivery or transfer
    3. Improving the S/N ratio of the system

1. **Define stability.[D] (May/June 2014)**
2. **State the significance of micro strip matching networks. [D](Nov/Dec 2014)**
3. **Give the expression that relates nodal quality factor with loaded quality factor.[D] (Nov/Dec 2013)**
4. **What the need of load matching in 2 port network.[I.D] (April/May2017)**

Matching networks can help stabilize the amplifier by keeping the source and load

Impedances in the appropriate range.

1. **What is transducer power gain.[D](April/May2017)**

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

1. **Distinguish between conditional and unconditional stability.[D] (May/June 2012)**
2. **Define power gain of an amplifier in terms of S parameters and reflection coefficients.[D] (Nov/Dec 2012)**
3. **Define available power gain.[D]**

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

1. **Give the expressions for noise figure of an amplifier.[I.D] (Nov/Dec 2012)**

The expression for noise figure of a two port amplifier is F = Fmin + (Gn/Rs) |Zs – Zopt|

Where,

F – Noise figure

Fmin – Minimum noise figure

Gn – Source conductance

Rs – Source resistance

Zs – Source impedance

Zopt – Optimum impedance

1. **What are the key parameters used to evaluate the performance of an amplifier?[D] (Rejinpaul)**

Key parameters of amplifier, to evaluate its performance are

1. Gain and gain flatness

2. Operating frequency and bandwidth

3. Output power

4. Power supply requirements

5. Input and output reflection coefficients

6. Noise figure

1. **Write the expression for noise figure of a two port amplifier.(Nov/Dec 2011)**

The generated noise of a two port network can be determined from the signal to noise ratio (SNR) from the input to the output.

1. **Define nodal quality factor.[D]**

Nodal quality factor is defined as the ratio of the absolute value of the reactance to the

corresponding resistance.

Qn=Xs/Rs

1. **Define unconditional stability. [D] (QB)**

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

1. **Write the function of matching network?April/May 2015)**

Matching networks can help stabilize the amplifier by keeping the source and load impedance in the appropriate range. Input and output matching networks are needed to reduce undesired reflections and improve the power flow capabilities.

**PART B**

**[First Half]**

**Amplifier power relations**

1. A microwave amplifier is characterized by its S-parameters. Derive equations for power, gain, available gain and transducer gain. **[I.D](16) (April/May 2015, April/May 2012)**

**(OR)**

Discuss various aspects of amplifier-power relation for RF transistor amplifier design**.[I.D]**

**(OR)**

Derive the amplifier power relations for 2 port amplifier**[D]**

**(OR)**

State and formulate the transducer power gain,available power gain and operating power gain of a microwave amplifier in terms of S parameters and different reflection coefficient?**[D](april/may 2019)(13)**

1. Discuss gain considerations for RF amplifier**.[D]**
2. Write the mathematical analysis of amplifier stability. (8**)[D] (April/may 2015)**
3. Design a microwave amplifier for transducer power gain. (8) **[D](April/May 2015)**

**Stability considerations**

1. With reference to RF transistor amplifier, discuss the considerations for stability and gain.(16**)[I.D] (Nov/Dec 2011) (Nov/Dec 2014)**
2. Explain input and output stability circles with different conditions**[D](8)**
3. Derive stability conditions for a microwave amplifier**?(13)(D)(april/may 2019)**

**Stabilization Methods**

1. Discuss various stabilization methods and stability considerations for RF transistor, amplifier gain. (16) **[D](Nov/Dec 2011)**
2. Explain various stabilization methods. **(16)[D]**

**Noise Figure & VSWR**

1. Explain noise figure circles and VSWR circles in detail. (16)**[D]**

**(OR)**

1. Analyze noise figure circles and VSWR circles and derive the expressions. (16) **[D]**
2. Describe the process of visualizing the noise performance of a transistor by plotting noise circles on the S plane. (16) **(May/June 2012) [I.D]**

**High power and Multistage Amplifiers**

1. Write detailed note on Broadband, High power and Multistage Amplifiers. (16**)[D]**

**[Second Half]**

**T and Pi Matching Networks**

1. Explain the concept of T and micro strip matching network? (10) **(Nov/Dec 2014)[D]**
2. Describe the smith chart. How can it be used to determine an unknown impedance?(6**)[D](Nov/Dec 2014)**
3. Discuss the design procedure for T and pi matching network. (16**) (Nov/Dec 2013) [D]**

**(OR)**

1. Explain the design procedure for T and π matching network. (16) **[D] (Nov/Dec 2013, April/May 2017)**
2. What are T and π matching network. Explain in detail. Also state its functions **[D]**
3. Explain different types of matching networks **(16) [D](Nov/Dec 2011)**
4. Explain 2 component matching network. (8**)[D]**

**Microstrip Line Matching Networks**

1. Explain the different types of micro strip lines and give a brief note of their characteristics. (16) **(April/May 2017)[D]**

**(OR)**

Explain in detail about micro strip line matching network with a neat diagram**.[D]**

1. Explain the following: (a) Impedance matching networks. (b) Microstripline matching networks(16**)[D] (Nov/Dec 2011)**

**\*\*\*\*\*\*\*\*\*\*\***

**UNIT 3 – PASSIVE AND ACTIVE MICROWAVE DEVICES**

**PART A**

1. **Give the significance of E plane and H plane bends?(D)(april/may 2019)**
2. **Find the S matrix of a matched isolator with 0.1 db insertion loss and 30 db isolation?(D)(april/may 2019)**
3. **Name the any two microwave passive devices which make use of Faraday rotation. [D](AU A/M 2015)**
4. Gyrator
5. Isolator
6. Circulator
7. Phase shifter
8. **Draw the equivalent circuit of Varactor diode.[D] (AU A/M 2015)**
9. **What is isolator? And why isolators are called uniline? [D](AU N/D 2016)**

An ideal isolator completely absorbs the power for propagation in one direction and provides lossless transmission in the opposite direction. Thus isolators are called unline.

1. **Mention the application of Gyrator and Isolator. [D](AU N/D 2014)**
2. **Write the necessary conditions for Gunn Effect. [D](AU N/D 2014)**
3. **What are the factors that reduce the efficiency of IMPATT diode? [D](AU M/J 2014)**

(i) Space charge effect

(ii) Reverse saturation current effect

(iii) High frequency skin effect

(iv) Ionization saturation effect.

1. **What is negative resistance in Gunn diode? [D](AU M/J 2014)**

The carrier drift velocity increases linearly from 0 to maximum when the electric field is increased from 0 to threshold value in gunn diodes. When the electric field is beyond the threshold value of 3000v/cm the drift velocity is decreased and the diode exhibit negative resistance.

1. **What are matched terminators? [D](AU M/J 2014)**

Matched termination is one port component that absorbs all the incident power. This requires that its impedance equal to the characteristics impedance of the line to which it is connected.

The common matched loads used for a waveguide are

i) Tapered loads

ii) Step loads

1. **What are ferrites? Why is its need in circulators? [D](AU M/J 2014)**
2. **What are power dividers?[D]**

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

1. **What is the S-matrix of 3 port circulators?[D]**

Anticlockwise [S] = 0 1 0

0 0 1

1 0 0

Clockwise [S] = 0 0 1

1 0 0

0 1 0

1. **Give the differences between Isolator and Circulator.[D]**

|  |  |  |
| --- | --- | --- |
| **s.no** | Isolator | Circulator |
| **1.** | It is a 2 port device | It is a 3 port device |
| **2.** | It cannot be used as circulator | It is used as isolator by terminating one port |
| **3.** | If input is given in port 1,output is obtained at port 2 and vice versa | Each terminal is connected only to the  versa next terminal |

1. **What is the S-matrix for 4 port circulators?[D]**

Clockwise

[S]= 0 0 0 1

1 0 0 0

0 1 0 0

0 0 1 0

Anticlockwise

[S] = 0 1 0 0

0 0 1 0

0 0 0 1

0 0 1 0

1. **What are ferrites and write its properties. Give some examples of ferrite devices.[D]**

Ferrites are ceramic like materials. These may by sintering a mixture of metallic oxides.

Properties

 Specific resistivities may be used as much as 1014 greater than that of metals

 Dielectric constants around 10 to 15 or greater

 Relative permeability is 1000

Some examples of ferrite devices:

(i) Isolator (ii) Circulator

(iii) Phase shifters (iv) Modulators

(v) Power limiters

1. **Give the S-matrix of series Tee.[D]**

[S] = 0.5 0.5 0.707

0.5 0.5 -0.707

0.5 -0.707 0

1. **Give the S-matrix of shunt Tee.[D]**

[S] = 0.5 -0.5 0.707

-0.5 0.5 0.707

0.707 0.707 0

1. **Give the S-matrix of hybrid Tee.[D]**

[S] = 0 0 0.707 0.707

0 0 0.707 -0.707

0.707 0.707 0 0

0.707 -0.707 0 0

1. **Give the S- Matrix of directional coupler.[D]**

[S] = 0 P 0 jq

P 0 jq 0

0 jq 0 P

Jq 0 P 0

1. **Give an example for a two port MW device.[D]**

Isolator is an example for a 2 port MW device

1. **Give the applications of directional coupler[D]**
   * 1. Unidirectional power measurement
     2. SWR measurement
     3. Unidirectional wave launching
     4. Reflectometer
     5. Balanced duplexer
2. **What is Faraday’s rotation law?[D]**

If a circularly polarized wave is made to pass through a ferrite rod which has been

influenced by an axial magnetic field B, then the axis of polarization gets tilted in clockwise

direction and amount of tilt depends upon the strength of magnetic field and geometry of the

ferrite.

1. **What is the principle of Microwave phase shifter?[D]**

When a wave propagates on a line,a phase difference prevails between any two arbitrary

points along its paths. The phase difference between two points,

1. **What are junctions? Give some examples[D]**

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

1. **What is Tee junction? Give two examples[D]**

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

1. **What is hybrid ring?[D]**

Hybrid ring consists of an annular line of proper electrical length to sustain standing waves, to which four arms are connected at proper intervals by means of series or parallel junctions.

1. **What are nonreciprocal devices? Give two examples[I.D]**

The devices which are having the property that the forward characteristics are not equal to the reverse characteristics are called non reciprocal devices.

1. **Why isolators are called uniline?[D]**

An ideal isolator completely absorbs the power for propagation in one direction and provides lossless transmission in the opposite direction. Thus isolators are called unline.

1. **A directional coupler is having coupling factor of 20 db and directivity of 40 db.if the incident power is 900mW, what is the coupled power?[D]**

**PART B**

**[First Half]**

**Attenuators, Phase shifters**

1. With neat diagram explain the various types of attenuators and phase shifters (8)**[D]**

**Directional couplers**

1. A directional coupler has coupling factor of 10 db and a directivity of 30 db.if the power in the isolator port is 40 mw.find the power in the input port and also in the through port.what is the insertion loss of the coupler?(**A/M 2019)(7)**
2. With neat diagram explain the operation and types of the directional coupler. (16) **(AU A/M 2015)[D]**
3. What do you mean by S parameters? Why do we require S parameters? Draw the diagram of a

Directional coupler and explain the working. Derive S matrix of a directional coupler. (16)**[D]**

**Hybrid Junctions**

1. Describe Magic Tee with neat sketch. (6)[D]
2. Discuss the properties of scattering matrix. Determine the Scattering matrix representation

of E plane Tee Junction. (10) **(AU N/D 2016)[D]**

1. Derive scattering matrix of H – plane tee using S – parameter theory. (8)**[D]**

**(OR)**

Derive scattering matrix of shunt tee using S – parameter theory**[I.D]**

1. Derive scattering matrix of E – plane tee using S – parameter theory. (8)**[D]**

**(OR)**

Derive scattering matrix of Series tee using S – parameter theory. (8)**[I.D]**

**Circulator, Isolator**

1. Why isolator is known as unilinedevice?what are the applications of an isolator?derivee the S Matrix for 3 port circulator and explain the physical significance of each paraamters?(april/may 2019)
2. Explain the operating principle of a microwave, circulator with neat schematic diagram. (8)

**(AU N/D 2014) [D]**

1. What is circulator? With neat diagram, explain the working principle, Construction, operation ofFour -port circulator using magic -tees. Verify the Circulator theory with necessary

S -parameter equations. **(AU N/D 2016)[I.D]**

1. Explain the construction working and application of isolator based on Faraday rotation? **[D]**
2. Discuss the structure and principle of operation of**[D]**
   * 1. Isolator (8)
     2. Circulator (8)

**(OR)**

Explain about Circulator and Isolator with its working principle (10)**[D]**

**[Second Half]**

**Crystal and Schottkey diode detector**

1. Conclude the operating principles of schottkey Barrier diode and step recovery diodes. (8)**[D]**
2. Explain the operating principle of varactor and schottkey diodes**. (AU M/J 2014)[D]**

**Gunn diode oscillator**

1. Explain the working principle of Gunn diode with two valley model andPlot its characteristics. **(AU A/M 2015)[D]**

**(OR)**

1. Explain Ridley-Watkins –Hilsum (RHW) theory with the help of two-valley modal. **[I.D]**
2. With neat diagram, explain the construction and characteristics of Gunn diode. **(AU N/D 2014)**

**(OR)**

Explain the operating principle of a Gunn diode. Describe its domain formation and various

Modes of operation? **(AU M/J 2014)[D]**

**(OR)**

1. Recall the working principle of Gunn diode (8)
2. What are the various modes of operations of the Gunn diode (4)
3. Plot Gunn Diode characteristics. (4)

**IMPATT diode oscillator**

1. What are avalanche transit time devices? Explain the operation and construction of IMPATT diode. (**AU A/M 2015)[D]**
2. Give the comparison between Gunn, IMPATT, TRAPATT andBaritt. **.(A/M 2017) [D]**

**Varactor diode**

1. Discuss briefly about working principle, operation, characteristics and application of varactor diode. (16) **(AU A/M 2015)[D]**

**UNIT 4 – MICROWAVE GENERATION**

**PART A**

1. **Why cant conventional tubes be used at microwave frequencies?(A/M 2019)**
2. **What are the different modes of operation realizable with gunn diodes?(A/M 2019)**

The modes available in negative resistance devices are,

i. Voltage controlled mode

ii. Current controlled mode

1. **What is magnetron?[D](N/D 2016)**
2. **Write the classification of microwave tubes and explain the difference between them.[D](A/M 2017)**

* O-type
* M-type

1. **What are slow wave structures? Give examples. (A/M 2017) ?[I.D]**

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. Eg: TWT

1. **What is the purpose of slow wave structures used in TWT amplifiers?[D] (N/D 2017)**

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.

1. **What do you mean by O type tube ?Name some O type tubes.(N/D 2017)**

In O – type tube a magnetic field whose axis coincides with that electron beam is used to hold the beam together as it travels the length of the tube. It is also called as linear beam tube.

i) Helix traveling wave tube

ii) Coupled cavity TWT

iii) Forward wave amplifier

iv) Backward wave amplifier

v) Backward wave oscillator

1. **What is Tetrodes and Pentodes?[D] (N/D 2016)**

The triodes, tetrodes and pentodes are known as conventional tubes which are useful at low microwave frequencies.

1. **Compare two cavity klystron and traveling wave tube[D]**
2. **What are the limitations of conventional vacuum devices?[D] .(N/D 2015)**
   * + Lead inductance effect
     + Inter-electrode capacitance effect
     + Transit-time and transit-angle effect
     + Gain-bandwidth product
3. **Mention the major differences between the TWT and Klystron.(A/M 2015) [D]**

|  |  |  |
| --- | --- | --- |
| **s.no** | **Klystron amplifier** | **TWTA** |
|  | Linear beam or „O‟ type device. | Linear beam or „O‟ type device. |
|  | Uses cavities for input and Output circuits. | Uses cavities for input and Output circuits. |
|  | Narrow band device due to resonant wave circuit. | Wide band device because use of Non resonant wave circuit. |

1. **What are the high frequency effects in conventional tubes?[D] .(A/M 2015) [**

The high frequency effects in conventional tubes are

* + 1. Circuit reactance
    2. Inter electrode capacitance
    3. Lead inductance
    4. Transit time effect
    5. Cathode emission
    6. Plate heat dissipation area
    7. Power loss due to skin effect, radiation and dielectric loss.

1. **What are the assumptions for calculation of RF power in Reflex Klystron?[D]**

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

1. **Give the drawbacks of klystron amplifiers[D]**

1. As the oscillator frequency changes then resonator frequency also changes and the

feedback path phase shift must be readjusted for a positive feedback.

2. The multicavity klystron amplifiers suffer from the noise caused because bunching is never

complete and electrons arrive at random at catcher cavity. Hence it is not used in receivers.

1. **What are the applications of reflex klystron?[D]**

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.

1. **What is the purpose of slow wave structures used in TWT amplifiers?[D]**

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.

1. **State the applications of TWT.[D]**

1) Low power, low noise TWT‟s used in radar and microwave receivers

2) Laboratory instruments

3) Drivers for more powerful tubes

4) Medium and high power CWTWT‟S are used for communication and radar.

1. **What do you mean by O-type tubes? Name some O-type tube?[I.D]**

In O – type tube a magnetic field whose axis coincides with that electron beam is used to

Hold the beam together as it travels the length of the tube. It is also called as linear beam tube.

* + - 1. Helix Traveling wave tube
      2. Coupled cavity TWT
      3. Forward wave amplifier
      4. Backward wave oscillator
      5. Backward wave amplifier

1. **What is the effect of transit time?[D]**

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.

1. **Explain Hull cutoff condition?[I.D]**

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

1. **How would you explain BWO? State the applications of BWO.[D]**

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.

1. **Why magnetron is called as Cross field Devices?[D]**

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.

1. **How the klystron amplifier can act as klystron oscillator? What are the applications of klystron amplifier?[I.D]**

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.

Applications:

(1) UHF TV Transmitters

(2) Long ranger radar

(3) Linear particle accelerator

(4) Troposcatter links

(5) Earth station transmitter.

1. **Compare TWTA & Klystron amplifier.(A/M 2015) [D]**

|  |  |  |
| --- | --- | --- |
| **s.no** | **Klystron amplifier** | **TWTA** |
|  | Linear beam or „O‟ type device. | Linear beam or „O‟ type device. |
|  | Uses cavities for input and Output circuits. | Uses cavities for input and Output circuits. |
|  | Narrow band device due to resonant wave circuit. | Wide band device because use of Non resonant wave circuit. |

1. **Give the performance Specification of Reflex klystron?[D]**

Frequency range: 2- 200 GHz

Band width: + 30 MHz for \_ VR = + 10V

Power output: 10 mw – 2.5W

Efficiency: 20 to 30%

1. **State the application of magnetron .why magnetron is called as cross field device?(NOV/DEC 2013)**
2. Pulse work in radar
3. Linear particle accelerators.

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.

1. **What is the condition for oscillation in Reflex klystron ?[D]**

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 ≥G.

Where

G=Gc + Gb +G1 = 1/ Rsh

Rsh - effective shunt resistance

Gc - copper losses of cavity

Gb- beam loading conductance

G1 - load conductance

1. **Give the drawbacks of klystron amplifiers.[D]**
   1. As the oscillator frequency changes then resonator frequency also changes and the feedback path phase shift must be readjusted for a positive feedback.
   2. The multicavity klystron amplifiers suffer from the noise caused because bunching is never complete and electrons arrive at random at catcher cavity. Hence it is not used in receivers.
2. **What are the applications of reflex klystron ?[D] ?(NOV/DEC 2013)**
   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.

**PART B**

**[First Half]**

**Two cavity Klystron Amplifier**

1. With neat diagram explain the operation of two cavity klystron amplifierand derive the equations for velocity modulation process. (16)**.(A/M 2017) [D]**

**(OR)**

Explain in detail about 2-cavity klystron amplifier.(16) **[D]**

1. What are the launching process of a two cavity klystron (8)**[I.D]**

**Reflex Klystron oscillator**

1. Discuss the operation of reflex klystron microwave oscillator with diagrams?(A/M 2919)(13)
2. Explain the operation of reflex klystron oscillator with neat diagram. Write the performance characteristics and applications of the reflex Klystron **(N/D 2017) [D]**

**(OR)**

Discuss the working principle of reflex klystron oscillator with necessary diagrams. (8)

**(OR)**

Explain briefly the working principle of the reflex klystron oscillator (6)

**(OR)**

Show the working principle of reflex klystron oscillator with necessary diagram (10)

1. Derive velocity modulation, transit time of reflex klystron oscillator.(8)**[D]**
2. Explain the working principle and operation of multi -cavity Klystronamplifier and derive the expressions for its output power. (16) **(N/D 2016) [D]**

**[Second Half]**

**Traveling wave tube amplifier**

1. What isan IMPATT diode?discuss the operation of an IMPATT diode with neat diagram? Mention the application of an IMPATT diode?(A/M 2019)(13)
2. Explain the operation of travelling wave tube and write its characteristics. **.(A/M 2017) [D]**

**(OR)**

Illustrate with interaction region diagram the mechanism of operation of TWT amplifier, its

Applications and the expression for the gain of a TWT**[D]**

1. With neat sketch explain how a travelling wave tube operates? Specify the role of slow wave structures in it?(A/M 2019)(15)
2. A travelling wave tube (TWT) operates under the following parameters : **(N/D 2016) [D]**

Beam Voltage Vo = 3 kV

Beam Current 10 = 30 mA

Characteristic impedance of helix = Zo =10 Q

Circuit length = N = 50 m

Frequency f = 10 GHz

Determine

* + - 1. Gain parameters C.
      2. Output power gain Ap in decibels.
      3. All four propagation constants. (16)

**Magnetron oscillator using Cylindrical, Linear, Coaxial Voltage tunable Magnetrons**

1. Write a detailed notes on the following**[D]**

Travellingwave tube amplifier. ii) Cylindrical magnetron(8)**(N/D 2017)**

1. With neat diagrams and relevant equations, explain about cylindrical and coaxial magnetron. (16)**[D]**
2. Discuss in detail about tunable magnetron and also explain in brief regarding Ricke diagram. (16)**[I.D]**
3. Explain coaxial voltage tunable magnetrons with necessary diagrams **[D]**
4. Explain the π mode of operation of magnetron. Mention few high Frequency limitations.**[D]**

**(OR)**

1. How would you describe the π mode of oscillations of Magnetron, what is meant by strapping in Magnetron and why it is done**?[AU M/J 2015][D]**

**Backward wave crossed field amplifier and oscillator**

1. Explain about (i) Backward wave Crossed field amplifier (8) (ii) Backward wave oscillator.

**(OR)**

1. Explain the construction, operation, characteristics and applications of BWO.**[D]**
2. Define optimum bunching distance Lopt. And derive the expression for it. **[I.D]**
3. Derive the equation of velocity modulated wave and discuss the concept of bunching effect in two cavity klystron. With neat diagrams and relevant equations, explain about helix traveling wave tube.(16)**[I.D]**

19. Explain the π mode of operation of magnetron

* 1. Show the High frequency effects in vacuum tubes.
  2. Explain the impact of frequency effects in real time vacuum tube applications.
  3. An X band pulsed cylindrical magnetron has the following
     1. Operating parameters:
     2. Anode voltage Vo = 26 kV
     3. Beam current Io = 27 A
     4. Magnetic flux density Bo = 0.336 Wb/m2
     5. Radius of cathode cylinder a = 5 cm
     6. Radius of vane edge to center b = 10 cm.
  4. Determine cyclotron angular frequency, cut off voltage for a fixed Bo and cut off magnetic flux density for a fixed Vo. (10)
  5. A travelling wave tube (TWT) operates under the following parameters :
  6. Beam Voltage Vo = 3 kV
  7. Beam Current 10 = 30 mA
  8. Characteristic impedance of helix = Zo =10 Q
  9. Circuit length = N = 50 m
  10. Frequency f = 10 GHz
  11. Determine Gain parameters C and Output power gain Ap in decibels and All four propagation constants

**UNIT 5 – MICROWAVE MEASUREMENTS**

**PART A**

1. **Mention the sensors used for microwave power measurement?(AM 2019)(D)**

Schottky barrier diode, bolometer and the thermocouple

1. **Mention few techniques used for measurement of an impedance at microwave frequency?(D)(AM 2019)**
2. **What is network analyzer?[D](N/D 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

1. **Classify microwave powers with its range?[D](N/D 2016)**

The range of microwave power is divided into 3 categories as,

* + - * 1. Measurement of low power(lea than 10 mw)
        2. Measurement of medium power?(from 10 mw to 10 W)
        3. Measurement of high power(>10 W)

1. **Differentiate barretter and thermistor.[D]**

**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**.**

1. **Demonstrate the errors possible in VSWR measurements.[I.D]**

The possible errors occur in measurement of standing wave ratio are,

* + 1. Vmax and Vmin may not be measured in the square law region of the crystal detector
    2. Probe thickness and depth may produce reflections in the line
    3. Residual VSWR arises due to mismatch impedance
    4. Harmonics and spurious signals from source cause measurement errors

1. **Explain how to measure dielectric measurement of a solid?[D]**

There are two methods commonly used for dielectric constant measurements are,

* + - * 1. Waveguide method
        2. Cavity perturbation method

1. **What is bolometer? Discuss the different types of Impedance measurement method?[D]**

Bolometer is a power sensor whose resistance changes with temperature as it absorbs microwave power. Examples: Barretter, Thermistor

1. **What is calorimeter?[D]**

Calorimeter is a convenient device for measuring the high power at microwave frequencies which involves conversion of microwave energy in to heat, absorbing the heat in a fluid and determine the temperature.

1. **What are tunable detectors?[D]**

The tunable detectors are used to demodulate the signal and couple therequired output to high frequency scope analyzer.The low frequencydemodulated output is detected using non reciprocal detector diode monunted in the microwave transmission line**.**

1. **What is calorimetric direct heating method?[D]**

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

1. **What is the principle by which high power measurements could be done by calorimetric method?[D]**

High power microwave measurements can be conveniently done by the calorimetric method which involves conversion of the microwave energy into heat in a fluid and then measuring of the dissipating medium

1. **Name the scales used in VSWR meter.[D]**
2. **Why direct microwave measuring instruments are not used in laboratory?[I.D]**

The vector network analysers, spectrum analyzers, power meter are the direct microwave measuring instruments. Due to the complications and high cost of these devices and instruments, they are not used for laboratory equipments.

1. **Define reflection coefficient?[D]**

The ratio of electrical field strength of reflected and incident wave is called reflection coefficient.

1. **Define guide wavelength.(A/M 2017) [D]**
2. **Define return loss and insertion loss in RF networks.(N/D 2017) [D]**
3. **What are the uses of network analyzer? What are the types of network analyzer? (N/D2017)[D]**
4. **How do you measure microwave frequency?[D]**
   1. Wavemeter method
   2. Slotted line method
   3. Downconversion method
5. **What is a wavemeter?[D]**

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 ofcavity by changing cavity length.

1. **Define dielectric constant?[D]**

It is defined by the ratio of permittivity of medium to permittivity

Of free space. Xr =x/xo=((10^-9)/36p)

1. **How the S-parameter of a microwave circuit measured?[D]**

Parameters are conveniently measured using the deschamps method which utilizes the measured value of complex input reflection coefficient under a number of a reactive termination.

1. **List the methods for measuring dielectric constants?[D]**

1. Waveguide method 2.cavity pertubaration method

1. **What is spectrum analyzer?[D]**

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.

1. **List the types of spectrum analyzer[D]**
2. Real time spectrum analyzer
3. Swept tuned frequency spectrum analyzer
4. **List some application of spectrum analyzer.[D]**

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

1. **How will you determine the vswr and return loss in reflecto meter method?[D]**

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)

1. **List the different types of Impedence measurement methods?[D]**

1.Slotted line method

2.Reflectometer method

3.Reactor discontructer method

**PART B**

**[First Half]**

**Measuring Instruments- VSWR meter**

1. Explain in detail the measurement of VSWR through return loss measurements.(16)**[D]**
2. Explain the measurement of high VSWR with the help of block diagram**[D]**
3. Explain how low VSWR can be measured using a microwave bench. .**[D] (N/D 2017)**
4. Explain the principle of operation of VSWR meter.**[D](N/D 2017)**

**Power meter**

1. Explain the operation of microwave power meter with neat sketches.**[D]**

**Spectrum analyzer, Network analyzer**

1. Explain Spectrum analyzer and Network analyzer with suitable diagrams.**[D]**
2. Explain the operation of network analyzer with neat sketches.**[D]**
3. Discuss the functions of the following with block diagram?**(A/M 2019)(13)**
   * + - 1. Spectrum analyzer
         2. Network analyzer

**[Second Half]**

**Measurement of Impedance, Frequency, Power, VSWR**

1. Explain the frequency and wavelength measurement with neat block diagram?(A/M 2019)(13)
2. Write notes on power sensors used for microwave power measurements **[D]** (8)
3. Identify how high power measurements are done using calorimetric method.**[D](8)**
4. Discuss the measurement ofpower at microwave frequency in detail.**[D] (N/D2017) (8)**
5. Discuss in detail the power measurement using microwave devices.(16) .**[D] (A/M 2017)**
6. Describe how the power of a microwave generator can be measuredusing bolometer**[D](8)**
7. Describe how the frequency of a given microwave source can be measured?**[D](8)**
8. Discuss in detail the impedance measurement using microwave devices.(16)**[D]**
9. Explain the impedance measurement technique using slotted line andReflectometer.(16)**[D]**

**(OR)**

1. Explain the procedure to measure the impedance of a load using slotted line method?(12)**[D] (N/D2017)**
2. Discuss the impedance, wavelength and frequency measurement using

Slotted line method.(16)**[D] (A/M 2017)**

1. Describe the measurement of Q by slotted line method with neat sketch.**[D](8)**

**Dielectric constant**

1. Explain in detail about the dielectric constant measurement of a solid using waveguide.**[D]**(16)